Appendix F
Essential Fish Habitat Assessment Reports

Prepared by

National Marine Fisheries Service

January 2004

APPENDIX F.1

ESSENTIAL FISH HABITAT ASSESSMENT REPORT

for the Groundfish Resources of the

Gulf of Alaska Region

August 22, 2003

NOAA Fisheries
NMFS Alaska Region
709 West 9th Street
Juneau, AK 99802

NOAA Fisheries
National Marine Fisheries Service

Table of Contents

Introduction F.1-1

Table 1- Summary of Major References and Atlases F.1-3

Table 2 - Summary of Habitat Associations for Groundfish in the GOA F.1-5

Table 3 - Summary of Reproductive Traits for Groundfish in the GOA F.1-8

Table 4 - Summary of Predator and Prey Associations for Groundfish in the GOA F.1-9

Habitat Description for Walleye pollock F.1-12

Habitat Description for Pacific cod F.1-20

Habitat Description for Dover Sole F.1-24

Habitat Description for Greenland Turbot F.1-27

Habitat Description for Rock Sole F.1-31

Habitat Description for Yellowfin sole F.1-35

Habitat Description for Rex Sole F.1-38

Habitat Description for Flathead Sole F.1-41

Habitat Description for Arrowtooth Flounder F.1-44

Habitat Description for Sablefish F.1-47

Habitat Description for Pacific Ocean Perch F.1-51

Habitat Description for Shortraker Rockfish and Rougheye Rockfish F.1-57

Habitat Description for Northern Rockfish F.1-61

Habitat Description for Light Dusky Rockfish F.1-65

Habitat Description for Yelloweye Rockfish F.1-69

Habitat Description for Thornyhead Rockfish F.1-73

Habitat Description for Atka mackerel F.1-77

Habitat Description for Capelin F.1-81

Habitat Description for Habitat Description for Eulachon F.1-85

Habitat Description for Sculpins F.1-89

Habitat Description for Sharks F.1-93

Habitat Description for Skates F.1-96

Habitat Description for Squid F.1-99

Habitat Description for Octopus F.1-103

Introduction

In 1996, the Sustainable Fisheries Act amended the Magnuson-Stevens Fishery Conservation and Management Act to require the description and identification of Essential Fish Habitat (EFH) in Fishery Management Plans (FMPs), adverse impacts on EFH, and actions to conserve and enhance EFH. Guidelines were developed by the National Marine Fisheries Service (NMFS) to assist Fishery Management Councils in fulfilling the requirements set forth by the Act.

Essential fish habitat means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat: "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means the habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

With respect to type, the information available for almost all species is primarily broad geographic distributions based on specific samples from surveys and fisheries, which have not been linked with habitat characteristics. Furthermore, our ability to precisely define the habitat (and its location) of each life stage of each managed groundfish species in terms of its oceanographic (temperature, salinity, nutrient, current), trophic (presence of food, absence of predators), and physical (depth, substrate, latitude, and longitude) characteristics is very limited. Consequently, the information included in the habitat descriptions for each species and life stage is restricted primarily to their position in the water column (e.g., demersal, pelagic), broad biogeographic and bathymetric areas (e.g., 100-200 m zone, south of the Pribilof Islands and throughout the Aleutian Islands), and occasional references to known bottom types associations.

Identification of EFH for some species included historical range information. Traditional knowledge and sampling data have indicated that fish distributions may contract and expand due to a variety of factors including, but not limited to, temperature changes, current patterns, changes in population size, and changes in predator and prey distribution.

Background

In preparation of the 1999 Essential Fish Habitat Environmental Assessment, EFH Technical Teams, comprised of scientific stock assessment authors, compiled scientific information and prepared the 1999 Habitat Assessment Reports. These reports provided the scientific information baseline to describe EFH. Importantly, recent scientific evidence has not proved to change existing life history profiles of the federally managed species. However, where new information does exist, new data helps to fill information gaps in the region's limited habitat data environment.

Stock assessment authors used information contained in these summaries and personal knowledge, along with data contained in reference atlases (NOAA 1987; 1990; NPFMC 1997a;b), fishery and survey data (Allen and Smith 1988; Wolotira et al. 1993; NOAA 1998), and fish identification books (Hart 1973; Eschmeyer and Herald 1983; Mecklenburg and Thorsteinson 2002), to describe EFH for each life stage using best scientific judgment and interpretation; see Table1.

Species Profiles and Habitat Descriptions

FMPs must describe EFH in text, map EFH distributions, and include tables, which provide information on habitat and biological requirements for each life history stage of the species; see Tables 2-4. Information contained in this report details life history information for federally managed fish species. This collection of scientific information is interpreted, then referenced to describe and delineate EFH for each species by life history stage using GIS. EFH text and map descriptions are not compiled in this report due to differences in the characteristics of a species life history and the overall distribution of the species. Specific EFH text descriptions and maps are in Appendix D.

References

Allen, M. J., and G. B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. U.S. Dep. Commerce., NOAA Tech. Rept. NMFS 66, 151 p.

Eschmeyer, W. N., and E. S. Herald. 1983. A field guide to Pacific coast fishes. Houghton Mifflin Co., Boston. 336 p.

Hart, J. L. 1973. Pacific fishes of Canada. Fisheries Research Board of Canada Bulletin 180. Ottawa. 740 p.

Mecklenburg, Commerce., Mecklenburg,T.A ., and Thorsteinson, L.K. 2002. Fishes of Alaska. American Fish Society. Bethsda, Maryland. 1037 p.

NOAA. 1987. Bering, Chukchi, and Beaufort Seas. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerce., NOAA, NOS.

NOAA. 1990. West coast of North America. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerce., NOAA, NOS.

NOAA. 1998. Catch-per-unit-effort, length, and depth distributions of major groundfish and bycatch species in the Bering Sea, Aleutian Islands and Gulf of Alaska regions based on groundfish fishery observer data. U.S. Dep. Commerce., NOAA Tech. Memo. NMFS-AFSC-88.

NPFMC. 1997a. Essential fish habitat assessment report for the groundfish resources of the Bering Sea and Aleutian Islands regions. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

NPFMC. 1997b. Essential fish habitat assessment report for the groundfish resources of the Gulf of Alaska region. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Wolotira, R. J., Jr., T. M. Sample, S. F. Noel, and C. R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U.S. Dep. Commerce., NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Table 1. Summary of Major References and Atlases

Species	References					
	Allen and Smith 1988	NOAA 1987	NOAA 1990	Wolotira et al. 1993	NOAA 1998	Mecklenburg and Thorsteinson 2002
Walleye pollock	X	X	X	X	X	X
Pacific cod	X	X	X	X	X	X
Yellowfin sole	X	X		X	X	X
Greenland turbot	X	X		X	X	X
Arrowtooth flounder	X	X	X	X	X	X
Rock sole	X	X		X	X	X
Alaska plaice	X	X		X	X	X
Flathead sole	X	X	X	X	X	X
Sablefish	X		X	X	X	X
Pacific ocean perch	X		X	X	X	X
Shortraker-rougheye rockfish	X				X	X
Northern rockfish	X				X	X
Dusky rockfish	X				X	X
Thornyhead rockfish	X				X	X
Atka mackerel	X		X	X	X	X
Sculpins	X				X	X
Skates	X				X	X

Abbreviations used in the EFH report tables to specify location, depth, bottom type, and other oceanographic features.

Location

ICS = inner continental shelf (1-50 m)
MCS = middle continental shelf (50-100 m)
OCS = outer continental shelf (100-200 m)
USP = upper slope (200-1000 m)
LSP = lower slope (1000-3000 m)
BSN= basin (>3000 m)

BCH = beach (intertidal)
BAY = nearshore bays, give depth if appropriate (e.g., fjords)
IP = island passes (areas of high current), give depth if appropriate

Water column

D = demersal (found on bottom)
SD/SP =semi-demersal or semi-pelagic if slightly greater or less than 50% on or off bottom
P = pelagic (found off bottom, not necessarily associated with a particular bottom type)
N = neustonic (found near surface)

Bottom Type

M = mud
S = sand
R = rock
SM = sandy mud
CB = cobble
C = coral
MS = muddy sand
G = gravel
K = kelp
SAV = subaquatic vegetation (e.g., eelgrass, not kelp)

Oceanographic Features

UP = upwelling
G = gyres
F = fronts
E = edges
CL = thermocline or pycnocline

General

U = Unknown
N/A = not applicable

Table 2. Summary of Habitat Associations for Groundfish in the GOA

GOA Groundfish		Nearshore				Shelf			Slope						Stratum Reference							Location							Physical Oceanography				
						Inner	Middle	Outer	Upper		Inter-mediate		Lower	Basin												Pelagic							
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surfce	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)
Walleye Pollock	M						x	x	x	x				x		x	x	x	x	x	x		x	x	x	x	x		x	x	x	x	x
	J					x	x	x								x	x	x	x	x	x		x	x	x	x			x	x	x	x	x
	L						x	x								x	x	x	x	x	x		x	x	x	x			x	x	x	x	x
	E						x	x	x	x	x	x	x	x		x	x	x	x	x	x		x	x		x			x	x	x	x	
Pacific Cod	M					x	x	x	x	x					x	x	x	x	x	x					x								
	LJ					x	x								x	x	x	x	x	x					x								
	EJ				x	x									x		x							x	x								
	L					x	x	x																		x							
	E					x	x	x																	x								
Atka Mackerel	M					x	x	x								x							x	x					x			x	x
	J																																
	L																					x	x										
	E					x										x									x								
Sablefish	M								x	x	x	x	x				x				x				x				x				
	LJ							x	x	x	x						x				x				x				x				
	EJ					x	x	x									x								x	x	x		x				
	L						x	x	x	x	x	x	x	x								x	x						x				
	E								x	x	x	x	x	x												x	x		x				
Pacific Ocean Perch	M							x	x	x								x	x	x	x			x	x	x			x				
	LJ					x	x	x	x																								
	EJ					x	x	x					x	x										x	x	x	x	x	x				
	L																						x	x		x	x		x				
Flathead Sole	M					x	x	x	x																x								x
	LJ					x	x	x																	x								
	EJ					x	x																		x								
	L					x	x	x																		x					x		
	E					x	x	x																		x							
Yellowfin Sole	M					x	x																		x								
	LJ					x	x																		x								
	EJ					x																			x								
	L					x	x																			x							
	E					x	x																			x							
Arrowtooth Flounder	M					x	x	x	x	x	x														x								
	LJ					x	x	x																	x								
	EJ					x	x																		x								
	L					x	x	x	x	x																x					x		
	E					x	x	x	x	x															x								
Rock Sole	M					x	x	x																	x								
	LJ					x	x																		x								
	EJ					x																			x								
	L					x	x	x																		x					x		
	E					x	x	x																	x								
Dover Sole	M					x	x	x	x	x	x	x													x								
	LJ					x	x	x	x	x															x								
	EJ					x	x																		x								
	L					x	x	x	x	x																x					x		
	E					x	x	x	x	x																x							
Rex Sole	M					x	x	x	x	x															x								

GOA Groundfish		Substrate													Structure									Community Associations												Oceanographic Properties			
Species	Life Stage	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
Walleye Pollock	M		x	x	x	x	x	x	x	x	x	x	x																							2-10			M
	J		x	x	x	x	x	x	x	x	x	x	x																							2-10			J
	L		x	x	x	x	x	x	x	x	x	x	x																										L
	E																																						E
Pacific Cod	M		x	x	x	x	x	x	x	x	x	x	x	x				x	x		x				x	x	x	x	x					x	x				M
	LJ		x	x	x	x	x	x	x	x	x	x	x	x				x	x		x				x	x	x	x	x					x	x				LJ
	EJ		x	x	x	x	x	x	x	x	x	x												x	x	x			x		x								EJ
	L																																						L
	E		x	x	x	x	x	x	x	x	x	x	x	x																						3-6	13-23	2-3	E
Atka Mackerel	M			x	x									x							x										x					3-5	>17		M
	J																																			3-5			J
	L																																			2-12			L
	E				x									x																	x					3-20			E
Sablefish	M		x	x	x								x	x																									M
	LJ		x	x	x								x	x																									LJ
	EJ																																						EJ
	L																																						L
	E																																						E
Pacific Ocean Perch	M				x								x	x													x												M
	LJ																																						LJ
	EJ				x								x	x																									EJ
	L																																						L
Flathead Sole	M		x	x	x			x		x																													M
	LJ		x	x	x			x		x																													LJ
	EJ			x	x																																		EJ
	L							x																															L
	E																																						E
Yellowfin Sole	M		x	x				x																															M
	LJ		x	x				x																															LJ
	EJ		x	x				x																															EJ
	L																																						L
	E																																						E
Arrowtooth Flounder	M		x	x	x			x																															M
	LJ		x	x	x			x																															LJ
	EJ		x	x	x			x																															EJ
	L																																						L
	E																																						E
Rock Sole	M		x	x				x																															M
	LJ		x	x				x																															LJ
	EJ		x	x				x																															EJ
	L																																						L
	E																																						E
Dover Sole	M		x	x			x																																M
	LJ		x	x			x																																LJ
	EJ		x	x			x																																EJ
	L																																						L
	E																																						E
Rex Sole	M		x	x				x																															M

Table 2. Summary of Habitat Associations for Groundfish in the GOA

GOA Groundfish		Nearshore				Shelf			Slope						Stratum Reference							Location							Physical Oceanography					Substrate														Structure								Community Associations									Oceanographic Properties			
						Inner	Middle	Outer	Upper	Inter-mediate		Lower	Basin													Pelagic																																											
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surface	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock	Bars	Sinks	Slumps/Rockfalls/Debris	Channels	Ledges	Pinnacles	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Echinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae/Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
	LJ					x	x	x	x																x										x	x				x																														LJ
	EJ					x	x																		x										x	x				x																														EJ
	L					x	x	x	x																	x									x	x																																	L
	E					x	x	x	x																	x																																									E
Greenland Turbot	M							x	x	x	x														x										x	x	x		x																														M
	LJ					x	x																		x										x	x			x																														LJ
	EJ																								x										x	x			x																														EJ
	L					x	x	x	x	x																x					x																																					L
	E					x	x	x	x	x																x																																									E
Yelloweye Rockfish	M					x	x	x	x	x						x	x								x											x								x	x					x		x															M
	LJ					x	x	x								x	x								x																				x																						LJ
	EJ					x	x	x								x	x								x																				x					x		x															EJ
	L																																																																	L
	E																																																																	E
Shortraker/Rougheye	M								x	x																x									x	x		x							x														x										M
Rockfish	LJ					x	x	x	x								x	x	x	x	x																																													LJ
	EJ												x	x									x																																												EJ
	L																										x																																								L
Northern Rockfish	M						x	x										x							x																		x	x																							M
	LJ						x	x										x	x						x																																								LJ
	EJ																									x																																								EJ
	L																																																																	L
Thornyhead Rockfish	M								x	x	x	x	x												x											x								x	x																							M
	LJ						x	x	x																x											x									x																							LJ
	EJ																									x																																								EJ
	L																									x																																								L
	E																									x																																								E
Light Dusky Rockfish	M							x	x									x		x	x				x											x								x	x																							M
	LJ						x	x										x		x					x																																									LJ
	EJ																																																																	EJ
	L																																																																	L
Sculpins	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x			x	x																																											M
	LJ																																																																	LJ
	EJ																																																																	EJ
	L																																																																	L
	E																																																																	E
Skates	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x			x	x																																											M
	LJ																																																																	LJ
	EJ																																																																	EJ
	L																																																																	L
	E																																																																	E
Sharks	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x																																								M
	LJ																																																																	LJ
	EJ																																																																	EJ
	L																																																																	L
	E																																																																	E
Squid	M				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x																																								M
	LJ																																																																	LJ

Table 2. Summary of Habitat Associations for Groundfish in the GOA

GOA Groundfish		Nearshore				Shelf			Slope						Stratum Reference							Location							Physical Oceanography					Substrate														Structure								Community Associations									Oceanographic Properties			
						Inner	Middle	Outer	Upper	Inter-mediate		Lower	Basin													Pelagic																																										
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surafce	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
	EJ																																																																											EJ
	L																																																																										L
	E																																																																										E
Octopus	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x				x	x	x																																											M
	LJ																																																																										LJ
	EJ																																																																										EJ
	L																																																																										L
	E																																																																										E
Eulachon	M						x	x	x								x									x			x		x	x																																								M
	LJ						x	x																		x			x		x	x																																								LJ
	EJ					x	x																			x			x		x																																										EJ
	L	x	x			x	x										x						x																																																L
	E	x																																																																				E
Capelin	M						x	x									x									x			x		x	x																																								M
	LJ						x	x																		x			x		x	x																																								LJ
	EJ					x	x																			x			x		x																																										EJ
	L		x			x	x										x						x																																																L
	E			x											x																				x	x				x																															E
Sand Lance	M			x	x	x									x		x					x	x	x	x	x									x	x				x																															M
	LJ			x	x	x									x		x					x	x	x	x	x									x	x				x																															LJ
	EJ		x		x	x									x		x					x	x			x																																													EJ
	L		x			x									x		x					x	x			x																																													L
	E			x													x																																																					E

Table 3. Summary of Reproductive Traits for Groundfish in the GOA

GOA Groundfish		Reproductive Traits																										
		Age at Maturity				Fertilization/Egg Development					Spawning Behavior						Spawning Season											
		Female		Male																								
Species	Life Stage	**50%**	**100%**	**50%**	**100%**	**External**	**Internal**	**Oviparous**	**Ovoviviparous**	**Viviparous**	**Batch Spawner**	**Broadcast Spawner**	**Egg Case Deposition**	**Nest Builder**	**Egg/Young Guarder**	**Egg/Young Bearer**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Walleye Pollock	M	4-5		4-5		x						x						x	x	x	x							
Pacific Cod	M	5		5		x						x					x	x	x	x	x							
Atka Mackerel	M	3.6		3.6		x								x	x						x	x	x	x	x	x		
Sablefish	M					x						x					x	x	x	x	x							
Pacific Ocean Perch	M	10.5					x			x	x														x	x	x	x
Flathead Sole	M	10				x											x	x	x	x								x
Yellowfin Sole	M	10.5				x					x										x	x	x					
Arrowtooth Flounder	M	5		4		x											x	x	x	x							x	x
Rock Sole	M	9				x					x						x	x	x									
Rex Sole	M	24cm		16cm		x												x	x	x	x	x	x					
Greenland Turbot	M	5-10				x											x	x	x							x	x	x
Dover Sole	M	33cm				x											x	x	x	x	x	x	x	x				
Yelloweye Rockfish	M	22							x											x	x	x	x					
Shortraker/Rougheye Rockfish	M	20+					x			x	x												x	x	x	x	x	x
Northern Rockfish	M	13					x			x	x																	
Thornyhead Rockfish	M	12									x							x				x						
Dusky Rockfish	M	11					x			x	x																	
Sculpins	M					x									x													
Skates	M						x	x					x															
Sharks	M						x	x	x	x			x			x												
Squid	M						x				x																	
Octopus	M						x				x			x	x													
Eulachon	M	3	5	3	5	X		X			X									X	X	X						
Capelin	M	2	4	2	4	X		X			X										X	X	X	X				
Sand Lance	M	1	2	1	2	X		X			X						X	X									X	X

Table 4. Summary of Predator and Prey Associations for Groundfish in the GOA

Predator to

GOA Groundfish Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut
Walleye Pollock	M				x			x			x			x						x	x	x	x	x		x			x	x	x
	LJ				x			x			x			x						x	x	x	x	x		x			x	x	x
	EJ				x			x			x									x	x	x									
	L				x			x			x																				
	E																														
Pacific Cod	M							x		x			x							x										x	
	LJ							x		x			x							x										x	
	EJ							x		x			x							x											
	L			x	x						x																				
	E																														
Atka Mackerel	M							x			x													x							
	J							x			x																				
	L										x																				
	E																														
Sablefish	M							x	x	x	x		x	x				x		x		x	x		x	x		x	x	x	
	LJ							x	x	x	x		x	x				x		x		x	x		x	x		x	x	x	
	EJ							x		x	x		x	x	x			x		x			x					x			
	L				x						x																				
	E																														
Pacifc Ocean Perch	M							x																							
	LJ							x			x																				
	EJ																														
	L			x	x																										
Flathead Sole	M							x		x	x		x			x	x	x	x		x	x								x	
	LJ							x		x	x		x			x	x	x	x											x	
	EJ				x								x			x			x											x	
	L	x		x																											
	E																														
Yellowfin Sole	M							x		x			x			x		x		x					x					x	
	LJ							x		x			x			x		x		x					x						
	EJ				x																										
	L	x		x																											
	E																														
Arrowtooth Flounder	M												x	x				x	x	x			x	x						x	
	LJ												x					x	x	x			x	x						x	
	EJ				x																										
	L	x		x																											
	E																														
Rock Sole	M									x			x			x	x														
	LJ									x			x			x	x														
	EJ				x																										
	L	x		x																											
	E																														

Prey of

GOA Groundfish Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Halibut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrestrial Mammals
Walleye Pollock	M								x						x	x	x	x	x	x										
	LJ							x	x						x	x		x	x	x				x		x	x	x		
	EJ							x	x						x	x		x	x	x				x		x	x	x		
	L							x	x						x	x								x		x	x	x		
	E																													
Pacific Cod	M															x	x	x		x		x	x	x						
	LJ															x	x	x		x		x	x	x						
	EJ															x	x	x				x	x	x			x			
	L																													
	E																													
Atka Mackerel	M								x						x	x			x	x	x			x						
	J																			x						x	x			
	L																													
	E																													
Sablefish	M																													
	LJ						x									x														
	EJ																													
	L																													
	E																													
Pacifc Ocean Perch	M															x														
	LJ																													
	EJ						x																							
	L																													
Flathead Sole	M								x				x		x	x														
	LJ																													
	EJ																													
	L																													
	E																													
Yellowfin Sole	M																													
	LJ								x							x														
	EJ								x							x														
	L																													
	E																													
Arrowtooth Flounder	M																													
	LJ							x	x																					
	EJ																													
	L																													
	E																													
Rock Sole	M																													
	LJ							x	x					x		x														
	EJ																													
	L																													
	E																													

Table 4. Summary of Predator and Prey Associations for Groundfish in the GOA

GOA Groundfish		Predator to																															Prey of																											
Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut		Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Halibut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrestrial Mammals
Dover Sole	M												X				X	X														M								X						X														
	LJ												X				X	X														LJ								X						X														
	EJ																															EJ																											
	L	X		X																												L																											
	E																															E																											
Rex Sole	M							X		X			X					X														M								X						X														
	LJ							X		X			X					X														LJ								X						X														
	EJ																															EJ																											
	L	X		X																												L																											
	E																															E																											
Greenland Turbot	M												X					X	X	X			X	X						X		M																											
	LJ																															LJ																											
	EJ				X																											EJ						X	X					X															
	L	X		X																												L																											
	E																															E																											
Yelloweye Rockfish	M																	X		X	X		X				X					M						X			X	X					X													
	LJ																															LJ																											
	EJ										X																					EJ																											
	L																															L																											
	E																															E																											
Shortraker/Rougheye Rockfish	M													X						X				X								M																											
	LJ																															LJ																											
	EJ																															EJ																											
	L																															L																											
Northern Rockfish	M							X			X																					M																											
	LJ																															LJ																											
	EJ																															EJ																											
	L																															L																											
Thornyhead Rockfish	M																			X					X							M																											
	LJ																															LJ																											
	EJ																															EJ																											
	L																															L																											
	E																															E																											
Light Dusky Rockfish	M							X																								M																											
	LJ																															LJ																											
	EJ																															EJ																											
	L																															L																											
Sculpins	M				X			X	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X			X	X		M						X	X		X	X	X		X	X	X	X	X	X	X									
	LJ																															LJ																											
	EJ																															EJ																											
	L																															L																											
	E																															E																											
Skates	M								X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		M																X												

Table 4. Summary of Predator and Prey Associations for Groundfish in the GOA

GOA Groundfish		Predator to																																Prey of																											
Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut		Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Halibut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrestrial Mammals
	LJ																															LJ																														
	EJ																															EJ																														
	L																															L																														
	E																															E																														
Sharks	M						x		x	x	x	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	M															x														
	LJ																															LJ																														
	EJ																															EJ																														
	L																															L																														
	E																															E																														
Squid	M							x			x										x	x	x	x								M	x					x	x	x	x					x	x	x	x	x	x		x	x		x	x	x	x	
	LJ																															LJ																														
	EJ																															EJ																														
	L																															L																														
	E																															E																														
Octopus	M															x	x	x														M						x	x	x	x					x	x	x	x	x										
	LJ																															LJ																														
	EJ																															EJ																														
	L																															L																														
	E																															E																														
Eulachon	M				X			X			X																					M						X	X	X						X		X	X	X	X					X	X			X
	LJ				X			X			X																					LJ						X	X	X						X		X	X	X	X					X	X			
	EJ				X			X			X																					EJ					X	X	X	X						X															
	L			X	X	X		X			X																					L					X	X	X	X						X															
	E																															E																														
Capelin	M				X			X			X		X							X												M						X	X	X						X	X		X	X	X	X					X	X			
	LJ				X			X			X																					LJ						X	X	X						X	X		X	X	X	X					X	X			
	EJ				X			X			X																					EJ					X	X	X	X						X	X														
	L			X	X	X		X			X																					L					X	X	X	X						X	X														
	E																															E																														
Sand Lance	M				X			X		X	X																					M						X	X	X						X	X		X	X	X	X					X	X			
	LJ				X			X		X	X																					LJ						X	X	X						X	X		X	X	X	X					X	X			
	EJ				X			X		X	X																					EJ					X	X	X	X						X	X														
	L			X	X	X		X		X	X																					L					X	X	X	X						X	X														
	E																															E																														

Habitat Description for Walleye pollock

(*Theragra calcogramma)*

Management Plan and Area GOA

The Gulf of Alaska are managed under the Gulf of Alaska Groundfish Fisheries Management Plan and the Eastern Bering Sea and Aleutian Islands pollock stocks are managed under the Eastern Bering Sea and Aleutian Islands Groundfish Fisheries Management Plan. Pollock occur throughout the area covered by the FMP and straddle into the Canadian and Russian EEZ, international waters of the central Bering Sea, and into the Chukchi Sea.

Life History and General Distribution

Pollock is the most abundant species within the eastern Bering Sea comprising 75-80% of the catch and 60% of the biomass. In the Gulf of Alaska, pollock is the second most abundant groundfish stock comprising 25-50% of the catch and 20% of the biomass.

Four stocks of pollock are recognized for management purposes: Gulf of Alaska, eastern Bering Sea, Aleutian Islands, and Aleutian Basin. There appears to be a high degree of interrelationship among the eastern Bering Sea, Aleutian Islands, and Aleutian Basin stocks with suggestions of movement from one area to the others. There appears to be stock separation between the Gulf of Alaska stocks and stocks to the north.

The most abundant stock of pollock is the eastern Bering Sea stock which is primarily distributed over the eastern Bering Sea outer continental shelf between approximately 70-200 m. Information on pollock distribution in the eastern Bering Sea comes from commercial fishing locations, annual bottom trawl surveys and triennial acoustic surveys.

The Aleutian Islands stock extends through the Aleutian Islands from 170E W to the end of the Aleutian Islands (Attu Island), with the greatest abundance in the eastern Aleutians (170E W to Seguam Pass). Most of the information on pollock distribution in the Aleutian Islands comes from triennial bottom trawl surveys. These surveys indicate that pollock are primarily located on the Bering Sea side of the Aleutian Islands, and have a spotty distribution throughout the Aleutian Islands chain. The bottom trawl data may not provide an accurate view of pollock distribution because a significant portion of the pollock biomass is likely to be unavailable to bottom trawls. Also, many areas of the Aleutian Islands shelf are untrawlable due to rough bottom.

The third stock, Aleutian Basin, appears to be distributed throughout the Aleutian Basin which encompasses the U.S. EEZ, Russian EEZ, and international waters in the central Bering Sea. This stock appears to move throughout the Basin for feeding, but concentrate in deepwater near the continental shelf for spawning. The principal spawning location is near Bogoslof Island in the eastern Aleutian Islands, but data from pollock fisheries in the first quarter of the year indicate that there are other concentrations of deepwater spawning concentrations in the western Aleutian Islands. The Aleutian Basin spawning stock appears to be derived from migrants from the eastern Bering Sea shelf stock, and possibly some western Bering Sea pollock. Recruitment to the stock occurs generally around age 5, very few pollock younger than age 5 have been found in the Aleutian Basin. Most of the pollock in the Aleutian Basin appear to originate from strong year classes.

The Gulf of Alaska stock extends from southeast Alaska to the Aleutian Islands (170E W), with the greatest abundance in the western and central regulatory areas (147E W to 170E W). Most of the information on

pollock distribution in the Gulf of Alaska comes from triennial bottom trawl surveys. These surveys indicate that pollock are distributed throughout the shelf regions of the Gulf of Alaska at depths less than 300 m. The bottom trawl data may not provide an accurate view of pollock distribution because a significant portion of the pollock biomass may be pelagic and not available to bottom trawls. The principal spawning location is in Shelikof Strait, but data from pollock fisheries and exploratory surveys indicate that there are other concentrations of spawning in the Shumagin Islands, the east side of Kodiak Island and near Prince William Sound.

Peak pollock spawning occurs on the southeastern Bering Sea and eastern Aleutian Islands along the outer continental shelf around mid-March. North of the Pribilof Islands spawning occurs later (April-May) in smaller spawning aggregations. The deep spawning pollock of the Aleutian Basin appear to spawn slightly earlier, late February-early March. In the Gulf of Alaska, peak spawning occurs in late March in Shelikof Strait. Peak spawning in the Shumagin area appears to 2-3 weeks earlier than in Shelikof Strait.

Spawning occurs in the pelagic zone and eggs develop throughout the water column (70-80 m in the Bering Sea shelf, 150-200 m in Shelikof Strait). Development is dependent on water temperature. In the Bering Sea, eggs take about 17-20 days to develop at 4 degrees in the Bogoslof area and 25.5 days at 2 degrees on the shelf. In the Gulf of Alaska, development takes approximately 2 weeks at ambient temperature (5 degrees C). Larvae are also distributed in the upper water column. In the Bering Sea the larval period lasts approximately 60 days. The larvae eat progressively larger naupliar stages of copepods as they grow and then small euphausiids as they approach transformation to juveniles (~25 mm standard length). In the Gulf of Alaska, larvae are distributed in the upper 40 m of the water column and the diet is similar to Bering Sea larvae. FOCI survey data indicate larval pollock may utilize the stratified warmer upper waters of the mid-shelf to avoid predation by adult pollock which reside in the colder bottom water.

At age 1 pollock are found throughout the eastern Bering Sea both in the water column and on bottom. Age 1 pollock from strong year-classes appear to be found in great numbers on the inner shelf, and further north on the shelf than weak year classes which appear to be more concentrated on the outer continental shelf. From age 2-3 pollock are primarily pelagic and then to be most abundant on the outer and mid-shelf northwest of the Pribilof Islands. As pollock reach maturity (age 4) in the Bering Sea, they appear to move from the northwest to the southeast shelf to recruit to the adult spawning population. Strong year-classes of pollock persist in the population in significant numbers until about age 12, and very few pollock survive beyond age 16. The oldest recorded pollock was age 31.
Growth varies by area with the largest pollock occurring on the southeastern shelf. On the northwest shelf the growth rate is slower. A newly maturing pollock is around 40 cm.

Fishery

The eastern Bering Sea pollock fishery has, since 1990 been divided into two fishing periods; an “A season” occurring in January-March, and a “B season” occurring in August-October. The A season concentrates fishing effort on prespawning pollock in the southeastern Bering Sea. During the B season fishing is still primarily in the southeastern Bering Sea, but some fishing also occurs on the northwestern shelf. Also during the B season catcher processor vessels are required to fish north of 56E N latitude because the area to the south is reserved for catcher vessels delivering to shoreside processing plants on Unalaska and Akutan.

Since 1992, the Gulf of Alaska pollock TAC has been apportioned spatially and temporally to reduce impacts on Steller sea lions. Although the details of the apportionment scheme have evolved over time, the general objective is to allocate the TAC to management areas based on the distribution of surveyed biomass, and to establish three or four seasons between mid-January and autumn during which some fraction of the TAC can be taken. The Steller Sea Lion Protection Measures implemented in 2001 establish four seasons in the Central and Western GOA beginning January 20, March 10, August 25, and October 1, with 25% of the total

TAC allocated to each season. Allocations to management areas 610, 620 and 630 are based on the seasonal biomass distribution as estimated by groundfish surveys. In addition, a new harvest control rule was implemented that requires a cessation of fishing when spawning biomass declines below 20% of unfished stock biomass.

In the Gulf of Alaska approximately 90% of the pollock catch is taken using pelagic trawls. During winter, fishing effort usually targeted primarily on pre-spawning aggregations in Shelikof Strait and near the Shumagin Islands. The pollock fishery has a very low bycatch rate with discards averaging about 2% since 1998 (with the 1991-1997 average around 9%). Most of the discards in the pollock fishery are juvenile pollock, or pollock too large to fit filleting machines. In the pelagic trawl fishery the catch is almost exclusively pollock.

The eastern Bering Sea pollock fishery primarily harvests mature pollock. The age where fish are selected by the fishery roughly corresponds to the age at maturity (management guidelines are oriented towards conserving spawning biomass). Fishery selectivity increases to a maximum around age 6-8 and declines slightly. The reduced selectivity for older ages is due to pollock becoming increasingly demersal with age. Younger pollock form large schools and are semi-demersal, thereby being easier to locate by fishing vessels. Immature fish (ages 2 and 3) are usually caught in low numbers. Generally the catch of immature pollock increases when strong year-classes occur and the abundance of juveniles increase sharply. This occurred with the 1989 year-class, the second largest year-class on record. Juvenile bycatch increased sharply in 1991 and 1992 when this year-class was age 2 and 3. A secondary problem is that strong to moderate year-classes may reside in the Russian EEZ adjacent to the U. S. EEZ as juveniles. Russian catch-age data and anecdotal information suggest that juveniles may comprise a major portion of the catch. There is a potential for the Russian fishery to reduce subsequent abundance in the U. S. fishery.
The Gulf of Alaska pollock fishery also targets mature pollock. Fishery selectivity increases to a maximum around age 5-7 and then declines. In both the EBS and GOA, the selectivity pattern varies between years due to shifts in fishing strategy and changes in the availability of different age groups over time.

In response to continuing concerns over the possible impacts groundfish fisheries may have on rebuilding populations of Steller sea lions, NMFS and the NPFMC have made changes to the Atka mackerel (mackerel) and pollock fisheries in the Bering Sea/Aleutian Islands and Gulf of Alaska. These have been designed to reduce the possibility of competitive interactions with Steller sea lions. For the pollock fisheries, comparisons of seasonal fishery catch and pollock biomass distributions (from surveys) by area in the eastern Bering Sea led to the conclusion that the pollock fishery had disproportionately high seasonal harvest rates within critical habitat which *could* lead to reduced sea lion prey densities. Consequently, the management measures were designed to redistribute the fishery both temporally and spatially according to pollock biomass distributions. The underlying assumption in this approach was that the independently derived area-wide and annual exploitation rate for pollock would not reduce local prey densities for sea lions. Here we examine the temporal and spatial dispersion of the fishery to evaluate the potential effectiveness of the measures.

Three types of measures were implemented in the pollock fisheries:

- Additional pollock fishery exclusion zones around sea lion rookery or haulout sites,
- Phased-in reductions in the seasonal proportions of TAC that can be taken from critical habitat, and
- Additional seasonal TAC releases to disperse the fishery in time.

Prior to the management measures, the pollock fishery occurred in each of the three major fishery management regions of the north Pacific ocean managed by the NPFMC: the Aleutian Islands (1,001,780 km^2 inside the EEZ), the eastern Bering Sea (968,600 km^2), and the Gulf of Alaska (1,156,100 km^2). The marine portion of Steller sea lion critical habitat in Alaska west of 150˚W encompasses 386,770 km^2 of ocean surface, or 12% of the fishery management regions.

Prior to 1999, a total of 84,100 km^2, or 22% of critical habitat, was closed to the pollock fishery. Most of this closure consisted of the 10 and 20 nm radius all-trawl fishery exclusion zones around sea lion rookeries (48,920 km^2 or 13% of critical habitat). The remainder was largely management area 518 (35,180 km^2, or 9% of critical habitat) which was closed pursuant to an international agreement to protect spawning stocks of central Bering Sea pollock.

In 1999, an additional 83,080 km^2 (21%) of critical habitat in the Aleutian Islands was closed to pollock fishing along with 43,170 km^2 (11%) around sea lion haulouts in the GOA and eastern Bering Sea. Consequently, a total of 210,350 km^2 (54%) of critical habitat was closed to the pollock fishery. The portion of critical habitat that remained open to the pollock fishery consisted primarily of the area between 10 and 20 nm from rookeries and haulouts in the GOA and parts of the eastern Bering Sea foraging area.

The Bering Sea/Aleutian Islands pollock fishery was also subject to changes in total catch and catch distribution. Disentangling the specific changes in the temporal and spatial dispersion of the EBS pollock fishery resulting from the sea lion management measures from those resulting from implementation of the 1999 American Fisheries Act (AFA) is difficult. The AFA reduced the capacity of the catcher/processor fleet and permitted the formation of cooperatives in each industry sector by 2000. Both of these changes would be expected to reduce the rate at which the catcher/processor sector (allocated 36% of the EBS pollock TAC) caught pollock beginning in 1999, and the fleet as a whole in 2000. Because of some of its provisions, the AFA gave the industry the ability to respond efficiently to changes mandated for sea lion conservation that otherwise could have been more disruptive to the industry.

In 2000, further reductions in seasonal pollock catches from BSAI sea lion critical habitat were realized by closing the entire Aleutian Islands region to pollock fishing and by phased-in reductions in the proportions of seasonal TAC that could be caught from the Sea Lion Conservation Area, an area which overlaps considerably with sea lion critical habitat. In 1998, over 22,000 t of pollock were caught in the Aleutian Island regions, with over 17,000 t caught in AI critical habitat. Since 1998 directed fishery removals of pollock have been prohibited.

Relevant Trophic Information

Juvenile pollock through newly maturing pollock primarily utilize copepods and euphausiids for food. At maturation and older ages pollock become increasingly piscivorous, with pollock (cannibalism) a major food item in the Bering Sea. Most of the pollock consumed by pollock are age 0 and 1 pollock, and recent research suggests that cannibalism can regulate year-class size. Weak year-classes appear to be those located within the range of adults, while strong year-classes are those that are transported to areas outside the range of adult abundance.

Being the dominant species in the eastern Bering Sea pollock is an important food source for other fish, marine mammals, and birds. On the Pribilof Islands hatching success and fledgling survival of marine birds has been tied to the availability of age 0 pollock to nesting birds.

Upper size limit of juvenile fish

The upper size limit for juvenile pollock in the eastern Bering Sea and Gulf of Alaska is about 38-42 cm. This is the size of 50% maturity. There is some evidence that this has changed over time.

Sources for Additional Information

Eggs and Larvae:

Jeff Napp, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA, 206-526-4148.

Shallow water concentrations:

Bill Bechtol, Alaska Department of Fish and Game, 3298 Douglas Place, Homer, Alaska 99603-8027.

Habitat and Biological Associations

Egg-Spawning: Pelagic on outer continental shelf generally over 100-200 m depth in Bering Sea. Pelagic on continental shelf over 100-200 m depth in Gulf of Alaska.

Larvae: Pelagic outer to mid-shelf region in Bering Sea. Pelagic throughout the continental shelf within the top 40 m in the Gulf of Alaska.

Juveniles: Age 0 appears to be pelagic, as is age 2 and 3. Age 1 pelagic and demersal with a widespread distribution and no known benthic habitat preference.

Adults: Adults occur both pelagically and demersally on the outer and mid-continental shelf of the Gulf of Alaska, eastern Bering Sea and Aleutian Islands. In the eastern Bering Sea few adult pollock occur in waters shallower than 70 m. Adult pollock also occur pelagically in the Aleutian Basin. Adult pollock range throughout the Bering Sea in both the U.S. and Russian waters, however, the maps provided for this document detail distributions for pollock in the U.S. Exclusive Economic Zone and the basin.

Literature

Bailey, K.M. 2000. Shifting control of recruitment of walleye pollock *Theragra chalcogramma* after a major climatic and ecosystem change. Mar. Ecol. Prog. Ser 198:215-224.

Bailey, K.M., P.J. Stabeno, and D.A. Powers. 1997. The role of larval retention and transport features in mortality and potential gene flow of walleye pollock. J. Fish. Biol. 51(Suppl. A):135-154.

Bailey, K.M., S.J. Picquelle, and S.M. Spring. 1996. Mortality of larval walleye pollock (*Theragra chalcogramma*) in the western Gulf of Alaska, 1988-91. Fish. Oceanogr. 5 (Suppl. 1):124-136.

Bailey, K.M., T.J. Quinn II, P. Bentzen, and W.S. Grant. 1999. Population structure and dynamics of walleye pollock, *Theragra chalcogramma*. Advances in Mar. Biol. 37: 179-255.

Bakkala, R.G., V.G. Wespestad and L.L. Low. 1987. Historical trends in abundance and current condition of walleye pollock in the eastern Bering Sea. Fish. Res.,5:199_215.

Bates, R.D. 1987. Ichthyoplankton of the Gulf of Alaska near Kodiak Island, April-May 1984. NWAFC Proc. Rep. 87-11, 53 pp.

Brodeur, R.D. and M.T. Wilson. 1996. A review of the distribution, ecology and population dynamics of age-0 walleye pollock in the Gulf of Alaska. Fish. Oceanogr. 5 (Suppl. 1):148-166.

Brown, A.L. and K.M. Bailey. 1992. Otolith analysis of juvenile walleye pollock *Theragra chalcogramma* from the western Gulf of Alaska. Mar. Bio. 112:23-30.

Dorn, M., S. Barbeaux, M. Guttormsen, B. Megrey, A. Hollowed, E. Brown, and K. Spalinger. 2002. Assessment of Walleye Pollock in the Gulf of Alaska. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, 2002. North Pacific Fishery Management Council, Box 103136, Anchorage, AK 99510. 88p.

Grant, W.S. and F.M. Utter. 1980. Biochemical variation in walleye pollock *Theragra chalcogramma*: population structure in the southeastern Bering Sea and Gulf of Alaska. Can. J. Fish. Aquat. Sci. 37:1093-1100.

Guttormsen , M. A., C. D. Wilson, and S. Stienessen. 2001. Echo integration-trawl survey results for walleye pollock in the Gulf of Alaska during 2001. In Stock Assessment and Fishery Evaluation Report for Gulf of Alaska. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510. North Pacific Fisheries Management Council, Anchorage, AK.

Hinckley, S. 1987. The reproductive biology of walleye pollock, *Theragra chalcogramma*, in the Bering Sea, with reference to spawning stock structure. Fish. Bull. 85:481-498.

Hollowed, A.B., J.N. Ianelli, P. Livingston. 2000. Including predation mortality in stock assessments: a case study for Gulf of Alaska pollock. ICES J. Mar. Sci. 57:279-293.

Hughes, S. E. and G. Hirschhorn. 1979. Biology of walleye pollock, *Theragra chalcogramma*, in Western Gulf of Alaska. Fish. Bull., U.S. 77:263-274.

Ianelli, J.N. 2002. Bering Sea walleye pollock stock structure using morphometric methods. Tech. Report Hokkaido National Fisheries Research Inst. No. 5, 53_58.

Ianelli, J.N., S. Barbeaux, T. Honkalehto, G. Walters, and N. Williamson. 2002. Bering Sea-Aleutian Islands Walleye Pollock Assessment for 2003. In Stock assessment and fishery evaluation report for the groundfish resources of the Eastern Bering Sea and Aleutian Island Region, 2002. North Pacific Fishery Management Council, Box 103136, Anchorage, AK 99510. 88p.

Kendall, A.W., Jr. and S.J. Picquelle. 1990. Egg and larval distributions of walleye pollock *Theragra chalcogramma* in Shelikof Strait, Gulf of Alaska. U.S. Fish. Bull. 88(1):133-154.

Kim, S. and A.W. Kendall, Jr. 1989. Distribution and transport of larval walleye pollock (*Theragra chalcogramma*) in Shelikof Strait, Gulf of Alaska, in relation to water movement. Rapp. P.-v. Reun. Cons. int. Explor. Mer 191:127-136.

Livingston, P.A. 1991. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1884-1986. U. S. Dept. Commerce, NOAA Tech Memo. NMFS F/NWC-207.

Meuter, F.J. and B.L. Norcross. 2002. Spatial and temporal patterns in the demersal fish community on the shelf and upper slope regions of the Gulf of Alaska. Fish. Bull. 100:559-581.

Mulligan, T.J., Chapman, R.W. and B.L. Brown. 1992. Mitochondrial DNA analysis of walleye pollock, *Theragra chalcogramma*, from the eastern Bering Sea and Shelikof Strait, Gulf of Alaska. Can. J. Fish. Aquat. Sci. 49:319-326.

Olsen, J.B., S.E. Merkouris, and J.E. Seeb. 2002. An examination of spatial and temporal genetic variation in walleye pollock (*Theragra chalcogramma*) using allozyme, mitochondrial DNA, and microsatellite data. Fish. Bull. 100:752-764.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Proc. Rep. 90-01, 162 pp.

Shima, M. 1996. A study of the interaction between walleye pollock and Steller sea lions in the Gulf of Alaska. Ph.D. dissertation, University of Washington, Seattle, WA 98195.

Stabeno, P.J., J.D. Schumacher, K.M. Bailey, R.D. Brodeur, and E.D. Cokelet. 1996. Observed patches of walleye pollock eggs and larvae in Shelikof Strait, Alaska: their characteristics, formation and persistence. Fish. Oceanogr. 5 (Suppl. 1): 81-91.

Wespestad V.G. and T.J. Quinn. II. 1997. Importance of cannibalism in the population dynamics of walleye pollock. In: Ecology of Juvenile Walleye Pollock, *Theragra chalcogramma*. NOAA Technical Report, NMFS 126.

Wespestad, V.G. 1993. The status of Bering Sea pollock and the effect of the "Donut Hole" fishery. Fisheries 18(3)18-25.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 pp.

SPECIES: Gulf of Alaska Walleye Pollock

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	14 d. at 5 C	None	Feb-Apr	OCS, UCS	P	N/A	G?	
Larvae	60 days	copepod naupli and small euphausiids	Mar-Jul	MCS, OCS	P	N/A	G? F	pollock larvae with jellyfish
Juveniles	0.4 to 4.5 years	Pelagic crustaceans, copepods and euphausiids	Aug. +	OCS, MCS, ICS	P, SD	N/A	CL, F	
Adults	4.5 - 16 years	Pelagic crustaceans and fish	Spawning Feb-Apr	OCS, BSN	P, SD	UNK	F UP	Increasingly demersal with age.

Habitat Description for Pacific cod

(Gadus macrocephalus)

Management Plan and Area GOA

Life History and General Distribution

Pacific cod is a transoceanic species, occurring at depths from shoreline to 500 m. The southern limit of the species' distribution is about 34° N latitude, with a northern limit of about 63° N latitude. Adults are demersal and form aggregations during the peak spawning season, which extends approximately from January through May. Pacific cod eggs are demersal and adhesive. Eggs hatch in about 15-20 days. Little is known about the distribution of Pacific cod larvae, which undergo metamorphosis at about 25-35 mm. Juvenile Pacific cod start appearing in trawl surveys at a fairly small size, as small as 10 cm in the eastern Bering Sea. Pacific cod can grow to be more than a meter in length, with weights in excess of 10 kg. Natural mortality is believed to be somewhere between 0.3 and 0.4. Approximately 50% of Pacific cod are mature by ages 5-6. The maximum recorded age of a Pacific cod from the Bering Sea/Aleutian Islands (BSAI) or Gulf of Alaska (GOA) is 19 years.

Fishery

The fishery is conducted with bottom trawl, longline, pot, and jig gear. The age at 50% recruitment varies between gear types and regions. In the BSAI, the age at 50% recruitment is 6 years for trawl gear, 4 years for longline and 5 years for pot gear. In the GOA, the age at 50% recruitment is 5 years for trawl gear and 6 years for longline and pot gear. More than 100 vessels participate in each of the three largest fisheries (trawl, longline, pot). The trawl fishery is typically concentrated during the first few months of the year, whereas fixed-gear fisheries may sometimes run, intermittently, at least, throughout the year. Bycatch of crab and halibut sometimes causes the Pacific cod fisheries to close prior to reaching the total allowable catch. In the BSAI, trawl fishing is concentrated immediately north of Unimak Island, whereas the longline fishery is distributed along the shelf edge to the north and west of the Pribilof Islands. In the GOA, the trawl fishery has centers of activity around the Shumagin Islands and south of Kodiak Island, while the longline fishery is located primarily in the vicinity of the Shumagins.

Relevant Trophic Information

Pacific cod are omnivorous. In terms of percent occurrence, the most important items in the diet of Pacific cod in the BSAI and GOA are polychaetes, amphipods, and crangonid shrimp. In terms of numbers of individual organisms consumed, the most important dietary items are euphausiids, miscellaneous fishes, and amphipods. In terms of weight of organisms consumed, the most important dietary items are walleye pollock, fishery discards, and yellowfin sole. Small Pacific cod feed mostly on invertebrates, while large Pacific cod are mainly piscivorous. Predators of Pacific cod include halibut, salmon shark, northern fur seals, sea lions, harbor porpoises, various whale species, and tufted puffin.

Upper size limit of juvenile fish (in cm): The estimated size at 50% maturity is 67 cm.

Source of additional information

NMFS, Alaska Fisheries Science Center, FOCI Program, Ann Matarese 206-526-4111

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: Spawning takes place in the sublittoral-bathyal zone (40-290 m) near bottom. Eggs sink to the bottom after fertilization, and are somewhat adhesive. Optimal

temperature for incubation is 3-6° C, optimal salinity is 13-23 ppt, and optimal oxygen concentration is from 2-3 ppm to saturation. Little is known about the optimal substrate type for egg incubation.

Larvae: Larvae are epipelagic, occurring primarily in the upper 45 m of the water column shortly after hatching, moving downward in the water column as they grow.

Juveniles: Juveniles occur mostly over the inner continental shelf at depths of 60-150 m.

Adults: Adults occur in depths from the shoreline to 500 m. Average depth of occurrence tends to vary directly with age for at least the first few years of life, with mature fish concentrated on the outer continental shelf. Preferred substrate is soft sediment, from mud and clay to sand.

Literature

Albers, W.D., and P.J. Anderson. 1985. Diet of Pacific cod, *Gadus macrocephalus*, and predation on the northern pink shrimp, *Pandalus borealis*, in Pavlof Bay, Alaska. Fish. Bull., U.S. 83:601-610.

Alderdice, D.F., and C.R. Forrester. 1971. Effects of salinity, temperature, and dissolved oxygen on early development of the Pacific cod (*Gadus macrocephalus*). J. Fish. Res. Board Can. 28:883-902.

Bakkala, R.G. 1984. Pacific cod of the eastern Bering Sea. Int. N. Pac. Fish. Comm. Bull. 42:157-179.

Dunn, J.R., and A.C. Matarese. 1987. A review of the early life history of northeast Pacific gadoid fishes. Fish. Res. 5:163-184.

Forrester, C.R., and D.F. Alderdice. 1966. Effects of salinity and temperature on embryonic development of Pacific cod (*Gadus macrocephalus*). J. Fish. Res. Board Can. 23:319-340.

Hirschberger, W.A., and G.B. Smith. 1983. Spawning of twelve groundfish species in Alaska and Pacific Coast regions, 1975-81. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS F/NWC-44. 50 p.

Ketchen, K.S. 1961. Observations on the ecology of the Pacific cod (*Gadus macrocephalus*) in Canadian waters. J. Fish. Res. Board Can. 18:513-558.

Livingston, P.A. 1989. Interannual trends in Pacific cod, *Gadus macrocephalus*, predation on three commercially important crab species in the eastern Bering Sea. Fish. Bull., U.S. 87:807-827.

Livingston, P.A. 1991. Pacific cod. *In* P.A. Livingston (editor), Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1984 to 1986, p. 31-88. U.S. Dept. Commer., NOAA Tech. Memo. NMFS F/NWC-207.

Matarese, A.C., A.W. Kendall Jr., D.M. Blood, and B.M. Vinter. 1989. Laboratory guide to early life history stages of northeast Pacific fishes. U.S. Dept. Commerce, NOAA Tech. Rep. NMFS 80. 652 p.

Moiseev, P.A. 1953. Cod and flounders of far eastern waters. Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 40. 287 p. (Transl. from Russian: Fish. Res. Board Can. Transl. Ser. 119.)

National Oceanic and Atmospheric Administration (NOAA). 1987. Bering, Chukchi, and Beaufort Seas--Coastal and ocean zones strategic assessment: Data Atlas. U.S. Dept. Commerce, NOAA, National Ocean Service.

National Oceanic and Atmospheric Administration (NOAA). 1990. West coast of North America--Coastal and ocean zones strategic assessment: Data Atlas. U.S. Dept. Commerce, NOAA, National Ocean Service and National Marine Fisheries Service.

Phillips, A.C., and J.C. Mason. 1986. A towed, self-adjusting sld sampler for demersal fish eggs and larvae. Fish. Res. 4:235-242.

Rugen, W.C., and A.C. Matarese. 1988. Spatial and temporal distribution and relative abundance of Pacific cod (*Gadus macrocephalus*) larvae in the western Gulf of Alaska. NWAFC Proc. Rep. 88-18. Available from Alaska Fish. Sci. Center, 7600 Sand Point Way NE., Seattle, WA 98115-0070.

Thompson, G.G., and M.W. Dorn. 2002. Assessment of the Pacific cod stock in the eastern Bering Sea and Aleutian Islands area. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, Plan Team for the Groundfish Fisheries of the Bering Sea and Aleutian Islands (editor), p. 121-205. Available from North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Thompson, G.G., H.H. Zenger, and M.W. Dorn. 2002. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, Plan Team for the Gulf of Alaska (editor), p. 89-167. Available from North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Westrheim, S.J. 1996. On the Pacific cod (*Gadus macrocephalus*) in British Columbia waters, and a comparison with Pacific cod elsewhere, and Atlantic cod (*G. morhua*). Can. Tech. Rep. Fish. Aquat. Sci. 2092. 390 p.

SPECIES: Pacific cod

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	15-20 d	NA	winter-spring	ICS, MCS, OCS	D	M, SM, MS ,S	U	optimum 3-6°C optimum salinity 13-23 ppt
Larvae	U	copepods (?)	winter-spring	U	P (?), N (?)	U	U	
Early Juveniles	to 2 yrs	small invertebrates (mysids, euphausiids, shrimp)	all year	ICS, MCS	D	M, SM, MS, S	U	
Late Juveniles	to 5 yrs	pollock, flatfish, fishery discards, crab	all year	ICS, MCS, OCS	D	M, SM, MS, S	U	
Adults	5+ yr	pollock, flatfish, fishery discards, crab	spawning (Jan-May) non-spawning (Jun-Dec)	ICS, MCS, OCS ICS, MCS, OCS	D	M, SM, MS, S,G	U	

Habitat Description for Dover Sole

(*Microstomus pacificus*)

The deep water flatfish management complex in the Gulf of Alaska is comprised of three species, Dover sole (*Microstomus pacificus*), Greenland turbot (*Reinhardtius hippglossoides*) and the deep sea sole (*Embassicthys bathbius*). Dover sole is the most abundant and commercially important species of this management complex in the Gulf of Alaska.

Management Plan and Area GOA

Life History and General Distribution

Dover sole are distributed in deep waters of the continental shelf and upper slope from northern Baja California to the Bering Sea and the western Aleutian Islands (Hart 1973, Miller and Lea 1972), and exhibit a widespread distribution throughout the Gulf of Alaska. Adults are demersal and are mostly found in water deeper than 300 meters. The spawning period off Oregon is reported to range from January through May (Hunter et al. 1992). Spawning in the Gulf of Alaska has been observed from January through August, with a peak period in May (Hirschberger and Smith 1983). Eggs have been collected in neuston and bongo nets in the summer, east of Kodiak Island (Kendall and Dunn 1985), but the duration of the incubation period is unknown. Larvae were captured in bongo nets only in summer over mid-shelf and slope areas (Kendall and Dunn 1985). The age or size at metamorphosis is unknown but the pelagic larval period is known to be protracted and may last as long as two years (Markle et al. 1992). Pelagic postlarvae as large as 48 mm have been reported and the young may still be pelagic at 10 cm (Hart 1973). Dover sole are batch spawners and Hunter et al. (1992) concluded that the average 1 kg. female spawns its 83,000 advanced yolked oocytes in about nine batches. Maturity studies from Oregon indicate that females were 50% mature at 33 cm total length. Juveniles less than 25 cm are rarely found with the adult population from bottom trawl surveys (Martin and Clausen 1995). The natural mortality rate used in recent stock assessments is 0.2 (Turnock et al. 2002).

Fishery

Caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 5. They are caught as bycatch in the rex sole, thornyhead and sablefish fisheries and are caught with these species and Pacific halibut in Dover sole directed fisheries.

Relevant Trophic Information

Groundfish predators include Pacific cod and most likely arrowtooth flounder.

Approximate upper size limit of juvenile fish: 32 cm.

Habitat and Biological Associations

> *Larvae/Juveniles*: Planktonic larvae for up to 2 years until metamorphosis occurs, juvenile distribution is unknown.
>
> *Adults*: Winter and spring spawning and summer feeding on soft substrates (combination of sand and mud) of the continental shelf and upper slope. Shallower summer distribution mainly on the middle to outer portion of the shelf and upper slope, feeding mainly on polychaetes, annelids, crustaceans and mollusks (Livingston and Goiney 1983).

Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Canada, Bull. No. 180. 740 p.

Hunter, J.R., B.J. Macewicz, N.C. Lo and C.A. Kimbrell. 1992. Fecundity, spawning, and maturity of female Dove sole *Microstomus pacificus*, with an evaluation of assumptions and precision. Fish. Bull. 90:101-128(1992).

Hirschberger, W.A. and G.B. Smith. 1983. Spawning of twelve groundfish species in the Alaska and Pacific coast regions. 50 p. NOAA Tech. Mem. NMFS F/NWC-44. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Kendall, A.W. Jr. and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. NOAA Tech. Rep. NMFS 20, U.S. Dep. Commer, NOAA, Natl. Mar. Fish. Serv.

Livingston, P.A. and B.J. Goiney, Jr. 1983. Food habits literature of North Pacific marine fishes: a review and selected bibliography. NOAA Tech. Mem. NMFS F/NWC-54, U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Markle, D.F., Harris, P, and Toole, C. 1992. Metamorphosis and an overview of early-life-history stages in Dover sole *Microstomus pacificus*. Fish. Bull. 90:285-301.

Martin, M.H. and D.M. Clausen. 1995. Data report: 1993 Gulf of Alaska Bottom Trawl Survey. U.S. Dept. Commer., NOAA, Natl. Mar. Fish. Serv., NOAA Tech. Mem. NMFS-AFSC-59, 217 p.

Miller, D.J. and R.N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dept. Fish. Game, Fish. Bull. 157, 235 p.

Turnock, B.J., T.K. Wilderbuer and E.S. Brown. 2002. Flatfish. In Appendix B Stock assessment and fishery evaluation Report for the groundfish resources of the Gulf of Alaska. p 169-197. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

SPECIES: Dover sole

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	spring summer	ICS? MCS OCS USP	P			
Larvae	up to 2 years	U phyto/zoo plankton?	all year	ICS? MCS OCS USP	P			
Early Juveniles	to 3 years	polychaetes amphipods annelids	all year	MCS? ICS?	D	S, M		
Late Juveniles	3-5 years	polychaetes amphipods annelids	all year	MCS? ICS?	D	S, M		
Adults	5+ years	polychaetes amphipods annelids mollusks	spawning Jan-August non-spawning July-January	MCS OCS USP	D	S, M		

Habitat Description for Greenland Turbot

(Reinhardtius hippoglossoides)

Management Plan and Area GOA

Life History and General Distribution

Greenland turbot has an amphiboreal distribution, occurring in the North Atlantic and North Pacific, but not in the intervening Arctic Ocean. In the North Pacific, species abundance is centered in the eastern Bering Sea and, secondly, in the Aleutians. On the Asian side, they occur in the Gulf of Anadyr along the Bering Sea coast of Russia, in the Okhotsk Sea, around the Kurile Islands, and south to the east coast of Japan to northern Honshu Island (Hubbs and Wilimovsky 1964, Mikawa 1963, Shuntov 1965). Adults exhibit a benthic lifestyle, living in deep waters of the continental slope but are known to have a tendency to feed off the sea bottom. During their first few years as immature fish, they inhabit relatively shallow continental shelf waters (<200 m) until about age 4 or 5 before joining the adult population (200 - 1,000 m or more, Templeman 1973). Adults appear to undergo seasonal shifts in depth distribution moving deeper in winter and shallower in summer (Chumakov 1970, Shuntov 1965). Spawning is reported to occur in winter in the eastern Bering Sea and may be protracted starting in September or October and continuing until March with an apparent peak period in November to February (Shuntov 1970, Bulatov 1983). Females spawn relatively small numbers of eggs with fecundity ranging from 23,900 to 149,300 for fish 83 cm and smaller in the Bering Sea (D'yakov 1982).

Eggs and early larval stages are benthypelagic (Musienko 1970). In the Atlantic Ocean, larvae (10-18 cm) have been found in benthypelagic waters which gradually rise to the pelagic zone in correspondence to absorption of the yolk sac which is reported to occur at 15-18 mm with the onset of feeding (Pertseva-Ostroumova 1961 and Smidt 1969). The period of larval development extends from April to as late as August or September (Jensen 1935) which results in an extensive larval drift and broad dispersal from the spawning waters of the continental slope. Metamorphosis occurs in August or September at about 7-8 cm in length at which time the demersal life begins. Juveniles are reported to be quite tolerant of cold temperatures to less than zero degrees Celsius (Hognestad 1969) and have been found on the northern part of the Bering Sea shelf in summer trawl surveys (Alton et al. 1988).

The age of 50% maturity is estimated to range from 5-10 yrs (D'yakov 1982, 60 cm used in stock assessment) and a natural mortality rate of 0.18 has been used in the most recent Bering Sea stock assessment (Ianelli et al. 2002).

Fishery

Greenland turbot are not a fishery target in the Gulf of Alaska. They are caught in bottom trawls and on longlines both as a directed fishery and in the pursuit of other bottom-dwelling species (primarily sablefish). These fisheries operate on the southern side of the Aleutian Islands. Bycatch primarily occurs in the sablefish directed fisheries and also to a smaller extent in the Pacific cod fishery. Recruitment begins at about 50 and 60 cm in the trawl and longline fisheries, respectively.

Relevant Trophic Information

Groundfish predators include Pacific cod, pollock and yellowfin sole, mostly on fish ranging from 2 to 5 cm standard length (probably age 0).

Approximate upper size limit of juvenile fish: 59 cm

Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for up to 9 months until metamorphosis occurs, usually with a widespread distribution inhabiting shallow waters. Juveniles live on continental shelf until about age 4 or 5 feeding primarily on euphausiids, polychaetes and small walleye pollock..

Adults: Inhabit continental slope waters with annual spring/fall migrations from deeper to shallower waters. Diet consists of walleye pollock and other miscellaneous fish species.

Literature

Alton, M.S., R.G. Bakkala, G.E. Walters and P.T. Munro. 1988. Greenland turbot, *Reinhardtius hippoglossoides*, of the Eastern Bering Sea and Aleutian Islands. U.S. Dept. Commer., NOAA Tech. Rpt. NMFS 71, 31 pages.

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Bulatov, O.A. 1983. Distribution of eggs and larvae of Greenland halibut, *Reinhardtius hippoglossoides*, (Pleuronectidae) in the eastern Bering Sea. J. Ichthyol. [Engl. Transl. Vopr. Ikhtiol.] 23(1):157-159.

Chumakov, A.K. 1970. The Greenland halibut, *Reinhardtius hippoglossoides*, in the Iceland area-The halibut fisheries and tagging. Tr. Polyarn. Nauchno-Issled. Proektn. Inst. Morsk. Rybn. Khoz. 1970:909-912.

D'yakov, Yu. P. 1982. The fecundity of the Greenland halibut, *Reinhardtius hippoglossoides* (Pleuronectidae), from the Bering Sea. J. Ichthyol. [Engl. Trans. Vopr. Ikhtiol.] 22(5):59-64.

Hognestad, P.T. 1969. Notes on Greenland halibut, *Reinhardtius hippoglossoides*, in the eastern Norwegian Sea. Fiskeridir. Skr. Ser. Havunders. 15(3):139-144.

Hubbs, C.L., and N.J. Wilimovsky. 1964. Distribution and synonymy in the Pacific Ocean and variation of the Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum). J. Fish. Res. Board Can. 21:1129-1154.

Ianelli, J.N.,C. Minte-Vera, T.K. Wilderbuer and T.M. Sample. 2002. Greenland turbot. *In* Appendix A Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Bering Sea/Aleutian Islands Regions, Pages 255-282. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Jensen, A.S. 1935. (*Reinhardtius hippoglossoides*) its development and migrations. K. dan. Vidensk. Selsk. Skr. 9 Rk., 6:1-32.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way, NE., Seattle, WA 98115.

Mikawa, M. 1963. Ecology of the lesser halibut, *Reinhardtius hippoglossoides matsuurae* Jordan and Snyder. Bull. Tohoku Reg. Fish. Res. Lab. 29:1-41.

Musienko, L.N. 1970. Reproduction and Development of Bering Sea. Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 70 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 72)161-224. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1972, p. 161-224. In P. A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part V. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT71-50127.

Pertseva-Ostroumova, T.A. 1961. The reproduction and development of far eastern flounders. Izdatel'stvo Akad. Nauk. SSSR, 483 p. [Transl. By Fish. Res. Board Can., 1967, Transl. Ser. 856, 1003 p.]

Shuntov, V.P. 1965. Distribution of the Greenland halibut and arrowtooth halibuts in the North Pacific. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 53):155-163. [Transl. In Soviet Fisheries Investigation in the Northeastern Pacific, Part IV, p. 147-156, by Israel Prog. Sci. Transl., 1972, avail. Natl. Tech. Inf. Serv., Springfield, VA as TT71-50127.]

Templeman, W. 1973. Distribution and abundance of the Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum), in the Northwest Atlantic. Int. Comm. Northwest Atl. Fish. Res. Bull. 10:82-98.

SPECIES: Greenland turbot

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	winter	OCS MCS	SD, SP			
Larvae	8-9 months	U phyto/zoo plankton?	Spring summer	OCS ICS MCS	P			
Juveniles	1-5 yrs	euphausiids polychaets small pollock	all year	ICS MCS OCS USL	D, SD	M/S+M[1]		
Adults	5+ years	pollock small fish	spawning Nov-February non-spawning March-October	OCS USP LSP OCS	D, SD	M/S+M[1]		

[1]Pers. Comm. Dr. Robert McConnaughey (206) 526-4150

Habitat Description for Rock Sole

(Lepidopsetta bilineatus)

The shallow water flatfish management complex in the Gulf of Alaska is comprised of eight species: rock sole (*Lepidopsetta bileneata and Lepidopsetta polyxystra*), yellowfin sole (*Limanda aspera*), starry flounder (*Platichthys stellatus*), butter sole (*Isopsetta isolepis*), English sole (*Parophrys vetulus*), Alaska plaice (*Pleuronectes quadrituberculatus*) and sand sole (*Psettichthys melanostictus*). The rock sole resource in the Gulf of Alaska consists of two separate species; a northern and a southern form which have distinct characteristics and overlapping distributions. The two species of rock sole and yellowfin sole are the most abundant and commercially important species of this management complex in the Gulf of Alaska, and the description of their habitat and life history best represent the shallow water complex species.

Management Plan and Area GOA

Life History and General Distribution

Distributed from California waters north into the Gulf of Alaska and Bering Sea to as far north as the Gulf of Anadyr. The distribution continues along the Aleutian Islands westward to the Kamchatka Peninsula and then southward through the Okhotsk Sea to the Kurile Islands, Sea of Japan, and off Korea. Centers of abundance occur off the Kamchatka Peninsula (Shubnikov and Lisovenko 1964), British Columbia (Forrester and Thompson 1969), the central Gulf of Alaska, and in the southeastern Bering Sea (Alton and Sample 1975). Adults exhibit a benthic lifestyle and, in the eastern Bering Sea, occupy separate winter (spawning) and summertime feeding distributions on the continental shelf. Rock sole spawn during the winter-early spring period of December-March. Soviet investigations in the early 1960s established two spawning concentrations: an eastern concentration north of Unimak Island at the mouth of Bristol Bay and a western concentration eastward of the Pribilof Islands between 55°30' and 55°0' N and approximately 165°2' W (Shubnikov and Lisovenko, 1964). Rock sole spawning in the eastern and western Bering Sea was found to occur at depths of 125-250 m, close to the shelf/slope break. Spawning females deposit a mass of eggs which are demersal and adhesive (Alton and Sample 1975). Fertilization is believed to be external. Incubation time is temperature dependent and may range from 6.4 days at 11 degrees C to about 25 days at 2.9 degrees C (Forrester 1964). Newly hatched larvae are pelagic and have occurred sporadically in eastern Bering Sea plankton surveys (Waldron and Vinter, 1978). Kamchatka larvae are reportedly 20 mm in length when they assume their side-swimming, bottom-dwelling form (Alton and Sample 1975). Forrester and Thompson (1969) report that by age 1 they are found with adults on the continental shelf during summer.

In the springtime, after spawning, rock sole begin actively feeding and commence a migration to the shallow waters of the continental shelf. This migration has been observed on both the eastern (Alton and Sample, 1975) and western (Shvetsov 1978) areas of the Bering Sea. During this time they spread out and form much less dense concentrations than during the spawning period . Summertime trawl surveys indicate most of the population can be found at depths from 50-100 m (Armistead and Nichol 1993). The movement from winter/spring to summer grounds is in response to warmer temperatures in the shallow waters and the distribution of prey on the shelf seafloor (Shvetsov 1978). In September, with the onset of cooling in the northern latitudes, rock sole begin the return migration to the deeper wintering grounds. Fecundity varies with size and was reported to be 450,00 eggs for fish 42 cm long. Larvae are pelagic but their occurrence in plankton surveys in the eastern Bering Sea are rare (Musienko 1963). The age or size at metamorphosis is unknown. Juveniles are separate from the adult population, remaining in

shallow areas until they reach age 1 (Forrester 1969). The estimated age of 50% maturity is 9 yrs for southern rock sole females (approx. 35 cm) and 7 years for northern rock sole females (Stark and Somerton 2002). Natural mortality rate is believed to range from 0.18 - 0.20 (Tournock et al. 2002).

Fishery

Caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 4 and they are fully selected at age 11. Historically, the fishery has occurred throughout the mid and inner Bering Sea shelf during ice-free conditions and on spawning concentrations north of the Alaska Peninsula during winter for their high-value roe. They are caught as bycatch in Pacific cod, bottom Pollock and other flatfish fisheries and are caught with these species and Pacific halibut in rock sole directed fisheries.

Relevant Trophic Information

Groundfish predators to rock sole include Pacific cod, walleye pollock, skates, Pacific halibut and yellowfin sole, mostly on fish ranging from 5 to 15 cm standard length.

Approximate upper size limit of juvenile fish: 34 cm

Habitat and Biological Associations

> *Larvae/Juveniles*: Planktonic larvae for at least 2-3 months until metamorphosis occurs, juveniles inhabit shallow areas at least until age 1.
>
> *Adults*: Summertime feeding on primarily sandy substrates of the eastern Bering Sea shelf. Widespread distribution mainly on the middle and inner portion of the shelf, feeding on bivalves, polychaetes, amphipods and miscellaneous crustaceans. Wintertime migration to deeper waters of the shelf margin for spawning and to avoid extreme cold water temperatures, feeding diminishes.

Literature

Alton, M.S. and Terry M. Sample 1976. Rock sole (Family Pleuronectidae) p. 461-474. *In*: Demersal fish and shellfish resources in the Bering Sea in the baseline year 1975. Principal investigators Walter T. Pereyra, Jerry E. Reeves, and Richard Bakkala. U.S. Dep. Comm., Natl. Oceanic Atmos. Admin., Natl. Mar. Serv., Northwest and Alaska Fish Center, Seattle, WA. Processed Rep., 619 p.

Armistead, C.E. and D.G. Nichol 1993. 1990 Bottom Trawl Survey of the Eastern Bering Sea Continental Shelf. U.S. Dep. Commer., NOAA Tech. Mem. NMFS-AFSC-7, 190 p.

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Forrester, C.R. 1964. Demersal Quality of fertilized eggs of rock sole. J. Fish. Res. Bd. Canada, 21(6), 1964. P. 1531.

Forrester, C.R. and J.A. Thompson 1969. Population studies on the rock sole, *Lepidopsetta bilineata*, of northern Hecate Strait British Columbia. Fish. Res. Bd. Canada, Tech. Rep. No. 108, 1969. 104 p.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Musienko, L.N. 1963. Ichthyoplankton of the Bering Sea (data of the Bering Sea expedition of 1958-59). Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 50)239-269. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1968, p. 251-286. In P. A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part I. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT67-51203.

Shubnikov, D.A. and L.A. Lisovenko 1964. Data on the biology of rock sole in the southeastern Bering Sea. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 49 (Izv. Tikookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 51) : 209-214. (Transl. In Soviet Fisheries Investigations in the Northeast Pacific, Part II, p. 220-226, by Israel Program Sci. Transl., 1968, available Natl. Tech. Inf. Serv., Springfield, VA, as TT 67-51204).

Shvetsov, F.G. 1978. Distribution and migrations of the rock sole, *Lepidopsetta bilineata*, in the regions of the Okhotsk Sea coast of Paramushir and Shumshu Islands. J. Ichthol., 18 (1), 56-62, 1978.

Stark, J.W. and D. A. Somerton. 2002. Maturation, spawning and growth of rock soles off Kodiak Island in the Gulf of Alaska. J. Fish. Biology (2002) 61, 417-431.

Turnock, B.J., T.K. Wilderbuer and E.S. Brown. 2002. Flatfish. In Appendix B Stock Assessment and Fishery Evaluation for Groundfish Resources of the Gulf of Alaska Region. Pages 169-197. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Waldron, K.D. And B. M. Vinter 1978. Ichthyoplankton of the eastern Bering Sea. U. S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv. Seattle, WA, Processed rep., 88 p.

SPECIES: Rock sole

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	winter	OCS	D			
Larvae	2-3 months?	U phyto/zoo plankton?	winter/spring	OCS MCS ICS	P			
Early Juveniles	to 3.5 years	polychaetes bivalves amphipods misc. crust.	all year	BAY ICS OCS MCS	D	S[1],G		
Late Juveniles	up to 9 years	polychaetes bivalves amphipods misc. crust.	all year	BAY ICS OCS MCS	D	S[1],G		
Adults	9+ years	polychaetes bivalves amphipods misc. crust.	feeding May- September	MCS ICS	D	S[1], G	ice edge	

[1]Pers. Comm. Dr. Robert McConnaughey (206) 526-4150

Habitat Description for Yellowfin sole

(Limanda aspera)

Management Plan and Area Shallow water flatfish complex in the GOA

Life History and General Distribution

Distributed in North American waters from off British Columbia, Canada, (approx. lat. 49° N) to the Chukchi Sea (about lat. 70° N) and south along the Asian coast to about lat. 35° N off the South Korean coast in the Sea of Japan. Adults exhibit a benthic lifestyle and occupy separate winter spawning and summertime feeding distributions on the eastern Bering Sea shelf. From over-winter grounds near the shelf margins, adults begin a migration onto the inner shelf in April or early May each year for spawning and feeding. A protracted and variable spawning period may range from as early as late May through August occurring primarily in shallow water. Fecundity varies with size and was reported to range from 1.3 to 3.3 million eggs for fish 25-45 cm long. Eggs have been found to the limits of inshore ichthyoplankton sampling over a widespread area to at least as far north as Nunivak Island. Larvae have been measured at 2.2-5.5 mm in July and 2.5-12.3 mm in late August - early September. The age or size at metamorphosis is unknown. Juveniles are separate from the adult population, remaining in shallow areas until they reach approximately 15 cm. The estimated age of 50% maturity is 10.5 yrs (approx. 29 cm) for females based on samples collected in 1992 and 1993. Natural mortality rate is believed to range from 0.12-0.16.

Fishery

Caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 6 and they are fully selected at age 13. Historically, the fishery has occurred throughout the mid and inner Bering Sea shelf during ice-free conditions although much effort has been directed at the spawning concentrations in nearshore northern Bristol Bay. They are caught as bycatch in Pacific cod, bottom pollock and other flatfish fisheries and are caught with these species and Pacific halibut in yellowfin sole directed fisheries.

Relevant Trophic Information

Groundfish predators include Pacific cod, skates and Pacific halibut, mostly on fish ranging from 7 to 25 cm standard length.

Approximate upper size limit of juvenile fish: 27 cm

Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for at least 2-3 months until metamorphosis occurs, usually inhabiting shallow areas.

Adults: Summertime spawning and feeding on sandy substrates of the eastern Bering Sea shelf. Widespread distribution mainly on the middle and inner portion of the shelf, feeding mainly on bivalves, polychaetes, amphipods and echiurids.. Wintertime

migration to deeper waters of the shelf margin to avoid extreme cold water temperatures, feeding diminishes.

Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Bakkala, R.G., V.G. Wespestad, and L.L. Low. 1982. The yellowfin sole (*Limanda aspera*) resource of the eastern Bering Sea--Its current and future potential for commercial fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-33, 43 p.

Fadeev, N.W. 1965. Comparative outline of the biology of fishes in the southeastern part of the Bering Sea and condition of their resources. [In Russ.] Tr. Vses. Nauchno-issled. Inst.Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled Inst. Morsk. Rybn. Khoz. Okeanogr. 53):121-138. (Trans. By Isr. Prog. Sci. Transl., 1968), p 112-129. In P.A. Moiseev (Editor), Soviet Fisheries Investigations in the northeastern Pacific, Pt. IV. Avail. Natl. Tech. Inf. Serv., Springfield, VA as TT 67-51206.

Kashkina, A.A. 1965. Reproduction of yellowfin sole (*Limanda aspera*) and changes in its spawning stocks in the eastern Bering Sea. Tr. Vses. Nauchno-issled, Inst. Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled. Inst. Rbn. Khoz. Okeanogr. 53):191-199. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1968, p. 182-190. In P.A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part IV. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT67-51206.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Musienko, L.N. 1963. Ichthyoplankton of the Bering Sea (data of the Bering Sea expedition of 1958-59). Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 50)239-269. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1968, p. 251-286. In P.A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part I. Avail. Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51203.

Musienko, L.N. 1970. Reproduction and Development of Bering Sea. Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 70 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 72)161-224. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1972, p. 161-224. In P.A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part V. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT71-50127.

Nichol, D.G. 1994. Maturation and Spawning of female yellowfin sole in the Eastern Bering Sea. Preceding of the International North Pacific Flatfish Symposium, Oct. 26-28, 1994, Anchorage, AK. Alaska Sea Grant Program.

Wakabayashi, K. 1986. Interspecific feeding relationships on the continental shelf of the eastern Bering Sea, with special reference to yellowfin sole. Int. N. Pac. Fish. Comm. Bull. 47:3-30.

Waldron, K.D. 1981. Ichthyoplankton. In D.W. Hood and J.A. Calder (Editors), The eastern Bering Sea shelf: Oceanography and resources, Vol. 1, p. 471-493. U.S. Dep. Commer., NOAA, Off. Mar. Poll. Asess., U.S. Gov. Print. Off., Wash., D.C.

Wilderbuer, T.K., G.E. Walters, and R.G. Bakkala. 1992. Yellowfin sole, Pleuronectes asper, of the Eastern Bering Sea: Biological Characteristics, History of Exploitation, and Management. Mar. Fish. Rev. 54(4) p 1-18.

SPECIES: Yellowfin sole

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	summer	BAY, BCH	P			
Larvae	2-3 months?	U phyto/zoo plankton?	summer autumn?	BAY BCH ICS	P			
Early Juveniles	to 5.5 yrs	polychaetes bivalves amphipods echiurids	all year	BAY ICS OCS MCS	D	S[1]		
Late Juveniles	5.5 to 10 yrs	polychaetes bivalves amphipods echiurids	all year	BAY ICS, OCS, MCS IP	D	S[1]		
Adults	10+ years	polychaetes bivalves amphipods echiurids	spawning/ feeding May-August non-spawning Nov.-April	BAY BEACH ICS, MCS, OCS IP	D	S[1]	ice edge	

1Pers. Comm. Dr. Robert McConnaughey (206) 526-4150

Habitat Description for Rex Sole

(*Glyptocephalus zachirus)*

Management Plan and Area GOA

Life History and General Distribution

Distributed from Baja California to the Bering Sea and western Aleutian Islands (Hart 1973, Miller and Lea 1972), and are widely distributed throughout the Gulf of Alaska. Adults exhibit a benthic lifestyle and are generally found in water deeper than 300 meters. From over-winter grounds near the shelf margins, adults begin a migration onto the mid and outer continental shelf in April or May each year. The spawning period off Oregon is reported to range from January through June with a peak in March and April (Hosie and Horton 1977). Spawning in the Gulf of Alaska was observed from February through July, with a peak period in April and May (Hirschberger and Smith 1983). Eggs have been collected in neuston and bongo nets mainly in the summer, east of Kodiak Island (Kendall and Dunn 1985), but the duration of the incubation period is unknown.. Larvae were captured in bongo nets only in summer over midshelf and slope areas (Kendall and Dunn 1985). Fecundity estimates from samples collected off the Oregon coast ranged from 3,900 to 238,100 ova for fish 24-59 cm (Hosie and Horton 1977). The age or size at metamorphosis is unknown Maturity studies from Oregon indicate that males were 50% mature at 16 cm and females at 24 cm. Juveniles less than 15 cm are rarely found with the adult population. The natural mortality rate used in recent stock assessments is 0.2 (Turnock et al. 2002).

Fishery

Caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 3 or 4. They are caught as bycatch in the Pacific ocean perch, Pacific cod, bottom pollock and other flatfish fisheries and are caught with these species and Pacific halibut in rex sole directed fisheries.

Relevant Trophic Information

Groundfish predators include Pacific cod and most likely arrowtooth flounder.

Approximate upper size limit of juvenile fish: Males 15 cm and females 23 cm.

Habitat and Biological Associations

> *Larvae/Juveniles*: Planktonic larvae for an unknown time period until metamorphosis occurs, juvenile distribution is unknown.
>
> *Adults*: Spring spawning and summer feeding on a combination of sand, mud and gravel substrates of the continental shelf. Widespread distribution mainly on the middle and outer portion of the shelf, feeding mainly on polychaetes, amphipods, euphausids and snow crabs.

Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Canada, Bull. No. 180. 740 p.

Hosie, M.J. and H.F. Horton. 1977. Biology of the rex sole, *Glyptocephalus zachirus*, in waters off Oregon. Fish. Bull. Vol. 75, No. 1, 1977, p. 51-60.

