Assessing Important Habitat of the Endangered Beluga Whale in Cook Inlet, Alaska

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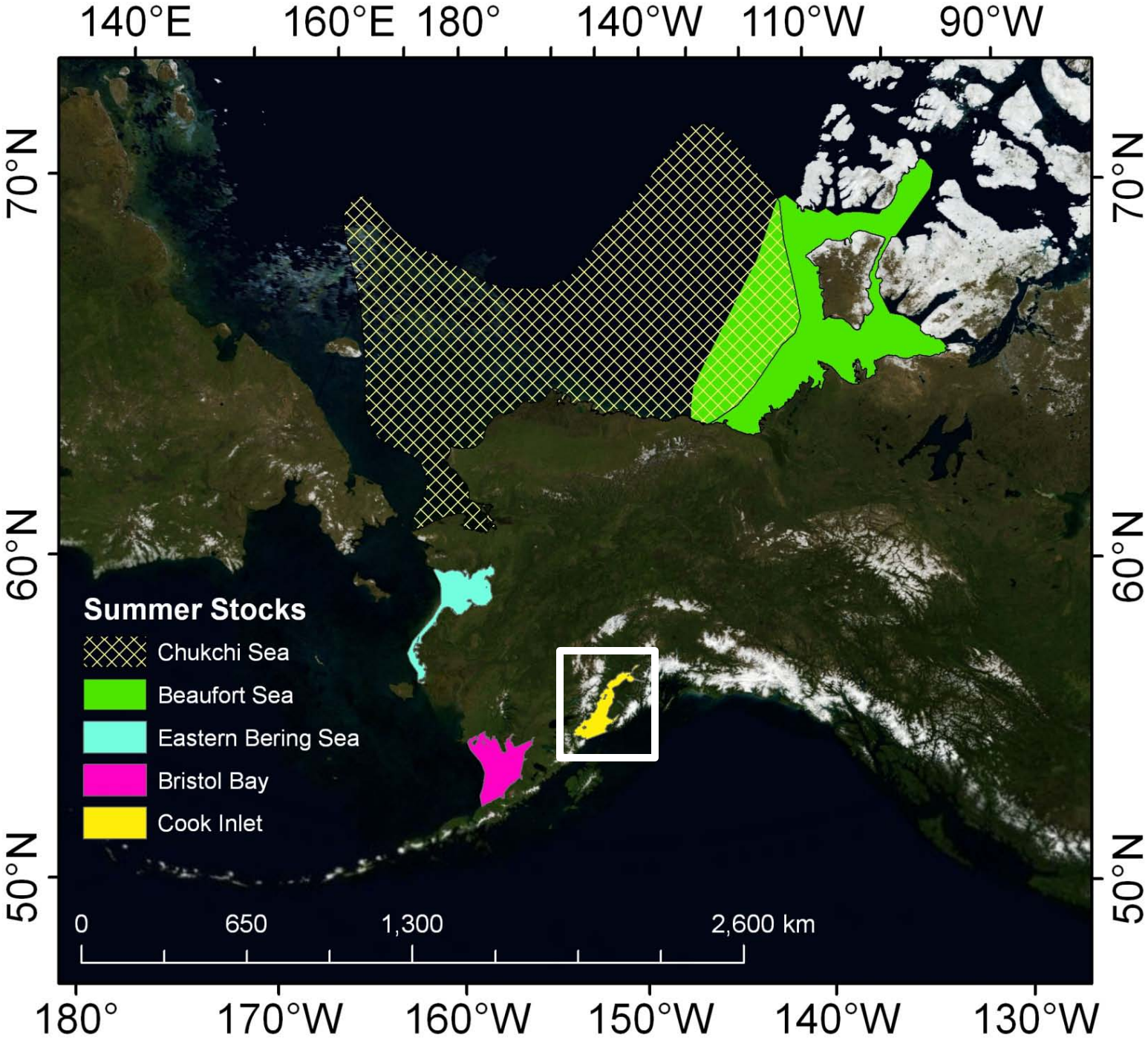
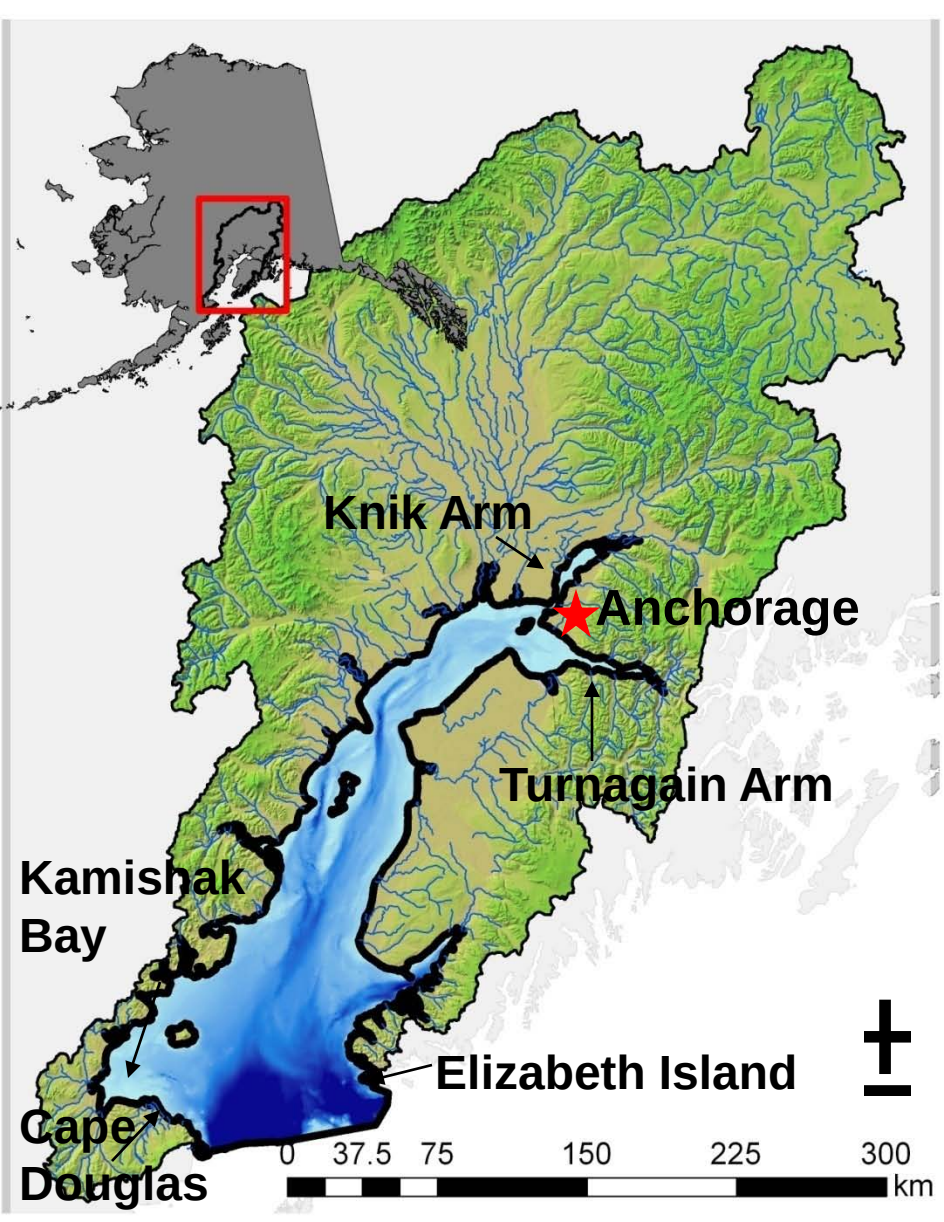
(2) Michigan State University

Photo Credit: Olga Shpak


140°E
160°E
180°
140°W
110°W
90°W
70°N
60°N
50°N
Summer Stocks
Chukchi Sea
Beaufort Sea
Eastern Bering Sea
Bristol Bay
Cook Inlet
0
650
1,300
2,600 km
180°
170°W
160°W
150°W
140°W
130°W