Hirschberger, W.A. and G.B. Smith. 1983. Spawning of twelve groundfish species in the Alaska and Pacific coast regions. 50 p. NOAA Tech. Mem. NMFS F/NWC-44. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Kendall, A.W. Jr. and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. NOAA Tech. Rep. NMFS 20, U.S. Dep. Commer, NOAA, Natl. Mar. Fish. Serv.

Livingston, P.A. and B.J. Goiney, Jr. 1983. Food habits literature of North Pacific marine fishes: a review and selected bibliography. NOAA Tech. Mem. NMFS F/NWC-54, U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Miller, D.J. and R.N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dep. Fish. Game, Fish. Bull. 157, 235 p.

Turnock, B.J., T.K. Wilderbuer and E. S. Brown. 2002. Flatfish. *In* Stock assessment and fishery evaluation Report for the groundfish resources of the Gulf of Alaska. p 169-197. North Pac. Fish. Mgmt. Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

SPECIES: Rex sole

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	Feb - May	ICS? MCS OCS	P			
Larvae	U	U phyto/zoo plankton?	spring summer	ICS? MCS OCS	P			
Juveniles	2 years	polychaetes amphipods euphausiids Tanner crab	all year	MCS ICS OCS	D	G, S, M		
Adults	2+ years	polychaetes amphipods euphausiids Tanner crab	spawning Feb-May non-spawning May-January	MCS, OCS USP	D	G, S, M		

Habitat Description for Flathead Sole

(Hippoglossoides elassodon)

Management Plan and Area GOA

Life History and General Distribution

Distributed from northern California, off Point Reyes, northward along the west coast of North America and throughout the Gulf of Alaska and the Bering Sea, the Kuril Islands and possibly the Okhotsk Sea (Hart 1973).

Adults exhibit a benthic lifestyle and occupy separate winter spawning and summertime feeding distributions on the eastern Bering Sea shelf and in the Gulf of Alaska. From over-winter grounds near the shelf margins, adults begin a migration onto the mid and outer continental shelf in April or May each year for feeding. The spawning period may range from as early as January but is known to occur in March and April, primarily in deeper waters near the margins of the continental shelf. Eggs are large (2.75-3.75 mm) and females have egg counts ranging from about 72,000 (20 cm fish) to almost 600,000 (38 cm fish). Eggs hatch in 9 to 20 days depending on incubation temperatures within the range of 2.4 to 9.8°C and have been found in ichthyoplankton sampling on the southern portion of the Bering Sea shelf in April and May (Waldron 1981). Larvae absorb the yolk sac in 6 to 17 days but the extent of their distribution is unknown.Nearshore sampling indicates that newly settled larvae are in the 40-50 mm size range (Norcross et al. 1996). Flathead sole females in the Gulf of Alaska become 50% mature at eight years or about 32 cm (Turnock et al. 2002). Juveniles less than age 2 have not been found with the adult population, remaining in shallow areas. The natural mortality rate used in recent stock assessments is 0.2.

Fishery

Caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 3. Historically, the fishery has occurred throughout the mid and outer Bering Sea shelf during ice-free conditions (mostly summer and fall). They are caught as bycatch in Pacific cod, bottom Pollock and other flatfish fisheries and are caught with these species and Pacific halibut in flathead sole directed fisheries.

Relevant Trophic Information

Groundfish predators include Pacific cod, Pacific halibut, arrowtooth flounder and also cannibalism by large flathead sole, mostly on fish less than 20 cm standard length.

Approximate upper size limit of juvenile fish: 31 cm.

Habitat and Biological Associations

> *Larvae/Juveniles*: Planktonic larvae for3 to 5 months until metamorphosis occurs, usually inhabiting shallow areas.
>
> *Adults*: Winter spawning and summer feeding on sand and mud substrates of the continental shelf. Widespread distribution mainly on the middle and outer portion of the shelf, feeding mainly on ophiuroids, tanner crab, osmerids, bivalves and polychaetes.

Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on sea floor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Forrester, C.R. And D.F. Alderdice. 1967. Preliminary observations on embryonic development of the flathead sole (*Hippoglossoides elassodon*). Fish. Res. Board Can. Tech. Rep. 100: 20 p

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Canada, Bull. No. 180. 740 p.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Miller, B.S. 1969. Life history observations on normal and tumor bearing flathead sole in East Sound, Orcas Island (Washington). Ph.D. Thesis. Univ. Wash. 131 p.

Norcross, B.L., B.A. Holladay, S.C. Dressel and M. Frandsen. 1996. Recruitment of juvenile flatfishes in Alaska: habitat

preference near Kodiak Island. U. Alaska Coastal Marine Institute, OCS Study MMS 96-0003, Vol. 1.

Pacunski, R.E. 1990. Food habits of flathead sole (*Hippoglossoides elassodon*) in the eastern Bering Sea. M.S. Thesis. Univ. Wash. 106 p.

Turnock, B.J., T.K. Wilderbuer and E. S. Brown. 2002. Flathead sole. *In* Stock assessment and fishery evaluation Report for the groundfish resources of the Gulf of Alaska. p 361-408. North Pac. Fish. Mgmt. Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Waldron, K.D. 1981. Ichthyoplankton. In D.W. Hood and J.A. Calder (Editors), The eastern Bering Sea shelf: Oceanography and resources, Vol. 1, p. 471-493. U.S. Dep. Commer., NOAA, Off. Mar. Poll. Asess., U.S. Gov. Print. Off., Wash., D.C.

SPECIES: Flathead sole

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	winter	ICS MCS OCS	P			
Larvae	U	U phyto/zoo plankton?	spring summer	ICS MCS OCS	P			
Juveniles	U	polychaetes bivalves ophiuroids	all year	MCS ICS OCS	D	S+M[1]		
Adults	U	polychaetes bivalves ophiuroids pollock and Tanner crab	spawning Jan-April non-spawning May-	MCS OCS ICS	D	S+M[1]	ice edge	

[1]Pers. Comm. Dr. Robert McConnaughey (206) 526-4150

Habitat Description for Arrowtooth Flounder

(Atheresthes stomias)

Management Plan and Area GOA

Life History and General Distribution

Distributed in North American waters from central California to the eastern Bering Sea on the continental shelf and upper slope.

Adults exhibit a benthic lifestyle and occupy separate winter and summer distributions on the eastern Bering Sea shelf. From over-winter grounds near the shelf margins and upper slope areas, adults begin a migration onto the middle and inner shelf in April or early May each year with the onset of warmer water temperatures. A protracted and variable spawning period may range from as early as September through March (Rickey 1994, Hosie 1976). Little is known of the fecundity of arrowtooth flounder. Larvae have been found from ichthyoplankton sampling over a widespread area of the eastern Bering Sea shelf in April and May and also on the continental shelf east of Kodiak Island during winter and spring (Waldron and Vinter 1978, Kendall and Dunn 1985). Nearshore sampling in the Kodiak Island area indicates that newly settled larvae are in the 40-60 mm size range (Norcross et al. 1996). Juveniles are separate from the adult population, remaining in shallow areas until they reach the 10-15 cm range (Martin and Clausen 1995). The estimated length at 50% maturity is 28 cm for males (4 years) and 37 cm for females (5 years) from samples collected off the Washington coast (Rickey 1994) and 47 cm for Gulf of Alaska females (Zimmerman 1997). The natural mortality rate used in stock assessments differs by sex with females estimated at 0.2 and male natural mortality ranging from 0.28 to 0.35 (Turnock et. al 2002, Wilderbuer and Sample 2002).

Fishery

Caught in bottom trawls usually in pursuit of other higher value bottom-dwelling species. Historically have been undesirable to harvest due to a flesh softening condition caused by protease enzyme activity. Recruitment begins at about age 3 and females are fully selected at age 10. They are caught as bycatch in Pacific cod, bottom Pollock, sablefish and other flatfish fisheries.

Relevant Trophic Information

Very important as a large, aggressive and abundant predator of other groundfish species. Groundfish predators include Pacific cod and pollock, mostly on small fish.

Approximate upper size limit of juvenile fish: Males 27 cm and females 46 cm.

Habitat and Biological Associations

> *Larvae/Juveniles*: Planktonic larvae for at least 2-3 months until metamorphosis occurs, juveniles usually inhabit shallow areas until about 10 cm in length.
>
> *Adults*: Widespread distribution mainly on the middle and outer portions of the continental shelf, feeding mainly on walleye pollock and other miscellaneous fish species when arrowtooth flounder attain lengths greater than 30 cm. Wintertime migration to

deeper waters of the shelf margin and upper continental slope to avoid extreme cold water temperatures and for spawning.

Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Can. Bull. 180, 740 p.

Hosie, M.J. 1976. The arrowtooth flounder. Oregon Dep. Fish. Wildl. Info. Rep. 76-3, 4 p.

Kendall, A.W. Jr. and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. NOAA Tech. Rep. NMFS 20, U. S. Dep. Commer, NOAA, Natl. Mar. Fish. Serv.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Martin, M.H. and D.M. Clausen. 1995. Data report: 1993 Gulf of Alaska Bottom Trawl Survey. U.S. Dept. Commer., NOAA, Natl. Mar. Fish. Serv., NOAA Tech. Mem. NMFS-AFSC-59, 217 p.

Norcross, B.L., B.A. Holladay, S.C. Dressel and M. Frandsen. 1996. Recruitment of juvenile flatfishes in Alaska: habitat preference near Kodiak Island. U. Alaska Coastal Marine Institute, OCS Study MMS 96-0003, Vol. 1.

Rickey, M.H. 1994. Maturity, spawning, and seasonal movement of arrowtooth flounder, *Atheresthes stomias*, off Washington. Fish. Bull. 93:127-138 (1995).

Turnock, B.J., T.K. Wilderbuer and E.S. Brown 2002. Arrowtooth flounder. *In* Appendix B Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Gulf of Alaska, Pages 199-228. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Waldron, K.D. and B.M. Vinter 1978. Ichthyoplankton of the eastern Bering Sea. U. S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv. Seattle, WA, Processed rep., 88 p.

Wilderbuer, T.K. and T.M. Sample 2002. Arrowtooth flounder. *In* Appendix A Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Bering Sea/Aleutian Islands, Pages 283-320. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Zimmerman, M. 1997. Maturity and fecundity of arrowtooth flounder, Atheresthes stomias, from the Gulf of Alaska. Fish. Bull. 95:598-611 (1997).

SPECIES: Arrowtooth flounder

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	winter, spring?	ICS OCS	P			
Larvae	2-3 months?	U phyto/zoo plankton?	spring summer?	BAY ICS OCS	P			
Juveniles	males - 4 yrs females - 5 yrs	euphausiids crustaceans amphipods pollock	all year	ICS OCS USP	D	GMS[1]		
Adults	males - 4+ yrs females- 5+ yrs	pollock misc. fish Gadidae sp. Euphausiids	spawning Nov-March non-spawning	ICS OCS USP BAY	D	GMS[1]	ice edge (EBS)	

[1]Pers. Comm., Dr. Robert McConnaughey (206) 526-4150

Habitat Description for Sablefish

(Anoplopoma fimbria)

Management Plan and Area GOA

Life History and General Distribution

Distributed from Mexico through the Gulf of Alaska to the Aleutian Chain, Bering Sea; along the Asian coast from Sagami Bay, and along the Pacific sides of Honshu and Hokkaido Islands and the Kamchatkan Peninsula. Adult sablefish occur along the continental slope, shelf gullies, and in deep fjords such as Prince William Sound and Southeastern Alaska, at depths generally greater than 200 m. Adults are assumed to be demersal. Spawning or very ripe sablefish are observed in late winter or early spring along the continental slope. Eggs are apparently released near the bottom where they incubate. After hatching and yolk adsorption the larvae rise to the surface where they have been collected with neuston nets. Larvae are oceanic through the spring and by late summer, small pelagic juveniles (10-15 cm) have been observed along the outer coasts of Southeast Alaska, where they apparently move into shallow waters to spend their first winter. During most years, there are only a few places where juveniles have been found during their first winter and second summer. It is not clear if the juvenile distribution is highly specific or appears so because sampling is highly inefficient and sparse. During the occasional times of large year-classes the juveniles are easily found in many inshore areas during their second summer. They are typically 30-40 cm in length during their second summer, after which they apparently leave the nearshore bays. One or two years later they begin appearing on the continental shelf and move to their adult distribution as they mature.

Fishery

The major fishery for sablefish in Alaska uses longlines, however sablefish are valuable in the trawl fishery as well. Sablefish enter the longline fishery at 4-5 years of age, perhaps slightly younger in the trawl fishery. The longline fishery takes place between March 1 and November 15. The take of the trawl share of sablefish occurs primarily in association with openings for other species, such as the July rockfish openings, where they are taken as allowed bycatch. Deeper dwelling rockfish, such as Shortraker, Rougheye, and Thornyhead rockfish are the primary bycatch in the longline sablefish fishery. Halibut and rattails (*Albatrossia pectoralis and Corphaenoides acrolepis*) also are taken. By regulation, there is no directed trawl fishery for sablefish, however, directed fishing standards have allowed some trawl hauls to target sablefish, where the bycatch is similar to the longline fishery, in addition perhaps to some deep dwelling flatfish.

Relevant Trophic Information

Larval sablefish feed on a variety of small zooplankton ranging from copepod naupli to small amphipods. The epipelagic juveniles feed primarily on macrozooplankton and micronekton (i.e., euphausiids).

The older demersal juveniles and adults appear to be opportunistic feeders, with food ranging from variety of benthic invertebrates, benthic fishes, as well as squid, mesopelagic fishes, jellyfish and fishery discards. Gadid fish (mainly pollock) comprise a large part of the sablefish diet. Nearshore residence during their second year provide the opportunity to feed on salmon fry and smolts during the summer months.

Young of the year sablefish are commonly found in the stomachs of salmon taken in the SE troll fishery during the late summer.

Approximate upper size limit of juvenile fish (in cm):

Size of 50% maturity: Bering Sea: males 65 cm, females 67 cm; Aleutian Islands: males 61 cm, females 65 cm; Gulf of Alaska: males 57 cm, females 65 cm. At the end of the second summer (~1.5 years old) they are 35-40 cm in length.

Additional Information Sources

Eggs and Larvae: NMFS, Alaska Fisheries Science Center, FOCI Program, Art Kendall 206-526-4108, NMFS Auke Bay Lab, Bruce Wing 907-789-6043.

Juveniles: ADFG groundfish surveys: Jim Blackburn, ADFG, Kodiak AK 907-486-186, Paul Anderson, NMFS/RACE, Kodiak AK 907-487-4961

Kendall, A.W. and A.C. Materese. Biology of eggs, larvae, and epipelagic juveniles of sablefish, *Anoplopoma fimbria*, in relation to their potential use in management. Mar. Fish. Rev. 49(1)1-13.

Smith, G.B., G.E. Walters, P.A. Raymore, Jr., and W.A, Hischberger. 1984. Studies of the distribution and abundance of juvenile groundfish in the northwestern Gulf of Alaska, 1980-82: Part I, Three-year comparisons. NOAA Tech. Memo. NMFS F/NWC-59. 100p.

Walters, G.E., G.B. Smith, P.A. Raymore, and W.A. Hirschberger. 1985. Studies of the distribution and abundance of juvenile groundfish in the northwestern Gulf of Alaska, 1980-82: Part II, Biological characteristics in the extended region. NOAA Tech. Memo. NMFS F/NWC-77. 95 p.

Wing, B.L. and D.J. Kamikawa. 1995. Distribution of neustonic sablefish larvae and associated ichthyoplankton in the eastern Gulf of Alaska, May 1990. NOAA Tech. Memo. NMFS-AFSC-53.

Habitat and Biological Associations (if known) Narrative

Egg/Spawning
Larvae
Juveniles
Adults - other than depth, none is noted.

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and Zoogeography of common fishes in the Bering Sea and northeastern Pacific. U.S. Dep. Commer., NOAAS Tech. Rept. NMFS 66, 151 p.

Boehlert, G.W., and M.M. Yoklavich. 1985. Larval and juvenile growth of sablefish, *Anoplopoma fimbria*, as determined from otolith increments. Fish. Bull. 83:475-481.

Grover, J.J., and B.L. Olla. 1986. Morphological evidence for starvation and prey size selection of sea-caught larval sablefish, *Anoplopoma fimbria*. Fish. Bull. 84:484-489.

Grover, J.J., and B.L. Olla. 1987. Effects of and El Niño event on the food habits of larval sablefish, *Anoplopoma fimbria*, off Oregon and Washington. Fish. Bull. 85: 71-79.

Grover, J.J., and B.L. Olla. 1990. Food habits of larval sablefish, *Anoplopoma fimbria* from the Bering Sea. Fish Bull. 88:811-814.

Hunter, J.R., B.J. Macewiccz, and C.A. Kimbrell. 1989. Fecundity and other aspects of the reproduction of Sablefish, *Anoplopoma fimbria*, in Central California Waters. Calif. Coop. Fish. Invst. Rep. 30: 61-72.

Kendall, A.W., Jr., and A.C. Matarese. 1984. Biology of eggs, larvae, and epipelagic juveniles of sablefish, *Anoplopoma fimbria*, in relation to their potential use in management. Mar. Fish. Rev. 49(1):1-13.

Mason, J.C. , R.J. Beamish, and G.A. McFralen. 1983. Sexual maturity, fecundity, spawning, and early life history of sablefish (*Anoplopoma fimbria*) off the Pacific coast of Canada. Can. J. Fish. Aquat. Sci. 40:2121-2134.

McFarlane, G.A., and R.J. Beamish. 1992. Climatic influence linking copepod production with strong year-classes in sablefish, *Anoplopoma fimbria*. Can J. Fish. Aquat. Sci. 49:743-753.

Moser, H.G., R.L. Charter, P.E. Smith, N.C.H. Lo., D.A. Ambrose, C.A. Meyer, E.M. Sanknop, and W. Watson. 1994. Early life history of sablefish, *Anoplopoma fimbria*, off Washington, Oregon, and California with application to biomass estimation. Calif. Coop. Oceanic Fish. Invest. Rep. 35:144-159.

Rutecki, T.L. and E.R. Varosi. 1993. Distribution, age, and growth of juvenile sablefish in Southeast Alaska. Paper presented at International Symposium on the Biology and Management of Sablefish. Seattle, Wash. April 1993.

Rutecki, T.L. and E.R. Varosi. 1993. Migrations of Juvenile Sablefish in Southeast Alaska. Paper presented at International Symposium on the Biology and Management of Sablefish. Seattle, Wash. April 1993.

Sasaki, T. 1985. Studies on the sablefish resources in the North Pacific Ocean. Bulletin 22, (1-108), Far Seas Fishery Laboratory. Shimizu, 424, Japan.

Sigler, M.F., E.R. Varosi, and T.R. Rutecki. 1993. Recruitment curve for sablefish in Alaska based on recoveries of fish tagged as juveniles. Paper presented at International Symposium on the Biology and Management of Sablefish. Seattle, Wash. April 1993.

Sigler, M. F., T. L. Rutecki, D. L. Courtney, J. F. Karinen, and M.-S.Yang. 2001. Young-of-the-year sablefish abundance, growth, and diet. Alaska Fisheries Research Bulletin 8(1): 57-70.

NOAA (National Oceanic and Atmospheric Administration). 1990. Sablefish, *Anoplopoma fimbria*. Pl 3.2.22. IN: West Coast of North America Coastal and Ocean Zones Strategic Assessment Data Atlas. Invertebrate and Fish Volume. U.S. Dep. Commer. NOAA. OMA/NOS, Ocean Assessment Division, Strategic Assessment Branch.

Wing, B.L. 1985. Salmon Stomach contents from the Alaska Troll Logbook Program, 1977-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-91, 41 p.

Wing, B.L. 1997. Distribution of sablefish, *Anoplopoma fimbria*, larvae in the eastern Gulf of Alaska: Neuston-net tows versus oblique tows. *In*: M. Wilkins and M. Saunders (editors), Proc. Int. Sablefish Symp., April 3-4, 1993, p. 13-25.. U.S. Dep. Commer., NOAA Tech. Rep. 130.

Wing, B.L., and D.J. Kamikawa. 1995. Distribution of neustonic sablefish larvae and associated ichthyoplankton in the eastern Gulf of Alaska, May 1990. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-AFSC-53, 48 p.

Wing, B.L., C. Derrah, and V. O'Connell. 1997. Ichthyoplankton in the eastern Gulf of Alaska, May 1990. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-AFSC-376, 42 p.

Wolotera, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. NOAA Tech. Memo. NMFS-AFSC-22. 150 p.

SPECIES: Gulf of Alaska Sablefish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	14-20 days	NA	late winter-early spring: Dec-Apr	USP, LSP, BSN	P,200-3000 m	NA	U	
Larvae	up to 3 months	copepod nauplii, small copepodites, etc	spring-summer: Apr-July	MCS, OCS, USP, LSP, BSN	N, neustonic near surface	NA	U	
Early Juveniles	up to 3 years	small prey fish, sandlance, salmon, herring, etc		OCS, MCS, ICS, during first summer, then obs in BAY, IP, till end of 2nd summer; not obs'd till found on shelf	P when offshore during first summer, then D, SD/SP when inshore	NA when pelagic. The bays where observed were soft bottomed, but not enough obs. to assume typical.	U	
Late Juveniles	3-5 yrs	opportunistic: other fish, shellfish, worms, jellyfish, fishery discards	all year	continental slope, and deep shelf gullies and fjords.	presumably D	varies	U	
Adults	5 to 35+ yrs	opportunistic: other fish, shellfish, worms, jellyfish, fishery discards	apparently year around, spawning movements (if any) are undescribed	continental slope, and deep shelf gullies and fjords.	presumably D	varies	U	

Habitat Description for Pacific Ocean Perch

(*Sebastes alutus*)

Management Plan and Area GOA

Life History and General Distribution

Pacific ocean perch has a wide distribution in the North Pacific from southern California around the Pacific rim to northern Honshu Is., Japan, including the Bering Sea. The species appears to be most abundant in northern British Columbia, the Gulf of Alaska, and the Aleutian Islands. Adults are found primarily offshore on the outer continental shelf and the upper continental slope in depths 150-420 m. Seasonal differences in depth distribution have been noted by many investigators. In the summer, adults inhabit shallower depths, especially those between 150 and 300 m. In the fall, the fish apparently migrate farther offshore to depths of ~300-420 m. They reside in these deeper depths until about May, when they return to their shallower summer distribution. This seasonal pattern is probably related to summer feeding and winter spawning. Although small numbers of Pacific ocean perch are dispersed throughout their preferred depth range on the continental shelf and slope, most of the population occurs in patchy, localized aggregations. Pacific ocean perch is are generally considered to be semi-demersal but there can at times be a significant pelagic component to their distribution. Apparently, Pacific ocean perch often move off-bottom at night to feed, and commercial fishing data in the GOA since 1995 show that pelagic trawls fished off-bottom have accounted for as much as 20% of the annual harvest of this species.

There is much uncertainty about the life history of Pacific ocean perch, although generally more is known than for other rockfish species. The species appears to be viviparous (the eggs develop internally and receive at least some nourishment from the mother), with internal fertilization and the release of live young. Insemination occurs in the fall, and sperm are retained within the female until fertilization takes place ~2 months later. The eggs hatch internally, and parturition (release of larvae) occurs in April-May. Information on early life history is very sparse, especially for the first year of life. Pacific ocean perch larvae are thought to be pelagic and to drift with the current, but larval studies of rockfish have been hindered by difficulties in species identification. At present, positive identification of Pacific ocean perch larvae is only possible using genetic techniques, which are expensive and labor intensive. Recently, post-larval and early young-of-the-year Pacific ocean perch have been positively identified in samples collected in July and August in offshore, surface waters of the Gulf of Alaska, which suggests this may be the preferred habitat of this life stage. Transformation to a demersal existence may take place within the first year. Small juveniles probably reside inshore in very rocky, high relief areas, and by age 3 begin to migrate to deeper offshore waters of the continental shelf. As they grow, they continue to migrate deeper, eventually reaching the continental slope, where they attain adulthood.

Pacific ocean perch is a very slow growing species, with a low rate of natural mortality (estimated at 0.05), a relatively old age at 50% maturity (10.5 years for females in the Gulf of Alaska), and a very old maximum age of 98 years in Alaska (84 years maximum age in the Gulf of Alaska). Age at 50% recruitment to the commercial fishery has been estimated to be between 9 and 10 years in the Gulf of Alaska. Despite their viviparous nature, the fish is relatively fecund with number of eggs/female in Alaska ranging from 10,000-300,000, depending upon size of the fish.

Fishery

Pacific ocean perch are caught almost exclusively with trawls. Before 1996, nearly all the catch was taken by factory trawlers using bottom trawls, but since then a sizeable portion (up to 20% some years) has also been taken by pelagic trawls. Also in 1996, a shore-based fishery developed that consisted of smaller vessels

operating out of the port of Kodiak. These shore-based trawlers now take about 50% of the catch in the central GOA. The fishery in the Gulf in recent years has occurred in the summer months, especially July, due to management regulations. Reflecting the summer distribution of this species, the fishery is concentrated in a relatively narrow depth band at ~180-250 m along the outer continental shelf and shelf break, inside major gullies and trenches running perpendicular to the shelf break, and along the upper continental slope. Major fishing grounds include Ommaney Trough (which is no longer fished because of a NPFMC amendment that prohibits trawling in the eastern GOA), Yakutat Canyon, Amatuli Trough, off Portlock and Albatross Banks, Shelikof Trough, off Shumagin Bank, and south of Unimak and Unalaska Is.

Major bycatch species in the Gulf of Alaska Pacific ocean perch trawl fishery in 1994- 96 (the most recent years for which an analysis was done) included (in descending order by percent bycatch rate): other species of rockfish, arrowtooth flounder, and sablefish. Among the "other species of rockfish," northern rockfish and shortraker/rougheye were most common, followed by pelagic shelf rockfish.

Relevant Trophic Information

All food studies of Pacific ocean perch have shown them to be overwhelmingly planktivorous. Small juveniles eat mostly calanoid copepods, whereas larger juveniles and adults consume euphausiids as their major prey items. Adults, to a much lesser extent, may also eat small shrimp and squids. It has been suggested that Pacific ocean perch and walleye pollock compete for the same euphausiid prey. Consequently, the large removals of Pacific ocean perch by foreign fishermen in the Gulf of Alaska in the 1960s may have allowed walleye pollock stocks to greatly expand in abundance.

Documented predators of adult Pacific ocean perch include, Pacific halibut, sablefish, and sperm whales, and it is likely that Pacific cod and arrowtooth flounder also prey on Pacific ocean perch. Pelagic juveniles are consumed by salmon, and benthic juveniles are eaten by lingcod and other large demersal fish.

Describe any potential gear impacts on the habitats of this or other species

Because collection of small juvenile Pacific ocean perch is virtually unknown in any existing type of commercial fishing gear, it is assumed that fishing does not occur in their habitat. Trawling on the offshore fishing grounds of adults may affect the composition of benthic organisms, but the impact of this on Pacific ocean perch or other fish is unknown.

Approximate upper size limit of juvenile fish (in cm):

For Gulf of Alaska: 38 cm for females; unknown for males, but presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*.

Additional Information

Larvae: NMFS, Alaska Fisheries Science Center, Auke Bay Laboratory, Bruce Wing, (907) 789-6043; NMFS, Alaska Fisheries Science Center, FOCI program, Ann Matarese (206) 526-4111; Art Kendall, AJALA Enterprises, La Conner, WA, (360) 466-0470.

Juveniles: Carlson, H.R. And R.E. Haight. 1976 . Juvenile life of Pacific ocean perch, *Sebastes alutus*, in coastal fiords of southeastern Alaska: Their environment, growth, food habits, and schooling behavior. Trans. Am, Fish. Soc. 105:191-201.

Adults: Lunsford, C. R. 1999. Distribution patterns and reproductive aspects of Pacific ocean perch (*Sebastes alutus*) in the Gulf of Alaska. M.S. Thesis. Univ. of Alaska Fairbanks, Juneau AK. 154 p.

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: Little information is known. Insemination is thought to occur after adults move to deeper offshore waters in the fall. Parturition is reported to occur from 20-30 m off bottom at depths of 360-400 m.

Larvae: Little information is known. Earlier information suggested that after parturition, larvae rise quickly to near surface, where they become part of the plankton. More recent data from British Columbia indicates that larvae may remain at depths >175 m for some period of time (perhaps two months), after which they slowly migrate upward in the water column.

Post-larvae and early young-of-the year: A recent, preliminary study has identified Pacific ocean perch in these life stages from samples collected in epipelagic waters far offshore in the Gulf of Alaska. Some of the samples were as much as 100 n. m. from land, beyond the continental slope and over very deep water.

Juveniles: Again, information is very sparse, especially for younger juveniles. It is unknown how long young-of-the-year remain in a pelagic stage before eventually becoming demersal. At age 1-3 the fish probably live in very rocky inshore areas. Afterward, they move to progressively deeper waters of the continental shelf. Older juveniles are often found together with adults at shallower locations of the continental slope in the summer months.

Adults: Commercial fishery and research data have consistently indicated that adult Pacific ocean perch are found in aggregations over reasonably smooth, trawlable bottom of the outer continental shelf and upper continental slope. Generally, they are found in shallower depths (150-300 m) in the summer, and deeper (300-420 m) in the fall, winter, and early spring. Observations in southeastern Alaska from a manned submersible found adult Pacific ocean perch associated with pebble substrate on flat or low-relief bottom. Pacific ocean perch have been observed in association with sea whips in both the GOA and the Bering Sea. The fish can at times also be found off bottom in the pelagic environment, especially at night when they may move up in the water column to feed. There presently is no evidence to support previous conjectures that adult Pacific ocean perch might sometimes inhabit rough, untrawlable bottom.

Literature

Ackley, D. R., and J. Heifetz. 2001. Fishing practices under maximum retainable bycatch rates in Alaska's groundfish fisheries. Alaska Fish. Res. Bull. 8(1): 22-44.

Allen, M .J., and G. B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. U.S. Dep. Commer., NOAA Tech. Rept. NMFS 66, 151 p.

Brodeur, R. D. 2001. Habitat-specific distribution of Pacific ocean perch (*Sebastes alutus*) in Pribilof Canyon, Bering Sea. Cont. Shelf Res. 21: 207-224.

Carlson, H. R., and R. E. Haight. 1976. Juvenile life of Pacific ocean perch, *Sebastes alutus*, in coastal fiords of southeastern Alaska: their environment, growth, food habits, and schooling behavior. Trans. Am. Fish. Soc. 105:191-201.

Carlson, H. R., and R. R. Straty. 1981. Habitat and nursery grounds of Pacific rockfish, *Sebastes* spp., in rocky coastal areas of Southeastern Alaska. Mar. Fish. Rev. 43: 13-19.

Doyle, M. J. 1992. Patterns in distribution and abundance of ichthyoplankton off Washington, Oregon, and Northern California (1980-1987). U.S. Dep. Commer. NOAA NMFS AFSC Processed Rept. 92-14, 344 p.

Gillespie, G. E., R. D. Stanley, and B. M. Leaman. 1992. Early life history of rockfishes in British Columbia; preliminary results of the first year of investigation. Proc. 1992 W. Groundfish Conf. Alderbrook Inn Resort, Union, WA, Jan 27-30, 1992.

Gharrett, A. J., Z. Li, C. M. Kondzela, and A. W. Kendall. 2002. Final report: species of rockfish (*Sebastes* spp.) collected during ABL-OCC cruises in the Gulf of Alaska in 1998-2002. (Unpubl. manuscr. available from the NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau AK 99801.)

Gunderson, D. R. 1971. Reproductive patterns of Pacific ocean perch (*Sebastodes alutus*) off Washington and British Columbia and their relation to bathymetric distribution and seasonal abundance. J. Fish. Res. Bd. Can. 28: 417-425.

Gunderson, D. R., and M. O. Nelson. 1977. Preliminary report on an experimental rockfish survey conducted off Monterey, California and in Queen Charlotte Sound, British Columbia during August-September, 1976. Prepared for Feb. 15-16, 1977, Interagency Rockfish Survey Coordinating Committee Meeting, NWAFC, Seattle, WA. Unpubl. manuscr. 82 p.

Heifetz, J., D. L. Courtney, D. M. Clausen, D. Hanselman, J. T. Fujioka, and J. N. Ianelli. 2002. Slope rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 295-382. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Ito, D. H. 1982. A cohort analysis of Pacific ocean perch stocks from the Gulf of Alaska and Bering Sea regions. U.S. Dep. Commer., NWAFC Processed Rept. 82-15, 157 p.

Ito, D. H., and J. N. Ianelli. 1996. Pacific ocean perch. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, p.331-359. North Pacific Fishery Management Council, 605 W. 4th. Ave., Suite 306, Anchorage, AK 99501-2252.

Kendall, A. W., and W. H. Lenarz. 1986. Status of early life history studies of northeast Pacific rockfishes. Proc. Int. Rockfish Symp. Oct. 1986, Anchorage Alaska; p. 99-117.

Krieger, K. J. 1993. Distribution and abundance of rockfish determined from a submersible and by bottom trawling. Fish. Bull., U.S. 91:87-96.

Love, M. S., M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the northeast Pacific. U. of Calif. Press, Berkeley. 405 p.

Lunsford, C. R. 1999. Distribution patterns and reproductive aspects of Pacific ocean perch (*Sebastes alutus*) in the Gulf of Alaska. M.S. Thesis. Univ. of Alaska Fairbanks, Juneau AK. 154 p.

Lunsford, C. R., L. Haldorson, J. T. Fujioka, and T. J. Quinn II. 2001. Distribution patterns and survey design considerations of Pacific ocean perch (*Sebastes alutus*) in the Gulf of Alaska. Spatial Processes and Management of Marine Populations, Alaska Sea Grant College Program. Lowell Wakefield Fisheries Symposium. Anchorage, AK., AK-SG-01- 02.

Major, R. L., and H. H. Shippen. 1970. Synopsis of biological data on Pacific ocean perch, *Sebastodes alutus*. FAO Fisheries Synopsis No. 79, NOAA Circular 347, 38 p.

Martin, M. H. and D. M. Clausen. 1995. Data report: 1993 Gulf of Alaska bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-59. 217 p.

Matarese, A. C., A. W. Kendall, Jr., D. M. Blood, and B. M. Vinter. 1989. Laboratory guide to early life history stages of northeast Pacific fishes. U.S. Dep. Commer. NOAA Tech. Rept. NMFS 80, 652 p.

Matthews, K. R., J. R. Candy, L. J. Richards, and C. M. Hand. 1989. Experimental gill net fishing on trawlable and untrawlable areas off northwestern Vancouver Island, from the MV Caledonian, August 15-28, 1989. Can. Manuscr. Rep. Fish. Aquat. Sci. 2046, 78 p.

Mattson, C. R., and B. L. Wing. 1978. Ichthyoplankton composition and plankton volumes from inland coastal waters of southeastern Alaska, April-November 1972. U.S. Dep. Commer., NOAA Tech. Rept. NMFS SSRF-723, 11 p.

Moser, H. G., 1996. SCORPAENIDAE: scorpionfishes and rockfishes. *In*: Moser, H.G., editor. The early stages of fishes in the California Current region, p. 733-795. CalCOFI Atlas No.33. 1505 p.

NOAA (National Oceanic and Atmospheric Administration). 1990. Pacific ocean perch, *Sebastes alutus*. *In*: West coast of North America coastal and ocean zones strategic assessment: data atlas. Invertebrate and fish volume, Plate 3.2.20. U.S. Dep. Commer. NOAA. OMA/NOS, Ocean Assessments Division, Strategic Assessment Branch.

Seeb, L. W. 1993. Biochemical identification of larval rockfishes of the genus *Sebastes*. Final Report Contract #43ABNF001082. U.S. Dept. Commer. NOAA/NMFS NWAFC/RACE Division, Seattle, WA. 28 p.

Seeb, L. W., and A. W. Kendall, Jr. 1991. Allozyme polymorphisms permit the identification of larval and juvenile rockfishes of the genus *Sebastes*. Environmental Biology of Fishes 30:191-201.

Stark, J. W., and D. M. Clausen. 1995. Data report: 1990 Gulf of Alaska bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-49. 221 p.

Westrheim, S. J. 1970. Survey of rockfishes, especially Pacific ocean perch, in the northeast Pacific Ocean, 1963-66. J. Fish. Res. Bd. Canada 27: 1781-1809.

Westrheim, S. J. 1975. Reproduction, maturation, and identification of larvae of some *Sebastes* (Scorpaenidae) species in the northeast Pacific Ocean. J. Fish. Res. Board Can. 32: 2399-2411.

Wing, B. L. 1985. Salmon stomach contents from the Alaska troll logbook program, 1977-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-91. 41 p.

Wing, B. L., C. Derrah, and V. O'Connell. 1997. Ichthyoplankton in the eastern Gulf of Alaska, May 1990. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-AFSC-376, 42 p.

Wolotira, R. J., Jr., T. M. Sample, S. F. Noel, and C. R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U. S. Dep. Commer., NOAA Tech. Memo. NMFS - AFSC-6, 184 p.

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

Yang, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-60, 105 p.

SPECIES: Gulf of Alaska Pacific Ocean Perch

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	Internal incub-tion; ~90 d	NA	Winter-spring	NA	NA	NA	NA	NA
Larvae	U;2 months (?)	U; assumed to be micro-zooplankton	Spring-summer	ICS, MCS, OCS, USP, LSP, BSN	P	NA	U	U
Post-larvae/ early juvenile	U; 2 months to ?	U	Summer to ?	LSP, BSN	Epipelagic	NA	U	U
Juveniles	<1 year (?) to 10 years	Calanoid copepods (young juv.); Euphausiids (older juv.)	All year	ICS, MCS, OCS, USP	D	R (<age 3); CB,G,?M, ?SM,?MS (>age 3)	U	U
Adults	10-84 years of age (98 years in Aleutian Islands)	Euphausiids	Insemination (fall); Fertilization, incubation (winter); Larval release (spring); Feeding in shallower depths (summer)	OCS, USP	D, SD, P	CB, G,?M, ?SM,?MS	U	U

Habitat Description for Shortraker Rockfish (*Sebastes borealis*) and Rougheye Rockfish (*Sebastes aleutianus*)

Management Plan and Area GOA

Life History and General Distribution

Shortraker and rougheye rockfishes are found around the arc of the north Pacific from southern California to northern Japan, including the Bering Sea. Both species are demersal and inhabit depths ranging from 25 to 875 m; however, commercial concentrations are usually found along a narrow band of the continental slope at depths of 300-500 m, where both shortraker and rougheye rockfish often co-occur in the same haul. Similar to other *Sebastes*, the fish appear to be viviparous (the eggs develop internally and receive at least some nourishment from the mother), with internal fertilization and the release of live young. Though relatively little is known about their biology and life history, both species appear to be K-selected with late maturation, slow growth, extreme longevity, and low natural mortality. Rougheye rockfish attain maturity relatively late in life, at about 20+ years of age. Age of maturity for shortraker rockfish is unknown, but is presumably similar to that of rougheye rockfish. Both species are among the largest *Sebastes* species in Alaskan waters, attaining sizes of up to 104 cm for shortraker and 96 cm for rougheye rockfish. Shortraker and rougheye rockfish are estimated to attain ages in excess of 100 years, and one ageing laboratory has reported ages up to 157 years for shortraker and 205 years for rougheye. Natural mortality for both species is low, estimated to be on the order of 0.01 to 0.04.

Fishery

Shortraker and rougheye rockfish are presently managed as bycatch-only species in Alaska. Trawl and longline gear are the primary methods of harvest. Even though both species are found as far south as southern California, commercial quantities are primarily harvested from northern Washington throughout Alaskan waters. Depths of commercial harvests usually occur from about 300 to 500 m. Both species are associated with a variety of habitats from soft to rocky habitats along the continental slope, although boulders and sloping terrain appear to be a desirable habitat feature for both species. Trawling in such habitats often requires specialized fishing skills to avoid gear damage and to keep the trawl in the proper fishing configuration. Age at recruitment is uncertain, but is probably on the order of 20+ years for both species. Shortraker and rougheye rockfish are often caught as bycatch in trawl and longline fisheries for sablefish and halibut.

Relevant Trophic Information

Rougheye rockfishes prey primarily on shrimps, and various fish species are also consumed. The diet of shortraker rockfish is not well-known; however, based on a small number of samples, the diet appears to be mostly squid, shrimp, and deepwater fish such as myctophids. It is uncertain what are the main predators on both species.

Approximate upper size limit of juvenile fish (in cm):

For shortraker rockfish, length at 50% sexual maturity is about 45 cm and about 44 cm for rougheye rockfish

Additional Information Sources

Larvae: Art Kendall, AJALA Enterprises, La Conner, WA, (360) 466-0470.

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: The timing of reproductive events is apparently protracted. One study indicated that vitellogenesis was present for four to five months and lasted from about July until late October and November. Parturition apparently occurs mainly in early spring through summer.

Larvae: No information is available regarding the habitats and biological associations of shortraker and rougheye rockfish larvae.

Post-larvae and early young-of-the year: A recent, preliminary study has identified two specimens of shortraker rockfish and one of rougheye rockfish in these life stages from samples collected in epipelagic waters far offshore in the Gulf of Alaska. This limited information is the only documentation of habitat preferences for these life stages.

Juveniles: Little information is available regarding the habitats and biological associations of shortraker and rougheye rockfish juveniles. This is especially true for shortraker rockfish, as only a few specimens <40 cm fork length have ever been caught in the Gulf of Alaska. In contrast, juvenile rougheye rockfish 15-40 cm fork length are frequently caught in GOA trawl surveys. They are generally found at shallower, more inshore areas than adults. These areas range from inshore fiords to offshore waters of the continental shelf, but habitat preferences for the fish within these environments is unknown.

Adults: Adults are demersal and are concentrated at depths of 300-500 m along the continental slope. Observations from a manned submersible indicate that these fish occur over a wide range of habitats. Soft substrates of sand or mud usually had the highest densities, whereas hard substrates of bedrock, cobble or pebble usually had the lowest adult densities. Habitats with steep slopes and frequent boulders were used at a higher rate than habitats with gradual slopes and few boulders. Submersible studies have also shown adults of the two species are sometimes associated with *Primnoa* spp. coral.

Literature

Allen, M. J., and G. B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce., NOAA Tech. Rept. NMFS 66, 151 p.

Archibald, C. P., W. Shaw, and B. M. Leaman. 1981. Growth and mortality estimates of rockfishes (Scorpaenidae) from B.C. coastal waters, 1977-79. Can. Tech. Rep. Fish. Aquat. Sci. 1048, 57 p.

Chilton, D. E., and R. J. Beamish. 1982. Age determination methods for fishes studied by the Groundfish Program at the Pacific Biological Station. Can. Spec. Publ. Fish. Aquat. Sci. 60, 102 p.

Gharrett, A. J., Z. Li, C. M. Kondzela, and A. W. Kendall. 2002. Final report: species of rockfish (*Sebastes* spp.) collected during ABL-OCC cruises in the Gulf of Alaska in 1998-2002. (Unpubl. manuscr. available from the NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau AK 99801.)

Heifetz, J., D. L. Courtney, D. M. Clausen, D. Hanselman, J. T. Fujioka, and J. N. Ianelli. 2002. Slope rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 295-382. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Kastelle, C. R., D. K. Kimura, and S. R. Jay. 2000. Using $^{210}Pb/^{226}Ra$ disequilibrium to validate conventional ages in Scorpaenids (genera *Sebastes* and *Sebastolobus*). Fish. Res. 46: 299-412.

Kramer, D. E., and V. M. O'Connell. 1986. Guide to northeast Pacific rockfishes, Genera *Sebastes* and *Sebastolobus*. Marine Advisory Bulletin No. 25: 1-78. Alaska Sea Grant College Program, University of Alaska.

Krieger, K. 1992. Shortraker rockfish, *Sebastes borealis*, observed from a manned submersible. Mar. Fish. Rev., 54(4): 34-37.

Krieger, K .J. 1993. Distribution and abundance of rockfish determined from a submersible and by bottom trawling. Fish. Bull. 91:87-96.

Krieger, K. J., and D. H. Ito. 1999. Distribution and abundance of shortraker rockfish, *Sebastes borealis*, and rougheye rockfish, *Sebastes aleutianus*, determined from a manned submersible. Fish. Bull. 97: 264-272.

Krieger, K. J., and B. L. Wing. 2002. Megafauna associations with deepwater corals (*Primnoa* spp.) in the Gulf of Alaska.. Hydrobiologia 471: 83-90.

Ito, D. H. 1999. Assessing shortraker and rougheye rockfishes in the Gulf of Alaska: addressing a problem of habitat specificity and sampling capability. PhD. Dissertation. Univ. Washington, Seattle. 205 p.

McDermott, S. F. 1994. Reproductive biology of rougheye and shortraker rockfish, *Sebastes aleutianus* and *Sebastes borealis*. Masters Thesis. Univ. Washington, Seattle.76 p.

Mecklenburg, C. W., T. A. Mecklenburg, and L. K. Thorsteinson. 2002. Fishes of Alaska. Am. Fish. Soc., Bethesda, Maryland. 1,037 p.

Munk, K. M. 2001. Maximum ages of groundfishes off Alaska and British Columbia and considerations of age determination. Alaska Fish. Res. Bull. 8(1): 12-21.

Sigler, M. F., and H. H. Zenger, Jr. 1994. Relative abundance of Gulf of Alaska sablefish and other groundfish based on the domestic longline survey, 1989. NOAA Tech. Memo. NMFS-AFSC-40.

Wolotira, R. J., Jr., T. M. Sample, S. F. Noel, and C. R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Yang, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-60, 105 p.

Yang, M-S., and M. W. Nelson. 2000. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990, 1993, and 1996. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-112, 174 p.

SPECIES: Shortraker and Rougheye Rockfish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	NA	NA	NA	NA	NA	
Larvae	U	U	Parturition: Early spring through summer	U	U	U	U	
Post-larvae/ early juvenile	< 6 months	U	Summer	U, LSP, BSN	Epipelagic	NA	U	
Juveniles	Up to 20 yrs of age	U Shrimp & amphipods?	U	U (short-raker) ICS, MCS, OCS?	U (shortraker) D (rougheye)	U	U	
Adults	20 to >100 yrs of age	Shrimp Squid Myctophids	Year-round?	OCS, USP	D	M, S, R, SM, CB, MS, G, steep slopes and boulders	U	Observed associated with *Primnoa* coral

Habitat Description for Northern Rockfish

(*Sebastes polyspinis*)

Management Plan and Area GOA

Life History and General Distribution

Northern rockfish range from northern British Columbia through the Gulf of Alaska and Aleutian Islands to eastern Kamchatka, including the Bering Sea. The species is most abundant from about Portlock Bank in the central Gulf of Alaska to the western end of the Aleutian Islands. Within this range, adult fish appear to be concentrated at discrete, relatively shallow offshore banks of the outer continental shelf. Typically, these banks are separated from land by an intervening stretch of deeper water. The preferred depth range is ~75-150 m in the Gulf of Alaska. Information available at present suggests the fish are mostly demersal, as very few have been caught in pelagic trawls. In common with many other rockfish species, northern rockfish tend to have a localized, patchy distribution, even within their preferred habitat, and most of the population occurs in aggregations. Most of what is known about northern rockfish is based on data collected during the summer months from the commercial fishery or in research surveys. Consequently, there is little information on seasonal movements or changes in distribution for this species.

Life history information on northern rockfish is extremely sparse. The fish are assumed to be viviparous, as other *Sebastes* appear to be, with internal fertilization and incubation of eggs. Observations during research surveys in the Gulf of Alaska suggest that parturition (larval release) occurs in the spring, and is mostly completed by summer. Pre-extrusion larvae have been described, but field-collected larvae cannot be identified to species at present. Length of the larval stage is unknown, but the fish apparently metamorphose to a pelagic juvenile stage, which also has been described. There is no information on when the juveniles become benthic or what habitat they occupy. Older juveniles are found on the continental shelf, generally at locations inshore of the adult habitat.

Northern rockfish is a slow growing species, with a low rate of natural mortality (estimated at 0.06), a relatively old age at 50% maturity (12.8 years for females in the Gulf of Alaska), and an old maximum age of 72 years in Alaska (maximum reported age in the GOA is 44 years). No information on fecundity is available.

Fishery

Northern rockfish are caught almost exclusively with bottom trawls. Age at 50% recruitment is unknown. The fishery in the Gulf of Alaska in recent years has mostly occurred in the summer months, especially July, due to management regulations. Catches are concentrated of live relatively shallow, offshore banks of the outer continental shelf: which include Portlock Bank, Albatross Bank, the "Snakehead" south of Kodiak Island, Shumagin Bank, and Davidson Bank. Of these, the Snakehead has been the most productive. Outside of these banks, catches are generally sparse. The majority of the catch in the Gulf of Alaska comes from depths of 75-125 m.

The major bycatch species in the Gulf of Alaska northern rockfish trawl fishery in 1994-96 included (in descending order by percent bycatch rate): light dusky rockfish, "other slope rockfish", and Pacific ocean perch. Of these, light dusky rockfish was by far the most common bycatch, having a bycatch rate as high as 34%, depending on the year.

Relevant Trophic Information

Although no comprehensive food study of northern rockfish has been done, smaller studies have ~~all~~ shown euphausiids to be the predominant food item of adults in both the Gulf of Alaska and Aleutian Islands. Copepods, hermit crabs, and shrimp have also been noted as prey items in much smaller quantities.

Predators of northern rockfish have not been documented, but likely include species that are known to consume rockfish in Alaska, such as Pacific halibut, sablefish, Pacific cod, and arrowtooth founder.

Approximate upper size limit of juvenile fish (in cm):

For Gulf of Alaska: 38 cm for females; unknown for males, but presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*.

Additional Information Sources

Eggs and Larvae: None at present

Older juveniles and adults: NMFS, Alaska Fisheries Science Center, Auke Bay Laboratory, David Clausen, (907) 789-6049.

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: No information known, except that parturition probably occurs in the spring.

Larvae: No information known.

Juveniles: No information known for small juveniles (<20 cm), except that juveniles apparently undergo a pelagic phase immediately after metamorphosis from the larval stage. Larger juveniles have been taken in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds. Substrate preference of these larger juveniles is unknown.

Adults: Commercial fishery and research survey data have consistently indicated that adult northern rockfish in the Gulf of Alaska are primarily found on offshore banks of the outer continental shelf at depths of 75-150 m. Preferred substrate in this habitat has not been documented, but observations from trawl surveys suggest that large catches of northern rockfish are often associated with hard or rough bottoms. For example, some of the largest catches in the trawl surveys have occurred in hauls in which the net hung-up on the bottom or was torn by a rough substrate. Generally, the fish appear to be demersal, and most of the population occurs in large aggregations. There is no information on seasonal migrations. Northern rockfish often co-occur with light dusky rockfish.

Literature

Ackley, D. R., and J. Heifetz. 2001. Fishing practices under maximum retainable bycatch rates in Alaska's groundfish fisheries. Alaska Fish. Res. Bull. 8(1): 22-44.

Allen, M. J., and G. B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. U.S. Dep. Commer., NOAA Tech. Rept. NMFS 66, 151 p.

Clausen, D. M., and J. Heifetz. 2003. The northern rockfish, *Sebastes polyspinis*, in Alaska: commercial fishery, distribution, and biology. Unpubl. manuscr. (submitted for publication to Mar. Fish. Rev. Avail. from NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau AK 99801).

Heifetz, J., D. L. Courtney, D. M. Clausen, D. Hanselman, J. T. Fujioka, and J. N. Ianelli. 2002. Slope rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 295-382. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Kendall, A. W. 1989. Additions to knowledge of *Sebastes* larvae through recent rearing. NWAFC Proc. Rept. 89-21. 46 p.

Martin, M. H. and D. M. Clausen. 1995. Data report: 1993 Gulf of Alaska bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-59. 217 p.

Matarese, A. C., A. W. Kendall, Jr., D. M. Blood, and B. M. Vinter. 1989. Laboratory guide to early life history stages of Northeast Pacific fishes. U.S. Dep. Commer. NOAA Tech. Rept. NMFS 80, 652 p.

Stark, J. W., and D. M. Clausen. 1995. Data report: 1990 Gulf of Alaska bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-49. 221 p.

Westrheim, S. J., and H. Tsuyuki. 1971. Taxonomy, distribution, and biology of the northern rockfish, *Sebastes polyspinis*. J. Fish. Res. Bd. Can. 28: 1621-1627.

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

Yang, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-60, 105 p.

SPECIES: Northern rockfish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	U	NA	NA	NA	NA	NA
Larvae	U	U	Spring-summer	U	P (assumed)	NA	U	U
Early Juveniles	From end of larval stage to ?	U	All year	U	?P	U	U	U
Late Juveniles	to 13 yrs	U	All year	MCS, OCS	D	U	U	U
Adults	13- 44 years of age (maximum of 72 yrs in Aleutian Is.)	Euphausiids	U, except that larval release is probably in the spring in the Gulf of Alaska	OCS,	D	CB, R	U	Often co-occur with light dusky rockfish

Habitat Description for Light Dusky Rockfish

(*Sebastes ciliatus*)

Note: Previously, the taxonomy of dusky rockfish was unclear. Two varieties occur which are now believed to be distinct species: an inshore, shallow water, dark-colored variety; and a lighter-colored variety found in deeper water offshore. A taxonomic study is soon to be completed that will describe the light variety as a new species. To avoid confusion, and because the light variety appears to be more abundant and is the object of a directed trawl fishery, this discussion of essential habitat will deal only with "light" dusky rockfish.

Management Plan and Area GOA

Life History and General Distribution

Light dusky rockfish range from Dixon Entrance at the U.S./Canada boundary, around the arc of the Gulf of Alaska, and westward throughout the Aleutian Islands. They are also found in the eastern Bering Sea north to about Zhemchug Canyon west of the Pribilof Is. In the northwest Pacific, dusky rockfish are reported to range southwestward to Japan, but it is unknown which variety this refers to. Their distribution south of Dixon Entrance in Canadian waters is likewise uncertain; dusky rockfish have been reported as far south as Johnstone Strait, Vancouver Is., but it is likely these were of the dark variety. The center of abundance for light dusky rockfish appears to be the Gulf of Alaska. Adult light dusky rockfish have a very patchy distribution, and are usually found in large aggregations at specific localities of the outer continental shelf. These localities are often relatively shallow offshore banks. Because the fish are taken with bottom trawls, they are presumed to be mostly demersal. Whether they also have a pelagic distribution is unknown, but there is no particular evidence of a pelagic tendency based on the information available at present. Most of what is known about light dusky rockfish is based on data collected during the summer months from the commercial fishery or in research surveys. Consequently, there is little information on seasonal movements or changes in distribution for this species.

Life history information on light dusky rockfish is extremely sparse. The fish are assumed to be viviparous, as are other *Sebastes*, with internal fertilization and incubation of eggs. Observations during research surveys in the Gulf of Alaska suggest that parturition (larval release) occurs in the spring, and is probably completed by summer. Another, older source, however, lists parturition as occurring "after May." Pre-extrusion larvae have been described, but field-collected larvae cannot be identified to species at present. Length of the larval stage, and whether a pelagic juvenile stage occurs, are unknown. There is no information on habitat and abundance of young juveniles (<25 cm fork length), as catches of these have been virtually nil in research surveys. Even the occurrence of older juveniles has been very uncommon in surveys, except for one year. In this latter instance, older juveniles were found on the continental shelf, generally at locations inshore of the adult habitat.

Light dusky rockfish is a slow growing species, with a low rate of natural mortality estimated at 0.09. However, it appears to be faster growing than many other rockfish species. Maximum age is 51-59 years. Estimated age at 50% maturity for females is 11.3 years. No information on fecundity is available.

Fishery

Light dusky rockfish are caught almost exclusively with bottom trawls. A precise estimate of age at 50% recruitment is not available, but has been roughly estimated to be about 10 years based on length frequency information from the fishery. The fishery in the Gulf of Alaska in recent years has mostly occurred in the summer months, especially July, due to management regulations. Catches are concentrated at a number of

relatively shallow, offshore banks of the outer continental shelf, especially the "W" grounds west of Yakutat, and Portlock Bank. Other fishing grounds include Albatross Bank, the "Snakehead" south of Kodiak Island, and Shumagin Bank. Outside of these banks, catches are generally sparse. Most of the catch appears to be taken at depths of 100-200 m.

The major bycatch species in the Gulf of Alaska light dusky rockfish trawl fishery in 1994-96 included (in descending order by percent bycatch rate) northern rockfish and Pacific ocean perch.

Relevant Trophic Information

Although no comprehensive food study of light dusky rockfish has been done, one smaller study in the Gulf of Alaska showed euphausiids to be the predominate food item of adults. Larvaceans, cephalopods, pandalid shrimp, and hermit crabs were also consumed.

Predators of light dusky rockfish have not been documented, but likely include species that are known to consume rockfish in Alaska, such as Pacific halibut, sablefish, Pacific cod, and arrowtooth founder.

Approximate upper size limit of juvenile fish (in cm): For Gulf of Alaska: 47 cm for females (size at 50% maturity is 43 cm); unknown for males, but presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*.

Additional Information Sources

Eggs, Larvae, and Juveniles: None at present.

Adults: Rebecca Reuter, c/o NMFS, Alaska Fisheries Science Center, REFM Division, (206) 526-4249.

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: No information known, except that parturition probably occurs in the spring, and may extend into summer.

Larvae: No information known.

Juveniles: No information known for small juveniles <25 cm fork length. Larger juveniles have been taken infrequently in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds. A manned submersible study in the eastern Gulf observed juvenile (<40 cm) light dusky rockfish associated with *Primnoa* spp. coral.

Adults: Commercial fishery and research survey data indicate that adult light dusky rockfish are primarily found on offshore banks of the outer continental shelf at depths of 100-200 m. Type of substrate in this habitat has not been documented, but it may be rocky. During submersible dives on the outer shelf (40-50 m) in the eastern Gulf, adult light dusky rockfish were observed in association with rocky habitats and in areas with extensive sponge beds where the fish were observed resting in large vase sponges (pers. Comm. V. O'Connell). Light dusky rockfish are the most highly aggregated of the rockfish species caught in Gulf of Alaska trawl surveys. Outside of these aggregations, the fish are sparsely distributed. Because the fish are generally taken only with bottom trawls, they are presumed to be mostly demersal. Whether they also have a pelagic distribution is unknown, but there is no evidence of a pelagic tendency based on the information available at present. There is no information on seasonal migrations. Light dusky rockfish often co-occur with northern rockfish.

Literature

Ackley, D. R., and J. Heifetz. 2001. Fishing practices under maximum retainable bycatch rates in Alaska's groundfish fisheries. Alaska Fish. Res. Bull. 8(1): 22-44.

Allen, M. J., and G. B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. U. S. Dep. Commer., NOAA Tech. Rept. NMFS 66, 151 p.

Clausen, D. M., C. R. Lunsford, and J. Fujioka. 2002. Pelagic shelf rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p.383-417. North Pacific Fishery Management Council, 605 W. 4th. Ave., Suite 306, Anchorage, AK 99501-2252.

Kendall, A. W. 1989. Additions to knowledge of *Sebastes* larvae through recent rearing. NWAFC Proc. Rept. 89-21. 46 p.

Krieger, K. J., and B. L. Wing. 2002. Megafauna associations with deepwater corals (*Primnoa* spp.) in the Gulf of Alaska.. Hydrobiologia 471: 83-90.

Martin, M. H. and D. M. Clausen. 1995. Data report: 1993 Gulf of Alaska bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-59. 217 p.

Matarese, A. C., A. W. Kendall, Jr., D. M. Blood, and B. M. Vinter. 1989. Laboratory guide to early life history stages of northeast Pacific fishes. U.S. Dep. Commer. NOAA Tech. Rept. NMFS 80, 652 p.

Reuter, R. F. 1999. Describing dusky rockfish (Sebastes ciliatus) habitat in the Gulf of Alaska using historical data. M.S. Thesis, Calif. State Univ., Hayward CA. 83 p.

Stark, J. W., and D. M. Clausen. 1995. Data report: 1990 Gulf of Alaska bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-49. 221 p.

Westrheim, S. J. 1973. Preliminary information on the systematics, distribution, and abundance of the dusky rockfish, *Sebastes ciliatus*. J. Fish. Res. Bd. Can. 30: 1230-1234.

Westrheim, S.J. 1975. Reproduction, maturation, and identification of larvae of some *Sebastes* (Scorpaenidae) species in the northeast Pacific Ocean. J. Fish. Res. Board Can. 32: 2399-2411.

SPECIES: Light dusky rockfish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	U	NA	NA	NA	NA	NA
Larvae	U	U	Spring-summer	U	P (assumed)	NA	U	U
Early Juveniles	U	U	All year	U	U	U	U	U
Late Juveniles	Up to 11 years	U	U	ICS, MCS, OCS	D	CB, R, G	U	Observed associated with *Primnoa* coral
Adults	11 up to 51-59 years.	Euphausiids	U, except that larval release may be in	OCS, USP	D,	CB, R, G	U	Observed associated with large vase-type sponges

Habitat Description for Yelloweye Rockfish (*Sebastes ruberrimus*) and Other Demersal Rockfishes

Management Plan and Area GOA

Yelloweye rockfish *Sebastes ruberrimus* (primary species, described below)
Quillback rockfish, *Sebastes maliger*
Rosethorn rockfish, *Sebastes helvomaculatus*
Tiger rockfish, *Sebastes nigrocinctus*
Canary rockfish, *Sebastes pinniger*
China rockfish, *Sebastes nebulosus*
Copper rockfish, *Sebastes caurinus*

Life History and General Distribution

Distributed from Ensendada, northern Baja California to Umnak I. and Unalaska I., Aleutians in depths from 60 to 1800 feet but commonly in 300 to 600 ft in rocky, rugged habitat (Allen and Smith, 1988, Eschmeyer et al 1983). Little is known about the young of the year and settlement. Young juveniles between 2.5 cm and 10 cm have been observed in areas of high and steep relief, in depths deeper than 15 m. Subadult and adult fish are generally solitary, occurring in rocky areas and high relief with refuge space, particularly overhangs, caves and crevices (O'Connell and Carlile 1993). Yelloweye are ovoviviparous. Parturition occurs in southeast Alaska between April and July with a peak in May (O'Connell 1987). Fecundity ranges from 1,200,000 to 2,700,000 eggs per season (Hart 1942, O'Connell unpublished data). Yelloweye feed on a variety of prey, primarily fishes (including other rockfishes, herring, and sandlance) as well as caridean shrimp and small crabs. Yelloweye are a K-selected species with late maturation, slow growth, extreme longevity, and low natural mortality. They reach a maximum length of about 91 cm and growth slows considerably after age 30. Approximately 50% are mature at 45 cm and 22 years, natural mortality (M) is estimated to be 0.02, and maximum age reported is 118 years (O'Connell and Fujioka 1991, O'Connell and Funk, 1987).

Fishery

Demersal shelf rockfish are the target of a directed longline fishery and are the primary bycatch species in the longline fishery for Pacific halibut. They recruit into the fishery at about age 18 to 20 at a length between 45 and 50 cm. The commercial fishery grounds are usually areas of rocky bottom between 20 and 100 fm. The directed fishery now occurs between November and March both because of higher winter prices and limitations imposed due to the halibut IFQ regulations.

Relevant Trophic Information:

Yelloweye rockfish eat a large variety of organisms, primarily fishes included small rockfishes, herring and sandlance as well as caridean shrimp and small crabs (Rosenthal et al 1988). They also opportunistically consume lingcod eggs. Young rockfishes are in turn eaten by a variety of predators including lingcod, large rockfish, salmon, and halibut.

Approximate upper size limit of juvenile fish (in cm):

Length at 50% sexual maturity is 45 cm for females and 50 cm for males.

Additional Information Sources

NMFS, Alaska Fisheries Science Center

Habitat and Biological Associations (if known) Narrative

Young juveniles between 2.5 (1 inch) and 10 cm (4 inches) have been observed in areas of high relief (vertical walls, cloud sponges, fjord-like areas) in depths deeper than 15 m (personal communication Jeff Christiansen, The Seattle Aquarium). Subadult (late juveniles) and adult fish are generally solitary, occurring in rocky areas and high relief with refuge spaces particularly overhangs, caves and crevices (O'Connell and Carlile 1993). Not infrequently an adult yelloweye rockfish will cohabitate a cave or refuge space with a tiger rockfish. Habitat specific density data shows an increasing density with increasing habitat complexity: deep water boulder fields consisting of very large boulders have significantly higher densities than other rock habitats (O'Connell and Carlile 1993). Although yelloweye do occur over cobble and sand bottoms, generally this is when foraging and often these areas directly interface with a rock wall or outcrop.

Literature

Hart, J.L. 1942. New Item. Red snapper fecundity. Fish. Res. Board. Can. Pac. Progr. Rep. 52: 18.

O'Connell, V.M. 1987. Reproductive seasons for some *Sebastes* species in Southeastern Alaska. Alaska Department of Fish and Game Information Leaflet No. 263. Juneau, AK.

O'Connell, V.M. and D.C Carlile. 1993. Habitat-specific density of adult yelloweye rockfish *Sebastes ruberrimus* in the eastern Gulf of Alaska. Fishery Bull. 91:304-309.

O'Connell, V.M. and J.T. Fujioka. 1991. Demersal Shelf Rockfishes. *In* Loh-Lee Low (ed.), Status of living marine resources off Alaska as assessed in 1991, p. 46-47. NOAA Tech. Memo. NMFS F/NWC-211, Northwest Fish. Sci. Cent., Auke Bay AK 95 P.

O'Connell, V.M. and F.C. Funk. 1987. Age and growth of yelloweye rockfish (*Sebastes ruberrimus*) landed in Southeastern Alaska. *In* B.R. Melteff (ed.), Proceedings of the International Rockfish Symposium. p 171-185. Alaska Sea Grant Report No. 87-2.

Rosenthal, R.J. V. Moran-O'Connell, and M.C. Murphy. 1988. Feeding ecology of ten species of rockfishes (Scorpaenidae) from the Gulf of Alaska. Calif. Fish and Game 74(1):16-37.

SPECIES: Yelloweye Rockfish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	na							
Larvae	<6 mo	Copepod	Spring/ Summer	U	N?	U	U	
Early Juveniles	to 10 yrs	U		ICS, MCS, OCS, BAY, IP	D	R, C	U	
Late Juveniles	10-18 yrs	U		ICS, MCS, OCS, BAY, IP	D	R, C	U	
Adults	At least 118 years	Fish, shrimp, crab	Parturition: Apr-Jul	ICS, MCS, OCS, USP, BAY, IP	D	R, C, CB	U	

Other Rockfishes:

Species	Range/Depth	Maximum Age	Trophic	Parturition	Known Habitat
Quillback	Kodiak Island to San Miguel Island, CA To 274 m (commonly 12-76 m)	At least 32 50% SM=30 cm	Main prey = crustaceans, herring, Sandlance	Spring (Mar-Jun)	Juveniles have been observed at the margins of kelp beds, adults occur over rock bottom, or over cobble/sand next to reefs
Copper	Shelikof St to central Baja, CA Shallow to 183 m (commonly to 122 m)	At least 31 years 50% SM=5 yr	Crustaceans Octopi Small fishes	Mar-Jul	Juveniles have been observed near eelgrass beds and in kelp, in areas of mixed sand and rock. Adults are in rocky bays and shallow coastal areas, generally less exposed than the other DSR
Tiger	Kodiak Is and Prince William Sound to Tanner-Cortes Banks, CA From 33 to 183 m	To 116 yrs	Invertebrates, primarily crustaceans	Early spring	Juveniles and adults in rocky areas: most frequently observed in boulder areas, generally under overhangs.
China	Kachemak Bay to San Miguel Island, CA To 128 m	To 72 yrs	Invertebrates, Brittle stars are significant component of diet	Apr-Jun	Juveniles have been observed in shallow kelp beds, adults in rocky reefs and boulder fields. Some indications that adults have a homesite.
Rosethorn	Kodiak Is to Guadalupe Is, Baja, CA To 25 m to 549 m	To 87 yrs Mature 7-10 yrs		Feb-Sept (May)	Observed over rocky habitats and in rock pavement areas with large sponge cover
Canary	Shelikof St to Cape Colnett, Baja, CA To 424 m (commonly to 137 m)	To 75 yrs 50% sm = 9	Macroplankton and small fishes		Occur over rocky and sand/cobble bottoms, often hovering in loose schools over soft bottom near rock outcrops. Schools often associate with schools of yellowtail and silvergrey.

Habitat Description for Thornyhead Rockfish

(Sebastolobus spp.)

Management Plan and Area GOA

Life History and General Distribution

Thornyheads of the northeastern Pacific Ocean are comprised of two species, the shortspine thornyhead (*Sebastolobus alascanus*) and the longspine thornyhead (*S. altivelis*). The longspine thornyhead is not common in the Gulf of Alaska. The shortspine thornyhead is a demersal species which inhabits deep waters from 93 to 1,460 m from the Bering Sea to Baja California. This species is common throughout the Gulf of Alaska, eastern Bering Sea and Aleutian Islands. The population structure of shortspine thornyheads, however, is not well defined. Thornyheads are slow-growing and long-lived with maximum age in excess of 50 years and maximum size greater than 75 cm and 2 kg. Thornyheads spawn buoyant masses of eggs during the late winter and early spring that resemble bilobate "balloons" which float to the surface. Juvenile shortspine thornyheads have a pelagic period of about 14-15 months and settle out at about 22 to 27 mm. Fifty percent of female shortspine thornyheads are sexually mature at about 21 cm and 12-13 years of age.

Fishery

Trawl and longline gear are the primary methods of harvest. The bulk of the fishery occurs in late winter or early spring through the summer. In the past, this species was seldom the target of a directed fishery. Today thornyheads are one of the most valuable of the rockfish species, with most of the domestic harvest exported to Japan. Thornyheads are taken with some frequency in the longline fishery for sablefish and cod and is often part of the bycatch of trawlers concentrating on pollock and Pacific ocean perch.

Relevant Trophic Information

Shortspine thornyheads prey mainly on epibenthic shrimp and fish. Yang (1993, 1996) showed that shrimp were the top prey item for shortspine thornyheads in the Gulf of Alaska; whereas, cottids were the most important prey item in the Aleutian Islands region. Differences in abundance of the main prey between the two areas might be the main reason for the observed diet differences. Predator size might by another reason for the difference since the average shortspine thornyhead in the Aleutian Islands area was larger than that in the Gulf of Alaska (33.4 cm vs 29.7 cm).

Approximate upper size limit of juvenile fish (in cm):

Female shortspine thornyheads appear to be mature at about 21-22 cm.

Additional Information Sources

NMFS, Alaska Fisheries Science Center

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: Eggs float in masses of various sizes and shapes. Frequently the masses are bilobed with the lobes 15 cm to 61 cm in length, consisting of hollow conical sheaths containing a single layer of eggs in a gelatinous matrix. The masses are transparent and not readily

observed in the daylight. Eggs are 1.2 to 1.4 mm in diameter with a 0.2 mm oil globule. They move freely in the matrix. Complete hatching time is unknown but is probably more than 10 days.

Larvae: Three day-old larvae are about 3 mm long and apparently float to the surface. It is believed that the larvae remain in the water column for about 14-15 months before settling to the bottom.

Juveniles: Very little information is available regarding the habitats and biological associations of juvenile shortspine thornyheads

Adults: Adults are demersal and can be found at depths ranging from about 90 to 1,500 m. Groundfish species commonly associated with thornyheads include: arrowtooth flounder (*Atheresthes stomias*), Pacific ocean perch (*Sebastes alutus*), sablefish *(Anoplopoma fimbria*), rex sole (*Glyptocephalus zachirus*), Dover sole (*Microstomus pacificus*), shortraker rockfish (*Sebastes borealis*), rougheye rockfish (*Sebastes aleutianus*), and grenadiers (family Macrouridae). Two congeneric thornyhead species, the longspine thornyhead (*Sebastolobus altivelis*) and a species common off of Japan, *S. Macrochir*, are infrequently encountered in the Gulf of Alaska.

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commer., NOAA Tech. Rept. NMFS 66, 151 p.

Aton, M. 1981. Gulf of Alaska bottomfish and shellfish resources. U.S. Dep. Commer. Tech. Memo. NMFS F/NWC-10, 51 p.

Archibald, C.P., W. Shaw, and B.M. Leaman. 1981. Growth and mortality estimates of rockfishes (Scorpaenidae) from B.C. coastal waters, 1977-79. Can. Tech. Rep. Fish. Aquat. Sci. 1048, 57 p.

Chilton, D.E., and R.J. Beamish. 1982. Age determination methods for fishes studied by the Groundfish Program at the Pacific Biological Station. Can. Spec. Publ. Fish. Aquat. Sci. 60, 102 p.

Heifetz, J., J.N. Ianelli, and D.M. Clausen. 1996. Slope rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 230-270. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Ianelli, J.N., D.H. Ito, and M. Martin. 1996. Thornyheads (*Sebastolobus sp*.). *In* Stock Assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 303-330. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Jacobson, L.D. 1993. Thornyheads. *In* Status of living marine resources off the Pacific coast of the United States for 1993. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-26, 35-37 p.

Kramer, D.E., and V.M. O'Connell. 1986. Guide to northeast Pacific rockfishes, Genera *Sebastes* and *Sebastolobus*. Marine Advisory Bulletin No. 25: 1-78. Alaska Sea Grant College Program, University of Alaska.

Low, L.L. 1994. Thornyheads. *In* Status of living marine resources off Alaska, 1993. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-27, 56-57 p.

Sigler, M.F., and H.H. Zenger, Jr. 1994. Relative abundance of Gulf of Alaska sablefish and other groundfish based on the domestic longline survey, 1989. NOAA Tech. Memo. NMFS-AFSC-40.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

Yang, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-60, 105 p.

SPECIES: Thornyhead Rockfish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	U	Spawning: Late winter and early spring	U	P	U	U	
Larvae	<15 Months	U	Early spring through summer	U	P	U	U	
Juveniles	> 15 months when settling to bottom occurs (?)	U Shrimp, Amphipods, Mysids, Euphausiids?	U	MCS, OCS, USP	D	M, S, R, SM, CB, MS, G	U	
Adults	U	Shrimp Fish (cottids), Small crabs	Year-round?	MCS, OCS, USP, LSP	D	M, S, R, SM, CB, MS, G	U	

Habitat Description for Atka mackerel

(Pleurogrammus monopterygius)

Management Plan and Area GOA

Life History and General Distribution

Distributed from the Gulf of Alaska to the Kamchatka Peninsula, most abundant along the Aleutians. Adult Atka mackerel occur in large localized aggregations usually at depths less than 200 m and generally over rough, rocky and uneven bottom near areas where tidal currents are swift. Adults are pelagic during much of the year, but migrate annually to moderately shallow waters where they become demersal during spawning. Spawning peaks in June through September, but may occur intermittently throughout the year. Atka mackerel deposit eggs in nests built and guarded by males on rocky substrates or on kelp in shallow water. Eggs hatch in 40-45 days, releasing planktonic larvae which have been found up to 800 km from shore. Little is known of the distribution of young Atka mackerel prior to their appearance in trawl surveys and the fishery at about age 2-3 years. r-traits: young age at maturity (approximately 50% are mature at age 3), fast growth rates, high natural mortality (M=0.3) and young average and maximum ages (about 5 and 14 years, respectively). K-selected traits low fecundity (only about 30,000 eggs/female/year, large egg diameters (1-2 mm) and male nest-guarding behavior).

Fishery

Bottom trawls, some pelagic trawling, recruit at about age 3, conducted in the Aleutian Islands and western GOA at depths between about 70-225 m, in trawlable areas on rocky, uneven bottom, along edges, and in lee of submerged hills during periods of high current. Currently, the fishery occurs on reefs west of Kiska Island, south and west of Amchitka Island, in Tanaga Pass and near the Delarof Islands, and south of Seguam and Umnak Islands. Historically fishery occurred east into the GOA as far as Kodiak Island (through the mid-1980s), but is no longer there. Fishery used to be entirely during summer, during spawning season; now occurs throughout the year. Very "clean" fishery; bycatch of other species is minimal.

Relevant Trophic Information

Important food for Steller sea lions in the Aleutian Islands, particularly during summer, and for other marine mammals (minke whales, Dall's porpoise and northern fur seal). Juveniles eaten by thick billed murres and tufted puffins. Main groundfish predators are Pacific halibut, arrowtooth flounder, and Pacific cod.

Approximate upper size limit of juvenile fish (in cm): 35 cm

Additional Information Sources

NMFS, Alaska Fishery Science Center, FOCI program, Sandra Lowe

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: Eggs deposited in nests built and guarded by males on rocky substrates or on kelp in shallow water.

Larvae/Juveniles: Planktonic larvae have been found up to 800 km from shore, usually in upper water column (neuston), but little is known of the distribution of Atka mackerel until they are about 2 years old and appear in fishery and surveys.

Adults: Adults occur in localized aggregations usually at depths less than 200 m and generally over rough, rocky and uneven bottom near areas where tidal currents are swift. Adults are semi-demersal/pelagic during much of the year, but migrate annually to moderately shallow waters where the males become demersal during spawning; females move between nesting and offshore feeding areas.

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce., NOAA Tech. Rept. NMFS 66, 151 p.

Byrd, G.V., J.C. Williams, and R. Walder. 1992. Status and biology of the tufted puffin in the Aleutian Islands, Alaska, after a ban on salmon driftnets. U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, Aleutian Islands Unit, PSC 486, Box 5251, FPO AP 96506-5251, Adak, Alaska.

Doyle, M.J., W.C. Rugen, and R.D. Brodeur. 1995. Neustonic ichthyoplankton in the western Gulf of Alaska during spring. Fishery Bulletin 93: 231-253.

Fritz, L.W. 1993. Trawl locations of walleye pollock and Atka mackerel fisheries in the Bering Sea, Aleutian Islands, and Gulf of Alaska from 1977-1992. AFSC Processed Report 93-08, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 pp.

Gorbunova, N.N. 1962. Razmnozhenie I razvite ryb semeistva terpugovykh (Hexagrammidae) (Spawning and development of greenlings (family Hexagrammidae). Tr. Inst. Okeanol., Akad. Nauk SSSR 59:118-182. In Russian. (Trans. by Isr. Program Sci. Trans., 1970, p. 121-185 in T.S. Rass (editor), Greenlings: taxonomy, biology, interoceanic transplantation; available from the U.S. Dep. Commer., Natl. Tech. Inf. Serv., Springfield, VA., as TT 69-55097).

Kajimura, H. 1984. Opportunistic feeding of the northern fur seal Callorhinus ursinus, in the eastern north Pacific Ocean and eastern Bering Sea. NOAA Tech. Rept. NMFS SSRF-779. USDOC, NOAA, NMFS, 49 pp.

Kendall, A.W., Jr., and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. U.S. Dep. Commerce., NOAA Tech. Rept NMFS 20, 89 p.

Kendall, A.W., Jr., J.R. Dunn, and R.J. Wolotira, Jr. 1980. Zooplankton, including ichthyoplankton and decapod larvae, of the Kodiak shelf. NWAFC Processed Rept. 80-8, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 393 p.

Lee, J.U. 1985. Studies on the fishery biology of the Atka mackerel *Pleurogrammus monopterygius* (Pallas) in the north Pacific Ocean. Bull. Fish. Res. Dev. Agency, 34, pp.65-125.

Levada, T.P. 1979. Comparative morphological study of Atka mackerel. Pac. Sci. Res. Inst. Fish. Oceanogr. (TINRO), Vladivostok, U.S.S.R., Unpublished manuscript.

Levada, T.P. 1979. Some data on biology and catch of Atka mackerel. Pac. Sci. Res. Inst. Fish. Oceanogr. (TINRO), Vladivostok, U.S.S.R., Unpublished manuscript.

Lowe, S.A. and L.W. Fritz. 1996. Atka mackerel. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Lowe, S.A. and L.W. Fritz. 1996. Atka mackerel. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

McDermott, S.F. and S.A. Lowe. 1997. The reproductive cycle and sexual maturity of Atka mackerel (*Pleurogrammus monopterygius*) in Alaskan waters. Fishery Bulletin 95: 321-333.

Morris, B.F. 1981. An assessment of the living marine resources of the central Bering Sea and potential resource use conflicts between commercial fisheries and Petroleum development in the Navarin Basin, Proposed sale No. 83. Anchorage, AK: USDOC, NOAA, NMFS, Environmental Assessment Division.

Musienko, L.N. 1970. Razmnozheine I razvitie ryb Beringova morya (Reproduction and development of Bering Sea fishes). Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Koz. Okeanogr. 70: 161-224 In P.A. Moiseev (ed.), Soviet fisheries investigations in the northeastern Pacific, Pt. 5, Avail. Natl. Tech. Info. Serv., Springfield, VA as TT 74-50127.

NMFS. 1995. Status review of the Unites States Steller sea lion (*Eumetopias jubatus*) population. National Marine Mammal Laboratory, Alaska Fishery Science Center, National Marine Fisheries Service, 7600 Sand Point Way, NE, Seattle, WA 98115.

Orlov, A.M. 1996. The role of mesopelagic fishes in feeding of Atka mackerel in areas of the North Kuril islands. Publ. Abstract in Role of forage fishes in marine ecosystems. Symposium held Nov 1996, AK Sea Grant, U. Alaska, Fairbanks.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Processed Rept 90-01, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 p.

Waldron, K.D. 1978. Ichthyoplankton of the eastern Bering Sea, 11 February-16 March 1978. REFM Report, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 33 p.

Waldron, K.D., and B.M. Vinter. 1978. Ichthyoplankton of the eastern Bering Sea. Final Report (RU 380), Environmental Assessment of the Alaskan continental shelf, REFM, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 88 p.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Yang, M-S. 1996. Trophic role of Atka mackerel in the Aleutian Islands. Publ. Abstract in Role of forage fishes in marine ecosystems. Symposium held Nov 1996, AK Sea Grant, U. Alaska, Fairbanks.

Zolotov, O.G. 1993. Notes on the reproductive biology of *Pleurogrammus monopterygius* in Kamchatkan waters. J. of Ichthy. 33(4), pp. 25-37.

SPECIES: Atka mackerel

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	40-45 d	NA	summer	IP,ICS	D	GR,R,K	U	develop 3-20˚C optimum 9-13˚C
Larvae	up to 6 mos	U copepods?	fall-winter	U	U N?	U	U	2-12˚C optimum 5-7˚C
Juveniles	½-2 yrs of age	U copepods & euphausiids?	all year	U	U	U	U	3-5˚C
Adults	3+ yrs of age	copepods euphausiids meso-pelagic fish (myctophids)	spawning (May-Oct) non-spawning (Nov-Apr) tidal/diurnal, year-round?	ICS and MCS, IP MCS and OCS, IP ICS,MCS,O CS,IP	D (males) SD females SD/D all sexes D when currents high/day	GR,R,K	F,E	3-5˚C all stages >17 ppt only

Habitat Description for Capelin

(*osmeridae*)

Management Plan and Area GOA

Species Representative:

Capelin (*Mallotus villosus*)

Life History and General Distribution

Capelin is a short-lived marine (neritic), pelagic, filter-feeding schooling fish distributed along the entire coastline of Alaska and the Bering Sea, and south along British Columbia to the Strait of Juan de Fuca; circumpolar. In the N. Pacific, capelin grow to a maximum of 25 cm and 5 years of age. Spawn at ages 2-4 in spring and summer (May-Aug; earlier in south, later in north) when about 11-17 cm on coarse sand, fine gravel beaches, especially in Norton Sound, northern Bristol Bay, along the Alaska Peninsula and near Kodiak. Age at 50% maturity=2 years. Fecundity: 10,000-15,000 eggs per female. Eggs hatch in 2-3 weeks. Most capelin die after spawning. Larvae and juveniles are distributed on inner-mid shelf in summer (rarely found in waters deeper than about 200 m), and juveniles and adults congregate in fall in mid-shelf waters east of the Pribilof Islands, west of St. Matthew and St. Lawrence Islands, and north into the Gulf of Anadyr. Distributed along outer shelf and under ice edge in winter. Larvae, juveniles and adults have diurnal vertical migrations following scattering layers - night near surface, at depth during the day. Smelts are captured during trawl surveys, but their patchy distribution both in space and time reduces the validity of biomass estimates.