Cook Inlet Study Area / Watershed



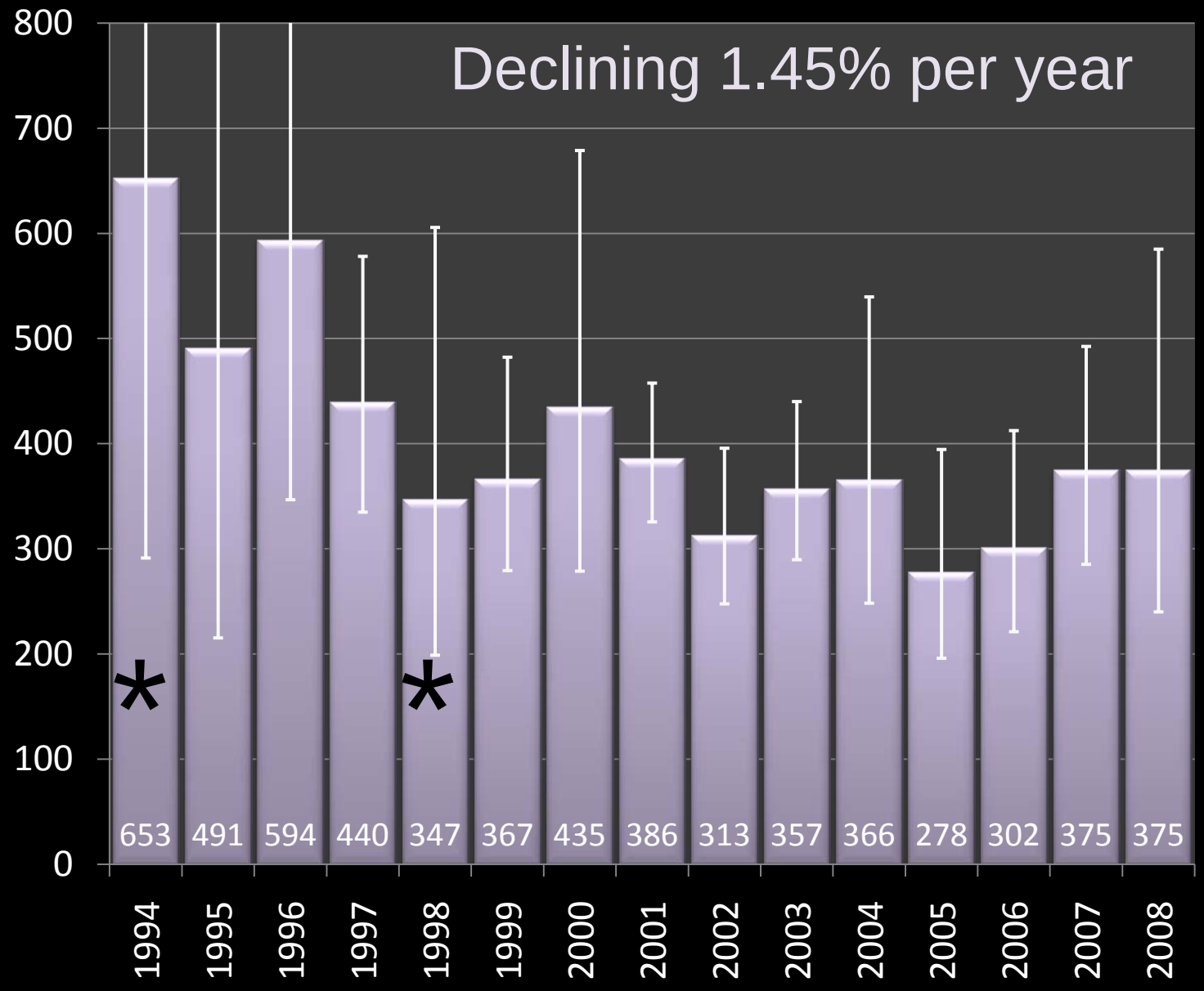
Study Area

- 370 km tidal estuary
- Over 20,000 km^2 area
- Extreme tidal cycle

Watershed

- 121,000 km^2
- Drains ~101,000 km^2
- 2/3 of AK population

Cook Inlet Beluga Abundance



Purpose of this Study

Identify which physical, ecological, and anthropogenic variables are important in **determining beluga presence**

And

Identify which physical, ecological, and anthropogenic variables are important in **determining beluga group size**, when they are present

Photo Credit: Olga Shpak

Survey Protocol

- June and July aerial surveys
- 3 observers, recorder and pilot
- GPS Interfaced with laptop
- Data entries included:
  1. Sightings
  2. Location
  3. Overcast
  4. Sea State
  5. Glare / Visibility
  6. Effort Status

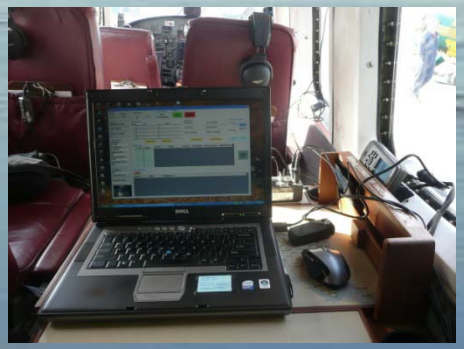
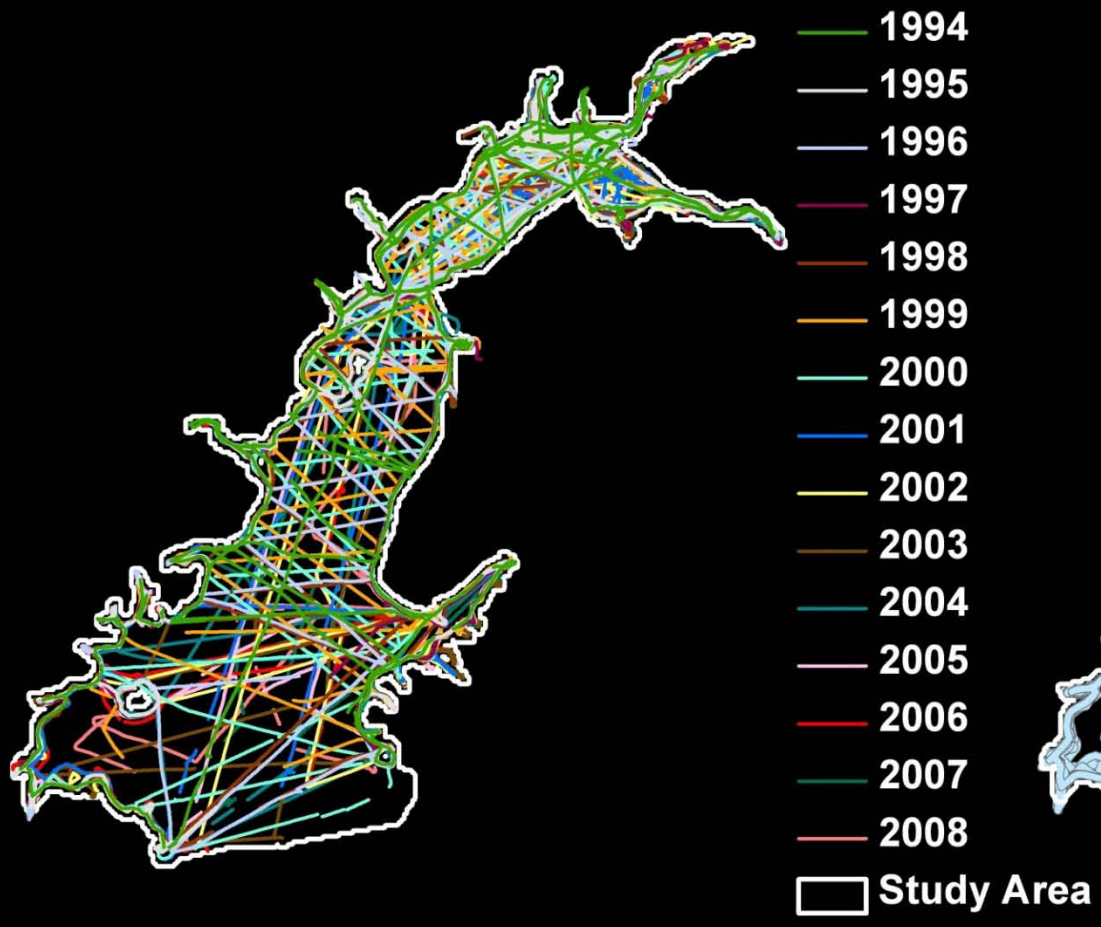
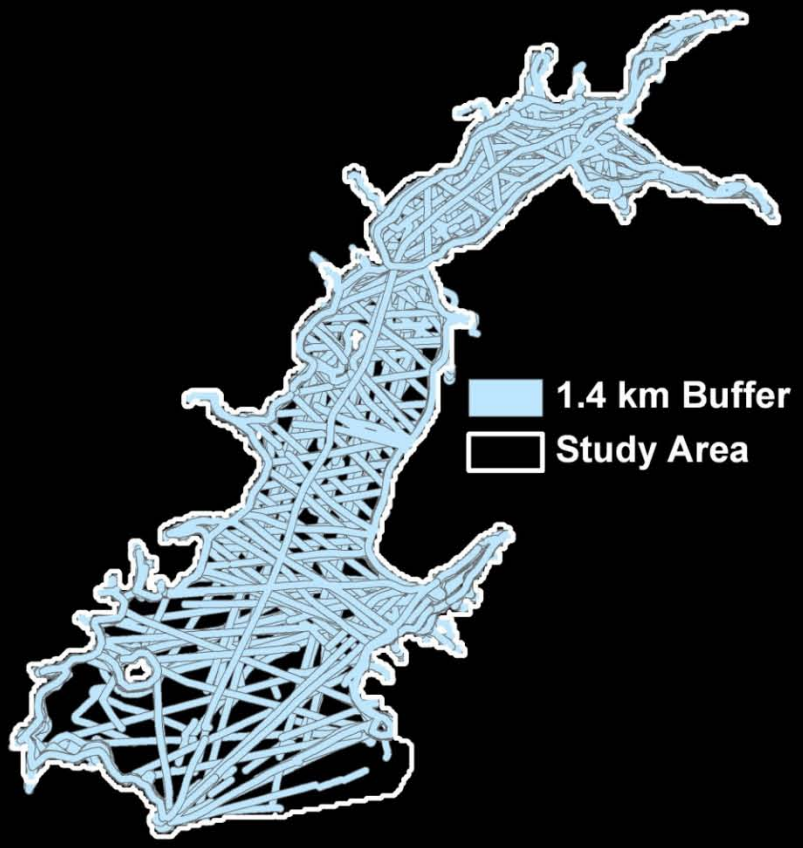


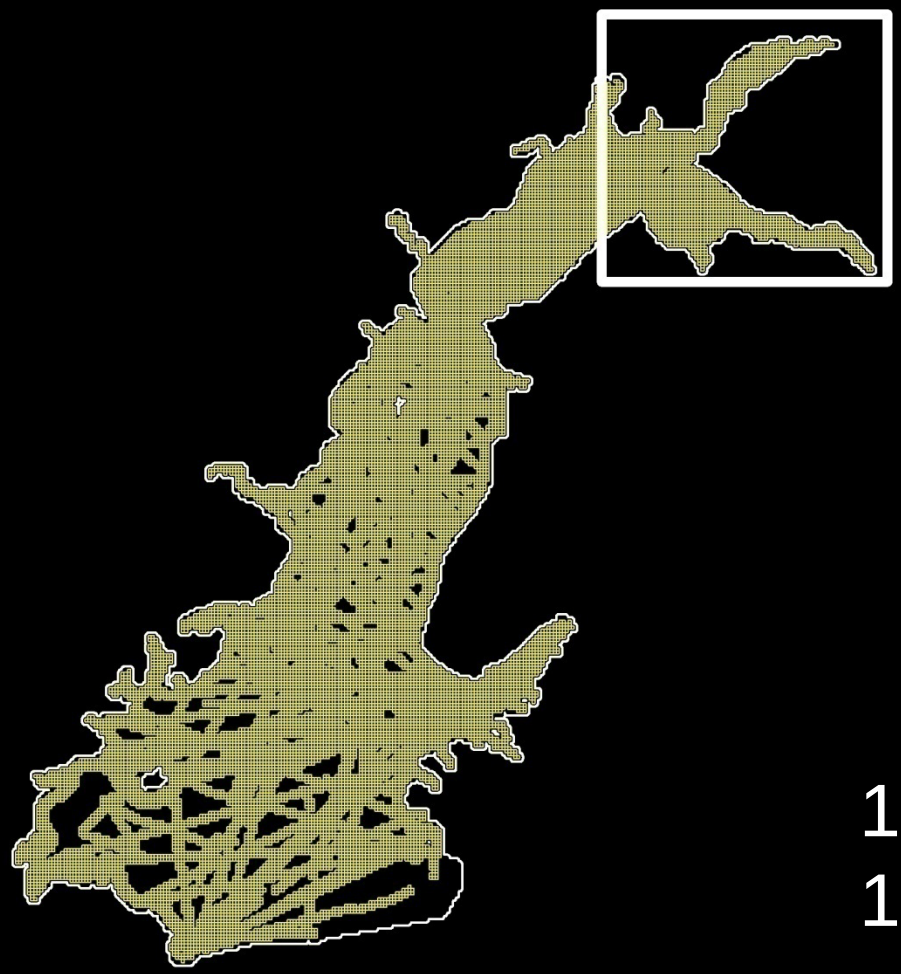
Photo Credit: Olga Shpak

Spatial Data Layers - Effort



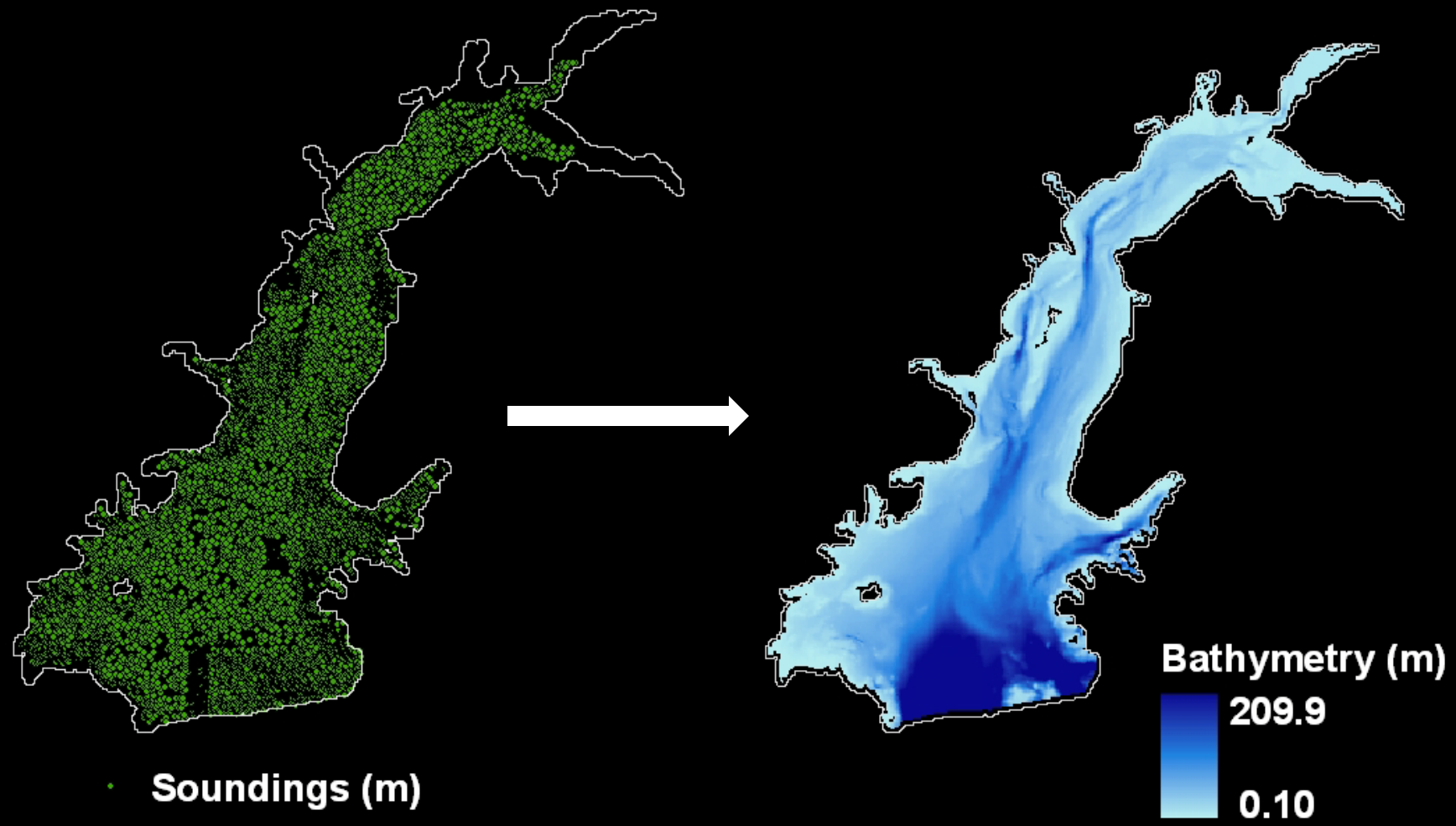


Spatial Data Layers – 1 km Grid

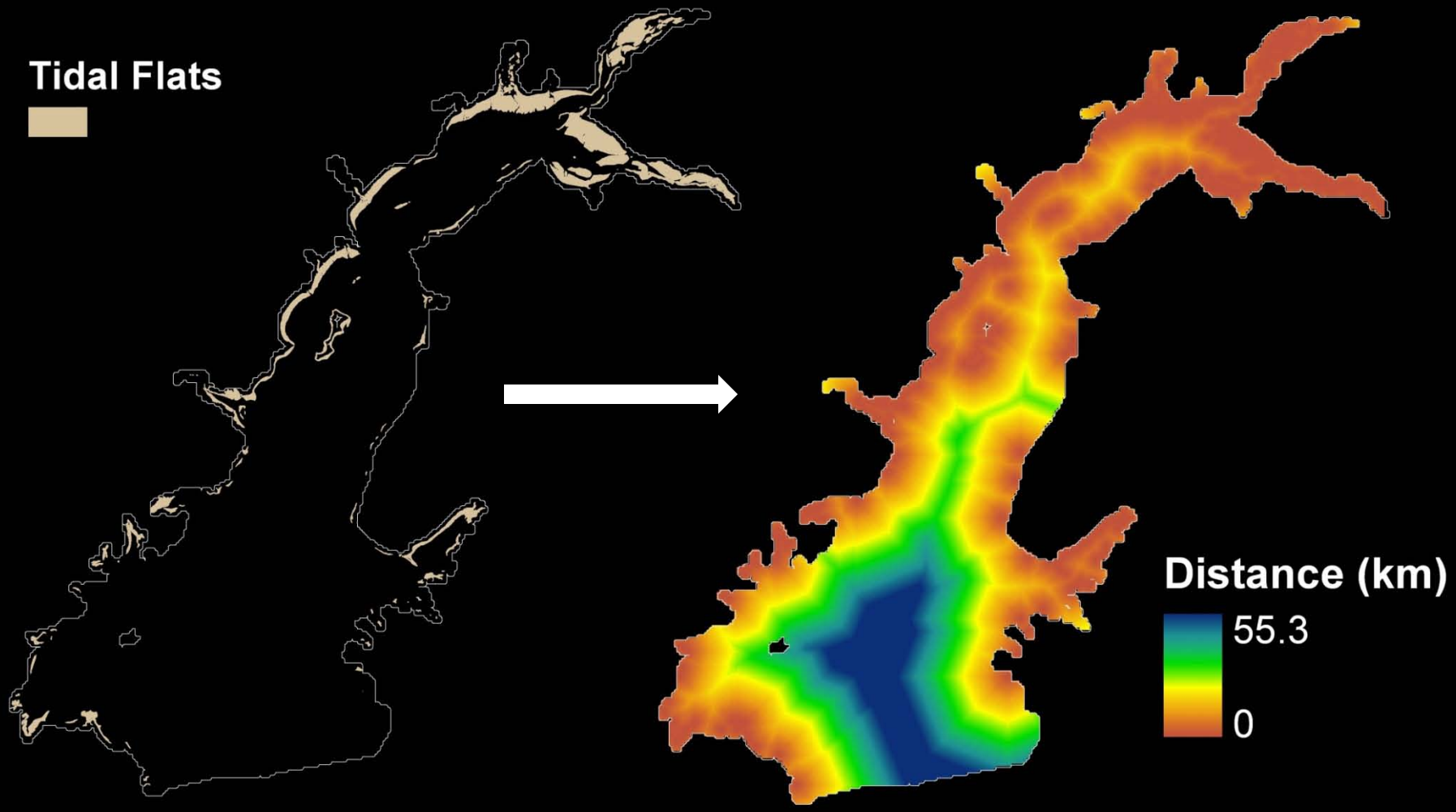


18,083 Unique Cells
100,731 Overall (w/ repeats)