Fishery

Not a target species in groundfish fisheries of BSAI or GOA, but caught as bycatch (up to several hundred tons per year in the 1990s) principally by yellowfin sole trawl fishery in Kuskokwim and Togiak Bays in spring in BSAI; almost all discarded. Small local coastal fisheries occur in spring and summer.

Relevant Trophic Information

Capelin are important prey for marine birds and mammals as well as other fish. Surface feeding (e.g., gulls and kittiwakes), as well as shallow and deep diving piscivorous birds (e.g., murres and puffins) largely consume small schooling fishes such as capelin, eulachon, herring, sand lance and juvenile pollock (Hunt et al. 1981a; Sanger 1983). Both pinnipeds (Steller sea lions, northern fur seals, harbor seals, and ice seals) and cetaceans (such as harbor porpoise, and fin, sei, humpback, beluga whales) feed on smelts, which may provide an important seasonal food source near the ice-edge in winter, and as they assemble nearshore in spring to spawn (Frost and Lowry 1987; Wespestad 1987). Smelts are also found in the diets of some commercially exploited fish species, such as Pacific cod, walleye pollock, arrowtooth flounder, Pacific halibut, sablefish, Greenland turbot and salmon, throughout the North Pacific Ocean and the Bering Sea (Allen 1987; Yang 1993; Livingston, in prep.).

Approximate upper size limit of juvenile fish (in cm): 13 cm

Additional Information Sources

Paul Anderson, NMFS/RACE, Kodiak AK 907-487-4961

Jim Blackburn, ADFG, Kodiak AK 907-486-1861
Mark W. Nelson, NMFS/REFM, Seattle WA 206-526-4699

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: Spawn adhesive eggs (about 1 mm in diameter) on fine gravel or coarse sand (0.5-1 mm grain size) beaches intertidally to depths of up to 10 m in May-July in Alaska (later to the north in Norton Sound). Hatching occurs in 2-3 weeks. Most intense spawning when coastal water temperatures are 5-9˚C.

Larvae: After hatching, 4-5 mm larvae remain on the middle-inner shelf in summer; distributed pelagically; centers of distribution are unknown, but have been found in high concentrations north of Unimak Island, in the western GOA, and around Kodiak Island.

Juveniles: In fall, juveniles are distributed pelagically in mid-shelf waters (50-100 m depth; -2-3˚C), and have been found in highest concentrations east of the Pribilof Islands, west of St. Matthew and St. Lawrence Islands and north into the Gulf of Anadyr.

Adults: Found in pelagic schools in inner-mid shelf in spring-fall, feed along semi-permanent fronts separating inner, mid, and outer shelf regions (~50 and 100 m). In winter, found in concentrations under ice-edge and along mid-outer shelf.

Literature

Allen, M.J. 1987. Demersal fish predators of pelagic forage fishes in the southeastern Bering Sea. Pp. 29-32 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce., NOAA Tech. Rept. NMFS 66, 151 p.

Crawford, T.W. 1981. Vertebrate prey of *Phocoenoides dalli* (Dall's porpoise), associated with the Japanese high seas salmon fishery in the North Pacific Ocean. M.S. Thesis, Univ. Washington, Seattle, 72 p.

Doyle, M.J., W.C. Rugen, and R.D. Brodeur. 1995. Neustonic ichthyoplankton in the western Gulf of Alaska during spring. Fishery Bulletin 93: 231-253.

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

Fritz, L.W. 1996. Other species *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Fritz, L.W., V.G. Wespestad, and J.S. Collie. 1993. Distribution and abundance trends of forage fishes in the Bering Sea and Gulf of Alaska. Pp. 30-44 In Is It Food: Addressing marine mammal and seabird declines. Workshop Summary. Alaska Sea Grant College Program Rept. No. AK-SG-93-01, Univ. Alaska, Fairbanks, AK 99775-5040.

Frost, K.J. and L. Lowry. 1987. Marine mammals and forage fishes in the southeastern Bering Sea. Pp. 11-18 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Hunt, G.L., Jr., B. Burgeson, and G.A. Sanger. 1981a. Feeding ecology of seabirds of the eastern Bering Sea. Pp 629-647 In D.W. Hood and J.A. Calder (eds.), The Eastern Bering Sea Shelf: Oceanography and

Resources, Vol. II. U.S. Dept. Commerce., NOAA, OCSEAP, Office of Marine Pollution Assessment, Univ. WA Press, Seattle, WA.

Hunt, G.L., Jr., Z. Eppley, B. Burgeson, and R. Squibb. 1981b. Reproductive ecology, foods and foraging areas of seabirds nesting on the Pribilof Islands, 1975-79. Environmental Assessment of the Alaskan Continental Shelf, Final Reports of Principal Investigators, RU-83, U.S. Dept. Commerce., NOAA, OCSEAP, Boulder, CO.

Kawakami, T. 1980. A review of sperm whale food. Sci. Rep. Whales Res. Inst. Tokyo 32: 199-218.

Kendall, A.W., Jr., and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. U.S. Dep. Commerce., NOAA Tech. Rept NMFS 20, 89 p.

Kendall, A.W., Jr., J.R. Dunn, and R.J. Wolotira, Jr. 1980. Zooplankton, including ichthyoplankton and decapod larvae, of the Kodiak shelf. NWAFC Processed Rept. 80-8, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 393 p.

Livingston, P.A. Groundfish utilization of walleye pollock (*Theragra chalcogramma*), Pacific herring (*Clupea pallasi*) and capelin (*Mallotus villosus*) resources in the Gulf of Alaska. In preparation.

Morris, B.F., M.S. Alton, and H.W. Braham. 1983. Living marine resources of the Gulf of Alaska: a resource assessment for the Gulf of Alaska/Cook Inlet Proposed Oil and Gas Lease Sale 88. U.S. Dept. Commerce., NOAA, NMFS.

Murphy, E.C., R.H. Day, K.L. Oakley, A.A. Hoover. 1984. Dietary changes and poor reproductive performances in glaucous-winged gulls. Auk 101: 532-541.

Naumenko, E.A. 1996. Distribution, biological condition, and abundance of capelin (*Mallotus villosus socialsis)* in the Bering Sea. Pp. 237-256 *In* O.A. Mathisen and K.O. Coyle (eds.), Ecology of the Bering Sea: a review of Russian literature. Alaska Sea Grant Report No. 96-01, Alaska Sea Grant College Program, U. Alaska, Fairbanks, AK 99775-5040. 306 p.

Pahlke, K.A. 1985. Preliminary studies of capelin Mallotus villosus in Alaska waters. Alaska Dept. Fish Game, Info. Leaf. 250, 64 p.

Perez, M.A. and M.A. Bigg. 1986. Diet of northern fur seals, *Callorhinus ursinus*, off western North America. Fish. Bull., U.S. 84: 957-971.

Pitcher, K.W. 1980. Food of the harbor seal, *Phoca vitulina richardsi*, in the Gulf of Alaska. Fish. Bull., U.S. 78: 544-549.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Processed Rept 90-01, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 p.

Waldron, K.D. 1978. Ichthyoplankton of the eastern Bering Sea, 11 February-16 March 1978. REFM Report, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 33 p.

Waldron, K.D., and B.M. Vinter. 1978. Ichthyoplankton of the eastern Bering Sea. Final Report (RU 380), Environmental Assessment of the Alaskan continental shelf, REFM, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 88 p.

Wespestad, V.G. 1987. Population dynamics of Pacific herring (*Clupea palasii*), capelin (*Mallotus villosus*), and other coastal pelagic fishes in the eastern Bering Sea. Pp. 55-60 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Yang, M.S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dept. Commerce., NOAA Tech. Memo. NMFS-AFSC-22. 150 pp.

SPECIES: Capelin

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	2-3 weeks to hatch	na	May-August	BCH (to 10 m)	D	S,CB		5-9˚C peak spawning
Larvae	4-8 months?	Copepods phytoplankton	summer/fall/ winter	ICS-MCS	N,P	U NA?	U	
Juveniles	1.5+ yrs up to age 2	Copepods Euphausiids	all year	ICS-MCS	P	U NA?	U F? Ice edge in winter	
Adults	2 yrs ages 2-4+	Copepods Euphausiids polychaetes small fish	spawning (May-August) non-spawning (Sep-Apr)	BCH (to 10 m) ICS-MCS-OCS	D,SD P	S,CB NA?	F Ice edge in winter	-2 - 3˚C Peak distributions in EBS?

Habitat Description for Eulachon

(*osmeridae*)

Management Plan and Area GOA

Species Representative:

Eulachon, candlefish *(Thaleichthys pacificus*)

Life History and General Distribution

Eulachon is a short-lived anadromous, pelagic schooling fish distributed from the Pribilof Islands in the eastern Bering Sea, throughout the Gulf of Alaska, and south to California. Consistently found pelagically in Shelikof Strait (hydroacoustic surveys in late winter-spring) and between Unimak Island and the Pribilof Islands (bycatch in groundfish trawl fisheries) from the middle shelf to over the slope. In the North Pacific, eulachon grow to a maximum of 23 cm and 5 years of age. Spawn at ages 3-5 in spring and early summer (April-June) when about 14-20 cm in rivers on coarse sandy bottom. Age at 50% maturity=3 years. Fecundity: ~25,000 eggs per female. Eggs adhere to sand grains and other substrates on river bottom. Eggs hatch in 30-40 days in BC at 4-7˚C. Most eulachon die after first spawning. Larvae drift out of rivers and develop at sea. Smelts are captured during trawl surveys, but their patchy distribution both in space and time reduces the validity of biomass estimates.

Fishery

Not a target species in groundfish fisheries of BSAI or GOA, but caught as bycatch (up to several hundred tons per year in the 1990s) principally by midwater pollock fisheries in Shelikof Strait (GOA), on the east side of Kodiak (GOA), and between the Pribilof Islands and Unimak Island on the outer continental shelf and slope (EBS); almost all discarded. Small local coastal fisheries occur in spring and summer.

Relevant Trophic Information:

Eulachon may be important prey for marine birds and mammals as well as other fish. Surface feeding (e.g., gulls and kittiwakes), as well as shallow and deep diving piscivorous birds (e.g., murres and puffins) largely consume small schooling fishes such as capelin, eulachon, herring, sand lance and juvenile pollock (Hunt et al. 1981a; Sanger 1983). Both pinnipeds (Steller sea lions, northern fur seals, harbor seals, and ice seals) and cetaceans (such as harbor porpoise, and fin, sei, humpback, beluga whales) feed on smelts, which may provide an important seasonal food source near the ice-edge in winter, and as they assemble nearshore in spring to spawn (Frost and Lowry 1987; Wespestad 1987). Smelts are also found in the diets of some commercially exploited fish species, such as Pacific cod, walleye pollock, arrowtooth flounder, Pacific halibut, sablefish, Greenland turbot and salmon, throughout the North Pacific Ocean and the Bering Sea (Allen 1987; Yang 1993; Livingston, in prep.).

Approximate upper size limit of juvenile fish (in cm): 14 cm

Additional Information Sources

Paul Anderson, NMFS/RACE, Kodiak AK 907-487-4961
Jim Blackburn, ADFG, Kodiak AK 907-486-1861
Mark W. Nelson, NMFS/REFM, Seattle WA 206-526-4699

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: Anadromous; return to spawn in spring (May-June) in rivers; demersal eggs adhere to bottom substrate (sand, cobble, etc.). Hatching occurs in 30-40 days.

Larvae: After hatching, 5-7 mm larvae drift out of river and develop pelagically in coastal marine waters; centers of distribution are unknown.

Juveniles and Adults: Distributed pelagically in mid-shelf to upper slope waters (50-1000 m water depth), and have been found in highest concentrations between the Pribilof Islands and Unimak Island on the outer shelf, and in Shelikofeast of the Pribilof Islands, west of St. Matthew and St. Lawrence Islands and north into the Gulf of Anadyr.

Literature

Allen, M.J. 1987. Demersal fish predators of pelagic forage fishes in the southeastern Bering Sea. Pp. 29-32 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Crawford, T.W. 1981. Vertebrate prey of *Phocoenoides dalli* (Dall's porpoise), associated with the Japanese high seas salmon fishery in the North Pacific Ocean. M.S. Thesis, Univ. Washington, Seattle, 72 p.

Fritz, L.W., V.G. Wespestad, and J.S. Collie. 1993. Distribution and abundance trends of forage fishes in the Bering Sea and Gulf of Alaska. Pp. 30-44 In Is It Food: Addressing marine mammal and seabird declines. Workshop Summary. Alaska Sea Grant College Program Rept. No. AK-SG-93-01, Univ. Alaska, Fairbanks, AK 99775-5040.

Frost, K.J. and L. Lowry. 1987. Marine mammals and forage fishes in the southeastern Bering Sea. Pp. 11-18 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Hunt, G.L., Jr., B. Burgeson, and G.A. Sanger. 1981a. Feeding ecology of seabirds of the eastern Bering Sea. Pp 629-647 In D.W. Hood and J.A. Calder (eds.), The Eastern Bering Sea Shelf: Oceanography and Resources, Vol. II. U.S. Dept. Commerce., NOAA, OCSEAP, Office of Marine Pollution Assessment, Univ. WA Press, Seattle, WA.

Hunt, G.L., Jr., Z. Eppley, B. Burgeson, and R. Squibb. 1981b. Reproductive ecology, foods and foraging areas of seabirds nesting on the Pribilof Islands, 1975-79. Environmental Assessment of the Alaskan Continental Shelf, Final Reports of Principal Investigators, RU-83, U.S. Dept. Commerce., NOAA, OCSEAP, Boulder, CO.

Kawakami, T. 1980. A review of sperm whale food. Sci. Rep. Whales Res. Inst. Tokyo 32: 199-218.

Livingston, P.A. Groundfish utilization of walleye pollock (*Theragra chalcogramma*), Pacific herring (*Clupea pallasi*) and capelin (*Mallotus villosus*) resources in the Gulf of Alaska. In preparation.

Morris, B.F., M.S. Alton, and H.W. Braham. 1983. Living marine resources of the Gulf of Alaska: a resource assessment for the Gulf of Alaska/Cook Inlet Proposed Oil and Gas Lease Sale 88. U.S. Dept. Commerce., NOAA, NMFS.

Perez, M.A. and M.A. Bigg. 1986. Diet of northern fur seals, *Callorhinus ursinus*, off western North America. Fish. Bull., U.S. 84: 957-971.

Pitcher, K.W. 1980. Food of the harbor seal, *Phoca vitulina richardsi*, in the Gulf of Alaska. Fish. Bull., U.S. 78: 544-549.

Sanger, G.A. 1983. Diets and food web relationships of seabirds in the Gulf of Alaska and adjacent marine regions. Outer Continental Shelf Environmental Assessment Program, Final Reports of Principal Investigators 45: 631-771.

Wespestad, V.G. 1987. Population dynamics of Pacific herring (*Clupea palasii*), capelin (*Mallotus villosus*), and other coastal pelagic fishes in the eastern Bering Sea. Pp. 55-60 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Yang, M.S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dept. Commerce., NOAA Tech. Memo. NMFS-AFSC-22. 150 pp.

SPECIES: EULACHON (Candlefish)

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	30-40 days	na	April-June	Rivers-FW	D	S (CB?)		4 - 8˚C for egg development
Larvae	1-2 months ?	Copepods phytoplankton mysids, larvae	summer/fall	ICS ?	P?	U NA?	U	
Juveniles	2.5+ yrs up to age 3	Copepods Euphausiids	all year	MCS-OCS-USP	P	U NA?	U F?	
Adults	3 yrs ages 3-5+		spawning (May-June)	Rivers-FW	D	S (CB?)		
		Copepods Euphausiids	non-spawning (July-Apr)	MCS-OCS-USP	P	NA?	F?	

Habitat Description for Sculpins

(*cottidae*)

Management Plan and Area GOA

Species Representatives:

Yellow Irish lord (*Hemilepidotus jordani)*
Red Irish lord (*Hemilepidotus hemilepidotus*)
Butterfly sculpin (*Hemilepidotus papilio*)
Bigmouth sculpin (*Hemitripterus bolini*)
Great sculpin (*Myoxocephalus polyacanthocephalus*)
Plain sculpin (*Myoxocephalus jaok*)

Life History and General Distribution:

The Cottidae (sculpins) is a large circumboreal family of demersal fishes inhabiting a wide range of habitats in the north Pacific Ocean and Bering Sea. Most species live in shallow water or in tidepools, but some inhabit the deeper waters (to 1000 m) of the continental shelf and slope. Most species do not attain a large size (generally 10-15 cm), but those that live on the continental shelf and are caught by fisheries can be 30-50 cm; the cabezon is the largest sculpin and can be as long as 100 cm. Most sculpins spawn in the winter. All species lay eggs, but in some genera, fertilization is internal. The female commonly lays demersal eggs amongst rocks where they are guarded by males. Egg incubation duration is unknown; larvae were found across broad areas of the shelf and slope, and were found all year-round, in ichthyoplankton collections from the southeast Bering Sea and Gulf of Alaska. Larvae exhibit diel vertical migration (near surface at night and at depth during the day). Sculpins generally eat small invertebrates (e.g., crabs, barnacles, mussels), but fish are included in the diet of larger species; larvae eat copepods.

Yellow Irish lords: distributed from subtidal areas near shore to the edge of the continental shelf (down to 200 m) throughout the Bering Sea, Aleutian Islands, and eastward into the GOA as far as Sitka, AK; up to 40 cm in length. 12-26 mm larvae collected in spring on the western GOA shelf.

Red Irish lords: distributed from rocky, intertidal areas to about 100 m depth on the middle continental shelf (most shallower than 50 m), from California (Monterey Bay) to Kamchatka; throughout the Bering Sea and Gulf of Alaska; rarely over 30 cm in length. Spawns masses of pink eggs in shallow water or intertidally. Larvae were 7-20 mm long in spring in the western GOA.

Butterfly sculpins: distributed primarily in the western north Pacific and northern Bering Sea, from Hokkaido, Japan, Sea of Okhotsk, Chukchi Sea, to southeast Bering Sea and in Aleutian Islands; depths of 20-250 m, most frequent 50-100 m.

Bigmouth sculpin: distributed in deeper waters offshore, between about 100-300 m in the Bering Sea, Aleutian Islands, and throughout the Gulf of Alaska; up to 70 cm in length.

Great sculpin: distributed from the intertidal to 200 m, but may be most common on sand and muddy/sand bottoms in moderate depths (50-100 m); up to 80 cm in length. Found throughout

the Bering Sea, Aleutian Islands, and Gulf of Alaska, but may be less common east of Prince William Sound. *Myoxocephalus* spp. larvae ranged in length from 9-16 mm in spring ichthyoplankton collections in the western GOA.

Plain sculpin: distributed throughout the Bering Sea and Gulf of Alaska (not common in the Aleutian Islands) from intertidal areas to depths of about 100 m, but most common in shallow waters (<50 m); up to 50 cm in length. *Myoxocephalus* spp. larvae ranged in length from 9-16 mm in spring ichthyoplankton collections in the western GOA.

Fishery

Not a target of groundfish fisheries of BSAI or GOA, but sculpin bycatch (second to skates in weight amongst the Other Species) has ranged from 6,000-11,000 mt per year in the BSAI from 1992-95, and 500-1,400 mt per year in the GOA. Bycatch occurs principally in bottom trawl fisheries for flatfish, Pacific cod and pollock, but also while longlining for Pacific cod; almost all is discarded. Annual sculpin bycatch in the BSAI ranges between 1-4% of annual survey biomass estimates, however little is known of the species distribution of the bycatch.

Relevant Trophic Information

Feed on bottom invertebrates (e.g., crabs, barnacles, mussels and other molluscs); larger species eat fish.

Approximate upper size limit of juvenile fish (in cm): Unknown

Additional Information Sources:

NMFS, Alaska Fisheries Science Center, Sarah Gaichas

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: Lay demersal eggs in nests guarded by males; many species in rocky shallow waters near shore.

Larvae: Distributed pelagically and in neuston across broad areas of shelf and slope, but predominantly on inner and middle shelf; have been found all year-round.

Juveniles and Adults: Sculpins are demersal fish, and live in a broad range of habitats from rocky intertidal pools to muddy bottoms of the continental shelf, and rocky, upper slope areas. Most commercial bycatch occurs on middle and outer shelf areas used by bottom trawlers for Pacific cod and flatfish.

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce., NOAA Tech. Rept. NMFS 66, 151 p.

Doyle, M.J., W.C. Rugen, and R.D. Brodeur. 1995. Neustonic ichthyoplankton in the western Gulf of Alaska during spring. Fishery Bulletin 93: 231-253.

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

Fritz, L.W. 1996. Other species *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Kendall, A.W., Jr., and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. U.S. Dep. Commerce., NOAA Tech. Rept NMFS 20, 89 p.

Kendall, A.W., Jr., J.R. Dunn, and R.J. Wolotira, Jr. 1980. Zooplankton, including ichthyoplankton and decapod larvae, of the Kodiak shelf. NWAFC Processed Rept. 80-8, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 393 p.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Processed Rept 90-01, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 p.

Waldron, K.D. 1978. Ichthyoplankton of the eastern Bering Sea, 11 February-16 March 1978. REFM Report, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 33 p.

Waldron, K.D., and B.M. Vinter. 1978. Ichthyoplankton of the eastern Bering Sea. Final Report (RU 380), Environmental Assessment of the Alaskan continental shelf, REFM, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 88 p.

SPECIES: Sculpins

Life Stage	Duration or Age	Diet/Prey	Season-Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	na	winter?	BCH,ICS (MSC-OSC?)	D	R (others?)	U	
Larvae	U	copepods	all year?	ICS-MSC,OCS,US	N,P	na?	U	
Juveniles and Adults	U	bottom invertebrates (crabs, molluscs, barnacles) and small fish	all year	BCH,ICS, MSC, OSC, USP	D	R, S, M, SM	U	

Habitat Description for Sharks

Management Plan and Area GOA

Species Representatives:

Lamnidae:	Salmon shark (*Lamna ditropis*)
Squalidae:	Sleeper shark (*Somniosus pacificus*)
	Spiny dogfish (*Squalus acanthias*)

Life History and General Distribution:

Sharks of the order Squaliformes (which includes the two families Lamnidae and Squalidae) are the higher sharks with five gill slits and two dorsal fins. The Lamnidae are large, ovoviviparous (with small litters, 1-4; embryos nourished by intrauterine cannibalism), widely migrating sharks which are highly aggressive predators (salmon and white sharks). The Lamnidae are partly warm-blooded; the heavy trunk muscles are warmer than water for greater power and efficiency. Salmon sharks are distributed epipelagically along the shelf (can be found in shallow waters) from California through the Gulf of Alaska (where they occur all year and are probably most abundant in our area), the Bering Sea and off Japan. In groundfish fishery and survey data, occur chiefly on outer shelf/upper slope areas in the Bering Sea, but near coast to the outer shelf in the Gulf of Alaska, particularly near Kodiak Island. Not commonly seen in Aleutian Islands. They are believed to eat primarily fish, including salmon, sculpins and gadids, and can be up to 3 m in length.

The Pacific sleeper shark is distributed from California around the Pacific rim to Japan and in the Bering Sea principally on the outer shelf and upper slope (but has been observed nearshore), generally demersal (but also seen near surface). Other members of the Squalidae are ovoviviparous, but fertilization and development of sleeper sharks are not known; adults up to 8 m in length. Voracious, omnivorous predator of flatfish, cephalopods, rockfish, crabs, seals, salmon; may also prey on pinnipeds. In groundfish fishery and survey data, occur chiefly on outer shelf/upper slope areas in the Bering Sea, but near coast to the outer shelf in the Gulf of Alaska, particularly near Kodiak Island.

Spiny dogfish (or closely related species?) are widely distributed through the Atlantic, Pacific and Indian Oceans. In the north Pacific, may be most abundant in the Gulf of Alaska, but also common in the Bering Sea. Pelagic species, found at surface and to depths of 700 m; mostly 200 m or less on shelf and neritic; often found in aggregations. Ovoviviparous, with litter size proportional to size of female, from 2-9; gestation may be 22-24 months. Young are 24-30 cm at birth, with growth initially rapid, then slows dramatically. Maximum adult size is about 1.6 m, and 10 kg; maximum age about 40 years. 50% of females are mature at 94 cm and 29 years old; males, 72 cm and 19 years old. Females give birth in shallow coastal waters, usually in Sept-Jan. Dogfish eat a wide variety of foods, including fish (smelts, herring, sand lance, and other small schooling fish), crustaceans (crabs, euphausiids, shrimp), and cephalopods (octopus). Tagging experiments indicate local indigenous populations in some areas and widely migrating groups in others. May move inshore in summer and offshore in winter.

Fishery

Not a target of groundfish fisheries of BSAI or GOA, but shark bycatch has ranged from 300-700 mt per year in the BSAI from 1992-95; 500-1,400 mt per year in the GOA) principally by pelagic trawl fishery for pollock, longline fisheries for Pacific cod and sablefish, and bottom trawl fisheries for pollock, flatfish and cod; almost all discarded. Little is known of shark biomass in BSAI or GOA.

Approximate upper size limit of juvenile fish (in cm): Unknown for salmon sharks and sleeper sharks; for spiny dogfish: 94 cm for females, 72 cm for males.

Additional Information Sources

NMFS, Alaska Fisheries Science Center, Sarah Gaichas

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: Salmon sharks and spiny dogfish are ovoviviparous; reproductive strategy of sleeper sharks is not known. Spiny dogfish give birth in shallow coastal waters, while salmon sharks probably offshore and pelagic.

Juveniles and Adults: Spiny dogfish are widely dispersed throughout the water column on shelf in the GOA, and along outer shelf in the EBS; apparently not as commonly found in the Aleutian Islands and not commonly at depths > 200 m.

Salmon sharks found throughout the GOA, but less common in the EBS and AI; epipelagic, primarily over shelf/slope waters in GOA, and outer shelf in EBS.

Sleeper sharks are widely dispersed on shelf/upper slope in the GOA, and along outer shelf/upper slope only in the EBS; generally demersal, and may be less commonly found in the Aleutian Islands.

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce., NOAA Tech. Rept. NMFS 66, 151 p.

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

Fritz, L.W. 1996. Other species *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

SPECIES: SHARKS

Life Stage	Duration or Age	Diet/Prey	Season-Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs and Larvae								
Juveniles and Adults								
Salmon shark	U	fish (salmon, sculpins and gadids)	all year	ICS, MSC. OCS, US in GOA; OCS, US in BSAI	P	NA	U	
Sleeper shark	U	omnivorous; flatfish, cephalopods, rockfish, crabs, seals, salmon, pinnipeds	all year	ICS, MSC, OCS, US in GOA; OCS, US in BSAI	D	U	U	
Spiny dogfish	40 years	fish (smelts, herring, sand lance, and other small schooling fish), crustaceans (crabs, euphausiids, shrimp), and cephalopods (octopus)	all year	ICS, MSC, OCS in GOA; OCS in BSAI give birth ICS in fall/winter?	P	U	U	Euhaline 4-16˚C

Habitat Description for Skates
(Rajidae)

Management Plan and Area GOA

Species Representatives:

Alaska skate (*Bathyraja parmifera*)
Aleutian skate (*Bathyraja aleutica*)
Bering skate (*Bathyraja interrupta*)

Life History and General Distribution:

Skates (Rajidae) that occur in the BSAI and GOA are grouped into two genera: *Bathyraja* sp., or soft-nosed species (rostral cartilage slender and snout soft and flexible), and *Raja* sp., or hard-nosed species (rostral cartilage is thick making the snout rigid). Skates are oviparous; fertilization is internal and eggs (one to five or more in each case) are deposited in horny cases for incubation. Adults and juveniles are demersal, and feed on bottom invertebrates and fish. Adult distributions from survey: Alaska skate: mostly 50-200 m on shelf in eastern Bering Sea (EBS) and Aleutian Islands (AI), less common in the Gulf of Alaska (GOA); Aleutian skate: throughout EBS and AI, but less common in GOA, mostly 100-350 m; Bering Skate: throughout EBS and GOA, less common in AI, mostly 100-350 m. Little is known of their habitat requirements for growth or reproduction, nor of any seasonal movements. BSAI skate biomass estimate more than doubled between 1982-96 from bottom trawl survey; may have decreased in GOA and remained stable in the AI in the 1980s.

Fishery

Until 2003, skates were not a target of groundfish fisheries of BSAI or GOA, but caught as bycatch (13,000-17,000 mt per year in the BSAI from 1992-95; 1,000-2,000 mt per year in the GOA) principally by the longline Pacific cod and bottom trawl pollock and flatfish fisheries; almost all discarded. Skate bycatches in the EBS groundfisheries ranged between 1-4% of the annual EBS trawl survey biomass estimates in 1992-95.

Starting in 2003 a directed fishery for skates developed in the GOA centered around Kodiak island. It is prosecuted primarily on longline vessels less than 60 feet long, with some additional targeting by trawlers using large mesh nets. The primary target species appears to be Raja binoculata, followed by Raja rhina, but this is difficult to determine given that there is almost no observer coverage of the fishery. As of late July 2003 over 2,000 tons of skates had been landed. Market price per pound of skates is comparable to that of cod so the fishery is expected to continue and perhaps expand.

Relevant Trophic Information: Feed on bottom invertebrates (crustaceans, molluscs, and polychaetes) and fish.

Approximate upper size limit of juvenile fish (in cm): Unknown

Additional Information Source

NMFS, Alaska Fisheries Science Center, Sarah Gaichas

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: Deposit eggs in horny cases on shelf and slope.

Juveniles and Adults: After hatching, juveniles probably remain in shelf and slope waters, but distribution is unknown. Adults found across wide areas of shelf and slope; surveys found most skates at depths <500 m in the GOA and EBS, but >500 m in the AI. In the GOA, most skates found between 4-7˚C, but data are limited.

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce., NOAA Tech. Rept. NMFS 66, 151 p.

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

Fritz, L.W. 1996. Other species *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Teshima, K., and T.K. Wilderbuer. 1990. Distribution and abundance of skates in the eastern Bering Sea, Aleutian Islands region, and the Gulf of Alaska. Pp. 257-267 *in* H.L. Pratt, Jr., S.H. Gruber, and T. Taniuchi (eds.)., Elasmobranchs as living resources: advances in the biology, ecology, systematics and the status of the fisheries. U.S. Dep. Commerce., NOAA Technical Report 90.

SPECIES: SKATES

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	na	U	MCS,OCS, USP	D	U	U	
Larvae	na	na	na	na	na	na	na	
Juveniles	U	Invertebrates small fish	all year	MCS,OCS, USP	D	U	U	
Adults	U	Invertebrates small fish	all year	MCS,OCS, USP	D	U	U	

Habitat Description for Squid

(*Cephalopoda, Teuthida*)

Management Plan and Area GOA

Species Representatives:

Gonaditae:
Red or magistrate armhook squid (*Berryteuthis magister*)
Onychoteuthidae:
Boreal clubhook squid (*Onychoteuthis banksii borealjaponicus)*
Giant or robust clubhook squid (*Moroteuthis robusta*);
Sepiolidae:
eastern Pacific bobtail squid (*Rossia pacifica*).

Life History and General Distribution:

Squid are members of the molluscan class Cephalopoda, along with octopus, cuttlefish and nautiloids. In the BSAI and GOA, gonatid and onychoteuthid squids are generally the most common, along with chiroteuthids. All cephalopods are stenohaline, occurring only at salinities > 30 ppt. Fertilization is internal, and development is direct ("larval" stages are only small versions of adults). The eggs of inshore neritic species are often enveloped in a gelatinous matrix attached to rocks, shells or other hard substrates, while the eggs of some offshore oceanic species are extruded as large, sausage-shaped drifting masses. Little is known of the seasonality of reproduction, but most species probably breed in spring-early summer, with eggs hatching during the summer. Most small squid are generally thought to live only 2-3 years, but the giant *Moroteuthis robusta* clearly lives longer.

B magister is widely distributed in the boreal north Pacific from California, throughout the Bering Sea, to Japan in waters of depth 30-1500 m; adults most often found at mesopelagic depths or near bottom on shelf, rising to the surface at night; juveniles are widely distributed across shelf, slope and abyssal waters in meso- and epipelagic zones, and rise to surface at night. Migrates seasonally, moving northward and inshore in summer, and southward and offshore in winter, particularly in the western north Pacific. Maximum size: females-50 cm mantle length (ML); males-40 cm ML. Spermatophores transferred into the mantle cavity of female, and eggs are laid on the bottom on the upper slope (200-800 m). Fecundity estimated at 10,000 eggs/female. Spawning of eggs occurs in Feb-Mar in Japan, but apparently all year-round in the Bering Sea. Eggs hatch after 1-2 months of incubation; development is direct. Adults are gregarious prior to, and most die after mating.

O. banksii borealjaponicus, an active, epipelagic species, is distributed in the north Pacific from the Sea of Japan, throughout the Aleutian Islands and south to California, but is absent from the Sea of Okhotsk and not common in the Bering Sea. Juveniles can be found over shelf waters at all depths and near shore. Adults apparently prefer the upper layers over slope and abyssal waters; diel migrators and gregarious. Development includes a larval stage; maximum size about 55 cm.

M. robusta, a giant squid, lives near the bottom on the slope, and mesopelagically over abyssal waters; rare on the shelf. It is distributed in all oceans, and is found in the Bering Sea, Aleutian

Islands and Gulf of Alaska. Mantle length can be up to 2.5 m long; with tentacles, at least 7 m, but most are about 2 m long.

R. pacifica is a small (maximum length with tentacles of less than 20 cm) demersal, neritic and shelf, boreal species, distributed from Japan to California in the North Pacific and in the Bering Sea in waters of about 20-300 m depth. Other *Rossia* spp. deposit demersal egg masses.

Fishery:

Not currently a target of groundfish fisheries of BSAI or GOA. A Japanese fishery catching up to 9,000 mt of squid annually existed until the early 1980s for *B. magister* in the Bering Sea and *O. banksii borealjaponicus* in the Aleutian Islands. Since 1990, annual squid bycatch has been about 1,000 mt or less in the BSAI, and between 30-150 mt in the GOA; in the BSAI, almost all squid bycatch is in the midwater pollock fishery near the continental shelf break and slope, while in the GOA, trawl fisheries for rockfish and pollock (again mostly near the edge of the shelf and on the upper slope) catch most of the squid bycatch.

Relevant Trophic Information

The principal prey items of squid are small forage fish pelagic crustaceans (e.g., euphausiids and shrimp), and other cephalopods; cannibalism is not uncommon. After hatching, small planktonic zooplankton (copepods) are eaten. Squid are preyed upon by marine mammals, seabirds, and, to a lesser extent by fish, and occupy an important role in marine food webs worldwide. Perez (1990) estimated that squids comprise over 80% of the diets of sperm whales, bottlenose whales and beaked whales, and about half of the diet of Dall's porpoise in the eastern Bering Sea and Aleutian Islands. Seabirds (e.g., kittiwakes, puffins, murres) on island rookeries close to the shelf break (e.g., Buldir Island, Pribilof Islands) are also known to feed heavily on squid (Hatch et al. 1990; Byrd et al. 1992; Springer 1993). In the Gulf of Alaska, only about 5% or less of the diets of most groundfish consisted of squid (Yang 1993). However, squid play a larger role in the diet of salmon (Livingston and Goiney 1983).

Approximate upper size limit of juvenile fish (in cm):

For *B. magister*, approx. 20 cm ML for males, 25 cm ML for females; both at approximately 1 year of age.

Additional Information Source

NMFS, Alaska Fisheries Science Center, Sarah Gaichas
NMFS, Alaska Fisheries Science Center, Beth Sinclair

Habitat Narrative for B. magister:

<u>*Egg/Spawning*</u>: Eggs are laid on the bottom on the upper slope (200-800 m); incubate for 1-2 months.

<u>*Young Juveniles*</u>: Distributed epipelagically (top 100 m) from the coast to open ocean.

<u>*Old Juveniles and Adults*</u>: Distributed mesopelagically (most from 150-500 m) on the shelf (summer only?), but mostly in outer shelf/slope waters (to lesser extent over the open ocean). Migrate to slope waters to mate and spawn demersally.

Literature

Arkhipkin, A.I., V.A. Bizikov, V.V. Krylov, and K.N. Nesis. 1996. Distribution, stock structure, and growth of the squid *Berryteuthis magister* (Berry, 1913) (Cephalopoda, Gonatidae) during summer and fall in the western Bering Sea. Fish. Bull. 94: 1-30.

Akimushkin, I.I. 1963. Cephalopods of the seas of the U.S.S.R. Academy of Sciences of the U.S.S.R., Institute of Oceanology, Moscow. Translated from Russian by Israel Program for Scientific Translations, Jerusalem 1965. 223 p.

Byrd, G.V., J.C. Williams, and R. Walder. 1992. Status and biology of the tufted puffin in the Aleutian Islands, Alaska, after a ban on salmon driftnets. U. S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, Aleutian Islands Unit, PSC 486, Box 5251, FPO AP 96506-5251, Adak, Alaska.

Fritz, L.W. 1996. Other species *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK.

Hatch, S.A., G.V. Byrd, D.B. Irons, and G.L. Hunt, Jr. 1990. Status and ecology of kittiwakes in the North Pacific. Proc. Pacific Seabird Group Symposium, Victoria, B.C., 21-25 February 1990.

Livingston, P.A., and B.J. Goiney, Jr. 1983. Food habits literature of North Pacific marine fishes: a review and selected bibliography. U.S. Dep. Commerce., NOAA Tech. Memo. NMFS F/NWC-54, 81 p.

Nesis, K. N. 1987. Cephalopods of the world. TFH Publications, Neptune City, NJ, USA. 351 pp.

Perez, M. 1990. Review of marine mammal population and prey information for Bering Sea ecosystem studies. U.S. Dep. Commerce., NOAA Tech. Memo. NMFS F/NWC-186, 81 p.

Sobolevsky, Ye. I. 1996. Species composition and distribution of squids in the western Bering Sea. Pp. 135-141 *In* O.A. Mathisen and K.O. Coyle (eds.), Ecology of the Bering Sea: a review of Russian literature. Alaska Sea Grant Rept 96-01, U. Alaska, Fairbanks, AK 99775.

Springer, A. 1993. Report of the seabird working group. pp. 14-29 In Is it food? Addressing marine mammal and seabird declines: a workshop summary. Alaska Sea Grant Report 93-01, Univ. Alaska, Fairbanks, AK, 99775.

Yang, M.S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commerce., NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

SPECIES: Berryteuthis magister (red squid)

Life Stage	Duration or Age	Diet/Prey	Season-Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	1-2 months	NA	varies	USP,LSP	D	M,SM, MS	U	
Young juveniles	4-6 months	zooplankton		All shelf, slope, BSN	P,N	NA	UP,F?	
Older Juveniles and Adults	1-2 years (may be up to 4 yrs)	euphausiids, shrimp, small forage fish, and other cephalopods	summer	All shelf, USP,LSP,BSN	SP	U	UP,F?	Euhaline waters, 2-4˚C

Habitat Description for Octopus

Management Plan and Area GOA

Species Representatives:

Octopoda: Octopus *(Octopus gilbertianus; O. dofleini*)
Vampyromorpha: Pelagic octopus (*Vampyroteuthis infernalis*)

Life History and General Distribution:

Octopus are members of the molluscan class Cephalopoda, along with squid, cuttlefish and nautiloids. In the BSAI and GOA, the most commonly encountered octopods are the shelf demersal species *O. gilbertianus* and *O. dofleini*, and the bathypelagic finned species, *V. infernalis*. Octopods, like other cephalopods are dioecious, with fertilization of eggs (usually within the mantle cavity of the female) requiring transfer of spermatophores during copulation. Octopods probably do not live longer than about 2-4 years, and females of some species (e.g., *O. vulgaris*) die after brooding their eggs on the bottom.

O. gilbertianus - Medium sized octopus (up to 2 m in total length) distributed across the shelf (to 500 m depth) in the eastern and western Bering Sea (where it is the most common octopus), Aleutian Islands, and Gulf of Alaska (endemic to the North Pacific). Little is known of its reproductive or trophic ecology, but eggs laid on the bottom and tended by females. Lives mainly among rocks and stones.

O. dofleini - Giant octopus (up to 10 m in total length, though mostly about 3-5 m) distributed in the southern boreal region from Japan and Korea, through the Aleutian Islands, Gulf Alaska, and south along the Pacific coast of North America to California. Inhabits the sublittoral to upper slope. Egg length 6-8 mm; laid on bottom. Copulation may occur in late fall-winter, but oviposition the following spring; each female lays several hundred eggs.

V. infernalis - Relatively small (up to about 40 cm total length) bathypelagic species, living at depths well below the thermocline; may be most commonly found at 700-1500 m. Found throughout the world's oceans. Eggs are large (3-4 mm in diameter) and are shed singly into the water. Hatched juveniles resemble adults, but with different fin arrangements, which change to the adult form with development. Little is known of their food habits, longevity, or abundance.

Fishery

Not currently a target of groundfish fisheries of BSAI or GOA. Bycatch has ranged between 200-1,000 mt in the BSAI and 40-100 mt in the GOA, chiefly in the pot fishery for Pacific cod and bottom trawl fisheries for cod and flatfish, but sometimes in the pelagic trawl pollock fishery. Directed octopus landings have been less than 8 mt/year for 1988-95. Age/size at 50% recruitment is unknown. Most of the bycatch occurs on the outer continental shelf (100-200 m depth), chiefly north of the Alaskan peninsula from Unimak I. To Port Moller and northwest to the Pribilof Islands; also around Kodiak Island and many of the Aleutian Islands.

Relevant Trophic Information

Octopus are eaten by pinnipeds (principally Steller sea lions, and spotted, bearded, and harbor seals) and a variety of fishes, including Pacific halibut and Pacific cod (Yang 1993). When small, octopods eat planktonic and small benthic crustaceans (mysids, amphipods, copepods). As adults, octopus eat benthic crustaceans (crabs) and molluscs (clams).

Approximate upper size limit of juvenile fish (in cm): Unknown

Additional Information Source

NMFS, Alaska Fisheries Science Center, Sarah Gaichas

Habitat Narrative for *Octopus* spp.:

Egg/Spawning: shelf; eggs laid on bottom, maybe preferentially among rocks and cobble.

Young Juveniles: semi-demersal; widely dispersed on shelf, upper slope

Old Juveniles and Adults: demersal, widely dispersed on shelf and upper slope, preferentially among rocks, cobble, but also on sand/mud.

Literature

Akimushkin, I.I. 1963. Cephalopods of the seas of the U.S.S.R. Academy of Sciences of the U.S.S.R., Institute of Oceanology, Moscow. Translated from Russian by Israel Program for Scientific Translations, Jerusalem 1965. 223 p.

Fritz, L.W. 1996. Other species *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Nesis, K.N. 1987. Cephalopods of the world. TFH Publications, Neptune City, NJ, USA. 351 pp.

Perez, M. 1990. Review of marine mammal population and prey information for Bering Sea ecosystem studies. U.S. Dep. Commerce., NOAA Tech. Memo. NMFS F/NWC-186, 81 p.

Yang, M.S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commerce., NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

SPECIES: ***Octopus dofleini*, *O. gilbertianus***

Life Stage	Duration or Age	Diet/Prey	Season-Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U (1-2 months?)	NA	spring-summer?	U (IS, MS?)	D	R, G?	U	Euhaline waters
Young juveniles	U	zooplankton	summer-fall	U (IS, MS, OS, USL?)	D,SD	U	U	Euhaline waters
Older Juveniles and Adults	U (2-3 yrs? for *O.gilbertianus*; older for *O.dofleini*)	crustaceans, molluscs	all year	IS, MS, OS, USL	D?	R, G, S, MS	U	Euhaline waters

APPENDIX F.2

ESSENTIAL FISH HABITAT ASSESSMENT REPORT

for the Groundfish Resources of the

Bering Sea and Aleutian Islands Regions

May 16, 2003

NOAA Fisheries
NMFS Alaska Region
709 West 9th Street
Juneau, AK 99802

NOAA Fisheries
National Marine Fisheries Service

Table of Contents

Introduction F.2-1
Table 1 - Summary of Major References and Atlases F.2-3
Table 2 - Summary of Habitat Associations for Groundfish in the BSAI F.2-5
Table 3 - Summary of Reproductive Traits for Groundfish in the BSAI F.2-8
Table 4 - Summary of Predator and Prey Relationships for Groundfish in the BSAI F.2-9
Habitat Description for Walleye pollock F.2-12
Habitat Description for Pacific cod F.2-20
Habitat Description for Yellowfin Sole F.2-24
Habitat Description for Greenland Turbot F.2-29
Habitat Description for Arrowtooth Flounder F.2-33
Habitat Description for Rock Sole F.2-37
Habitat Description for Alaska Plaice F.2-41
Habitat Description for Rex Sole F.2-44
Habitat Description for Dover Sole F.2-47
Habitat Description for Flathead Sole F.2-50
Habitat Description for Sablefish F.2-53
Habitat Description for Pacific Ocean Perch F.2-58
Habitat Description for Shortraker Rockfish and Rougheye Rockfish F.2-63
Habitat Description for Northern Rockfish F.2-66
Habitat Description for Thornyhead Rockfish F.2-70
Habitat Description for Habitat Description for Dusky Rockfish F.2-74
Habitat Description for Atka Mackerel F.2-78
Habitat Description for Capelin F.2-82
Habitat Description for Eulachon F.2-86
Habitat Description for Sculpins F.2-90
Habitat Description for Sharks F.2-94
Habitat Description for Skates F.2-97
Habitat Description for Squid F.2-100
Habitat Description for Octopus F.2-104

Introduction

In 1996, the Sustainable Fisheries Act amended the Magnuson-Stevens Fishery Conservation and Management Act to require the description and identification of Essential Fish Habitat (EFH) in Fishery Management Plans (FMPs), adverse impacts on EFH, and actions to conserve and enhance EFH. Guidelines were developed by the National Marine Fisheries Service (NMFS) to assist Fishery Management Councils in fulfilling the requirements set forth by the Act.

Essential fish habitat means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat: "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means the habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

With respect to type, the information available for almost all species is primarily broad geographic distributions based on specific samples from surveys and fisheries, which have not been linked with habitat characteristics. Furthermore, our ability to precisely define the habitat (and its location) of each life stage of each managed groundfish species in terms of its oceanographic (temperature, salinity, nutrient, current), trophic (presence of food, absence of predators), and physical (depth, substrate, latitude, and longitude) characteristics is very limited. Consequently, the information included in the habitat descriptions for each species and life stage is restricted primarily to their position in the water column (e.g., demersal, pelagic), broad biogeographic and bathymetric areas (e.g., 100-200 m zone, south of the Pribilof Islands and throughout the Aleutian Islands), and occasional references to known bottom types associations.

Identification of EFH for some species included historical range information. Traditional knowledge and sampling data have indicated that fish distributions may contract and expand due to a variety of factors including, but not limited to, temperature changes, current patterns, changes in population size, and changes in predator and prey distribution.

Background

In preparation of the 1999 Essential Fish Habitat Environmental Assessment, EFH Technical Teams, comprised of scientific stock assessment authors, compiled scientific information and prepared the 1999 Habitat Assessment Reports. These reports provided the scientific information baseline to describe EFH. Importantly, recent scientific evidence has not proved to change existing life history profiles of the federally managed species. However, where new information does exist, new data helps to fill information gaps in the region's limited habitat data environment.

Stock assessment authors used information contained in these summaries and personal knowledge, along with data contained in reference atlases (NOAA 1987; 1990; 1997a;b), fishery and survey data (Allen and Smith 1988; Wolotira et al. 1993; NOAA 1998), and fish identification books (Hart 1973; Eschmeyer and Herald 1983; Mecklenburg and Thorsteinson 2002), to describe EFH for each life stage using best scientific judgment and interpretation; see Table 1.

Species Profiles and Habitat Descriptions

FMP's must describe EFH in text, map EFH distributions, and include tables, which provide information on habitat and biological requirements for each life history stage of the species; see Tables 2-4. Information contained in this report details life history information for federally managed fish species. This collection of scientific information is interpreted, then referenced to describe and delineate EFH for each species by life history stage using GIS. EFH text and map descriptions are not compiled in this report due to differences in the characteristics of a species life history and the overall distribution of the species. Specific EFH text descriptions and maps are in Appendix D.

References

Allen, M. J., and G. B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Eschmeyer, W. N., and E. S. Herald. 1983. A field guide to Pacific coast fishes. Houghton Mifflin Co., Boston. 336 p.

Hart, J. L. 1973. Pacific fishes of Canada. Fisheries Research Board of Canada Bulletin 180. Ottawa. 740 p.

Mecklenburg, C.W. , Mecklenburg ,T.A ., and Thorsteinson, L.K. 2002. Fishes of Alaska. American Fish Society. Bethesda, Maryland. 1037 p.

NOAA. 1987. Bering, Chukchi, and Beaufort Seas. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerce, NOAA, NOS.

NOAA. 1990. West coast of North America. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerce, NOAA, NOS.

NOAA. 1998. Catch-per-unit-effort, length, and depth distributions of major groundfish and bycatch species in the Bering Sea, Aleutian Islands and Gulf of Alaska regions based on groundfish fishery observer data. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-88.

NPFMC. 1997a. Essential fish habitat assessment report for the groundfish resources of the Bering Sea and Aleutian Islands regions. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

NPFMC. 1997b. Essential fish habitat assessment report for the groundfish resources of the Gulf of Alaska region. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Wolotira, R. J., Jr., T. M. Sample, S. F. Noel, and C. R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U.S. Dep. Commerce., NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Table 1. Summary of Major References and Atlases

Species	References					
	Allen and Smith 1988	NOAA 1987	NOAA 1990	Wolotira et al. 1993	NOAA 1998	Mecklenburg and Thorsteinson 2002
Walleye pollock	X	X	X	X	X	X
Pacific cod	X	X	X	X	X	X
Yellowfin sole	X	X		X	X	X
Greenland turbot	X	X		X	X	X
Arrowtooth flounder	X	X	X	X	X	X
Rock sole	X	X		X	X	X
Alaska plaice	X	X		X	X	X
Flathead sole	X	X	X	X	X	X
Sablefish	X		X	X	X	X
Pacific ocean perch	X		X	X	X	X
Shortraker-rougheye rockfish	X				X	X
Northern rockfish	X				X	X
Dusky rockfish	X				X	X
Thornyhead rockfish	X				X	X
Atka mackerel	X		X	X	X	X
Sculpins	X				X	X
Skates	X				X	X

Abbreviations used in the EFH report tables to specify location, depth, bottom type, and other oceanographic features.

Location

ICS = inner continental shelf (1-50 m)
MCS = middle continental shelf (50-100 m)
OCS = outer continental shelf (100-200 m)
USP = upper slope (200-1000 m)
LSP = lower slope (1000-3000 m)
BSN= basin (>3000 m)

BCH = beach (intertidal)
BAY = nearshore bays, give depth if appropriate (e.g., fjords)
IP = island passes (areas of high current), give depth if appropriate

Water column

D = demersal (found on bottom)
SD/SP =semi-demersal or semi-pelagic if slightly greater or less than 50% on or off bottom
P = pelagic (found off bottom, not necessarily associated with a particular bottom type)
N = neustonic (found near surface)

Bottom Type

M = mud
S = sand
R = rock
SM = sandy mud
CB = cobble
C = coral
MS = muddy sand
G = gravel
K = kelp
SAV = subaquatic vegetation (e.g., eelgrass, not kelp)

Oceanographic Features

UP = upwelling
G = gyres
F = fronts
E = edges
CL = thermocline or pycnocline

General

U = Unknown
N/A = not applicable

Table 2. Summary of Habitat Associations for Groundfish in the BSAI

BSA Groundfish		Nearshore				Shelf			Slope					Stratum Reference							Location							Physical Oceanography					Substrate														Structure								Community Associations									Oceanographic Properties			
						Inner	Middle	Outer	Upper	Inter-mediate	Lower	Basin													Pelagic																																										
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surface	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Echinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
Walleye Pollock	M						x	x	x	x				x		x	x	x	x	x	x		x	x	x	x	x		x	x	x	x		x	x	x	x	x	x	x	x	x	x	x																							M
	J					x	x	x								x	x	x	x	x	x		x	x	x	x			x	x	x	x		x	x	x	x	x	x	x	x	x	x	x																								J
	L						x	x								x	x	x	x	x	x		x	x	x	x			x	x	x	x		x	x	x	x	x	x	x	x	x	x	x																								L
	E						x	x	x	x	x	x	x	x		x	x	x	x	x	x		x	x		x			x	x	x	x																																			E
Pacific Cod	M					x	x	x	x	x					x	x	x	x	x	x	x				x									x	x	x	x	x	x	x	x	x	x	x					x	x		x				x	x	x	x	x					x	x				M
	LJ					x	x								x	x	x	x	x	x	x				x									x	x	x	x	x	x	x	x	x	x	x					x	x		x				x	x	x	x	x					x	x				LJ
	EJ				x	x									x		x							x	x									x	x	x	x	x	x	x	x	x	x													x	x	x			x		x							EJ
	L					x	x	x																		x																																									L
	E					x	x	x																	x									x	x	x	x	x	x	x	x	x	x	x																						3-6	13-23	2-3	E
Atka Mackerel	M					x	x	x								x							x	x				x			x	x			x	x								x							x								x					3-5	>17		M
	J																																																															3-5			J
	L																					x	x																																									2-12			L
	E					x										x									x											x								x															x					3-20			E
Sablefish	M								x	x	x	x	x				x				x				x				x						x	x							x	x																							M
	LJ							x	x	x	x						x				x				x				x						x	x	x							x	x																							LJ
	EJ					x	x	x									x								x	x	x		x																																						EJ
	L						x	x	x	x	x	x	x	x								x	x						x																																						L
	E								x	x	x	x	x	x												x	x		x																																							E
Pacific Ocean Perch	M							x	x	x								x	x	x	x			x	x	x			x							x							x	x														x										M
	LJ					x	x	x	x																																																								LJ
	EJ					x	x	x					x	x										x	x	x	x	x	x							x								x	x																							EJ
	L																					x	x		x	x		x																																							L
	E								x	x	x	x	x	x												x	x		x																																							E
Flathead Sole	M					x	x	x	x																x							x		x	x	x			x		x																												M
	LJ					x	x	x																	x									x	x	x			x		x																											LJ
	EJ					x	x																		x										x	x																																EJ
	L					x	x	x																		x				x																																						L
	E					x	x	x																		x																																									E
Yellowfin Sole	M					x	x																		x									x	x				x																													M
	LJ					x	x																		x									x	x				x																													LJ
	EJ					x																			x									x	x				x																													EJ
	L					x	x																			x																																									L
	E					x	x																			x																																									E
Alaska Plaice	M					x	x	x																	x									x	x				x																													M
	LJ					x	x	x																	x									x	x				x																													LJ
	EJ					x	x																		x									x	x				x																													EJ
	L					x	x	x																		x				x																																					L
	E					x	x	x																		x																																									E
Arrowtooth Flounder	M					x	x	x	x	x	x														x									x	x	x			x																													M
	LJ					x	x	x																	x									x	x	x			x																													LJ
	EJ					x	x																		x									x	x	x			x																													EJ
	L					x	x	x	x	x																x				x																																					L
	E					x	x	x	x	x															x																																									E
Rock Sole	M					x	x	x																	x									x	x				x																													M
	LJ					x	x																		x									x	x				x																													LJ
	EJ					x																			x									x	x				x																													EJ
	L					x	x	x																		x				x																																					L
	E					x	x	x																	x																																										E
Dover Sole	M					x	x	x	x	x	x	x													x									x	x			x																														M
	LJ					x	x	x	x	x															x									x	x			x																													LJ
	EJ					x	x																		x									x	x			x																													EJ

Table 2. Summary of Habitat Associations for Groundfish in the BSAI

BSA Groundfish		Nearshore				Shelf			Slope					Stratum Reference							Location							Physical Oceanography					Substrate															Structure								Community Associations									Oceanographic Properties			
						Inner	Middle	Outer	Upper	Inter-mediate		Lower	Basin												Pelagic																																											
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surface	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
	L					x	x	x	x	x																x					x																																								L
	E					x	x	x	x	x																x																																											E
Rex Sole	M					x	x	x	x	x															x									x	x				x																															M
	LJ					x	x	x	x																x									x	x				x																															LJ
	EJ					x	x																		x									x	x				x																															EJ
	L					x	x	x	x																	x									x	x																																		L
	E					x	x	x	x																	x																																										E
Greenland Turbot	M							x	x	x	x														x									x	x	x		x																															M
	LJ					x	x																		x									x	x			x																															LJ
	EJ																								x									x	x			x																															EJ
	L					x	x	x	x	x																x					x																																					L
	E					x	x	x	x	x																x																																										E
Shortraker/Rougheye	M								x	x																x									x	x		x							x																									M
Rockfish	LJ					x	x	x	x								x	x	x	x	x																																														LJ
	EJ												x	x									x																																												EJ
	L																										x																																									L
Northern Rockfish	M						x	x										x							x																			x	x																							M
	LJ						x	x										x	x						x																																									LJ
	EJ																									x																																									EJ
	L																																																																		L
Thornyhead Rockfish	M								x	x	x	x	x												x											x							x	x																								M
	LJ						x	x	x																x											x								x																								LJ
	EJ																									x																																									EJ
	L																									x																																									L
	E																									x																																									E
Light Dusky Rockfish	M							x	x									x		x	x				x											x							x	x																								M
	LJ						x	x										x		x					x																																									LJ
	EJ																																																																		EJ
	L																																																																		L
Sculpins	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x			x	x																																												M
	LJ																																																																		LJ
	EJ																																																																		EJ
	L																																																																		L
	E																																																																			E
Skates	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x			x	x																																												M
	LJ																																																																		LJ
	EJ																																																																		EJ
	L																																																																			L
	E																																																																			E
Sharks	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x																																										M
	LJ																																																																		LJ
	EJ																																																																			EJ
	L																																																																				L
	E																																																																				E
Squid	M				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x																																										M
	LJ																																																																			LJ
	EJ																																																																			EJ
	L																																																																				L
	E																																																																				E
Octopus	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x				x	x	x																																										M

Table 2. Summary of Habitat Associations for Groundfish in the BSAI

BSA Groundfish		Nearshore				Shelf			Slope						Stratum Reference							Location							Physical Oceanography					Substrate														Structure								Community Associations									Oceanographic Properties			
						Inner	Middle	Outer	Upper	Inter-mediate	Lower	Basin														Pelagic																																										
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surafce	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
	LJ																																																																										LJ
	EJ																																																																									EJ
	L																																																																									L
	E																																																																									E
Eulachon	M						X	X	X								X									X			X			X	X																																							M
	LJ						X	X																		X			X			X	X																																								LJ
	EJ					X	X																			X			X			X																																									EJ
	L	X	X			X	X										X						X																																															L
	E	X																																																																				E
Capelin	M						X	X									X									X			X			X	X																																								M
	LJ						X	X																		X			X			X	X																																								LJ
	EJ					X	X																			X			X			X																																									EJ
	L		X			X	X										X						X																																																L
	E			X											X																				X	X				X																																E
Sand Lance	M			X	X	X									X		X					X	X	X	X	X									X	X				X																															M
	LJ			X	X	X									X		X					X	X	X	X	X									X	X				X																															LJ
	EJ		X		X	X									X		X					X	X			X																																													EJ
	L		X			X									X		X					X	X			X																																													L
	E			X													X																																																					E

Table 3. Summary of Reproductive Traits for Groundfish in the BSAI

BSAI Groundfish		Reproductive Traits																										
		Age at Maturity				Fertilization/Egg Development					Spawning Behavior						Spawning Season											
		Female		Male																								
Species	Life Stage	**50%**	**100%**	**50%**	**100%**	**External**	**Internal**	**Oviparous**	**Ovoviviparous**	**Viviparous**	**Batch Spawner**	**Broadcast Spawner**	**Egg Case Deposition**	**Nest Builder**	**Egg/Young Guarder**	**Egg/Young Bearer**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Walleye Pollock	M	4-5		4-5		x						x						x	x	x	x							
Pacific Cod	M	5		5		x						x					x	x	x	x	x							
Atka Mackerel	M	3.6		3.6		x								x	x						x	x	x	x	x	x		
Sablefish	M					x						x					x	x	x	x	x							
Pacific Ocean Perch	M	10.5					x			x	x														x	x	x	x
Flathead Sole	M	10				x											x	x	x	x								x
Yellowfin Sole	M	10.5				x					x										x	x	x					
Alaska Plaice	M	6-7				x													x	x	x							
Arrowtooth Flounder	M	5		4		x											x	x	x	x							x	x
Rock Sole	M	9				x					x						x	x	x									
Rex Sole	M	24cm		16cm		x												x	x	x	x	x	x					
Greenland Turbot	M	5-10				x											x	x	x							x	x	x
Dover Sole	M	33cm				x											x	x	x	x	x	x	x	x				
Shortraker/Rougheye Rockfish	M	20+					x			x	x												x	x	x	x	x	x
Northern Rockfish	M	13					x			x	x																	
Thornyhead Rockfish	M	12									x							x				x						
Dusky Rockfish	M	11					x			x	x																	
Sculpins	M					x									x													
Skates	M						x	x					x															
Sharks	M						x	x	x	x			x			x												
Squid	M						x				x																	
Octopus	M						x				x			x	x													
Eulachon	M	3	5	3	5	X		X			X									X	X	X						
Capelin	M	2	4	2	4	X		X			X										X	X	X	X				
Sand Lance	M	1	2	1	2	X		X			X						X	X									X	X

Table 4. Summary of Predator and Prey Relationships for Groundfish in the BSAI

Predator to

BSAI Groundfish Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut
Walleye Pollock	M				x			x			x			x						x	x	x	x	x		x			x	x	x
	LJ				x			x			x			x						x	x	x	x	x		x			x	x	x
	EJ				x			x			x									x	x	x									
	L				x			x			x																				
	E																														
Pacific Cod	M							x		x			x							x										x	
	LJ							x		x			x							x										x	
	EJ							x		x			x							x											
	L			x	x						x																				
	E																														
Atka Mackerel	M							x			x													x							
	J							x			x																				
	L										x																				
	E																														
Sablefish	M							x	x	x	x		x	x				x		x		x	x		x	x		x	x	x	
	LJ							x	x	x	x		x	x				x		x		x	x		x	x		x	x	x	
	EJ							x		x	x		x	x	x			x		x			x					x			
	L				x						x																				
	E																														
Pacifc Ocean Perch	M							x																							
	LJ							x			x																				
	EJ																														
	L			x	x																										
Flathead Sole	M							x		x	x		x			x	x	x	x		x	x								x	
	LJ							x		x	x		x			x	x	x	x											x	
	EJ				x								x			x			x											x	
	L	x		x																											
	E																														
Yellowfin Sole	M							x		x			x			x		x		x					x					x	
	LJ							x		x			x			x		x		x					x						
	EJ				x																										
	L	x		x																											
	E																														
Arrowtooth Flounder	M												x	x				x	x	x			x	x						x	
	LJ												x					x	x	x			x	x						x	
	EJ				x																										
	L	x		x																											
	E																														
Rock Sole	M									x			x			x	x														
	LJ									x			x			x	x														
	EJ				x																										
	L	x		x																											
	E																														

Prey of

BSAI Groundfish Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Halibut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrestrial Mammals
Walleye Pollock	M								x						x	x	x	x	x	x										
	LJ							x	x						x	x		x	x	x				x		x	x	x		
	EJ							x	x						x	x		x	x	x				x		x	x	x		
	L							x	x						x	x								x		x	x	x		
	E																													
Pacific Cod	M															x	x	x		x		x	x	x						
	LJ															x	x	x		x		x	x	x						
	EJ															x	x	x				x	x	x			x			
	L																													
	E																													
Atka Mackerel	M								x						x	x			x	x	x			x						
	J																			x						x	x			
	L																													
	E																													
Sablefish	M																													
	LJ						x									x														
	EJ																													
	L																													
	E																													
Pacifc Ocean Perch	M															x														
	LJ																													
	EJ						x																							
	L																													
Flathead Sole	M								x				x		x	x														
	LJ																													
	EJ																													
	L																													
	E																													
Yellowfin Sole	M																													
	LJ								x							x														
	EJ								x							x														
	L																													
	E																													
Arrowtooth Flounder	M																													
	LJ							x	x																					
	EJ																													
	L																													
	E																													
Rock Sole	M																													
	LJ							x	x					x		x														
	EJ																													
	L																													
	E																													

Table 4. Summary of Predator and Prey Relationships for Groundfish in the BSAI

Predator to

BSAI Groundfish Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut
Dover Sole	M												X				X	X													
	LJ												X				X	X													
	EJ																														
	L	X		X																											
	E																														
Rex Sole	M							X		X			X					X													
	LJ							X		X			X					X													
	EJ																														
	L	X		X																											
	E																														
Greenland Turbot	M												X					X	X	X			X	X						X	
	LJ																														
	EJ				X																										
	L	X		X																											
	E																														
Shortraker/Rougheye Rockfish	M													X						X				X							
	LJ																														
	EJ																														
	L																														
Northern Rockfish	M							X			X																				
	LJ																														
	EJ																														
	L																														
Thornyhead Rockfish	M																			X					X						
	LJ																														
	EJ																														
	L																														
	E																														
Light Dusky Rockfish	M							X																							
	LJ																														
	EJ																														
	L																														
Sculpins	M				X			X	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X		X	X		
	LJ																														
	EJ																														
	L																														
	E																														
Skates	M									X		X	X					X		X	X		X		X	X	X	X	X	X	X
	LJ																														
	EJ																														
	L																														
	E																														
Sharks	M													X				X		X							X	X		X	X

Prey of

Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Halibut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrestrial Mammals
Dover Sole	M								X						X															
	LJ								X						X															
	EJ																													
	L																													
	E																													
Rex Sole	M								X						X															
	LJ								X						X															
	EJ																													
	L																													
	E																													
Greenland Turbot	M																													
	LJ																													
	EJ							X	X					X																
	L																													
	E																													
Shortraker/Rougheye Rockfish	M																													
	LJ																													
	EJ																													
	L																													
Northern Rockfish	M																													
	LJ																													
	EJ																													
	L																													
Thornyhead Rockfish	M																													
	LJ																													
	EJ																													
	L																													
	E																													
Light Dusky Rockfish	M																													
	LJ																													
	EJ																													
	L																													
Sculpins	M										X		X		X	X		X	X	X	X	X								
	LJ																													
	EJ																													
	L																													
	E																													
Skates	M																													
	LJ																													
	EJ																													
	L																													
	E																													
Sharks	M																													

Table 4. Summary of Predator and Prey Relationships for Groundfish in the BSAI

BSAI Groundfish		Predator to																																Prey of																										
Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut		Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Halibut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrestrial Mammals
	LJ																															LJ																													
	EJ																															EJ																													
	L																															L																													
	E																															E																													
Squid	M							x			x									x	x	x	x								M	x					x	x	x	x	x	x	x			x		x	x	x	x	x		x		x	x	x		
	LJ																															LJ																													
	EJ																															EJ																													
	L																															L																													
	E																															E																													
Octopus	M																x	x	x												M								x			x	x		x		x	x	x		x								
	LJ																															LJ																													
	EJ																															EJ																													
	L																															L																													
	E																															E																													
Eulachon	M				X			X			X																				M						X	X	X							X		X	X	X	X					X	X			X
	LJ				X			X			X																				LJ						X	X	X							X		X	X	X	X					X	X			
	EJ				X			X			X																				EJ					X	X	X	X							X														
	L			X	X	X		X			X																				L					X	X	X	X							X														
	E																															E																													
Capelin	M				X			X			X		X							X											M						X	X	X						X	X		X	X	X	X					X	X			
	LJ				X			X			X																				LJ						X	X	X						X	X		X	X	X	X					X	X			
	EJ				X			X			X																				EJ					X	X	X	X						X	X														
	L			X	X	X		X			X																				L					X	X	X	X						X	X														
	E																															E																													
Sand Lance	M				X			X		X	X																				M						X	X	X						X	X		X	X	X	X					X	X			
	LJ				X			X		X	X																				LJ						X	X	X						X	X		X	X	X	X					X	X			
	EJ				X			X		X	X																				EJ					X	X	X	X						X	X														
	L			X	X	X		X		X	X																				L					X	X	X	X						X	X														
	E																															E																													

Habitat Description for

Walleye pollock (*Theragra calcogramma)*

Management Plan and Area BSAI

The Gulf of Alaska are managed under the Gulf of Alaska Groundfish Fisheries Management Plan and the Eastern Bering Sea (EBS) and Aleutian Islands pollock stocks are managed under the EBS and Aleutian Islands Groundfish Fisheries Management Plan. Pollock occur throughout the area covered by the FMP and straddle into the Canadian and Russian EEZ, international waters of the central Bering Sea, and into the Chukchi Sea.

Life History and General Distribution

Pollock is the most abundant species within the eastern Bering Sea comprising 75-80% of the catch and 60% of the biomass. In the Gulf of Alaska, pollock is the second most abundant groundfish stock comprising 25-50% of the catch and 20% of the biomass.

Four stocks of pollock are recognized for management purposes: Gulf of Alaska, eastern Bering Sea, Aleutian Islands, and Aleutian Basin. There appears to be a high degree of interrelationship among the eastern Bering Sea, Aleutian Islands, and Aleutian Basin stocks with suggestions of movement from one area to the others. There appears to be stock separation between the Gulf of Alaska stocks and stocks to the north.

The most abundant stock of pollock is the eastern Bering Sea stock which is primarily distributed over the eastern Bering Sea outer continental shelf between approximately 70-200 m. Information on pollock distribution in the eastern Bering Sea comes from commercial fishing locations, annual bottom trawl surveys and triennial acoustic surveys.

The Aleutian Islands stock extends through the Aleutian Islands from 170° W to the end of the Aleutian Islands (Attu Island), with the greatest abundance in the eastern Aleutians (170° W to Seguam Pass). Most of the information on pollock distribution in the Aleutian Islands comes from triennial bottom trawl surveys. These surveys indicate that pollock are primarily located on the Bering Sea side of the Aleutian Islands, and have a spotty distribution throughout the Aleutian Islands chain. The bottom trawl data may not provide an accurate view of pollock distribution because a significant portion of the pollock biomass is likely to be unavailable to bottom trawls. Also, many areas of the Aleutian Islands shelf are untrawlable due to rough bottom.

The third stock, Aleutian Basin, appears to be distributed throughout the Aleutian Basin which encompasses the U.S. EEZ, Russian EEZ, and international waters in the central Bering Sea. This stock appears to move throughout the Basin for feeding, but concentrate in deepwater near the continental shelf for spawning. The principal spawning location is near Bogoslof Island in the eastern Aleutian Islands, but data from pollock fisheries in the first quarter of the year indicate that there are other concentrations of deepwater spawning concentrations in the western Aleutian Islands. The Aleutian Basin spawning stock appears to be derived from migrants from the eastern Bering Sea shelf stock, and possibly some western Bering Sea pollock. Recruitment to the stock occurs generally around age 5, very few pollock younger than age 5 have been found in the Aleutian Basin. Most of the pollock in the Aleutian Basin appear to originate from strong year classes.

The Gulf of Alaska stock extends from southeast Alaska to the Aleutian Islands (170° W), with the greatest abundance in the western and central regulatory areas (147° W to 170° W). Most of the information on pollock distribution in the Gulf of Alaska comes from triennial bottom trawl surveys. These surveys indicate that pollock are distributed throughout the shelf regions of the Gulf of Alaska at depths less than 300 m. The bottom trawl data may not provide an accurate view of pollock distribution

because a significant portion of the pollock biomass may be pelagic and not available to bottom trawls. The principal spawning location is in Shelikof Strait, but data from pollock fisheries and exploratory surveys indicate that there are other concentrations of spawning in the Shumagin Islands, the east side of Kodiak Island and near Prince William Sound.

Peak pollock spawning occurs on the southeastern Bering Sea and eastern Aleutian Islands along the outer continental shelf around mid-March. North of the Pribilof Islands spawning occurs later (April-May) in smaller spawning aggregations. The deep spawning pollock of the Aleutian Basin appear to spawn slightly earlier, late February-early March. In the Gulf of Alaska, peak spawning occurs in late March in Shelikof Strait. Peak spawning in the Shumagin area appears to 2-3 weeks earlier than in Shelikof Strait.

Spawning occurs in the pelagic zone and eggs develop throughout the water column (70-80 m in the Bering Sea shelf, 150-200 m in Shelikof Strait). Development is dependent on water temperature. In the Bering Sea, eggs take about 17-20 days to develop at 4 degrees in the Bogoslof area and 25.5 days at 2 degrees on the shelf. In the Gulf of Alaska, development takes approximately 2 weeks at ambient temperature (5 degrees C). Larvae are also distributed in the upper water column. In the Bering Sea the larval period lasts approximately 60 days. The larvae eat progressively larger naupliar stages of copepods as they grow and then small euphausiids as they approach transformation to juveniles (~25 mm standard length). In the Gulf of Alaska, larvae are distributed in the upper 40 m of the water column and the diet is similar to Bering Sea larvae. FOCI survey data indicate larval pollock may utilize the stratified warmer upper waters of the mid-shelf to avoid predation by adult pollock which reside in the colder bottom water.

At age 1 pollock are found throughout the eastern Bering Sea both in the water column and on bottom. Age 1 pollock from strong year-classes appear to be found in great numbers on the inner shelf, and further north on the shelf than weak year classes which appear to be more concentrated on the outer continental shelf. From age 2-3 pollock are primarily pelagic and then to be most abundant on the outer and mid-shelf northwest of the Pribilof Islands. As pollock reach maturity (age 4) in the Bering Sea, they appear to move from the northwest to the southeast shelf to recruit to the adult spawning population. Strong year-classes of pollock persist in the population in significant numbers until about age 12, and very few pollock survive beyond age 16. The oldest recorded pollock was age 31.

Growth varies by area with the largest pollock occurring on the southeastern shelf. On the northwest shelf the growth rate is slower. A newly maturing pollock is around 40 cm.

Fishery

The eastern Bering Sea pollock fishery has, since 1990 been divided into two fishing periods; an "A season" occurring in January-March, and a "B season" occurring in August-October. The A season concentrates fishing effort on prespawning pollock in the southeastern Bering Sea. During the B season fishing is still primarily in the southeastern Bering Sea, but some fishing also occurs on the northwestern shelf. Also during the B season catcher processor vessels are required to fish north of 56° N latitude because the area to the south is reserved for catcher vessels delivering to shoreside processing plants on Unalaska and Akutan.

Since 1992, the Gulf of Alaska pollock TAC has been apportioned spatially and temporally to reduce impacts on Steller sea lions. Although the details of the apportionment scheme have evolved over time, the general objective is to allocate the TAC to management areas based on the distribution of surveyed biomass, and to establish three or four seasons between mid-January and autumn during which some fraction of the TAC can be taken. The Steller Sea Lion Protection Measures implemented in 2001 establish four seasons in the Central and Western GOA beginning January 20, March 10, August 25, and October 1, with 25% of the total TAC allocated to each season. Allocations to management areas 610, 620 and 630 are based on the seasonal biomass distribution as estimated by groundfish surveys. In

addition, a new harvest control rule was implemented that requires a cessation of fishing when spawning biomass declines below 20% of unfished stock biomass.

In the Gulf of Alaska approximately 90% of the pollock catch is taken using pelagic trawls. During winter, fishing effort usually targeted primarily on pre-spawning aggregations in Shelikof Strait and near the Shumagin Islands. The pollock fishery has a very low bycatch rate with discards averaging about 2% since 1998 (with the 1991-1997 average around 9%). Most of the discards in the pollock fishery are juvenile pollock, or pollock too large to fit filleting machines. In the pelagic trawl fishery the catch is almost exclusively pollock.

The eastern Bering Sea pollock fishery primarily harvests mature pollock. The age where fish are selected by the fishery roughly corresponds to the age at maturity (management guidelines are oriented towards conserving spawning biomass). Fishery selectivity increases to a maximum around age 6-8 and declines slightly. The reduced selectivity for older ages is due to pollock becoming increasingly demersal with age. Younger pollock form large schools and are semi-demersal, thereby being easier to locate by fishing vessels. Immature fish (ages 2 and 3) are usually caught in low numbers. Generally the catch of immature pollock increases when strong year-classes occur and the abundance of juveniles increase sharply. This occurred with the 1989 year-class, the second largest year-class on record. Juvenile bycatch increased sharply in 1991 and 1992 when this year-class was age 2 and 3. A secondary problem is that strong to moderate year-classes may reside in the Russian EEZ adjacent to the U. S. EEZ as juveniles. Russian catch-age data and anecdotal information suggest that juveniles may comprise a major portion of the catch. There is a potential for the Russian fishery to reduce subsequent abundance in the U. S. fishery.

The Gulf of Alaska pollock fishery also targets mature pollock. Fishery selectivity increases to a maximum around age 5-7 and then declines. In both the EBS and GOA, the selectivity pattern varies between years due to shifts in fishing strategy and changes in the availability of different age groups over time.

In response to continuing concerns over the possible impacts groundfish fisheries may have on rebuilding populations of Steller sea lions, NMFS and the NPFMC have made changes to the Atka mackerel (mackerel) and pollock fisheries in the Bering Sea/Aleutian Islands and Gulf of Alaska. These have been designed to reduce the possibility of competitive interactions with Steller sea lions. For the pollock fisheries, comparisons of seasonal fishery catch and pollock biomass distributions (from surveys) by area in the eastern Bering Sea led to the conclusion that the pollock fishery had disproportionately high seasonal harvest rates within critical habitat which *could* lead to reduced sea lion prey densities. Consequently, the management measures were designed to redistribute the fishery both temporally and spatially according to pollock biomass distributions. The underlying assumption in this approach was that the independently derived area-wide and annual exploitation rate for pollock would not reduce local prey densities for sea lions. Here we examine the temporal and spatial dispersion of the fishery to evaluate the potential effectiveness of the measures.

Three types of measures were implemented in the pollock fisheries:

> Additional pollock fishery exclusion zones around sea lion rookery or haulout sites,
>
> Phased-in reductions in the seasonal proportions of TAC that can be taken from critical habitat, and
>
> Additional seasonal TAC releases to disperse the fishery in time.

Prior to the management measures, the pollock fishery occurred in each of the three major fishery management regions of the north Pacific ocean managed by the NPFMC: the Aleutian Islands (1,001,780 km^2 inside the EEZ), the eastern Bering Sea (968,600 km^2), and the Gulf of Alaska (1,156,100 km^2). The marine portion of Steller sea lion critical habitat in Alaska west of 150˚W encompasses 386,770 km^2 of ocean surface, or 12% of the fishery management regions.

Prior to 1999, a total of 84,100 km^2, or 22% of critical habitat, was closed to the pollock fishery. Most of this closure consisted of the 10 and 20 nm radius all-trawl fishery exclusion zones around sea lion rookeries (48,920 km^2 or 13% of critical habitat). The remainder was largely management area 518 (35,180 km^2, or 9% of critical habitat) which was closed pursuant to an international agreement to protect spawning stocks of central Bering Sea pollock.

In 1999, an additional 83,080 km^2 (21%) of critical habitat in the Aleutian Islands was closed to pollock fishing along with 43,170 km^2 (11%) around sea lion haulouts in the GOA and eastern Bering Sea. Consequently, a total of 210,350 km^2 (54%) of critical habitat was closed to the pollock fishery. The portion of critical habitat that remained open to the pollock fishery consisted primarily of the area between 10 and 20 nm from rookeries and haulouts in the GOA and parts of the eastern Bering Sea foraging area.

The Bering Sea/Aleutian Islands pollock fishery was also subject to changes in total catch and catch distribution. Disentangling the specific changes in the temporal and spatial dispersion of the EBS pollock fishery resulting from the sea lion management measures from those resulting from implementation of the 1999 American Fisheries Act (AFA) is difficult. The AFA reduced the capacity of the catcher/processor fleet and permitted the formation of cooperatives in each industry sector by 2000. Both of these changes would be expected to reduce the rate at which the catcher/processor sector (allocated 36% of the EBS pollock TAC) caught pollock beginning in 1999, and the fleet as a whole in 2000. Because of some of its provisions, the AFA gave the industry the ability to respond efficiently to changes mandated for sea lion conservation that otherwise could have been more disruptive to the industry.

In 2000, further reductions in seasonal pollock catches from BSAI sea lion critical habitat were realized by closing the entire Aleutian Islands region to pollock fishing and by phased-in reductions in the proportions of seasonal TAC that could be caught from the Sea Lion Conservation Area, an area which overlaps considerably with sea lion critical habitat. In 1998, over 22,000 t of pollock were caught in the Aleutian Island regions, with over 17,000 t caught in AI critical habitat. Since 1998 directed fishery removals of pollock have been prohibited.

Relevant Trophic Information

Juvenile pollock through newly maturing pollock primarily utilize copepods and euphausiids for food. At maturation and older ages pollock become increasingly piscivorous, with pollock (cannibalism) a major food item in the Bering Sea. Most of the pollock consumed by pollock are age 0 and 1 pollock, and recent research suggests that cannibalism can regulate year-class size. Weak year-classes appear to be those located within the range of adults, while strong year-classes are those that are transported to areas outside the range of adult abundance.

Being the dominant species in the eastern Bering Sea pollock is an important food source for other fish, marine mammals, and birds. On the Pribilof Islands hatching success and fledgling survival of marine birds has been tied to the availability of age 0 pollock to nesting birds.

Upper size limit of juvenile fish

The upper size limit for juvenile pollock in the eastern Bering Sea and Gulf of Alaska is about 38-42 cm. This is the size of 50% maturity. There is some evidence that this has changed over time.

Sources for additional distribution data

Eggs and Larvae:

Jeff Napp, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA, 206-526-4148.

Shallow water concentrations:

Bill Bechtol, Alaska Department of Fish and Game, 3298 Douglas Place, Homer, Alaska 99603-8027.

Habitat and Biological Associations

Egg-Spawning: Pelagic on outer continental shelf generally over 100-200 m depth in Bering Sea. Pelagic on continental shelf over 100-200 m depth in Gulf of Alaska.

Larvae: Pelagic outer to mid-shelf region in Bering Sea. Pelagic throughout the continental shelf within the top 40 m in the Gulf of Alaska.