Spatial Data Layers - Bathymetry

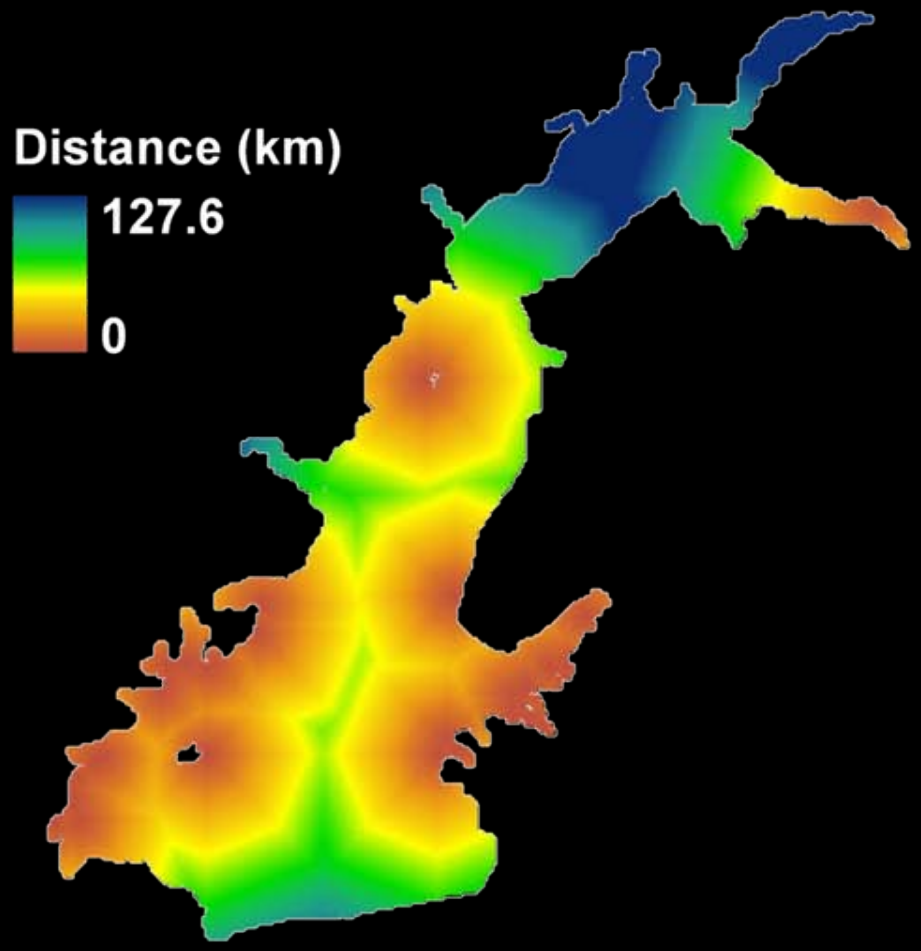


Spatial Data Layers – Substrates

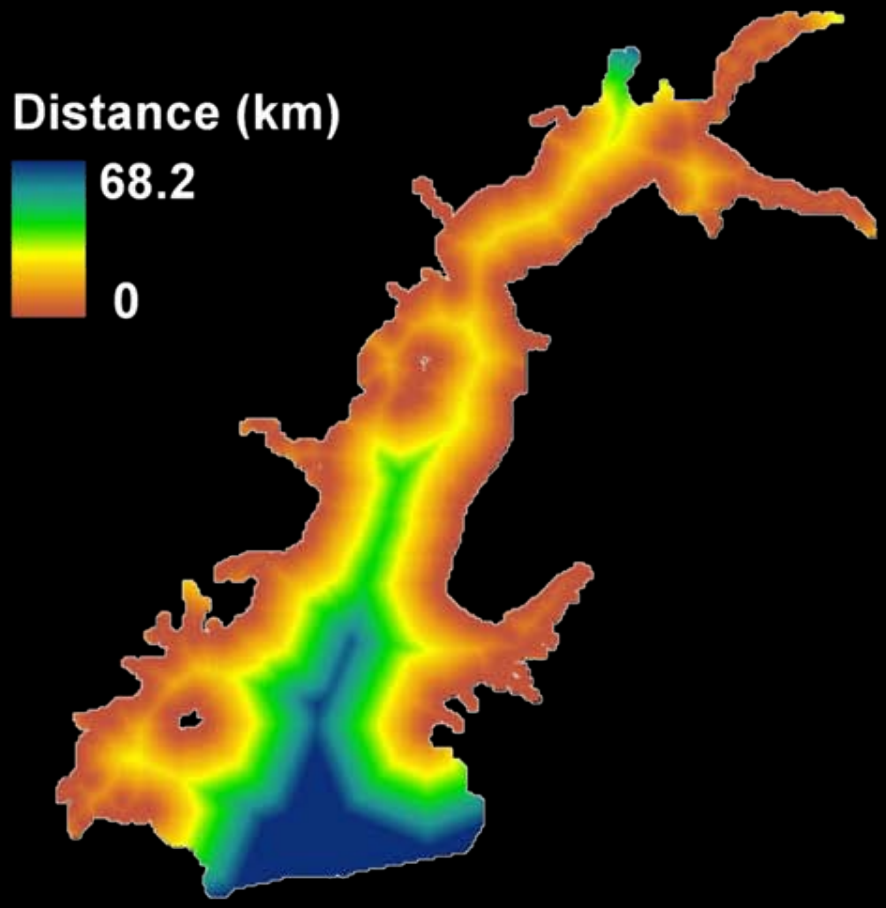


Spatial Data Layers – Substrates

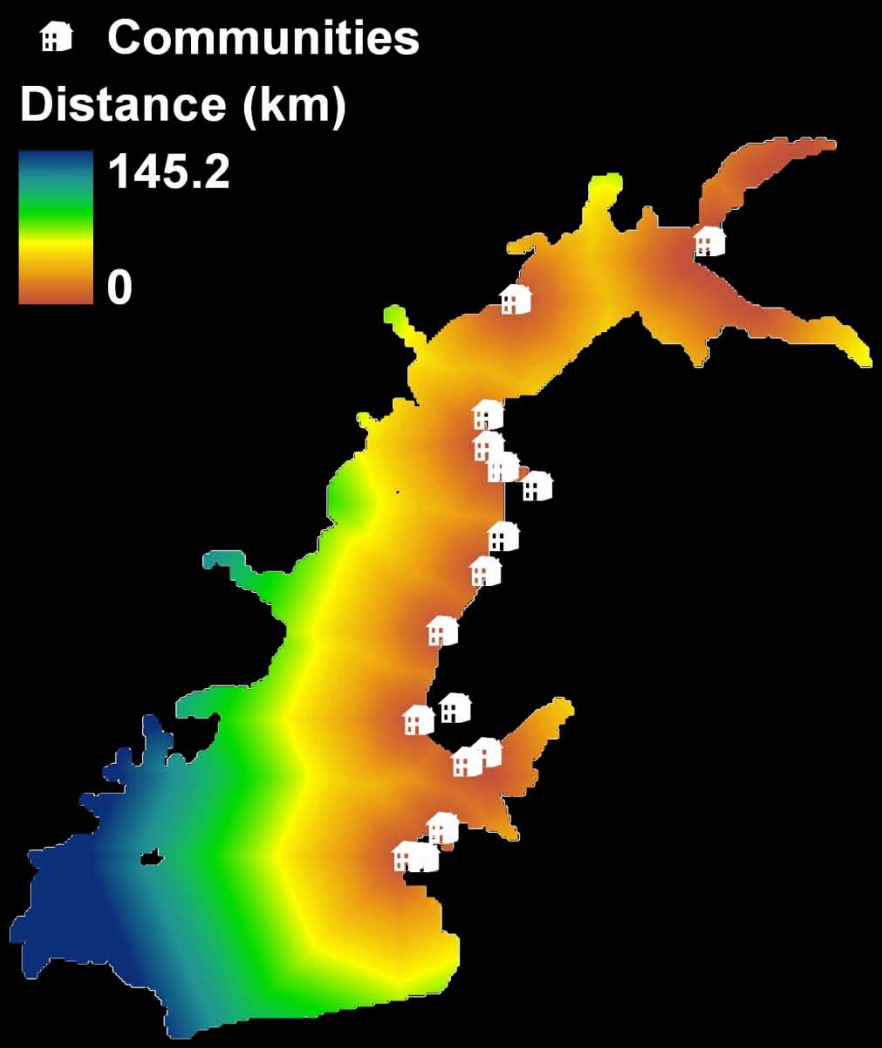
Rock

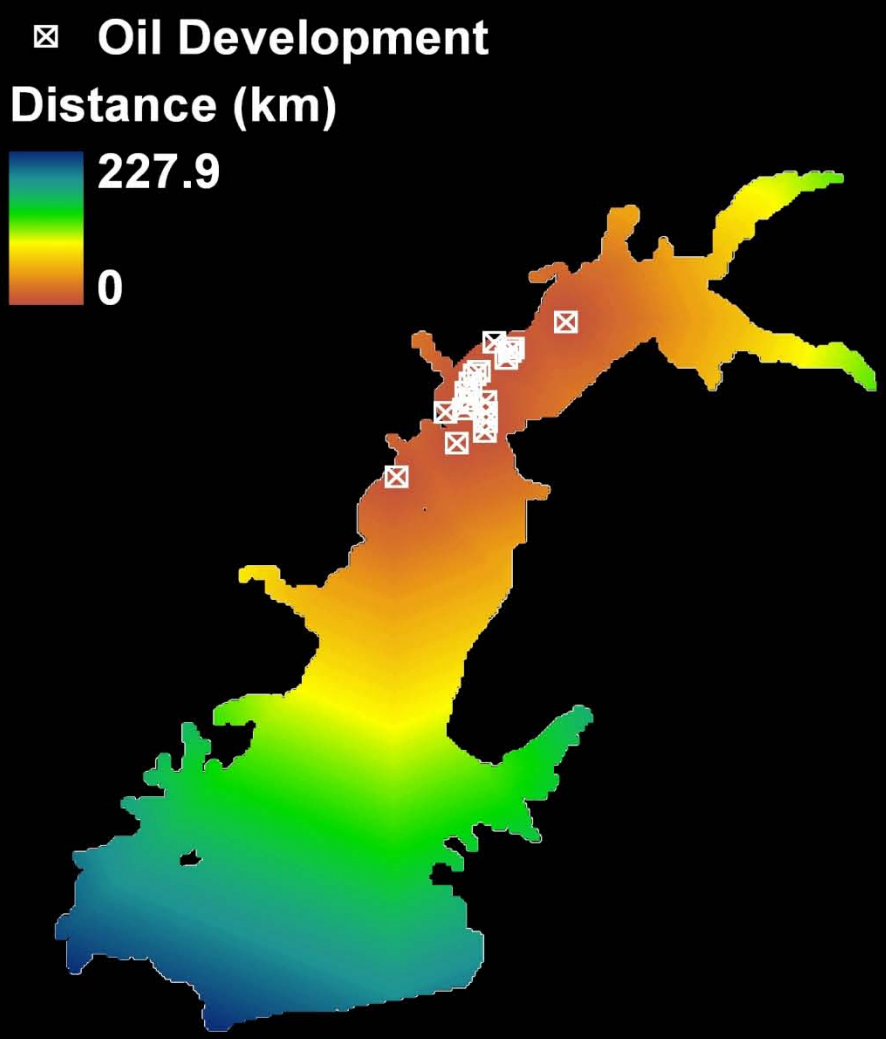


Sand