Juveniles: Age 0 appears to be pelagic, as is age 2 and 3. Age 1 pelagic and demersal with a widespread distribution and no known benthic habitat preference.

Adults: Adults occur both pelagically and demersally on the outer and mid-continental shelf of the Gulf of Alaska, eastern Bering Sea and Aleutian Islands. In the eastern Bering Sea few adult pollock occur in waters shallower than 70 m. Adult pollock also occur pelagically in the Aleutian Basin. Adult pollock range throughout the Bering Sea in both the U.S. and Russian waters, however, the maps provided for this document detail distributions for pollock in the U.S. Exclusive Economic Zone and the basin.

Literature

Bailey, K.M. 2000. Shifting control of recruitment of walleye pollock *Theragra chalcogramma* after a major climatic and ecosystem change. Mar. Ecol. Prog. Ser 198:215-224.

Bailey, K.M., P.J. Stabeno, and D.A. Powers. 1997. The role of larval retention and transport features in mortality and potential gene flow of walleye pollock. J. Fish. Biol. 51(Suppl. A):135-154.

Bailey, K.M., S.J. Picquelle, and S.M. Spring. 1996. Mortality of larval walleye pollock (*Theragra chalcogramma*) in the western Gulf of Alaska, 1988-91. Fish. Oceanogr. 5 (Suppl. 1):124-136.

Bailey, K.M., T.J. Quinn II, P. Bentzen, and W.S. Grant. 1999. Population structure and dynamics of walleye pollock, *Theragra chalcogramma*. Advances in Mar. Biol. 37: 179-255.

Bakkala, R.G., V.G. Wespestad and L.L. Low. 1987. Historical trends in abundance and current condition of walleye pollock in the eastern Bering Sea. Fish. Res.,5:199_215.

Bates, R.D. 1987. Ichthyoplankton of the Gulf of Alaska near Kodiak Island, April-May 1984. NWAFC Proc. Rep. 87-11, 53 pp.

Brodeur, R.D. and M.T. Wilson. 1996. A review of the distribution, ecology and population dynamics of age-0 walleye pollock in the Gulf of Alaska. Fish. Oceanogr. 5 (Suppl. 1):148-166.

Brown, A.L. and K.M. Bailey. 1992. Otolith analysis of juvenile walleye pollock *Theragra chalcogramma* from the western Gulf of Alaska. Mar. Bio. 112:23-30.

Dorn, M., S. Barbeaux, M. Guttormsen, B. Megrey, A. Hollowed, E. Brown, and K. Spalinger. 2002. Assessment of Walleye Pollock in the Gulf of Alaska. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, 2002. North Pacific Fishery Management Council, Box 103136, Anchorage, AK 99510. 88p.

Grant, W.S. and F.M. Utter. 1980. Biochemical variation in walleye pollock *Theragra chalcogramma*: population structure in the southeastern Bering Sea and Gulf of Alaska. Can. J. Fish. Aquat. Sci. 37:1093-1100.

Guttormsen , M. A., C. D. Wilson, and S. Stienessen. 2001. Echo integration-trawl survey results for walleye pollock in the Gulf of Alaska during 2001. In Stock Assessment and Fishery Evaluation Report for Gulf of Alaska. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510. North Pacific Fisheries Management Council, Anchorage, AK.

Hinckley, S. 1987. The reproductive biology of walleye pollock, *Theragra chalcogramma*, in the Bering Sea, with reference to spawning stock structure. Fish. Bull. 85:481-498.

Hollowed, A.B., J.N. Ianelli, P. Livingston. 2000. Including predation mortality in stock assessments: a case study for Gulf of Alaska pollock. ICES J. Mar. Sci. 57:279-293.

Hughes, S. E. and G. Hirschhorn. 1979. Biology of walleye pollock, *Theragra chalcogramma*, in Western Gulf of Alaska. Fish. Bull., U.S. 77:263-274.

Ianelli, J.N. 2002. Bering Sea walleye pollock stock structure using morphometric methods. Tech. Report Hokkaido National Fisheries Research Inst. No. 5, 53_58.

Ianelli, J.N., S. Barbeaux, T. Honkalehto, G. Walters, and N. Williamson. 2002. Bering Sea-Aleutian Islands Walleye Pollock Assessment for 2003. In Stock assessment and fishery evaluation report for the groundfish resources of the Eastern Bering Sea and Aleutian Island Region, 2002. North Pacific Fishery Management Council, Box 103136, Anchorage, AK 99510. 88p.

Kendall, A.W., Jr. and S.J. Picquelle. 1990. Egg and larval distributions of walleye pollock *Theragra chalcogramma* in Shelikof Strait, Gulf of Alaska. U.S. Fish. Bull. 88(1):133-154.

Kim, S. and A.W. Kendall, Jr. 1989. Distribution and transport of larval walleye pollock (*Theragra chalcogramma*) in Shelikof Strait, Gulf of Alaska, in relation to water movement. Rapp. P.-v. Reun. Cons. int. Explor. Mer 191:127-136.

Livingston, P.A. 1991. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1884-1986. U. S. Dept. Commerce, NOAA Tech Memo. NMFS F/NWC-207.

Meuter, F.J. and B.L. Norcross. 2002. Spatial and temporal patterns in the demersal fish community on the shelf and upper slope regions of the Gulf of Alaska. Fish. Bull. 100:559-581.

Mulligan, T.J., Chapman, R.W. and B.L. Brown. 1992. Mitochondrial DNA analysis of walleye pollock, *Theragra chalcogramma*, from the eastern Bering Sea and Shelikof Strait, Gulf of Alaska. Can. J. Fish. Aquat. Sci. 49:319-326.

Olsen, J.B., S.E. Merkouris, and J.E. Seeb. 2002. An examination of spatial and temporal genetic variation in walleye pollock (*Theragra chalcogramma*) using allozyme, mitochondrial DNA, and microsatellite data. Fish. Bull. 100:752-764.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Proc. Rep. 90-01, 162 pp.

Shima, M. 1996. A study of the interaction between walleye pollock and Steller sea lions in the Gulf of Alaska. Ph.D. dissertation, University of Washington, Seattle, WA 98195.

Stabeno, P.J., J.D. Schumacher, K.M. Bailey, R.D. Brodeur, and E.D. Cokelet. 1996. Observed patches of walleye pollock eggs and larvae in Shelikof Strait, Alaska: their characteristics, formation and persistence. Fish. Oceanogr. 5 (Suppl. 1): 81-91.

Wespestad V.G. and T.J. Quinn. II. 1997. Importance of cannibalism in the population dynamics of walleye pollock. In: Ecology of Juvenile Walleye Pollock, *Theragra chalcogramma*. NOAA Technical Report, NMFS 126.

Wespestad, V.G. 1993. The status of Bering Sea pollock and the effect of the "Donut Hole" fishery. Fisheries 18(3)18-25.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 pp.

SPECIES: Gulf of Alaska Walleye Pollock

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	14 d. at 5 C	None	Feb-Apr	OCS, UCS	P	N/A	G?	
Larvae	60 days	copepod naupli and small euphausiids	Mar-Jul	MCS, OCS	P	N/A	G? F	pollock larvae with jellyfish
Juveniles	0.4 to 4.5 years	Pelagic crustaceans, copepods and euphausiids	Aug. +	OCS, MCS, ICS	P, SD	N/A	CL, F	
Adults	4.5 - 16 years	Pelagic crustaceans and fish	Spawning Feb-Apr	OCS, BSN	P, SD	UNK	F UP	Increasingly demersal with age.

Habitat Description for Pacific cod

(Gadus macrocephalus)

Management Plan and Area: BSAI

Life History and General Distribution

Pacific cod is a transoceanic species, occurring at depths from shoreline to 500 m. The southern limit of the species' distribution is about 34° N latitude, with a northern limit of about 63° N latitude. Adults are demersal and form aggregations during the peak spawning season, which extends approximately from January through May. Pacific cod eggs are demersal and adhesive. Eggs hatch in about 15-20 days. Little is known about the distribution of Pacific cod larvae, which undergo metamorphosis at about 25-35 mm. Juvenile Pacific cod start appearing in trawl surveys at a fairly small size, as small as 10 cm in the eastern Bering Sea. Pacific cod can grow to be more than a meter in length, with weights in excess of 10 kg. Natural mortality is believed to be somewhere between 0.3 and 0.4. Approximately 50% of Pacific cod are mature by ages 5-6. The maximum recorded age of a Pacific cod from the Bering Sea/Aleutian Islands (BSAI) or Gulf of Alaska (GOA) is 19 years.

Fishery

The fishery is conducted with bottom trawl, longline, pot, and jig gear. The age at 50% recruitment varies between gear types and regions. In the BSAI, the age at 50% recruitment is 6 years for trawl gear, 4 years for longline and 5 years for pot gear. In the GOA, the age at 50% recruitment is 5 years for trawl gear and 6 years for longline and pot gear. More than 100 vessels participate in each of the three largest fisheries (trawl, longline, pot). The trawl fishery is typically concentrated during the first few months of the year, whereas fixed-gear fisheries may sometimes run, intermittently, at least, throughout the year. Bycatch of crab and halibut sometimes causes the Pacific cod fisheries to close prior to reaching the total allowable catch. In the BSAI, trawl fishing is concentrated immediately north of Unimak Island, whereas the longline fishery is distributed along the shelf edge to the north and west of the Pribilof Islands. In the GOA, the trawl fishery has centers of activity around the Shumagin Islands and south of Kodiak Island, while the longline fishery is located primarily in the vicinity of the Shumagin.

Relevant Trophic Information

Pacific cod are omnivorous. In terms of percent occurrence, the most important items in the diet of Pacific cod in the BSAI and GOA are polychaete, amphipods, and crangonid shrimp. In terms of numbers of individual organisms consumed, the most important dietary items are euphausiids, miscellaneous fishes, and amphipods. In terms of weight of organisms consumed, the most important dietary items are walleye pollock, fishery discards, and yellowfin sole. Small Pacific cod feed mostly on invertebrates, while large Pacific cod are mainly piscivorous. Predators of Pacific cod include halibut, salmon shark, northern fur seals, sea lions, harbor porpoises, various whale species, and tufted puffin.

What is the approximate upper size limit of juvenile fish (in cm)? The estimated size at 50% maturity is 67 cm.

Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)

Larvae/juveniles: NMFS, Alaska Fisheries Science Center, FOCI Program, Ann Matarese 206-526-4111

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: Spawning takes place in the sublittoral-bathyal zone (40-290 m) near bottom. Eggs sink to the bottom after fertilization, and are somewhat adhesive. Optimal temperature for incubation is 3-6° C, optimal salinity is 13-23 ppt, and optimal oxygen concentration is from 2-3 ppm to saturation. Little is known about the optimal substrate type for egg incubation.

Larvae: Larvae are epipelagic, occurring primarily in the upper 45 m of the water column shortly after hatching, moving downward in the water column as they grow.

Juveniles: Juveniles occur mostly over the inner continental shelf at depths of 60-150 m.

Adults: Adults occur in depths from the shoreline to 500 m. Average depth of occurrence tends to vary directly with age for at least the first few years of life, with mature fish concentrated on the outer continental shelf. Preferred substrate is soft sediment, from mud and clay to sand.

Literature

Albers, W.D., and P.J. Anderson. 1985. Diet of Pacific cod, *Gadus macrocephalus*, and predation on the northern pink shrimp, *Pandalus borealis*, in Pavlof Bay, Alaska. Fish. Bull., U.S. 83:601-610.

Alderdice, D.F., and C.R. Forrester. 1971. Effects of salinity, temperature, and dissolved oxygen on early development of the Pacific cod (*Gadus macrocephalus*). J. Fish. Res. Board Can. 28:883-902.

Bakkala, R.G. 1984. Pacific cod of the eastern Bering Sea. Int. N. Pac. Fish. Comm. Bull. 42:157-179.

Dunn, J.R., and A.C. Matarese. 1987. A review of the early life history of northeast Pacific gadoid fishes. Fish. Res. 5:163-184.

Forrester, C.R., and D.F. Alderdice. 1966. Effects of salinity and temperature on embryonic development of Pacific cod (*Gadus macrocephalus*). J. Fish. Res. Board Can. 23:319-340.

Hirschberger, W.A., and G.B. Smith. 1983. Spawning of twelve groundfish species in Alaska and Pacific Coast regions, 1975-81. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS F/NWC-44. 50 p.

Ketchen, K.S. 1961. Observations on the ecology of the Pacific cod (*Gadus macrocephalus*) in Canadian waters. J. Fish. Res. Board Can. 18:513-558.

Livingston, P.A. 1989. Interannual trends in Pacific cod, *Gadus macrocephalus*, predation on three commercially important crab species in the eastern Bering Sea. Fish. Bull., U.S. 87:807-827.

Livingston, P.A. 1991. Pacific cod. *In* P.A. Livingston (editor), Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1984 to 1986, p. 31-88. U.S. Dept. Commerce., NOAA Tech. Memo. NMFS F/NWC-207.

Matarese, A.C., A.W. Kendall Jr., D.M. Blood, and B.M. Vinter. 1989. Laboratory guide to early life history stages of northeast Pacific fishes. U.S. Dept. Commerce, NOAA Tech. Rep. NMFS 80. 652 p.

Moiseev, P.A. 1953. Cod and flounders of far eastern waters. Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 40. 287 p. (Transl. from Russian: Fish. Res. Board Can. Transl. Ser. 119.)

National Oceanic and Atmospheric Administration (NOAA). 1987. Bering, Chukchi, and Beaufort Seas--Coastal and ocean zones strategic assessment: Data Atlas. U.S. Dept. Commerce, NOAA, National Ocean Service.

National Oceanic and Atmospheric Administration (NOAA). 1990. West coast of North America--Coastal and ocean zones strategic assessment: Data Atlas. U.S. Dept. Commerce, NOAA, National Ocean Service and National Marine Fisheries Service.

Phillips, A.C., and J.C. Mason. 1986. A towed, self-adjusting sld sampler for demersal fish eggs and larvae. Fish. Res. 4:235-242.

Rugen, W.C., and A.C. Matarese. 1988. Spatial and temporal distribution and relative abundance of Pacific cod (*Gadus macrocephalus*) larvae in the western Gulf of Alaska. NWAFC Proc. Rep. 88-18. Available from Alaska Fish. Sci. Center, 7600 Sand Point Way NE., Seattle, WA 98115-0070.

Thompson, G.G., and M.W. Dorn. 2002. Assessment of the Pacific cod stock in the eastern Bering Sea and Aleutian Islands area. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, Plan Team for the Groundfish Fisheries of the Bering Sea and Aleutian Islands (editor), p. 121-205. Available from North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Thompson, G.G., H.H. Zenger, and M.W. Dorn. 2002. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, Plan Team for the Gulf of Alaska (editor), p. 89-167. Available from North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Westrheim, S.J. 1996. On the Pacific cod (*Gadus macrocephalus*) in British Columbia waters, and a comparison with Pacific cod elsewhere, and Atlantic cod (*G. morhua*). Can. Tech. Rep. Fish. Aquat. Sci. 2092. 390 p.

SPECIES: Pacific cod

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	15-20 d	NA	winter-spring	ICS, MCS, OCS	D	M, SM, MS ,S	U	optimum 3-6°C optimum salinity 13-23 ppt
Larvae	U	copepods (?)	winter-spring	U	P (?), N (?)	U	U	
Early Juveniles	to 2 yrs	small invertebrates (mysids, euphausiids, shrimp)	all year	ICS, MCS	D	M, SM, MS, S	U	
Late Juveniles	to 5 yrs	pollock, flatfish, fishery discards, crab	all year	ICS, MCS, OCS	D	M, SM, MS, S	U	
Adults	5+ yr	pollock, flatfish, fishery discards, crab	spawning (Jan-May) non-spawning (Jun-Dec)	ICS, MCS, OCS ICS, MCS, OCS	D	M, SM, MS, S,G	U	

Habitat Description for Yellowfin Sole

(Limanda aspera)

Management Plan and Area BSAI

Life History and General Distribution

Distributed in North American waters from off British Columbia, Canada, (approx. lat. 49° N) to the Chukchi Sea (about lat. 70° N) and south along the Asian coast to about lat. 35° N off the South Korean coast in the Sea of Japan. Adults exhibit a benthic lifestyle and occupy separate winter spawning and summertime feeding distributions on the eastern Bering Sea shelf. From over-winter grounds near the shelf margins, adults begin a migration onto the inner shelf in April or early May each year for spawning and feeding. A protracted and variable spawning period may range from as early as late May through August occurring primarily in shallow water. Fecundity varies with size and was reported to range from 1.3 to 3.3 million eggs for fish 25-45 cm long. Eggs have been found to the limits of inshore ichthyoplankton sampling over a widespread area to at least as far north as Nunivak Island. Larvae have been measured at 2.2-5.5 mm in July and 2.5-12.3 mm in late August - early September. The age or size at metamorphosis is unknown. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and burrowing for protection. Juveniles are separate from the adult population, remaining in shallow areas until they reach approximately 15 cm. The estimated age of 50% maturity is 10.5 yrs (approx. 29 cm) for females based on samples collected in 1992 and 1993. Natural mortality rate is believed to range from 0.12-0.16.

Fishery

Caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 6 and they are fully selected at age 13. Historically, the fishery has occurred throughout the mid and inner Bering Sea shelf during ice-free conditions although much effort has been directed at the spawning concentrations in nearshore northern Bristol Bay. They are caught as bycatch in Pacific cod, bottom pollock and other flatfish fisheries and are caught with these species and Pacific halibut in yellowfin sole directed fisheries.

Relevant Trophic Information

Groundfish predators include Pacific cod, skates and Pacific halibut, mostly on fish ranging from 7 to 25 cm standard length.

Approximate upper size limit of juvenile fish? 27 cm

Habitat and Biological Associations

> *Larvae/Juveniles*: Planktonic larvae for at least 2-3 months until metamorphosis occurs, usually inhabiting shallow areas.
>
> *Adults*: Summertime spawning and feeding on sandy substrates of the eastern Bering Sea shelf. Widespread distribution mainly on the middle and inner portion of the shelf, feeding mainly on bivalves, polychaete, amphipods and echiurids. Wintertime migration to deeper waters of the shelf margin to avoid extreme cold water temperatures, feeding diminishes.

Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Bakkala, R.G., V.G. Wespestad, and L.L. Low. 1982. The yellowfin sole (*Limanda aspera*) resource of the eastern Bering Sea--Its current and future potential for commercial fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-33, 43 p.

Fadeev, N.W. 1965. Comparative outline of the biology of fishes in the southeastern part of the Bering Sea and condition of their resources. [In Russ.] Tr. Vses. Nauchno-issled. Inst.Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled Inst. Morsk. Rybn. Khoz. Okeanogr. 53):121-138. (Trans. By Isr. Prog. Sci. Transl., 1968), p 112-129. In P.A. Moiseev (Editor), Soviet Fisheries Investigations in the northeastern Pacific, Pt. IV. Avail. Natl. Tech. Inf. Serv., Springfield, VA as TT 67-51206.

Kashkina, A.A. 1965. Reproduction of yellowfin sole (*Limanda aspera*) and changes in its spawning stocks in the eastern Bering Sea. Tr. Vses. Nauchno-issled, Inst. Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled. Inst. Rbn. Khoz. Okeanogr. 53):191-199. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1968, p. 182-190. In P.A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part IV. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT67-51206.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Moles, A., and B. L. Norcross. 1995. Sediment preference in juvenile Pacific flatfishes. Netherlands J. Sea Res. 34(1-3):177-182 (1995).

Musienko, L.N. 1963. Ichthyoplankton of the Bering Sea (data of the Bering Sea expedition of 1958-59). Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 50)239-269. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1968, p. 251-286. In P.A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part I. Avail. Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51203.

Musienko, L.N. 1970. Reproduction and Development of Bering Sea. Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 70 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 72)161-224. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1972, p. 161-224. In P.A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part V. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT71-50127.

Nichol, D.G. 1994. Maturation and Spawning of female yellowfin sole in the Eastern Bering Sea. Preceding of the International North Pacific Flatfish Symposium, Oct. 26-28, 1994, Anchorage, AK. Alaska Sea Grant Program.

Wakabayashi, K. 1986. Interspecific feeding relationships on the continental shelf of the eastern Bering Sea, with special reference to yellowfin sole. Int. N. Pac. Fish. Comm. Bull. 47:3-30.

Waldron, K.D. 1981. Ichthyoplankton. In D.W. Hood and J.A. Calder (Editors), The eastern Bering Sea shelf: Oceanography and resources, Vol. 1, p. 471-493. U.S. Dep. Commer., NOAA, Off. Mar. Poll. Asess., U.S. Gov. Print. Off., Wash., D.C.

Wilderbuer, T.K., G.E. Walters, and R.G. Bakkala. 1992. Yellowfin sole, Pleuronectes asper, of the Eastern Bering Sea: Biological Characteristics, History of Exploitation, and Management. Mar. Fish. Rev. 54(4) p 1-18.

SPECIES: Yellowfin sole

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	summer	BAY BCH	P			
Larvae	2-3 months?	U phyto/zoo plankton?	summer autumn?	BAY BCH ICS	P			
Early Juveniles	to 5.5 yrs	polychaete bivalves amphipods echiurids	all year	BAY ICS OCS	D	S[1]		
Late Juveniles	5.5 to 10 yrs	polychaete bivalves amphipods echiurids	all year	BAY ICS OCS	D	S[1]		

Adults	10+ years	polychaete bivalves amphipods echiurids	spawning/ feeding May-August non-spawning Nov.-April	BAY BEACH ICS MCS OCS	D	S[1]	ice edge	

[1]Pers. Comm. Dr. Robert McConnaughey (206) 526-4150

Habitat Description for Greenland Turbot

(Reinhardtius hippoglossoides)

Management Plan and Area BSAI

Life History and General Distribution

Greenland turbot has an amphiboreal distribution, occurring in the North Atlantic and North Pacific, but not in the intervening Arctic Ocean. In the North Pacific, species abundance is centered in the eastern Bering Sea and, secondly, in the Aleutians. On the Asian side, they occur in the Gulf of Anadyr along the Bering Sea coast of Russia, in the Okhotsk Sea, around the Kurile Islands, and south to the east coast of Japan to northern Honshu Island (Hubbs and Wilimovsky 1964, Mikawa 1963, Shuntov 1965). Adults exhibit a benthic lifestyle, living in deep waters of the continental slope but are known to have a tendency to feed off the sea bottom. During their first few years as immature fish, they inhabit relatively shallow continental shelf waters (<200 m) until about age 4 or 5 before joining the adult population (200 - 1,000 m or more, Templeman 1973). Adults appear to undergo seasonal shifts in depth distribution moving deeper in winter and shallower in summer (Chumakov 1970, Shuntov 1965). Spawning is reported to occur in winter in the eastern Bering Sea and may be protracted starting in September or October and continuing until March with an apparent peak period in November to February (Shuntov 1970, Bulatov 1983). Females spawn relatively small numbers of eggs with fecundity ranging from 23,900 to 149,300 for fish 83 cm and smaller in the Bering Sea (D'yakov 1982).

Eggs and early larval stages are benthypelagic (Musienko 1970). In the Atlantic Ocean, larvae (10-18 cm) have been found in benthypelagic waters which gradually rise to the pelagic zone in correspondence to absorption of the yolk sac which is reported to occur at 15-18 mm with the onset of feeding (Pertseva-Ostroumova 1961 and Smidt 1969). The period of larval development extends from April to as late as August or September (Jensen 1935) which results in an extensive larval drift and broad dispersal from the spawning waters of the continental slope. Metamorphosis occurs in August or September at about 7-8 cm in length at which time the demersal life begins. Juveniles are reported to be quite tolerant of cold temperatures to less than zero degrees Celsius (Hognestad 1969) and have been found on the northern part of the Bering Sea shelf in summer trawl surveys (Alton et al. 1988).

The age of 50% maturity is estimated to range from 5-10 yrs (D'yakov 1982, 60 cm used in stock assessment) and a natural mortality rate of 0.18 has been used in the most recent stock assessments (Ianelli et al. 2002).

Fishery

Caught in bottom trawls and on longlines both as a directed fishery and in the pursuit of other bottom-dwelling species (primarily sablefish). Recruitment begins at about 50 and 60 cm in the trawl and longline fisheries, respectively. The fishery operates on the continental slope throughout the eastern Bering Sea and on both sides of the Aleutian Islands. Bycatch primarily occurs in the sablefish directed fisheries and also to a smaller extent in the Pacific cod fishery.

Relevant Trophic Information

Groundfish predators include Pacific cod, pollock and yellowfin sole, mostly on fish ranging from 2 to 5 cm standard length (probably age 0).

Approximate upper size limit of juvenile fish? 59 cm

Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for up to 9 months until metamorphosis occurs, usually with a widespread distribution inhabiting shallow waters. Juveniles live on continental shelf until about age 4 or 5 feeding primarily on euphausiids, polychaete and small walleye pollock..

Adults: Inhabit continental slope waters with annual spring/fall migrations from deeper to shallower waters. Diet consists of walleye pollock and other miscellaneous fish species.

Literature

Alton, M.S., R.G. Bakkala, G.E. Walters and P.T. Munro. 1988. Greenland turbot, *Reinhardtius hippoglossoides*, of the Eastern Bering Sea and Aleutian Islands. U.S. Dept. Commer., NOAA Tech. Rpt. NMFS 71, 31 pages.

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Bulatov, O.A. 1983. Distribution of eggs and larvae of Greenland halibut, *Reinhardtius hippoglossoides*, (Pleuronectidae) in the eastern Bering Sea. J. Ichthyol. [Engl. Transl. Vopr. Ikhtiol.] 23(1):157-159.

Chumakov, A.K. 1970. The Greenland halibut, *Reinhardtius hippoglossoides*, in the Iceland area-The halibut fisheries and tagging. Tr. Polyarn. Nauchno-Issled. Proektn. Inst. Morsk. Rybn. Khoz. 1970:909-912.

D'yakov, Yu. P. 1982. The fecundity of the Greenland halibut, *Reinhardtius hippoglossoides* (Pleuronectidae), from the Bering Sea. J. Ichthyol. [Engl. Trans. Vopr. Ikhtiol.] 22(5):59-64.

Hognestad, P.T. 1969. Notes on Greenland halibut, *Reinhardtius hippoglossoides*, in the eastern Norwegian Sea. Fiskeridir. Skr. Ser. Havunders. 15(3):139-144.

Hubbs, C.L., and N.J. Wilimovsky. 1964. Distribution and synonymy in the Pacific Ocean and variation of the Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum). J. Fish. Res. Board Can. 21:1129-1154.

Ianelli, J.N., C. Minte-Vera, T.K. Wilderbuer, and T. M. Sample. 2002. Greenland turbot. *In* Appendix A Stock Assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands Regions. Pages 255-282. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Jensen, A.S. 1935. (*Reinhardtius hippoglossoides*) its development and migrations. K. dan. Vidensk. Selsk. Skr. 9 Rk., 6:1-32.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way, NE., Seattle, WA 98115.

Mikawa, M. 1963. Ecology of the lesser halibut, *Reinhardtius hippoglossoides matsuurae* Jordan and Snyder. Bull. Tohoku Reg. Fish. Res. Lab. 29:1-41.

Musienko, L.N. 1970. Reproduction and Development of Bering Sea. Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 70 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 72)161-224. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1972, p. 161-224. In P. A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part V. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT71-50127.

Pertseva-Ostroumova, T.A. 1961. The reproduction and development of far eastern flounders. Izdatel'stvo Akad. Nauk. SSSR, 483 p. [Transl. By Fish. Res. Board Can., 1967, Transl. Ser. 856, 1003 p.]

Shuntov, V.P. 1965. Distribution of the Greenland halibut and arrowtooth halibuts in the North Pacific. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 53):155-163. [Transl. In Soviet Fisheries Investigation in the Northeastern Pacific, Part IV, p. 147-156, by Israel Prog. Sci. Transl., 1972, avail. Natl. Tech. Inf. Serv., Springfield, VA as TT71-50127.]

Templeman, W. 1973. Distribution and abundance of the Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum), in the Northwest Atlantic. Int. Comm. Northwest Atl. Fish. Res. Bull. 10:82-98.

SPECIES: Greenland turbot

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	winter	OCS MCS	SD, SP			
Larvae	8-9 months	U phyto/zoo plankton?	Spring summer	OCS ICS MCS	P			
Juveniles	1-5 yrs	euphausiids polychaets small pollock	all year	ICS MCS OCS USP	D, SD	M/S+M[1]		
Adults	5+ years	pollock small fish	spawning Nov-February non-spawning March-October	OCS USP LSP USP LSP	D, SD	M/S+M[1]		

[1]Pers. Comm. Dr. Robert McConnaughey (206) 526-4150

Habitat Description for Arrowtooth Flounder

(Atheresthes stomias)

Management Plan and Area BSAI

Life History and General Distribution

Distributed in North American waters from central California to the eastern Bering Sea on the continental shelf and upper slope.

Adults exhibit a benthic lifestyle and occupy separate winter and summer distributions on the eastern Bering Sea shelf. From over-winter grounds near the shelf margins and upper slope areas, adults begin a migration onto the middle and outer shelf in April or early May each year with the onset of warmer water temperatures. A protracted and variable spawning period may range from as early as September through March (Rickey 1994, Hosie 1976). Little is known of the fecundity of arrowtooth flounder. Larvae have been found from ichthyoplankton sampling over a widespread area of the eastern Bering Sea shelf in April and May and also on the continental shelf east of Kodiak Island during winter and spring (Waldron and Vinter 1978, Kendall and Dunn 1985). The age or size at metamorphosis is unknown. Juveniles are separate from the adult population, remaining in shallow areas until they reach the 10-15 cm range (Martin and Clausen 1995). The estimated length at 50% maturity is 28 cm for males (4 years) and 37 cm for females (5 years) from samples collected off the Washington coast (Rickey 1994). The natural mortality rate used in stock assessments differs by sex and is estimated at 0.2 for females and 0.35 - 0.37 for females (Turnock et. al 2002, Wilderbuer and Sample 2002).

Fishery

Caught in bottom trawls usually in pursuit of other higher value bottom-dwelling species. Historically have been undesirable to harvest due to a flesh softening condition caused by protease enzyme activity. Recruitment begins at about age 3 and females are fully selected at age 10. They are caught as bycatch in Pacific cod, bottom Pollock, sablefish and other flatfish fisheries by both trawls and longline.

Relevant Trophic Information

Very important as a large, aggressive and abundant predator of other groundfish species. Groundfish predators include Pacific cod and pollock, mostly on small fish.

Approximate upper size limit of juvenile fish Males 27 cm and females 37 cm.

Habitat and Biological Associations

> *Larvae/Juveniles*: Planktonic larvae for at least 2-3 months until metamorphosis occurs, juveniles usually inhabit shallow areas until about 10 cm in length.
>
> *Adults*: Widespread distribution mainly on the middle and outer portions of the continental shelf, feeding mainly on walleye pollock and other miscellaneous fish species when arrowtooth flounder attain lengths greater than 30 cm. Wintertime migration to deeper waters of the shelf margin and upper continental slope to avoid extreme cold water temperatures and for spawning.

Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Can. Bull. 180, 740 p.

Hosie, M.J. 1976. The arrowtooth flounder. Oregon Dep. Fish. Wildl. Info. Rep. 76-3, 4 p.

Kendall, A.W. Jr. and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. NOAA Tech. Rep. NMFS 20, U. S. Dep. Commer, NOAA, Natl. Mar. Fish. Serv.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Martin, M.H. and D.M. Clausen. 1995. Data report: 1993 Gulf of Alaska Bottom Trawl Survey. U.S. Dept. Commer., NOAA, Natl. Mar. Fish. Serv., NOAA Tech. Mem. NMFS-AFSC-59, 217 p.

Rickey, M.H. 1994. Maturity, spawning, and seasonal movement of arrowtooth flounder, *Atheresthes stomias*, off Washington. Fish. Bull. 93:127-138 (1995).

Turnock, B.J., T.K. Wilderbuer and E.S. Brown 2002. Arrowtooth flounder. *InAppendix B* Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Gulf of Alaska, Pages 199-228. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Waldron, K.D. and B.M. Vinter 1978. Ichthyoplankton of the eastern Bering Sea. U. S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv. Seattle, WA, Processed rep., 88 p.

Wilderbuer, T.K. and T.M. Sample 2002. Arrowtooth flounder. *In* Appendix A Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Bering Sea/Aleutian Islands, Pages 283-320. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

SPECIES: Arrowtooth flounder

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	winter, spring?	ICS MCS OCS	P			
Larvae	2-3 months?	U phyto/zoo plankton?	Spring summer?	BAY ICS MCS OCS	P			
Early Juveniles	to 2 yrs	euphausiids crustaceans amphipods pollock	all year	ICS MCS	D	GMS[1]		
Late Juveniles	males 2-4 yrs females 2-5 yrs	euphausiids crustaceans amphipods pollock	all year	ICS MCS OCS USP	D	GMS[1]		

Adults	males - 4+ yrs females- 5+ yrs	pollock misc. fish Gadidae sp. Euphausiids	spawning Nov-March non-spawning April-Oct.	 MCS OCS USP	D	GMS[1]	ice edge (EBS)	

[1]Pers. Comm., Dr. Robert McConnaughey (206) 526-4150

Habitat Description for Rock Sole

(Lepidopsetta bilineatus)

Management Plan and Area BSAI

Life History and General Distribution

Distributed from California waters north into the Gulf of Alaska and Bering Sea to as far north as the Gulf of Anadyr. The distribution continues along the Aleutian Islands westward to the Kamchatka Peninsula and then southward through the Okhotsk Sea to the Kurile Islands, Sea of Japan, and off Korea. Centers of abundance occur off the Kamchatka Peninsula (Shubnikov and Lisovenko 1964), British Columbia (Forrester and Thompson 1969), the central Gulf of Alaska, and in the southeastern Bering Sea (Alton and Sample 1975). Two forms were recently found to exist in Alaska by Orr and Matarese (2000), a southern rock sole (*L. bilineatus*) and a northern rock sole (*L. polyxystra*). Adults exhibit a benthic lifestyle and, in the eastern Bering Sea, occupy separate winter (spawning) and summertime feeding distributions on the continental shelf. Rock sole spawn during the winter-early spring period of December-March. Soviet investigations in the early 1960s established two spawning concentrations: an eastern concentration north of Unimak Island at the mouth of Bristol Bay and a western concentration eastward of the Pribilof Islands between 55°30' and 55°0' N and approximately 165°2' W (Shubnikov and Lisovenko, 1964). Rock sole spawning in the eastern and western Bering Sea was found to occur at depths of 125-250 m, close to the shelf/slope break. Spawning females deposit a mass of eggs which are demersal and adhesive (Alton and Sample 1975). Fertilization is believed to be external. Incubation time is temperature dependent and may range from 6.4 days at 11 degrees C to about 25 days at 2.9 degrees C (Forrester 1964). Newly hatched larvae are pelagic and have occurred sporadically in eastern Bering Sea plankton surveys (Waldron and Vinter, 1978). Kamchatka larvae are reportedly 20 mm in length when they assume their side-swimming, bottom-dwelling form (Alton and Sample 1975). Norcross et al. (1996) found newly settled larvae in the 40-50 mm size range. Forrester and Thompson (1969) report that by age 1 they are found with adults on the continental shelf during summer.

In the springtime, after spawning, rock sole begin actively feeding and commence a migration to the shallow waters of the continental shelf. This migration has been observed on both the eastern (Alton and Sample, 1975) and western (Shvetsov 1978) areas of the Bering Sea. During this time they spread out and form much less dense concentrations than during the spawning period . Summertime trawl surveys indicate most of the population can be found at depths from 50-100 m (Armistead and Nichol 1993). The movement from winter/spring to summer grounds is in response to warmer temperatures in the shallow waters and the distribution of prey on the shelf seafloor (Shvetsov 1978). In September, with the onset of cooling in the northern latitudes, rock sole begin the return migration to the deeper wintering grounds. Fecundity varies with size and was reported to be 450,00 eggs for fish 42 cm long. Larvae are pelagic but their occurrence in plankton surveys in the eastern Bering Sea are rare (Musienko 1963). Juveniles are separate from the adult population, remaining in shallow areas until they reach age 1 (Forrester 1969). The estimated age of 50% maturity is 9 yrs (approx. 35 cm) for southern rock sole females and 7 years for northern rock sole females (Stark and Somerton 2002). Natural mortality rate is believed to range from 0.18 - 0.20.

Fishery

Caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 4 and they are fully selected at age 11. Historically, the fishery has occurred throughout the mid and inner Bering Sea shelf during ice-free conditions and on spawning concentrations north of the Alaska Peninsula during winter for their high-value roe. They are caught as bycatch in Pacific cod, bottom Pollock, yellowfn sole and other flatfish fisheries and are caught with these species and Pacific halibut in rock sole directed fisheries.

Relevant Trophic Information

Groundfish predators include Pacific cod, walleye pollock, skates, Pacific halibut and yellowfin sole, mostly on fish ranging from 5 to 15 cm standard length.

Approximate upper size limit of juvenile fish? 34 cm

Habitat and Biological Associations

> Larvae/Juveniles: Planktonic larvae for at least 2-3 months until metamorphosis occurs, juveniles inhabit shallow areas at least until age 1.
>
> Adults: Summertime feeding on primarily sandy substrates of the eastern Bering Sea shelf. Widespread distribution mainly on the middle and inner portion of the shelf, feeding on bivalves, polychaete, amphipods and miscellaneous crustaceans. Wintertime migration to deeper waters of the shelf margin for spawning and to avoid extreme cold water temperatures, feeding diminishes.

Literature

Alton, M.S. and Terry M. Sample 1976. Rock sole (Family Pleuronectidae) p. 461-474. *In*: Demersal fish and shellfish resources in the Bering Sea in the baseline year 1975. Principal investigators Walter T. Pereyra, Jerry E. Reeves, and Richard Bakkala. U.S. Dep. Comm., Natl. Oceanic Atmos. Admin., Natl. Mar. Serv., Northwest and Alaska Fish Center, Seattle, WA. Processed Rep., 619 p.

Armistead, C.E. and D.G. Nichol 1993. 1990 Bottom Trawl Survey of the Eastern Bering Sea Continental Shelf. U.S. Dep. Commer., NOAA Tech. Mem. NMFS-AFSC-7, 190 p.

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Forrester, C.R. 1964. Demersal Quality of fertilized eggs of rock sole. J. Fish. Res. Bd. Canada, 21(6), 1964. P. 1531.

Forrester, C.R. and J.A. Thompson 1969. Population studies on the rock sole, *Lepidopsetta bilineata*, of northern Hecate Strait British Columbia. Fish. Res. Bd. Canada, Tech. Rep. No. 108, 1969. 104 p.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Musienko, L.N. 1963. Ichthyoplankton of the Bering Sea (data of the Bering Sea expedition of 1958-59). Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 50)239-269. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1968, p. 251-286. In P. A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part I. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT67-51203.

Norcross, B.L., B.A. Holladay, S. C. Dressel, and M. Frandsen. 1996 .Recruitment of juvenile flatfishes in Alaska: habitat preference near Kodiak Island. U. Alaska, Coastal Marine Institute, OCS study MMS 96-003. Vol. 1.

Orr, J. M. and A. C. Matarese. 2000. Revision of the genus *Lepidipsetta* Gill, 1862 (Teleostei: Pleuronectidae) based on larval and adult morphology, with a description of a new species from the North Pacific Ocean and Bering Sea. Fish. Bull.98:539-582 (2000).

Shubnikov, D.A. and L.A. Lisovenko 1964. Data on the biology of rock sole in the southeastern Bering Sea. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 49 (Izv. Tikookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 51) : 209-214. (Transl. In Soviet Fisheries Investigations in the Northeast Pacific, Part II, p. 220-226, by Israel Program Sci. Transl., 1968, available Natl. Tech. Inf. Serv., Springfield, VA, as TT 67-51204).

Shvetsov, F.G. 1978. Distribution and migrations of the rock sole, *Lepidopsetta bilineata*, in the regions of the Okhotsk Sea coast of Paramushir and Shumshu Islands. J. Ichthol., 18 (1), 56-62, 1978.

Stark, J. W. and D. A. Somerton. 2002. Maturation, spawning and growth of rock sole off Kodiak Island in the Gulf of Alaska. J. Fish. Biology (2002)61, 417-431.

Waldron, K.D. And B. M. Vinter 1978. Ichthyoplankton of the eastern Bering Sea. U. S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv. Seattle, WA, Processed rep., 88 p.

SPECIES: Rock sole

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	winter	OCS	D			
Larvae	2-3 months?	U phyto/zoo plankton?	winter/spring	OCS MCS ICS	P			
Early Juveniles	to 3.5 yrs	polychaete bivalves amphipods misc. crust.	all year	BAY ICS	D	S[1] G		
Late Juveniles	to 9 years	polychaete bivalves amphipods misc. crust.	all year	BAY ICS MCS OCS	D	S[1] G		
Adults	9+ years	polychaete bivalves amphipods misc. crust.	feeding May-September spawning Dec.-April	MCS ICS OCS	D	S[1] G	ice edge	

[1]Pers. Comm. Dr. Robert McConnaughey (206) 526-4150

Habitat Description for Alaska Plaice

(*Pleuronectes quadrituberculatus*)

Management Plan and Area BSAI

Formerly a constituent of the "other flatfish" management category, Alaska plaice were split out in recent years and are managed as a separate stock.

Life History and General Distribution

Alaska plaice inhabit continental shelf waters of the North Pacific ranging from the Gulf of Alaska to the Bering and Chukchi Seas and in Asian waters as far south as Peter the Great Bay (Pertseva-Ostroumova 1961; Quast and Hall 1972). Adults exhibit a benthic lifestyle and live year round on the shelf and move seasonally within its limits (Fadeev 1965). From over-winter grounds near the shelf margins, adults begin a migration onto the central and northern shelf of the eastern Bering Sea, primarily at depths of less than 100 m. Spawning usually occurs in March and April on hard sandy ground (Zhang 1987). The eggs and larvae are pelagic and transparent and have been found in ichthyoplankton sampling in late spring and early summer over a widespread area of the continental shelf (Waldron and Favorite 1977).

Fecundity estimates (Fadeev 1965) indicate female fish produce an average of 56 thousand eggs at lengths of 28 to 30 cm and 313 thousand eggs at lengths of 48 to 50 cm. The age or size at metamorphosis is unknown. The estimated length of 50% maturity is 32 cm from collections made in March and 28 cm from April, which corresponds to an age of 6 to 7 years. Natural mortality rate estimates range from 0.19 to 0.22 (Wilderbuer and Zhang 1999).

Fishery

Caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 6 and they are fully selected at age 12. The fishery occurs throughout the mid and inner Bering Sea shelf during ice-free conditions .In recent years catches have been low due to a lack of targeting and they are now primarily caught as bycatch in Pacific cod, bottom pollock, yellowfin sole and other flatfish fisheries and are caught with these species and Pacific halibut the directed fishery.

Relevant Trophic Information

Groundfish predators include Pacific halibut (Novikov, 1964) yellowfin sole, beluga whales and fur seals (Salveson 1976).

Approximate upper size limit of juvenile fish? 27 cm

Habitat and Biological Associations

> *Larvae/Juveniles*: Planktonic larvae for at least 2-3 months until metamorphosis occurs, usually inhabiting shallow areas.
>
> *Adults*: Summertime feeding on sandy substrates of the eastern Bering Sea shelf. Wide-spread distribution mainly on the middle, northern portion of the shelf, feeding on polychaete, amphipods and echiurids (Livingston and DeReynier 1996). Wintertime migration to deeper waters of the shelf margin to avoid extreme cold water temperatures. Feeding diminishes until spring after spawning.

Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Fadeev, N.W. 1965. Comparative outline of the biology of fishes in the southeastern part of the Bering Sea and condition of their resources. [In Russ.] Tr. Vses. Nauchno-issled. Inst.Morsk. Rybn. Khoz. Okeanogr. 58 (Izv.Tikhookean. Nauchno-issled Inst. Morsk. Rybn. Khoz. Okeanogr. 53):121-138. (Trans. By Isr. Prog. Sci. Transl., 1968), p 112-129. In P.A. Moiseev (Editor), Soviet Fisheries Investigations in the northeastern Pacific, Pt. IV. Avail. Natl. Tech. Inf. Serv., Springfield, Va. As TT 67-51206.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Novikov, N.P. 1964. Basic elements of the biology of the Pacific Halibut (*Hippoglossoides stenolepis* Schmidt) in the Bering Sea. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 49 (Izv. Tikhookean. Nauchno-isslled. Inst. Morsk. Rybn. Khoz. Okeanogr. 51):167-204. (Transl. In Soviet Fisheries Investigations in the Northeast Pacific, Part II, p.175-219, by Israel Program Sci. Transl., 1968, avail. Natl. Tech. Inf. Serv. Springfield, VA, as TT67-51204.)

Pertseva-Ostroumova, T.A. 1961. The reproduction and development of far eastern flounders. (Transl. By Fish. Res. Bd. Can. 1967. Transl. Ser. 856, 1003 p.).

Quast, J.C. and E.L. Hall. 1972. List of fishes of Alaska and adjacent waters with a guide to some of their literature. U.S. Dep. Commer. NOAA, Tech. Rep. NMFS SSRF-658, 48p.

Salveson, S.J. 1976. Alaska plaice. In Demersal fish and shellfish resources of the eastern Bering Sea in the baseline year 1975 (eds. W.T. Pereyra, J.E. Reeves, and R.G. Bakkala). Processed Rep., 619 p. NWAFC, NMFS, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Waldron, K.D. and F. Favorite. 1977. Ichthyoplankton of the eastern Bering Sea. In Environmental assessment of the Alaskan continental shelf, Annual reports of principal investigators for the year ending March 1977, Vol. IX. Receptors-Fish, littoral, benthos, p. 628-682. U.S. Dep. Comm., NOAA, and U.S. Dep. Int., Bur. Land. Manage.

Wilderbuer, T.K. and C.I. Zhang. 1999. Evaluation of the population dynamics and yield characteristics of Alaska plaice (Pleuronectes quadrituberculatus) in the eastern Bering Sea Fisheries Research 41 (1999) 183-200.

Zhang, C.I. 1987. Biology and Population Dynamics of Alaska plaice, Pleuronectes quadriterculatus, in the Eastern Bering Sea. PhD. dissertation, University of Washington: p.1-225.

SPECIES: Alaska plaice

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	spring and summer	ICS MCS OCS	P			
Larvae	2-4 months?	U phyto/zoo plankton?	spring and summer	ICS MCS	P			
Juveniles	up to 7 years	polychaete amphipods echiurids	all year	ICS MCS	D	S+M[1]		
Adults	7+ years	polychaete amphipods echiurids	spawning March-May non-spawning and feeding June.-February	ICS MCS ICS MCS	D	S+M[1]	 ice edge	

[1]Pers. Comm. Dr. Robert McConnaughey (206) 526-4150

Habitat Description for Rex Sole

(Glyptocephalus zachirus)

Management Plan and Area BSAI

Rex sole are a constituent of the "other flatfish" management category in the BSAI where they are less abundant than in the Gulf of Alaska.

Other members of the "other flatfish" category include:

Dover sole (*Microstomus pacificus*)

Starry flounder (*Platichthys stellatus*)

Longhead dab (*Pleuronectes proboscidea*)

Butter sole (*Pleuronectes isolepis*)

Life History and General Distribution

Distributed from Baja California to the Bering Sea and western Aleutian Islands (Hart 1973, Miller and Lea 1972), and are widely distributed throughout the Gulf of Alaska. Adults exhibit a benthic lifestyle and are generally found in water deeper than 300 meters. From over-winter grounds near the shelf margins, adults begin a migration onto the mid and outer continental shelf in April or May each year. The spawning period off Oregon is reported to range from January through June with a peak in March and April (Hosie and Horton 1977). Spawning in the Gulf of Alaska was observed from February through July, with a peak period in April and May (Hirschberger and Smith 1983). Eggs have been collected in neuston and bongo nets mainly in the summer, east of Kodiak Island (Kendall and Dunn 1985), but the duration of the incubation period is unknown.. Larvae were captured in bongo nets only in summer over midshelf and slope areas (Kendall and Dunn 1985). Fecundity estimates from samples collected off the Oregon coast ranged from 3,900 to 238,100 ova for fish 24-59 cm (Hosie and Horton 1977). The age or size at metamorphosis is unknown Maturity studies from Oregon indicate that males were 50% mature at 16 cm and females at 24 cm. Juveniles less than 15 cm are rarely found with the adult population. The natural mortality rate used in recent stock assessments is 0.2 (Spencer et al. 2002).

Fishery

Caught in bottom trawls mostly in the pursuit of other bottom-dwelling species. Recruitment begins at about age 3 or 4. They are caught as bycatch in the Pacific ocean perch, Pacific cod, bottom pollock and other flatfish fisheries.

Relevant Trophic Information

Groundfish predators include Pacific cod and most likely arrowtooth flounder.

Approximate upper size limit of juvenile fish? Males 15 cm and females 23 cm.

Habitat and Biological Associations

> <u>*Larvae/Juveniles*</u>: Planktonic larvae for an unknown time period until metamorphosis occurs, juvenile distribution is unknown.
>
> <u>*Adults*</u>: Spring spawning and summer feeding on a combination of sand, mud and gravel substrates of the continental shelf. Widespread distribution mainly on the middle and outer portion of the shelf, feeding mainly on polychaete, amphipods, euphausids and snow crabs.

Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Canada, Bull. No. 180. 740 p.

Hosie, M.J. and H.F. Horton. 1977. Biology of the rex sole, *Glyptocephalus zachirus*, in waters off Oregon. Fish. Bull. Vol. 75, No. 1, 1977, p. 51-60.

Hirschberger, W.A. and G.B. Smith. 1983. Spawning of twelve groundfish species in the Alaska and Pacific coast regions. 50 p. NOAA Tech. Mem. NMFS F/NWC-44. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Kendall, A.W. Jr. and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. NOAA Tech. Rep. NMFS 20, U.S. Dep. Commer, NOAA, Natl. Mar. Fish. Serv.

Livingston, P.A. and B.J. Goiney, Jr. 1983. Food habits literature of North Pacific marine fishes: a review and selected bibliography. NOAA Tech. Mem. NMFS F/NWC-54, U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Miller, D.J. and R.N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dep. Fish. Game, Fish. Bull. 157, 235 p.

Spencer, P. D., G. W. Walters and T. K. Wilderbuer. 2002. Other flatfish. *In* Appendix A Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Region. Pages 437-447. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

SPECIES: Rex sole

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	Feb - May	ICS? MCS OCS	P			
Larvae	U	U phyto/zoo plankton?	spring summer	ICS? MCS OCS	P			
Juveniles	2 years	polychaete amphipods euphausiids Tanner crab	all year	MCS ICS OCS	D	G, S, M		
Adults	2+ years	polychaete amphipods euphausiids Tanner crab	spawning Feb-May non-spawning May-January	MCS, OCS USP MCS, OCS, USP	D	G, S, M		

Habitat Description for Dover Sole

(*Microstomus pacificus*)

Management Plan and Area BSAI

Life History and General Distribution

Dover sole are distributed in deep waters of the continental shelf and upper slope from northern Baja California to the Bering Sea and the western Aleutian Islands (Hart 1973, Miller and Lea 1972), and exhibit a widespread distribution throughout the Gulf of Alaska. Adults are demersal and are mostly found in water deeper than 300 meters. The spawning period off Oregon is reported to range from January through May (Hunter et al. 1992). Spawning in the Gulf of Alaska has been observed from January through August, with a peak period in May (Hirschberger and Smith 1983). Eggs have been collected in neuston and bongo nets in the summer, east of Kodiak Island (Kendall and Dunn 1985), but the duration of the incubation period is unknown. Larvae were captured in bongo nets only in summer over mid-shelf and slope areas (Kendall and Dunn 1985). The age or size at metamorphosis is unknown but the pelagic larval period is known to be protracted and may last as long as two years (Markle et al. 1992). Pelagic postlarvae as large as 48 mm have been reported and the young may still be pelagic at 10 cm (Hart 1973). Dover sole are batch spawners and Hunter et al. (1992) concluded that the average 1 kg. female spawns its 83,000 advanced yolked oocytes in about nine batches. Maturity studies from Oregon indicate that females were 50% mature at 33 cm total length. Juveniles less than 25 cm are rarely found with the adult population from bottom trawl surveys (Martin and Clausen 1995). The natural mortality rate used in recent stock assessments is 0.2 (Turnock et al. 1996).

Fishery

Caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 5. They are caught as bycatch in the rex sole, thornyhead and sablefish fisheries and are caught with these species and Pacific halibut in Dover sole directed fisheries.

Relevant Trophic Information

Groundfish predators include Pacific cod and most likely arrowtooth flounder.

Approximate upper size limit of juvenile fish? 32 cm.

Habitat and Biological Associations

> *Larvae/Juveniles*: Planktonic larvae for up to 2 years until metamorphosis occurs, juvenile distribution is unknown.
>
> *Adults*: Winter and spring spawning and summer feeding on soft substrates (combination of sand and mud) of the continental shelf and upper slope. Shallower summer distribution mainly on the middle to outer portion of the shelf and upper slope, feeding mainly on polychaete, annelids, crustaceans and mollusks (Livingston and Goiney 1983).

Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Canada, Bull. No. 180. 740 p.

Hunter, J.R., B.J. Macewicz, N.C. Lo and C.A. Kimbrell. 1992. Fecundity, spawning, and maturity of female Dove sole *Microstomus pacificus*, with an evaluation of assumptions and precision. Fish. Bull. 90:101-128(1992).

Hirschberger, W.A. and G.B. Smith. 1983. Spawning of twelve groundfish species in the Alaska and Pacific coast regions. 50 p. NOAA Tech. Mem. NMFS F/NWC-44. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Kendall, A.W. Jr. and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. NOAA Tech. Rep. NMFS 20, U.S. Dep. Commer, NOAA, Natl. Mar. Fish. Serv.

Livingston, P.A. and B.J. Goiney, Jr. 1983. Food habits literature of North Pacific marine fishes: a review and selected bibliography. NOAA Tech. Mem. NMFS F/NWC-54, U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Markle, D.F., Harris, P, and Toole, C. 1992. Metamorphosis and an overview of early-life-history stages in Dover sole *Microstomus pacificus*. Fish. Bull. 90:285-301.

Martin, M.H. and D.M. Clausen. 1995. Data report: 1993 Gulf of Alaska Bottom Trawl Survey. U.S. Dept. Commer., NOAA, Natl. Mar. Fish. Serv., NOAA Tech. Mem. NMFS-AFSC-59, 217 p.

Miller, D.J. and R.N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dept. Fish. Game, Fish. Bull. 157, 235 p.

Turnock, B.J., T.K. Wilderbuer and E.S. Brown. 1996. Flatfish. In Stock assessment and fishery evaluation Report for the groundfish resources of the Gulf of Alaska. p 279-290. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

SPECIES: Dover sole

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	spring summer	ICS? MCS OCS UCS	P			
Larvae	up to 2 years	U phyto/zoo plankton?	all year	ICS? MCS OCS UCS	P			
Early Juveniles	to 3 years	polychaete amphipods annelids	all year	MCS? ICS?	D	S, M		
Late Juveniles	3-5 years	polychaete amphipods annelids	all year	MCS? ICS?	D	S, M		
Adults	5+ years	polychaete amphipods annelids mollus	ning July-January	MCS OCS UCS	D	S, M		

(Hippoglossoides elassodon)

Management Plan and Area BSAI

Life History and General Distribution

Distributed from northern California, off Point Reyes, northward along the west coast of North America and throughout the Gulf of Alaska and the Bering Sea, the Kuril Islands and possibly the Okhotsk Sea (Hart 1973).

Adults exhibit a benthic lifestyle and occupy separate winter spawning and summertime feeding distributions on the eastern Bering Sea shelf and in the Gulf of Alaska. From over-winter grounds near the shelf margins, adults begin a migration onto the mid and outer continental shelf in April or May each year for feeding. The spawning period may range from as early as January but is known to occur in March and April, primarily in deeper waters near the margins of the continental shelf. Eggs are large (2.75-3.75 mm) and females have egg counts ranging from about 72,000 (20 cm fish) to almost 600,000 (38 cm fish). Eggs hatch in 9 to 20 days depending on incubation temperatures within the range of 2.4 to 9.8°C (Forrester and Alderdice 1967) and have been found in ichthyoplankton sampling on the southern portion of the Bering Sea shelf in April and May (Waldron 1981). Larve absorb the yolk sac in 6 to 17 days but the extent of their distribution is unknown. The age or size at metamorphosis is unknown as well as the age at 50% maturity. Juveniles less than age 2 have not been found with the adult population, remaining in shallow areas. The natural mortality rate used in recent stock assessments is 0.2 (Spencer et al. 2002).

Fishery

Caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 3. Historically, the fishery has occurred throughout the mid and outer Bering Sea shelf during ice-free conditions (mostly summer and fall). They are caught as bycatch in Pacific cod, bottom pollock and other flatfish fisheries and are caught with these species and Pacific halibut in flathead sole directed fisheries.

Relevant Trophic Information

Groundfish predators include Pacific cod, Pacific halibut, arrowtooth flounder and also cannibalism by large flathead sole, mostly on fish less than 20 cm standard length (Livingston and DeReynier 1996).

Approximate upper size limit of juvenile fish? Unknown age at 50% maturity.

Habitat and Biological Associations

> *Larvae/Juveniles*: Planktonic larvae for an unknown time period until metamorphosis occurs, usually inhabiting shallow areas.
>
> *Adults*: Winter spawning and summer feeding on sand and mud substrates of the continental shelf. Widespread distribution mainly on the middle and outer portion of the shelf, feeding mainly on ophiuroids, tanner crab, osmerids, bivalves and polychaete (Pakunski 1990).

Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on sea floor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Forrester, C.R. and D.F. Alderdice. 1967. Preliminary observations on embryonic development of the flathead sole (*Hippoglossoides elassodon*). Fish. Res. Board Can. Tech. Rep. 100: 20 p

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Canada, Bull. No. 180. 740 p.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Miller, B.S. 1969. Life history observations on normal and tumor bearing flathead sole in East Sound, Orcas Island (Washington). Ph.D. Thesis. Univ. Wash. 131 p.

Pacunski, R.E. 1990. Food habits of flathead sole (*Hippoglossoides elassodon*) in the eastern Bering Sea. M.S. Thesis. Univ. Wash. 106 p.

Spencer, P. D., G. W. Walters and T. K. Wilderbuer. 2002. Flathead sole. In Appendix A Stock Assessment and Fishery

Evaluation Document for the Groundfish Resources of the Bering Sea/Aleutian Islands Region. Pages 361-408. North

Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage AK 99501.

Waldron, K.D. 1981. Ichthyoplankton. In D.W. Hood and J.A. Calder (Editors), The eastern Bering Sea shelf: Oceanography and resources, Vol. 1, p. 471-493. U.S. Dep. Commer., NOAA, Off. Mar. Poll. Asess., U.S. Gov. Print. Off., Wash., D.C.

Walters, G.E. and T.K. Wilderbuer 1996. Flathead sole. *In* Stock assessment and fishery evaluation Report for the groundfish resources of the Bering Sea/Aleutian Islands Regions. p 279-290. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

SPECIES: Flathead sole

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	winter	ICS MCS OCS	P			
Larvae	U	U phyto/zoo plankton?	spring summer	ICS MCS OCS	P			
Early Juveniles	to 2 yrs	polychaete bivalves ophiuroids	all year	MCS ICS	D	S+M[1]		
Late Juveniles	3 yrs	polychaete bivalves ophiuroids pollock and Tanner crab	all year	MCS ICS OCS	D	S+M[1]		
Adults	U	polychaete bivalves ophiuroids pollock and Tanner crab	spawning Jan-April non-spawning May-December	MCS OCS ICS	D	S+M[1]	ice edge	

[1]Pers. Comm. Dr. Robert McConnaughey (206) 526-4150

Habitat Description for Sablefish

(Anoplopoma fimbria)

Management Plan and Area BSAI

Life History and General Distribution

Distributed from Mexico through the Gulf of Alaska to the Aleutian Chain, Bering Sea; along the Asian coast from Sagami Bay, and along the Pacific sides of Honshu and Hokkaido Islands and the Kamchatkan Peninsula. Adult sablefish occur along the continental slope, shelf gulleys, and in deep fjords such as Prince William Sound and Southeastern Alaska, at depths generally greater than 200 m. Adults are assumed to be demersal. Spawning or very ripe sablefish are observed in late winter or early spring along the continental slope. Eggs are apparently released near the bottom where they incubate. After hatching and yolk adsorption the larvae rise to the surface where they have been collected with neuston nets. Larvae are oceanic through the spring and by late summer, small pelagic juveniles (10-15 cm) have been observed along the outer coasts of Southeast Alaska, where they apparently move into shallow waters to spend their first winter. During most years, there are only a few places where juveniles have been found during their first winter and second summer. It is not clear if the juvenile distribution is highly specific or appears so because sampling is highly inefficient and sparse. During the occasional times of large year-classes the juveniles are easily found in many inshore areas during their second summer. They are typically 30-40 cm in length during their second summer, after which they apparently leave the nearshore bays. One or two years later they begin appearing on the continental shelf and move to their adult distribution as they mature.

Fishery

The major fishery for sablefish in Alaska uses longlines, however sablefish are valuable in the trawl fishery as well. Sablefish enter the longline fishery at 4-5 years of age, perhaps slightly younger in the trawl fishery. The longline fishery takes place March 1 and November 15. The take of the trawl share of sablefish occurs primarily in association with openings for other species, such as the July rockfish openings, where they are taken as allowed bycatch. Deeper dwelling rockfish, such as Shortraker, Rougheye, and Thornyhead rockfish are the primary bycatch in the longline sablefish fishery. Halibut and rattails (Albatrossia pectoralis and Corphaenoides acrolepis) also are taken. By regulation, there is no directed trawl fishery for sablefish, however, directed fishing standards have allowed some trawl hauls to target sablefish, where the bycatch is similar to the longline fishery, in addition perhaps to some deep dwelling flatfish.

Relevant Trophic Information

Larval sablefish feed on a variety of small zooplankton ranging from copepod naupli to small amphipods. The epipelagic juveniles feed primarily on macrozooplankton and micronekton (i.e., euphausiids).

The older demersal juveniles and adults appear to be opportunistic feeders, with food ranging from variety of benthic invertebrates, benthic fishes, as well as squid, mesopelagic fishes, jellyfish and fishery discards. Gadid fish (mainly pollock) comprise a large part of the sablefish diet. Nearshore residence during their second year provide the opportunity to feed on salmon fry and smolts during the summer months.

Young of the year sablefish are commonly found in the stomachs of salmon taken in the southeast (SE) troll fishery during the late summer.

What is the approximate upper size limit of juvenile fish (in cm)?

Size of 50% maturity: Bering Sea: males 65 cm, females 67 cm; Aleutian Islands: males 61 cm, females 65 cm; Gulf of Alaska: males 57 cm, females 65 cm. At the end of the second summer (~1.5 years old) they are 35-40 cm in length. Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)

Eggs and Larvae:

NMFS, Alaska Fisheries Science Center, FOCI Program, Art Kendall 206-526-4108, NMFS Auke Bay Lab, Bruce Wing 907-789-????

Juveniles:

ADFG groundfish surveys: Jim Blackburn, ADFG, Kodiak AK 907-486-186, Paul Anderson, NMFS/RACE, Kodiak AK 907-487-4961

Kendall, A.W. and A.C. Materese. Biology of eggs, larvae, and epipelagic juveniles of sablefish, Anoplopoma fimbria, in relation to their potential use in management. Mar. Fish. Rev. 49(1)1-13.

Smith, G.B., G.E. Walters, P.A. Raymore, Jr., and W.A, Hischberger. 1984. Studies of the distribution and abundance of juvenile groundfish in the northwestern Gulf of Alaska, 1980-82: Part I, Three-year comparisons. NOAA Tech. Memo. NMFS F/NWC-59. 100p.

Walters, G.E., G.B. Smith, P.A. Raymore, and W.A. Hirschberger. 1985. Studies of the distribution and abundance of juvenile groundfish in the northwestern Gulf of Alaska, 1980-82: Part II, Biological characteristics in the extended region. NOAA Tech. Memo. NMFS F/NWC-77. 95 p.

Wing, B.L. and D.J. Kamikawa. 1995. Distribution of neustonic sablefish larvae and associated ichthyoplankton in the eastern Gulf of Alaska, May 1990. NOAA Tech. Memo. NMFS-AFSC-53.

Habitat and Biological Associations (if known) Narrative

Egg/Spawning

Larvae

Juveniles

Adults - other than depth, none is noted.

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and Zoogeography of common fishes in the Bering Sea and northeastern Pacific. U.S. Dep. Commer., NOAAS Tech. Rept. NMFS 66, 151 p.

Boehlert, G.W., and M.M. Yoklavich. 1985. Larval and juvenile growth of sablefish, Anoplopoma fimbria, as determined from otolith increments. Fish. Bull. 83:475-481.

Grover, J.J., and B.L. Olla. 1986. Morphological evidence for starvation and prey size selection of sea-caught larval sablefish, Anoplopoma fimbria. Fish. Bull. 84:484-489.

Grover, J.J., and B.L. Olla. 1987. Effects of and El Niño event on the food habits of larval sablefish, Anoplopoma fimbria, off Oregon and Washington. Fish. Bull. 85: 71-79.

Grover, J.J., and B.L. Olla. 1990. Food habits of larval sablefish, Anoplopoma fimbria from the Bering Sea. Fish Bull. 88:811-814.

Hunter, J.R., B.J. Macewiccz, and C.A. Kimbrell. 1989. Fecundity and other aspects of the reproduction of Sablefish, Anoplopoma fimbria, in Central California Waters. Calif. Coop. Fish. Invst. Rep. 30: 61-72.

Kendall, A.W., Jr., and A.C. Matarese. 1984. Biology of eggs, larvae, and epipelagic juveniles of sablefish, Anoplopoma fimbria, in relation to their potential use in management. Mar. Fish. Rev. 49(1):1-13.

Mason, J.C. , R.J. Beamish, and G.A. McFralen. 1983. Sexual maturity, fecundity, spawning, and early life history of sablefish (Anoplopoma fimbria) off the Pacific coast of Canada. Can. J. Fish. Aquat. Sci. 40:2121-2134.

McFarlane, G.A., and R.J. Beamish. 1992. Climatic influence linking copepod production with strong year-classes in sablefish, Anoplopoma fimbria. Can J. Fish. Aquat. Sci. 49:743-753.

Moser, H.G., R.L. Charter, P.E. Smith, N.C.H. Lo., D.A. Ambrose, C.A. Meyer, E.M. Sanknop, and W. Watson. 1994. Early life history of sablefish, Anoplopoma fimbria, off Washington, Oregon, and California with application to biomass estimation. Calif. Coop. Oceanic Fish. Invest. Rep. 35:144-159.

Rutecki, T.L. and E.R. Varosi. 1993. Distribution, age, and growth of juvenile sablefish in Southeast Alaska. Paper presented at International Symposium on the Biology and Management of Sablefish. Seattle, Wash. April 1993.

Rutecki, T.L. and E.R. Varosi. 1993. Migrations of Juvenile Sablefish in Southeast Alaska. Paper presented at International Symposium on the Biology and Management of Sablefish. Seattle, Wash. April 1993.

Sasaki, T. 1985. Studies on the sablefish resources in the North Pacific Ocean. Bulletin 22, (1-108), Far Seas Fishery Laboratory. Shimizu, 424, Japan.

Sigler, M.F., E.R. Varosi, and T.R. Rutecki. 1993. Recruitment curve for sablefish in Alaska based on recoveries of fish tagged as juveniles. Paper presented at International Symposium on the Biology and Management of Sablefish. Seattle, Wash. April 1993.

Sigler, M. F., T. L. Rutecki, D. L. Courtney, J. F. Karinen, and M.-S.Yang. 2001. Young-of-the-year sablefish abundance, growth, and diet. Alaska Fisheries Research Bulletin 8(1): 57-70.

NOAA (National Oceanic and Atmospheric Administration). 1990. Sablefish, Anoplopoma fimbria. Pl 3.2.22. In: West Coast of North America Coastal and Ocean Zones Strategic Assessment Data Atlas. Invertebrate and Fish Volume. U.S. Dep. Commer. NOAA. OMA/NOS, Ocean Assessment Division, Strategic Assessment Branch.

Wing, B.L. 1985. Salmon Stomach contents from the Alaska Troll Logbook Program, 1977-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-91, 41 p.

Wing, B.L. 1997. Distribution of sablefish, Anoplopoma fimbria, larvae in the eastern Gulf of Alaska: Neuston-net tows versus oblique tows. In: M. Wilkins and M. Saunders (editors), Proc. Int. Sablefish Symp., April 3-4, 1993, p. 13-25.. U.S. Dep. Commer., NOAA Tech. Rep. 130.

Wing, B.L. and D.J. Kamikawa. 1995. Distribution of neustonic sablefish larvae and associated ichthyoplankton in the eastern Gulf of Alaska, May 1990. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-AFSC-53, 48 p.

Wing, B.L., C. Derrah, and V. O'Connell. 1997. Ichthyoplankton in the eastern Gulf of Alaska, May 1990. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-AFSC-376, 42 p.

Wolotera, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. NOAA Tech. Memo. NMFS-AFSC-22. 150 p.

SPECIES: Bering Sea/Aleutian Islands Sablefish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	14-20 days	NA	late winter-early spring: Dec-Apr	USP, LSP, BSN	P, 200-3000 m	NA	U	
Larvae	up to 3 months	copepod nauplii, small copepodites, etc	spring-summer: Apr-July	MCS, OCS, USP, LSP, BSN	N, neustonic near surface	NA	U	
Early Juveniles	to 3 yrs	small prey fish, sandlance, salmon, herring, etc		OCS, MCS, ICS, during first summer, then obs in BAY, IP, till end of 2nd summer; not obs'd till found on shelf	P when offshore during first summer, then D, SD/SP when inshore	NA when pelagic. The bays where observed were soft bottomed, but not enough obs. to assume typical.	U	
Late Juveniles	3-5 yrs	opportunistic: other fish, shellfish, worms, jellyfish, fishery discards	all year	continental slope, and deep shelf gulleys and fjords.	caught with bottom tending gear. presumably D	varies	U	
Adults	5 yrs to 35+	opportunistic: other fish, shellfish, worms, jellyfish, fishery discards	apparently year around, spawning movements (if any) are undescribed	continental slope, and deep shelf gulleys and fjords.	caught with bottom tending gear. presumably D	varies	U	

Habitat Description for Pacific Ocean Perch

(Sebastes alutus)

Management Plan and Area BSAI

Life History and General Distribution

Pacific ocean perch has a wide distribution in the North Pacific from southern California around the Pacific rim to northern Honshu Is., Japan, including the Bering Sea. The species appears to be most abundant in northern British Columbia, the Gulf of Alaska, and the Aleutian Islands. Adults are found primarily offshore along the continental slope in depths 180-420 m. Seasonal differences in depth distribution have been noted by many investigators. In the summer, adults inhabit shallower depths, especially those between 180 and 250 m. In the fall, the fish apparently migrate farther offshore to depths of ~300-420 m. They reside in these deeper depths until about May, when they return to their shallower summer distribution. This seasonal pattern is probably related to summer feeding and winter spawning. Although small numbers of Pacific ocean perch are dispersed throughout their preferred depth range on the continental slope, most of the population occurs in patchy, localized aggregations. At present, the best evidence indicates that Pacific ocean perch is mostly a demersal species. A number of investigators have speculated that there is also a pelagic component to their distribution, especially at night when they may move off-bottom to feed, but hard evidence for this is lacking.

There is much uncertainty about the life history of Pacific ocean perch, although generally more is known than for other rockfish species. The species appears to be viviparous, with internal fertilization and the release of live young. Insemination occurs in the fall, and sperm are retained within the female until fertilization takes place ~2 months later. The eggs develop and hatch internally, and parturition (release of larvae) occurs in April-May. Information on early life history is very sparse, especially for the first year of life. Positive identification of Pacific ocean perch larvae is not possible at present, but the larvae are thought to be pelagic and to drift with the current. Transformation to an adult form and the assumption of a demersal existence may take place within the first year. Small juveniles probably reside inshore in very rocky, high relief areas, and by age 3 begin to migrate to deeper offshore waters of the continental shelf. As they grow, they continue to migrate deeper, eventually reaching the continental slope, where they attain adulthood.

Pacific ocean perch is a very slow growing species, with a low rate of natural mortality (estimated at 0.05), a relatively old age at 50% maturity (10.5 years for females in the Gulf of Alaska), and a very old maximum age of 98 years in Alaska. Despite their viviparous nature, the fish is relatively fecund with number of eggs/female in Alaska ranging from 10,000-300,000, depending upon size of the fish.

Fishery

Pacific ocean perch are caught almost exclusively with bottom trawls. Age at 50% recruitment has been estimated to be about 6.6 years. The fishery is concentrated in the summer months due to management regulations and opens in July, when most of the harvest is taken. Harvest data from 2000-2002 indicates that approximately 80% of the POP in the BSAI are harvested during this month; there is no directed fishing for POP in the EBS management area. The harvest of POP is distributed across the Aleutian Islands subareas in proportion to relative biomass. From 2000-2002, approximately 44% of the harvest occurred in area 543, with 23% and 26% in the eastern and central Aleutians, respectively. POP are patchily distributed, and are harvested in relatively few areas within the broad management subareas of the Aleutian Islands.

The 2000-2002 blend data indicates that about 15% of the harvested BSAI POP is obtained as bycatch in the Atka mackerel fishery, with ~80% of the harvest of POP occurring in the POP fishery. Similarly, BSAI

POP target fishery consists largely of POP, with percentages ranging from 71% to 91% from 2000 to 2002. Other species obtained as bycatch in the BSAI POP fishery include Atka mackerel, arrowtooth flounder, walleye pollock, northern rockfish, and shortraker/rougheye.

Relevant Trophic Information

All food studies of Pacific ocean perch have shown them to be overwhelmingly planktivorous. Small juveniles eat mostly calanoid copepods, whereas larger juveniles and adults consume euphausiids as their major prey items. Adults, to a much lesser extent, may also eat small shrimp and squids. It has been suggested that Pacific ocean perch and walleye pollock compete for the same euphausiid prey. Consequently, the large removals of Pacific ocean perch by foreign fishermen in the Gulf of Alaska in the 1960s may have allowed walleye pollock stocks to greatly expand in abundance.

Documented predators of adult Pacific ocean perch include Pacific halibut and sablefish, and it is likely that Pacific cod and arrowtooth flounder also prey on Pacific ocean perch. Pelagic juveniles are consumed by salmon, and benthic juveniles are eaten by lingcod and other large demersal fish.

What is the approximate upper size limit of juvenile fish (in cm)?

For Gulf of Alaska: 38 cm for females; unknown for males, but presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*. For Aleutian Islands and Bering Sea: unknown for both sexes.

Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)

Eggs and Larvae: NMFS, Alaska Fisheries Science Center, Auke Bay Laboratory; NMFS, Alaska Fisheries Science Center, FOCI program; Canada Dept. of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C.

Juveniles: Carlson, H.R. and R.E. Haight. 1976 . Juvenile life of Pacific ocean perch, *Sebastes alutus*, in coastal fiords of southeastern Alaska: Their environment, growth, food habits, and schooling behavior. Trans. Am, Fish. Soc. 105:191-201.

Habitat and Biological Associations (if known) Narrative

<u>*Egg/Spawning*</u>: Little information is known. Insemination is thought to occur after adults move to deeper offshore waters in the fall. Parturition is reported to occur from 20-30 m off bottom at depths of 360-400 m.

<u>*Larvae*</u>: Little information is known. Earlier information suggested that after parturition, larvae rise quickly to near surface, where they become part of the plankton. More recent data from British Columbia indicates that larvae may remain at depths >175 m for some period of time (perhaps two months), after which they slowly migrate upward in the water column.

<u>*Juveniles*</u>: Again, information is very sparse, especially for younger juveniles. After metamorphosis from the larval stage, juveniles may reside in a pelagic stage for an unknown length of time. They eventually become demersal, and at age 1-3 probably live in very rocky inshore areas. Afterward, they move to progressively deeper waters of the continental shelf. Older juveniles are often found together with adults at shallower locations of the continental slope in the summer months.

<u>*Adults*</u>: Commercial fishery data have consistently indicated that adult Pacific ocean perch are found in aggregations over reasonably smooth, trawlable bottom of the continental slope. Generally, they are found in shallower depths (180-250 m) in the summer, and

deeper (300-420 m) in the fall, winter, and early spring. In addition, investigators in the 1960s and 1970s speculated that the fish sometimes inhabited the mid-water environment off bottom and also might be found in rough, untrawlable areas. Hard evidence to support these latter two conjectures, however, has been lacking. The best information available at present suggests that adult Pacific ocean perch is mostly a demersal species that prefers a flat, pebbled substrate along the continental slope. More research is needed, however, before definitive conclusions can be drawn as to its habitat preferences.

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. U.S. Dep. Commer., NOAA Tech. Rept. NMFS 66, 151 p.

Carlson, H.R., and R.E. Haight. 1976. Juvenile life of Pacific ocean perch, *Sebastes alutus*, in coastal fiords of southeastern Alaska: their environment, growth, food habits, and schooling behavior. Trans. Am. Fish. Soc. 105:191-201.

Carlson, H.R., and R.R. Straty. 1981. Habitat and nursery grounds of Pacific rockfish, *Sebastes* spp., in rocky coastal areas of Southeastern Alaska. Mar. Fish. Rev. 43: 13-19.

Doyle, M.J. 1992. Patterns in distribution and abundance of ichthyoplankton off Washington, Oregon, and Northern California (1980-1987). U.S. Dep. Commer. NOAA NMFS AFSC Processed Rept. 92-14, 344 p.

Gillespie, G.E., R.D. Stanley, and B.M. Leaman. 1992. Early life history of rockfishes in British Columbia; preliminary results of the first year of investigation. Proc. 1992 W. Groundfish Conf. Alderbrook Inn Resort, Union, WA, Jan 27-30, 1992.

Gunderson, D.R. 1971. Reproductive patterns of Pacific ocean perch (*Sebatodes alutus*) off Washington and British Columbia and their relation to bathymetric distribution and seasonal abundance. J. Fish. Res. Bd. Can. 28: 417-425.

Gunderson, D.R., and M.O. Nelson. 1977. Preliminary report on an experimental rockfish survey conducted off Monterey, California and in Queen Charlotte Sound, British Columbia during August-September, 1976. Prepared for Feb. 15-16, 1977, Interagency Rockfish Survey Coordinating Committee Meeting, NWAFC, Seattle, WA. Unpubl. manuscr. 82 p.

Harrison, R.C. 1993. Data report: 1991 bottom trawl survey of the Aleutian Islands area. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-12. 144 p.

Heifetz, J., and D. Ackley. 1997. Bycatch in rockfish fisheries in the Gulf of Alaska. Unpubl. Manuscr. 20 p. (Available from NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK 99801.

Heifetz, J., J.N. Ianelli, and D.M. Clausen. 1996. Slope rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p.229-269. North Pacific Fishery Management Council, 605 W. 4th. Ave., Suite 306, Anchorage, AK 99501-2252.

Ito, D.H. 1982. A cohort analysis of Pacific ocean perch stocks from the Gulf of Alaska and Bering Sea regions. U.S. Dep. Commer., NWAFC Processed Rept. 82-15, 157 p.

Ito, D.H., and J.N. Ianelli. 1996. Pacific ocean perch. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, p.331-359. North Pacific Fishery Management Council, 605 W. 4th. Ave., Suite 306, Anchorage, AK 99501-2252.

Kendall, A.W., and W.H. Lenarz. 1986. Status of early life history studies of northeast Pacific rockfishes. Proc. Int. Rockfish Symp. Oct. 1986, Anchorage Alaska; p. 99-117.

Krieger, K.J. 1993. Distribution and abundance of rockfish determined from a submersible and by bottom trawling. Fish. Bull., U.S. 91:87-96.

Martin, M.H. and D.M. Clausen. 1995. Data report: 1993 Gulf of Alaska bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-59. 217 p.

Matarese, A.C., A.W. Kendall, Jr., D.M. Blood, and B.M. Vinter. 1989. Laboratory guide to early life history stages of northeast Pacific fishes. U.S. Dep. Commer. NOAA Tech. Rept. NMFS 80, 652 p.

Matthews, K.R., J.R. Candy, L.J. Richards, and C.M. Hand. 1989. Experimental gill net fishing on trawlable and untrawlable areas off northwestern Vancouver Island, from the MV Caledonian, August 15-28, 1989. Can. Manuscr. Rep. Fish. Aquat. Sci. 2046, 78 p.

Mattson, C.R., and B.L. Wing. 1978. Ichthyoplankton composition and plankton volumes from inland coastal waters of southeastern Alaska, April-November 1972. U.S. Dep. Commer., NOAA Tech. Rept. NMFS SSRF-723, 11 p.

Moser, H.G., 1996. SCORPAENIDAE: scorpionfishes and rockfishes. *In*: Moser, H.G., editor. The early stages of fishes in the California Current region, p. 733-795. CalCOFI Atlas No.33. 1505 p.

NOAA (National Oceanic and Atmospheric Administration). 1990. Pacific ocean perch, *Sebastes alutus*. *In*: West coast of North America coastal and ocean zones strategic assessment: data atlas. Invertebrate and fish volume, Plate 3.2.20. U.S. Dep. Commer. NOAA. OMA/NOS, Ocean Assessments Division, Strategic Assessment Branch.

Ronholt, L.L., K. Teshima, and D.W. Kessler. 1994. The groundfish resources of the Aleutian Islands region and southern Bering Sea 1980, 1983, and 1986. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-31. 351 p.

Seeb, L.W. 1993. Biochemical identification of larval rockfishes of the genus *Sebastes*. Final Report Contract #43ABNF001082. U.S. Dept. Commer. NOAA/NMFS NWAFC/RACE Division, Seattle, WA. 28 p.

Seeb, L.W., and A.W. Kendall, Jr. 1991. Allozyme polymorphisms permit the identification of larval and juvenile rockfishes of the genus *Sebastes*. Environmental Biology of Fishes 30:191-201.

Stark, J.W., and D.M. Clausen. 1995. Data report: 1990 Gulf of Alaska bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-49. 221 p.

Westrheim, S.J. 1970. Survey of rockfishes, especially Pacific ocean perch, in the northeast Pacific Ocean, 1963-66. J. Fish. Res. Bd. Canada 27: 1781-1809.

Westrheim, S.J. 1975. Reproduction, maturation, and identification of larvae of some *Sebastes* (Scorpaenidae) species in the northeast Pacific Ocean. J. Fish. Res. Board Can. 32: 2399-2411.

Wing, B.L. 1985. Salmon stomach contents from the Alaska troll logbook program, 1977-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-91. 41 p.

Wing, B.L., C. Derrah, and V. O'Connell. 1997. Ichthyoplankton in the eastern Gulf of Alaska, May 1990. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-AFSC-376, 42 p.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U. S. Dep. Commer., NOAA Tech. Memo. NMFS - AFSC-6, 184 p.

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

Yang, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-60, 105 p.

SPECIES: Pacific ocean perch

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	Internal incub-tion; ~90 d	NA	Winter	NA	NA	NA	NA	NA
Larvae	U; assumed between 60 and 180 days	U; assumed to be micro-zooplankton	Spring-summer	ICS, MCS, OCS, USP, LSP, BSN	P	NA	U	U
Juveniles	3-6 months to 10 years	Early juv: calanoid copepods; late juv: euphausiids	All year	ICS, MCS, OCS, USP	?P (early juv. only), D	R (<age 3)	U	U
Adults	10-98 years of age	Euphausiids	Insemination (fall); Fertilization, incubation (winter); Larval release (spring); Feeding in shallower depths (summer)	OCS, USP	D	CB, G,?M, ?SM,?MS	U	U

Habitat Description for Shortraker Rockfish (*Sebastes borealis*)

and

Rougheye Rockfish (*Sebastes aleutianus*)

Management Plan and Area BSAI

Life History and General Distribution

Shortraker and rougheye rockfishes are found along the northwest slope of the eastern Bering Sea, throughout the Aleutian Islands and south to Point Conception, California. Both species are demersal and can be found at depths ranging from 25 to 875 m; however, commercial concentrations usually occur at depths from 300 to 500 m. Though relatively little is known about their biology and life history, both species appear to be K-selected with late maturation, slow growth, extreme longevity, and low natural mortality. Rougheye rockfish attain maturity relatively late in life, at about 20+ years of age. Both species are among the largest *Sebastes* species in Alaskan waters, attaining sizes of up to 104 cm for shortraker and 96 cm for rougheye rockfish. Shortraker rockfish have been estimated to attain ages in excess of 120 years and rougheye rockfish in excess of 140 years. Natural mortality for both species is low, estimated to be on the order of 0.01 to 0.04.

Fishery

A directed fishery does not exist for shortraker rockfish or rougheye rockfish in the BSAI area. Harvest data from 2000-2000 indicates that over 90% of the harvest of BSAI shortraker and rougheye rockfish is taken in the Aleutian Islands, with the proportion among the three subareas ranging from 26% to 34%. Rougheye and shortraker rockfish are most commonly caught in July, with 58% of the harvest from 2000-2002, and the bulk of this harvest is obtained as bycatch in the POP trawl fishery. Rougheye and shortraker are also caught in the sablefish longline fishery, particularly in the eastern and central Aleutian Islands, and in the Pacific cod longline fishery, particularly in the central and western Aleutians.

Relevant Trophic Information

Shortraker and rougheye rockfishes prey primarily on shrimps, squids, and myctophids. It is uncertain what are the main predators on both species.

What is the approximate upper size limit of juvenile fish (in cm)

For shortraker rockfish, length at 50% sexual maturity is about 45 cm and about 44 cm for rougheye rockfish

Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)

NMFS, Alaska Fisheries Science Center.

Habitat and Biological Associations (if known) Narrative

<u>*Egg/Spawning*</u>: The timing of reproductive events is apparently protracted. One study indicated that vitellogenesis was present for four to five months and lasted from about July until late October and November. Parturition apparently occurs mainly in early spring through summer.

<u>*Larvae*</u>: No information is available regarding the habitats and biological associations of shortraker and rougheye rockfish larvae.

Juveniles: Very little information is available regarding the habitats and biological associations of shortraker and rougheye rockfish juveniles. It is suspected, however, that the juveniles of both species occupy shallower habitats than that of the adults.

Adults: Adults are demersal and can be found at depths ranging from 25 to 875 m. Submersible observations indicate that adults occur over a wide range of habitats. Soft substrates of sand or mud usually had the highest densities; whereas hard substrates of bedrock, cobble or pebble usually had the lowest adult densities. Habitats with steep slopes and frequent boulders were used at a higher rate than habitats with gradual slopes and few boulders.

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Archibald, C. P., W. Shaw, and B. M. Leaman. 1981. Growth and mortality estimates of rockfishes (Scorpaenidae) from B.C. coastal waters, 1977-79. Can. Tech. Rep. Fish. Aquat. Sci. 1048, 57 p.

Chilton, D. E., and R. J. Beamish. 1982. Age determination methods for fishes studied by the Groundfish Program at the Pacific Biological Station. Can. Spec. Publ. Fish. Aquat. Sci. 60, 102 p.

Heifetz, J., J.N. Ianelli, and D.M. Clausen. 1996. Slope rockfish. *In* Stock assessment and fishery evaluation report for the 1997 Gulf of Alaska groundfish fishery, p. 230-270. North Pacific Fishery Management Council, 605 W. 4th Avenue, Suite 306, Anchorage, AK 99501.

Kramer, D.E., and V.M. O'Connell. 1986. Guide to northeast Pacific rockfishes, Genera *Sebastes* and *Sebastolobus*. Marine Advisory Bulletin No. 25: 1-78. Alaska Sea Grant College Program, University of Alaska.

Krieger, K. 1992. Shortraker rockfish, *Sebastes borealis*, observed from a manned submersible. Mar. Fish. Rev., 54(4): 34-37.

Krieger, K.J. 1993. Distribution and abundance of rockfish determined from a submersible and by bottom trawling. Fish. Bull. 91:87-96.

Krieger, K.J., and D.H. Ito. Unpublished. Distribution and abundance of shortraker rockfish, *Sebastes borealis*, and rougheye rockfish, *Sebastes aleutianus*, determined from a submersible. Unpublished manuscript.

McDermott, S.F. 1994. Reproductive biology of rougheye and shortraker rockfish, *Sebastes aleutianus* and *Sebastes borealis*. Masters Thesis. Univ. Washington, Seattle.76 p.

Sigler, M.F., and H.H. Zenger, Jr. 1994. Relative abundance of Gulf of Alaska sablefish and other groundfish based on the domestic longline survey, 1989. NOAA Tech. Memo. NMFS-AFSC-40.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

Yang, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-60, 105 p.

SPECIES: Shortraker and Rougheye Rockfish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	U	U	U	U	U	U	
Larvae	U	U	Spawning: Early spring through summer	U	U	U	U	
Early Juveniles	U	U Shrimp & amphipods?	U	U MCS, OCS?	U	U	U	
Late Juveniles								
Adults	15+ yrs of age	Shrimp Squid Myctophids	Year-round?	OCS, USP	D	M, S, R, SM, CB, MS, G	U	

Habitat Description for Northern Rockfish

(*Sebastes polyspinus*)

Management Plan and Area BSAI

Life History and General Distribution

Northern rockfish range from northern British Columbia through the Gulf of Alaska and Aleutian Islands to eastern Kamchatka, including the Bering Sea. The species is most abundant from about Portlock Bank in the central Gulf of Alaska to the western end of the Aleutian Islands. Within this range, adult fish appear to be concentrated at discrete, relatively shallow offshore banks of the outer continental shelf. Typically, these banks are separated from land by an intervening stretch of deeper water. The preferred depth range is ~75-125 m in the Gulf of Alaska, and ~100-150 m in the Aleutian Islands. The fish appear to be demersal, although small numbers are occasionally taken in pelagic tows. In common with many other rockfish species, northern rockfish tend to have a localized, patchy distribution, even within their preferred habitat, and most of the population occurs in aggregations. Most of what is known about northern rockfish is based on data collected during the summer months from the commercial fishery or in research surveys. Consequently, there is little information on seasonal movements or changes in distribution for this species.

Life history information on northern rockfish is extremely sparse. The fish are assumed to be viviparous, as are other Sebastes, with internal fertilization and incubation of eggs. Observations during research surveys in the Gulf of Alaska suggest that parturition (larval release) occurs in the spring, and is mostly completed by summer. Pre-extrusion larvae have been described, but field-collected larvae cannot be identified to species at present. Length of the larval stage is unknown, but the fish apparently metamorphose to a pelagic juvenile stage, which also has been described. There is no information on when the juveniles become benthic or what habitat they occupy. Older juveniles are found on the continental shelf, generally at locations inshore of the adult habitat.

Northern rockfish is a slow growing species, with a low rate of natural mortality (estimated at 0.06), a relatively old age at 50% maturity (12.8 years for females in the Gulf of Alaska), and an old maximum age of 57 years in Alaska. No information on fecundity is available.

Fishery

In the BSAI area, there is no directed fishery for northern rockfish. Harvest data from 2000-2002 indicates that approximately 90% of the BSAI northern rockfish are harvested in the Atka mackerel fishery, with a large amount of the catch occurring in September in the western Aleutians (area 543). The distribution of northern rockfish harvest by Aleutian Islands subarea reflects both the spatial regulation of the Atka mackerel fishery and the increased biomass of northern rockfish in the western Aleutian Islands. The average proportion of northern rockfish biomass occurring in the western, central, and eastern Aleutian Islands, based on trawl surveys from 1991-2002, were 72%, 22% and 5%, respectively. Northern rockfish are patchily distributed, and are harvested in relatively few areas within the broad management subareas of the Aleutian Islands, with important fishing grounds being Petral Bank, Sturdevant Rock, south of Amchitka I., and Seguam Pass (Dave Clausen, NMFS-AFSC, personal communication).

Relevant Trophic Information

Although no comprehensive food study of northern rockfish has been done, several smaller studies have all shown euphausiids to be the predominate food item of adults in both the Gulf of Alaska and Bering Sea. Copepods, hermit crabs, and shrimp have also been noted as prey items in much smaller quantities.

Predators of northern rockfish have not been documented, but likely include species that are known to consume rockfish in Alaska, such as Pacific halibut, sablefish, Pacific cod, and arrowtooth founder.

What is the approximate upper size limit of juvenile fish (in cm)?

For Gulf of Alaska: 38 cm for females; unknown for males, but presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*. For Aleutian Islands and Bering Sea: unknown for both sexes. Because northern rockfish in the Aleutian Islands attain a much smaller size than in the Gulf, the upper size limit of juveniles there is probably much less than in the Gulf.

Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)

Eggs and Larvae: None at present

Older juveniles and adults: NMFS, Alaska Fisheries Science Center, Auke Bay Laboratory, David Clausen, (907) 789-6049.

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: No information known, except that parturition probably occurs in the spring.

Larvae: No information known.

Juveniles: No information known for small juveniles (<20 cm), except that juveniles apparently undergo a pelagic phase immediately after metamorphosis from the larval stage. Larger juveniles have been taken in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds.

Adults: Commercial fishery and research survey data have consistently indicated that adult northern rockfish are primarily found over reasonably flat, trawlable bottom of offshore banks of the outer continental shelf at depths of 75-150 m. Preferred substrate in this habitat has not been documented, but observations from trawl surveys suggest that large catches of northern rockfish are often associated with hard bottoms. Generally, the fish appear to be demersal, and most of the population occurs in large aggregations. There is no information on seasonal migrations. Northern rockfish often co-occur with dusky rockfish.

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Harrison, R.C. 1993. Data report: 1991 bottom trawl survey of the Aleutian Islands area. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-12. 144 p.

Heifetz, J., and D. Ackley. 1997. Bycatch in rockfish fisheries in the Gulf of Alaska. Unpubl. Manuscr. 20 p. (Available from NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK 99801.)

Heifetz, J., J.N. Ianelli, and D.M. Clausen. 1996. Slope rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p.229-269. North Pacific Fishery Management Council, 605 W. 4th. Ave., Suite 306, Anchorage, AK 99501-2252.

Kendall, A.W. 1989. Additions to knowledge of *Sebastes* larvae through recent rearing. NWAFC Proc.Rept. 89-21. 46 p.

Martin, M.H. and D.M. Clausen. 1995. Data report: 1993 Gulf of Alaska bottom trawl survey. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-59. 217 p.

Matarese, A.C., A.W. Kendall, Jr., D.M. Blood, and B.M. Vinter. 1989. Laboratory guide to early life history stages of Northeast Pacific fishes. U.S. Dep. Commerce NOAA Tech. Rept. NMFS 80, 652 p.

Ronholt, L.L., K. Teshima, and D.W. Kessler. 1994. The groundfish resources of the Aleutian Islands region and southern Bering Sea 1980, 1983, and 1986. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-31. 351 p.

Stark, J.W., and D.M. Clausen. 1995. Data report: 1990 Gulf of Alaska bottom trawl survey. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-49. 221 p.

Westrheim, S.J., and H. Tsuyuki. 1971. Taxonomy, distribution, and biology of the northern rockfish, *Sebastes polyspinis*. J. Fish. Res. Bd. Can. 28: 1621-1627.

SPECIES: Northern rockfish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	U	NA	NA	NA	NA	NA
Larvae	U	U	?Spring-summer	U	P (assumed)	NA	U	U
Early Juveniles	From end of larval stage to ?	U	All year	ICS, MCS, OCS,	?P (early juv. only), D	U (juv.< 20 cm); substrate (juv.>20 cm)	U	U
Late Juveniles	to 13 yrs	U	All year	OCS		CB, R	U	U
Adults	13-57 years of age	Euphausiids	U, except that larval release is probably in the spring in the Gulf of Alaska	OCS, USP	SD	CB, R	U	U

Habitat Description for Thornyhead Rockfish

(Sebastolobus sp.)

Management Plan and Area BSAI

Life History and General Distribution

Thornyheads of the northeastern Pacific Ocean are comprised of two species, the shortspine thornyhead (*Sebastolobus alascanus*) and the longspine thornyhead (*S. altivelis*). The longspine thornyhead is not common in the Gulf of Alaska. The shortspine thornyhead is a demersal species which inhabits deep waters from 93 to 1,460 m from the Bering Sea to Baja California. This species is common throughout the Gulf of Alaska, eastern Bering Sea and Aleutian Islands. The population structure of shortspine thornyheads, however, is not well defined. Thornyheads are slow-growing and long-lived with maximum age in excess of 50 years and maximum size greater than 75 cm and 2 kg. Thornyheads spawn buoyant masses of eggs during the late winter and early spring that resemble bilobate "balloons" which float to the surface (Pearcy 1962). Juvenile shortspine thornyheads have a pelagic period of about 14-15 months and settle out on the shelf (100 m) at about 22 to 27 mm (Moser 1974). Fifty percent of female shortspine thornyheads are sexually mature at about 21 cm and 12-13 years of age.

Fishery

Trawl and longline gear are the primary methods of harvest. The bulk of the fishery occurs in late winter or early spring through the summer. In the past, this species was seldom the target of a directed fishery. Today thornyheads are one of the most valuable of the rockfish species, with most of the domestic harvest exported to Japan. Thornyheads are taken with some frequency in the longline fishery for sablefish and cod and is often part of the bycatch of trawlers concentrating on pollock and Pacific ocean perch.

Relevant Trophic Information

Shortspine thornyheads prey mainly on epibenthic shrimp and fish. Yang (1996, 2003) showed that shrimp were the top prey item for shortspine thornyheads in the Gulf of Alaska; whereas, cottids were the most important prey item in the Aleutian Islands region. Differences in abundance of the main prey between the two areas might be the main reason for the observed diet differences. Predator size might by another reason for the difference since the average shortspine thornyhead in the Aleutian Islands area was larger than that in the Gulf of Alaska (33.4 cm vs 29.7 cm).

What is the approximate upper size limit of juvenile fish (in cm)

~27 mm (pelagic stage) ~60 mm (benthic stage)? See Moser 1974

Female shortspine thornyheads appear to be mature at about 21-22 cm (Miller 1985).

Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)

NMFS, Alaska Fisheries Science Center

Habitat and Biological Associations (if known) Narrative

<u>*Egg/Spawning*</u>: Eggs float in masses of various sizes and shapes. Frequently the masses are bilobed with the lobes 15 cm to 61 cm in length, consisting of hollow conical sheaths containing a single layer of eggs in a gelatinous matrix. The masses are transparent and not readily observed in the daylight. Eggs are 1.2 to 1.4 mm in diameter with a 0.2 mm oil globule. They move freely in the matrix. Complete hatching time is unknown but is probably more than 10 days.

Larvae: Three day-old larvae are about 3 mm long and apparently float to the surface. It is believed that the larvae remain in the water column for about 14-15 months before settling to the bottom.

Juveniles: Very little information is available regarding the habitats and biological associations of juvenile shortspine thornyheads.

Adults: Adults are demersal and can be found at depths ranging from about 90 to 1,500 m. Groundfish species commonly associated with thornyheads include: arrowtooth flounder (*Atheresthes stomias*), Pacific ocean perch (*Sebastes alutus*), sablefish *(Anoplopoma fimbria*), rex sole (*Glyptocephalus zachirus*), Dover sole (*Microstomus pacificus*), shortraker rockfish (*Sebastes borealis*), rougheye rockfish (*Sebastes aleutianus*), and grenadiers (family Macrouridae). Two congeneric thornyhead species, the longspine thornyhead (*Sebastolobus altivelis*) and a species common off of Japan , *S. Macrochir*, are infrequently encountered in the Gulf of Alaska.

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Aton, M. 1981. Gulf of Alaska bottomfish and shellfish resources. U.S. Dep. Commerce Tech. Memo. NMFS F/NWC-10, 51 p.

Archibald, C.P., W. Shaw, and B.M. Leaman. 1981. Growth and mortality estimates of rockfishes (Scorpaenidae) from B.C. coastal waters, 1977-79. Can. Tech. Rep. Fish. Aquat. Sci. 1048, 57 p.

Chilton, D.E., and R.J. Beamish. 1982. Age determination methods for fishes studied by the Groundfish Program at the Pacific Biological Station. Can. Spec. Publ. Fish. Aquat. Sci. 60, 102 p.

Heifetz, J., J.N. Ianelli, and D.M. Clausen. 1996. Slope rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 230-270. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Ianelli, J.N., D.H. Ito, and M. Martin. 1996. Thornyheads (*Sebastolobus sp*.). *In* Stock Assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 303-330. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Jacobson, L.D. 1993. Thornyheads. *In* Status of living marine resources off the Pacific coast of the United States for 1993. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-26, 35-37 p.

Kramer, D.E., and V.M. O'Connell. 1986. Guide to northeast Pacific rockfishes, Genera *Sebastes* and *Sebastolobus*. Marine Advisory Bulletin No. 25: 1-78. Alaska Sea Grant College Program, University of Alaska.

Low, L.L. 1994. Thornyheads. *In* Status of living marine resources off Alaska, 1993. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-27, 56-57 p.

Miller, P.P. 1985. Life history study of the shortspine thornyhead, Sebastolobus alascanus, at Cape Ommaney, sorth-eastern Alaska. M.S. Thesis, Univ. Alaska, Fairbanks, AK, 61p.

Moser, H.G. 1974. Development and distribution of larvae and juveniles of Sebastolobus (Pisces: family Scorpaenidae). Fish. Bull. 72: 865-884.

Pearcy, W.G. 1962. Egg masses and early developmental stages of the scorpaenid fish, Sebastolobus. J. Fish. Res. Board Can.19: 1169-1173.

Sigler, M.F., and H.H. Zenger, Jr. 1994. Relative abundance of Gulf of Alaska sablefish and other groundfish based on the domestic longline survey, 1989. NOAA Tech. Memo. NMFS-AFSC-40.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Yang, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-60, 105 p.

Yang, M-S. 2003. Food Habits of the Important Groundfishes in the Aleutian Islands in 1994 and 1997. AFSC processed report 2003-07.

SPECIES: Thornyhead Rockfish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	U	Spawning: Late winter and early spring	U	P	U	U	
Larvae	<15 Months	U	Early spring through summer	U	P	U	U	
Juveniles	> 15 months when settling to bottom occurs (?)	U Shrimp, Amphipods, Mysids, Euphausiids?	U	MCS, OCS, USP	D	M, S, R, SM, CB, MS, G	U	
Adults	U	Shrimp Fish (cottids), Small crabs	Year-round?	MCS, OCS, USP, LSP	D	M, S, R, SM, CB, MS, G	U	

Habitat Description for Light Dusky Rockfish

(*Sebastes ciliatus*)

Management Plan and Area BSAI

Note: The taxonomy of dusky rockfish is unclear. Two varieties occur which are likely distinct species: an inshore, shallow water, dark-colored variety; and a lighter-colored variety found in deeper water offshore. A taxonomic study is in progress that will probably describe the light variety as a new species. To avoid confusion, and because the light variety appears to be more abundant and is the object of a large, directed trawl fishery, this discussion of essential habitat will deal only with "light" dusky rockfish.

Life History and General Distribution

Light dusky rockfish range from Dixon Entrance at the U.S./Canada boundary, around the arc of the Gulf of Alaska, and westward throughout the Aleutian Islands. They are also found in the eastern Bering Sea north to about Zhemchug Canyon west of the Pribilof Is. Their distribution south of Dixon Entrance in Canadian waters is uncertain; dusky rockfish have been reported as far south as Johnstone Strait, Vancouver Is., but it is likely these were of the dark variety. The center of abundance for light dusky rockfish appears to be the Gulf of Alaska (Reuter 1999). The species is much less abundant in the Aleutian Islands and Bering Sea (Reuter and Spencer 2002). Adult light dusky rockfish have a very patchy distribution, and are usually found in large aggregations at specific localities of the outer continental shelf. These localities are often relatively shallow offshore banks. Because the fish are taken with bottom trawls, they are presumed to be mostly demersal. Whether they also have a pelagic distribution is unknown, but there is no evidence of a pelagic tendency based on the information available at present. Most of what is known about light dusky rockfish is based on data collected during the summer months from the commercial fishery or in research surveys. Consequently, there is little information on seasonal movements or changes in distribution for this species.

Life history information on light dusky rockfish is extremely sparse. The fish are assumed to be viviparous, as are other *Sebastes*, with internal fertilization and incubation of eggs. Observations during research surveys in the Gulf of Alaska suggest that parturition (larval release) occurs in the spring, and is probably completed by summer. Another, older source, however, lists parturition as occurring "after May." Pre-extrusion larvae have been described, but field-collected larvae cannot be identified to species at present. Length of the larval stage, and whether a pelagic juvenile stage occurs, are unknown. There is no information on habitat and abundance of young juveniles (<25 cm fork length), as catches of these have been virtually nil in research surveys. Even the occurrence of older juveniles has been very uncommon in surveys, except for one year. In this latter instance, older juveniles were found on the continental shelf, generally at locations inshore of the adult habitat.

Light dusky rockfish is a slow growing species, with a low rate of natural mortality estimated at 0.09. However, it appears to be faster growing than many other rockfish species. Maximum age is 49-59 years. No information on age of maturity or fecundity is available.

Fishery

Light dusky rockfish are caught almost exclusively with bottom trawls. Age at 50% recruitment is unknown. The fishery in the Gulf of Alaska in recent years has mostly occurred in the summer months, especially July, due to management regulations. Catches are concentrated at a number of relatively shallow, offshore banks of the outer continental shelf, especially the "W" grounds west of Yakutat, and Portlock Bank. Other fishing grounds include Albatross Bank, the "Snakehead" south of Kodiak Island, and Shumagin Bank. Outside of these banks, catches are generally sparse. Catch distribution by depth has not been summarized, but most of the fish are apparently taken at depths of 75-200 m. There is no directed fishery in the Aleutians and Bering Sea, and catches there have been generally sparse.

For NPFMC-managed species, the major bycatch species in the Gulf of Alaska light dusky rockfish trawl fishery in 1993-95 included (in descending order by percent): "other" species of slope rockfish, northern rockfish, and Pacific ocean perch. There is no information available on the bycatch of non-NPFMC-managed species in the Gulf of Alaska light dusky rockfish fishery.

Relevant Trophic Information

Although no comprehensive food study of light dusky rockfish has been done, one smaller study in the Gulf of Alaska showed euphausiids to be the predominate food item of adults. Larvaceans, cephalopods, pandalid shrimp, and hermit crabs were also consumed.

Predators of light dusky rockfish have not been documented, but likely include species that are known to consume rockfish in Alaska, such as Pacific halibut, sablefish, Pacific cod, and arrowtooth founder.

What is the approximate upper size limit of juvenile fish (in cm)? For Gulf of Alaska: 47 cm for females; unknown for males, but presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*.

Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)

Eggs, Larvae, and Juveniles: None at present.

Adults: Rebecca Reuter, c/o NMFS, Alaska Fisheries Science Center, REFM Division,

(206) 526-6546.

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: No information known, except that parturition probably occurs in the spring, and may extend into summer.

Larvae: No information known.

Juveniles: No information known for small juveniles <25 cm fork length. Larger juveniles have been taken infrequently in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds.

Adults: Commercial fishery and research survey data suggest that adult light dusky rockfish are primarily found over reasonably flat, trawlable bottom of offshore banks of the outer continental shelf at depths of 75-200 m. Type of substrate in this habitat has not been documented. During submersible dives on the outer shelf (40-50m) in the eastern Gulf, light dusky rockfish were observed in association with rocky habitats and in areas with extensive sponge beds where adult duskys were observed resting in large vase sponges (pers. Comm. V. O'Connell). Generally, the fish appear to be demersal, and most of the population occurs in large aggregations. Light dusky rockfish are the most highly aggregated of the rockfish species caught in Gulf of Alaska trawl surveys. Outside of these aggregations, the fish are sparsely distributed. Because the fish are taken with bottom trawls, they are presumed to be mostly demersal. Whether they also have a pelagic distribution is unknown, but there is no evidence of a pelagic tendency based on the information available at present. There is no information on seasonal migrations. Light dusky rockfish often co-occur with northern rockfish.

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. U. S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Clausen, D.M., and J. Heifetz. 1996. Pelagic shelf rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p.271-288. North Pacific Fishery Management Council, 605 W. 4th. Ave., Suite 306, Anchorage, AK 99501-2252.

Harrison, R.C. 1993. Data report: 1991 bottom trawl survey of the Aleutian Islands area. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-12. 144 p.

Heifetz, J., and D. Ackley. 1997. Bycatch in rockfish fisheries in the Gulf of Alaska. Unpubl. Manuscr. 20 p. (Available from NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK 99801.

Kendall, A.W. 1989. Additions to knowledge of *Sebastes* larvae through recent rearing. NWAFC Proc.Rept. 89-21. 46 p.

Martin, M.H. and D.M. Clausen. 1995. Data report: 1993 Gulf of Alaska bottom trawl survey. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-59. 217 p.

Matarese, A.C., A.W. Kendall, Jr., D.M. Blood, and B.M. Vinter. 1989. Laboratory guide to early life history stages of northeast Pacific fishes. U.S. Dep. Commerce NOAA Tech. Rept. NMFS 80, 652 p.

Reuter, R.F. 1999. Describing Dusky rockfish (*Sebastes ciliatus*) habitat in the Gulf of Alaska using Historical data. M.S. thesis. California State University, Hayward 83 p.

Reuter, R.F. and P.D. Spencer. 2002. Other rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea and Aleutian Islands, p. 579-608.

Stark, J.W., and D.M. Clausen. 1995. Data report: 1990 Gulf of Alaska bottom trawl survey. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-49. 221 p.

Westrheim, S.J. 1973. Preliminary information on the systematics, distribution, and abundance of the dusky rockfish, *Sebastes ciliatus*. J. Fish. Res. Bd. Can. 30: 1230-1234.

Westrheim, S.J. 1975. Reproduction, maturation, and identification of larvae of some *Sebastes* (Scorpaenidae) species in the northeast Pacific Ocean. J. Fish. Res. Board Can. 32: 2399-2411.

SPECIES: Light dusky rockfish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	U	NA	NA	NA	NA	NA
Larvae	U	U	?Spring-summer	U	P (assumed)	NA	U	U
Early Juveniles	U	U	All year	ICS, MCS, OCS,	U (small juv.< 25 cm): ?D (Larger juv.)	U (juv.< 25 cm); ?Trawlable substrate (juv.>25 cm)	U	U
Late Juveniles	U	U	U	U	U	CB, R, G	U	U
Adults	Up to 49-50 years.	Euphausiids	U, except that larval release may be in the spring in the Gulf of Alaska	OCS, USP	SD, SP	CB, R, G	U	U

Habitat Description for Atka Mackerel

(Pleurogrammus monopterygius)

Management Plan and Area BSAI

Life History and General Distribution

Distributed from the Gulf of Alaska to the Kamchatka Peninsula, most abundant along the Aleutians. Adult Atka mackerel occur in large localized aggregations usually at depths less than 200 m and generally over rough, rocky and uneven bottom near areas where tidal currents are swift. Adults are pelagic during much of the year, but migrate annually to moderately shallow waters where they become demersal during spawning. Spawning peaks in June through September, but may occur intermittently throughout the year. Atka mackerel deposit eggs in nests built and guarded by males on rocky substrates or on kelp in shallow water. Eggs hatch in 40-45 days, releasing planktonic larvae which have been found up to 800 km from shore. Little is known of the distribution of young Atka mackerel prior to their appearance in trawl surveys and the fishery at about age 2-3 years. Atka mackerel exhibit intermediate life history traits. R-traits include young age at maturity (approximately 50% are mature at age 3), fast growth rates, high natural mortality (M=0.3) and young average and maximum ages (about 5 and 14 years, respectively). K-selected traits include low fecundity (only about 30,000 eggs/female/year, large egg diameters (1-2 mm) and male nest-guarding behavior).

Fishery

Bottom trawls, some pelagic trawling, recruit at about age 3, conducted in the Aleutian Islands and western GOA at depths between about 70-225 m, in trawlable areas on rocky, uneven bottom, along edges, and in lee of submerged hills during periods of high current. Currently, the fishery occurs on reefs west of Kiska Island, south and west of Amchitka Island, in Tanaga Pass and near the Delarof Islands, and south of Seguam and Umnak Islands. Historically fishery occurred east into the GOA as far as Kodiak Island (through the mid-1980s), but is no longer there. Fishery used to be entirely during summer, during spawning season; now occurs throughout the year. Very "clean" fishery; bycatch of other species is minimal.

Relevant Trophic Information

Important food for Steller sea lions in the Aleutian Islands, particularly during summer, and for other marine mammals (minke whales, Dall's porpoise and northern fur seal). Juveniles eaten by thick billed murres and tufted puffins. Main groundfish predators are Pacific halibut, arrowtooth flounder, and Pacific cod.

What is the approximate upper size limit of juvenile fish (in cm)? 35 cm

Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)

NMFS, Alaska Fishery Science Center

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: Eggs deposited in nests built and guarded by males on rocky substrates or on kelp in shallow water.

Larvae/Juveniles: Planktonic larvae have been found up to 800 km from shore, usually in upper water column (neuston), but little is known of the distribution of Atka mackerel until they are about 2 years old and appear in fishery and surveys.

Adults: Adults occur in localized aggregations usually at depths less than 200 m and generally over rough, rocky and uneven bottom near areas where tidal currents are swift. Adults are semi-demersal/pelagic during much of the year, but migrate annually to moderately shallow waters where the males become demersal during spawning; females move between nesting and offshore feeding areas.

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerc., NOAA Tech. Rept. NMFS 66, 151 p.

Byrd, G.V., J.C. Williams, and R. Walder. 1992. Status and biology of the tufted puffin in the Aleutian Islands, Alaska, after a ban on salmon driftnets. U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, Aleutian Islands Unit, PSC 486, Box 5251, FPO AP 96506-5251, Adak, Alaska.

Doyle, M.J., W.C. Rugen, and R.D. Brodeur. 1995. Neustonic ichthyoplankton in the western Gulf of Alaska during spring. Fishery Bulletin 93: 231-253.

Fritz, L.W. 1993. Trawl locations of walleye pollock and Atka mackerel fisheries in the Bering Sea, Aleutian Islands, and Gulf of Alaska from 1977-1992. AFSC Processed Report 93-08, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 pp.

Gorbunova, N.N. 1962. Razmnozhenie I razvite ryb semeistva terpugovykh (Hexagrammidae) Spawning and development of greenlings (family Hexagrammidae). Tr. Inst. Okeanol., Akad. Nauk SSSR 59:118-182. In Russian. (Trans. by Isr. Program Sci. Trans., 1970, p. 121-185 in T.S. Rass (editor), Greenlings: taxonomy, biology, interoceanic transplantation; available from the U.S. Dep. Commerce, Natl. Tech. Inf. Serv., Springfield, VA., as TT 69-55097).

Kajimura, H. 1984. Opportunistic feeding of the northern fur seal Callorhinus ursinus, in the eastern north Pacific Ocean and eastern Bering Sea. NOAA Tech. Rept. NMFS SSRF-779. USDOC, NOAA, NMFS, 49 pp.

Kendall, A.W., Jr., and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. U.S. Dep. Commerc., NOAA Tech. Rept NMFS 20, 89 p.

Kendall, A.W., Jr., J.R. Dunn, and R.J. Wolotira, Jr. 1980. Zooplankton, including ichthyoplankton and decapod larvae, of the Kodiak shelf. NWAFC Processed Rept. 80-8, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 393 p.

Lee, J.U. 1985. Studies on the fishery biology of the Atka mackerel *Pleurogrammus monopterygius* (Pallas) in the north Pacific Ocean. Bull. Fish. Res. Dev. Agency, 34, pp.65-125.

Levada, T.P. 1979. Comparative morphological study of Atka mackerel. Pac. Sci. Res. Inst. Fish. Oceanogr. (TINRO), Vladivostok, U.S.S.R., Unpublished manuscript.

Levada, T.P. 1979. Some data on biology and catch of Atka mackerel. Pac. Sci. Res. Inst. Fish. Oceanogr. (TINRO), Vladivostok, U.S.S.R., Unpublished manuscript.

Lowe, S.A. and L.W. Fritz. 1996. Atka mackerel. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Lowe, S.A. and L.W. Fritz. 1996. Atka mackerel. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

McDermott, S.F. and S.A. Lowe. 1997. The reproductive cycle and sexual maturity of Atka mackerel (*Pleurogrammus monopterygius*) in Alaskan waters. Fishery Bulletin 95: 321-333.

Morris, B.F. 1981. An assessment of the living marine resources of the central Bering Sea and potential resource use conflicts between commercial fisheries and Petroleum development in the Navarin Basin, Proposed sale No. 83. Anchorage, AK: USDOC, NOAA, NMFS, Environmental Assessment Division.

Musienko, L.N. 1970. Razmnozheine I razvitie ryb Beringova morya (Reproduction and development of Bering Sea fishes). Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Koz. Okeanogr. 70: 161-224 In P.A. Moiseev (ed.), Soviet fisheries investigations in the northeastern Pacific, Pt. 5, Avail. Natl. Tech. Info. Serv., Springfield, VA as TT 74-50127.

NMFS. 1995. Status review of the Unites States Steller sea lion (*Eumetopias jubatus*) population. National Marine Mammal Laboratory, Alaska Fishery Science Center, National Marine Fisheries Service, 7600 Sand Point Way, NE, Seattle, WA 98115.

Orlov, A.M. 1996. The role of mesopelagic fishes in feeding of Atka mackerel in areas of the North Kuril islands. Publ. Abstract in Role of forage fishes in marine ecosystems. Symposium held Nov 1996, AK Sea Grant, U. Alaska, Fairbanks.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Processed Rept 90-01, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 p.

Waldron, K.D. 1978. Ichthyoplankton of the eastern Bering Sea, 11 February-16 March 1978. REFM Report, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 33 p.

Waldron, K.D., and B.M. Vinter. 1978. Ichthyoplankton of the eastern Bering Sea. Final Report (RU 380), Environmental Assessment of the Alaskan continental shelf, REFM, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 88 p.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Yang, M-S. 1996. Trophic role of Atka mackerel in the Aleutian Islands. Publ. Abstract in Role of forage fishes in marine ecosystems. Symposium held Nov 1996, AK Sea Grant, U. Alaska, Fairbanks.

Zolotov, O.G. 1993. Notes on the reproductive biology of *Pleurogrammus monopterygius* in Kamchatkan waters. J. of Ichthy. 33(4), pp. 25-37.

SPECIES: Atka mackerel

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	40-45 d	NA	summer	IP, ICS	D	GR, R, K	U	develop 3-20˚C optimum 9-13˚C
Larvae	up to 6 mos	U copepods?	fall-winter	U	U N?	U	U	2-12˚C optimum 5-7˚C
Juveniles	½-2 yrs of age	U copepods & euphausiids?	all year	U	U	U	U	3-5˚C
Adults	3+ yrs of age	copepods euphausiids meso-pelagic fish (myctophids)	spawning (May-Oct) non-spawning (Nov-Apr) tidal/diurnal, year-round?	ICS and MCS, IP MCS and OCS, IP ICS, MCS, OCS, IP	D (males) SD females SD/D all sexes D when currents high/day SD slack tides/night	GR, R, K	F, E	3-5˚C all stages >17 ppt only

Habitat Description for Capelin

(*osmeridae*)

Management Plan and Area BSAI

Species Representative:

Capelin (*Mallotus villosus*)

Life History and General Distribution

Capelin is a short-lived marine (neritic), pelagic, filter-feeding schooling fish distributed along the entire coastline of Alaska and the Bering Sea, and south along British Columbia to the Strait of Juan de Fuca; circumpolar. In the N. Pacific, capelin grow to a maximum of 25 cm and 5 years of age. Spawn at ages 2-4 in spring and summer (May-Aug; earlier in south, later in north) when about 11-17 cm on coarse sand, fine gravel beaches, especially in Norton Sound, northern Bristol Bay, along the Alaska Peninsula and near Kodiak. Age at 50% maturity=2 years. Fecundity: 10,000-15,000 eggs per female. Eggs hatch in 2-3 weeks. Most capelin die after spawning. Larvae and juveniles are distributed on inner-mid shelf in summer (rarely found in waters deeper than about 200 m), and juveniles and adults congregate in fall in mid-shelf waters east of the Pribilof Islands, west of St. Matthew and St. Lawrence Islands, and north into the Gulf of Anadyr. Distributed along outer shelf and under ice edge in winter. Larvae, juveniles and adults have diurnal vertical migrations following scattering layers - night near surface, at depth during the day. Smelts are captured during trawl surveys, but their patchy distribution both in space and time reduces the validity of biomass estimates.

Fishery:

Not a target species in groundfish fisheries of BSAI or GOA, but caught as bycatch (up to several hundred tons per year in the 1990s) principally by yellowfin sole trawl fishery in Kuskokwim and Togiak Bays in spring in BSAI; almost all discarded. Small local coastal fisheries occur in spring and summer.

Relevant Trophic Information

Capelin are important prey for marine birds and mammals as well as other fish. Surface feeding (e.g., gulls and kittiwakes), as well as shallow and deep diving piscivorous birds (e.g., murres and puffins) largely consume small schooling fishes such as capelin, eulachon, herring, sand lance and juvenile pollock (Hunt et al. 1981a; Sanger 1983). Both pinnipeds (Steller sea lions, northern fur seals, harbor seals, and ice seals) and cetaceans (such as harbor porpoise, and fin, sei, humpback, beluga whales) feed on smelts, which may provide an important seasonal food source near the ice-edge in winter, and as they assemble nearshore in spring to spawn (Frost and Lowry 1987; Wespestad 1987). Smelts are also found in the diets of some commercially exploited fish species, such as Pacific cod, walleye pollock, arrowtooth flounder, Pacific halibut, sablefish, Greenland turbot and salmon, throughout the North Pacific Ocean and the Bering Sea (Allen 1987; Yang 1993; Livingston, in prep.).

What is the approximate upper size limit of juvenile fish (in cm)? 13 cm

Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)

Paul Anderson, NMFS/RACE, Kodiak AK 907-487-4961

Jim Blackburn, ADFG, Kodiak AK 907-486-1861

Mark W. Nelson, NMFS/REFM, Seattle WA 206-526-4699

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: Spawn adhesive eggs (about 1 mm in diameter) on fine gravel or coarse sand (0.5-1 mm grain size) beaches intertidally to depths of up to 10 m in May-July in Alaska (later to the north in Norton Sound). Hatching occurs in 2-3 weeks. Most intense spawning when coastal water temperatures are 5-9˚C.

Larvae: After hatching, 4-5 mm larvae remain on the middle-inner shelf in summer; distributed pelagically; centers of distribution are unknown, but have been found in high concentrations north of Unimak Island, in the western GOA, and around Kodiak Island.

Juveniles: In fall, juveniles are distributed pelagically in mid-shelf waters (50-100 m depth; -2-3˚C), and have been found in highest concentrations east of the Pribilof Islands, west of St. Matthew and St. Lawrence Islands and north into the Gulf of Anadyr.

Adults: Found in pelagic schools in inner-mid shelf in spring-fall, feed along semi-permanent fronts separating inner, mid, and outer shelf regions (~50 and 100 m). In winter, found in concentrations under ice-edge and along mid-outer shelf.

Literature

Allen, M.J. 1987. Demersal fish predators of pelagic forage fishes in the southeastern Bering Sea. Pp. 29-32 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Crawford, T.W. 1981. Vertebrate prey of *Phocoenoides dalli* (Dall's porpoise), associated with the Japanese high seas salmon fishery in the North Pacific Ocean. M.S. Thesis, Univ. Washington, Seattle, 72 p.

Doyle, M.J., W.C. Rugen, and R.D. Brodeur. 1995. Neustonic ichthyoplankton in the western Gulf of Alaska during spring. Fishery Bulletin 93: 231-253.

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

Fritz, L.W. 1996. Other species *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Fritz, L.W., V.G. Wespestad, and J.S. Collie. 1993. Distribution and abundance trends of forage fishes in the Bering Sea and Gulf of Alaska. Pp. 30-44 *In* Is It Food: Addressing marine mammal and seabird declines. Workshop Summary. Alaska Sea Grant College Program Rept. No. AK-SG-93-01, Univ. Alaska, Fairbanks, AK 99775-5040.

Frost, K.J. and L. Lowry. 1987. Marine mammals and forage fishes in the southeastern Bering Sea. Pp. 11-18 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Hunt, G.L., Jr., B. Burgeson, and G.A. Sanger. 1981a. Feeding ecology of seabirds of the eastern Bering Sea. Pp 629-647 *In* D.W. Hood and J.A. Calder (eds.), The Eastern Bering Sea Shelf: Oceanography and Resources, Vol. II. U.S. Dept. Commerce, NOAA, OCSEAP, Office of Marine Pollution Assessment, Univ. WA Press, Seattle, WA.

Hunt, G.L., Jr., Z. Eppley, B. Burgeson, and R. Squibb. 1981b. Reproductive ecology, foods and foraging areas of seabirds nesting on the Pribilof Islands, 1975-79. Environmental Assessment of the Alaskan Continental Shelf, Final Reports of Principal Investigators, RU-83, U.S. Dept. Commerce, NOAA, OCSEAP, Boulder, CO.

Kawakami, T. 1980. A review of sperm whale food. Sci. Rep. Whales Res. Inst. Tokyo 32: 199-218.

Kendall, A.W., Jr., and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. U.S. Dep. Commerce, NOAA Tech. Rept NMFS 20, 89 p.

Kendall, A.W., Jr., J.R. Dunn, and R.J. Wolotira, Jr. 1980. Zooplankton, including ichthyoplankton and decapod larvae, of the Kodiak shelf. NWAFC Processed Rept. 80-8, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 393 p.

Livingston, P.A. Groundfish utilization of walleye pollock (*Theragra chalcogramma*), Pacific herring (*Clupea pallasi*) and capelin (*Mallotus villosus*) resources in the Gulf of Alaska. In preparation.

Morris, B.F., M.S. Alton, and H.W. Braham. 1983. Living marine resources of the Gulf of Alaska: a resource assessment for the Gulf of Alaska/Cook Inlet Proposed Oil and Gas Lease Sale 88. U.S. Dept. Commerce, NOAA, NMFS.

Murphy, E.C., R.H. Day, K.L. Oakley, A.A. Hoover. 1984. Dietary changes and poor reproductive performances in glaucous-winged gulls. Auk 101: 532-541.

Naumenko, E.A. 1996. Distribution, biological condition, and abundance of capelin (*Mallotus villosus socialsis)* in the Bering Sea. Pp. 237-256 *In* O.A. Mathisen and K.O. Coyle (eds.), Ecology of the Bering Sea: a review of Russian literature. Alaska Sea Grant Report No. 96-01, Alaska Sea Grant College Program, U. Alaska, Fairbanks, AK 99775-5040. 306 p.

Pahlke, K.A. 1985. Preliminary studies of capelin Mallotus villosus in Alaska waters. Alaska Dept. Fish Game, Info. Leaf. 250, 64 p.

Perez, M.A. and M.A. Bigg. 1986. Diet of northern fur seals, *Callorhinus ursinus*, off western North America. Fish. Bull., U.S. 84: 957-971.

Pitcher, K.W. 1980. Food of the harbor seal, *Phoca vitulina richardsi*, in the Gulf of Alaska. Fish. Bull., U.S. 78: 544-549.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Processed Rept 90-01, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 p.

Waldron, K.D. 1978. Ichthyoplankton of the eastern Bering Sea, 11 February-16 March 1978. REFM Report, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 33 p.

Waldron, K.D., and B.M. Vinter. 1978. Ichthyoplankton of the eastern Bering Sea. Final Report (RU 380), Environmental Assessment of the Alaskan continental shelf, REFM, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 88 p.

Wespestad, V.G. 1987. Population dynamics of Pacific herring (*Clupea palasii*), capelin (*Mallotus villosus*), and other coastal pelagic fishes in the eastern Bering Sea. Pp. 55-60 *In* Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Yang, M.S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-AFSC-22. 150 pp.

SPECIES: CAPELIN

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	2-3 weeks to hatch	na	May-August	BCH (to 10 m)	D	S, CB		5-9˚C peak spawning
Larvae	4-8 months?	Copepods phytoplankton	summer/fall/ winter	ICS, MCS	N, P	U NA?	U	
Juveniles	1.5+ yrs up to age 2	Copepods Euphausiids	all year	ICS, MCS	P	U NA?	U F? Ice edge in winter	
Adults	2 yrs ages 2-4+		spawning (May-August)	BCH (to 10 m)	D, SD	S, CB, G		
		Copepods Euphausiids polychaetes small fish	non-spawning (Sep-Apr)	ICS, MCS, OCS	P	NA?	F Ice edge in winter	-2 - 3˚C Peak distributions in EBS?

Habitat Description for Eulachon

(*osmeridae*)

Management Plan and Area BSAI

Species Representative:

Eulachon, candlefish *(Thaleichthys pacificus*)

Life History and General Distribution:

Eulachon is a short-lived anadromous, pelagic schooling fish distributed from the Pribilof Islands in the eastern Bering Sea, throughout the Gulf of Alaska, and south to California. Consistently found pelagically in Shelikof Strait (hydroacoustic surveys in late winter-spring) and between Unimak Island and the Pribilof Islands (bycatch in groundfish trawl fisheries) from the middle shelf to over the slope. In the North Pacific, eulachon grow to a maximum of 23 cm and 5 years of age. Spawn at ages 3-5 in spring and early summer (April-June) when about 14-20 cm in rivers on coarse sandy bottom. Age at 50% maturity=3 years. Fecundity: ~25,000 eggs per female. Eggs adhere to sand grains and other substrates on river bottom. Eggs hatch in 30-40 days in BC at 4-7˚C. Most eulachon die after first spawning. Larvae drift out of rivers and develop at sea. Smelts are captured during trawl surveys, but their patchy distribution both in space and time reduces the validity of biomass estimates.

Fishery:

Not a target species in groundfish fisheries of BSAI or GOA, but caught as bycatch (up to several hundred tons per year in the 1990s) principally by midwater pollock fisheries in Shelikof Strait (GOA), on the east side of Kodiak (GOA), and between the Pribilof Islands and Unimak Island on the outer continental shelf and slope (EBS); almost all discarded. Small local coastal fisheries occur in spring and summer.

Relevant Trophic Information

Eulachon may be important prey for marine birds and mammals as well as other fish. Surface feeding (e.g., gulls and kittiwakes), as well as shallow and deep diving piscivorous birds (e.g., murres and puffins) largely consume small schooling fishes such as capelin, eulachon, herring, sand lance and juvenile pollock (Hunt et al. 1981a; Sanger 1983). Both pinnipeds (Steller sea lions, northern fur seals, harbor seals, and ice seals) and cetaceans (such as harbor porpoise, and fin, sei, humpback, beluga whales) feed on smelts, which may provide an important seasonal food source near the ice-edge in winter, and as they assemble nearshore in spring to spawn (Frost and Lowry 1987; Wespestad 1987). Smelts also comprise significant portions of the diets of some commercially exploited fish species, such as Pacific cod, walleye pollock, arrowtooth flounder, Pacific halibut, sablefish, Greenland turbot and salmon, throughout the North Pacific Ocean and the Bering Sea (Allen 1987; Yang 1993; Livingston, in prep.).

What is the approximate upper size limit of juvenile fish (in cm)? 14 cm

Source of Additional Data

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: Anadromous; return to spawn in spring (May-June) in rivers; demersal eggs adhere to bottom substrate (sand, cobble, etc.). Hatching occurs in 30-40 days.

Larvae: After hatching, 5-7 mm larvae drift out of river and develop pelagically in coastal marine waters; centers of distribution are unknown.

Juveniles and Adults: Distributed pelagically in mid-shelf to upper slope waters (50-1000 m water depth), and have been found in highest concentrations between the Pribilof Islands and Unimak Island on the outer shelf, and in Shelikof east of the Pribilof Islands, west of St. Matthew and St. Lawrence Islands and north into the Gulf of Anadyr

Literature

Allen, M.J. 1987. Demersal fish predators of pelagic forage fishes in the southeastern Bering Sea. Pp. 29-32 *In* Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Crawford, T.W. 1981. Vertebrate prey of *Phocoenoides dalli* (Dall's porpoise), associated with the Japanese hign seas salmon fishery in the North Pacific Ocean. M.S. Thesis, Univ. Washington, Seattle, 72 p.

Fritz, L.W., V.G. Wespestad, and J.S. Collie. 1993. Distribution and abundance trends of forage fishes in the Bering Sea and Gulf of Alaska. Pp. 30-44 *In* Is It Food: Addressing marine mammal and seabird declines. Workshop Summary. Alaska Sea Grant College Program Rept. No. AK-SG-93-01, Univ. Alaska, Fairbanks, AK 99775-5040.

Frost, K.J. and L. Lowry. 1987. Marine mammals and forage fishes in the southeastern Bering Sea. Pp. 11-18 *In* Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Hunt, G.L., Jr., B. Burgeson, and G.A. Sanger. 1981a. Feeding ecology of seabirds of the eastern Bering Sea. Pp 629-647 *In* D.W. Hood and J.A. Calder (eds.), The Eastern Bering Sea Shelf: Oceanography and Resources, Vol. II. U.S. Dept. Commerce, NOAA, OCSEAP, Office of Marine Pollution Assessment, Univ. WA Press, Seattle, WA.

Hunt, G.L., Jr., Z. Eppley, B. Burgeson, and R. Squibb. 1981b. Reproductive ecology, foods and foraging areas of seabirds nesting on the Pribilof Islands, 1975-79. Environmental Assessment of the Alaskan Continental Shelf, Final Reports of Principal Investigators, RU-83, U.S. Dept. Commerce, NOAA, OCSEAP, Boulder, CO.

Kawakami, T. 1980. A review of sperm whale food. Sci. Rep. Whales Res. Inst. Tokyo 32: 199-218.

Livingston, P.A. Groundfish utilization of walleye pollock (*Theragra chalcogramma*), Pacific herring (*Clupea pallasi*) and capelin (*Mallotus villosus*) resources in the Gulf of Alaska. In preparation.

Morris, B.F., M.S. Alton, and H.W. Braham. 1983. Living marine resources of the Gulf of Alaska: a resource assessment for the Gulf of Alaska/Cook Inlet Proposed Oil and Gas Lease Sale 88. U.S. Dept. Commerce, NOAA, NMFS.

Perez, M.A. and M.A. Bigg. 1986. Diet of northern fur seals, *Callorhinus ursinus*, off western North America. Fish. Bull., U.S. 84: 957-971.

Pitcher, K.W. 1980. Food of the harbor seal, *Phoca vitulina richardsi*, in the Gulf of Alaska. Fish. Bull., U.S. 78: 544-549.

Sanger, G.A. 1983. Diets and food web relationships of seabirds in the Gulf of Alaska and adjacent marine regions. Outer Continental Shelf Environmental Assessment Program, Final Reports of Principal Investigators 45: 631-771.

Wespestad, V.G. 1987. Population dynamics of Pacific herring (*Clupea palasii*), capelin (*Mallotus villosus*), and other coastal pelagic fishes in the eastern Bering Sea. Pp. 55-60 *In* Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Yang, M.S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-AFSC-22. 150 pp.

SPECIES: EULACHON (Candlefish)

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	30-40 days	na	April-June	Rivers, FW	D	S (CB?)		4 - 8˚C for egg development
Larvae	1-2 months ?	Copepods phytoplankton mysids, larvae	summer/fall	ICS ?	P?	U NA?	U	
Juveniles	2.5+ yrs up to age 3	Copepods Euphausiids	all year	MCS, OCS, USP	P	U NA?	U F?	
Adults	3 yrs ages 3-5+		spawning (May-June)	Rivers-FW	D	S (CB?)		
		Copepods Euphausiids	non-spawning (July-Apr)	MCS, OCS, USP	P	NA?	F?	

Habitat Description for Sculpins

(*cottidae*)

Management Plan and Area BSAI

Species Representatives:

Yellow Irish lord (*Hemilepidotus jordani)*

Red Irish lord (*Hemilepidotus hemilepidotus*)

Butterfly sculpin (*Hemilepidotus papilio*)

Bigmouth sculpin (*Hemitripterus bolini*)

Great sculpin (*Myoxocephalus polyacanthocephalus*)

Plain sculpin (*Myoxocephalus jaok*)

Life History and General Distribution

The Cottidae (sculpins) is a large circumboreal family of demersal fishes inhabiting a wide range of habitats in the north Pacific Ocean and Bering Sea. Most species live in shallow water or in tidepools, but some inhabit the deeper waters (to 1000 m) of the continental shelf and slope. Most species do not attain a large size (generally 10-15 cm), but those that live on the continental shelf and are caught by fisheries can be 30-50 cm; the cabezon is the largest sculpin and can be as long as 100 cm. Most sculpins spawn in the winter. All species lay eggs, but in some genera, fertilization is internal. The female commonly lays demersal eggs amongst rocks where they are guarded by males. Egg incubation duration is unknown; larvae were found across broad areas of the shelf and slope, and were found all year-round, in ichthyoplankton collections from the southeast Bering Sea and Gulf of Alaska. Larvae exhibit diel vertical migration (near surface at night and at depth during the day). Sculpins generally eat small invertebrates (e.g., crabs, barnacles, mussels), but fish are included in the diet of larger species; larvae eat copepods.

Yellow Irish lords: distributed from subtidal areas near shore to the edge of the continental shelf (down to 200 m) throughout the Bering Sea, Aleutian Islands, and eastward into the GOA as far as Sitka, AK; up to 40 cm in length. 12-26 mm larvae collected in spring on the western GOA shelf.

Red Irish lords: distributed from rocky, intertidal areas to about 100 m depth on the middle continental shelf (most shallower than 50 m), from California (Monterey Bay) to Kamchatka; throughout the Bering Sea and Gulf of Alaska; rarely over 30 cm in length. Spawns masses of pink eggs in shallow water or intertidally. Larvae were 7-20 mm long in spring in the western GOA.

Butterfly sculpins: distributed primarily in the western north Pacific and northern Bering Sea, from Hokkaido, Japan, Sea of Okhotsk, Chukchi Sea, to southeast Bering Sea and in Aleutian Islands; depths of 20-250 m, most frequent 50-100 m.

Bigmouth sculpin: distributed in deeper waters offshore, between about 100-300 m in the Bering Sea, Aleutian Islands, and throughout the Gulf of Alaska; up to 70 cm in length.

Great sculpin: distributed from the intertidal to 200 m, but may be most common on sand and muddy/sand bottoms in moderate depths (50-100 m); up to 80 cm in length. Found throughout the Bering Sea, Aleutian Islands, and Gulf of Alaska, but may be less common east of Prince William Sound. *Myoxocephalus* spp. larvae ranged in length from 9-16 mm in spring ichthyoplankton collections in the western GOA.

Plain sculpin: distributed throughout the Bering Sea and Gulf of Alaska (not common in the Aleutian Islands) from intertidal areas to depths of about 100 m, but most common in shallow waters (<50 m); up to 50 cm in length. *Myoxocephalus* spp. larvae ranged in length from 9-16 mm in spring ichthyoplankton collections in the western GOA.

Fishery:

Not a target of groundfish fisheries of BSAI or GOA, but sculpin bycatch (second to skates in weight amongst the Other Species) has ranged from 6,000-11,000 mt per year in the BSAI from 1992-95, and 500-1,400 mt per year in the GOA. Bycatch occurs principally in bottom trawl fisheries for flatfish, Pacific cod and pollock, but also while longlining for Pacific cod; almost all is discarded. Annual sculpin bycatch in the BSAI ranges between 1-4% of annual survey biomass estimates, however little is known of the species distribution of the bycatch.

Relevant Trophic Information

Feed on bottom invertebrates (e.g., crabs, barnacles, mussels and other molluscs); larger species eat fish.

What is the approximate upper size limit of juvenile fish (in cm)? Unknown

Sources for Additional Data:

Sarah Gaichas, NMFS, Alaska Fisheries Science Center

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: Lay demersal eggs in nests guarded by males; many species in rocky shallow waters near shore.

Larvae: Distributed pelagically and in neuston across broad areas of shelf and slope, but predominantly on inner and middle shelf; have been found all year-round.

Juveniles and Adults: Sculpins are demersal fish, and live in a broad range of habitats from rocky intertidal pools to muddy bottoms of the continental shelf, and rocky, upper slope areas. Most commercial bycatch occurs on middle and outer shelf areas used by bottom trawlers for Pacific cod and flatfish.

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Doyle, M.J., W.C. Rugen, and R.D. Brodeur. 1995. Neustonic ichthyoplankton in the western Gulf of Alaska during spring. Fishery Bulletin 93: 231-253.

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

Fritz, L.W. 1996. Other species *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Kendall, A.W., Jr., and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. U.S. Dep. Commerce, NOAA Tech. Rept NMFS 20, 89 p.

Kendall, A.W., Jr., J.R. Dunn, and R.J. Wolotira, Jr. 1980. Zooplankton, including ichthyoplankton and decapod larvae, of the Kodiak shelf. NWAFC Processed Rept. 80-8, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 393 p.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Processed Rept 90-01, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 p.

Waldron, K.D. 1978. Ichthyoplankton of the eastern Bering Sea, 11 February-16 March 1978. REFM Report, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 33 p.

Waldron, K.D., and B.M. Vinter. 1978. Ichthyoplankton of the eastern Bering Sea. Final Report (RU 380), Environmental Assessment of the Alaskan continental shelf, REFM, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 88 p.

SPECIES: SCULPINS

Life Stage	Duration or Age	Diet/Prey	Season-Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	na	winter?	BCH, ICS (MSC, OSC?)	D	R (others?)	U	
Larvae	U	copepods	all year?	ICS, MSC, OCS, US	N, P	na?	U	
Juveniles and Adults	U	bottom invertebrates (crabs, molluscs, barnacles) and small fish	all year	BCH, ICS, MSC, OSC, US	D	R, S, M, SM	U	

Habitat Description for Sharks

Management Plan and Area BSAI

Species Representatives:

Lamnidae: Salmon shark (*Lamna ditropis*)

Squalidae: Sleeper shark (*Somniosus pacificus*)

Spiny dogfish (*Squalus acanthias*)

Life History and General Distribution

Sharks of the order Squaliformes (which includes the two families Lamnidae and Squalidae) are the higher sharks with five gill slits and two dorsal fins. The Lamnidae are large, ovoviviparous (with small litters, 1-4; embryos nourished by intrauterine cannibalism), widely migrating sharks which are highly aggressive predators (salmon and white sharks). The Lamnidae are partly warm-blooded; the heavy trunk muscles are warmer than water for greater power and efficiency. Salmon sharks are distributed epipelagically along the shelf (can be found in shallow waters) from California through the Gulf of Alaska (where they occur all year and are probably most abundant in our area), the Bering Sea and off Japan. In groundfish fishery and survey data, occur chiefly on outer shelf/upper slope areas in the Bering Sea, but near coast to the outer shelf in the Gulf of Alaska, particularly near Kodiak Island. Not commonly seen in Aleutian Islands. They are believed to eat primarily fish, including salmon, sculpins and gadids, and can be up to 3 m in length.

The Pacific sleeper shark is distributed from California around the Pacific rim to Japan and in the Bering Sea principally on the outer shelf and upper slope (but has been observed nearshore), generally demersal (but also seen near surface). Other members of the Squalidae are ovoviviparous, but fertilization and development of sleeper sharks are not known; adults up to 8 m in length. Voracious, omnivorous predator of flatfish, cephalopods, rockfish, crabs, seals, salmon; may also prey on pinnipeds. In groundfish fishery and survey data, occur chiefly on outer shelf/upper slope areas in the Bering Sea, but near coast to the outer shelf in the Gulf of Alaska, particularly near Kodiak Island.

Spiny dogfish (or closely related species?) are widely distributed through the Atlantic, Pacific and Indian Oceans. In the north Pacific, may be most abundant in the Gulf of Alaska, but also common in the Bering Sea. Pelagic species, found at surface and to depths of 700 m; mostly 200 m or less on shelf and neritic; often found in aggregations. Ovoviviparous, with litter size proportional to size of female, from 2-9; gestation may be 22-24 months. Young are 24-30 cm at birth, with growth initially rapid, then slows dramatically. Maximum adult size is about 1.6 m, and 10 kg; maximum age about 40 years. 50% of females are mature at 94 cm and 29 years old; males, 72 cm and 19 years old. Females give birth in shallow coastal waters, usually in Sept-Jan. Dogfish eat a wide variety of foods, including fish (smelts, herring, sand lance, and other small schooling fish), crustaceans (crabs, euphausiids, shrimp), and cephalopods (octopus). Tagging experiments indicate local indigenous populations in some areas and widely migrating groups in others. May move inshore in summer and offshore in winter.

Fishery

Not a target of groundfish fisheries of BSAI or GOA, but shark bycatch has ranged from 300-700 mt per year in the BSAI from 1992-95; 500-1,400 mt per year in the GOA) principally by pelagic trawl fishery for pollock, longline fisheries for Pacific cod and sablefish, and bottom trawl fisheries for pollock, flatfish and cod; almost all discarded. Little is known of shark biomass in BSAI or GOA.

What is the approximate upper size limit of juvenile fish (in cm)?

Unknown for salmon sharks and sleeper sharks; for spiny dogfish: 94 cm for females, 72 cm for males.

Source of Additional Data

Sarah Gaichas, NMFS, Alaska Fisheries Science Center

Habitat and Biological Associations (if known) Narrative

Egg/Spawning: Salmon sharks and spiny dogfish are ovoviviparous; reproductive strategy of sleeper sharks is not known. Spiny dogfish give birth in shallow coastal waters, while salmon sharks probably offshore and pelagic.

Juveniles and Adults: Spiny dogfish are widely dispersed throughout the water column on shelf in the GOA, and along outer shelf in the EBS; apparently not as commonly found in the Aleutian Islands and not commonly at depths > 200 m.

Salmon sharks found throughout the GOA, but less common in the EBS and AI; epipelagic, primarily over shelf/slope waters in GOA, and outer shelf in EBS.

Sleeper sharks are widely dispersed on shelf/upper slope in the GOA, and along outer shelf/upper slope only in the EBS; generally demersal, and may be less commonly found in the Aleutian Islands.

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

Fritz, L.W. 1996. Other species *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

SPECIES: SHARKS

Life Stage	Duration or Age	Diet/Prey	Season-Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs								
Larvae								
Juveniles and Adults								
Salmon shark	U	fish (salmon, sculpins and gadids)	all year	ICS, MSC, OCS, US in GOA; OCS, US in BSAI	P	NA	U	
Sleeper shark	U	omnivorous; flatfish, cephalopods, rockfish, crabs, seals, salmon, pinnipeds	all year	ICS, MSC, OCS, US in GOA; OCS, US in BSAI	D	U	U	
Spiny dogfish	40 years	fish (smelts, herring, sand lance, and other small schooling fish), crustaceans (crabs, euphausiids, shrimp), and cephalopods (octopus)	all year	ICS, MSC, OCS in GOA; OCS in BSAI give birth ICS in fall/winter?	P	U	U	Euhaline 4-16˚C

Habitat Description for Skates

(*Rajidae*)

Management Plan and Area BSAI

Species Representatives:

Alaska skate (*Bathyraja parmifera*)

Aleutian skate (*Bathyraja aleutica*)

Bering skate (*Bathyraja interrupta*)

Life History and General Distribution:

Skates (Rajidae) that occur in the BSAI and GOA are grouped into two genera: *Bathyraja* sp., or soft-nosed species (rostral cartilage slender and snout soft and flexible), and *Raja* sp., or hard-nosed species (rostral cartilage is thick making the snout rigid). Skates are oviparous; fertilization is internal and eggs (one to five or more in each case) are deposited in horny cases for incubation. Adults and juveniles are demersal, and feed on bottom invertebrates and fish. Adult distributions from survey: Alaska skate: mostly 50-200 m on shelf in eastern Bering Sea (EBS) and Aleutian Islands (AI), less common in the Gulf of Alaska (GOA); Aleutian skate: throughout EBS and AI, but less common in GOA, mostly 100-350 m; Bering Skate: throughout EBS and GOA, less common in AI, mostly 100-350 m. Little is known of their habitat requirements for growth or reproduction, nor of any seasonal movements. BSAI skate biomass estimate more than doubled between 1982-96 from bottom trawl survey; may have decreased in GOA and remained stable in the AI in the 1980s.

Fishery

Not a target of groundfish fisheries of BSAI or GOA, but caught as bycatch (13,000-17,000 mt per year in the BSAI from 1992-95; 1,000-2,000 mt per year in the GOA) principally by the longline Pacific cod and bottom trawl pollock and flatfish fisheries; almost all discarded. Skate bycatches in the EBS groundfisheries ranged between 1-4% of the annual EBS trawl survey biomass estimates in 1992-95.

Relevant Trophic Information

Feed on bottom invertebrates (crustaceans, molluscs, and polychaetes) and fish.

What is the approximate upper size limit of juvenile fish (in cm)? Unknown

Source of Additional Data

Sarah Gaichas, NMFS, Alaska Fisheries Science Center

Habitat and Biological Associations (if known) Narrative

<u>*Egg/Spawning*</u>: Deposit eggs in horny cases on shelf and slope.

<u>*Juveniles and Adults*</u>: After hatching, juveniles probably remain in shelf and slope waters, but distribution is unknown. Adults found across wide areas of shelf and slope; surveys found most skates at depths <500 m in the GOA and EBS, but >500 m in the AI. In the GOA, most skates found between 4-7˚C, but data are limited.

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

Fritz, L.W. 1996. Other species *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Teshima, K., and T.K. Wilderbuer. 1990. Distribution and abundance of skates in the eastern Bering Sea, Aleutian Islands region, and the Gulf of Alaska. Pp. 257-267 *in* H.L. Pratt, Jr., S.H. Gruber, and T. Taniuchi (eds.), Elasmobranchs as living resources: advances in the biology, ecology, systematics and the status of the fisheries. U.S. Dep. Commerce, NOAA Technical Report 90.

SPECIES: SKATES

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	na	U	MCS, OCS, USP	D	U	U	
Larvae	na	na	na	na	na	na	na	
Juveniles	U	Invertebrates small fish	all year	MCS, OCS, USP	D	U	U	
Adults	U	Invertebrates small fish	all year	MCS, OCS, USP	D	U	U	

Habitat Description for Squid

(*Cephalopoda*, *Teuthida*)

Management Plan and Area BSAI

Species Representatives:

Gonaditae: Red or magistrate armhook squid (*Berryteuthis magister*)

Onychoteuthidae:

Boreal clubhook squid (*Onychoteuthis banksii borealjaponicus)*

Giant or robust clubhook squid (*Moroteuthis robusta*)

Sepiolidae: eastern Pacific bobtail squid (*Rossia pacifica*)

Life History and General Distribution:

Squid are members of the molluscan class Cephalopoda, along with octopus, cuttlefish and nautiloids. In the BSAI and GOA, gonatid and onychoteuthid squids are generally the most common, along with chiroteuthids. All cephalopods are stenohaline, occurring only at salinities > 30 ppt. Fertilization is internal, and development is direct ("larval" stages are only small versions of adults). The eggs of inshore neritic species are often enveloped in a gelatinous matrix attached to rocks, shells or other hard substrates, while the eggs of some offshore oceanic species are extruded as large, sausage-shaped drifting masses. Little is known of the seasonality of reproduction, but most species probably breed in spring-early summer, with eggs hatching during the summer. Most small squid are generally thought to live only 2-3 years, but the giant *Moroteuthis robusta* clearly lives longer.

B magister is widely distributed in the boreal north Pacific from California, throughout the Bering Sea, to Japan in waters of depth 30-1500 m; adults most often found at mesopelagic depths or near bottom on shelf, rising to the surface at night; juveniles are widely distributed across shelf, slope and abyssal waters in meso- and epipelagic zones, and rise to surface at night. Migrates seasonally, moving northward and inshore in summer, and southward and offshore in winter, particularly in the western north Pacific. Maximum size: females-50 cm mantle length (ML); males-40 cm ML. Spermatophores transferred into the mantle cavity of female, and eggs are laid on the bottom on the upper slope (200-800 m). Fecundity estimated at 10,000 eggs/female. Spawning of eggs occurs in Feb-Mar in Japan, but apparently all year-round in the Bering Sea. Eggs hatch after 1-2 months of incubation; development is direct. Adults are gregarious prior to, and most die after mating.

O. banksii borealjaponicus, an active, epipelagic species, is distributed in the north Pacific from the Sea of Japan, throughout the Aleutian Islands and south to California, but is absent from the Sea of Okhotsk and not common in the Bering Sea. Juveniles can be found over shelf waters at all depths and near shore. Adults apparently prefer the upper layers over slope and abyssal waters; diel migrators and gregarious. Development includes a larval stage; maximum size about 55 cm.

M. robusta, a giant squid, lives near the bottom on the slope, and mesopelagically over abyssal waters; rare on the shelf. It is distributed in all oceans, and is found in the Bering Sea, Aleutian Islands and Gulf of Alaska. Mantle length can be up to 2.5 m long; with tentacles, at least 7 m, but most are about 2 m long.

R. pacifica is a small (maximum length with tentacles of less than 20 cm) demersal, neritic and shelf, boreal species, distributed from Japan to California in the North Pacific and in the Bering Sea in waters of about 20-300 m depth. Other *Rossia* spp. deposit demersal egg masses.

Fishery:

Not currently a target of groundfish fisheries of BSAI or GOA. A Japanese fishery catching up to 9,000 mt of squid annually existed until the early 1980s for *B. magister* in the Bering Sea and *O. banksii borealjaponicus* in the Aleutian Islands. Since 1990, annual squid bycatch has been about 1,000 mt or less in the BSAI, and between 30-150 mt in the GOA; in the BSAI, almost all squid bycatch is in the midwater pollock fishery near the continental shelf break and slope, while in the GOA, trawl fisheries for rockfish and pollock (again mostly near the edge of the shelf and on the upper slope) catch most of the squid bycatch.

Relevant Trophic Information

The principal prey items of squid are small forage fish pelagic crustaceans (e.g., euphausiids and shrimp), and other cephalopods; cannibalism is not uncommon. After hatching, small planktonic zooplankton (copepods) are eaten. Squid are preyed upon by marine mammals, seabirds, and, to a lesser extent by fish, and occupy an important role in marine food webs worldwide. Perez (1990) estimated that squids comprise over 80% of the diets of sperm whales, bottlenose whales and beaked whales, and about half of the diet of Dall's porpoise in the eastern Bering Sea and Aleutian Islands. Seabirds (e.g., kittiwakes, puffins, murres) on island rookeries close to the shelf break (e.g., Buldir Island, Pribilof Islands) are also known to feed heavily on squid (Hatch et al. 1990; Byrd et al. 1992; Springer 1993). In the Gulf of Alaska, only about 5% or less of the diets of most groundfish consisted of squid (Yang 1993). However, squid play a larger role in the diet of salmon (Livingston and Goiney 1983).

What is the approximate upper size limit of juvenile fish (in cm)?

For *B. magister*, approx. 20 cm ML for males, 25 cm ML for females; both at approximately 1 year of age.

Additional source of information

Sarah Gaichas, NMFS, Alaska Fisheries Science Center

Habitat Narrative for *B. magister*:

<u>*Egg/Spawning*</u>: Eggs are laid on the bottom on the upper slope (200-800 m); incubate for 1-2 months.

<u>*Young Juveniles*</u>: Distributed epipelagically (top 100 m) from the coast to open ocean.

<u>*Old Juveniles and Adults*</u>: Distributed mesopelagically (most from 150-500 m) on the shelf (summer only?), but mostly in outer shelf/slope waters (to lesser extent over the open ocean). Migrate to slope waters to mate and spawn demersally.

Literature

Arkhipkin, A.I., V.A. Bizikov, V.V. Krylov, and K.N. Nesis. 1996. Distribution, stock structure, and growth of the squid *Berryteuthis magister* (Berry, 1913) (Cephalopoda, Gonatidae) during summer and fall in the western Bering Sea. Fish. Bull. 94: 1-30.

Akimushkin, I.I. 1963. Cephalopods of the seas of the U.S.S.R. Academy of Sciences of the U.S.S.R., Institute of Oceanology, Moscow. Translated from Russian by Israel Program for Scientific Translations, Jerusalem 1965. 223 p.

Byrd, G.V., J.C. Williams, and R. Walder. 1992. Status and biology of the tufted puffin in the Aleutian Islands, Alaska, after a ban on salmon driftnets. U. S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, Aleutian Islands Unit, PSC 486, Box 5251, FPO AP 96506-5251, Adak, Alaska.

Fritz, L.W. 1996. Other species *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK.

Hatch, S.A., G.V. Byrd, D.B. Irons, and G.L. Hunt, Jr. 1990. Status and ecology of kittiwakes in the North Pacific. Proc. Pacific Seabird Group Symposium, Victoria, B.C., 21-25 February 1990.

Livingston, P.A., and B.J. Goiney, Jr. 1983. Food habits literature of North Pacific marine fishes: a review and selected bibliography. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS F/NWC-54, 81 p.

Nesis, K. N. 1987. Cephalopods of the world. TFH Publications, Neptune City, NJ, USA. 351 pp.

Perez, M. 1990. Review of marine mammal population and prey information for Bering Sea ecosystem studies. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS F/NWC-186, 81 p.

Sobolevsky, Ye. I. 1996. Species composition and distribution of squids in the western Bering Sea. Pp. 135-141 *In* O.A. Mathisen and K.O. Coyle (eds.), Ecology of the Bering Sea: a review of Russian literature. Alaska Sea Grant Rept 96-01, U. Alaska, Fairbanks, AK 99775.

Springer, A. 1993. Report of the seabird working group. pp. 14-29 *In* Is it food? Addressing marine mammal and seabird declines: a workshop summary. Alaska Sea Grant Report 93-01, Univ. Alaska, Fairbanks, AK, 99775.

Yang, M.S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

SPECIES: ***Berryteuthis magister*** **(red squid)**

Life Stage	Duration or Age	Diet/Prey	Season-Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	1-2 months	NA	varies	USP, LSP	D	M, SM, MS	U	
Young juveniles	4-6 months	zooplankton		All shelf, slope, BSN	P, N	NA	UP, F?	
Older Juveniles and Adults	1-2 years (may be up to 4 yrs)	euphausiids, shrimp, small forage fish, and other cephalopods	summer	All shelf, USP, LSP, BSN	SP	U	UP, F?	Euhaline waters, 2-4˚C

Habitat Description for Octopus

Management Plan and Area BSAI

Species Representatives:

Octopoda: Octopus *(Octopus gilbertianus; O. dofleini*)

Vampyromorpha: Pelagic octopus (*Vampyroteuthis infernalis*)

Life History and General Distribution

Octopus are members of the molluscan class Cephalopoda, along with squid, cuttlefish and nautiloids. In the BSAI and GOA, the most commonly encountered octopods are the shelf demersal species *O. gilbertianus* and *O. dofleini*, and the bathypelagic finned species, *V. infernalis*. Octopods, like other cephalopods are dioecious, with fertilization of eggs (usually within the mantle cavity of the female) requiring transfer of spermatophores during copulation. Octopods probably do not live longer than about 2-4 years, and females of some species (e.g., *O. vulgaris*) die after brooding their eggs on the bottom.

O. gilbertianus - Medium sized octopus (up to 2 m in total length) distributed across the shelf (to 500 m depth) in the eastern and western Bering Sea (where it is the most common octopus), Aleutian Islands, and Gulf of Alaska (endemic to the North Pacific). Little is known of its reproductive or trophic ecology, but eggs laid on the bottom and tended by females. Lives mainly among rocks and stones.

O. dofleini - Giant octopus (up to 10 m in total length, though mostly about 3-5 m) distributed in the southern boreal region from Japan and Korea, through the Aleutian Islands, Gulf Alaska, and south along the Pacific coast of North America to California. Inhabits the sublittoral to upper slope. Egg length 6-8 mm; laid on bottom. Copulation may occur in late fall-winter, but oviposition the following spring; each female lays several hundred eggs.

V. infernalis - Relatively small (up to about 40 cm total length) bathypelagic species, living at depths well below the thermocline; may be most commonly found at 700-1500 m. Found throughout the world's oceans. Eggs are large (3-4 mm in diameter) and are shed singly into the water. Hatched juveniles resemble adults, but with different fin arrangements, which change to the adult form with development. Little is known of their food habits, longevity, or abundance.

Fishery:

Not currently a target of groundfish fisheries of BSAI or GOA. Bycatch has ranged between 200-1,000 mt in the BSAI and 40-100 mt in the GOA, chiefly in the pot fishery for Pacific cod and bottom trawl fisheries for cod and flatfish, but sometimes in the pelagic trawl pollock fishery. Directed octopus landings have been less than 8 mt/year for 1988-95. Age/size at 50% recruitment is unknown. Most of the bycatch occurs on the outer continental shelf (100-200 m depth), chiefly north of the Alaskan peninsula from Unimak I. To Port Moller and northwest to the Pribilof Islands; also around Kodiak Island and many of the Aleutian Islands.

Relevant Trophic Information

Octopus are eaten by pinnipeds (principally Steller sea lions, and spotted, bearded, and harbor seals) and a variety of fishes, including Pacific halibut and Pacific cod (Yang 1993). When small, octopods eat planktonic and small benthic crustaceans (mysids, amphipods, copepods). As adults, octopus eat benthic crustaceans (crabs) and molluscs (clams).

What is the approximate upper size limit of juvenile fish (in cm)? Unknown

Additional source of information

Sarah Gaichas, NMFS, Alaska Fisheries Science Center

Habitat Narrative for *Octopus* spp.:

Egg/Spawning: shelf; eggs laid on bottom, maybe preferentially among rocks and cobble.

Young Juveniles: semi-demersal; widely dispersed on shelf, upper slope

Old Juveniles and Adults: demersal, widely dispersed on shelf and upper slope, preferentially among rocks, cobble, but also on sand/mud.

Literature

Akimushkin, I.I. 1963. Cephalopods of the seas of the U.S.S.R. Academy of Sciences of the U.S.S.R., Institute of Oceanology, Moscow. Translated from Russian by Israel Program for Scientific Translations, Jerusalem 1965. 223 p.

Fritz, L.W. 1996. Other species *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Nesis, K.N. 1987. Cephalopods of the world. TFH Publications, Neptune City, NJ, USA. 351 pp.

Perez, M. 1990. Review of marine mammal population and prey information for Bering Sea ecosystem studies. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS F/NWC-186, 81 p.

Yang, M.S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

SPECIES: ***Octopus dofleini*, *O. gilbertianus***

Life Stage	Duration or Age	Diet/Prey	Season-Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U (1-2 months?)	NA	spring-summer?	U, ICS, MCS	D	R, G?	U	Euhaline waters
Young juveniles	U	zooplankton	summer-fall?	U, ICS, MCS, OCS, USP	D, SD	U	U	Euhaline waters
Older Juveniles and Adults	U (2-3 yrs? for *O.gilbertianus*; older for *O.dofleini*)	crustaceans, molluscs	all year	ICS, MCS, OCS, USP	D	R, G, S, MS?	U	Euhaline waters

APPENDIX F.3

ESSENTIAL FISH HABITAT ASSESSMENT REPORT

for the Bering Sea and Aleutian Islands

King and Tanner Crabs

August 22, 2003

NOAA Fisheries
NMFS Alaska Region
709 West 9th Street
Juneau, AK 99802

NOAA Fisheries
National Marine Fisheries Service

TABLE OF CONTENTS

Introduction F.3-1

General Life History Information for Crab F.3-2

Table 1 - Summary Table of Major References and Atlases F.3-4

Table 2 - Summary of Habitat Associations for BSAI Crab. F.3-6

Table 3 - Summary Table of Reproductive Traits for BSAI Crab F.3-7

Table 4 - Summary Table of Predator and Prey Relationships for BSAI Crab F.3-8

Habitat Description for Red King Crab F.3-9

Habitat Description for Blue King Crab F.3-12

Habitat Description for Golden King Crab F.3-15

Habitat Description for Scarlet King Crab F.3-18

Habitat Description for Tanner Crab F.3-21

Habitat Description for Snow Crab F.3-24

Habitat Description for Grooved Tanner Crab F.3-27

Habitat Description for Triangle Tanner Crab F.3-29

References F.3-32

Introduction

In 1996, the Sustainable Fisheries Act amended the Magnuson-Stevens Fishery Conservation and Management Act to require the description and identification of Essential Fish Habitat (EFH) in Fishery Management Plans (FMPs), adverse impacts on EFH, and actions to conserve and enhance EFH. Guidelines were developed by the National Marine Fisheries Service (NMFS) to assist Fishery Management Councils in fulfilling the requirements set forth by the Act.

Essential fish habitat means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat: "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means the habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

With respect to type, the information available for almost all species is primarily broad geographic distributions based on specific samples from surveys and fisheries, which have not been linked with habitat characteristics. Furthermore, our ability to precisely define the habitat (and its location) of each life stage of each managed groundfish species in terms of its oceanographic (temperature, salinity, nutrient, current), trophic (presence of food, absence of predators), and physical (depth, substrate, latitude, and longitude) characteristics is very limited. Consequently, the information included in the habitat descriptions for each species and life stage is restricted primarily to their position in the water column (e.g., demersal, pelagic), broad biogeographic and bathymetric areas (e.g., 100-200 m zone, south of the Pribilof Islands and throughout the Aleutian Islands), and occasional references to known bottom types associations.

Identification of EFH for some species included historical range information. Traditional knowledge and sampling data have indicated that fish distributions may contract and expand due to a variety of factors including, but not limited to, temperature changes, current patterns, changes in population size, and changes in predator and prey distribution.

Background

In preparation of the 1999 Essential Fish Habitat Environmental Assessment, EFH Technical Teams, comprised of scientific stock assessment authors, compiled scientific information and prepared the 1999 Habitat Assessment Reports. These reports provided the scientific information baseline to describe EFH. Importantly, recent scientific evidence has not proved to change existing life history profiles of the federally managed species. However, where new information does exist, new data helps to fill information gaps in the region's limited habitat data environment.