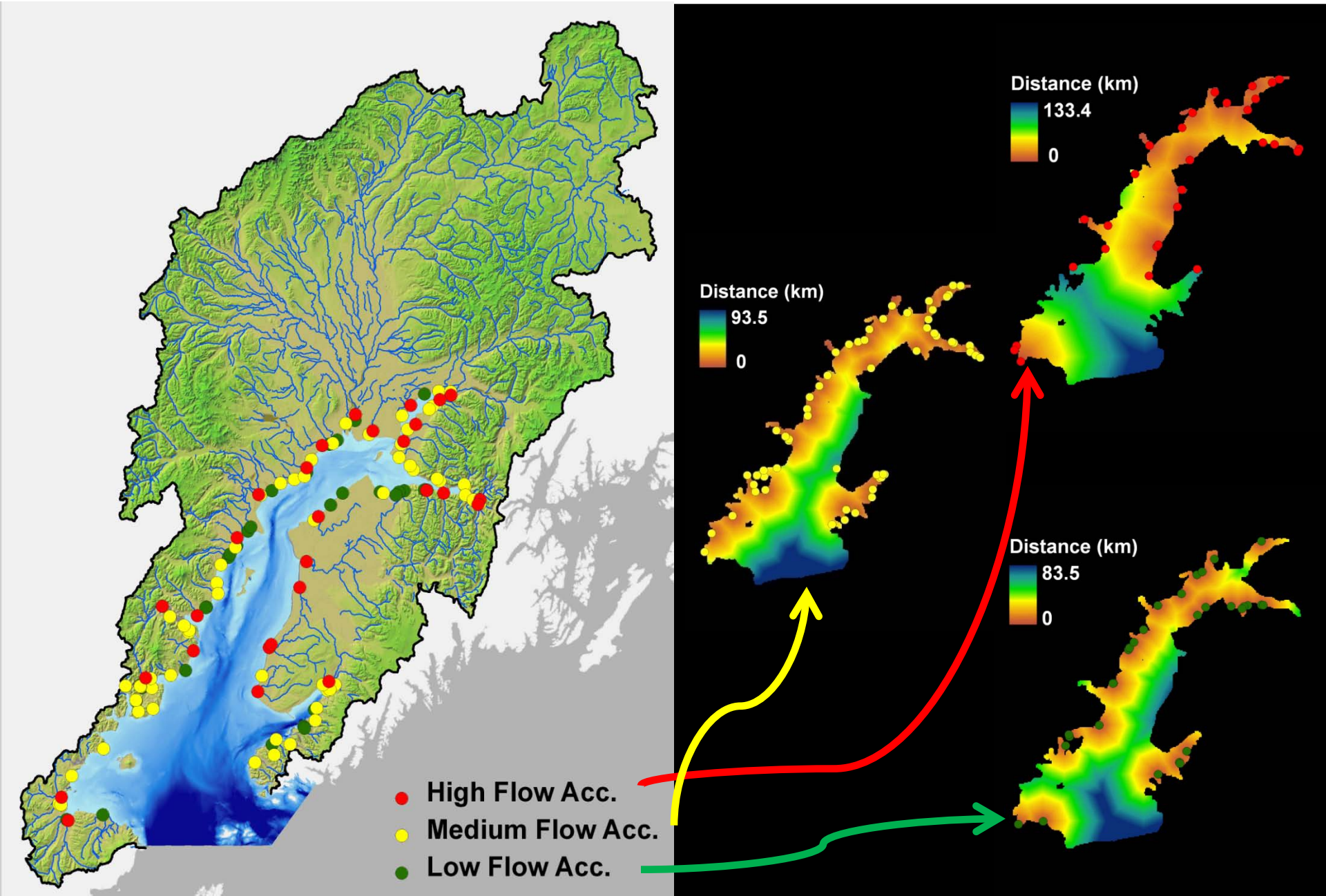


Spatial Data Layers – Communities and Oil

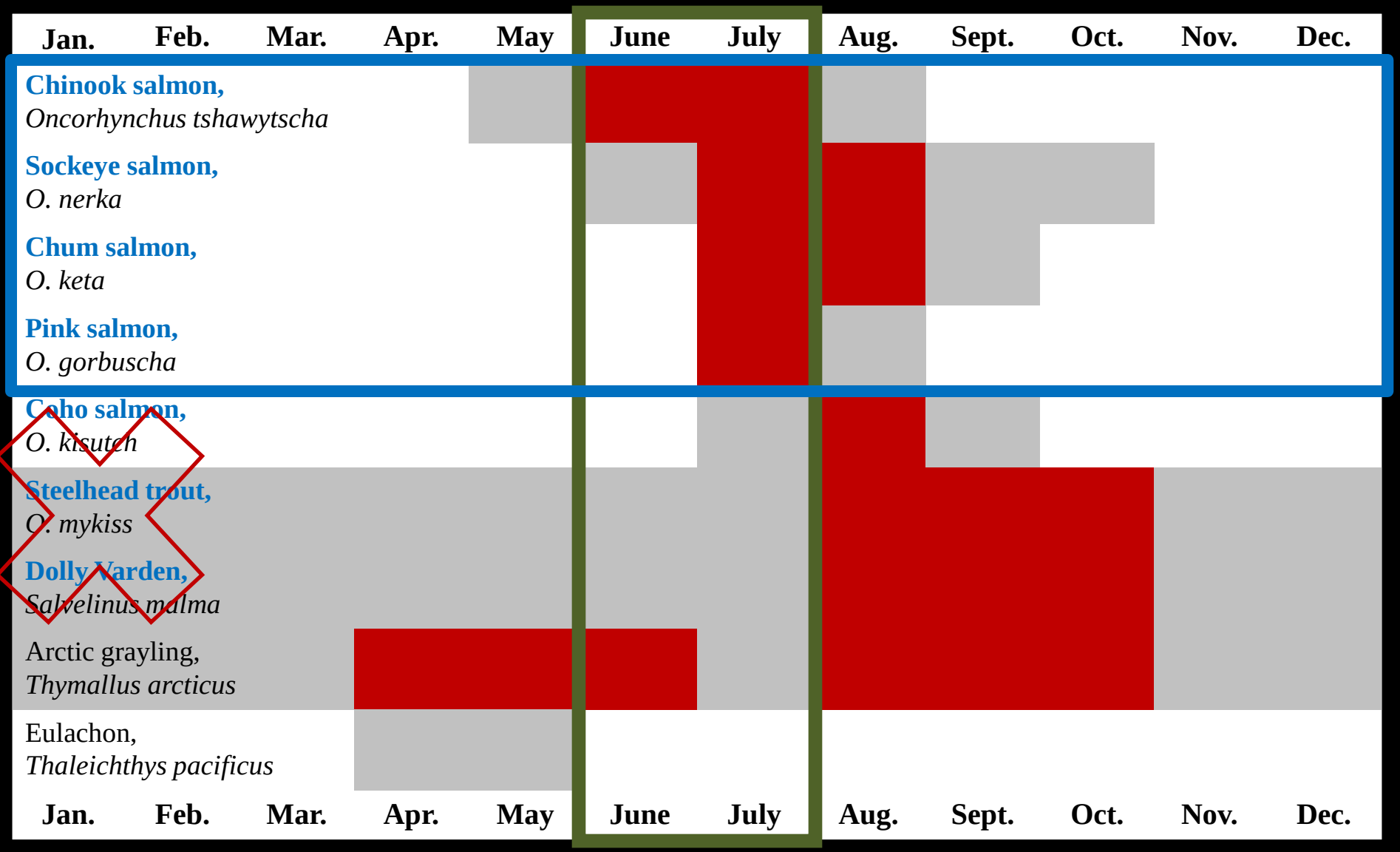




Spatial Data Layers – Flow Accumulation



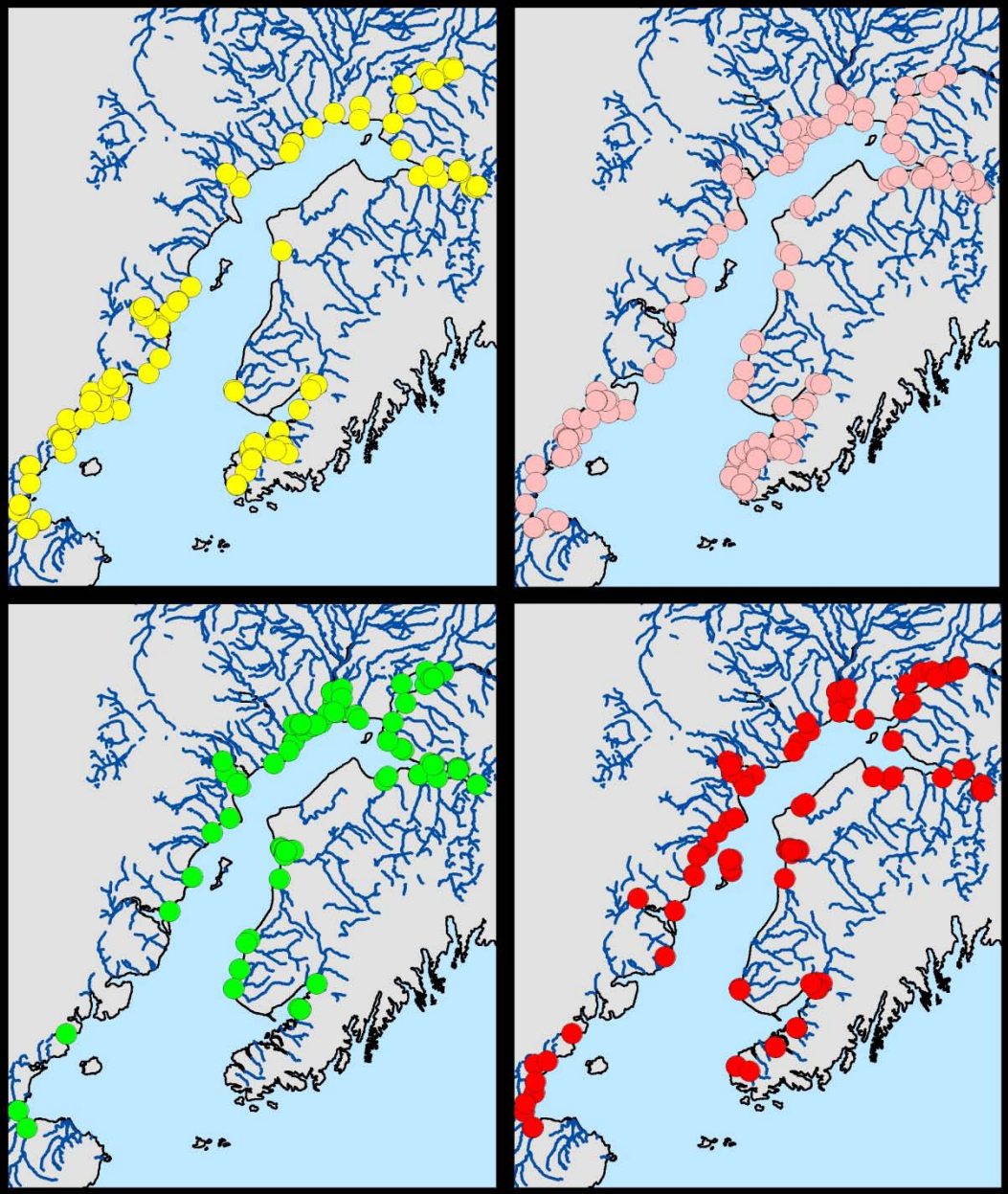
Timing of Fish Species Entering Fresh Water Drainages in Upper Cook Inlet



Gray = Approximate timing of presence **Red = Peak availability**

Moore *et al*, 2000

Spatial Data Layers – Anadromous Fish



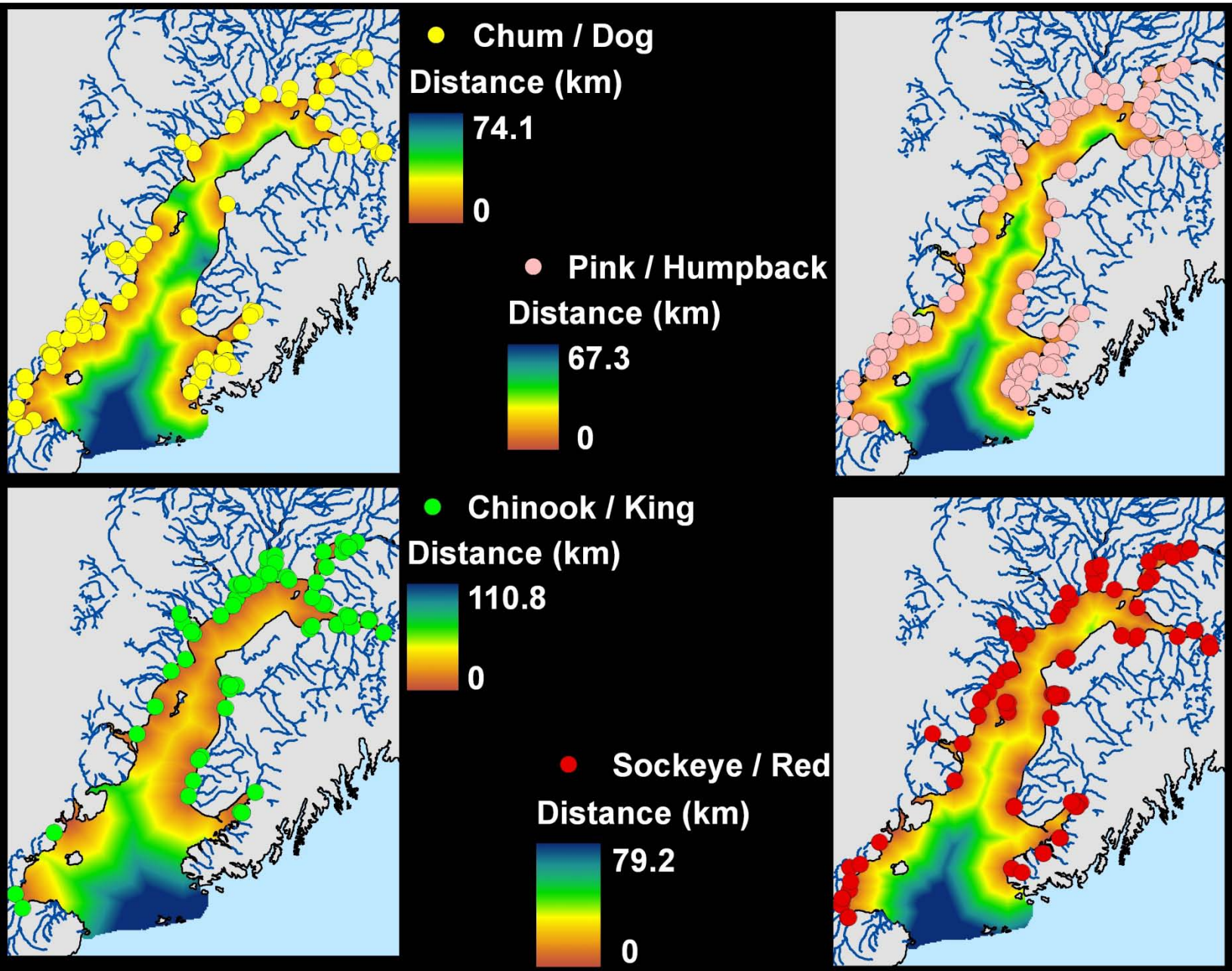
Chum / Dog

Pink / Humpback

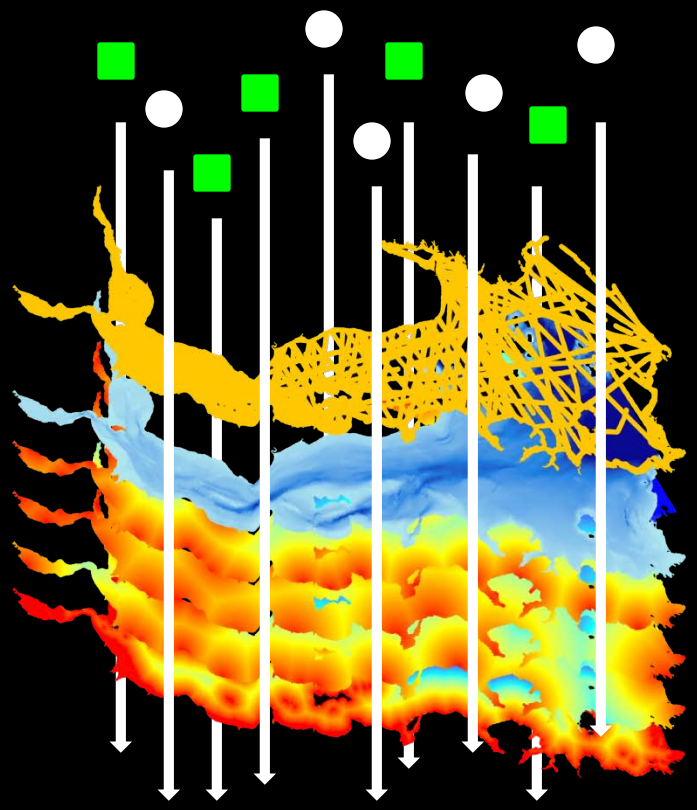
Chinook / King

Sockeye / Red

Spatial Data Layers – Anadromous Fish



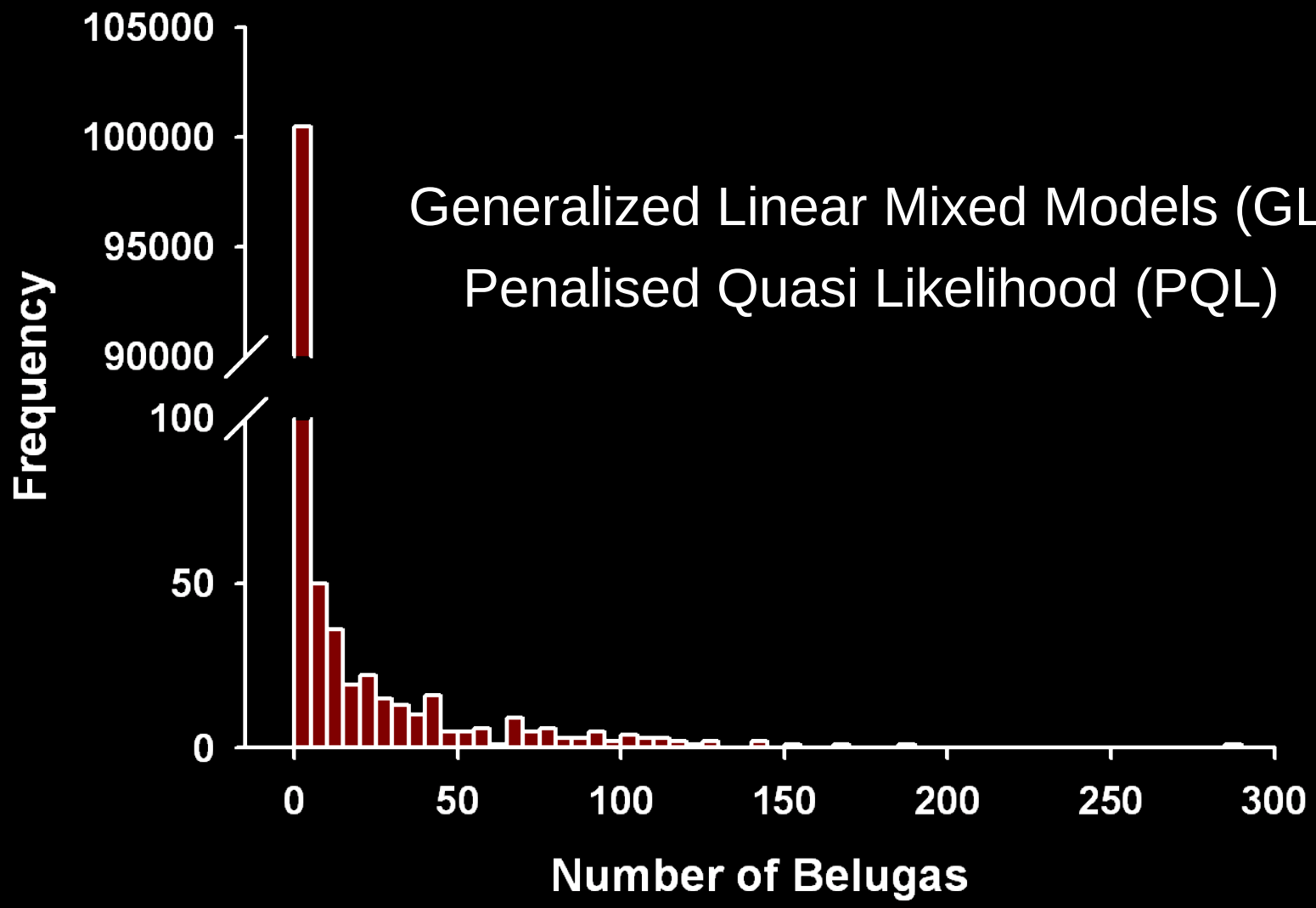
Analysis



Lots of Data!

100,731 Data Rows

Analysis



Generalized Linear Mixed Models (GLMM)

Penalised Quasi Likelihood (PQL)

Analysis

GLMM - Binary (Presence/Absence)

0 belugas

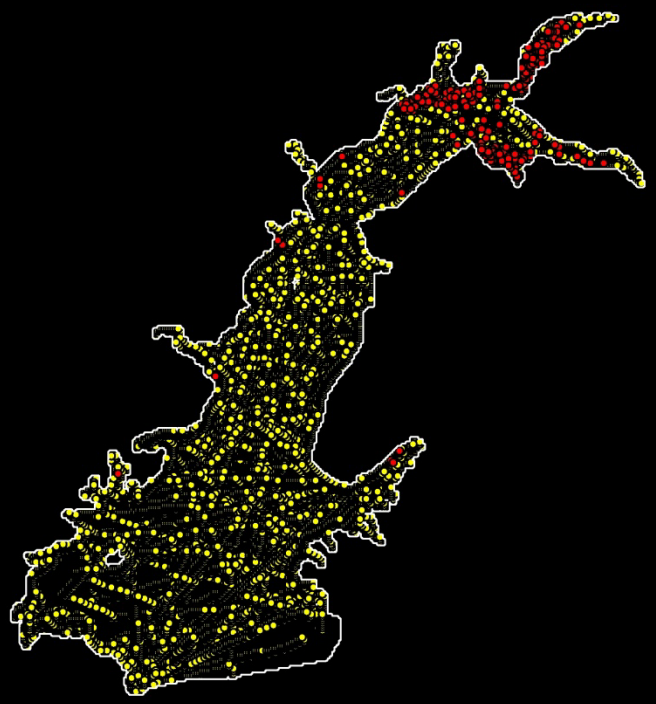