Stock assessment authors used information contained in these summaries and personal knowledge, along with data contained in reference atlases (NOAA 1987; 1990; 1997a;b), fishery and survey data (Allen and Smith 1988; Wolotira et al. 1993; NOAA 1998), and fish identification books (Hart 1973; Eschmeyer and Herald 1983; NPFMC 1996;Mecklenburg and Thorsteinson 2002), to describe EFH for each life stage using best scientific judgment and interpretation; see Table 1.

Species Profiles and Habitat Descriptions

FMPs must describe EFH in text, map EFH distributions, and include tables, which provide information on habitat and biological requirements for each life history stage of the species; see Tables 2-4.

Information contained in this report details life history information for federally managed fish species. This collection of scientific information is interpreted, then referenced to describe and delineate EFH for each species by life history stage using GIS. EFH text and map descriptions are not compiled in this report due to differences in the characteristics of a species life history and the overall distribution of the species. Specific EFH text descriptions and maps are in Appendix D.

References

Allen, M. J., and G. B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Eschmeyer, W. N., and E. S. Herald. 1983. A field guide to Pacific coast fishes. Houghton Mifflin Co., Boston. 336 p.

Hart, J. L. 1973. Pacific fishes of Canada. Fisheries Research Board of Canada Bulletin 180. Ottawa. 740 p.

Mecklenburg, C.W. , Mecklenburg,T.A ., and Thorsteison, L.K. 2002. Fishes of Alaska. American Fish Society. Bethsda, Maryland. 1037 p.

NOAA. 1987. Bering, Chukchi, and Beaufort Seas. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerce, NOAA, NOS.

NOAA. 1990. West coast of North America. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerc., NOAA, NOS.

NOAA. 1998. Catch-per-unit-effort, length, and depth distributions of major groundfish and bycatch species in the Bering Sea, Aleutian Islands and Gulf of Alaska regions based on groundfish fishery observer data. U.S. Dep. Commerc., NOAA Tech. Memo. NMFS-AFSC-88.

NPFMC. 1996. King and Tanner Crabs of the Bering Sea and Aleutian Islands Area: Species Profiles. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

NPFMC. 1997a. Essential fish habitat assessment report for the groundfish resources of the Bering Sea and Aleutian Islands regions. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

NPFMC. 1997b. Essential fish habitat assessment report for the groundfish resources of the Gulf of Alaska region. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Wolotira, R. J., Jr., T. M. Sample, S. F. Noel, and C. R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U.S. Dep. Commerc., NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

General Life History Information for Crab

Shallow inshore areas (less than 50 m depth) are very important to king crab reproduction as they move onshore to molt and mate. Tanner crabs also occupy shallower depths during molting and mating. All BSAI crab are highly vulnerable to predation and damage during molting when they shed their exoskeleton. Female king crab molt annually to mate while Tanner and snow crab exhibit terminal molt and carry sperm for future clutch fertilization. The habitat occupied by molting and mating crab differs from that occupied by mature crabs during the remainder of the year. The crab technical team noted protection of crab in molting mating habitat during this sensitive life history stage is important.

Larval stages are distributed according to vertical swimming abilities, and the currents, mixing, or stratification of the water column. Generally, the larval stages occupy the upper 30 m, often in the mixed layer near the sea surface. As the larvae molt and grow into more actively swimming stages they are able to seek a preferred depth. After molting through multiple larval stages, crabs settle on the bottom. Settlement on habitat with adequate shelter, food, and temperature is imperative to survival of first settling crabs. Young of the year red and blue king crabs require nearshore shallow habitat with significant cover that offers protection (e.g., sea stars, anemones, macroalgae, shell hash, cobble, shale) to this frequently molting life stage. Early juvenile stage Tanner and snow crab also occupy shallow waters and are found on mud habitat. Late Juvenile stage crabs are most active at night when they feed and molt. The crab technical team emphasized the importance of shallow areas to all early juvenile stage crabs and in particular the importance to red and blue king crabs of high relief habitat nearshore with extensive biogenic assemblages. The area north and adjacent to the Alaska peninsula (Unimak Island to Port Moller), the eastern portion of Bristol Bay, and nearshore areas of the Pribilof and Saint Matthew Islands are locations known to be particularly important for king crab spawning and juvenile rearing.

Egg Stage

Female king and Tanner crab extrude eggs, carry and nurture them outside the maternal body. The number of eggs developed by the female increases with body size and is linked to nutrition at favorable temperatures. Information on egg bearing females is used to define habitat for the egg stage of crabs.

Larval Stage

Successful hatch of king and Tanner crab larvae is a function of temperature and concentration of diatoms, so presence of larvae in the water column can vary accordingly. Larvae are planktonic. Their sustained horizontal swimming is inconsequential compared to horizontal advection by oceanographic conditions. Larvae vertically migrate within the water column to feed. Diel vertical migration may be a retention mechanism to transport larvae inshore.

Early Juvenile Stage

The early juvenile stage includes crabs first settling on the bottom (glacothoe and megalops), young of the year crabs, and crabs up to a size approximating age 2. Habitat relief is obligatory for red and blue King crabs of this life stage. Individuals are typically less than 20 mm CL distributed in nearshore waters among niches provided by sea star arms, anemones, shell hash, rocks and other bottom relief. Early juvenile Tanner crab settle on mud, are known to occur there during summer but are not easily found in this habitat in winter.

Late Juvenile Stage

The late juvenile stage for crab is defined as the size at about age 2 to the first size of functional maturity. Late juvenile crabs are typically found further offshore in cooler water than early juvenile crabs. Smaller red king crabs of this life stage form pods during day that break apart during the night when the crabs forage and molt. As these crabs increase in size, podding behavior declines and the animals are found to forage throughout the day.

Mature Stage

Mature crabs are defined as those crabs of a size that is functionally mature. Functional maturity is based on size observed in mating pairs of crabs. This maturity definition differs from morphometric maturity based on chela height and physiological maturity when sperm or eggs can be produced. The mature stage includes crabs from the first size of functional maturity to senescence.

Table 1. Summary Table of Major References and Atlases

	References					
Species	NOAA 1988	Epifanio 1988	NOAA 1990	Wolotira et al. 1993	NPFMC Witherell 1996	Tyler and Kruse 1996;1997
Red king crab	X	X	X	X	X	X
Blue king crab	X	X	X	X	X	X
Golden king crab	X	X	X	X	X	X
Tanner crab	X	X	X	X	X	X
Snow crab	X	X	X		X	X

Abbreviations used in the EFH report tables to specify location, depth, bottom type, and other oceanographic features.

Location

ICS = inner continental shelf (1-50 m)
MCS = middle continental shelf (50-100 m)
OCS = outer continental shelf (100-200 m)
USP = upper slope (200-1000 m)
LSP = lower slope (1000-3000 m)
BSN= basin (>3000 m)

BCH = beach (intertidal)
BAY = nearshore bays, give depth if appropriate (e.g., fjords)
IP = island passes (areas of high current), give depth if appropriate

Water column

D = demersal (found on bottom)
SD/SP =semi-demersal or semi-pelagic if slightly greater or less than 50% on or off bottom
P = pelagic (found off bottom, not necessarily associated with a particular bottom type)
N = neustonic (found near surface)

Bottom Type

M = mud
S = sand
R = rock
SM = sandy mud
CB = cobble
C = coral
MS = muddy sand
G = gravel
K = kelp
SAV = subaquatic vegetation (e.g., eelgrass, not kelp)

Oceanographic Features

UP = upwelling
G = gyres
F = fronts
E = edges
CL = thermocline or pycnocline

General

U = Unknown
N/A = not applicable

Table 2. Summary of Habitat Associations for BSAI Crab

BSAI Crab		Nearshore				Shelf			Slope						Stratum Reference							Location							Physical Oceanography					Substrate															Structure								Community Associations											Oceanographic Properties			
						Inner	Middle	Outer	Upper		Inter-mediate		Lower	Basin											Pelagic																																														
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surafce	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Reefs	Vertical Walls	Man-made	Algal Cover	Anemones	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
Blue King Crab	M					x	x	x																	x											x	x							x	x			x	x	x	x	x	x			x	x	x		x			x								M
	LJ					x	x	x																	x											x	x							x	x			x	x	x	x	x	x			x	x	x		x			x								LJ
	EJ					x	x																		x																																													EJ
	L					x	x																			x																																												L
	E					x	x	x																	x											x	x							x	x			x	x	x	x	x	x			x	x	x		x			x								E
Golden King Crab	M							x	x	x	x	x				x		x							x											x	x							x	x			x	x	x	x	x	x			x	x	x		x			x				<5	>30		M
	LJ												x	x				x							x											x	x							x	x			x	x	x	x	x	x			x	x	x		x			x				<5	>30		LJ
	EJ												x	x											x																																										<5	>30		EJ
	L																									x																																									<5	>30		L
	E							x	x	x	x							x							x											x	x							x	x			x	x	x	x	x	x			x	x	x		x			x				<5	>30		E
Red King Crab	M					x	x	x																	x								x	x	x	x	x	x	x	x	x	x													x	x	x		x			x								M
	LJ					x	x	x																	x								x	x	x	x	x	x	x	x	x	x													x	x	x		x			x								LJ
	EJ					x	x																		x											x								x	x																									EJ
	L					x	x																			x																																											L
	E					x	x	x																	x								x	x	x	x	x	x	x	x	x	x													x	x	x		x			x								E
Snow Crab	M					x	x	x																	x								x	x	x	x	x	x	x	x	x	x																												M
	LJ					x	x	x																	x								x	x	x	x	x	x	x	x	x	x																												LJ
	EJ					x	x																		x								x	x	x	x	x	x	x	x	x	x																												EJ
	L					x	x																			x																																										L
	E					x	x	x																	x								x	x	x	x	x	x	x	x	x	x																												E
Tanner	M					x	x	x	x	x	x						x	x							x						x		x	x	x	x	x	x	x	x	x	x	x		x	x	x	x				x		x	x	x	x	x	x	x	x		x	x	>4	>30		M
	LJ			x	x	x	x	x	x	x								x							x					x	x		x	x	x	x	x	x	x	x	x	x	x		x	x	x	x				x		x	x	x	x	x	x	x	x		x	x	>4	>30		LJ
	EJ				x	x	x	x	x	x								x							x								x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x				x		x	x	x	x	x	x	x	x		x	x	>4	>30		EJ
	L		x	x	x	x	x																			x						x																																				L
	E				x	x	x	x	x	x	x	x													x						x		x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x				x		x	x	x	x	x	x	x	x		x	x	>4	>30		E

Table 3. Summary of Reproductive Traits of BSAI Crab

BSAI Crab		Reproductive Traits																											
		Age at Maturity				Fertilization/Egg Development					Spawning Behavior							Spawning Season											
		Female		Male																									
Species	Life Stage	50%	100%	50%	100%	External	Internal	Oviparous	Ovoviviparous	Viviparous	Batch Spawner	Broadcast Spawner	Egg Case Deposition	Nest Builder	Egg/Young Guarder	Egg/Young Bearer	January	February	March	April	May	June	July	August	September	October	November	December
Blue King Crab	M	6+			6+	X		X								X	X	X	X	X	X	X	X					
	LJ																											
	EJ																											
	L																											
	E																											
Golden King Crab	M	6+			6+	X		X								X	X	X	X	X	X	X	X	X	X	X	X	X
	LJ																											
	EJ																											
	L																											
	E																											
Red King Crab	M	7 to 8		7 to 10		X		X								X	X	X	X	X	X	X	X					
	LJ																											
	EJ																											
	L																											
	E																											
Snow Crab	M	5 to 6		6 to 8		X	X	X								X	X	X	X	X	X	X						
	LJ																											
	EJ																											
	L																											
	E																											
Tanner Crab	M	5 to 6		6 to 8		X	X	X								X	X	X	X	X	X	X						
	LJ																											
	EJ																											
	L																											
	E																											

Snow and tanner crab fertilization is internal. Eggs are extruded and carried externally until hatching. King crab fertilization and egg carrying are external.

Table 4. Summary of Predator and Prey Relationships for BSAI Crab

BSAI Crab		Predator to																														Prey of																										
Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Salmon	Cod	Pollock	Halibut		Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pac fic Cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Halibut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrestrial Mammals
Blue King Crab	M	X				X			X			X	X			X	X	X																				X						X														
	LJ	X				X			X			X	X			X	X	X																				X						X														
																																						X						X														
	L																																																									
	E																																																									
Golden King Crab	M	X				X			X			X	X			X	X	X	X																			X						X														
	LJ	X				X			X			X	X			X	X	X																				X						X														
	EJ																																					X						X														
	L																																																									
	E																																																									
Red King Crab	M	X				X			X			X	X			X	X	X																				X						X														
	LJ	X				X			X			X	X			X	X	X																				X						X														
	EJ																																					X						X														
	L																																																									
	E																																																									
Snow Crab	M	X				X			X			X	X			X	X	X																				X																				
	J	X				X			X			X	X			X	X	X																				X			X	X		X														
	L																																																									
Tanner Crab	M	X				X			X			X	X			X	X	X																				X																				
	LJ	X				X			X			X	X			X	X	X																				X		X	X	X		X														
																																						X		X	X	X		X														
	L	X			X	X																										X		X		X	X	X																					
	E																																																									

Skates are predators on snow and tanner crabs.

Habitat Description for Red King Crab

(Paralithodes camtschaticus)

Management Plan Area BSAI

Life History and General Distribution

Red king crab (*Paralithodes camtshaticus*) is widely distributed throughout the Bering Sea and Aleutian Islands, Gulf of Alaska, Sea of Okhotsk, and along the Kamchatka shelf. Red king crab are typically at depths < 100 fm. King crab molt multiple times per year through age 3 after which molting is annual. At larger sizes, king crab may skip molt as growth slows. Females grow slower and do not get as large as males. In Bristol Bay, fifty percent maturity is attained by males at 12 cm carapace length and 9 cm carapace length by females (about 7 years). Female red king crab in the Norton Sound area reach 50% maturity at 6.8 cm and do not attain maximum sizes found in other areas. Size at 50% maturity for females in the Western Aleutians is 8.9 cm carapace length. Natural mortality of adult red king crab is assumed to be about 18 percent per year (M=0.2), due to old age, disease, and predation.

Fishery

The red king crab fisheries are prosecuted using mesh covered pots (generally 7 or 8 foot square) set on single lines. Mean age at recruitment is about 8-9 years. Two discrete populations of red king crab are actively fished in the BSAI region: Bristol Bay and Norton Sound. A third population surrounding the Aleutian Islands was managed separately as Adak and Dutch Harbor stocks until 1996 when the management areas were combined. The fishery on the Adak stock was closed in 1996 and the fishery on the Dutch Harbor stock has closed since the 1983-84 season. These fisheries historically occurred in the winter-spring. Red king crab are allowed as bycatch during golden king crab fisheries in those areas. Other populations of red king crab are fished in the Pribilof Islands area, St. Matthew, and St. Lawrence Island area, but are managed in conjunction with the predominant blue king crab fisheries. Red king crab stocks are managed separately to accommodate different life histories and fishery characteristics. Male only red king crab >16.5 cm carapace length are allowed to be taken from Bristol Bay and the Pribilof and Aleutian Islands. The minimum size limit for harvest of male only crab from the Norton Sound and the St. Matthew and St. Lawrence Island population is 12 cm. The season in Bristol Bay begins on November 1, and generally has lasted less than 10 days in recent years. Bycatch in red king crab fisheries is comprised primarily of Tanner crab and nonlegal red king crab. The commercial fishery for red king crab in Norton Sound occurs in the summer, opening July 1 and a winter through the ice fishery opens November 15 and closes May 15.

Relevant Trophic Information

Pacific cod is the main predator on red king crabs. Walleye pollock, yellowfin sole, and Pacific halibut are minor consumers of pelagic larvae, settling larvae, and larger crabs, respectively. Juvenile crab may be cannibalistic during molting.

Describe any potential gear impacts on the habitats of this or other species

Bottom trawls and dredges could disrupt nursery and adult feeding areas.

What is the approximate upper size limit of juvenile fish (in cm)?
The size of 50 percent maturity is 7 and 9 cm carapace length for female and male red king crabs from Norton Sound and St. Matthew and St. Lawrence Islands; 9 and 12 cm for Bristol Bay and Pribilof and Aleutian Islands.

Source (agency, name and phone number, or literature reference) for additional distribution data

ADF&G, Dutch Harbor, AK, Larry Boyle, (907)-581-1239
ADF&G, Dutch Harbor, AK, Rance Morrison, Robert Gish (907)-581-1239

Habitat and Biological Associations Narrative

Egg
Egg hatch of larvae is synchronized with the spring phytoplankton bloom in Southeast Alaska suggesting temporal sensitivity in the transition from benthic to planktonic habitat. Also see mature; eggs are carried by adult female crab

Larvae
Red king crab larvae spend 2-3 months in pelagic larval stages before settling to the benthic life stage. Reverse diel migration and feeding patterns of larvae coincide with the distribution of food sources.

Early Juvenile
Early juvenile stage red king crabs are solitary and need high relief habitat or coarse substrate such as boulders, cobble, shell hash, and living substrates such as bryozoans and stalked ascidians. Young-of-the-year crabs occur at depths of 50 m or less.

Late Juvenile
Late juvenile stage red king crabs of the ages of two and four years exhibit decreasing reliance on habitat and a tendency for the crab to form pods consisting of thousands of crabs. Late juvenile crab associate with deeper waters and migrate to shallower water for molting and mating in the spring. Aggregation behavior continues into adulthood.

Mature
Mature red king crabs exhibit seasonal migration to shallow waters for reproduction. The remainder of the year red king crabs are found in deeper waters. In Bristol Bay, red king crabs mate when they enter shallower waters (<50 m), generally beginning in January and continuing through June. Males grasp females just prior to female molting, after which the eggs (43,000 to 500,000 eggs) are fertilized and extruded on the female's abdomen. The female red king crab carries the eggs for 11 months before they hatch, generally in April.

SPECIES: Red king crab, *Paralithodes camtschaticus*

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	11 mo	NA	May-April	NA	NA	NA	F	
Larvae	3-5 mo	Diatoms, Phytoplankto n Copepod nauplii	April-August	MCS, JCS	P	NA	F	
Juveniles	1 to 5-6 yrs	Diatoms Hydroids	All year	ICS, MCS, BCH, BAY	D	SAV (epifauna), R, CB, G	F	Found among biogenic assemblages (sea onions, tube worms, bryozoans, ascidians, sea stars)
Adults	5-6+ yrs	Mollusks, echinoderms, polychaetes, decapod, crustaceans, Algae, urchins, hydroids, sea stars	Spawning Jan-June	MCS, ICS, BAY, BCH	D	S, M, CB, G	F	

Habitat Description for Blue King Crab

(Paralithodes platypus)

Management Plan Area BSAI

Life History and General Distribution

Blue king crab (*Paralithodes platypus*) has a discontinuous distribution throughout their range (Hokkaido, Japan to Southeast Alaska). In the Bering Sea, discrete populations exist in the cooler waters around the Pribilof Islands, St. Matthew Island, and St. Lawrence Island. Smaller populations have been found in Herendeen Bay, and around Nunivak and King Island, as well as isolated populations in the Gulf of Alaska. Blue king crab molt multiple times as juveniles. In the Pribilof area, 50 percent maturity of females is attained at 9.6 cm carapace length, which occurs at about 5 years of age. Blue king crab in the St. Matthew area mature at smaller sizes (50 percent maturity at 8.1 cm carapace length for females) and do not get as large overall. Skip molting occurs with increasing probability for those males larger than 10 cm carapace length and is more prevalent for St. Matthew Island crab. Larger female blue king crab have a biennial ovarian cycle and a 14 month embryonic period. Unlike red king crab, juvenile blue king crab do not form pods, instead relying on cryptic coloration for protection from predators. Adult male blue king crab occur at an average depth of 70 m and an average temperature of 0.6 degrees C.

Fishery

The blue king crab fisheries are prosecuted using mesh covered pots (generally 7 or 8 foot square) set on single lines. Two discrete stocks of blue king crab are fished: the Pribilof Islands and St. Matthew Island stocks. These blue king crab fisheries have occurred in September in recent years. Bycatch in the blue king crab fisheries consist almost entirely of non-legal blue king crabs. Male only crabs >16.5 cm carapace width are harvested in the Pribilof Islands while the St. Matthew Islands fishery is managed with a minimum size limit of 140 mm.

Relevant Trophic Information

Pacific cod is a predator on blue king crabs.

Describe any potential gear impacts on the habitats of this or other species

Bottom trawls and dredges could disrupt nursery and adult feeding areas.

What is the approximate upper size limit of juvenile fish (in cm)?

The size of 50 percent maturity is 9 and 12 cm carapace length for female and male crabs from the Pribilof Islands, and 8 and 10.5 cm for St. Matthew Island.

Source (agency, name and phone number, or literature reference) for additional distribution data

ADF&G, Dutch Harbor, AK, Larry Boyle, 907-581-1239
ADF&G, Dutch Harbor, AK, Rance Morrison, 907-581-1239

Habitat and Biological Associations Narrative

Egg
See mature; eggs are carried by adult female crab.

Larvae
Blue king crab larvae spend 3.5 to 4 months in pelagic larval stages before settling to the benthic life stage. Larvae are found in waters of depths between 40 to 60 m.

Early Juvenile
Early juvenile blue king crabs require area found in substrate characterized by gravel and cobble overlaid with shell hash, and sponge, hydroid and barnacle assemblages. These habitat areas have been found at 40-60 m around the Pribilof Islands.

Late Juvenile
Late juvenile blue king crab are found in nearshore rocky habitat with shell hash.

Mature
Mature blue king crabs occur most often between 45-75 m depth on mud-sand substrate adjacent to gravel rocky bottom. Female crabs are found in a habitat with a high percentage of shell hash. Mating occurs in mid-spring. Larger older females reproduce biennially while small females tend to reproduce annually. Fecundity of females range from 50,000-200,000 eggs per female. It has been suggested that spawning may depend on availability of nearshore rocky-cobble substrate for protection of females. Larger older crabs disperse farther offshore and are thought to migrate inshore for molting and mating.

SPECIES: Blue king crab, *Paralithodes platypus*

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	14 mo.	NA	Starting April-May	NA	NA	NA	F	
Larvae	3.5 to 4 mo.		April-July	MCS, ICS	P	NA	F	
Juveniles	to about 5 years		All year	MCS, ICS	D	CB, G, R	F	
Adults	5+ years		Spawning Feb-Jun	MCS, ICS	D	S, M, CB, G, R	F	

Habitat Description for Golden King Crab

(Lithodes aequispina)

Management Plan Area BSAI

Life History and General Distribution

Golden king crab (*Lithodes aequispina*), also called brown king crab, range from Japan to British Columbia. In the Bering Sea and Aleutian Islands, golden king crab are found at depths from 100 m to 1,000 m, generally in high relief habitat such as inter-island passes, and are usually slope-dwelling. Size at sexual maturity depends on latitude ranging from 9.8 - 11 cm carapace length, with crabs in the northern areas maturing at smaller sizes. Females carry up to 20,000 eggs, depending on female size. The season of reproduction appears to be protracted, and perhaps year-round.

Fishery

The golden king crab fisheries are prosecuted using mesh covered pots set on longlines to minimize gear loss. The primary fishery is in the Aleutian Islands, with minor catches coming from localized areas in the Bering Sea and Gulf of Alaska. Until 1996, the golden king crabs in the Aleutian Islands were managed as two separate stocks: Adak and Dutch Harbor. The fishing season opens September 1 and male crab >15.2 cm are harvested. Golden king crab are harvested in the Bering Sea under conditions of a permit issued by the Commissioner of Fish and Game. Bycatch consists almost exclusively of non-legal golden king crab. Escape rings were adopted by the Board in 1996 to reduce capture and handling mortality of non-target crab; a minimum of four 5.5" rings are required on pots used in golden king crab fisheries.

Relevant Trophic Information None

Describe any potential gear impacts on the habitats of this or other species Unknown

What is the approximate upper size limit of juvenile fish (in cm)?

The size (carapace length) at 50% maturity for females and males: Aleutians 11 and 12.5 cm, Pribilofs 10 and 10.7 cm, Northern Bering Sea 9.8 and 9.2 cm.

Source (agency, name and phone number, or literature reference) for additional distribution data

ADF&G, Dutch Harbor, AK, Larry Boyle, 907-581-1239
ADF&G, Dutch Harbor, AK, Robert Gish, 907-581-1239

Habitat and Biological Associations Narrative

Golden king crabs occur on hard bottom, over steep rocky slopes and on narrow ledges. Strong currents are prevalent. Golden king crabs coexist with abundant quantities of epifauna; sponges, hydroids, coral, sea stars, bryozoans, and brittle stars.

<u>Egg</u>

Information is limited. See mature; eggs are carried by adult female crab.

Larvae
Information is not available.

Early Juvenile
Information is not available.

Late Juvenile
Late juvenile golden king crabs are found throughout the depth range of the species. Abundance of late juvenile crab increases with depth and these crab are most abundant at depths >548 m.

Mature
Mature golden king crabs occur at all depths within their distribution. Males tend to congregate in somewhat shallower waters than females, and this segregation appears to be maintained throughout the year. Legal male crabs are most abundant between 274 m and 639 m. Abundance of sub-legal males increases at depth >364 m. Female abundance is greatest at intermediate depths between 274 m and 364 m.

SPECIES: Golden king crab, *Lithodes aequispina*

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		n/a	all year	LSP	D			
Larvae	U		all year	U	P			
Juveniles			all year		D			
Adults		Ophiuroids, sponges, plants	Spawning Feb.-Aug.	LSP BSN	D			

Habitat Description for Scarlet King Crab

(Lithodes couesi)

Management Plan Area BSAI

Life History and General Distribution

Little information is available on the biology of the scarlet king crab (*Lithodes couesi*), found in the Bering Sea and Aleutian Islands area. Based on data from the Gulf of Alaska, this species occurs in deep water, primarily on the continental slope. Spawning may be asynchronous. Females can produce up to 5,000 eggs, depending
on female size.

Fishery

Scarlet king crab are harvested by longlining mesh covered pots. Directed fishing may occur only under conditions of a permit issued by the commissioner of Fish and Game. Scarlet king crab also taken incidentally in the golden king crab fishery.

Relevant Trophic Information None

Describe any potential gear impacts on the habitats of this or other species Unknown

What is the approximate upper size limit of juvenile fish (in cm)?

The size (carapace length) of 50% maturity for female and males is 8 cm and 9.1 cm.

Source (agency, name and phone number, or literature reference) for additional distribution data

ADF&G, Dutch Harbor, AK, Larry Boyle, 907-581-1239
ADF&G, Dutch Harbor, AK, Robert Gish, 907-581-1239

Habitat and Biological Associations Narrative

Scarlet king crab are associated with steep rocky outcrops and narrow ledges. Strong currents are prevalent.

<u>Egg</u>
Information is limited. See mature; eggs are carried by adult female crab.

<u>Larvae</u>
Information is not available.

<u>Early</u> <u>Juvenile</u>
Information is not available.

Late Juvenile
Information is not available.

Mature
Information is limited. Mature scarlet king crabs are caught incidentally in the golden king crab and *C. tanneri* fisheries.

SPECIES: Scarlet king crab, *Lithodes couesi*

Stage - EFH Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs								
Larvae								
Juveniles								
Adults								

Habitat Description for Tanner Crab

(Chionoecetes bairdi)

Management Plan and Area BSAI

Life History and General Distribution

Tanner crab (*Chionoecetes bairdi*) are distributed on the continental shelf of the North Pacific Ocean and Bering Sea from Kamchatka to Oregon. Off Alaska, Tanner crab are concentrated around the Pribilof Islands and immediately north of the Alaska Peninsula, and are found in lower abundance in the Gulf of Alaska. Size at 50% maturity, as measured by carapace width, is 11 cm for males and 9 cm for females in the Bering Sea. The corresponding age of maturity for male Tanner crab is approximately 6 to 8 years. Mature male Tanner crabs may skip a year of molting as they attain maturity. Natural mortality of adult Tanner crab is assumed to be about 25% per year (M=0.3).

Fishery

The Tanner crab fisheries are prosecuted using mesh covered pots (generally 7 or 8 foot square) set on single lines. Mean age at recruitment is 8-9 years to the fishery. Male crab >14 cm carapace width may be harvested. Fisheries operate on 3 separate stocks: eastern Bering Sea, eastern Aleutian Islands, and western Aleutian Islands. The directed fishery was closed in 1996 due to low CPUE relative to pre-season expectations. The Tanner crab stocks of the Aleutian Islands are very small, and populations are found in only a few large bays and inlets. As such, the fisheries are limited, occurring during the winter. No commercial fishery was allowed for Tanners in either the east or west Aleutian Island in 1995 and 1996. The directed fishery for Bering Sea Tanner crab opens seven days after closure of the Bristol Bay red king crab fishery. However, retention of Tanner crab is allowed during the Bristol Bay red king crab fishery that opens November 1. Bycatch in the directed fishery is comprised primarily of non-legal Tanner crab and red king crab. A 3" maximum tunnel height opening for Tanner crab pots is required to inhibit the bycatch of red king crab. Also, escape rings are required to reduce capture and handling mortality of all non-target crab; a minimum of four 5.0" rings are required on pots used in Tanner crab fisheries.

Relevant Trophic Information

Pacific cod is the main predator on Tanner crabs in terms of biomass. Predators consume primarily age 0 and 1 juvenile Tanner crab less than 7 cm carapace width. However, flathead sole, rock sole, halibut, skates, and yellowfin sole are important in terms of numbers of small crab. Larval predators include salmon, herring, jellyfish and chaetognaths. Cannibalism has been observed in laboratory environments among juvenile crabs during molting.

Describe any potential gear impacts on the habitats of this or other species

Bottom trawls and dredges could disrupt nursery and adult feeding areas.

What is the approximate upper size limit of juvenile fish (in cm)?

The size of 50% maturity is 9 and 11 cm carapace width for female and male crabs.

Source (agency, name and phone number, or literature reference) for additional distribution data

ADF&G, Dutch Harbor, AK, Larry Boyle, 907-581-1219
ADF&G, Kodiak, AK, Al Spalinger, 907-486-1840

Habitat and Biological Associations Narrative

Egg
See mature; eggs are carried by adult female crab.

Larvae
Larvae of *C. bairdi* Tanner crabs are typically found in Bering Sea Aleutian Island water column from 0 – 100 m in early summer. They are strong swimmers and perform diel migrations in the water column (down at night). They usually stay near the depth of the chlorophyll maximum during the day. The last larval stage settles onto the bottom mud.

Early Juvenile
Early juvenile *C. bairdi* Tanner crabs occur at depths of 10 - 20 m in mud habitat in summer and are known to borough or associate with many types of cover. Early juvenile *C. bairdi* Tanner crabs are not easily found in winter.

Late Juvenile
The preferred habitat for late juvenile *C. bairdi* Tanner crabs is mud. Late juvenile Tanner crab migrate offshore of their early juvenile nursery habitat. Essential habitat of late juvenile *C. bairdi*

Mature
Mature *C. bairdi* Tanner crabs migrate inshore and mating is known to occur February through June. Mature female *C. bairdi* Tanner crabs have been observed in high density mating aggregations, or pods, consisting of hundreds of crabs per mound. These mounds may provide protection from predators and also attract males for mating. Mating need not occur every year, as female *C. bairdi* Tanner crabs can retain viable sperm in spermathecae up to 2 years or more. Females carry clutches of 50,000 to 400,000 eggs and nurture the embryos for one year after fertilization. Primiparous females may carry the fertilized eggs for as long as 1.5 years. Brooding occurs in 100-150 m depths.

SPECIES: Tanner crab, *Chionoecetes bairdi*

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	1 year	NA	April-March	NA	NA	NA	F	
Larvae	2 to 7 mo.	Diatoms Algae Zooplankton	Summer	MCS, ICS	P	NA	F	
Juveniles	1 to 6 years	Crustaceans polychaetes mollusks diatoms algae hydroids	All year	MCS, ICS, BAY, BCH	D	M	F	
Adults	6+ years	Polychaetes crustaceans mollusks hydroids alsae diatoms	Spawning Jan. To June (peak April-May)	MCS, ICS	D	M	F	

Habitat Description for Snow Crab

(Chionoecetes opilio)

Management Plan and Area BSAI

Life History and General Distribution

Snow crabs (*Chionoecetes opilio*) are distributed on the continental shelf of the Bering Sea, Chukchi Sea, and in the western Atlantic Ocean as far south as Maine. Snow crab are not present in the Gulf of Alaska. In the Bering Sea, snow crabs are common at depths less than 200 meters. The eastern Bering Sea population within U.S. waters is managed as a single stock, however, the distribution of the population extends into Russian waters to an unknown degree. While 50% of the females are mature at 5 cm carapace width, the mean size of mature females varies from year to year over a range of 6.3 cm to 7.2 cm carapace width. Females cease growing with a terminal molt upon reaching maturity, and rarely exceed 8 cm carapace width. The median size of maturity for males is about 8.5 cm carapace width (approximately 6-8 years old). Males larger than 6 cm grow at about 2 cm per molt, up to an estimated maximum size of 14.5 cm carapace width, but individual growth rates vary widely. Natural mortality of adult snow crab is assumed to be about 25% per year (M=0.3).

Fishery

The snow crab fishery is prosecuted using mesh covered pots (generally 7 or 8 foot square) set on single lines. Male only crab greater than 7.8 cm carapace width may be harvested, however a market minimum size of about 10.2 cm carapace width is generally observed. Most male snow crab are thought to enter the fishery at around age 6 to 8 years. Snow crab are thought to be one stock in the Bering Sea. The season opening date is January 15. A 3" maximum tunnel height opening for snow crab pots is required to inhibit the bycatch of red king crab. A minimum of four 3.75" escape rings are required on snow crab pots to reduce capture and handling mortality of non-target crab. Bycatch in the snow crab fishery is comprised primarily of *C. bairdi* and non-legal *C. opilio*.

Relevant Trophic Information

Pacific cod, sculpins, skates, and halibut are the main predator on snow crabs in terms of biomass. Snow crabs less than 7 cm carapace width are most commonly consumed. Other predators include yellowfin sole, flathead sole, Alaska plaice, walleye pollock, rock sole, bearded seals and walrus. Juvenile snow crabs have been observed to be cannibalistic during molting in laboratory environments.

Describe any potential gear impacts on the habitats of this or other species

Bottom trawls and dredges could disrupt nursery and adult feeding areas.

What is the approximate upper size limit of juvenile fish (in mm)?

The size of 50% maturity is 5 and 8.5 cm carapace width for female and male crabs.

Source (agency, name and phone number, or literature reference) for additional distribution data

ADF&G, Dutch Harbor, AK, Rance Morrison, 907-581-1239
ADF&G, Dutch Harbor, AK, Larry Boyle, 907-581-1239

Habitat and Biological Associations Narrative

Egg
See mature; eggs are carried by adult female crab.

Larvae
Larvae of *C. opilio* snow crab are found in early summer and exhibit diel migration. The last of 3 larval stages settles onto bottom in nursery areas.

Early Juvenile
Shallow water areas of the Eastern Bering Sea are considered nursery areas for *C. opilio* snow crabs and are confined to the mid-shelf area due to the thermal limits of early and late juvenile life stages.

Late Juvenile
A geographic cline in size of *C. opilio* snow crabs indicates a large number of morphometrically immature crabs occur in shallow waters less than 80 m.

Mature
Female *C. opilio* snow crabs are acknowledged to attain terminal molt status at maturity. Primiparous female snow crabs mate January through June and may exhibit longer egg development period and lower fecundity than multiparous female crabs. Multiparous female snow crabs are able to store spermatophores in seminal vesicles and fertilize subsequent egg clutches without mating. At least two clutches can be fertilized from stored spermatophores, but the frequency of this occurring in nature is not known. Females carry clutches of approximately 36,000 eggs and nurture the embryos for approximately one year after fertilization. However, fecundity may decrease up to 50% between the time of egg extrusion and hatching presumably due to predation, parasitism, abrasion or decay of unfertilized eggs. Brooding probably occurs in depths greater than 50 m.

SPECIES: Snow crab, *Chionoecetes opilio*

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	1 year	NA		NA	NA	NA	F	
Larvae	2 to 7 mo.	Diatoms algae zooplankton	Spring, summer	ICS, MCS	P	NA	F	
Juveniles	1 to 4 years	Crustaceans polychaetes mollusks diatoms algae hydroids	All year	ICS, MCS, OCS	D	M	F	
Adults	4+ years	Ploychaetes brittle stars mollusks crustaceans hydroids algae diatoms	Spawning Jan. To June (peak April-May)	ICS, MCS, OCS	D	M	F	

Habitat Description for Grooved Tanner Crab

(Chionoecetes tanneri)

Management Plan Area BSAI

Life History and General Distribution

In the eastern North Pacific Ocean the grooved Tanner crab (*Chionoecetes tanneri*) ranges from northern Mexico to Kamchatka. Little information is available on the biology of the grooved Tanner crab. This species occurs in deep water and not common at depth <300 m. Male and female crabs are found at similar depths. Male and female grooved Tanner crab generally reach maturity at 11.9 cm and 7.9 cm carapace width, respectively.

Fishery

Directed harvest of grooved Tanner crab has been sporadic since first reported landings in 1988. Crabs are taken in mesh covered pots deployed on a longline. Harvest can occur only under conditions of a permit issued by the Commissioner of Fish and Game.

Relevant Trophic Information None.

Describe any potential gear impacts on the habitats of this or other species Unknown

What is the approximate upper size limit of juvenile fish (in cm)?

Size at 50% maturity is 11.9 cm carapace width for males and 7.9 cm for females.

Source (agency, name and phone number, or literature reference) for additional distribution data

ADF&G, Dutch Harbor, AK., Larry Boyle, Rance Morrison 907-581-1219

Habitat and Biological Associations Narrative

Egg
Information is not available.

Larvae
Information is not available.

Early Juvenile
Information is not available.

Late Juvenile
Information is not available.

Mature
In the Eastern Bering Sea mature male grooved Tanner crabs may be found somewhat more shallow than mature females but male and female crabs don't show clear segregation by depth.

SPECIES: Grooved Tanner crab, *Chionoecetes tanneri*

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs								
Larvae								
Juveniles								
Adults		Polychaetes, crustaceans, ophiuroids						

Habitat Description for Triangle Tanner Crab

Chionoecetes angulatus

Management Plan Area BSAI

Life History and General Distribution

In the eastern North Pacific Ocean the distribution of triangle Tanner crab (*Chionoecetes angulatus*) ranges from Oregon to the Sea of Okhotsk. This species occurs on the continental slope in waters >300 m and has been reported as deep as 2,974 m in the Eastern Bering Sea. A survey limited in depth found mature male crabs inhabit depths around 647 m shallower than the mean depth of 748 m for female crabs. Size at 50% maturity for male triangle Tanner crabs is 9.1 cm carapace width and 5.8 cm for females.

Fishery

A directed fishery for triangle Tanner crab was documented for the first time in 1995. Prior to 1995, these crab had been harvested as bycatch in the *C. tanneri* fishery. Directed harvest is allowed only under the conditions of a permit issued by the Commissioner of Fish and Game. Crab are taken in mesh covered pots deployed on a longline.

Relevant Trophic Information None.

Describe any potential gear impacts on the habitats of this or other species Unknown.

What is the approximate upper size limit of juvenile fish (in cm)?

In the eastern Bering Sea, male triangle Tanner crabs reach size at 50% maturity at 9.1 cm carapace width and females at 5.8 cm.

Source (agency, name and phone number, or literature reference) for additional distribution data

ADF&G, Dutch Harbor, AK., Larry Boyle, Rance Morrison 907-581-1219

Habitat and Biological Associations Narrative

Egg
Information is not available.

Larvae
Information is not available.

Early Juvenile
Information is not available.

Late Juvenile
Information is not available.

Mature
The mean depth of mature male triangle Tanner crabs (647 m) is significantly less than for mature females (748 m) indicating some pattern of sexual segregation by depth.

SPECIES: Triangle Tanner crab, *Chionoecetes angulatus*

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs								
Larvae								
Juveniles								
Adults				USP LSP BSN				

References

Adams, A.E. 1979. The life history of the snow crab, *Chionoecetes opilio*: a literature review. UA Sea Grant Report 78-13, 141 p.

Alaska Department of Fish and Game. 1996. Shellfish fishing regulations of the Alaska Board of Fisheries for commercial fishing in Alaska, 1996-97 edition. Alaska Department of Fish and Game. Commercial Fisheries Management and Development Division. 146 pp.

Armstrong, D.A., J.L. Armstrong, R. Palacios, G. Williams, G.C. Jensen, and W. Pearson 1985. Early life history of juvenile blue king crab, *Paralithodes platypus*, around the Pribilof Islands. *In:* Proceedings of the International King Crab Symposium UA Sea Grant report No. 85-12:211-230.

Balsiger, J., R. Narita, and C. Lynde. 1984. Background information for southeastern Bering Sea incidental catch studies. NWAFC Processed Report 84-07.

Blau, S.F., D. Pengilly, and D.A. Tracy. 1995. Distribution of Golden King crabs by sex, size and depth zones in the Eastern Aleutian Islands. *In*: International Symposium on Biology, Management, and Economics of Crabs from High Latitude Habitats. Lowell Wakefield Symposium, Univ. of Alaska Sea Grant College Program. AK-SG-96-02:167-186.

Blau. S. F. 1996. The 1995 St. Matthew Island blue king crab survey. Alaska Department of Fish and Game. Commercial Fisheries Management and Development Division. Regional Information Report No. 4K96-27. Kodiak. 36 p.

Blau. S. F., L. J. Watson, and J. Blackburn. 1996. The 1996 Norton Sound red king crab trawl survey. Alaska Department of Fish and Game. Commercial Fisheries Management and Development Division. Regional Information Report No. 4K96-54. Kodiak. 40 p.

Boyle, L., L.C. Byrne, and H. Moore. 1997. Alaska Department of Fish and Game Summary of the 1996 mandatory shellfish observer program database. Confidential. Alaska Department of Fish and Game. Commercial Fisheries Management and Development Division. Regional Information Report No. 4K97-51. Kodiak. 165 p.

Dew, C. B. 1990. Behavioral ecology of podding red king crab, *Paralithodes camtschatica*. Can. J. Fish. Aquat. Sci. 47: 1944-1958.

Elner, R.W. and P.G. Beninger. 1992. The reproductive biology of snow crab, *Chionoecetes opili*o: A synthesis of recent contributions. Amer. Zool., 32:524-533.

Feder, H.M. and S.C. Jewett 1981. Feeding interactions in the eastern Bering Sea with emphasis on the benthos. Pages 1229-1262 *In:* Hood, D.W. and J.A. Calder. The eastern Bering Sea shelf: oceanography and resources, Vol. II. University of Washington Press, Seattle, WA.

Fritz, L. W., A. Greig, and R. Reuter. Catch-per-unit-effort, length, and depth distributions of major groundfish and bycatch species in the Bering Sea, Aleutian Islands and Gulf of Alaska regions based on research trawl survey data. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC. In press.

Fukuhara, F.M. 1985. Biology and fishery of southeastern Bering Sea red king crab (*Paralithodes* camtschatica, Tilesius). NWAFC Proc. Rpt. 85-11, 170 p.

Haflinger, K.E. and C.P. McRoy 1983. Yellowfin sole (*Limanda aspera*) predation on three commercial crab species (*Chionoecetes opilio, C. bairdi,* and *Paralithodes camtschatica*) in the southeastern Bering Sea. Final Report to the U.S. NMFS, Contract #82-ABC-00202, Inst. Marine Science, U. Alaska, Fairbanks.

Incze, L. S., D. A. Armstrong, and S. L. Smith. 1987. Abundance of larval Tanner crabs (*Chionoecetes* spp.) in relation to adult females and regional oceanography of the southeastern Bering Sea. Can. J. Fish. Aquat. Sci. 44: 1143-1156.

INPFC. 1955. King crab research by the United States in 1955. *In* Annual Report of the International North Pacific Fisheries Commission. Vancouver, British Columbia.

Jewett, S.C. and H. M. Feder. 1981. Epifaunal invertebrates of the continental shelf of the eastern Bering and Chukchi Seas. Pages 1131-1153 *In* Hood, D.W. and J.A. Calder. The eastern Bering Sea shelf: oceanography and resources, Vol. II. University of Washington Press, Seattle, WA.

Kruse, G.H. 1993. Biological perspectives on crab management in Alaska. Pages 355-407 *In* Proceedings of the International Symposium on Management Strategies for Exploited Fish Populations, Alaska Sea Grant College Program, AK-SG-93-02.

Lang, G.M., P.A. Livingston, R. Pacunski, J. Parkhurst, and M. Yang. 1991. Groundfish food habits and predation on commercially important prey species in the Eastern Bering Sea from 1984 to 1986. NOAA Tech. Memo NMFS F/NWC-207.

Livingston, P.A., A. Ward, G.M. Lang, and M. Yang. 1993. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1987 to 1989. NOAA Tech. Memo NMFS-AFSC-11.

Livingston, P.A. and Y. DeReynier 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC Processed Report 96-04, NMFS, U.S. Dept. Commerce, 214 p.

Lovrich, G.A. and B. Stainte-Marie. 1997. Cannibalism in the snow crab, *Chionoecetes opilio* (O. Fabricius) (Brachura: Majidae), and its potential importance to recruitment. Journal of Experimental Marine Biology and Ecology 211:225-245.

Mcbride, J., D. Fraser, and J. Reeves. 1982. Information on the distribution and biology of the golden (brown) king crab in the Bering Sea and Aleutian Islands Area. NWAFC Processed Report 82-02. 23 p.

McLaughlin, P.A. and J. Hebard. 1961. Stomach contents of the Bering Sea king crab. International North Pacific Fisheries Commission. Bulletin 5:5-8.

McMurray, G., A.H. Vogel, P.A. Fishman, D.A. Armstrong, and S.C. Jewett. 1984. Distribution of larval and juvenile red king crabs (*Paralithodes camtschatica*) in Bristol Bay. Final Report, Outer Continental Shelf Environmental Assessment Program, Research Unit 639.

Miyahara, T., H. Sakuda, and H. Shippen. 1962. Eastern Bering Sea king crab investigation, 1962. Annual report 1962. International North Pacific Fisheries Commission. P. 120-123.

NOAA. 1987. Bering, Chukchi, and Beaufort Seas. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerce, NOAA, NOS.

NOAA. 1990. West coast of North America. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerce, NOAA, NOS.

Otto, R.S. 1981. Eastern Bering Sea crab fisheries. In: Hood, D.W. and J.A. Calder. The eastern Bering Sea shelf: oceanography and resources, vol. 2:1037-66

Otto, R. S. *In press*. Assessment of the eastern Bering Sea snow crab, *Chionoecetes opili*o, stock under the terminal molting hypothesis. *In*: G. S. Jamieson and A. Cambell [eds.] North Pacific Symposium on Invertebrate Stock Assessment and Management. Can. Spec. Publ. Fish. and Aquatic. Sci.

Palacios, R., D.A. Armstrong, J.L. ARMSTRONG, and G. Williams 1985. Community analysis applied to characterization blue king crab habitat around the Pribilof Islands. *In:* Proceedings of the International King Crab Symposium UA Sea Grant report No. 85-12:193-210.

Pereyra, W.T., J.E. Reeves, and R.G. Bakkala. 1976. Demersal fish and shellfish resources of the eastern Bering Sea in the Baseline Year 1975. NWAFC Processed Report.

Pereyra, W.T. 1966. The bathymetric and seasonal distribution, and reproduction of adult Tanner crabs, *Chionoecetes tanneri*, Rathbun, off the northern Oregon coast. Deepsea Res. 13:1185-1205.

Reeves, J.E. 1987. Incidental crab catches associated with rock sole. NWAFC Processed Report 87-02.

Reeves, J.E. 1994. Shellfish resources. *In*: Status of living marine resources off Alaska, 1993. NOAA Tech. Memo. NMFS-AFSC-27,65-75.

Slizkin, A.G., and S.D. Bukin. 1989. Distribution, biology and abundance of blue crab, *Paralithodes platypus* in the Bering Sea. Pages 306-315 *In* Proceedings of the International Scientific Symposium on Bering Sea Fisheries. NOAA Tech. Memo NMFS F/NWC-163.

Somerton, D.A. 1981. Contribution to the life history of the deep-sea king crab, *Lithodes couesi*, in the Gulf of Alaska. Fish. Bull 79(2):259-69.

Somerton, D.A. 1981. Life history and population dynamics of two species of Tanner crab, *Chionoecetes bairdi* and *C. opilio*, in the eastern Bering Sea with implications for the management of the commercial harvest. UW dissertation, 220 p.

Somerton, D.A. and R.S. Otto 1986. Distribution and reproductive biology of the golden king crab, *Lithodes aequispina*, in the eastern Bering Sea. Fish. Bull 84(3):571-84.

Somerton, D.A. and W. Donaldson. 1996. Contribution to the biology of the grooved and triangle Tanner crabs, *Chionoecetes tanneri* and *C. angulatus*, in the Eastern Bering Sea. Fishery Bulletin

Tracy, D.A. 1995. Alaska Department of Fish and Game summary of the 1994 mandatory shellfish observer program database. ADFG Regional Information Report No. 4K95-32, 96 p.

Tyler, A.V. and G.H. Kruse 1995. Report of the modeling workshop on year-class strength formation of red king crab. ADFG Regional Information Report No. 5J95-11, 20 p.

Tyler, A.V. and G.H. Kruse 1997. Modeling workshop on year-class strength of Tanner crab, *Chionoecetes bairdi*. ADFG Regional Information Report No. 5J97-02, 46 p.

U.S. Department of the Interior. 1986. Outer Continental Shelf Environmental Assessment Program, Final Report of Principle Investigators, Volume 53. Mineral Management Service, OCS Study, MMS 86-0115.

Wainwright, T.C., D.A. Armstrong, H.B. Andersen, P.A. Dinnel, D.W. Herren, G.C. Jensen, J.M. Orensanz, and J.A. Shaffer. Coastal fisheries oceanography of the southern Bering Sea and north Aleutian Basin: Port Moller king crab studies. OCS Study MMS 92-0040.

White, L. E. and C. Nielson. 1992. Proceedings of the International Crab Rehabilitation and Enhancement Symposium. Alaska Department of Fish and Game, Fisheries Rehabilitation, Enhancement and Development Division.

Witherell, D. And G. Harrington, 1995. Evaluation of alternative management measures to reduce the impacts of trawling and dredging on Bering Sea crab stocks. NPFMC Discussion Paper, North Pacific Fishery Management Council, 605 W. 4th Avenue, Suite 306, Anchorage AK, 99501. 13 p.

Witherell, D. 1996. King and Tanner crabs of the Bering Sea and Aleutian Islands area: Species profiles. North Pacific Fishery Management Council, 13 p.

APPENDIX F.4

ESSENTIAL FISH HABITAT ASSESSMENT REPORT

for Scallop Resources of the Gulf of Alaska,

Bering Sea, and Aleutian Islands Regions

August 22, 2003

NOAA Fisheries
NMFS Alaska Region
709 West 9th Street
Juneau, AK 99802

NOAA Fisheries
National Marine Fisheries Service

Table of Contents

Introduction F.4-1

Table 1 - Summary of Major References and Atlases F.4-3

Table 2 - Summary of Habitat Associations for Scallops. F.4-5

Table 3 - Summary of Reproductive Traits for Scallops. F.4-6

Table 4 - Summary of Predator and Prey Relationships for Scallops. F.4-7

Habitat Description for Weathervane Scallops F.4-8

Note:

Limited biological and site-specific scientific information may exist for the species. However, information is not adequate to describe accurate life histories for the species.

Introduction

In 1996, the Sustainable Fisheries Act amended the Magnuson-Stevens Fishery Conservation and Management Act to require the description and identification of Essential Fish Habitat (EFH) in Fishery Management Plans (FMPs), adverse impacts on EFH, and actions to conserve and enhance EFH. Guidelines were developed by the National Marine Fisheries Service (NMFS) to assist Fishery Management Councils in fulfilling the requirements set forth by the Act.

Essential fish habitat means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat: "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means the habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

With respect to type, the information available for almost all species is primarily broad geographic distributions based on specific samples from surveys and fisheries, which have not been linked with habitat characteristics. Furthermore, our ability to precisely define the habitat (and its location) of each life stage of each managed groundfish species in terms of its oceanographic (temperature, salinity, nutrient, current), trophic (presence of food, absence of predators), and physical (depth, substrate, latitude, and longitude) characteristics is very limited. Consequently, the information included in the habitat descriptions for each species and life stage is restricted primarily to their position in the water column (e.g., demersal, pelagic), broad biogeographic and bathymetric areas (e.g., 100-200 m zone, south of the Pribilof Islands and throughout the Aleutian Islands), and occasional references to known bottom types associations.

Identification of EFH for some species included historical range information. Traditional knowledge and sampling data have indicated that fish distributions may contract and expand due to a variety of factors including, but not limited to, temperature changes, current patterns, changes in population size, and changes in predator and prey distribution.

Background

In preparation of the 1999 Essential Fish Habitat Environmental Assessment, EFH Technical Teams, comprised of scientific stock assessment authors, compiled scientific information and prepared the 1999 Habitat Assessment Reports. These reports provided the scientific information baseline to describe EFH. Importantly, recent scientific evidence has not proved to change existing life history profiles of the federally managed species. However, where new information does exist, new data helps to fill information gaps in the region's limited habitat data environment.

Stock assessment authors used information contained in these summaries and personal knowledge, along with data contained in reference atlases (NOAA 1987; 1990; 1997a;b), fishery and survey data (Allen and Smith 1988; Wolotira et al. 1993; NOAA 1998), and fish identification books (Hart 1973; Eschmeyer and Herald 1983; Mecklenburg and Thorsteinson 2002), to describe EFH for each life stage using best scientific judgment and interpretation; see Table 1.

Species Profiles and Habitat Descriptions

FMP's must describe EFH in text, map EFH distributions, and include tables, which provide information on habitat and biological requirements for each life history stage of the species; see Tables 2-4. Information contained in this report details life history information for federally managed fish species. This collection of scientific information is interpreted, then referenced to describe and delineate EFH for each species by life history stage using GIS. EFH text and map descriptions are not compiled in this report due to differences in the characteristics of a species life history and the overall distribution of the species. Specific EFH text descriptions and maps are in Appendix D.

References

Allen, M. J., and G. B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Barnhart, J.P. and S.J. Carpenter. 2003. Warm-water annual checks in weathervane scallops, Patinopecten caurinus. 14th International Pectinid Workshop Abstracts w. Programs, April 2003, p.122.

Barnhart, J.P. 2003. Weathervane scallop fishery in Alaska with a focus on the Westward Region, 1967-2002. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K03-5, Kodiak.

Barnhart, J. P., and G. Rosenkranz. 2003. Summary and analysis of onboard observer-collected data from the 1999/2000 through 2001/2002 statewide commercial weathervane scallop fishery. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 4K03-9, Kodiak.

Carpenter S.J. and J. Barnhart. 2000. Seasonality and physiological changes observed in the carbon and oxygen isotope ratios in modern weathervane scallops (Patinopecten caurinus) from the Alaskan Coast. Geological Society of America Annual Meeting Abstracts w. Programs, v. 32, p. 93.

Eschmeyer, W. N., and E. S. Herald. 1983. A field guide to Pacific coast fishes. Houghton Mifflin Co., Boston. 336 p.

Hart, J. L. 1973. Pacific fishes of Canada. Fisheries Research Board of Canada Bulletin 180. Ottawa. 740 p.

NOAA. 1987. Bering, Chukchi, and Beaufort Seas. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerce, NOAA, NOS.

NOAA. 1990. West coast of North America. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerce, NOAA, NOS.

NOAA. 1998. Catch-per-unit-effort, length, and depth distributions of major groundfish and bycatch species in the Bering Sea, Aleutian Islands and Gulf of Alaska regions based on groundfish fishery observer data. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-88.

NPFMC. 1997a. Essential fish habitat assessment report for the groundfish resources of the Bering Sea and Aleutian Islands regions. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

NPFMC. 1997b. Essential fish habitat assessment report for the groundfish resources of the Gulf of Alaska region. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Wolotira, R. J., Jr., T. M. Sample, S. F. Noel, and C. R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U.S. Dep. Commerce, NOAA Tech. Memo. NFS-AFSC-6, 184 p.

Table 1. Summary of Major References and Atlases

Species	References				
	Allen and Smith 1988	NOAA 1987	NOAA 1990	Wolotira et al. 1993	NOAA 1998
Weathervane scallop	X	X	X	X	X
Pink scallop - see note					
Spiny scallop - see note					
Rock scallop - see note					

Note:

Limited biological and site-specific scientific information may exist for the species. However, information is neither available nor adequate to describe accurate life histories for the species.

Abbreviations used in the EFH report tables to specify location, depth, bottom type, and other oceanographic features.

Location

ICS =	inner continental shelf (1-50 m)	USP =	upper slope (200-1000 m)
MCS =	middle continental shelf (50-100 m)	LSP =	lower slope (1000-3000 m)
OCS =	outer continental shelf (100-200 m)	BSN=	basin (>3000 m)

BCH = beach (intertidal)
BAY = nearshore bays, give depth if appropriate (e.g., fjords)
IP = island passes (areas of high current), give depth if appropriate

Water column

D = demersal (found on bottom)
SD/SP =semi-demersal or semi-pelagic if slightly greater or less than 50% on or off bottom
P = pelagic (found off bottom, not necessarily associated with a particular bottom type)
N = neustonic (found near surface)

Bottom Type

M = mud	S = sand	R = rock
SM = sandy mud	CB = cobble	C = coral
MS = muddy sand	G = gravel	K = kelp

SAV = subaquatic vegetation (e.g., eelgrass, not kelp)

Oceanographic Features

UP = upwelling	G = gyres	F = fronts	E = edges

CL = thermocline or pycnocline

General

Table 2. Summary of Habitat Associations for Scallops

Scallop		Nearshore				Shelf			Slope						Stratum Reference							Location							Physical Oceanography					Substrate														Structure								Community Associations											Oceanographic			
						Inner	Middle	Outer	Upper		Inter-mediate		Lower	Basin											Pelagic																																												
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surafce	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Reefs	Vertical Walls	Man-made	Algal Cover	Anemones	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
WV Scallop	M					x	x	x																	x				x						x	x	x	x	x	x	x	x	x	x																							**3-9.6**			M
	J					x	x	x																	x										x	x	x	x	x	x	x	x	x	x																										J
	L					x	x	x																		x																																										L
	E					x	x	x																	x																																											E

Table 3. Summary of Reproductive Traits for Scallops

Scallop		Reproductive Traits																										
		Age at Maturity				Fertilization/Egg Development					Spawning Behavior						Spawning Season											
		Female		Male																								
Species	Life Stage	**50%**	**100%**	**50%**	**100%**	**External**	**Internal**	**Oviparous**	**Ovoviviparous**	**Viviparous**	**Batch Spawner**	**Broadcast Spawner**	**Egg Case Deposition**	**Nest Builder**	**Egg/Young Guarder**	**Egg/Young Bearer**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
WV Scallop	M					X						X									X	X	X					
	LJ																											
	EJ																											
	L																											
	E																											

Table 4. Summary of Predator and Prey Relationships for Scallops

Scallop		Predator to																														Prey of																											
Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Salmon	Cod	Pollock	Halibut		Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pac fic Cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Halibut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrerstrial Mammals
WV Scallop	M			X																													X																											
	LJ																																X																											
	EJ																																X																											
	L																																																										
	E																																																										

Habitat Description for Weathervane Scallops

(*Patinopectin caurinus*)

Management Plan and Area BSAI GOA

Scallops are managed under the Fishery Management Plan for the Scallop Fishery off Alaska. Scallops occur throughout the area covered by the FMP and extend south to California.

Life History and General Distribution

Weathervane scallops are distributed from Point Reyes, California, to the Pribilof Islands, Alaska. The highest known densities in Alaska have been found to occur in the Bering Sea, off Kodiak Island, and along the eastern gulf coast from Cape Spencer to Cape St. Elias. Weathervane scallops are found from intertidal waters to depths of 300 m, but abundance tends to be greatest between depths of 40-130 m on beds of mud, clay, sand, and gravel. Beds tend to be elongated along the direction of current flow. A combination of large-scale (overall spawning population size and oceanographic conditions) and small-scale (site suitability for settlement) processes influence recruitment of scallops to these beds. Sexes are separate and mature male and female scallops are distinguishable based on gonad color. Although spawning time varies with latitude and depth, weathervane scallops in Alaska spawn in May to July depending on location. Eggs and spermatozoa are released into the water, where the eggs become fertilized. After a few days, eggs hatch, and larvae rise into the water column and drift with ocean currents. Larvae are pelagic and drift for about one month until metamorphosis to the juvenile stage when they settle to the bottom.

Several other species of scallops found in the EEZ off Alaska have commercial potential. These scallops grow to smaller sizes than weathervanes, and thus have not been extensively exploited in Alaska. Pink scallops, *Chlamys rubida*, range from California to the Pribilof Islands. Pink scallops are found in deep waters (to 200 m) in areas with soft bottom, whereas spiny scallop occur in shallower (to 150 m) areas characterized by hard bottom and strong currents. Pink scallops mature at age 2, and spawn in the winter (January-March). Maximum age for this species is 6 years. Spiny scallops, *Chlamys hastata*, are found in coastal regions from California to the Gulf of Alaska. Spiny scallops grow to slightly larger sizes (75 mm) than pink scallops (60 mm). Spiny scallops also mature at age 2 (35 mm) and spawn in the autumn (August-October). Rock scallops, *Crassadoma gigantea*, range from Mexico to Unalaska Island. Rock scallops are found in relatively shallower water (0-80 m) with strong currents. Apparently, distribution of these animals is discontinuous, and the abundance in most areas is low. These scallops attach themselves to rocks, attain a large size (to 250 mm), and exhibit fast growth rates. Rock scallops are thought to spawn during two distinct periods, one in the autumn (October -January), and one in the spring-summer (March-August).

Fishery

The weathervane scallop resource consists of multiple, discrete, self sustaining populations that are managed as separate stock units. Scallop stocks in Alaska have been managed under a federal fishery management plan (FMP) since 1995. The FMP controls the fishery through permits, registration areas and districts, seasons, closed waters, gear restrictions, efficiency limits, crab bycatch limits, scallop catch limits, inseason adjustments, and observer monitoring. Most of these regulations were developed by the State prior to 1995. Dredge size is limited to a maximum width of 15 feet, and only 2 dredges may be used at any one time. In the Kamishak District of Cook Inlet, only 1 dredge with a 6' maximum width is allowed. Dredges are required to have rings with a 4" minimum inside diameter. To reduce incentives to harvest small scallops, crew size on scallop vessels is limited to 12 persons and all scallops must be manually shucked. Dredging is prohibited in areas designated as crab habitat protection areas, similar to the groundfish FMPs.

Since 1967, when the first landings were made, fishing effort and total scallop harvest (weight of shucked meats) have varied annually. Total commercial harvest of weathervane scallops has fluctuated from a high of 157 landings totaling 1,850,187 pounds of shucked meats by 19 vessels in 1969 to no landings in 1978. Prices and demand for scallops have remained high since fishery inception. Prior to 1990, about two-thirds of the scallop harvest has been taken off Kodiak Island and about one-third has come from the Yakutat area; other areas had made minor contributions to overall landings. Harvests in 1990 and 1991 were the highest on record since the early 1970s. The 1992 scallop harvest was even higher at 1,810,788 pounds. The increased harvests in the 1990s occurred with new exploitation in the Bering Sea.

Relevant Trophic Information

Scallop predators have not been well studied. Scallops are likely prey to various fish and invertebrates during the early part of their life cycle. Flounders are known to prey on juvenile weathervane scallops, and seastars may also be important predators.

Upper size limit of juveniles

Weathervane scallops begin to mature by age 3 at about 7.6 cm (3 inches) in shell height (SH), and virtually all scallops are mature by age 4. Growth, maximum size, and size at maturity vary significantly within and between beds and geographic areas. Weathervane scallops are long-lived; individuals may live 28 years old or more. The natural mortality rate is thought to be about 15% annually (M = 0.16).

Sources for additional distribution data

Distributional information is contained in the Literature cited section.

Habitat and Biological Associations

Scallops are found from intertidal waters and to 300 m. Abundance tends to be greatest between 45-130 m on beds of mud, clay, sand and gravel (Hennick 1973). Weathervane scallops are associated with other benthic species, such as red king crabs, Tanner crabs, shrimps, octopi, flatfishes, Pacific cod, and other species of benthic invertebrates and fishes.

Literature

Barnhart, J.P., I.W. Vining, and L.C. Byrne. 1996. A summary of data collected by scallop observers from the 1994/1995 commercial scallop fishery in Alaska's westward region. ADF&G, Commercial Fisheries Management & Development Division, Regional information report 4K96-33, Kodiak, AK.

Haynes, E.B. and G.C. Powell. 1968. A preliminary report on the Alaska sea scallop—fishing exploration, biology and commercial processing. ADF&G, Division of Commercial Fisheries, Informational leaflet 125, Juneau, AK.

Hennick, D.P. 1973. Sea scallop, *Patinopectin caurinus*, investigations in Alaska. ADF&G, Division of Commercial Fisheries Completion Report 5-23-R, Juneau, AK.

Kaiser, R.J. 1986. Characteristics of the Pacific Weathervane Scallop, *Patinopectin caurinus* (Gould, 1850), Fishery in Alaska, 1967-1981. Alaska Department of Fish and Game.

Kruse, G.H. 1994. DRAFT Fishery Management Plan for Commercial Scallop Fisheries in Alaska. Alaska Department of Fish and Game, Draft Special Publication No. 5.

Shirley, S.M., and G.H. Kruse. 1995. Development of the fishery for weathervane scallops, *Patinopectin caurinus* (Gould, 1850), in Alaska. Journal of Shellfish Research 14(1):71-78.

SPECIES: Weathervane Scallops off Alaska

Stage - EFH Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	several days	None	May-July	MCS, ICS	D		N/A	
Larvae	2-3 weeks		May-August	ICS, MCS, OCS	P		N/A	
Juveniles	Age 0 to Age 3		Aug. +	MCS	D	CL, M, S, G	N/A	
Adults	Age 3 - 28		Spawning May-July	MCS	D	CL, M, S, G	UNK	

APPENDIX F.5

ESSENTIAL FISH HABITAT ASSESSMENT REPORT

for the Salmon Fisheries in the

EEZ off the Coast of Alaska

August 22, 2003

NOAA Fisheries
NMFS Alaska Region
709 West 9th Street
Juneau, AK 99802

NOAA Fisheries
National Marine Fisheries Service

Table of Contents

Introduction F.5-1

Information Specific to Salmon F.5-2

Table 1 - Summary of Major References and Atlases F.5-6

Table 2 - Summary of Habitat Associations for Salmon. F.5-8

Table 3 - Summary of Reproductive Traits for Salmon. F.5-9

Table 4 - Summary of Predator and Prey Associations for Salmon. F.5-10

Habitat Description for Pink salmon F.5-11

Habitat Description for Chum salmon F.5-24

Habitat Description for Sockeye Salmon F.5-35

Habitat Description for Chinook Salmon F.5-45

Habitat Description for Coho Salmon F.5-57

Introduction

In 1996, the Sustainable Fisheries Act amended the Magnuson-Stevens Fishery Conservation and Management Act to require the description and identification of Essential Fish Habitat (EFH) in Fishery Management Plans (FMPs), adverse impacts on EFH, and actions to conserve and enhance EFH. Guidelines were developed by the National Marine Fisheries Service (NMFS) to assist Fishery Management Councils in fulfilling the requirements set forth by the Act.

Essential fish habitat means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat: "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means the habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

With respect to type, the information available for almost all species is primarily broad geographic distributions based on specific samples from surveys and fisheries, which have not been linked with habitat characteristics. Furthermore, our ability to precisely define the habitat (and its location) of each life stage of each managed groundfish species in terms of its oceanographic (temperature, salinity, nutrient, current), trophic (presence of food, absence of predators), and physical (depth, substrate, latitude, and longitude) characteristics is very limited. Consequently, the information included in the habitat descriptions for each species and life stage is restricted primarily to their position in the water column (e.g., demersal, pelagic), broad biogeographic and bathymetric areas (e.g., 100-200 m zone, south of the Pribilof Islands and throughout the Aleutian Islands), and occasional references to known bottom types associations.

Identification of EFH for some species included historical range information. Traditional knowledge and sampling data have indicated that fish distributions may contract and expand due to a variety of factors including, but not limited to, temperature changes, current patterns, changes in population size, and changes in predator and prey distribution.

Background

In preparation of the 1999 Essential Fish Habitat Environmental Assessment, EFH Technical Teams, comprised of scientific stock assessment authors, compiled scientific information and prepared the 1999 Habitat Assessment Reports. These reports provided the scientific information baseline to describe EFH. Importantly, recent scientific evidence has not proved to change existing life history profiles of the federally managed species. However, where new information does exist, new data helps to fill information gaps in the region's limited habitat data environment.

Stock assessment authors used information contained in these summaries and personal knowledge, along with data contained in reference atlases (NOAA 1987; 1990; 1997a;b), fishery and survey data (Allen and Smith 1988; Wolotira et al. 1993; NOAA 1998), and fish identification books (Hart 1973; Eschmeyer and Herald 1983; Mecklenburg and Thorsteinson 2002), to describe EFH for each life stage using best scientific judgment and interpretation; see Table 1.

Species Profiles and Habitat Descriptions

FMP's must describe EFH in text, map EFH distributions, and include tables, which provide information on habitat and biological requirements for each life history stage of the species; see Tables 2-4. Information contained in this report details life history information for federally managed fish species. This collection of scientific information is interpreted, then referenced to describe and delineate EFH for each species by life history stage using GIS. EFH text and map descriptions are not compiled in this report due to differences in the characteristics of a species life history and the overall distribution of the species. Specific EFH text descriptions and maps are in Appendix D.

References

Allen, M. J., and G. B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. U.S. Dep. Commerce., NOAA Tech. Rept. NMFS 66, 151 p.

Eschmeyer, W. N., and E. S. Herald. 1983. A field guide to Pacific coast fishes. Houghton Mifflin Co., Boston. 336 p.

Hart, J. L. 1973. Pacific fishes of Canada. Fisheries Research Board of Canada Bulletin 180. Ottawa. 740 p.

Mecklenburg, C.W. , Mecklenburg,T.A ., and Thorsteison, L.K. 2002. Fishes of Alaska. American Fish Society. Bethsda, Maryland. 1037 p.

NOAA. 1987. Bering, Chukchi, and Beaufort Seas. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerce., NOAA, NOS.

NOAA. 1990. West coast of North America. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerce., NOAA, NOS.

NOAA. 1998. Catch-per-unit-effort, length, and depth distributions of major groundfish and bycatch species in the Bering Sea, Aleutian Islands and Gulf of Alaska regions based on groundfish fishery observer data. U.S. Dep. Commerce., NOAA Tech. Memo. NMFS-AFSC-88.

NPFMC. 1997a. Essential fish habitat assessment report for the groundfish resources of the Bering Sea and Aleutian Islands regions. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

NPFMC. 1997b. Essential fish habitat assessment report for the groundfish resources of the Gulf of Alaska region. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Wolotira, R. J., Jr., T. M. Sample, S. F. Noel, and C. R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U.S. Dep. Commerce., NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Information Specific to Salmon

Freshwater EFH for the salmon fisheries in Alaska includes all streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon in the State.

This represents a vast array of diverse aquatic habitats over an extremely large geographic area. Alaska contains over 3,000 rivers and has over 3 million lakes > 8 ha. Over 14,000 water bodies containing anadromous salmonids identified in the State represent only part of the salmon EFH

in Alaska because many likely habitats have not been surveyed. In addition to current and historically accessible waters used by Alaska salmon, other potential spawning and rearing habitats exist beyond the limits of upstream migration due to barrier falls or steep-gradient rapids. Salmon access to existing or potential habitats can change over time due to many factors, including glacial advance or recession, post-glacial rebound, and tectonic subsidence or uplifting of streams in earthquakes.

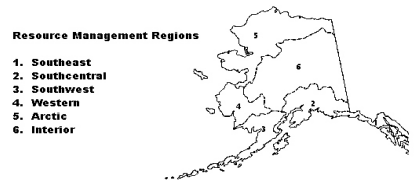

Figure 1. Regional boundaries of the Resource Management Regions established by the Joint Boards of Fisheries and Game.

A significant body of information exists on the life histories and general distribution of salmon in Alaska. The location of many freshwater water bodies used by salmon are contained in documents organized and maintained by the ADF&G. Alaska Statute 16.05.870 requires ADF&G to specify the various streams that are important for spawning, rearing, or migration of anadromous fishes. This is accomplished through the *Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fishes* and the *Atlas to the Catalog of Waters Important for Spawning, Returning or Migration of Anadromous Fishes*. The Catalog lists water bodies documented to be used by anadromous fish. The Atlas shows locations of these waters and the species and life stages that use them. The Catalog and Atlas are divided into six volumes for the six resource management regions established in 1982 by the Joint Boards of Fisheries and Game; see figure at right.

The Catalog and Atlas, however, have significant limitations. The location information and maps are derived from U.S. Geological Survey quadrangles which may be out of date because of changes in channel and coastline configurations. In Southeast Alaska, for example, new streams are colonized by salmon in Glacier Bay as glaciers rapidly recede. Polygons are sometimes used to specify areas with a number of salmon streams that could not be depicted legibly on the maps. Waters within these polygons are often productive for juvenile salmon.

Data for the Catalog come from personal, in-field surveys by aircraft, boat, and foot for purposes of managing fish habitat and fisheries, and the upper limit of salmon is not always observed. Upper points specified in the Catalog usually reflect the extent of surveys or known fish usage rather than actual limits of anadromous fish. Upper areas used by salmon are further limited due to the remoteness and vastness of the Alaska regions. Comparably, the Alaska region has identified salmon for freshwater reaches in an area that would span between the states of Washington and Ohio and between the northern and southern borders of the U.S.

In addition, only a limited number of water bodies have actually been surveyed. Virtually all coastal waters in the State provide important habitat for anadromous fish, as do many unsurveyed small- and medium-sized tributaries to known anadromous fish-bearing water bodies in remote parts of the State. Small tributaries, flood channels, intermittent streams and beaver ponds are often used for juvenile rearing. Because of their remote location, small size, or ephemeral nature, most of these systems have not been surveyed and are not included in the Catalog or Atlas.

Marine EFH for the salmon fisheries in Alaska include all estuarine and marine areas utilized by Pacific salmon of Alaska origin, extending from the influence of tidewater and tidally submerged habitats to the limits of the U.S. EEZ.

This habitat includes waters of the Continental Shelf, which extends to about 30-100 km offshore from Dixon Entrance to Kodiak Island, then becomes more narrow along the Pacific Ocean side of the Alaska Peninsula and Aleutian Islands chain. In Bering Sea areas of Southwest and Western Alaska and in Chukchi and Beaufort Seas areas of Northwest and Northern Alaska, the Continental Shelf becomes much wider. In oceanic waters beyond the Continental Shelf, the documented range of Alaska salmon extends from 42° N latitude north to the Arctic Ocean and to 160° E longitude. In the deeper waters of the Continental Slope and ocean basin, salmon occupy the upper water column, generally from the surface to a depth of about 50 m. Chinook and chum salmon, however, use deeper layers, generally to about 300 m, but on occasion to 500 m. The range of EFH for salmon is the subset of this habitat that occurs within the 320 km EEZ boundary of the United States. Foreign waters (i.e., off British Columbia in the Gulf of Alaska and off Russia in the Bering Sea) and international waters are not included in salmon EFH because they are outside U.S. jurisdiction. The marine EFH for Alaska salmon fisheries described above is also EFH for the Pacific coast salmon fishery for those salmon stocks of Pacific Northwest origin that migrate through Canadian waters into the Alaska EFH zone.

References

Alaska Department of Fish and Game. 2002. An atlas to the catalog of waters important for spawning, rearing, or migration of anadromous fishes. ADF&G, Habitat and Restoration Division, 333 Raspberry Road, Anchorage, AK. 99518-1599 .

Alaska Department of Fish and Game (ADF&G). 1986. Alaska habitat management guide; guidelines for the protection of fish and their habitat. ADF&G, Habitat Division, 142 p. Juneau, AK 99801

Groot, C., and L. Margolis. (eds.) 1991. Pacific salmon life histories. Univ. British Columbia Press.

Gustafson, R. G., T. C. Wainwright, G. A. Winans, F. W. Waknitz, L. T. Parker, and R.S. Waples. 1997. Status review of sockeye salmon from Washington and Oregon. NOAA Tech. Memo. NMFS-NWFSC-33. NMFS, 2725 Montlake Blvd. E., Seattle, WA 98112-2097

Halupka, K.C., M. F. Wilson, M. D. Bryant, F. H. Everest and A. J. Gharrett. in press. Intraspecific diversity of Pacific salmon in Southeast Alaska. Forestry Sci. Lab., Pacific Northwest Research Station, USDA. 2770 Sherwood Lane, Suite 2A Juneau, AK 99801-8545

Hard, J. J., R. G. Kope, W. S. Grant, F. W. Waknitz, L. T. Parker, and R. S. Waples. 1996. Status review of pink salmon from Washington, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-25. NMFS, 2725 Montlake Blvd. E., Seattle, WA 98112-2097

Johnson, O. W., W. S. Grant, R. G. Kope, K. Neely, F. W. Waknitz, and R. S. Waples 1997. Status review of chum salmon from Washington, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-32. NMFS, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.

Myers, K.W., K. Y. Aydin, R. V. Walker, S. Fowler, and M. L. Dalhberg. 1996. Known ocean ranges of stocks of Pacific salmon and steelhead as shown by tagging experiments, 1956-1995. (NPAFC Doc. 192.) FRI-UW-9614. Univ. Wash., Fisheries Research Institute, Box 357980, Seattle, WA 98195-7980.

USDA Forest Service, Geographic Information System, Streams Layer. U.S. Forest Service, Juneau, AK 99801.

Weitkamp, L. A., T. W. Wainwright, G. J. Bryant, G. B. Miller, D. J. Teel, R. G. Kope, and R. S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-24. NMFS, 2725 Montlake Blvd. E., Seattle, WA 98112-2097

Wertheimer, W.C. 1996. The status of Alaska salmon. Pages 179-197 *In* J. D. Stroder, P. A. Bisson, and R. J. Naiman (eds.). Pacific salmon and their ecosystems: status and future options. Symposium Proc., Seattle, WA., Jan. 10-12, 1994. Chapman Hall, NY.

Table 1. Summary of Major References and Atlases

	References					
Species	Allen and Smith 1988	Wolotira et al. 1993	NOAA 1997b	NOAA 1997a	Meckelenburg and Thorsteinson 2002	ADF&G Anadromous Waters Catalogue 2002
Pink salmon	X	X	X	X	X	X
Chum salmon	X	X	X	X	X	X
Sockeye salmon	X	X	X	X	X	X
Chinook salmon	X	X	X	X	X	X
Coho salmon	X	X	X	X	X	X

Abbreviations used in the EFH Reports.

Location: WC = water courses, rivers, streams, sloughs; LK = lakes, ponds (some are temporary); BCH = beach (intertidal); EST = estuarine, intermediate salinity, nearshore bays with inlet watercourses, eelgrass and kelp beds; ICS = inner continental shelf (1-50 m deep); MCS = middle continental shelf (1-100 m deep); OCS = outer continental shelf (1-200 m); BAY = nearshore bays (e.g., fjords); IP = island passes (areas of high current).

Water Column: P = pelagic (found off bottom, not necessarily associated with a particular bottom type); N = neustonic (found near surface).

Bottom Type: G = gravel; K = kelp; SAV = subaquatic vegetation (e.g., eelgrass).

Oceanographic/Riverine Features: UP = upwelling; G = gyres; F = fronts; CL = thermo- or pycnocline; E = edges.