GLMM - Poisson (Group Size)

> 0 belugas

GLMM - Binary (Presence/Absence)

Response Variable

- Presence
  or
- Absence



Start Variables

- ~~Bathymetry~~
- ~~Sockeye Salmon~~
- ~~Pink Salmon~~
- Chinook Salmon
- Chum Salmon
- Communities
- Oil Development
- High Flow Acc.
- ~~Low Flow Acc.~~
- Med Flow Acc.
- Tidal Flats
- Rock
- Sand

Fixed Effects

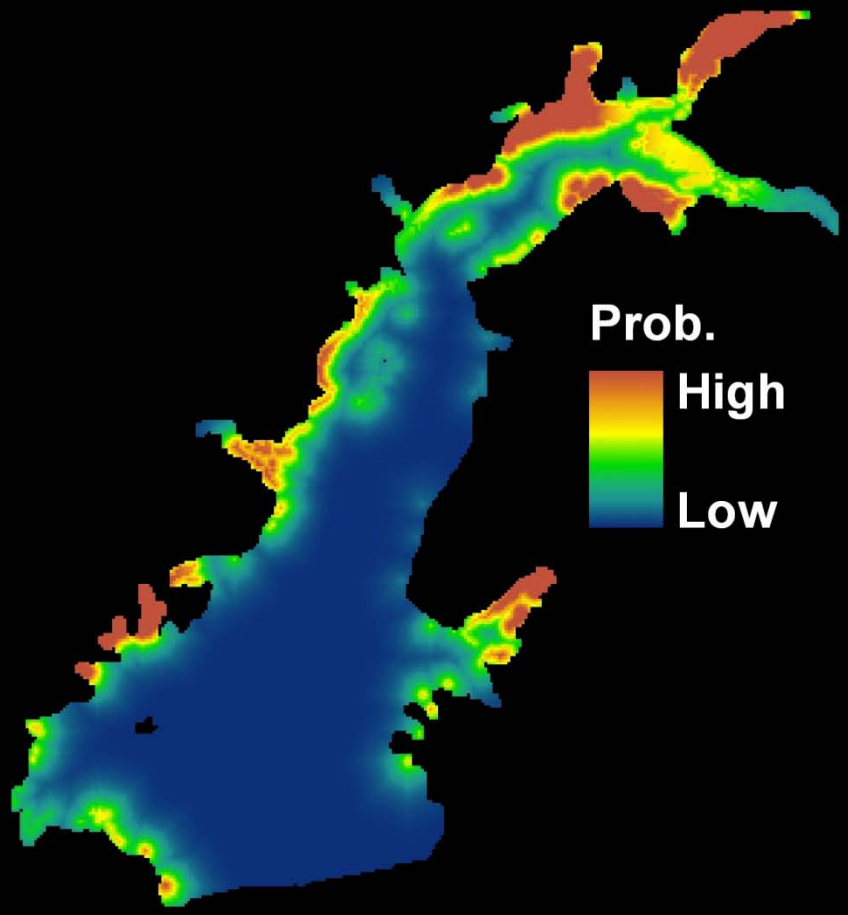
- Chinook Salmon
- Chum Salmon
- Communities
- Oil Development
- High Flow Acc.
- Med Flow Acc.
- Tidal Flats
- Rock
- Sand
- Sample

Random Effect

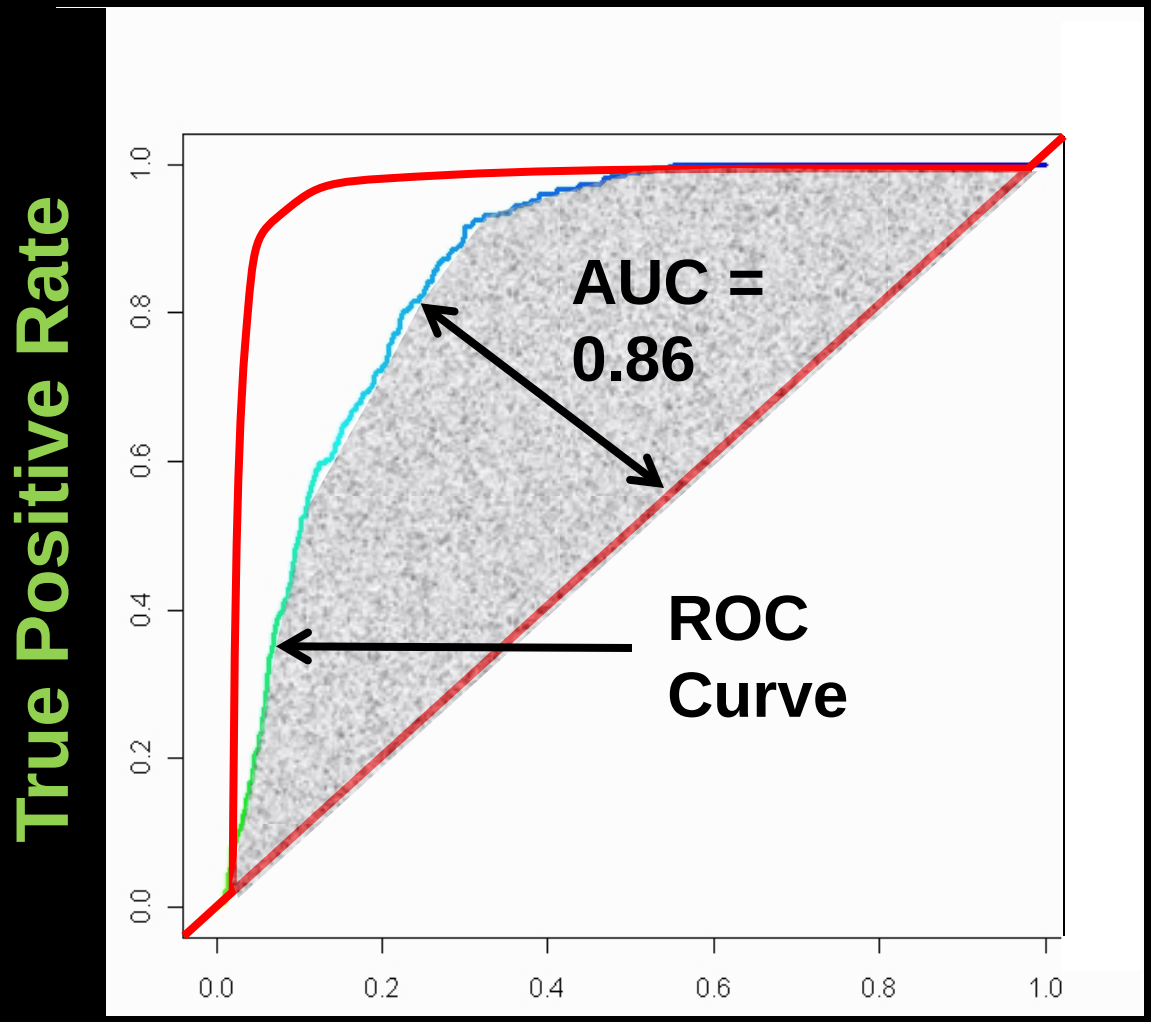
Cell ID (18,083)