General: U = Unknown; NA = not applicable

Table 2. Summary of Habitat Associations for Salmon

Salmon		Nearshore				Shelf			Slope						Stratum Reference						
						Inner	Middle	Outer	Upper		Inter-mediate		Lower	Basin							
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully
Chinook	M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
	LJ														x	x	x	x			
	EJ	x	x	x											x	x	x				
	L	x																			
	E	x																			
Chum	M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
	LJ				x	x	x	x	x	x						x	x	x			
	EJ	x	x	x	x	x	x								x	x	x	x			
	L	x		x																	
	E	x		x																	
Coho	M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
	LJ		x	x		x	x									x	x				
	EJ	x	x	x		x									x						
	E/L	x																			
Pink	M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
	LJ		x		x		x	x	x						x	x	x				
	EJ		x	x	x	x	x	x	x						x	x	x				
	L	x																			
	E	x																			
Sockeye	M	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
	LJ		x	x	x	x	x	x	x							x	x				
	EJ	x				x															
	L	x																			
	E	x				x															

Salmon		Location							Physical Oceanography					Substrate												
						Pelagic																				
Species	Life Stage	Surafce	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock
Chinook	M	x	x	x	x	x			x	x	x	x	x													
	LJ	x	x	x	x	x			x	x	x	x	x													
	EJ	x	x	x	x									x		x						x			x	x
	L				x												x								x	
	E				x												x								x	
Chum	M	x	x	x	x	x	x		x	x	x	x	x	x			x					x			x	
	LJ	x	x	x	x	x	x		x	x	x	x	x													
	EJ	x	x	x		x			x	x		x		x	x	x	x					x		x	x	x
	L													x		x	x					x			x	x
	E													x		x	x					x			x	
Coho	M	x	x			x						x	x	x			x					x			x	
	LJ	x	x			x																				
	EJ	x		x											x	x	x					x			x	
	E/L													x			x									
Pink	M	x	x			x			x	x	x	x		x			x					x			x	
	LJ	x	x						x	x	x	x														
	EJ	x													x	x	x					x		x	x	
	L													x			x									
	E													x			x					x			x	
Sockeye	M	x	x			x											x					x			x	
	LJ	x	x			x																				
	EJ				x																					
	L																x					x			x	
	E																x					x			x	

Salmon		Structure									Community Associations												Oceanographic Properties			
Species	Life Stage	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
Chinook	M	x		x	x	x	x	x	x	x								x					<15			M
	LJ	x		x	x	x	x	x	x	x							x	x					<15			LJ
	EJ																x	x		x			<20			EJ
	L																						0-14			L
	E																						0-14	0		E
Chum	M	x		x	x	x	x	x	x	x							x	x		x			<15		8	M
	LJ	x			x	x	x	x	x	x							x	x					<15		8	LJ
	EJ	x		x	x	x	x	x	x	x	x						x	x		x			<15		8	EJ
	L																						>4		>4	L
	E																						>4		>4	E
Coho	M	x		x	x	x	x	x	x	x								x					<15		8	M
	LJ																x	x		x			<15		8	LJ
	EJ	x		x	x	x	x	x	x	x							x	x		x			<15		>4	EJ
	E/L																						>4		>4	E/L
Pink	M	x		x	x	x	x	x	x	x								x					<15		8	M
	LJ																						<15		8	LJ
	EJ	x		x	x	x	x	x	x	x	x						x	x		x			<15		8	EJ
	L																						>4		>4	L
	E																						>4		>4	E
Sockeye	M																						<15			M
	LJ																						<15			LJ
	EJ																						<15			EJ
	L																									L
	E																									E

Table 3. Summary of Reproductive Traits for Salmon

Reproductive Traits																													
Salmon		Age at Maturity				Fertilization/Egg Development					Spawning Behavior						Spawning Season												
		Female		Male																									
Species	Life Stage	**50%**	**100%**	**50%**	**100%**	**External**	**Internal**	**Oviparous**	**Ovoviviparous**	**Viviparous**	**Batch Spawner**	**Broadcast Spawner**	**Egg Case Deposition**	**Nest Builder**	**Egg/Young Guarder**	**Egg/Young Bearer**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Chinook	M	4	7	4	7	X		X						X			X						X	X	X	X	X	X
	LJ																											
	EJ																											
	L																											
	E																											
Chum	M	4	7	4	7	X		X						X			X	X					X	X	X	X	X	X
	LJ																											
	EJ																											
	L																											
	E																											
Coho	M		4		4	X		X						X									X	X	X	X	X	X
	LJ																											
	EJ																											
	L																											
	E																											
Pink	M		2		2	X		X						X									X	X	X	X		
	LJ																											
	EJ																											
	L																											
	E																											
Sockeye	M	5	6	5	6	X		X						X									X	X	X	X	X	X
	LJ																											
	EJ																											
	L																											
	E																											

Table 4. Summary of Predator and Prey Associations for Salmo

Predator to

Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Salmon	Cod	Pollock	Halibut
Chinook	M							X						X						X	X	X	X	X			X	X	X	
	LJ							X						X						X	X	X	X	X			X	X	X	
	EJ				X			X		X	X		X	X				X		X										
	L																													
	E																													
Chum	M			X	X			X		X	X			X						X	X	X	X	X	X			X	X	
	LJ			X	X			X		X	X			X				X		X	X	X	X	X	X			X	X	
	EJ			X	X			X		X	X		X					X		X	X	X	X		X			X	X	
	L			X	X																									
	E																													
Coho	M							X						X						X	X	X	X							
	LJ				X			X													X						X			
	EJ				X			X		X	X									X					X		X			
	L																													
	E																													
Pink	M				X			X		X	X									X	X	X	X	X						
	LJ				X			X		X	X									X	X	X	X							
	EJ				X			X		X	X									X	X	X	X							
	L				X																									
	E																													
Sockeye	M			X	X			X		X	X		X	X						X	X	X	X	X	X			X	X	
	LJ			X	X			X		X	X																			
	EJ			X	X																									
	L																													
	E																													

Prey of

Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pac fic Cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Halibut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrerstrial Mammals
Chinook	M															X		X	X			X		X					X
	LJ															X			X			X							
	EJ						X	X	X																X		X	X	X
	L																												
	E																												
Chum	M															X	X	X	X			X		X				X	X
	LJ															X	X	X	X			X							
	EJ						X	X	X																X		X	X	X
	L																											X	
	E																											X	
Coho	M															X		X	X		X	X		X					X
	LJ																												
	EJ				X		X																		X	X	X	X	X
	L																												
	E																												
Pink	M															X	X	X	X	X			X	X				X	X
	LJ															X	X	X	X	X			X						
	EJ						X	X	X	X																			
	L																												
	E																												
Sockeye	M															X	X	X	X			X		X					X
	LJ						X	X	X																				
	EJ																												
	L																												
	E																												

Habitat Description for Pink salmon

(Oncorhynchus gorbuscha)

Management Plan and area(s) Salmon Fisheries in the EEZ Off the Coast of Alaska, NPFMC, 1990

Life History and General Distribution

The natural freshwater range of pink salmon includes the Pacific rim of Asia and North America north of about 40°N. Within this vast area, spawning pink salmon are widely distributed in coastal streams of both continents up to the Bering Strait. North, east and west of the Bering Strait, spawning populations become more irregular and occasional. Centers of large spawning populations occur at roughly parallel positions along the two continents from about latitudes 44°N to 65°N in Asia and about 48°N to 64°N in North America. In marine environments along both the Asian and North American coastlines pink salmon occupy ocean waters south of the limits of spawning streams.

Pink salmon are distinguished from other Pacific salmon by having a fixed two-year life span, being the smallest of the Pacific salmon as adults (averaging 1.0-2.5 kg), the fact that the young migrate to sea soon after emerging from the gravel, and developing a marked hump in large maturing males. This last characteristic is responsible for the vernacular name humpback salmon used in some areas. Because of the fixed two-year life cycle, pink salmon spawning in a particular river system in old and even years are reproductively isolated from each other and have developed into genetically different lines. In some river systems, like the Fraser River in British Columbia, only the odd-year line exists; returns in even years are negligible. In Bristol Bay, Alaska, the major runs occur in even years, whereas the coastal area between these two river systems is characterized by runs in both even and odd years. In different parts of the range populations are sometimes characterized by the phenomena of dominance where one brood line is much stronger than the other brood line. Upon emergence, pink salmon fry migrate quickly to sea and grow rapidly as they make extensive feeding migrations. After eighteen months in the ocean the maturing fish return to their river of origin to spawn and die.

Pink salmon are considered to be have either the simplest or most specialized life cycle within the genus, depending on whether Pacific salmon originated from marine or freshwater ancestors. One view holds that *Oncorhynchus* evolved from an ancestral freshwater form of Pacific *Salmo* during the Pleistocene, probably in the vicinity of the present-day Sea of Japan. Under this scenario, pink salmon that rely least on the freshwater environment are the most specialized. Pink salmon have 52 chromosomes, fewer than other Pacific salmon, which also may suggest specialization. Another view considers Salmonidae as relatively primitive teleosts, of probable marine pelagic origin, and about five million years old. This alternative view to freshwater origin of Pacific salmon is supported, in part, by Pliocene fossils from California and Oregon. The marine origin view holds that during evolution salmonids tended towards greater dependence on fresh water and away from dependence on the sea. Under this scenario, pink salmon, with the least dependence on the freshwater environment, is considered the least advanced extant *Oncorhynchus* species.

Fisheries

Pink salmon are the most abundant Pacific salmon, contributing about 40% by weight and 60% in numbers of all salmon caught commercially in the North Pacific Ocean and adjacent waters. Coastal fisheries for pink salmon presently occur in Asian (Japan and Russia) and North America (Canada and the United States) with major fisheries in both Russia and the U.S. Historically some pink salmon were caught in high seas fisheries by Japan and Russia. Most pink salmon in the U.S. are caught in Alaska

where major fisheries occur in Southeast, Prince William Sound, and Kodiak regions. Lessor fisheries for pink salmon occur in Cook Inlet, Alaska Peninsula and Bristol Bay regions. Alaska fisheries for pink salmon occur primarily within State of Alaska territorial seas (inside 3-miles).

Pink salmon catches have been at historic records in Alaska over the past decade with catches exceeding 100 million fish in several years. Most pink salmon in Alaska are caught by purse seines with smaller commercial catches made by set and drift gill net and troll fisheries. Recreational fisheries in Alaska usually harvest between 200 and 400 thousand pink salmon annually. Historically, pink salmon in Alaska have been harvested, on average, at between 60% and 75% of the total annual run.

Purse seine fisheries for pink salmon have some bycatch associated with them, primarily other salmon. The most important bycatch issue is in the Southeastern region where younger marine-age chinook salmon, similar in size to adult pink salmon, are caught in pink salmon purse seine fisheries. The total harvest of chinook salmon in this region is controlled by quotas under auspices of the Pacific Salmon Treaty. The Alaska Board of Fisheries allocates a portion of the quota for chinook salmon as an allowable bycatch in purse seine fisheries targeted on pink salmon.

Measured marine survivals of pink salmon, from entry of fry into stream mouth estuaries to returning adults, have ranged from 0.2% to over 20%. Scientist, in general, believe that much of the natural mortality of pink salmon in the marine environment occurs within the first few months before advanced juveniles move offshore into more pelagic ocean waters. Pink salmon populations can be very resilient, rebounding from weak to strong run strength in regional stock groups within one or two generations.

Relevant Trophic Information

Pink salmon eggs, alevins, and fry in freshwater streams provide an important nutrient input and food source for aquatic invertebrates, other fishes, birds and small mammals. In the marine environment, pink salmon fry and juveniles are food for a host of other fishes and coastal sea birds.

Subadult and adult pink salmon are known to be eaten by fifteen different marine mammals, sharks, other fishes such as Pacific halibut, and humpback whales. Because pink salmon are the most abundant salmon in the North Pacific, it is likely they comprise a significant portion of the salmonids eaten by marine mammals.

Millions of pink salmon adults returning to spawn in thousands of streams through out Alaska provide significant nutrient input into the trophic level of these coastal watersheds. Adult pink salmon in streams are major food sources for gulls, eagles, and other birds, along with bear, otter, mink and other mammals.

Describe any potential gear impacts on the habitats of this or other species

Because pink salmon are primarily caught in purse seines there are no known gear impacts to the marine habitats where these fisheries occur.

What is the approximate upper size limit of juvenile fish (in cm)? Roughly 25 cm.

Provide source (agency, name and phone number or literature reference for any possible additional distribution data

Karl Hofmeister, Alaska Department of Fish and Game, 907-465-4250
Chris Kondzela, NMFS, Auke Bay Laboratory, 907-789-6084

Habitat and Biological Associations (if known) Narrative

Eggs and Spawning: Pink salmon choose a fairly uniform spawning bed in small and large streams in both Asia and North America. Generally, these spawning beds are situated on riffles with clean gravel, or along the borders between pools and riffles in shallow water with moderate to fast currents. In large rivers, they may spawn in discrete sections of main channels or in tributary channels. Pink salmon avoid spawning in quiet deep water, in pools, in areas with a slow current, or over heavily silted or mud-covered streambeds. Places selected for egg deposition is determined by the optimal combination of two main interconnecting variables: depth of water and velocity of current.

On both the Asian and North American sides of the Pacific Ocean, pink salmon generally spawn at depths of 30-100 cm. Well populated spawning grounds of pink salmon are mainly at depths of 20-25 cm, less often reaching depths of 100-150 cm. In dry years, when spawning grounds are crowded, nests can be found at shallower depths of 10-15 cm. Current velocities in pink salmon spawning grounds varied from 30 to 100 cm/s, sometimes reaching 140 cm/s. Directly over the redds, about 5-7 cm from the surface, the velocity can range from 30 to 140 cm/s but usually averages from 60 to 80 cm/s.

In general, pink salmon select sites in gravel where the gradient increases and the currents are relatively fast. In these areas, surface stream water must have permeated sufficiently to provide intragravel flow for dissolved oxygen delivery to eggs and alevins. Chum salmon, by contrast, tended to select spawning sites in areas with upwelling spring water and a relatively constant water temperature, without much regard to surface stream water. Pink salmon spawning beds consist primarily of coarse gravel with a few large cobbles, a large mixture of sand, and a small amount of silt. High quality spawning grounds of pink salmon can best be summarized as clean, coarse gravel.

Larvae/alevins: Fertilized eggs begin their five- to eight-month period of embryonic development and growth in intragravel interstices. To survive successfully, the eggs, alevins and pre-emergent fry must first be protected from freezing, desiccation, stream bed scouring or shifting, mechanical injury and predators. Water surrounding them must be non-toxic and of sufficient quality and quantity to provide basic requirements of suitable temperatures, adequate supply of oxygen, and removal of waste materials. Collectively, these requirements are, on average, only partially met even under the most favorable natural conditions. Overall freshwater survival of pink salmon from egg to advanced alevin and emerged fry, even in highly productive streams, commonly reaches only 10%-20% and at times is as low as about 1%.

Rates of egg development, survival, size of hatched alevins and percentage of deformed fry are related to temperature and oxygen levels during incubation. Temporary low stream temperatures or dissolved oxygen concentrations, however, may be relatively unimportant at some developmental stages, but lethal at others. Generally, low oxygen levels are non-lethal early, but lethal late in development. Eggs subjected to low dissolved oxygen levels hatched prematurely at a rate dependent on the degree of hypoxia. Spinal deformities occurred in eggs incubated at 3.0° and 4.5°C before gastrulation. In one study, over 50% of developing pink salmon eggs died at dissolved oxygen levels of 3-4 mg/l, and among those that hatched many alevins were deformed.

Juveniles: Newly emerged pink salmon fry show a preference for saline water over fresh water which may, in some situations, facilitate migration from the natal stream area. Schools of pink salmon fry may move quickly from the natal stream area or remain to feed along shorelines up to several weeks. The timing and pattern of seaward dispersal is influenced by many factors, including general size and location of the spawning stream, characteristics of adjacent shoreline

and marine basin topography, extent of tidal fluctuations and associated current patterns, physiological and behavioral changes with growth, and, possibly, different genetic characteristics of individual stocks.

Early marine schools of pink salmon fry, often in tens or hundreds of thousands of fish, tend to follow shorelines and, during the first weeks at sea, spend much of their time in shallow water of only a few centimeters deep. It has been suggested that this onshore period involves a distinct ecological life history stage in both pink and chum salmon. In many areas throughout their ranges, pink salmon and chum salmon fry of similar age and size co-mingle in both large and small schools during early sea life. Juvenile pink salmon in the Bering Sea off the northeastern Kamchatka coast are found in one of three hydrological zones during their first three to four months of marine life: (1) the littoral zone, up to 150 m from shore; (2) open parts of inlets and bays from 150 m to 3.2 km from shore; and (3) the open parts of the large Karaginskiy Gulf, 3.2 to 96.5 km from shore. Distribution within these regions is seasonally related to the size of pinks, with an offshore movement of larger fish in August and September.

Pink salmon juveniles routinely obtain large quantities of food sufficient to sustain rapid growth from a broad range of habitats providing pelagic and epibenthic foods. Collectively, diet studies show that pink salmon are both opportunistic and generalized feeders and on occasion they specialize in specific prey items. Diel sampling of stomachs showed fewer and more digested food items at night than during the day indicating that juvenile pinks are primarily diurnal feeders.

Adults: Ocean growth of pink salmon is a matter of considerable interest because, although this species has the shortest life span among Pacific salmon, it also is among the fastest growing. Entering the estuary as fry at around 3 cm in length, maturing adults return to the same area 14-16 months later ranging in length from 45 to 55 cm.

The population biology of pink salmon revolves around the two-year life cycle. A phenomena of cycle dominance between odd- and even-year brood lines within specific regions is common. Dominance can be weak or strong, complete or non-existent. It can also shift between brood lines. With complete dominance, the “off-year” line is absent while non-dominance is characterized by similar population strength between odd- and even-year runs. Although many causes for dominance and its various characteristics in pink salmon populations have been proposed, none satisfactorily explains the event. Genetically, pink salmon are more similar within odd- or even-year brood lines across broad geographic regions than across brood lines within the same stream. It has been suggested for some geographic areas that present odd- and even-year pink salmon populations arose from separate glacial refuges during late Pleistocene times.

Scientists have recognized six distinct ocean migration patterns for regional stock groups of pink salmon throughout the North Pacific. Only two of these stock groups, those originating in Washington state and British Columbia and those originating in Southeastern, Central and Southwestern Alaska, occur in marine waters where they might interact in some way with the salmon fisheries off the coast of Southeast Alaska. Pink salmon from these two broad stock groups co-mingle in the Gulf of Alaska during their second summer at sea while migrating towards natal areas.

References

Alderdice, D.F., and F.P.J. Velsen. 1978. Relation between temperature and incubation time for eggs of chinook salmon *(Oncorhynchus tshawytscha).* J. Fish. Res. Board Can. 35:69-75.

Alderdice, D.F., W.P. Wickett, and J.R. Brett. 1958. Some effects of temporary exposure to low dissolved oxygen levels on Pacific salmon eggs. J. Fish. Res. Board Can. 15:229-249.

Allen, G.H., and W. Aron. 1958. Food of salmonid fishes of the western North Pacific Ocean. U.S. Fish Wild. Serv. Spec. Sci. Rep. Fish. 237:11 p.

Aron, W.I. 1956. Food of salmonid fishes of the North Pacific Ocean. C. Food of pink salmon *Oncorhynchus gorbuscha. D.* Preliminary comparative study of the feeding behavior of the pink, sockeye and chum salmons. Univ. Wash. Dep. Oceanogr. Fish. Rep. 4:10 p.

Aspinwall, N. 1974. Genetic analysis of North American populations of pink salmon, *Oncorhynchus gorbuscha,* possible evidence for the neutral mutation-random drift hypothesis. Evolution 28:295-305.

Atkinson, C.E., T.H. Rose, and T.O. Duncan. 1967. Pacific salmon in the United States, p. 43-223. *In:* Salmon of the North Pacific Ocean. Part IV. Spawning populations of North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 23.

Baggerman, B. 1960. Salinity preference, thyroid activity and the seaward migration of four species of Pacific salmon *(Oncorhynchus). J.* Fish. Res. Board Can. 17:295-322.

Bailey, J.E. 1969. Alaska's fishery resources - the pink salmon. Fish Leafl. (U.S.) 619:8 p.

Bailey, J.E., and D.R. Evans. 1971. The low-temperature threshold for pink salmon eggs in relation to a proposed hydroelectric installation. Fish. Bull. (U.S.) 69:587-593.

Bailey, J.E., S.D. Rice, J.J. Pella, and S.G. Taylor. 1980. Effects of seeding density of pink salmon, *Oncorhynchus gorbuscha,* eggs on water chemistry, fry characteristics, and fry survival in gravel incubators. Fish. Bull. (U.S.) 78:649-658.

Bailey, J.E., B.L. Wing, and C.R. Mattson. 1975. Zooplankton abundance and feeding habits of fry of pink salmon, *Oncorhynchus gorbuscha,* and chum salmon, *Oncorhynchus keta,* in Traitors Cove, Alaska, with speculations on the carrying capacity of the area. Fish. Bull. (U.S.) 73:846-861.

Baitey, J.E., B.L. Wing, and J.H. Landingham. 1983. juvenile Pacific sandfish, *Trichodon trichodon,* associated with pink salmon, *Oncorhynchus gorbuscha,* fry in the nearshore area, southeastern Alaska. Copeia. 1983(2):549-551.

Baker, TT; Wertheimer, AC; Burkett, RD; Dunlap, R; Eggers, DM; Fritts, EI; Gharrett, AJ*; Holmes, RA; Wilmot, RL. 1996. Status of Pacific salmon and steelhead escapements in southeastern Alaska. Fisheries, vol. 21, no. 10, pp. 6-19.

Beamish, R.J., I.A. Pearsall, and M.C. Healey. 2003. A history of the research on the early marine life of pacific salmon off Canada's Pacific coast. N. Pac. Anadr. Fish Comm. Bull. 3:1-40.

Boldt, J.L., Haldorson, L.J., 2002. A bioenergetics approach to estimating consumption of zooplankton by juvenile pink salmon in Prince William Sound, Alaska. Alaska Fishery Research Bulletin 9(2), 111-127.

Bradford, M.J., 1995. Comparative review of Pacific salmon survival rates. Canadian Journal of Fisheries and Aquatic Sciences 52, 1327-1338.

Brodeur, R.D., K.W. Myers, and J.H. Helle. 2003. Research conducted by the United States on the early ocean life history of Pacific salmon. N. Pac. Anadr. Fish Comm. Bull. 3:89-131.

Brodeur, R.D., Boehlert, G.W., Casillas, E., Eldridge, M.B., Helle, J.H., Peterson, W.T., Heard, W.R., Lindley, S. T., Schiewe, M.H., 2000. A coordinated research plan for estuarine and ocean research on Pacific salmon. Fisheries 25, 7-16.

Carlson, H.R., E.V. Farley, Jr., K.W. Myers. 2000. The use of otolith marks to determine stock-specific ocean distribution and migration patterns of Alaskan pink and chum salmon in the North Pacific Ocean 1996-1999. N. Pac. Anadr. Fish. Comm. Bull. No. 2:291-300

Cooney, R.T., Willette, T.M., Sharr, S., Sharp, D., Olsen, J., 1995. The effect of climate on North Pacific pink salmon (*Oncorhynchus gorbuscha*) production: examining some details of a natural experiment. In: Beamish, R.J. (Ed.), Climate change and northern fish populations. Canadian Special Publication of Fisheries and Aquatic Sciences 121, pp. 475-482.

Cooney, R.T., Brodeur, R.D., 1998. Carrying capacity and North Pacific salmon production: stock-enhancement implications. Bulletin of Marine Science 62, 443-464.

Cooney, R.T., Allen, J.R., Bishop, M.A., Eslinger, D.L., Kline, T., Norcross, B.L.,

Davidson, F.A. 1934. The homing instinct and age at maturity of pink salmon *(Oncorhynchus gorbuscha).* Bull. Bur. Fish. (U.S.) 48:27-29.

_____. 1935. The development of the secondary sexual characters in the pink salmon (*Oncorhynchus gorbuscha*). J. Morphol. 57:169-183.

Davidson, F.A., E. Vaughan, S.J. Hutchinson, and A.L. Pritchard. 1943. Factors influencing the upstream migration of the pink salmon *(Oncorhynchus gorbuscha).* Ecology 24:149-168.

Donnelly, R.F. 1983. Factors affecting the abundance of Kodiak Archipelago pink salmon *(Oncorhynchus gorbuscha,* Walbaum). Ph.D. thesis. University of Washington, Seattle, WA. 157 p.

Dubrovskaia, N.V. 1934. The life cycle of the pink salmon of Primorye. Rybn. Khoz. 1-2:65-68 (Transl. from Russian; Fish. Res. Board Can. Transl. Ser. 542).

Eniutina, R.I. 1954. Local stocks of pink salmon in the Amur Basin and neighboring waters. Vopr. Ikhtiol. 2:139-143. (Transl. from Russian; Fish. Res. Board Can. Transl. Ser. 284).

Farley, E.V. Jr., and H.R. Carlson. 2000. Spatial variations in early marine growth and condition of thermally marked juvenile pink and chum salmon in the coastal waters of the Gulf of Alaska. N. Pac. Anadr. Fish. Comm. Bull. No. 2:317-324.

Fiscus, C.H. 1980. Marine mammal-salmonid interactions: a review. P. 121-132. *In:* W.J. McNeil and D.C. Himsworth (eds.). Salmonid ecosystems of the North Pacific. Oregon State University Press, Corvallis, OR.

Gerke, R.J., and V.W. Kaczynski. 1972. Food of juvenile pink and chum salmon in Puget Sound, Washington. Wash. Dep. Fish. Tech. Rep.10:27 p.

Gharrett, A.J., C. Smoot, and A.J. McGregor. 1988. Genetic relationships of even-year northwestern Alaskan pink salmon. Trans. Am. Fish. Soc. 117:536-545.

Godin, J.G.J. 1980a. Temporal aspects of juvenile pink salmon *(Oncorhynchus gorbuscha* Walbaum) emergence from a simulated gravel redd. Can. J. Zool. 58:735-744.

_____. 1980b. Ontogenetic changes in the daily rhythms of swimming activity and of vertical distribution in juvenile pink salmon *(Oncorhynchus gorbuscha* Walbaum). Can. J. Zool. 58:745-753.

_____. 1981. Daily patterns of feeding behavior, daily rations, and diets of juvenile pink salmon *(Oncorhynchus gorbuscha)* in two marine bays of British Columbia. Can. J. Fish. Aquat. Sci. 38: 10-15.

Hanavan, M.G., and B.E. Skud. 1954. Intertidal spawning of pink salmon. Fish. Bull. Fish Wild. Serv. 56:167-185.

Hawkins, SL; Varnavskaya, NV; Matzak, EA; Efremov, VV; Guthrie, CM III; Wilmot, RL; Mayama, H; Yamazaki, F; Gharrett, AJ. 2002. Population structure of odd-broodline Asian pink salmon and its contrast to the even-broodline structure. J. Fish Biol.,Vol.60,no.2, pp. 370-388.

Healey, M.C. 1967. Orientation of pink salmon (*Oncorhynchus gorbuscha*) during early marine migration from Bella Coola River system. J. Fish. Res. Board Can. 24:2321-2338.

Heard, W.R. 1978. Probable case of streambed overseeding: 1967 pink salmon, *Oncorhynchus gorbuscha,* spawners and survival of their progeny in Sashin Creek, southeastern Alaska Fish. Bull. (U.S.) 76:569-582.

_____. 1991. Life history of pink salmon, *Oncorhynchus gorbuscha*, p 119-230 *in* C. Groot and L. Margolis, eds. Pacific salmon life histories. UBC Press, Vancouver

Heintz, R. A., S. D. Rice, A. C. Wertheimer, R. Bradshaw, F. P. Thrower, J. E. Joyce, and J. W. Short. 2000. Delayed effects on growth and marine survival of pink salmon after exposure to crude oil during embryonic development. Marine Ecology Progress Series 208: 205-216.

Helle, J.H., R.S. Williamson, and J.E. Bailey. 1964. Intertidal ecology and life history of pink salmon at Olsen Creek, Prince William Sound, Alaska. U.S. Fish Wild. Serv. Spec. Sci. Rep. Fish. 483: 26 p.

Helle, J.H. 1966. Behavior of displaced adult pink salmon. Trans. Am. Fish. Soc. 95:188-195.

_____. 1970. Biological characteristics of intertidal and fresh-water spawning pink salmon at Olsen Creek, Prince William Sound, Alaska, 1962- 63. U.S. Fish Wild. Serv. Spec. Sci. Rep. Fish. 602: 19 p.

Hilborn, R., Eggers, D., 2000. A review of the hatchery programs for pink salmon in Prince William Sound and Kodiak Island, Alaska. Transactions of the American Fisheries Society 129(2), 333-350.

Hoar, W.S. 1951. The chum and pink salmon fisheries of British Columbia 1917-1947. Bull. Fish. Res. Board Can. 90:46 p.

_____. 1956. The behaviour of migrating pink and chum salmon fry. J. Fish. Res. Board Can. 13:309-325.

_____. 1958. The evolution of migratory behaviour among juvenile salmon of the genus *Oncorhynchus.* J. Fish. Res. Board Can. 15:391-428.

Hunter, J.G. 1959. Survival and production of pink and chum salmon in a coastal stream. J. Fish. Res. Board Can. 16:835-886.

Ishida, T. 1966. Pink salmon in the Far East. P. 29-39. *In:* Salmon of the North Pacific Ocean. Part III. A review of the life history of North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 18.

Jaenicke, H.W., Celewycz, A.G., 1994. Marine distribution and size of juvenile Pacific salmon in Southeast Alaska and northern British Columbia. Fishery Bulletin 92(1), 79-90.

Karpenko, V.I. 2003. Review of Russian marine investigations of juvenile Pacific salmon. N. Pac. Anadr. Fish Comm. Bull. 3:69-88.

Karpenko, V.I. 1979. Feeding habits of juvenile Pacific salmon in the coastal waters of Kamchatka. Sov. J. Mar. Biol. 5:398-405.

_____. 1987. Growth variation of juvenile pink salmon, *Oncorhynchus gorbuscha,* and chum salmon *Oncorhynchus keta,* during the coastal period of life. J. Ichthyol. 27:117-125.

Kirkwood, J.B. 1962. Inshore-marine and freshwater life history phases of pink salmon, *Oncorhynchus gorbuscha* (Walbaum), and the chum salmon, *O. keta* (Walbaum), in Prince William Sound, Alaska. Ph.D. thesis. University of Kentucky, Louisville, KY. 300 p.

Kron, T.M., and H.J. Yuen. 1978. Zooplankton abundance and the feeding habits and migration of juvenile pink salmon, Tutka Bay, Alaska, 1975. Alaska Department of Fish and Game, FRED Division. Anchorage. AK. 25 p.

Krupitskiy, Yu. G., and A.F. Ustyugov. 1977. The pink salmon, *Oncorhynchus gorbuscha,* in the rivers of the north of Krasnoyarsk territory. J. Ichthyol. 17:320-322.

Landingham, J.H. 1982. Feeding ecology of pink and chum salmon fry in the nearshore habitat of Auke Bay, Alaska. M.Sc. thesis. University of Alaska, Juneau, AK. 132 p.

Landingham, J.H., M.V. Sturdevant and R.D. Brodeur. 1998. Feeding habits of juvenile Pacific salmon in marine waters of southeastern Alaska and northern British Columbia. Fishery Bulletin 96(2):285-302.

Mantua, N.J., Hare, S.R., Zhang, Y., Wallace, J.M., Francis, R.C., 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78, 1069-1079.

Martin, J.W. 1966. Early sea life of pink salmon. P. 111-125. *In:* W.L. Sheridan (ed.). Proceedings of the 1966 Northeast Pacific Pink Salmon Workshop. Alaska Dep. Fish Game Inf. Leafl. 87.

Mayama, H. and Y. Ishida. 2003. Japanese studies on the early ocean life of juvenile salmon. N. Pac. Anadr. Fish Comm. Bull. 3:41-67.

McDonald, J. 1960. The behaviour of Pacific salmon fry during their downstream migration to freshwater and saltwater nursery areas. J. Fish. Res. Board Can. 17:655-676.

McIntyre, JD; Reisenbichler, RR; Emlen, JM; Wilmot, RL; Finn, JE. 1988. Predation of Karluk River sockeye salmon by coho salmon and char. FISH. BULL., vol. 86, no. 3, pp. 611-616.

McNeil, W.J. 1962. Mortality of pink and chum salmon eggs and larvae in southeast Alaska streams. Ph.D. thesis. University of Washington, Seattle, WA. 270 p.

McRoy, C.P., Milton, J., Olsen, J., Patrick, V., Paul, A.J., Salmon, D., Scheel, D., Thomas, G.L., Vaughan, S.L., Willette, T.M., 2001a. Ecosystem controls of juvenile pink salmon (*Oncorhynchus gorbuscha*) and Pacific herring (*Clupea pallasi*) populations in Prince William Sound, Alaska. Fisheries Oceanography 10(1), 1-13.

Merrell, T.R. 1962. Freshwater survival of pink salmon at Sashin Creek. P. 59-72. *In:* N.J. Wilimovskv (ed.). Symposium on Pink Salmon. H.R. MacMillan Lectures in Fisheries. Institute of Fisheries, University of British Columbia, Vancouver, BC.

Meuter, F.J., Peterman, R.M., Pyper, B.J., 2002. Opposite effects of ocean temperature on survival rates of 120 stocks of Pacific salmon (Oncorhynchus spp.) in northern and southern areas. Canadian Journal of Fisheries and Aquatic Sciences 59, 456-463.

Mortensen, D., Wertheimer, A., Taylor, S., Landingham, J., 2000. The relation between early marine growth of pink salmon, *Oncorhynchus gorbuscha*, and marine water temperature, secondary production, and survival to adulthood. Fishery Bulletin 98, 319-335.

Mortensen, D.G. 1983. Laboratory studies on factors influencing the first feeding of newly emerged pink salmon *(Oncorhynchus gorbuscha)* fry. M.Sc. thesis. University of Alaska, Juneau, AK. 108 p.

Mortensen, D. G., A. C. Wertheimer, J. M. Maselko, and S. G. Taylor. 2002. Survival and straying of Auke Creek, Alaska, pink salmon marked with coded-wire tags and thermally induced otolith marks. Transactions of the American Fisheries Society, Volume 131: 14- 26.

Moulton, L.L. 1997. Early marine residence, growth, and feeding by juvenile salmon in Northern Cook Inlet, Alaska. Alaska Fishery Research Bulletin 4(2):154-177.

Murray, C.B., and T.D. Beacham. 1986. Effect of varying temperature regimes on the development of pink salmon *(Oncorhynchus gorbuscha)* eggs and alevins. Can. J. Zool. 64:670-676.

Neave, F., T. Ishida, and S. Murai. 1967. Salmon of the North Pacific Ocean. Part VI. Pink salmon in offshore waters. Int. North Pac. Fish. Comm. Bull. 22:33 p.

_____. 1952. "Even-year" and "odd-year" pink salmon populations. Proc. Trans. R. Soc. Can. Ser. 3 46(5):55-70.

_____. 1953. Principles affecting the size of pink and chum salmon populations in British Columbia. J. Fish. Res. Board Can. 9:450-491.

_____. 1955. Notes on the seaward migration of pink and chum salmon fry. J. Fish. Res. Board Can. 12:369-374.

_____. 1958. The origin and speciation of *Oncorhynchus.* Proc. Trans. R. Soc. Can. Ser. 3 52(5):25-34.

_____. 1962. The observed fluctuations of pink salmon in British Columbia. P. 3-14. *In*: N.J. Wilimovsky (ed.). Symposium on Pink Salmon. H.R. MacMillan Lectures in Fisheries. Institute of Fisheries, University of British Columbia, Vancouver, BC.

Neave, F. 1948. Fecundity and mortality in Pacific salmon. Proc. Trans. R. Soc. Can. Ser. 3 42(5):97-105.

Nicola, S.J. 1968. Scavenging *by Alloperla (Plecop*tera: Chloroperlidae) nymphs on dead pink *(Oncorhynchus gorbuscha)* and chum (O. *keta)* salmon embryos. Can. J. Zool. 46:787-796.

Olson, J.M., and W.J. McNeil. 1967. Research on pink salmon at Little Port Walter, Alaska, 1934-64. U.S. Fish Wild. Serv. Data Rep. 17:301 p.

Parker, R.R. 1962a. A concept of the dynamics of pink salmon populations. P. 203-211. *In*: N.J. Wilimovsky (ed.). Symposium on Pink Salmon. H.R. MacMillan Lectures in Fisheries. Institute of Fisheries, University of British Columbia, Vancouver, BC.

_____. 1962b. Estimations of ocean mortality rates for Pacific salmon *(Oncorhynchus). J.* Fish. Res. Board Can. 19:561-589.

_____. 1968. Marine mortality schedules of pink salmon of the Bella Coola River, central British Columbia. J. Fish. Res. Board Can. 25:757-794.

Perry, R.I., N.B. Hargreaves, B.J. Waddell and D.L. Mackas. 1996. Spatial variations in feeding and condition of juvenile pink and chum salmon off Vancouver Island, British Columbia. Fisheries Oceanography 5(2):73-88.

Pirtle, R.B. 1977. Historical pink and chum salmon estimated spawning escapements from Prince William Sound, Alaska streams, 1960-1975. Alaska Dept. Fish Game, ADF&G Tech. Data Rep. 35:332 p.

Pritchard, A.L. 1934a. Do caddis fly larvae kill fish? Can. Field-Nat. 48:39 p.

_____. 1939. Homing tendency and age at maturity of pink salmon *(Oncorhynchus gorbuscha)* in British Columbia. J. Fish. Res. Board Can. 4:233-251.

_____. 1948b. A discussion of the mortality in pink salmon *(Oncorhynchus gorbuscha)* during their period of marine life. Proc. Trans. R. Soc. Can. Ser. 3 42(5):125-133.

Ricker, W.E. 1962. Regulation of the abundance of pink salmon populations. P. 155-206. *In:* N.J. Wilimovsky (ed.). Symposium on Pink Salmon. H.R. MacMillan Lectures in Fisheries. Institute of Fisheries, University of British Columbia, Vancouver, BC.

Royce, W.F. 1962. Pink salmon fluctuations in Alaska. P. 15-23. *In:* N.J. Wilimovsky (ed.). Symposium on Pink Salmon. H.R. MacMillan Lectures in Fisheries. Institute of Fisheries, University of British Columbia, Vancouver, BC.

Ruggerone, G.T., M. Zimmermann, K.W. Myers, J.L. Nielsen, and D.E. Rogers. 2003. Competition between Asian pink salmon (Oncorhynchus gorbuscha) and Alaskan sockeye salmon (O. nerka) in the North Pacific Ocean. Fish. Oceanogr. 12:3. 209-219.

Sakagawa, G.T. 1972. The dynamics of juvenile salmon, with particular emphasis on pink salmon *(Oncorhynchus gorbuscha),* during their early marine life. Ph.D. thesis. University of Washington, Seattle, WA. 352 p.

Shershnev, A.P., V.M. Chupakhin, and V.A. Rudnev. 1982. Ecology of juvenile pink salmon, *Oncorhynchus gorbuscha* (Salmonidae), from Sakhalin and Iturup islands during the marine period of life. J. Ichthyol. 22:90-97.

Skud, B.E. 1958. Relation of adult pink salmon size to time of migration and freshwater survival. Copeia 1958:170-176.

Smoker, W. W., R. A. Heintz, A. C. Wertheimer, and S. D. Rice. 2001. Genetic Analysis of Development Mortality in Oiled and Unoiled Lines of Pink Salmon. *In* Proc. 23rd Northeast Pacific Pink and Chum Salmon Workshop. Seattle, Washington.

Takagi, K., K.V. Aro, A.C. Hartt, and M.B. Dell. 1981. Distribution and origin of pink salmon *(Oncorhynchus gorbuscha)* in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 40:195 p.

Taylor, S.G. 1980. Marine survival of pink salmon fry from early and late spawners. Trans. Am. Fish. Soc. 109:79-82.

Thorsteinson, F.V. 1959. Pink salmon migrations along the Alaska Peninsula. P. 1-7. *In:* Alaska fisheries briefs. U.S. Fish Wild. Serv. Circ. 59.

Trudel, M. E.V. Farley, Jr., B.L. Wing, and D.W. Welch. 2002. Prevalence and intensity of sea lice (Lepeophtheirus salmonis) infestation on juvenile pink salmon (Oncorhynchus gorbuscha) in the Bering Sea - September 2002. Canadian Data Report of Fish. Aquat. Scienc. XXXX

Vallion, A.C., A.C. Wertheimer, W.R. Heard, and R.M. Martin. 1981. Summary of data and research pertaining to the pink salmon population at Little Port Walter, Alaska, 1964-80. NWAFC Processed Rep. 81-10:102 p.

Walters, C.J., Hilborn, R., Peterman, R.M., Staley, M., 1978. A model for examining early ocean limitation of Pacific salmon production. Journal of the Fisheries Research Board of Canada 35, 1303-1315.

Wertheimer, A.C, W.R. Heard, and W. W. Smoker. 2002. Effects of hatchery releases and environmental variation on wild-stock productivity: Consequences for hatchery enhancement of pink salmon in Prince William Sound, Alaska. pp. 64-71. *In* C. Orr, P. Gallaugher, and J. Penikett (Eds.) Speaking for the salmon: hatcheries and the protection of wild salmon. Simon Fraser University Continuing Studies in Science. Vancouver, B.C.

Wertheimer A. C., W. W. Smoker, T. L. Joyce, and W. R. Heard. 2001. Hatchery pink salmon in Prince William Sound: enhancement or replacement? Transactions American Fisheries Society 130: 712-720.

Wertheimer, A. C., J. F. Thedinga, R. A. Heintz, R. Bradshaw, and A. G. Celewycz. 2002. Comparative effects of pectoral fin removal and half-length coded-wire tagging of pink salmon fry on survival and size. North American Journal Aquaculture. 64:150-157.

Willette, T.M. 2001. Foraging behavior of juvenile pink salmon (*Oncorhynchus gorbushca*) and size-dependent predation risk. Fisheries Oceanography 10 (Suppl. 1):110-131.

Willette, M., 1996. Impacts of the *Exxon Valdez* oil spill on the migration, growth, and survival of juvenile pink salmon in Prince William Sound. American Fisheries Society Symposium 18, 533-550.

Wilmot, RL; Burger, CV. 1985. Genetic differences among populations of Alaskan sockeye salmon. TRANS. AM. FISH. SOC., vol. 114, no. 2, pp. 236-243.

Yefanov, V.N., and V.M. Chupakhin. 1982. The dynamics of some population indices of pink salmon, *Oncorhynchus gorbuscha,* from Iturup (Kuril Islands). J. Ichthyol. 22:42-50.

SPECIES: Pink salmon, *Onchorynchus gorbuscha*

Stage - EFH Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs and larvae	90-125 d	eggs predated by birds, fish and mammals	late summer, fall, winter, and early spring	intragravel in stream beds WC, LK, BHC	15 to 50 cm in gravel depth	medium to coarse gravel CB, G	NA	Develop at 1-10°C, eggs hatch at about 100 d, larvae emerge from gravel about 125 d post hatch
Juveniles, freshwater	1-15 d; short streams = 1d, longer rivers=15 d	fry are predated by birds, fish and mammals	spring	rivers and streams WC, LK, BHC	generally migrating in upper portion of water column	varied	NA	downstream migration is mostly in darkness
Juveniles, estuarine	2-3 months	copepods, euphausiids, decapod larva, amphipods	summer	EST, initially nearshore, then offshore in bays and inlets , along kelp beds	generally occupying the upper portion of water column	varied: K, SAV	NA	Preference for increasing salinities, school with other salmon and Pacific sandfish
Juveniles, marine	3 to 6 months	copepods, euphausiids, decapod larva, amphipods	summer, fall, and early, pre anulus winter	coastal, ICS, MCS, OCS; moving further offshore with growth	generally migrating in upper portion of water column	varied: K, SAV	UP, F, CL, E	Coastal and shelf migrations move into oceanic waters in later stages

Immature and maturing adults marine	6 to 10 months	fish, squid, euphausiids, amphipods, and copepods	spring, summer, and early fall	Oceanic to nearshore in final migration	P, N	NA	UP, F, CL, E: Regional stocks have specific oceanic migratory patterns	Rapid marine growth; onset of maturation timing varies among stocks; earlier north, later south
Adults, freshwater	2 yrs of age from egg to mature adult, final stage 1-2 months	Active feeding ceases, digestive organs atrophy	spawning (Aug-Oct)	WC, LK, BCH	Varied, holding in pools, spawning on shallow riffles	medium to coarse gravel CB, G	NA	sexual dimorphism in spawning males, called humpback salmon

Habitat Description for Chum salmon

(*Oncorhynchus keta)*

Management Plan and area(s) Salmon Fisheries in the EEZ Off the Coast of Alaska, NPFMC, 1990

Life History and General Distribution

Chum salmon spawn in streams emptying into the North Pacific Ocean north of about 40°N in both Asia and North America. In Asia chum salmon spawn in streams on the east side of the Korean peninsula in both South and North Korea northward, including Japan, China (tributaries to the Amur River), Russia and westward into the Arctic Ocean as far west as the Lena River. In North America chum salmon spawn in streams entering the North Pacific Ocean as far south as northern California and northward in streams along the coasts of Oregon, Washington, British Columbia, and Alaska on into the Bering Sea, Arctic Ocean and Beaufort Sea as far east as the Mackenzie River in Northwest Territory. Chum salmon spawn in Yukon Territory, Canada, in tributaries of the Yukon River. Only populations small in numbers spawn north and east of the Noatak River, which enters the ocean at Kotzebue, Alaska, and south of Tillamook Bay, Oregon.

In general, chum salmon spawn in the lower reaches of coastal streams less than 100 miles upstream from the ocean. Two notable exceptions are the Yukon River in North America and the Amur River in Russia and China where chum salmon migrate upstream more than 1,500 miles to spawning areas. In Prince William Sound, and to a lesser extent Southeast Alaska, chum salmon will spawn in the intertidal portions of streams in areas where ground water upwells into the streams. Chum salmon throughout their range tend to build their redds in areas of streams where ground water (about 4 to 7 C.) upwells.

In North America chum salmon return from the ocean to spawn, for the most part, between June and January. In general, spawning starts earlier in the north and ends later in the southern part of their range. Of course, major exceptions in this pattern occur. The latest spawning in Southeast Alaska occurs in the Chilkat River, near Haines, Alaska, in September through January. Most chum salmon spawning in Alaska is usually finished by early November. Most spawning in Washington/Oregon takes place in August through November; however, August spawners have been declining in recent years. Chum salmon return to the Quilcene National Fish Hatchery in December and the Nisqually River, near Olympia, Washington has spawners during January and February and sometimes into March.

So called summer and fall races of chum salmon occur in Asia and North America. Summer and fall races both enter the Yukon River. The summer chum salmon start entering the river in May and the fall chum enter the river in June and July. The fall stocks tend to spawn farthest up river in September through November. Summer chum are more abundant than fall chum in the Yukon River; however, the fall chum are larger. In southern Southeast Alaska and northern British Columbia summer chum enter mostly mainland rivers in mid June and spawning may extend into late October and early November. Fall chum in southern Southeast Alaska and northern British Columbia spawn mostly in streams on the Islands and spawning typically occurs during September and October. Unlike the Yukon River, summer chum salmon in southern Southeast Alaska and northern British Columbia are larger than the fall stocks for the same age, even though the summer stocks may spawn more than 3 months earlier.

Chum salmon return to spawn as 2- to 7-year olds. Two-year old chum are rare in North America and occur primarily in the southern part of their range, e.g., Oregon. Seven-year old chum are also rare and occur mostly in the northern areas. In general, chum salmon get older from south to north. Three- and four-year olds tend to dominate in the southern areas and four, five, and six-year olds tend to dominate

in the more northern areas. For the most part older chum salmon are larger than younger fish but much overlap occurs between the age groups. The largest chum salmon in North America (and probably the world) occur in the Portland Canal area which forms the border between Alaska and British Columbia.

Chum salmon fry, like pink salmon, do not overwinter in the streams but migrate (mostly at night) out of the streams directly to the sea shortly after emergence. The range of this outmigration occurs between February and June but most fry leave the streams during April and May. Chum salmon do tend to linger and forage in the intertidal areas at the head of bays. Estuaries are very important for chum salmon rearing during the spring and summer.

Juvenile chum salmon are present in the coastal waters mostly during July through October(?), and generally move to the north and west along the coasts of Oregon, Washington, British Columbia, and Alaska. Most juvenile chum salmon are thought to leave the coastal waters and move south into the North Pacific Ocean between Kodiak and False Pass during late fall. After chum salmon form an annulus on their scales (January - March) they are considered immature. They may remain immature for several years until they start maturing and begin their migration to their spawning streams.

Both Asian and North American chum salmon winter in the North Pacific but Asian chum salmon migrate much further east than North American chum salmon migrate to the west. North American chum salmon are seldom found west of 175°E, however, Asian salmon are found eastward to at least 140°W. However, Asian and North American stocks of chum salmon are intermingled on the high seas.

After the 1976-77 Regime Shift in the North Pacific Ocean most chum salmon stocks increased in abundance through the mid-1990s. The Regime Shift apparently created very favorable ocean conditions for all species of salmon from northern British Columbia to northern Alaska. However, as the abundance increased age at maturity increased and the size at age decreased drastically. Chum salmon of the same age in the early 1990s weighed up to 46% less than they weighed in the early 1970s. During this same time, Asian chum salmon also matured older and their size at age declined. These changes in size and age at maturity as population numbers increased suggests that the North Pacific Ocean may have carrying capacity limits for chum salmon under certain conditions.

Fisheries

Chum salmon are captured primarily in purse seines and gill-nets in North America after traps were outlawed in Alaska in 1960. Some chum salmon are captured in troll fisheries, primarily in Canada.

Major fisheries occur for chum salmon from southern Washington to the Noatak River in northwestern Alaska. Significant declines of chum salmon in Oregon in the 1940s caused the state to abandon net fisheries and the stocks still have not recovered.

Most net fisheries for chum salmon occur in the coastal waters in Alaska but some in-river gill-net fisheries occur in the larger rivers for both commercial and subsistence fisheries. Chum salmon are often captured incidently in fisheries targeting pink or sockeye salmon. Large incidental catches of chum salmon occur in Southeast Alaska and Prince William Sound. When the Pacific Salmon Treaty between the U.S.A. and Canada was signed in 1984 chum salmon in Portland Canal (on both sides of the border but particularly in Canada) were identified as a major conservation concern. The cause of this problem was blamed on incidental capture of chum salmon in fisheries targeting pink and sockeye salmon.

Chum salmon have also been captured incidentally in the trawl fisheries for pollock in the Bering Sea. Apparently, the chum are “scooped” at the surface when the trawl is being let out and brought in. In some years this can be a major problem, e.g., in 1994 when about 250,000 chum were estimated to be part of the bycatch.

Relevant Trophic Information

Chum salmon eggs, alevins, and juveniles in freshwater streams provide an important food source for many birds (e.g., gulls, crows, magpies, ouzels, kingfishers), small mammals, other fishes, and many invertebrates. Chum salmon carcasses provide nutrients for the freshwater watersheds and estuaries. Carcasses are also highly important for food for many birds (e.g., eagles, ravens, crows, gulls, magpies). The late chum salmon return to the Chilkat River system near Haines, Alaska, is the reason that large numbers of bald eagles congregate on the spawning grounds every year in September through December. Adult chum salmon and spawned carcasses provide a major food source for brown and black bears, wolverines, wolves, and many other small mammals. Many species of invertebrates utilize carcasses for food.

Potential Gear Impacts on Habitats of Chum or other Species of Fish

Chum salmon fisheries utilize seines, gill-nets, and troll gear and there are no apparent impacts of the gear on marine or freshwater habitats.

Upper Size Limit of Juvenile Fish

If the term juvenile chum salmon refers to the fry stage up to the time of the first annulus formation in the ocean, which occurs in January-March, the upper size limit is about 30 cm. Juvenile chum salmon in the outside waters of Southeast Alaska in mid to late August range in size up to about 25 cm.

Sources of Additional Data

_____Ben van Alen, Alaska Department of Fish and Game, Douglas, (907) 465-4250
Christene Kondzela, NMFS, Auke Bay Laboratory, Juneau, (907) 789-6084

Habitat and Biological Associations

Eggs and Spawning: Chum salmon spawn in gravel in streams, side-channel sloughs, and intertidal portions of streams when the tide is below the spawning area. In all of these areas upwelling ground water is often the common denominator. Many side-channel sloughs have very little current on the surface and can be very silty; however, the upwelling ground water keeps the silt in suspension in the intragravel water. The upwelling water also keeps these spawning areas with slow moving surface water from freezing in the winter. The depth that eggs are deposited in the streams varies according to the gravel size, current, and size of the female but the range is about 8 to 50 cm. Eggs and sperm are deposited in the redd simultaneously and each female spawns with up to 6 males at the same time. Several redds are constructed by each female and different males may be involved in the spawning act in subsequent redds. Stream life of both sexes varies and is longer in the early stages of the run (about 14 days) and shorter near the end of the run (as few as 6 days) in coastal streams.

Larvae/alevins: Fertilized eggs incubate in the streambed gravel for about five to eight months. Eggs, alevins, and pre-emergent fry can be killed by desiccation, freezing, mechanical injuries due to streambed shifting, e.g., during floods, and predators. The intragravel water during incubation and rearing must be of suitable temperatures and be free of toxins with adequate oxygen and flow to remove waste products. Survival from deposited eggs to emergent fry is highly variable, ranging from about 1% to 20%. The health of the eggs and emerging fry is also dependent on gravel composition, spawning time, spawning density, and genetic characteristics. In general chum salmon eggs have

to be fertilized in water above 4 C. and in salinity less than 2 parts per thousand. Dissolved oxygen levels during incubation need to be above 3 to 4 mg/l.
Juveniles: After emerging from the streambed (as early as February and as late as June) schooling chum salmon fry migrate downstream, mostly at night, to the estuaries where they tend to feed in the intertidal grass flats and along the shore. Chums can utilize these intertidal wetlands for several months before actively migrating out of bays and into channels on the way to the outside waters. Pink salmon on the other hand tend to move more directly to more open water areas. Chum salmon utilize a wide variety of food items, including mostly invertebrates (including insects), and gelatinous species. Offshore movement of larger juveniles occurs mostly in July - September.

Adults: Chum salmon reside in the ocean for about one to six years. Adults mature at ages 2 through 7 years; however, 2- and 7-year old chum salmon are rare. Throughout their range 3-, 4-, and 5-year olds are common but 3- and 4-year old salmon dominate the southern stocks and 4-, 5-, and 6-year old chum salmon dominate the northern stocks. Slow or rapid growth in the ocean can modify age at maturity. Slower growth during the second year at sea causes some chum salmon to mature one or two years later. Chum salmon eat a variety of foods during their ocean life, e.g., amphipods, euphausiids, pteropods, copepods, fish, and squid larvae. Chum salmon also utilize gelatinous zooplankton for food more often than any of the other species of salmon. Chum salmon have a much larger stomach than the other species of salmon and this large capacity may allow them to utilize the nutrients from the gelatinous zooplankton more efficiently.

Asian and North American chum salmon are intermingled on the high seas as immature and during their last year at sea. Recently, immature and maturing chum salmon from Washington, British Columbia, and southeast Alaska have been identified in the Bering Sea in August. Chum salmon spawn mostly in November in Washington and southern British Columbia so these fish are capable of long distant migrations in their last year in the sea.

Special Habitat Concerns: Chum salmon are subject to the same habitat concerns as the other species of salmon, e.g., habitat destruction or silting due to logging and road building activities, blockages due to dams, and pollution. In addition, chum salmon have two habitat requirements that are essential in their life history that make them very vulnerable: (1) reliance on upwelling ground water for spawning and incubation, and (2) reliance on estuaries/tidal wetlands for juvenile rearing after migrating out of the streams. The hydrology of upwelling ground water into stream gravel is highly complex and poorly understood. Whatever activities change the amount and quality of ground water that upwells would very likely affect chum salmon survival in a negative manner. Drilling activities and uplift of land masses due to earthquakes are two phenomena known to affect ground water. Wetlands and estuaries near communities are very vulnerable to pollution and filling activities that would negatively affect essential chum salmon rearing areas.

Chum salmon will spawn in intertidal portions of streams, most notably in Prince William Sound. The intertidal portion of streams is very vulnerable to coastal pollution from oil spills et al. In Prince William Sound, chum salmon spawners are active in the intertidal zone of streams from late June through September. Eggs, alevins, and fry are in the intertidal gravel from late June through May. That leaves a very narrow "window" in June when the intertidal zone may be free of adults, eggs, alevins, or fry.

References

Alderdice, D. F., W. P. Wickett, and J. R. Brett. 1958. Some effects of temporary exposure to low dissolved oxygen levels on Pacific salmon eggs. J. Fish. Res. Board Can. 15: 229-249.

Aro, K. V., and M. P. Shepard. 1967. Pacific salmon in Canada, p. 225-327. *In*: Salmon of the North Pacific Ocean. Part IV. Spawning populations of North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 23.

Atkinson, C. E., J. H. Rose, and R. O. Duncan. 1967. Pacific salmon in the United States, p. 43-224. *In*: Salmon of the North Pacific Ocean. Part IV. Spawning populations of North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 23.

Bailey, J. E., B. L. Wing, and C. R. Mattson. 1975. Zooplankton abundance and feeding habits of fry of pink salmon, *Oncorhynchus gorbuscha*, and chum salmon, *Oncorhynchus keta*, in Traitors Cove, Alaska, with speculation on the carrying capacity of the area. Fish. Bull. (U.S.) 73: 846-861.

Bakkala, R. G. 1970. Synopsis of biological data on the chum salmon, *Oncorhynchus keta* (Walbaum) 1792. FAO Fish. Synop. 41: U.S. Fish. Wildl. Serv. Circ. 315: 89 p.

Bams, R. A. 1970. Evaluation of a revised hatchery method tested on pink and chum salmon fry. J. Fish. Res. Board Can. 27: 1429-1452.

Beacham, T. D. 1982. Fecundity of coho salmon (*Oncorhynchus kisutch*) and chum salmon (*O. keta*) in the northeast Pacific Ocean. Can. J. Zool. 60: 1463-1469.

Beacham, T. D. 1984a. Age and morphology of chum salmon in southern British Columbia. Trans. Am. Fish Soc. 113: 727-736.

Beacham, T. D., and C. B. Murray. 1986. Comparative developmental biology of chum salmon (*Oncorhynchus keta*) from the Fraser River, British Columbia. Can. J. Fish. Aquat. Sci. 43: 252-262.

Beacham, T. D., and C. B. Murray. 1987. Adaptive variation in body size and developmental biology of chum salmon (*Oncorhyunchus keta*) in British Columbia. Can. J. Fish. Aquat. Sci. 44: 244-261.

Beacham, T. D., and P. Starr. 1982. Population biology of chum salmon, *Oncorhynchus keta*, from the Fraser River, British Columbia. Can. J. Fish. Aquat. Sci. 43: 252-262.

Beacham, T.D., F.C. Withler, and R.B. Morley. 1985. Effect of egg size on incubation time and alevin and fry size in chum salmon (*Oncorhynchus keta*) and coho salmon. (*O. kisutch*). Can. J. Zool. 63: 847-850.

Beacham, T.D., R.E. Withler, and A.P. Gould. 1985. Biochemical genetic stock identification of chum salmon (*Oncorhynchus keta*) in southern British Columbia, 1985. Can. J. Fish. Aquat. Sci. 43: 437-448.

Beamish, R J., and D.R. Bouillon. 1993. Pacific salmon production trends in relation to climate. Can. J. Fish. Aquat. Sci. 50: 1004-1016.

Beamish, R.J., I.A. Pearsall, and M.C. Healey. 2003. A history of the research on the early marine life of pacific salmon off Canada's Pacific coast. N. Pac. Anadr. Fish Comm. Bull. 3:1-40.

Bigler, B.S., D.W. Welch, and J.H. Helle. 1996. A review of size trends among North Pacific salmon *(Oncorhynchus* spp.). Can J. Fish. Aquatic. Sci. 53: 455-465.

Bilton, H.T., and S. A M. Ludwig. 1966. Times of annulus formation on scales of sockeye, pink, and chum salmon in the Gulf of Alaska. J. Fish. Res. Board Can. 23: 1403-1410.

Birman, I. B. 1951. Qualitative characteristics of the stocks and the dynamics of abundance of the autumn chum salmon in the Amur River. Izv. Tikhookean. Nauchno-lssled. Inst. Rybn. Khoz. Okeanogr. 35: 17-31. (Transl. from Russian; Fish. Res. Board Can. Transl. Ser. 349).

Bradford, M.J., 1995. Comparative review of Pacific salmon survival rates. Canadian Journal of Fisheries and Aquatic Sciences 52, 1327-1338.

Brodeur, R.D., Boehlert, G.W., Casillas, E., Eldridge, M.B., Helle, J.H., Peterson, W.T., Heard, W.R., Lindley, S. T., Schiewe, M.H., 2000. A coordinated research plan for estuarine and ocean research on Pacific salmon. Fisheries 25, 7-16.

Brodeur, R.D., K.W. Myers, and J.H. Helle. 2003. Research conducted by the United States on the early ocean life history of Pacific salmon. N. Pac. Anadr. Fish Comm. Bull. 3:89-131.

Carlson, H.R., E.V. Farley, Jr., K.W. Myers. 2000. The use of otolith marks to determine stock-specific ocean distribution and migration patterns of Alaskan pink and chum salmon in the North Pacific Ocean 1996-1999. N. Pac. Anadr. Fish. Comm. Bull. No. 2:291-300.

Cooney, R.T., Brodeur, R.D., 1998. Carrying capacity and North Pacific salmon production: stock-enhancement implications. Bulletin of Marine Science 62, 443-464.

Dill, L. M., and T. G. Northcote. 1970. Effects of some environmental factors on survival, condition, and timing of emergence of chum salmon fry (*Oncorhyunchus keta*). J. Fish. Res. Board Can. 27: 196-201.

Farley, E.V. Jr., and H.R. Carlson. 2000. Spatial variations in early marine growth and condition of thermally marked juvenile pink and chum salmon in the coastal waters of the Gulf of Alaska. N. Pac. Anadr. Fish. Comm. Bull. No. 2:317-324.

Forbes, L. S., and R. M. Peterman. 1994. Simple size-structured models of recruitment and harvest in Pacific salmon *(Oncorhynchus* spp.). Can. J. Fish. Aquat. Sci. 51: 603-616.

Freeland, H. J. 1990. Sea surface temperatures along the coast of British Columbia: regional evidence for a warming trend. Can. J. Fish. Aquat. Sci. 47: 346-350.

Gilbert, C. H., and W. H. Rich. 1927. Second experiment in tagging salmon in the Alaska Peninsula fisheries reservation, summer of 1923. Fish. Bull. U.S. 42: 27-75.

Hare, S. R., and R. C. Francis. 1995. Climate change and salmon production in the northeast Pacific Ocean. Can. Spec. Publ. Fish. Aquat Sci. 121: 357-372.

Healey, M. C. 1982b. Timing and relative intensity of size selective mortality of juvenile chum salmon *(Oncorhynchus keta)* during early sea life. Can. J. Fish. Aquat. Sci. 39:952-957.

Helle, J. H. 1979. Influence of marine environment on age and size-at-maturity, growth, and abundance of chum salmon, *Oncorhynchus keta* (Walbaum), from Olsen Creek, Prince William Sound, Alaska. Ph.D. thesis, Oregon State University, Corvallis, OR. 118 p.

Helle, J. H. 1981. Significance of the stock concept in artificial propagation of salmonids in Alaska. Can. J. Fish. Aquat. Sci. 38: 1665-1671.

Helle, J. H. 1984. Age and size-at-maturity of some populations of chum salmon in North America, p. 126-143. *In P.* A. Moiseev [ed.], Proceedings of the Pacific Salmon Biology Conference, 3-13 Oct. 1978, Yuzhno-Sakhalinsk, USSR. Pacific Scientific Institute of Fisheries and Oceanography (TINRO), 4 Shevchenko Alley, 690600, Vladivostok, USSR.

Helle, J. H. 1989. Relation between size-at-maturity and survival of progeny in chum salmon, *Oncorhynchus keta* (Walbaum). J. Fish. Biol. 35 (Suppl. A): 99-107.

Helle, J. H., and M. S. Hoffman. 1995. Size decline and older age-at-maturity of two chum salmon *(Oncorhynchus keta)* stocks in western North America, 1972-92. *In* Climate change and northern fish populations. Edited by R. J. Beamish. Can. Spec. Publ. Fish. Aquat. Sci. 121: 245-260.

Helle, J. H., and M. S. Hoffman. 1998. Changes in size and age at maturity of two North. American stocks of chum salmon (*Oncorhynchus keta)* before and after a major regime shift in the North Pacific Ocean. North Pacific Anadromous Fish Commission. Bulletin No. 1, 81-89.

Henry, K.A. 1953. Analysis of factors affecting the production of chum salmon (*Oncorhynchus keta*) in Tillamook Bay. Fish. Comm. Oreg. Contrib. 18: 37 p.

Henry, K.A. 1954. Age and growth study of Tillamook Bay chum salmon (*Oncorhynchus keta*). Fish. Comm. Oreg. Contrib. 19: 28 p.

Hoar, W. S. 1958. The evolution of migratory behaviour among juvenile salmon of the genus *Oncorhynchus*. J. Fish. Res. Board Can. 15: 391-428.

Hunter, J. G. 1959. Survival and production of pink and chum salmon in a coastal stream. J. Fish. Res. Board Can. 16: 835-886.

Ishida, Y., S. Ito, M. Kaeriyama, S. McKinnell, and K. Nagasawa. 1993. Recent changes in age and size of chum salmon *(Oncorhynchus keta)* in the North Pacific Ocean and possible causes. Can. J. Fish. Aquat. Sci. 50: 290-295.

Jaenicke, H.W., Celewycz, A.G., 1994. Marine distribution and size of juvenile Pacific salmon in Southeast Alaska and northern British Columbia. Fishery Bulletin 92(1), 79-90.

Kaeriyama, M. 1989. Aspects of salmon ranching in Japan. Physiol. Ecol. Jpn. Spec. Vol. 1: 625-638.

Kaeriyama, M. 1996. Population dynamics and stock management of hatchery-reared salmons in Japan. Bull. Natl. Res. Inst. Aquacult. (Suppl. 2): 11-15.

Karpenko, V.I. 2003. Review of Russian marine investigations of juvenile Pacific salmon. N. Pac. Anadr. Fish Comm. Bull. 3:69-88.

Kondzela, C. M., C. M. Guthrie, S. L. Hawkins, C. D. Russell, J. H. Helle, and A. J. Gharrett. 1994. Genetic relationships among chum salmon populations in southeast Alaska and northern British Columbia. Can. J. Fish. Aquat. Sci. 51(Suppl. 1):50-64

Koski, K.V. 1975. The survival and fitness of two stocks of chum salmon (*Oncorhynchus keta*) from egg deposition to emergence in a controlled-stream environment at Big Beef Creek. Ph.D. thesis. University of Washington, Seattle, WA. 212 p.

LaLanne, J. J. 1971. Marine growth of chum salmon. Int. North Pac. Fish. Comm. Bull. 27: 71-91.

Landingham, J.H., M.V. Sturdevant and R.D. Brodeur. 1998. Feeding habits of juvenile Pacific salmon in marine waters of southeastern Alaska and northern British Columbia. Fishery Bulletin 96(2):285-302.

LeBrasseur, R. J. 1969. Growth of juvenile chum salmon (*Oncorhynchus keta*) under different feeding regimes. J. Fish. Res. Board Can. 26: 1631-1645.

Mantua, N.J., Hare, S.R., Zhang, Y., Wallace, J.M., Francis, R.C., 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78, 1069-1079.

Manzer, J. I., T. Ishida, A. E. Peterson, and M. G. Hanavan. 1965. Salmon of the North Pacific Ocean. Part V. Offshore distribution of salmon. Int. North Pac. Fish. Comm. Bull. 15.

Marr, J.C. 1943. Age, length and weight studies of three species of Columbia River salmon *(Oncorhynchus keta, O. gorbuscha* and *O. kisutch).* Stanford Ichthyol. Bull. 2: 157-197.

Mason, J.C. 1974. Behavioral ecology of chum salmon fry (*Oncorhynchus keta*) in a small estuary. J. Fish. Res. Board Can. 31: 83-02.

Mayama, H. and Y. Ishida. 2003. Japanese studies on the early ocean life of juvenile salmon. N. Pac. Anadr. Fish Comm. Bull. 3:41-67.

McNeil, W. J. 1966. Effect of the spawning bed environment on reproduction of pink and chum salmon. Fish. Bull. (U.S.) 65: 495-523.

Meuter, F.J., Peterman, R.M., Pyper, B.J., 2002. Opposite effects of ocean temperature on survival rates of 120 stocks of Pacific salmon (Oncorhynchus spp.) in northern and southern areas. Canadian Journal of Fisheries and Aquatic Sciences 59, 456-463.

Miller, A.J., D.R. Cayan, T. P. Barnett, N. E. Graham, and J. M. Oberhuber. 1994. The 1976-77 climate shift of the Pacific Ocean. Oceanography 7(1): 21-26.

Moulton, L.L. 1997. Early marine residence, growth, and feeding by juvenile salmon in Northern Cook Inlet, Alaska. Alaska Fishery Research Bulletin 4(2):154-177.

Myers, K. W., K. Y. Aydin, R. V. Walker, S. Fowler, and M. L. Dahlberg. 1996. Known ocean ranges of stocks of Pacific salmon and steelhead as shown by tagging experiments, 1956-1995. NPAFC Doc. No. 192. Fisheries Research Institute, University of Washington, Seattle, WA.

Neave, F. 1953. Principles affecting the size of pink and chum salmon populations in British Columbia. J. Fish. Res. Board Can. 9: 450-491.

Neave, F. 1958. The origin and speciation of *Oncorhynchus*. Proc. Trans. R. Soc. Can. Ser. 3 52(5): 25-39.

Neave, F., T. Yonemori, and R. G. Bakkala. 1976. Distribution and origin of chum salmon in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 35. 79 p.

Oakley, A. L. 1966. A summary of information concerning chum salmon in Tillamook Bay. Res. Briefs Fish Comm. Oreg. 12(1): 5-21.

Ogura, M., and S. Ito. 1994. Change in the known ocean distribution of Japanese chum salmon, *Oncorhynchus keta*, in relation to the program of stock enhancement. Can. J. Fish. Aquat. Sci. 51: 501-505.

Pearcy, W. G. 1992. Ocean ecology of North Pacific salmonids. Washington Sea Grant Program, University of Washington Press, Seattle, WA. 179 p.

Perry, R.I., N.B. Hargreaves, B.J. Waddell and D.L. Mackas. 1996. Spatial variations in feeding and condition of juvenile pink and chum salmon off Vancouver Island, British Columbia. Fisheries Oceanography 5(2):73-88.

Pirtle, R. B. 1977. Historical pink and chum salmon estimated spawning escapements from Prince William sound, Alaska streams, 1960-1975. Alaska Dept. Fish & Game, ADF&G Tech. Data Rep. 35:332P.

Ricker, W. E. 1964. Ocean growth and mortality of pink and chum salmon. J. Fish. Res. Board Can. 21: 905-931.

Ricker, W. E. 1972. Hereditary and environmental factors affecting certain salmonid populations. P. 19-160 *In* R. C. Simon and P. A. Larkin [ed.} The stock concept in Pacific salmon. H. R. MacMillan Lectures in Fisheries, University of British Columbia.

Salo, E. O. 1988. Chum salmon as indicators of ocean carrying capacity, p. 81-85. *In* W.J. McNeil [ed.], Salmon production, management, and allocation. Oregon State University Press, Corvallis.

Salo, E. O. 1991. Life history of chum salmon *(Oncorhynchus keta), p.* 233-309. *In C.* Groot and L. Margolis [eds.], Pacific salmon life histories. University of British Columbia Press, Vancouver, B.C.

Sano, S. 1966. Chum salmon in the Far East, p. 4-58. *In*: Salmon of the North Pacific Ocean. Part III. A review of the life history of the North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 18.

Sano, S. 1967. Chum salmon in the Far East, p. 23-42. *In*: Salmon of the North Pacific Ocean. Part IV. Spawning populations of North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 23.

Schroder, S. L. 1981. The role of sexual selection in determining overall mating patterns and mate choice in chum salmon. Ph.D. thesis. University of Washington, Seattle, WA. 274 p.

Shepard, M. P., A. C. Hartt, and T. Yonemori. 1968. Salmon of the North Pacific Ocean. Part VIII. Chum salmon in offshore waters. Int. North Pac. Fish. Comm. Bull. 25: 69 p.

Thorsteinson, F. V., J. H. Helle, and D. G. Birkholz. 1971. Salmon survival in intertidal zones of Prince William Sound streams in uplifted and subsided areas, p.194-219. *In:* The great Alaska earthquake of 1964: biology. Natl. Acad. Sci. NAS Publ. 1604.

Thorsteinson, F.V., W.H. Noerenberg, and H.D. Smith. 1963. The length, age, and sex ratio of chum salmon in the Alaska Peninsula, Kodiak Island, and Prince William Sound areas of Alaska. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. 430:84 p.

Walters, C.J., Hilborn, R., Peterman, R.M., Staley, M., 1978. A model for examining early ocean limitation of Pacific salmon production. Journal of the Fisheries Research Board of Canada 35, 1303-1315.

Welch, D. W. 1997. Anatomical specialization in the gut of Pacific salmon (*Oncorhynchus)*: evidence for oceanic limits to salmon production? Can. J. Zool. 75: 936-942.

Wilmot, RL; Everett, RJ; Spearman, WJ; Baccus, R; Varnavskaya, NV; Putivkin, SV. 1994. Genetic stock structure of western Alaska chum salmon and a comparison with Russian far east stocks. International Symposium on Genetics of Subarctic Fish and Shellfish, Juneau, AK (USA), 17-19 May 1993 CAN. J. FISH. AQUAT. SCI.], vol. 51, no. Supplement 1, pp. 84-94.

SPECIES: Chum salmon, *Onchorhynchus keta*

Stage - EFH Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs and larvae	90-125 d	eggs predated by birds, fish and mammals	early summer, fall, winter, and early spring	intragravel in stream beds WC, LK, BCH	7.5 to 50 cm in gravel depth	small to coarse gravel CB, G	NA	Develop at 1-10°C, eggs hatch at 52-173 d, larvae emerge from gravel 146-325 d
Juveniles (freshwater)	1-15 d; short streams = 1d, longer rivers=30 d	fry are predated by birds, fish and mammals	spring	rivers and streams WC, LK, BCH	generally migrating in upper portion of water column	varied	NA	downstream migration is mostly in darkness
Juveniles (estuarine)	2-3 months	copepods, euphausiids, decapod larva, amphipods, gelatinous zooplankton	summer	EST, initially nearshore, then offshore in bays and inlets , along kelp beds	generally occupying the upper portion of water column	varied: K, SAV	NA	Preference for increasing salinities, school with other salmon and Pacific sandfish
Juveniles, (marine)	3 to 6 months	copepods, euphausiids, decapod larva, amphipods, gelatinous zooplankton	summer, fall, and winter prior to annulus formation in Jan.-Mar.	coastal, ICS, MCS, OCS; moving further offshore with growth	generally migrating in upper portion of water column	varied: K, SAV	UP, F, CL, E	Coastal and shelf migrations move into oceanic waters in later stages

Immature and maturing adults (marine)	6 to 10 months	fish, squid, euphausiids, amphipods, copepods, and gelatinous zooplankton	spring, summer, and early fall	Oceanic to nearshore in final migration	P, N	NA	UP, F, CL, E: Regional stocks have specific oceanic migratory patterns	Rapid marine growth; onset of maturation timing varies widely among stocks; generally earlier north, later south
Adults (freshwater)	2-7 yrs of age from egg to mature adult, final stage 1-2 months	Active feeding ceases, digestive organs atrophy	spawning (June-January)	WC, LK, BCH	Varied, holding in pools, spawning on shallow riffles, pools or side-channel sloughs	small to coarse gravel CB, G	NA	sexual dimorphism in spawners, males develop large teeth, called dog salmon

Habitat Description for Sockeye Salmon

(*Oncorhynchus nerka*)

Management Plan and Area(s) Salmon Fisheries in the EEZ Off the Coast of Alaska, NPFMC, 1990

Life History and General Distribution

The natural freshwater range of sockeye salmon includes the Pacific rim of Asia and North America north of about 40°N. Within this area, the primary spawning grounds of sockeye salmon in North America extend from tributaries of the Columbia River to the Kuskokwim River in western Alaska, and on the Asian side, the spawning areas are found mainly on the Kamchatka Peninsula. Spawning populations become more irregular and occasional north of the Bering Strait, on the north coast of the Sea of Okhotsk, and in the Kuril Islands. Centers of the two largest spawning complexes in the North Pacific rim occur in the Bristol Bay watershed of southwestern Alaska and the Fraser River drainage of British Columbia. In marine environments along both the Asian and North American coastlines sockeye salmon occupy ocean waters south of the limits of spawning systems.

Sockeye salmon exhibit a greater variety of life history patterns than other members of the genus *Oncorhynchus,* and characteristically make more use of lake rearing habitat in juvenile stages. Although sockeye salmon are primarily anadromous, there are distinct populations called kokanee which mature, spawn and die in fresh water without a period of sea life. Typically, but not universally, juvenile anadromous sockeye utilize lake rearing areas for one to three years after emergence from the gravel, however, some populations utilize stream areas for rearing and migrate to sea soon after emergence. Anadromous sockeye may spend from one to four years in the ocean before returning to fresh water to spawn and die in late summer and fall.

The adaptations of sockeye salmon to lake environments appear to require more precise homing to spawning areas, both as to time and location than is found in the other species of Pacific salmon. Although available spawning localities are more restricted because of the usual requirement of a lake rearing environment for the juveniles, the overall success of this adaptation is indicated by the fact that sockeye are much more abundant than chinook (*O. tshawytscha*) and coho salmon (*O. kisutch*), which utilize stream rearing environments as juveniles. Juvenile sockeye salmon in fresh water do not need the territorial stream behavior displayed by juvenile chinook and coho salmon, but do exhibit schooling tendencies more characteristic of pelagic feeding fishes.

Other distinctions of sockeye salmon include growth rate and size at maturity. Sockeye do not exhibit the rapid marine growth of coho or pink salmon (*O. gorbuscha*) which mature and return to fresh water after a single winter in the ocean, or of chinook or chum salmon (*O. keta*) which attain a much larger average size at maturity. The flesh of sockeye is a darker red than that of the other salmon species, a color long considered to be a marketing attribute of the canned and, more recently, the fresh or fresh-frozen product.

Fisheries

Sockeye salmon are an important component, and often the most lucrative fishery for Pacific salmon. Coastal fisheries for sockeye salmon presently occur in North America (Canada and the United States) and Asia (Japan and Russia) with major fisheries in all areas except Japan. From 1920 through 1945, sockeye salmon were caught on the high seas by a Japanese mother ship fishery. This fishery started again in 1953 and a land based driftnet fishery moved sufficiently offshore to begin substantial catches of sockeye in 1958. Restrictions in fishing areas resulting from renegotiation of international fishery treaties

ended the high seas fisheries in the mid 1980s. In recent years, about 22% of the numbers and 28% by weight of all salmon caught commercially in the North Pacific Ocean and adjacent waters were sockeye. Catches in North America, primarily Alaska and British Columbia, have always been greater than Asian catches. North American catches averaged about 30 million through 1940, declined to 10-15 million in the early 1960s and surged to 40 million and more in the 1990s. The recent record high catches resulted primarily from an increase in run magnitudes of natural stocks in central and western Alaska. Historically, Asian catches of sockeye salmon have averaged fewer than 10 million fish. Most sockeye salmon in the U.S. are caught in Alaska where major fisheries occur in Southeast, central and westward areas. In Alaska, sockeye fisheries occur primarily within State territorial seas (inside 3-miles).

Sockeye salmon catches have been at historic records in Alaska over the past decade with catches exceeding 60 million fish in several years. Most sockeye salmon in Alaska are caught by set and drift gill net fisheries. Recreational fisheries in Alaska usually harvest between 200 and 400 thousand sockeye salmon annually, mostly in river system of the Kenai Peninsula in central Alaska. Subsistence catches of sockeye salmon are not universally maintained, but the catches are important, particularly to native people in a number of localities. The Fraser River Indian tribes recorded annual subsistence catches for the years 1970-82 of 240,000. The subsistence catch of sockeye salmon in the United States was 315,000 in 1993, and over 307,000 was caught in Alaskan waters.

Gill net fisheries for sockeye salmon have some bycatch associated with them, primarily other salmon. The most important bycatch issue is in the southeastern region where younger marine-age chinook salmon, similar in size to sockeye, are caught in sockeye net fisheries. The total harvest of chinook salmon in this region is controlled by quotas under auspices of the Pacific Salmon Treaty. The Alaska Board of Fisheries allocates a portion of the quota for chinook salmon as an allowable bycatch in gill net fisheries.

Measured marine survivals of sockeye salmon, from entry of smolts into stream mouth estuaries to returning adults, have ranged from about 5% to over 50%. Scientists, in general, believe that much of the natural mortality of sockeye salmon juveniles in the marine environment occurs within the first few months, and in probably influenced by three factors of unknown relative importance: (1) size and age at seaward migration; (2) timing of entry into the marine environment; and (3) length of stay in the ocean. Variations in oceanographic conditions and in marine predator populations (fish, mammals and birds) undoubtedly have affected the marine survival of sockeye populations in different ways around the North Pacific rim, but these effects are poorly understood.

Relevant Trophic Information

Sockeye salmon eggs, alevins, and juveniles in freshwater streams and lake systems provide an important nutrient and food source for aquatic invertebrates, other fishes, birds and small mammals. In the marine environment sockeye salmon juveniles are food for many other fishes and coastal sea birds. Adult sockeye salmon are known to be eaten by marine mammals and sharks.

Millions of sockeye salmon adults returning to spawn in thousands of streams through out Alaska provide significant nutrient input into the trophic level of these coastal watersheds. Adult sockeye salmon in streams are major food sources for gulls, eagles, and other birds, along with bear, otter, mink and other mammals.

Describe any potential gear impacts on the habitats of this or other species.

Because sockeye salmon are primarily caught in gill nets there are no known gear impacts to the habitats where these fisheries occur.

What is the approximate upper size limit of juvenile fish (in cm)? Roughly 25 cm.

Provide source (agency, name and phone number or literature reference for any possible additional distribution data.

Karl Hofmeister, Alaska Department of Fish and Game, 907-465-4250
Andy MacGregor, Alaska Department of Fish and Game, 907-465-4224
David Barto, Alaska Department of Fish and Game, 907-465-4268

Habitat and Biological Associations (if known) Narrative

Eggs and Spawning: Sockeye salmon generally spawn in late summer and autumn. Within this period, time of spawning for different stocks can vary greatly, apparently because of adaptations to the most favorable survival conditions for spawning, egg and alevin incubation, emergence, and subsequent juvenile feeding. Although timing of spawning varies little from year to year within a specific spawning area, there are great differences in timing among spawning areas. The timing of spawning appears to be dependent to some degree on the temperature regimen in the gravel where the eggs are incubated. This varies distinctly among spawning area types. In the Bristol Bay region of Alaska, spawning begins in late July in the smaller streams, in early to mid-August in the tributaries of some lakes, and in late August to mid-September in most lake beach areas. In Lake Kuril and its tributaries spawning continues from the end of June until early February with the main spawning occurring from September to November.

Among the species of Pacific salmon, the sockeye salmon exhibits the greatest diversity in adaptation to a wide variety of spawning habitats. The selection of habitats and timing of spawning by a sockeye stock are linked to success of survival, not only during spawning and incubation of the eggs and alevins, but also in the chain of freshwater and marine environments to which the progeny are subsequently exposed. In most instances, but not all, the subsequent environment of the juveniles is a lake or lake chain, and the behavior of the juveniles after emergence depends on the location of the spawning area in relation to the lake rearing area to be utilized. Lake-beach spawning has been recorded in most sockeye lake systems, and is apparently important habitat. Sockeye are also known to spawn in areas which lack lake rearing habitat. These “river spawning” or “sea type” sockeye lay their eggs in river systems with no lake, and emergent fry apparently feed in the stream or low-salinity estuaries for several months before migrating to offshore ocean areas. The circumstances surrounding the initial establishment of a spawning colony and the subsequent adaptive behavior of the progeny can only be surmised. However, the continued use of a specific spawning environment by a sockeye stock depends on the precise homing ability of the species, in which straying to other potential spawning locations is minimal.

The composition of spawning substrate utilized by sockeye salmon varies widely. Some lake-beach spawning occurs to a depth of nearly 30 m in areas of strong upwelling groundwater. In some lakes mass spawning takes place over large angular gravel, too large to be moved by salmon in the normal digging process. The eggs settle in the crevices between the rocks. Generally, however, spawning along lake beaches and in streams takes place in gravel small enough to be readily dislodged by digging, and the digging process tends to remove the silt and clean the gravel where the eggs are deposited. Water depth does not seem to be a critical factor to sockeye in selecting a spawning site. In the small streams and spring ponds it is common to observe pairs of salmon in the spawning process with their dorsal surfaces protruding from the water. In larger rivers, spawning depths are generally not great because riffle areas are preferred. Spawning on lake beaches can extend to considerable depths. It is clear that sockeye can detect

upwelling groundwater areas along lake beaches and in spring ponds areas in which to spawn. Generally, the spawning beds are situated in areas with clean gravel, or along the borders between pools and riffles in shallow water with moderate to fast currents. In large rivers, they may spawn in discrete sections of main channels or in tributary channels.

Superimposition is minimized by the territorial defense of the redd by the female following egg deposition, which protects the redd for a few days. Female territory is partly a function of spawner density. Estimates of the capacity of streams to support spawning sockeye were based on density of one female/2 m^2. In spawning channels, maximum fry production was achieved at the spawner density of one female/m^2.

Larvae/alevins: Fertilized eggs begin their five- to eight-month period of embryonic development and growth in intragravel interstices. To survive successfully, the eggs, alevins and pre-emergent fry must first be protected from freezing, desiccation, stream bed scouring or shifting, mechanical injury and predators. Water surrounding them must be non-toxic and of sufficient quality and quantity to provide basic requirements of suitable temperatures, adequate supply of oxygen, and removal of waste materials. Collectively, these requirements are, on average, only partially met even under the most favorable natural conditions. Overall freshwater survival of sockeye salmon from egg to advanced alevin and emerged fry, even in highly productive streams, commonly reaches only 10%-20%, and at times is as low as 1%.

Rates of egg development, survival, size of hatched alevins and percentage of deformed fry are related to temperature and oxygen levels during incubation. Temporary low stream temperatures or dissolved oxygen concentrations, however, may be relatively unimportant at some developmental stages, but lethal at others. Generally, low oxygen levels are non-lethal early, but lethal late in development.

Juveniles: Fry emergence apparently begins in early to mid-April in most instances, peaks in early to mid-May, and ends in late May to early June. Newly emerged sockeye salmon fry show a marked negative rheotaxis, and actively swim downstream to lakes. In some lake outlet spawning areas, the emerging fry swim laterally in an attempt to reach the river banks and avoid being swept downstream. The emergence behavior of fry in lakeshore spawning areas has not been reported. It has been suggested that the seasonal timing of sockeye fry emergence, optimizes the timing of dispersal into their feeding habitat, particularly to take advantage of the seasonal peak abundance of zooplankton of appropriate size. It is postulated that fry emerging earlier or later than the optimum may suffer greater mortality, and thus that timing is a response to this selective pressure. The survival value in entering the lake early is to take advantage of feeding in the lake as long as possible during the summer, thus achieving larger size in preparation for spring smoltification. Annual timing of fry migration and its seasonal pattern is a function of the seasonal timing of the adult spawning period, ecological factors within the incubation habitat that affects development rate and alevin behavior, and transit time needed by the fry to reach their feeding habitat.

Upon entering nursery lakes, sockeye fry disperse quickly into their lake feeding areas. Movement of fry into the nursery areas may be direct and immediate, or sequential, the latter involving occupation of intermediate feeding areas for a period of time. The plasticity of response suggests definite racial adaptations to a variety of different environmental conditions. Intermediate feeding and growth can occur along outlet river banks before migration into the nursery lake. In-lake dispersions of fry is probably a

mechanism whereby the lake zooplankton is effectively utilized as food for the juvenile fish.

Sockeye salmon juveniles typically spend one or more growing seasons in the limnetic zone of a nursery lake before smoltification. The transition in feeding behavior and diet from the time of emergence of the fry from stream or lakeshore to the time of smoltification takes many forms. In general, it is a shift from dependence on dipteran insects to pelagic zooplankton. The annual growth attained by juvenile sockeye and length of residence in fresh water varies greatly among populations in different lake systems, as well as between years within individual lakes. Factors affecting growth are highly complex and include (1) size and species composition of the food supply; (2) water temperature and thermal stratification of the lake; (3) photoperiod and length of growing season; (4) relative turbidity of the lake and available light intensity in the water column; (5) intra- and interspecific competition; (6) parasitism and disease; (7) feeding behavior of juvenile sockeye to minimize predation; and (8) migratory movements to seek favorable feeding environments. Growth influences durations of stay in fresh water before smoltification, and within many lake populations the larger members of a year class tend to migrate to sea earlier the spring or migrate a year earlier than smaller members. In the more southern systems, smoltification after one year is nearly universal. Size is not strictly the determinant for duration of stay in fresh water, because some populations with very poor freshwater growth in their first year migrate as yearlings, whereas other populations exhibiting good first-year growth migrate predominantly after a second year of growth. Emergent fry of "river spawning" or "sea type" sockeye which spawn in systems lacking lake rearing habitat, feed in the stream or low-salinity estuaries for several months before migrating to offshore ocean areas.

Sockeye fry at the beginning of lake life are between 25 and 31 mm and weigh between 0.1 and 0.2 g. Yearling smolts vary greatly in size; average range 60 to 125 mm and 2.0 to 30.0 g. After a second year of growth in a lake, two-year old smolts often overlap the size range of yearlings, and have been reported at an average of 200 mm and 84.0 g at Hidden Lake in central Alaska. Sea type sockeye smolts are typically the same size as yearling smolts when they migrate to offshore ocean areas.

After smoltification and exodus from natal river systems in spring or early summer, juvenile sockeye enter the marine environment where they reside for one to four years, usually two or three years, before returning to spawn. Depending on the stock, they may reside in the estuarine or nearshore environment before moving into oceanic waters. They are typically distributed in offshore waters by autumn following outmigration. During the initial marine period, yearling sockeye forage actively on a variety of organisms, apparently preferring copepods and insects, but also eating amphipods, euphausiids, and fish larvae when available. Their growth rate is about 0.6 mm/d.

After entering the open sea during their first summer, juvenile sockeye salmon remain in a band relatively close to the coast. Off the outer coast of British Columbia and southeast Alaska, the juveniles are often recorded on the open sea in late June. By July, the fish are found moving northwestward into the Gulf of Alaska. Sampling in the North Pacific has shown that by October juvenile sockeye are still somewhat distributed primarily nearshore. Evidence indicates the northwestward movement up the eastern Pacific rim is followed by a southwestward movement along the Alaska Peninsula. An offshore movement into the Gulf of Alaska in late autumn or winter is conjectured for the location of age 1 sockeye in early spring.

Adults: Sockeye salmon from different regions differ in growth rate and age and size at maturity. Growth in length is greatest during the first year at sea, and increase in weight is greatest during the second year. Most sockeye spend two to three years feeding in the ocean before their final summer of return. There is substantial variation in size among populations within an age class. In Alaska, the average size of females that had spent 2 years in the ocean ranged from 45 to 54 cm, and of those that had spent 3 years the average ranged from 51 to 60 cm.

References

Atkinson, C.E., T.H. Rose, and T.O. Duncan. 1967. Pacific salmon in the United States, p. 43-223. *In:* Salmon of the North Pacific Ocean. Part IV. Spawning populations of North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 23.

Baggerman, B. 1960. Salinity preference, thyroid activity and the seaward migration of four species of Pacific salmon *(Oncorhynchus). J.* Fish. Res. Board Can. 17:295-322.

Bakkala, R.G. 1971. Distribution and migration of immature sockeye salmon taken by U.S. research vessels with gillnets in offshore waters, 1956-67. Int. North Pac. Fish. Comm. Bull. 27:170.

Beamish, R.J., I.A. Pearsall, and M.C. Healey. 2003. A history of the research on the early marine life of pacific salmon off Canada's Pacific coast. N. Pac. Anadr. Fish Comm. Bull. 3:1-40.

Bergander, F. 1985. Sockeye salmon (*Oncorhynchus nerka)* stock assessment and evaluation in southeastern Alaska, 1982-1983. Alaska Dep. Fish Game ADF&G Tech Rep. 142:27 p.

Bill, D. 1984. 1982 Kwichak River sockeye smolt studies, p. 2-13. In: D.M. Eggers and H.J. Yuen (eds.) 1982 Bristol Bay sockeye salmon smolt studies. Alaska Dep. Fish Game ADF&G Tech Rep. 103.

Birman, I.B. 1960. New information on the marine period of life and the marine fishery of Pacific salmon, p. 151-164. In: Trudy Soveshchaniia po bioligicheskim osnovam okeanicheskovo rybolovostva, 1958. Tr. Soveshch. Iktiol. Komm. Akad. Nauk SSSR 10 (Trans. From Russian; Fish. Res. Board Can. Transl. Ser. 357).

Blair, GR, DE Rogers, and TP Quinn. 1993. Variation in history characteristics and morphology of sockeye salmon in the Kvichak River system, Bristol Bay, Alaska. Transactions of the American Fisheries Society: Vol. 122, No. 4, pp. 550-559.

Bradford, M.J., 1995. Comparative review of Pacific salmon survival rates. Canadian Journal of Fisheries and Aquatic Sciences 52, 1327-1338.

Brannon, E.L. 1965. The influence of physical factors on the development and weight of sockeye salmon embryos and aliveness. Int. Pac. Salmon Fish. Comm. Prog. Rep. 12:26 p.

Brett, J.R., and J.E. Shelbourn. 1975. Growth rate of young sockeye salmon, (*Oncorhynchus nerka)*, in relation to fish size and ration level. J. Fish. Res. Board Can. 32:2103-10.

Brodeur, R.D., Boehlert, G.W., Casillas, E., Eldridge, M.B., Helle, J.H., Peterson, W.T., Heard, W.R., Lindley, S. T., Schiewe, M.H., 2000. A coordinated research plan for estuarine and ocean research on Pacific salmon. Fisheries 25, 7-16.

Brodeur, R.D., K.W. Myers, and J.H. Helle. 2003. Research conducted by the United States on the early ocean life history of Pacific salmon. N. Pac. Anadr. Fish Comm. Bull. 3:89-131.

Bugaev, V.F. 1978. Using the structure of zones of converged sclerites on scales as a criterion for differentiation of local groupings of the sockeye salmon, (*Oncorhynchus nerka)*, of the Kamchatka River basin. J. Ichthyol. 18:826-836.

Burgner, R.L. 1991. Life history of sockeye salmon, *Oncorhynchus nerka*, p 3-117 *in* C. Groot and L. Margolis, eds. Pacific salmon life histories. UBC Press, Vancouver.

Chernenko, E.V., and G.D. Kurenkov. 1980. Differentiation of the stock of kokanee *Oncorhynchus nerka* (Walbaum) from Kronotsk Lake, p. 11-15. In: S.M. Konovalov (ed.) Populyatsionnaya biologiya I sistematika lososevykh. Db. Rab. Aakad. Nauk SSSR Dal'nev. Nauch. Tsentr. Inst. Biol. Morya 18 (In Russian).

Cooney, R.T., Brodeur, R.D., 1998. Carrying capacity and North Pacific salmon production: stock-enhancement implications. Bulletin of Marine Science 62, 443-464.

Drucker, B. 1970. Red Salmon studies at Karluk Lake, 1968. U.S. Fish and Wildlife Service, Auke Bay, AK. 55 p.

Edmundson, JA, and A Mazumder. 2001. Linking growth of juvenile sockeye salmon to habitat temperature in Alaskan lakes. Transactions of the American Fisheries Society: Vol. 130, No. 4, pp. 644-662.

Ellis, R.J. 1974 Distribution, abundance, and growth of juvenile sockeye salmon, *Oncorhynchus nerka*, and associated species in the Naknek River system, 1961-1964. NOAA Tech Rep. NMFS SSRF-678:53p.

Flagg, L.C., P. Shields, and D.C. Waite. 1985. Sockeye salmon smolt studies, Kasilof River, Alaska 1984. Alaska Dep. Fish Game FRED Rep. 47:43 p.

Foerster, R.E. 1968. The sockeye salmon, *Oncorhynchus nerka*. Bull. Fish. Res. Board Can. 162:422 p.

French, R., H. Bilton, M. Osako, and A. Hartt. 1976. Distribution and origin of sockeye salmon *(Oncorhynchus nerka)* in offshore water of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 34: 113 p.

French, R.R., and J.E. Mason. 1964. Salmon distribution and abundance on the high seas-winter season 1962 and 1963. Int. North Pac. Fish. Comm. Annu. Rep. 1963:131-141.

French, R.R., and R.G. Bakkala. 1974. A new model of ocean migrations of Bristol Bay sockeye salmon. Fish. Bull. (U.S.) 72:589-614.

Fujii, T. 1975. On the relation between the homing migration of the western Alaska sockeye salmon *Oncorhynchus nerka* (Walbaum) and oceanic conditions in the eastern Bering Sea. Mem. Fac, Fish. Hokkaido Univ. 22:99-191.

Fulton, L.A. 1970. Spawning areas and abundance of steelhead trout and coho, sockeye, and chum salmon in the Columbia River basin - past and present. U.S. Nat. Mar. Fish. Ser. Spec. Sci. Rep. Fish. 618:37 p.

Gard, R., and B. Drucker. 1985. Differentiation of subpopulations of sockeye salmon in the Karluk River system. Annu. Rep. School Fish. Sci. Univ. Alaska, Juneau 1983/84:7.

Groot, C., and K. Cooke. 1987. Homing migration of sockeye salmon, *Oncorhynchus nerka,* to the Fraser River. Fish. Bull. (U.S.) 85:455-469.

Guthrie, C.M. III., E.V. Farley, Jr., N.L Weemes, and E.C. Martinson. 2000. Genetic stock identification of sockeye salmon captured in the coastal waters of Unalaska Island during April/May and August 1998. N. Pac. Anadr. Fish. Comm. Bull. No. 2:309-316.

Hanamura, N. 1966. Sockeye salmon in the far east, p. 1-27. *In:* Salmon of the North Pacific Ocean. Part III. A review of the life history of North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 18.

Harris, C. 1987. Catches of North American sockeye salmon *(Oncorhynchus nerka)* by the Japanese high seas salmon fisheries, 1972-1984, p. 458-479. In: H.D. Smith, L. Margolis, and C.C. Wood (eds.). Sockeye salmon *(Oncorhynchus nerka)* population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96.

Hartman, W.L., and R.L. Burgner. 1972. Limnology and fish ecology of sockeye salmon nursery lakes of the world. J. Fish. Res. Board Can. 29:699-715.

Healey, M.C. 1987. The adaptive significance of age and size at maturity in female sockeye salmon *(Oncorhynchus nerka)*, p. 110-117. In: H.D. Smith, L. Margolis, and C.C. Wood (eds.). Sockeye salmon *(Oncorhynchus nerka)* population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96.

Healey, M.C. 1991. Diets and feeding rates of juvenile pink, chum, and sockeye salmon in Hecate Strait, British Columbia. Transactions of the American Fisheries Society: Vol. 120, No. 3, pp. 303-318.

Hoag, S.H. 1972. The relationship between the summer food of juvenile sockeye salmon, *Oncorhynchus nerka*, and the standing stock of zooplankton in Iliamna Lake, Alaska. Fish. Bull. (U.S.) 70:355-362.

Huttunen, D.C. 1987. Abundance, age, sex and size of salmon (*Oncorhynchus* sp.) catches and escapements in the Kuskokwim area, 1985. Alaska Dep. Fish Game ADF&G Tech. Data Rep. 212:83 p.

Jaenicke, H.W., Celewycz, A.G., 1994. Marine distribution and size of juvenile Pacific salmon in Southeast Alaska and northern British Columbia. Fishery Bulletin 92(1), 79-90.

Kaeriyama, M. M. Nakamura, M, Yamaguchi, H. Ueda, G. Anma, S. Takagi, KY Aydin, RV Walker, and KW Myers. 2000. Feeding ecology of sockeye and pink salmon in the Gulf of Alaska. Recent changes in ocean production of Pacific salmon. No. 2, pp.55-63. [Bull.NPAFC].

Karpenko, V.I. 2003. Review of Russian marine investigations of juvenile Pacific salmon. N. Pac. Anadr. Fish Comm. Bull. 3:69-88.

Lander, A.H., and G.K. Tanonaka. 1964. Marine growth of western Alaskan sockeye salmon (*Oncorhynchus nerka* Walbaum). Int. North Pac. Fish. Comm. Bull. 14:1-31.

Landingham, J.H., M.V. Sturdevant and R.D. Brodeur. 1998. Feeding habits of juvenile Pacific salmon in marine waters of southeastern Alaska and northern British Columbia. Fishery Bulletin 96(2):285-302.

Lebida, R.C. 1984. Larson Lake sockeye and coho salmon smolt enumeration and sampling, 1982. Alaska Dep. Fish Game FRED Rep. 35:31p.

LeBrasseur, R.J. 1966. Stomach contents of salmon and steelhead trout in the northeastern Pacific Ocean. J. Fish. Res. Board Can. 23:85-100.

Mantua, N.J., Hare, S.R., Zhang, Y., Wallace, J.M., Francis, R.C., 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78, 1069-1079.

Manzer, J.I., T. Ishida, A.E. Peterson, and M.G. Hanavan. 1965. Salmon of the North Pacific Ocean. Part V. Offshore distribution of salmon. Int. North Pac. Fish. Comm. Bull. 15:452 p.

Mathisen, OA, and NJ Sand. 2001. Density-dependent ocean growth of some Bristol Bay sockeye salmon stocks. Spatial Processes and Management of Marine Populations, pp. 349-362. Lowell Wakefield Fisheries Symposium Series. No. 17. Univ. of Alaska Sea Grant, PO Box 755010, Fairbanks, Alaska, 99775.

Mayama, H. and Y. Ishida. 2003. Japanese studies on the early ocean life of juvenile salmon. N. Pac. Anadr. Fish Comm. Bull. 3:41-67.

Meuter, F.J., Peterman, R.M., Pyper, B.J., 2002. Opposite effects of ocean temperature on survival rates of 120 stocks of Pacific salmon (Oncorhynchus spp.) in northern and southern areas. Canadian Journal of Fisheries and Aquatic Sciences 59, 456-463.

Moulton, L.L. 1997. Early marine residence, growth, and feeding by juvenile salmon in Northern Cook Inlet, Alaska. Alaska Fishery Research Bulletin 4(2):154-177.

Nelson, J.S. 1968. Distribution and nomenclature of North American kokanee, *Oncorhynchus nerka.* J. Fish. Res. Board Can. 25:409-414.

Olsen, J.C. 1968. Physical environment and egg development in a mainland beach area and an island beach area of Iliamna Lake, p. 169-197. In: R.L. Burgner (ed.). Further studies of Alaska sockeye salmon. Univ. Wash. Publ. Fish. New Ser. 3.

Peterson, DP. And CJ Foote. 2000. Disturbance of small-stream habitat by spawning sockeye salmon in Alaska. Transactions of the American Fisheries Society: Vol. 129, No. 4, pp. 924-934.

Raleigh, R.F. 1967. Genetic control in the lakeward migrations of sockeye salmon *(Oncorhynchus nerka)* fry. J. FISH. Res. Board Can. 24:2613-2622.

Rand, P.S., Scandol, J.P., Walter, E.E., 1997. NerkaSim: A research and educational tool to simulate the marine life history of Pacific salmon in a dynamic environment. Fisheries 22 (10), 6-13.

Ricker, W.E. 1962. Comparison of ocean growth and mortality of sockeye salmon during their last two years. J. Fish. Res. Board Can. 19:531-560.

Ricker, W.E. Size and age of British Columbia sockeye salmon (*Oncorhynchus nerka*) in relation to environmental factors and the fishery. Can. Tech. Rep. Fish. Aquat. Sci.1115:32 p.

Rogers, D.E. 1987. The regulation of age at maturity in Wood River sockeye salmon (*Oncorhynchus nerka*), p. 78-89. In: H.D. Smith, L. Margolis, and C.C. Wood (eds.).Sockeye salmon *(Oncorhynchus nerka)* population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96.

Ruggerone, G.T., M. Zimmermann, K.W. Myers, J.L. Nielsen, and D.E. Rogers. 2003. Competition between Asian pink salmon (Oncorhynchus gorbuscha) and Alaskan sockeye salmon (O. nerka) in the North Pacific Ocean. Fish. Oceanogr. 12:3. 209-219.

Sharr, S. 1983. Catch and escapement statistics for Copper and Bering River sockeye (*Oncorhynchus nerka*), chinook (*O. tshawytscha*), and coho salmon (*O. kisutch*), 1982. Alaska Dep. Fish Game. ADF&G Tech. Data Rep 98:45 p.

Simpson, K., L. Hop Wo, and I. Miki. 1981. Fish surveys of 15 sockeye salmon (*Oncorhynchus nerka*) nursery lakes in British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 1022:87 p.

Straty, R.R. 1974. Ecology and behavior of juvenile sockeye salmon (*Oncorhynchus nerka*), in Bristol Bay and the eastern Bering Sea, p. 285-320. In: D.W. Hood and E.J. Kelley (eds.) Oceanography of the Bering Sea with emphasis on renewable resources. Univ. Alaska Inst. Mar. Sci. Occ. Publ.2

Takeuchi, I. 1972. Food animals collected from the stomachs of three salmonid fishes (*Oncorhynchus*) and their distribution in the natural environments in the northern North Pacific. Bull. Hokkaido Reg. Fish. Res. Lab. 38:119 p.

Walters, C.J., Hilborn, R., Peterman, R.M., Staley, M., 1978. A model for examining early ocean limitation of Pacific salmon production. Journal of the Fisheries Research Board of Canada 35, 1303-1315.

Welch, D.W., Ishida, Y.; Nagasawa, K., 1998. Thermal limits and ocean migrations of sockeye salmon (*Oncorhynchus nerka*): Long-term consequences of global warming. Canadian Journal of Fisheries and Aquatic Sciences 55(4), 937-948.

Wood, C.C., B.E. Riddell, and D.T. Rutherford. 1987. Alternative juvenile life histories of sockeye salmon *Oncorhynchus nerka*) and their contribution to production in the Stikine River, northern British Columbia, p. 12-24. In: H.D. Smith, L. Margolis, and C.C. Wood (eds.).Sockeye salmon *(Oncorhynchus nerka)* population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96.

SPECIES: Sockeye salmon, *Onchorynchus nerka*

Stage	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs and larvae (alevins)	eggs: 90-100 d larvae: 100-125 d	NA	late summer, fall and winter	WC, LK	Intragravel	CB, G	NA	Develop at 1-10°C, eggs hatch about 100 d, alevins emerge from gravel about 125 d post hatch
Juveniles, Freshwater	1 to 3 years, fry emerge and move quickly to lakes, or, rarely, 3-4 mo in estuaries	copepods, bosminids, Daphnia chironomids dipterans, stoneflies	for yearling and older smolt, early to late summer for sea type run	WC, LK EST	P, N	NA	NA	Preference pelagic feeding in lakes, usually not with other fishes, except when predators present
Juveniles, estuarine	1-4 mo	copepods, amphipods,	spring, summer, fall	BCH, EST, to 30 m	P, N	NA	UP, CL	larger fish progressively farther from shore
Juveniles, marine	6-8 mo	copepods, amphipods, small fishes, squid mysids, euphausiids	early summer to late winter	BCH, ICS, MCS, IP BAY	P, N	NA	UP, CL	movements from near-shore to offshore areas
Adult, immature and maturing, marine	1 - 4 yrs from smolt to mature adult	copepods, amphipods, insects, small fishes, squid	immature: year round 1-3 yr	BCH, ICS, MCS, OCS, USP, LSP, BSN, BAY,	P, N	NA	UP	migration timing for different regional stock groups varies; earlier in the north, later in the south
Adults, freshwater	2 - 4 mo	no active feeding in freshwater	Spawning migration (May-August)	WC, LK	depth in streams <10 cm, depth in lakes to 20 m	CB, G	NA	migration timing for different regional stock groups varies; earlier in the north, later in the south

Habitat Description for Chinook Salmon

(*Oncorhynchus tshawytscha*)

Management Plan and Area(s): Salmon Fisheries in the EEZ Off the Coast of Alaska, NPFMC, 1990

Life History and General Distribution

Chinook salmon, also called king, spring, or tyee salmon, are the least abundant and largest of the Pacific salmon. They are distinguished from other species of Pacific salmon by their large size, the small black spots on both lobes of the caudal fin, black pigment at the base of the teeth, and a large number of pyloric caeca. The natural freshwater range of the species includes large portions of the Pacific rim of North America and Asia. In North America, chinook salmon historically ranged from the Ventura River in California (~34° latitude) to Kotzebue Sound in Alaska (~66° N); in addition, the species has been identified in North America in the Mackenzie River, which drains into the Arctic Ocean. In Asia, natural populations of chinook salmon have been documented from Hokkaido Island, Japan (~42° N) to the Andyr River in Russia (~64° N). Within this range, the largest rivers tend to support the largest aggregate runs of chinook salmon and have the largest individual spawning populations. Major rivers near the southern and northern extremes of the range support populations of chinook salmon comparable to those near the middle of the range. For example, in North America, the Yukon River near the north edge of the range and the Sacramento-San Joaquin River system near the south edge of the range have historically supported chinook salmon runs comparable to those of the Columbia River and the Fraser River, which are near the center of the species range along this Pacific coast.

In marine environments, chinook salmon range widely throughout the North Pacific Ocean and the Bering Sea, from 38° latitude. The southern edge of the marine distribution expands and contracts seasonally and between years depending on ocean temperature patterns. While the marine distribution of chinook salmon can be highly variable even within a population, there are general migration and ocean distribution patterns characteristic of populations in specific geographic areas. For example, chinook salmon that spawn in rivers from the Rogue River in Oregon south to California disperse and rear in oceanic waters off the Oregon and California Coast, whereas those that spawn north of the Rogue River to southeastern Alaska migrate north and westward along the Pacific coast. These migration patterns are of particular interest for the management of chinook salmon in the EEZ off Alaska, as they result in the harvest of fish from Oregon, Washington, British Columbia, and Alaska within the management zone.

Pacific salmon have a generalized life history that includes the incubation and hatching of embryos and emergence and initial rearing of juveniles in freshwater; migration to oceanic habitats for extended periods of feeding and growth; and return to natal waters for completion of maturation, spawning, and death. Within this general life history strategy, chinook salmon display diverse and complex life history patterns and tactics. Their spawning environments range from just above tidewater to over 3,200 km from the ocean, from coastal rainforest streams to arid mountain tributaries at elevations over 1,500 m. At least 16 age categories of mature chinook salmon have been documented, involving 3 possible freshwater ages and total ages of 2-8 years, reflecting the high variability within and among populations in length of freshwater, estuarine, and oceanic residency. Chinook salmon also demonstrate variable ocean migration patterns and timing of spawning migrations.

This variation in life history strategy has been explained by separating chinook salmon into two races: stream- and ocean-type fish. Stream-type fish have long freshwater residence as juveniles (1-2 years), migrate rapidly to oceanic habitats, enter freshwater as immature or "bright" fish, and spawn far upriver in late summer or early fall. Ocean-type fish have short, highly variable freshwater residency (from a few

days to 1 year), extensive estuarine residency, enter fresh-water at a more advanced state of maturity, and spawn within a few weeks of freshwater entry in the lower portions of the watershed. Within these two types, there is also substantial variability due to a combination of phenotypic plasticity and genetic selection to local conditions. For example, adult run-timing is strongly influenced by in-river flow volumes and temperature levels.

Chinook salmon have distinctly different feeding habits and distribution and in ocean habitats than do other species of Pacific salmon. Chinook salmon are the most piscivorous of the Pacific salmon, and are also distributed deeper in the water column. While other species of salmon generally are surface oriented, utilizing primarily the upper 20 m, chinook salmon tend to be at greater depths and are often associated with bottom topography. Because of their distribution in the water column, the majority of chinook salmon harvested in commercial troll fisheries are caught at depths of 30 m or greater, and chinook salmon is the most common salmon species taken as bycatch in mid-water and bottom trawl fisheries.

Declines in the abundance of chinook salmon have been well documented throughout the southern portion of the range. Concern over coast-wide declines from southeastern Alaska to the Pacific Northwest was a major factor leading to the signing of the Pacific Salmon Treaty between the United States and Canada in 1985. Wild chinook salmon populations have been extirpated from large portions of their historic range in a number of watersheds in California, Oregon, Washington, Idaho, and southern British Columbia, and a number of Evolutionarily Significant Units (ESUs) have been listed by National Marine Fisheries Service as at risk of extinction under the Endangered Species Act (ESA). Habitat degradation is the major cause for extinction of populations; most are related to dam construction. Urbanization, agricultural land use and water diversion, and logging are also factors contributing to habitat degradation and the decline of chinook salmon. The development of large-scale hatchery programs, have, to some degree, mitigated the decline in abundance of chinook in some areas. However, genetic and ecological interactions of hatchery and wild fish have also been identified as risk factors for wild populations, and the high harvest rates directed at hatchery fish may cause over-exploitation of co-mingled wild populations.

Fisheries

Because of their large size and excellent palatability, chinook salmon are highly prized by commercial, sport, and subsistence fishers. In Alaska, approximately 1 million chinook salmon are harvested annually. While this is less than 1% of the annual salmon catch in the State, chinook salmon typically are the focus of a disproportionately larger amount of management and regulatory effort because of the conservation concerns and intense allocation issues for this species.

In most of the State, there is no directed harvest of chinook salmon in the EEZ. Most fishing effort takes place in the coastal or riverine waters of the State. The FMP for salmon in the Alaska EEZ prohibits commercial harvest in the EEZ, with a few exceptions. The most notable exception is the commercial troll harvest off of southeast Alaska. While much of this fishery is also in State waters, it has been traditionally managed since Alaska statehood (1959) with little recognition of the boundary separating State and Federal waters. Chinook and coho salmon are the primary target species of this hook-and-line fishery.

The commercial troll fishery for chinook salmon in southeast Alaska developed in the early 1900s. The fishery occurred all year with no overall catch limits. Peak harvests of chinook were in the 1930s, when annual catch averaged over 600,000. Concurrent with the development of the Columbia River hydroelectric dams, catches declined to average 250,000-350,000 chinook annually. Beginning in 1978, the Alaska Department of Fish and Game (ADFG) and the North Pacific Fishery Management Council (NPFMC) set harvest limits for the fishery in the first FMP for salmon in Alaska. These limits were initially a harvest range of 286,000-320,000 chinook salmon for the Southeast Alaska troll fishery. The

FMP also banned commercial salmon fishing in the EEZ west of 175° E longitude, banned fishing for salmon with nets throughout the EEZ (with a few specific exceptions), and imposed time closures on commercial trolling in the EEZ east of 175°.

These harvest ranges became part of a 15-year stock rebuilding program begun in 1981 for stocks that spawn in southeast Alaska and in transboundary rivers that originate in Canada and flow through southeast Alaska. In 1985, the Pacific Salmon Treaty between the U.S. and Canada included specific provisions for rebuilding chinook salmon stocks coast-wide. The Chinook Annex to the treaty established specific total catch limits for chinook in Southeast Alaska and in certain fisheries in British Columbia in 1985 and 1986; subsequently, the catch limits were to be negotiated annually. The catch ceiling in southeast Alaska was originally established at 263,000 "treaty fish", with a provision for additional harvest of fish produced by new enhancement operations in the region. The catch ceiling included an allocation for incidental catch of chinook salmon in net fisheries directed at other salmon species, as well as the commercial and recreational troll harvests. It resulted in a reduction of approximately 100,000 chinook in the commercial troll fishery relative to its average catches over the prior two decades.

In 1990, the NPFMC revised the salmon FMP to reduce redundant regulation of the salmon fisheries in the EEZ with ADFG and the Pacific Salmon Commission (PSC). While recognizing that the salmon fisheries require Federal participation and oversight stipulated in the Magnuson Act, the NPFMC deferred setting harvest levels to ADFG and the PSC, and regulation of the sport and commercial fishery to ADFG providing the harvest levels and allocations are consistent with NPFMC goals and objectives stated in the FMP and the National Standards of the Magnuson Act. To date, the NPFMC has not exercised its option of specifying management measures in the EEZ that differ from State regulation.

Management and catch limits in the southeast Alaska chinook salmon fishery have continued to be a contentious issue. While chinook salmon spawning in southeast Alaska and the transboundary rivers have been generally stable or increasing in abundance since the establishment of the PSC management regime, abundance of many wild populations of chinook salmon in British Columbia and the Pacific Northwest have not recovered or have continued to decline. Fixed harvest levels were formulated to result in decreasing exploitation rates of chinook salmon in mixed-stock fisheries: as wild stocks rebuilt and enhancement activities increased, general abundance of chinook salmon in the mixed-stock fisheries, in concert with catch ceilings, would result in a lower proportion harvested by these fisheries. In the first few years after the Treaty, this concept seemed reasonable, but poor survivals due to ocean conditions in the early 1990s resulted in declining abundances in the ocean fisheries, so that fixed harvest levels result in increasing exploitation. Due to this and other allocation and conservation concerns, there has been no agreement on catch ceilings within the PSC since 1993. In 1995, ADFG proposed a management regime based on the estimated abundance of chinook salmon. ADFG implemented this abundance-based management approach in 1995, but tribal groups and the state management agencies in the Pacific Northwest sued successfully for the closure of the fishery in August of 1995. In 1996, the fishery reopened with a management ceiling agreed to by the U.S. Commissioners (which represent both Alaska and Pacific Northwest interests) to the PSC. In 1997, the U.S. Commissioners agreed to apply an abundance-based management approach using a modified version of the original ADFG proposal. The agreement calls for setting preseason catch targets based on the forecasts made by the Chinook Technical Committee (CTC) of the PSC, then refining these preseason forecasts using catch per unit effort data from the summer troll fishery. This agreement has been implemented by ADFG in 1997, but has not been agreed to by Canada in the PSC process.

Because fish from chinook salmon ESUs that have been listed as threatened or endangered occur in the southeast Alaska troll fishery, NMFS reviews the fishery under Section 7 of the ESA and, in association with the Biological Opinion, issues an incidental take statement that covers the ESA listed fish that are inadvertently and unknowingly taken in the fishery. The biological assessment has found that the take of

listed ESUs in the fishery has been incidental to other stocks and a small percentage of the total mortality, either on a single year or cohort basis. To date, NMFS has found that this fishery is not likely to jeopardize the continued existence or recovery of ESA listed species.

Chinook salmon fisheries in Alaska have some bycatch associated with them. Generally, the numbers of other species taken during directed chinook fishing is small and not considered a conservation issue. The most important bycatch issue in the commercial and recreational hook-and-line fisheries is the capture of undersized chinook salmon which must be released. While the majority of these fish survive the hooking encounter, large numbers can be hooked and substantial mortality incurred. The Pacific Salmon Treaty requires accounting for the degree of such bycatch mortality, and the CTC uses this information in modeling the status and abundance of component stocks.

Relevant Trophic Information

Chinook salmon eggs, alevins, and juveniles in freshwater streams provide an important nutrient input and food source for aquatic invertebrates, other fishes, birds and small mammals. The carcasses of chinook adults can also be an important nutrient input in their natal watersheds, as well as providing food sources for terrestrial mammals such as bears, otters, and minks, and birds such as gulls, eagles, and ravens. Because of their relatively low abundance in coastal and oceanic waters, chinook salmon in the marine environment are typically only an incidental food item in the diet of other fishes, marine mammals, and coastal sea birds.

Potential gear impacts on the habitats of this or other species:

Directed fisheries of chinook salmon in Alaska include marine commercial and recreational hook-and-line fisheries; marine commercial gill-net and seine fisheries; and estuarine and riverine gill-net (both set-net and drift), recreational, personal use, and subsistence fisheries. Two types of impacts can occur: (1) direct effects of the gear to habitat; and (2) bycatch or entanglement of non-target species. In the marine fisheries, direct impact of the gear to marine habitats is limited, but some localized effects can occur, such as trolling weights damaging coral or purse seines damaging kelp beds or benthic structure. Because these types of impacts also endanger the gear itself, they are typically self-limiting. Bycatch and entanglement of non-target species can occur in the marine fisheries, such as bycatch of demersal rockfish in hook-and-line fisheries, and entanglement of seabirds and marine mammals in net fisheries. In the estuarine and riverine fisheries, direct impact to riparian vegetation and channel morphology can occur from the shore-based fishing gears, such as set-nets and recreational fishing. Where use levels are high, this type of impact can be sufficient to require restoration management initiatives. An example is the Kenai River restoration work needed to repair damage from recreational fishing for chinook salmon and other salmonids.

Upper size limit of juvenile fish (in cm):

71 CM TOTAL LENGTH. This is the regulatory minimum harvest size used in the Alaska hook-and-line fisheries in order to minimize catches of immature fish. However, because chinook salmon can mature at ages of 2-8 total years, the term “juvenile” is better defined by physiological progress of maturation rather than a threshold size.

Sources for additional distribution data:

Dave Gaudet , Alaska Department of Fish and Game, 907-465-4250
William Heard, NMFS, Auke Bay Laboratory, 907-789-6003

Habitat and Biological Associations:

As noted above, chinook salmon occur over abroad geographic range, encompassing different ecotypes and very diverse habitats. Across the geographic range which the species has colonized, populations of chinook salmon have developed localized adaptations to site specific characteristics. These local adaptations result in different and diverse characteristics of biological importance, including timing of spawning, adult and juvenile migration timing, age and size at maturity, duration of freshwater residency, and ocean distribution. Chinook salmon have been studied and managed intensively for decades. There is a large body of literature describing their biology and ecology. But for freshwater habitats, habitat specific information for chinook salmon in particular watersheds is sparse, especially in the northern portion of the range, and for estuarine and marine habitats, there is little data beyond presence/absence or density information. The range in the amount of habitat specific information by life-history stage is reflected in the information levels assigned the different life-history stages. EFH is defined for this species on the basis of watershed-specific information available about the species' distribution, and its known range of marine distribution within the EEZ.

Eggs and Spawning: Chinook salmon spawn in a broad range of habitats. They have been known to spawn in water ranging from a few centimeters deep to several meters deep, and in channel widths ranging from small tributaries 2-3 m wide to the main-stems of large rivers such as the Columbia and Sacramento. Typically, redd (nest) size is 5-15 m^2, and water velocities are 40-60 cm/sec. The depth of the redd is inversely related to water velocity; generally the female buries her eggs in clean gravel, 20-36 cm deep. Because of their large size, chinook salmon are able to spawn in higher water velocities and utilize coarser substrates than other salmon species. In general, female chinook salmon select sections of the spawning stream with high subgravel flow. Because their eggs are the largest of the Pacific salmon, with a correspondingly small surface-volume ratio, they may be more sensitive to reduced oxygen levels and require a higher rate of irrigation. Fertilization of the eggs occurs simultaneous with deposition. Males compete for the right to breed with a spawning females. Chinook females remain on their redds 6-25 days after spawning, defending the area from superimposition of eggs from another female.

Larvae/alevins: Fertilized eggs begin their five- to eight-month period of embryonic development and growth in intragravel interstices. To survive successfully, the eggs, alevins and pre-emergent fry must first be protected from freezing, desiccation, stream bed scouring or shifting, mechanical injury and predators. Water surrounding them must be non-toxic and of sufficient quality and quantity to provide basic requirements of suitable temperatures, adequate supply of oxygen, and removal of waste materials. Rates of egg development, survival, size of hatched alevins and percentage of deformed fry are related to temperature and oxygen levels during incubation. Generally, low oxygen levels are non-lethal early, but lethal late in development. Under natural conditions, 30% or less of the eggs survive to emerge from the gravel as fry.

Juveniles: Chinook salmon are typically 33-36 mm in length when they emerge from the incubation gravel. Residency in freshwater and size and timing of seawater migration are highly variable. Ocean-type fish can migrate seaward immediately after yolk absorption.

The majority of ocean-type fish migrate at 30-90 days after emergence, but some fish move seaward as fingerlings in the late summer of their first year, while others overwinter and migrate as yearling fish. Stream-type fish, in contrast, generally spend at least one year in freshwater, migrating as one- or two-year old fish. In Alaska, the stream-type life history predominates although ocean-type life histories have been documented in a few Alaska watersheds. Water and habitat quality and quantity determine the productivity of a watershed for chinook salmon. Both stream- and ocean-type fish utilize a wide variety of habitats during their freshwater residency, and are dependent on the quality of the entire watershed, from headwater to salt water. The stream/river ecosystem must provide adequate rearing habitat, and migration corridors from spawning and rearing areas to the sea. Stream-type juveniles are more dependent on freshwater ecosystems because of their extended residence in these areas. The principal foods in freshwater are larval and adult insects. The seaward migration of smolts is timed so that the smolts arrive in the estuary when food is plentiful. Migration and rearing habitats overlap. Stream flows during the migratory period tend to be high, which facilitates seaward movement and provides some sheltering from predation.

After entering saltwater, chinook juveniles disperse to oceanic feeding areas. Ocean-type fish have more extended estuarine residency, tend to be more coastal oriented, and do not generally migrate as far as stream-type fish. Food in estuarine areas include epibenthic organisms, insects, and zooplankton.

Adults: Chinook salmon typically remain at sea for 1 to 6 years. They have been found in oceanic waters at temperatures ranging from 1-15° C. They do not concentrate at the surface as do other Pacific salmon, but are most abundant at depths of 30-70 m. Fish make up the largest component of their diet at sea, although squid, pelagic amphipods, copepods, and euphausiids are also important at times.

Ocean distribution patterns have been shown to be influenced by both genetics and environmental factors. Migratory patterns in the ocean may have evolved as a balance between the benefits of accessing specific feeding grounds and the energy expenditure and dispersion risks necessary to reach them. Along the eastern Pacific rim, chinook salmon originating north of Cape Blanco on the Oregon coast tend to migrate north towards and into the Gulf of Alaska, while those originating south of Cape Blanco migrate south and west into waters off Oregon and California. As a result, chinook salmon that occur in the EEZ fishery in Alaska originate from the Oregon coast to southeast Alaska. Not all stocks within this large geographic area are distributed into the southeast Alaska fishery, however. For example, Puget Sound stocks do not normally migrate that far north.

Habitat Concerns

Habitat loss and alteration have reduced, and in some cases, extirpated chinook salmon over a large portion of their range. Losses of chinook habitat have occurred as a result of other resource development, such as hydroelectric power and logging, agriculture, and urbanization. Most habitat loss has occurred in freshwater ecosystems that support chinook salmon development; estuarine rearing areas have also been affected in some areas by industrial development, urbanization, and dredging. The oceanic environment of chinook salmon is considered largely unchanged by anthropogenic activities, although offshore petroleum production and local, transitory pollution events such as oil spills do pose some degree of risk.

Offshore petroleum production and large-scale transport of petroleum occurs in the Alaska EEZ, although at this time there is no offshore production of petroleum in the commercial troll area of the EEZ. Offshore oil and gas development and transport will inevitably result in some oil entering the environment at levels exceeding background amounts. The *Exxon Valdez* oil spill was shown to have direct effects on the survival and habitats of pink salmon. Chinook salmon were not directly affected, because of their different habitat utilization in the spill area. In general, the early life history stages of fish are more susceptible to oil pollution than juveniles or adults.

By far, the most serious habitat concern for chinook salmon is the degradation of the freshwater watersheds that support those stages of their life history. Dams and impoundments for hydroelectric power and water diversion have caused large-scale extirpation of chinook salmon in the Pacific Northwest by eliminating access to anadromous fish, and have altered the spawning, rearing, and migration corridors of chinook salmon in many watersheds. There are presently no dams in place or in planning that would block rivers used by chinook salmon in Alaska. However, because many chinook salmon harvested under the FMP for Alaska originate in the Pacific Northwest, these types of habitat impacts in other regions directly affect the Alaska fishery.

Logging and associated road construction has resulted in degraded habitat by causing increased erosion and sedimentation, changes in temperature regimes, and changes in seasonal flow patterns. Timber harvest has been a major resource use in Southeast Alaska, and is increasing in southcentral Alaska. Timber harvest in the Pacific Northwest and British Columbia also impacts the Alaska fishery because of the presence of stocks from these regions in the Alaska EEZ.

Placer mining has caused serious degradation of chinook habitats in some river systems, especially in Yukon River drainages. While these impacts are of concern, most of the stocks directly affected do not migrate into the chinook fishery managed under the FMP.

Urbanization and coastal development can have pronounced effects on coastal ecosystems, particularly estuaries, through modification of the hydrography, biology, and chemistry in the developed area. Increased nutrient input, filling of productive wetlands, and influx of contaminants commonly occur with coastal development. These impacts can reduce or eliminate rearing potential for juvenile chinook salmon. Increased levels of coastal development in Alaska as well as in the Pacific Northwest and British Columbia can be expected.

There is a definite south-north cline to the degree of habitat degradation and the status of chinook populations in the eastern Pacific. Habitat degradation in Alaska is certainly a management concern, but to date has not had the degree of impacts on chinook populations as in the Pacific Northwest. In southeast Alaska, logging is considered the largest potential threat to anadromous fish habitat. Relatively little logging has occurred, however, in watersheds supporting chinook salmon in the region. However, because of the stock composition of the fish harvested in the EEZ of southeast Alaska, freshwater ecosystems in the Pacific Northwest represent essential fish habitat for sustaining the diversity and abundance of chinook salmon in the Alaska EEZ.

References

Alderdice, D.F., and F.P.J. Velsen. 1978. Relation between temperature and incubation time for eggs of chinook salmon *(Oncorhynchus tshawytscha).* J. Fish. Res. Board Can. 35:69-75.

Alderdice, D.F., W.P. Wickett, and J.R. Brett. 1958. Some effects of temporary exposure to low dissolved oxygen levels on Pacific salmon eggs. J. Fish. Res. Board Can. 15:229-249.

Atkinson, C.E., T.H. Rose, and T.O. Duncan. 1967. Pacific salmon in the United States, p. 43-223. *In:* Salmon of the North Pacific Ocean. Part IV. Spawning populations of North Pacific salmon. Int. North Pac. Fish. Comm. Bull. 23.

Baker, T.T., A.C. Wertheimer, R.D. Burkett, R. Dunlap, D.M. Eggers, E.I. Fritts, A.J. Gharrett, R.A. Holmes, and R.L. Wilmot. 1996. Status of Pacific salmon and steelhead escapements in southeastern Alaska. Fisheries 21(10): 6-19.

Beamish, R.J., I.A. Pearsall, and M.C. Healey. 2003. A history of the research on the early marine life of pacific salmon off Canada's Pacific coast. N. Pac. Anadr. Fish Comm. Bull. 3:1-40.

Beamish, R.J., Riddell, B.E., Neville, C., E.M., Thomson, B.L., Zhang, Z., 1995. Declines in chinook salmon catches in the Strait of Georgia in relation to shifts in the marine environment. Fisheries Oceanography 4(3), 243-256.

Bradford, M.J., 1995. Comparative review of Pacific salmon survival rates. Canadian Journal of Fisheries and Aquatic Sciences 52, 1327-1338.

Brodeur, R.D., Boehlert, G.W., Casillas, E., Eldridge, M.B., Helle, J.H., Peterson, W.T. Heard, W.R., Lindley, S. T., Schiewe, M.H., 2000. A coordinated research plan for estuarine and ocean research on Pacific salmon. Fisheries 25, 7-16.

Brodeur, R.D., Francis, R.C., Pearcy, W.G., 1992. Food consumption of juvenile coho (*Oncorhynchus kisutch*) and chinook salmon (*O. tshawytscha*) on the continental shelf off Washington and Oregon. Canadian Journal of Fisheries and Aquatic Sciences 49, 1670-1685.

Brodeur, R.D., K.W. Myers, and J.H. Helle. 2003. Research conducted by the United States on the early ocean life history of Pacific salmon. N. Pac. Anadr. Fish Comm. Bull. 3:89-131.

Burger, CV; Wilmot, RL; Wangaard, DB. 1985. Comparison of spawning areas and times for two runs of chinook salmon (Oncorhynchus tshawytscha) in the Kenai River, Alaska. CAN. J. FISH. AQUAT. SCI., vol. 42, no. 4, pp. 693-700.

Cooney, R.T., Brodeur, R.D., 1998. Carrying capacity and North Pacific salmon production: stock-enhancement implications. Bulletin of Marine Science 62, 443-464.

Cronin, MA; Spearman, WJ; Wilmot, RL; Patton, JC; Bickham, JW. 1993. Mitochondrial DNA variation in chinook (Oncorhynchus tshawytscha) and chum salmon (O. keta) detected by restriction enzyme analysis of polymerase chain reaction (PCR) products. CAN. J. FISH. AQUAT. SCI.], vol. 50, no. 4, pp. 708-715.

Fiscus, C.H. 1980. Marine mammal-salmonid interactions: a review. P. 121-132. *In:* W. J. McNeil and D. C. Himsworth (eds.). Salmonid ecosystems of the North Pacific. Oregon State University Press, Corvallis, OR.

Gharrett, A.J., S.M. Shirley, and G.R. Tromble. 1987. Genetic relationships among populations of Alaskan chinook salmon. Canadian Journal Fish. Aquat. Sci. 44:765-774.

Hartt, A.C. 1966. Migrations of salmon in the North Pacific Ocean and Bering Sea as determined by seining and tagging, 1959-1960. Int. North Pac. Fish. Comm. Bull. 19: 141p.

Hartt, A.C., and M.B. Dell. 1986. Early oceanic migrations and growth of juvenile Pacific salmon and steelhead trout. Int. North Pac. Fish. Comm. Bull. 46: 105p.

Healey, M.C. 1991. Life history of chinook salmon, *Oncorhynchus tshawytscha*, p 311-394 *in* C. Groot and L. Margolis (eds.), Pacific salmon life histories. UBC Press, Vancouver

Healey, M.C. 1980. The ecology of juvenile salmon in Georgia Strait, British Columbia. Pages 203-229 *in* W. J. McNeil and D.C. Hinsworth (eds.), Salmonid ecosystems of the North Pacific. Oregon State University Press, Corvallis, Or.

Healey, M.C. 1983. Coast-wide distribution and ocean migration patterns of stream-type and ocean-type chinook salmon. Canadian Field-Naturalist 97:427-433.

Heard, W.R., R. Burkett, F. Thrower, and S. McGee. 1995. A review of chinook salmon resources in southeast Alaska and development of an enhancement program designed for minimal hatchery-wild stock interactions. Amer. Fish. Soc. Symposium 15: 21-37.

Jaenicke, H.W., Celewycz, A.G., 1994. Marine distribution and size of juvenile Pacific salmon in Southeast Alaska and northern British Columbia. Fishery Bulletin 92(1), 79-90.

Karpenko, V.I. 2003. Review of Russian marine investigations of juvenile Pacific salmon. N. Pac. Anadr. Fish Comm. Bull. 3:69-88.

Landingham, J.H., M.V. Sturdevant and R.D. Brodeur. 1998. Feeding habits of juvenile Pacific salmon in marine waters of southeastern Alaska and northern British Columbia. Fishery Bulletin 96(2):285-302.

Major, R.L., J. Ito, S. Ito, and H. Godfrey. 1978. Distribution and origin of chinook salmon in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 38:54p.

Mantua, N.J., Hare, S.R., Zhang, Y., Wallace, J.M., Francis, R.C., 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78, 1069-1079.

Martin, R. M., A. C. Wertheimer, F. Thrower, and J. E. Joyce. 2001. Growth and survival of Alaska stream-type chinook salmon cultured in estuarine net-pens or freshwater raceways. North American Journal Aquaculture 63: 256-261.

Mathews, G.M., and R.S. Waples. Status review for Snake River spring and summer chinook salmon. NOAA Tech. Memo. NMFS F/NWC-200.

Mayama, H. and Y. Ishida. 2003. Japanese studies on the early ocean life of juvenile salmon. N. Pac. Anadr. Fish Comm. Bull. 3:41-67.

McIsaac, D.O., and T.P. Quinn. 1988. Evidence for a hereditary component in homing behavior of chinook salmon (*Oncorhynchus tshawytscha*). Can. Journal Fish. Aquat. Sci. 45: 2201-2205.

Meacham, C.P., and J.H. Clark. 1994. Pacific salmon management - the view from Alaska. Alaska Fishery Research Bulletin 1(1): 76-80.

Meuter, F.J., Peterman, R.M., Pyper, B.J., 2002. Opposite effects of ocean temperature on survival rates of 120 stocks of Pacific salmon (Oncorhynchus spp.) in northern and southern areas. Canadian Journal of Fisheries and Aquatic Sciences 59, 456-463.

Moulton, L.L. 1997. Early marine residence, growth, and feeding by juvenile salmon in Northern Cook Inlet, Alaska. Alaska Fishery Research Bulletin 4(2):154-177.

Nehlson, W., J.E. Williams, and J.A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.

NPFMC. 1990. Fishery management plan for the salmon fisheries in the EEZ off the coast of Alaska. North Pacific Fishery Management Council, Anchorage, AK.

Orsi, J.A., and A.C. Wertheimer. 1995. Marine vertical distribution of juvenile chinook and coho salmon in southeastern Alaska. Tran. Amer. Fish. Soc. 124: 159-169.

Orsi, J.A., and H.W. Jaenicke. 1996. Marine distribution and origin of prerecruit chinook salmon, *Oncorhynchus tshawytscha*, in southeastern Alaska. Fish. Bull. 94: 482-497.

Pacific Salmon Commission. 1994. Joint Chinook Technical Committee 1993 Annual Report. Pacific Salmon Commission Report TCCHINOOK 94-1. Vancouver, British Columbia.

Pearcy, W. 1992. Ocean ecology of North Pacific salmonids. Univ. Wash. Press, Seattle, WA.

Rigby, P., J. McConnaughey, and H. Savikko. 1991 . Alaska Commercial Salmon Fisheries, 1878-1991. Alaska Department of Fish and Game Regional Information Report 5J91-16.

Roni, P., and T.P. Quinn. 1995. Geographic variation in size and age of North American chinook salmon. N. Am. J. Fish. Manag. 15: 325-345.

Taylor, E.B. 1990. Environmental correlates of life-history variation in juvenile chinook salmon, *Oncorhynchus tshawytscha*. J, Fish. Biol. 31: 1-17.

Utter, F., G. Milner, G. Stahl, and D. Teel. 1989. Genetic population structure of the chinook salmon, *Oncorhynchus tshawytscha*, in the Pacific northwest. Fish. Bull. 87: 239-264.

Walters, C.J., Hilborn, R., Peterman, R.M., Staley, M., 1978. A model for examining early ocean limitation of Pacific salmon production. Journal of the Fisheries Research Board of Canada 35, 1303-1315.

Waples, R.S., J.R.P. Jones, B.R. Beckman, and G.A. Swan. 1991. Status review for Snake River fall chinook salmon. NOAA Tech. Memo. NMFS F/NWC-201.

Wertheimer, A.C. 1996. The status of Alaska salmon. Pages 179-197 *In* D. J. Stouder, P.A. Bisson, and R.J. Naiman (eds), Pacific salmon and their ecosystems: status and future options. Proceedings of a Symposium, Seattle, Washington, Jan. 10-12, 1994. Chapman Hall, New York.

Wertheimer, A.C., and A.G. Celewycz. 1996. Abundance and growth of juvenile pink salmon in oiled and non-oiled locations of western Prince William Sound after the *Exxon Valdez* oil spill. Pp.518-532. *In* S.D. Rice, R.B. Spies, D.A. Wolfe, and B.A. Wright (Eds.). *Exxon Valdez* Oil Spill Symposium Proceedings. American Fisheries Society Symposium Number 18.

Chinook salmon, *Oncorhynchus tshawytscha*

Stage - EFH Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic/ Riverine Features	Other
Eggs and larvae (alevins)	50-250 d	NA	late summer, fall, winter, early spring	streambeds	intragravel 20 to 80 cm deep	G	Riverbed	**DO**< 3 mg/l lethal, optimum >7 **Temp** 0-17 C, Optimum 4-12 C
Juveniles (freshwater)	days-years	insect larvae and adults, zooplankton	year-round, depending on race	streams, sloughs, rivers	surface to several meters	varied	Pools, stream and river margins, woody debris	Extremely varied freshwater life history. **DO**< 2 mg/l lethal, optimum >7 **Temp** 0-22 C, Optimum 8-12 C
Juveniles (Estuary)	days-6-months	copepods, euphausiids, amphipods, juvenile fish	Spring, summer, fall	BCH, BAY	N, P	All bottom types	estuarine, littoral	Sea-type can be estuarine dependent **Temp** 2-22 C, Optimum 8-12 C **Salinity** 0-33 ppt
Juvenile (marine)	6-9 months: Up to first marine annulus	epipelagic fish, euphasiids, large copepods, pelagic amphipods	Spring-Winter	IP, ICS, MCS, OCS, USP, BSN	P	All bottom types	UP, F, G, CL, E	Initially surface oriented; some stocks move rapidly offshore, some remain nearshore. **Temp:** 1-15 C, Optimum 5-12 C

Immature and Maturing Adults (marine)	2-8 years of age	epipelagic fish (herring, sand lance, smelt, anchovy), shrimp, squid	Year Round	BAY, IP, ICS, MCS, OCS, USP, BSN	N, P	All bottom types	UP, F, G, CL, E	Not surface oriented until maturing. Use salinity gradients, olfaction for terminal homing. **Temp:** 5-22 C
Adults (freshwater)	2 weeks-4 months	little or none	Spawning: (July-Feb) Freshwater Migration: Year round, varies greatly among populations	Rivers, large streams and tributaries	0.5-10 m	Alluvial bottom types; G for spawning	Deep pools for resting, Riffles, pool-riffle transition for spawning	Entry timing to freshwater highly variable. **Temp:** 1-26 C, Optimum 4-15 C

Habitat Description for Coho Salmon

(Oncorhynchus kisutch)

Management Plan and Area(s) Salmon Fisheries in the EEZ off the Coast of Alaska, NPFMC, 1990

General Distribution and Life History

Coho salmon are widely distributed in cool areas of the North Pacific Ocean and most adjoining fresh and estuarine waters. Coho use more diverse habitats than other anadromous salmonids. They spawn in most accessible freshwater streams throughout their range, rear for at least 1 year in fresh or estuarine waters, and spend about 18 months at sea before reaching maturity. In North America, coho range along the Pacific coast from Monterey Bay, California, to Point Hope, Alaska, through the Aleutians (Figure 1). The species is most abundant in coastal areas from central Oregon north through southeast Alaska. In the southern part of their range, coho stocks are generally depressed from historical levels, and hatcheries are often used to supplement wild runs. The Central California Coast Evolutionary Significant Unit (ESU) and the Southern Oregon/Northern California Coast ESU are listed as threatened species under the Endangered Species Act. Coho are cultured for market in several countries; attempts to establish self-sustaining coho runs in other areas of the world have had limited success.

In the NMFS Alaska Region, most coho are wild fish with a distribution north to Point Hope on the eastern Chukchi Sea, west and south to the limits of U.S. territorial waters, and east to the Canadian border as far north as the Yukon River drainage. Coho catch in the Alaska Region is at historically high levels, and trends in abundance of most stocks are rated as stable.

Fishery

Important commercial, sport, and subsistence fisheries for coho occur from the Soviet Far East through the Bering Sea and along the west coast of North America as far south as central California. Trolling, gill nets, and purse seines are the primary commercial gear types. Gill nets, dip nets, rod and reel, traps, fish wheels, long lines, and snagging gear are used to harvest coho for subsistence and personal use. Subsistence fisheries are often cultural or traditional and take precedence over other fisheries. Personal use fisheries require a sport fishing license or exemption. Both subsistence and personal use fisheries are restricted to designated locations and specified bag limits. Sport catches of coho are taken by hook and line and snagging.

Most coho from the Alaska Region recruit to fisheries after 1 to 2 years in fresh water and about 16 months at sea. Fisheries in the Alaska Region primarily target adult coho and take place in coastal marine migration corridors, near the mouths of rivers and streams, and in freshwater migration areas. Those fisheries coincide with migrations toward spawning areas from July through October. A few areas are stocked annually with juvenile coho to provide put-and-take sport fishing.

Bycatch depends on gear type, but is usually limited to other salmon species. Chinook salmon bycatch is limited by regulation or treaty in most coho fisheries, but other salmon species are often targeted as part of the fishery. Species such as steelhead, Dolly Varden, pollock, Pacific cod, halibut, salmon sharks, and coastal rockfish make up a small part of the catch.

Relevant Trophic Information

Adult coho provide important food for bald eagles, terrestrial mammals (e.g., brown bear, black bear, and river otter), marine mammals (e.g., Steller sea lion, harbor seal, beluga, and orca), and salmon sharks. Adults also transfer essential nutrients from marine to freshwater environments. Juveniles are eaten by a variety of birds (e.g., gulls, terns, kingfishers, cormorants, mergansers, herons), fish (e.g., Dolly Varden, steelhead, cutthroat trout, and arctic char), and mammals (e.g., mink and water shrew). Juvenile coho are also significant predators of pink salmon fry during their seaward migration.

Potential Gear Impacts on the Habitats of this or Other Species

Directed fisheries on coho salmon in Alaska include marine commercial and recreational hook-and-line fisheries; marine commercial gill-net and seine fisheries; and estuarine and riverine gill-net (both set-net and drift), recreational, personal use, and subsistence fisheries. Two types of impacts can occur: (1) direct effects of the fishing gear on habitat; and (2) bycatch or entanglement of non-target species. In the marine fisheries, direct impact of the gear on marine habitats is limited, but some localized effects can occur, such as trolling weights damaging coral or purse seines damaging kelp beds or benthic structure. Bycatch and entanglement of non-target species can occur in the marine fisheries, such as bycatch of demersal rockfish in hook-and-line fisheries, and entanglement of seabirds and marine mammals in net fisheries. In the estuarine and riverine fisheries, direct impacts on riparian vegetation and channel morphology can occur from fishing activities, such as damage to the stream bank from boat wakes and removal of woody debris to provide access. Trampling of stream banks and the stream channel can also damage coho habitat. Where use levels are high, this type of impact may require restoration or management initiatives. An example is the Kenai River where restoration work was needed to repair damage from recreational fishing for chinook salmon and other salmonids.

Approximate Upper Size Limit of Juvenile Fish (in cm) 35 cm

Sources for Additional Distribution Data

Adults: ADF&G, Commercial Fisheries Management and Development Division, 907-465-4160; ADF&G, Sport Fish Division, 907-465-4180; ADF&G, Subsistence Division, 907-465-4147;

Juveniles: ADF&G, Habitat and Restoration Division, 907-465-4105; USFS, Region 10 Office of Wildlife, Fish Ecology, and Watershed, 907-586-8752; NMFS, Alaska Fisheries Science Center, Auke Bay Laboratory, Mike Murphy, 907-789-6036.

The known distribution of adults and juveniles is given in the current ADF&G *Atlas to the Catalogue of Waters Important for Spawning, Rearing, or Migration of Anadromous Fishes*. The Catalogue and Atlas are divided into six volumes corresponding to the State's six resource management regions (Arctic, Interior, Western, Southwest, Southcentral, and Southeast). The principal contact for the ADF&G catalogue/atlas project is Ed Weiss, ADF&G Regional Office in Anchorage (907-267-2305). Copies of the entire Atlas and Catalogue are available for inspection at the ADF&G Habitat and Restoration Division Regional Offices in Fairbanks and Anchorage and the Headquarters Office in Juneau. Copies of a regional volume of the Atlas are available for inspection at ADF&G offices in Ketchikan, Wrangell, Petersburg, Sitka, Haines, Yakutat, Palmer, Cordova, Glennallen, Soldotna, Homer, Kodiak, Sand Point, King Salmon, Dillingham, Bethel, Delta Junction, Tok, Nome, and Dutch Harbor.

Habitat and Biological Associations

Juvenile and adult coho are highly migratory and depend on suitable habitat in their migration routes. Unobstructed passage and suitable water depth, water velocity, water quality, and cover are important elements in all migration habitat. Soon after emergence in spring, fry may move around considerably seeking optimal, unoccupied habitat for rearing. In fall, juveniles may migrate from summer rearing areas to areas with winter habitat. Such juvenile migrations may be extensive within the natal stream basin or between basins through salt water or connecting estuaries. Seaward migration of coho smolts occurs usually after 1-2 years in fresh water. The migration is timed primarily by photoperiod and occurs in spring, usually coincident with a spring freshet. During this transition, coho undergo major physiological changes to enable them to osmoregulate in salt water and are at that time, especially sensitive to environmental stress. At sea, juvenile Alaska coho generally migrate north and offshore into the North Pacific Ocean and Bering Sea. After 12 to 14 months at sea, they migrate to coastal areas and then along the coast to their natal streams.

Egg/Larvae: Fertilized eggs and larvae require incubation in porous substrate that allows constant circulation of cool, high-quality water that provides oxygen and removes waste. Interstitial space in the substrate must be great enough to allow growth and movement through the gravel to accommodate emergence. Sand or silt in the substrate can limit intragravel flow and trap emerging fry. As the yolk sac is absorbed, the larvae become photopositive and move through the substrate into the water column. Fry emerge between March and July, depending on when the eggs were fertilized and water temperature during development.

Juveniles (Fresh Water): In Alaska, juvenile coho usually spend 1-2 years in fresh or estuarine waters before migrating to sea, although they may spend up to 5 years where growth is slow. Coho need to attain a length of about 85 mm to become smolts. Coho smolt production is most often limited by the productivity of freshwater and estuarine habitats used for juvenile rearing. Survival from eggs to smolts is usually less than 2%. If spawning escapement is adequate, sufficient fry are usually produced to exceed the carrying capacity of rearing habitat. In this case, carrying capacity of summer habitat sets a density-dependent limit on the juvenile population. This summer population is then reduced by density-independent mortality over winter depending on the severity of winter conditions, fish size, and quality of winter habitat.

Coastal streams, lakes, estuaries, and tributaries to large rivers can all provide coho rearing habitat. The most productive habitats are in smaller streams less than fourth order having low-gradient alluvial channels with abundant pools often formed by large woody debris or fluvial processes. Beaver ponds can provide some of the best summer rearing areas for juvenile coho. Coho juveniles also may use brackish-water estuarine areas in summer and migrate upstream to fresh water to overwinter.

During the summer rearing stage, fish density tends to be highest in areas with abundant food (drifting aquatic invertebrates and terrestrial insects that fall into the water) and structural habitat elements (e.g., large woody debris and associated pools). Preferred habitats include a mixture of different types of pools, glides, and riffles with large woody debris, undercut banks, and overhanging vegetation which provide advantageous positions for feeding. Coho grow best where water temperature is between 10 and 15°C, and dissolved oxygen (DO) is near saturation. Juvenile coho can tolerate temperatures between 0° and 26°C if changes are not abrupt. Their growth and stamina decline significantly when DO levels drop below 4 mg/l, and a sustained concentration less that 2

mg/l is lethal. Summer populations are usually constrained by density- dependant effects mediated through territorial behavior. In flowing water, juvenile coho usually establish individual feeding territories, whereas in lakes, large pools, and estuaries they are less likely to establish territories and may aggregate where food is abundant. Growth in summer is often density-dependent, and the size of juveniles in late summer is often inversely related to population density.

In winter, food is less important and territorial behavior fades. Juveniles aggregate in freshwater habitats that provide cover with relatively stable temperature, depth, velocity, and water quality. Winter mortality factors include hazardous conditions during winter peak stream flow, stranding of fish by ice damming, physiological stress from low temperature, and progressive starvation. In winter, juveniles prefer a narrower range of habitats than in summer, especially large mainstream pools, backwaters, and secondary channel pools with abundant large woody debris, and undercut banks and debris along riffle margins. Survival in winter, in contrast to summer, is generally not density-dependent, and varies directly with fish size and amount of cover and ponded water, and inversely with the magnitude of the peak stream flow.

The seaward migration of smolts in native stocks is typically in May and June, and is presumably timed so that the smolts arrive in the estuary when food is plentiful. Habitat requirements during seaward migration are similar to those of rearing juveniles, except that smolts tend to be more fragile and more susceptible to predation. High streamflow aids their migration by assisting them downstream and reducing their vulnerability to predators. Turbidity from melting glaciers may also provide cover from predators. Migration cover is also provided by woody debris and submerged riparian vegetation. Migrating smolts are particularly vulnerable to predation because they are concentrated and moving through areas of reduced cover where predators congregate. Mortality during seaward migration can exceed 50%.

Juveniles (Estuarine): Juvenile coho primarily use estuarine habitat during their first summer and also as they are leaving fresh water during their seaward migration. Intertidal sections of freshwater streams (i.e., stream-estuary ecotones) can be important rearing habitat for age-0 coho from May to October. These areas may account for one-quarter of the juvenile production in small streams. Growth in these areas is particularly rapid because of abundant invertebrate food. Habitats used include glides and pools during low tide, and coho occupy the freshwater lens during high tide. In fall, juvenile coho move upstream to fresh water to overwinter.

During seaward migration, coho smolts may be present in the estuary from May to August. Rapid growth during the early period in the estuary is critical to survival because of high size-dependent mortality from predation.

Juveniles (Marine): After leaving fresh water, coho in the Alaska Region spend up to 4 months in coastal waters before migrating offshore and dispersing throughout the North Pacific Ocean and Bering Sea. Southeast Alaska juvenile coho are ubiquitous in inside waters from June to August at depths up to 50 m, and move offshore by September. Offshore, juvenile salmon are concentrated over the continental shelf within 37 km of shore where the shelf is narrow, but may extend to at least 74 km from shore in some areas. Stock-specific aggregations have not been noted at this stage. Marine invertebrates are the primary food when coho first enter salt water, and fish prey increase in importance as the coho grow.

Immature and Maturing Adults (Marine): Most coho occupy epipelagic areas in the central Gulf of Alaska and Bering Sea during the 12 to 14 months after leaving coastal areas. Some coho also use coastal and inshore waters at this life stage, but those are likely to be smaller at maturity. The spatial distribution of suitable habitat conditions is affected by annual and seasonal changes in oceanographic conditions; however, coho generally use offshore areas of the North Pacific Ocean and the Bering Sea from 40 to 60° north latitude (Figure 2). The distribution of ocean harvest is generally more northerly than that for stocks from other regions (Figure 3).

Growth is the objective at this stage of the coho life cycle, and bioenergetics are controlled mainly by food quantity, food quality, and temperature. Food for salmon is most abundant above the halocline which may range from 100 to 200 meters in depth in the North Pacific. The bioenergetics of growth is best in epipelagic offshore habitat where forage is abundant and sea surface temperature is between 12 and 15°C. Coho rarely use areas where sea surface temperature exceeds 15°C.

Most coho remain at sea for about 16 months before returning to coastal areas and entering fresh water to spawn, although some precocious males will return to spawn after about 6 months at sea. Before entering fresh water to spawn, most coho slow their feeding and begin to lose weight as they develop secondary sex characteristics. Survival from smolt to adult averages about 10 percent.

Adults (Freshwater): Adult coho enter fresh water from early July through December and spawn from September through January. Fidelity to natal streams is high and straying rates are generally less than 5 percent. The fish feed little and migrate upstream using olfactory cues that were imprinted in early development.

Adult coho may travel for a short time and distance upstream to spawn in small streams or may enter large river systems and travel for weeks to reach spawning areas more than 2,000 km upstream. Upstream migrations are blocked where fall heights exceed 3.3 m or falls more than 1.2 m high have jumping pools less than 1.25 times the falls height. Blockages also occur where stream gradient exceeds 12 percent for more than 70 m, or 16 percent for more than 30 m, or 20 percent for more than 15 m, or 24 percent for more than 8 m.

Spawning sites selected for use have relatively silt-free gravels ranging from 2 mm to 10 cm in diameter, well-oxygenated intragravel flow, and nearby cover. In Alaska streams, between 2,500 and 4,000 eggs are deposited among several nests by each female coho. Several males may attend each female, but larger males usually dominate by driving off smaller males. Soon after spawning, adult coho die in or near the spawning areas.

References

Baker, T. T., A.C. Wertheimer, R. D. Burkett, R. Dunlap, D.M. Eggers, E. L. Fritts, A. J. Gharrett, R.A. Holmes, and R. L. Wilmot. 1996. Status of Pacific salmon and steelhead escapements in Southeastern Alaska. Fisheries 21(10): 6-18.

Beamish, R.J., I.A. Pearsall, and M.C. Healey. 2003. A history of the research on the early marine life of pacific salmon off Canada's Pacific coast. N. Pac. Anadr. Fish Comm. Bull. 3:1-40.

Bjornn, T. C. and D. W. Reiser. 1991. Habitat requirements of salmonids in streams. *In*: W.R. Meehan, ed. Influences of forest and rangeland management on salmonid fishes and their habitats. AFS Special Publication 19:83-138.

Bradford, M.J., 1995. Comparative review of Pacific salmon survival rates. Canadian Journal of Fisheries and Aquatic Sciences 52, 1327-1338.

Brodeur, R.D., Boehlert, G.W., Casillas, E., Eldridge, M.B., Helle, J.H., Peterson, W.T. Heard, W.R., Lindley, S. T., Schiewe, M.H., 2000. A coordinated research plan for estuarine and ocean research on Pacific salmon. Fisheries 25, 7-16.

Brodeur, R.D., K.W. Myers, and J.H. Helle. 2003. Research conducted by the United States on the early ocean life history of Pacific salmon. N. Pac. Anadr. Fish Comm. Bull. 3:89-131.

Burger, C. V. and A. C. Wertheimer. 1995. Pacific salmon in Alaska. Pages 343-347 *In*: E.T. LaRoe, G. S. Farris, C.E. Puckett, P.D. Doran, and M. J. Mac, eds. Our living resources: a report to the Nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S.D.I., NBS, Washington, D.C.

Burgner, R.L. 1980. Some features of ocean migrations and timing of Pacific salmon. Pages 153-164 *in*: W.J. McNeil and D.C. Himsworth, eds. Salmonid ecosystems of the North Pacific. OSU Press. Corvallis, Oregon.

Cooney, R.T., Brodeur, R.D., 1998. Carrying capacity and North Pacific salmon production: stock-enhancement implications. Bulletin of Marine Science 62, 443-464.

Crone, R.A. and C.E. Bond. 1976. Life history of coho salmon, *Oncorhynchus kisutch*, in Sashin Creek, Southeastern Alaska. Fishery Bulletin 74(4):897-923.

Elliott, S. 1994. Coho salmon. Alaska Department of Fish and Game Wildlife Notebook Series. Alaska Dept. of Fish and Game, Juneau. 2 p.

Elliott, S.T., A.E. Schmidt, and D.A Sterritt. 1989. A study of coho salmon in southeast Alaska. Fishery Data Series No. 113, Alaska Dep. Fish and Game, Div. Sport Fish, Juneau.

Elliott, S.T., and D.A Sterritt. 1990. A study of coho salmon in southeast Alaska, 1989: Chilkoot Lake, Yehring Creek, Auke Lake, and Vallenar Creek. Fishery Data Series No. 90-53, Alaska Dep. Fish and Game, Div. Sport Fish, Anchorage.

Fraidenburg, M.E., M.A. Hunter, A.J. M. Stohr, and P.L. Pattillo. 1985. The ocean journeys of Pacific Northwest chinooks and cohos, and steelheads, pages 109-126 *In* R.H, Stroud, ed., Proceedings of the tenth annual marine recreational fisheries symposium. National Coalition for Marine Conservation, Inc., Savannah, GA.

Geiger, H.J., and B. Frennette, eds. 1997. Run forecasts and harvest projections for 1997 Alaska salmon fisheries and review of the 1996 season: the short version. Alaska Dept. of Fish and Game, Regional Information Report No. 5197-01. 9 p.

Gray, P.L., J.F. Koerner, R.A. Marriott. 1981. The age structure and length-weight relationship of southeastern Alaska coho salmon (*Oncorhynchus kisutch*, 1969-1970. Alaska Department of Fish and Game, Div. Commercial Fisheries, Southeastern Alaska Coho Research, Juneau, AK.

Halupka, L.C., M.D. Bryant, M.F. Willson, J.K. Troyer, and F.H. Everest. 1996. Coho salmon (*Oncorhynchus kisutch*). Chapter 6 *In*: Biological characteristics and population status of anadromous salmon in Southeast Alaska. USDA Forestry Sciences Laboratory 2770 Sherwood Lane, Suite 2A, Juneau, AK 99801-8545.

Hasler, T.J. 1987. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) -- coho salmon. U.S. Fish and Wildlife Serv. Biol. Rep. 82(11.70). U.S. Army Corps of Engineers, TR EL-82-4.

Hobday, A.J., Boehlert, G.W., 2001. The role of coastal ocean variation in spatial and

Jaenicke, H.W., Celewycz, A.G., 1994. Marine distribution and size of juvenile Pacific salmon in Southeast Alaska and northern British Columbia. Fishery Bulletin 92(1), 79-90.

Karpenko, V.I. 2003. Review of Russian marine investigations of juvenile Pacific salmon. N. Pac. Anadr. Fish Comm. Bull. 3:69-88.

Landingham, J.H., M.V. Sturdevant and R.D. Brodeur. 1998. Feeding habits of juvenile Pacific salmon in marine waters of southeastern Alaska and northern British Columbia. Fishery Bulletin 96(2):285-302.

Laufle, J.C., G.B. Pauley, and M.F. Shepard. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) -- coho salmon. U.S. Fish and Wildlife Service Biological Report 82(11.48). U.S. Army Corps of Engineers, TR EL-82-4. 18 pp.

Lorenz, J.M., M.L. Murphy, J.F. Thedinga, and K.V. Koski. 1991. Distribution and abundance of juvenile salmon in two main channel habitats of the Taku River, Alaska and British Columbia. NOAA Tech. Memo. NMFS F/NWC-206.

Mantua, N.J., Hare, S.R., Zhang, Y., Wallace, J.M., Francis, R.C., 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78, 1069-1079.

Manzer, J.I., T. Ishida, A.E. Peterson, and M.G. Hanavan. 1965. Salmon of the North Pacific Ocean. Part V. Offshore distribution of salmon. Int. North Pac. Fish. Comm. Bull. 15:452 pp.

Mayama, H. and Y. Ishida. 2003. Japanese studies on the early ocean life of juvenile salmon. N. Pac. Anadr. Fish Comm. Bull. 3:41-67.

McMahon, T.E. 1983. Habitat suitability index models: coho salmon. U.S. Dept. Of the Interior, Fish and Wildlife Service. FWS/OBS-82/10.49. 29 pp.

Meehan, W.R. and T.C. Bjornn. 1991. Salmonid distributions and life histories. Pages 47-82 *in*: W.R. Meehan, ed. Influences of forest and rangeland management on salmonid fishes and their habitats. AFS Special Publication 19.

Meuter, F.J., Peterman, R.M., Pyper, B.J., 2002. Opposite effects of ocean temperature on survival rates of 120 stocks of Pacific salmon (Oncorhynchus spp.) in northern and southern areas. Canadian Journal of Fisheries and Aquatic Sciences 59, 456-463.

Moulton, L.L. 1997. Early marine residence, growth, and feeding by juvenile salmon in Northern Cook Inlet, Alaska. Alaska Fishery Research Bulletin 4(2):154-177.

Murphy, J. 1995. Patterns in the spatial distribution of salmon *(Oncorhynchus* spp.) captured in the Pacific driftnet fishery for flying squid (*Ommastrephes bartrami*). M.S. Thesis. Univ. Of Alaska, Fairbanks. 110 p.

Murphy, M.L., J. Heifetz, J.F. Thedinga, S.W. Johnson, and K.V. Koski. 1989. Habitat utilization by juvenile Pacific salmon (*Oncorhynchus*) in the glacial Taku River, southeast Alaska. Can. J. Fish. Aquat. Sci. 46:1677-1685.

Murphy, M.L., J.F. Thedinga, K.V. Koski, and G.B. Grette. 1984. A stream ecosystem in an old-growth forest in Southeast Alaska. Part V: Seasonal changes in habitat utilization by juvenile salmonids, p. 89-98. In W.R. Meehan, T.R. Merrell, Jr., and T.A. Hanley [eds.] Fish and wildlife relationships in old-growth forests: proceedings of a symposium. Am. Inst. Fish. Res. Biol.

Murphy, M.L., K.V. Koski J. M. Lorenz, and J. F. Thedinga. In press. Downstream migrations of juvenile Pacific salmon (*Oncorhynchus* sp.) in a glacial transboundary river. Can. J. Fish. Aquat. Sci.

Myers, K. W., K. Y. Aydin, R. V. Walker, S. Fowler, and M. L. Dahlberg. 1996. Known ocean ranges of stocks of Pacific salmon and steelhead as shown by tagging experiments, 1956-1995. (NPAFC Doc. 192.) FRI-UW-9614. University of Washington, Fisheries Research Institute, Box 357980, Seattle, WA 98195-7980.

Nickleson, T.E. and J.A. Lichatowich. The influence of the marine environment on the interannual variation in coho salmon abundance. Pages 24-36 *in*: W.G. Pearcy, ed. The influence of ocean conditions on the production of salmonids in the North Pacific. OSU Sea Grant Publication ORESU-W-83-001.

Olsen, J.C. 1994. Alaska salmon resources. Pages 77-89 *in* L. Low, J. Olsen, and H. Braham, eds. Status of living marine resources off Alaska. 1993. NOAA Tech. Memo. NMFS-AFSC-27. U.S.D.C. Alaska Fisheries Science Center, Seattle.

Orsi, J. A., J. M. Murphy, and A. L. J. Brase. 1997. Survey of juvenile salmon in the marine waters of southeastern Alaska, May-August 1997. (NPAFC Doc. 277).

Orsi, J.A., A.G. Celewycz, D. G. Mortensen, and K. A. Herndon. 1987. Sampling juvenile chinook salmon (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*) by small trolling gear in the northern and central regions of southeastern Alaska, 1985. NOAA Technical Memorandum NMFS F/NWC-115.

Sandercock, F.K. 1991. Life history of coho salmon. Pages 395-445 *in*: C. Groot and L. Margolis, eds. Pacific salmon life histories. UBC Press, Vancouver, BC.

Slaney, T.L., K.D. Hyatt, T.G. Northcote, and R.J. Fielden. Status of anadromous salmon and trout in British Columbia and Yukon. Fisheries 21(10): 20-35.

temporal patterns in survival and size of coho salmon (Oncorhynchus kisutch). Canadian Journal of Fisheries and Aquatic Sciences 58, 2021-2036.

Thedinga, J.F., M.L. Murphy, S.W. Johnson, J.M. Lorenz, and K.V. Koski. 1994. Determination of salmonid smolt yield with rotary-screw traps in the Situk River, Alaska, to predict effects of glacial flooding. N. Am. J. Fish. Manage. 14:837-851.

Walters, C.J., Hilborn, R., Peterman, R.M., Staley, M., 1978. A model for examining early ocean limitation of Pacific salmon production. Journal of the Fisheries Research Board of Canada 35, 1303-1315.

Wertheimer, A.C. Status of Alaska salmon. 1997. Pages 179-197 *in*: D.J. Stouder, P.A. Bisson, and R.J. Naiman, eds. Pacific salmon and their ecosystems: status and future options.

SPECIES: Coho Salmon *(Oncorhynchus kisutch)*

Stage -EFH Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic/ Riverine Features	Other
Eggs/Larvae	150 days at optimum temperature	NA	Fall/winter	WC, LK	Intra-gravel	G	Streambed	DO < 2 mg/l lethal, optimum >8 mg/l; Temperature 0-17˚C; optimum 4.4-13.3˚C; substrate 2-10 cm with <15% fines (<3.3 mm), optimum <5% fines
Juveniles, Fresh water (fry to smolt)	1-5 yrs, most (>90%) 1-2 yrs	invertebrates and fish	Entire year	WC, LK	Entire column	N/A	Pools, woody debris, currents for migration	DO lethal at <3 mg/l, optimum at saturation; Temperature 0-26˚C; optimum 12-14˚C.
Juveniles, Estuarine	1-6 months	Invertebrates and fish	Rearing - summer, Migration - spring	EST	Mid-water and surface, P, N	N/A	Pools, glides, etc.	
Juveniles, Marine	up to 4 months	fish and invertebrates	June - September	BCH, ICS, MCS, BA, IP	P, N	N/A	UP, CL	Temperature <15˚C; Depth <10 m
Immature/ Maturing Adults, Marine	12-14 months	Fish (e.g., herring, sand lance)		BCH, ICS, MCS, OCS, USP, LSP, BSN, BAY, IP	P, N	N/A	U	Temperature range 1-26˚C; optimum 12-14˚C
Adults, Fresh water	up to 2 months	little or none	migration - fall; spawning - fall, winter	WC, LK	Deep parts of streams and lakes	Alluvial bottom types	Deep pools, Pool-riffle transition	Temperature range 1-26˚C; optimum 12-14˚C