GLMM - Binary (Presence/Absence)

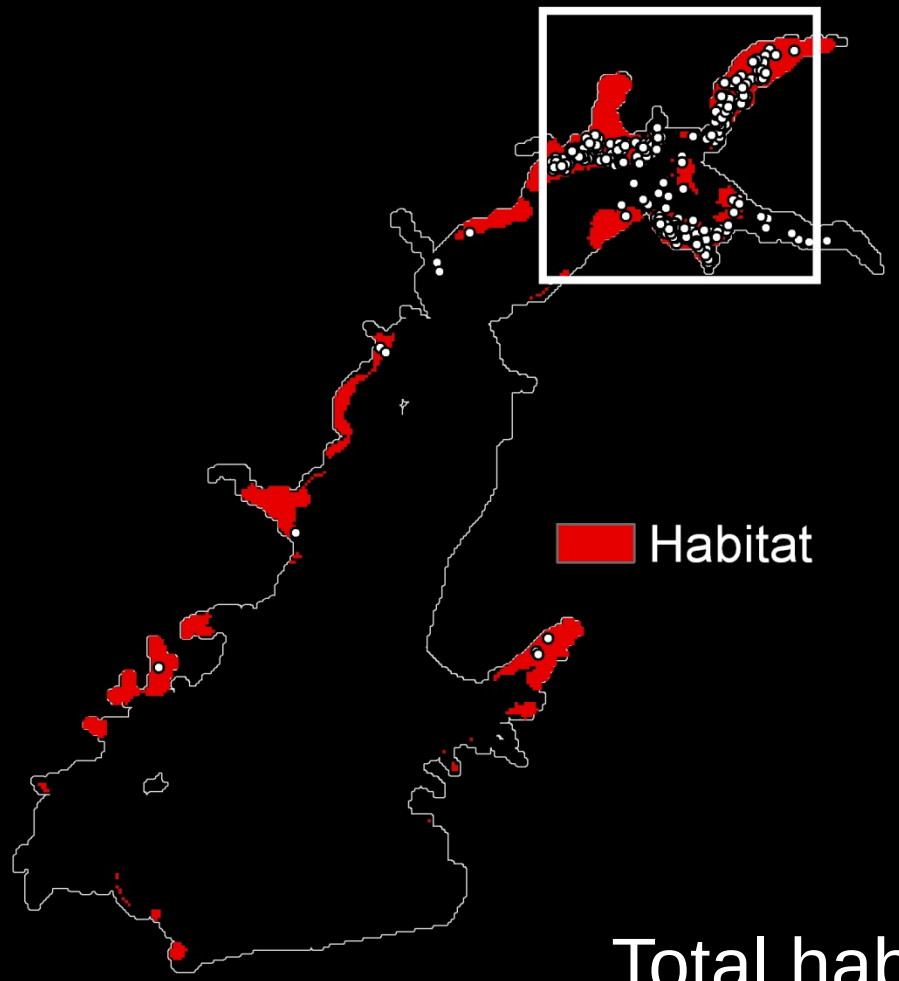
Variable	Coefficient	p-value
(Intercept)	-8.283	< 0.001
Sample	0.245	< 0.001
Chinook	-0.009	< 0.001
Chum	0.009	< 0.001
Oil	0.003	< 0.001
Community	0.006	< 0.001
High Flow	0.024	< 0.001
Med Flow	-0.019	< 0.001
Tidal Flats	-0.177	< 0.001
Rock	0.025	< 0.001
Sand	-0.008	0.017



GLMM - Binary (Presence/Absence)

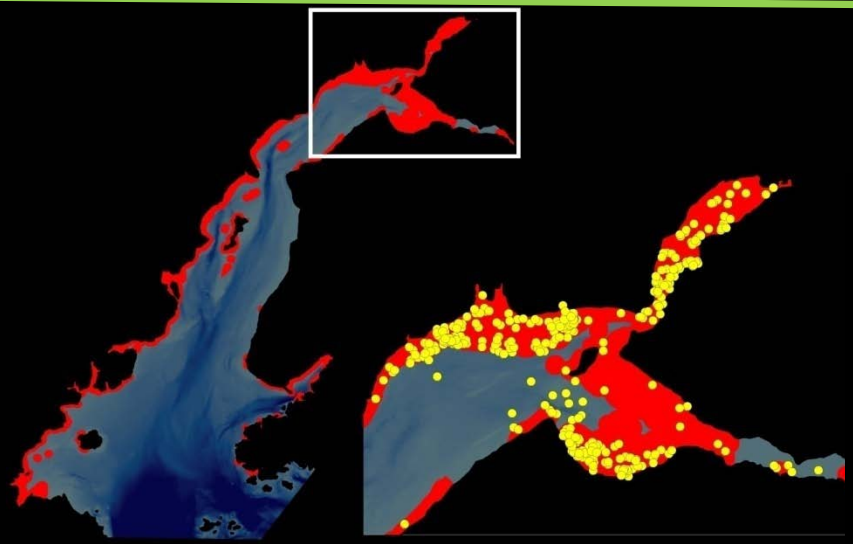


GLMM - Binary (Presence/Absence)

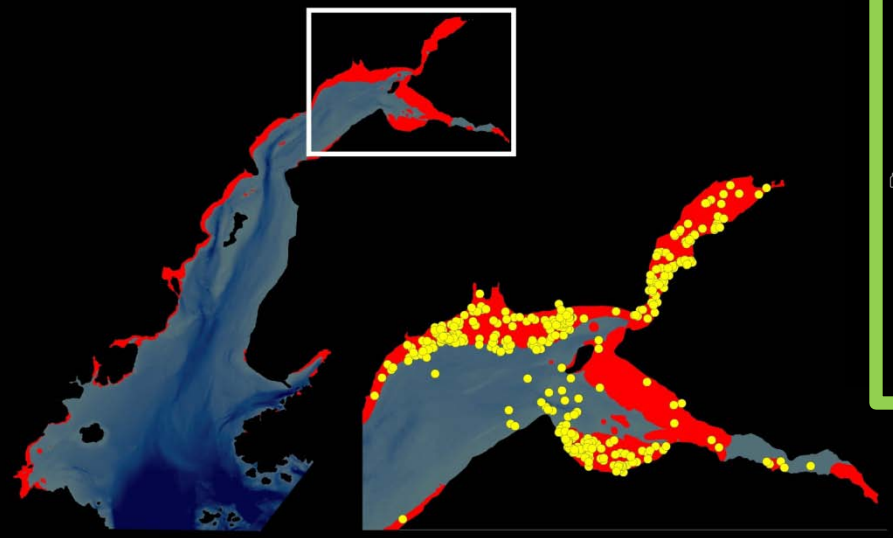


Total habitat area = 2857 km^2

GLMM - Binary (Presence/Absence)

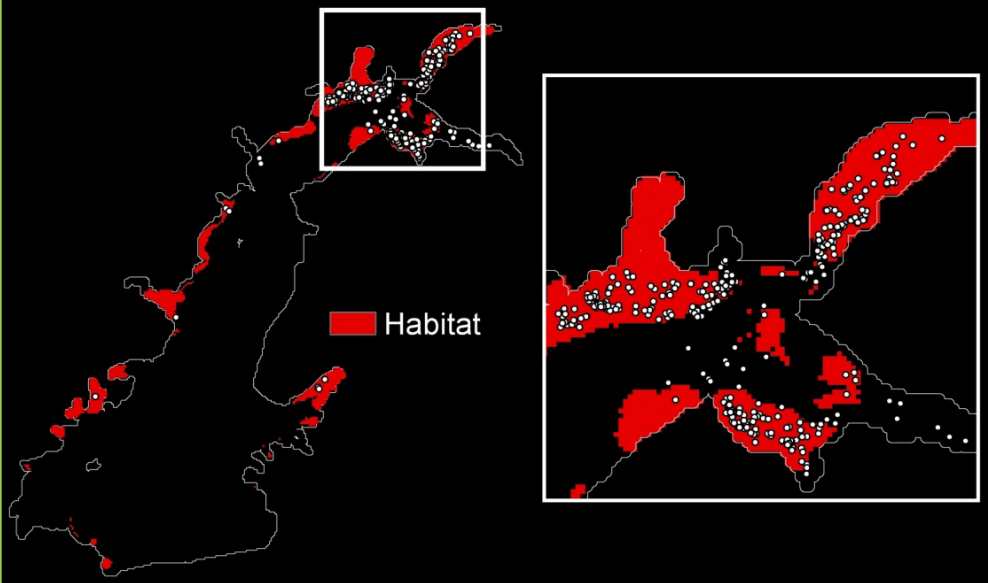


Habitat (CART) = 3784 km^2



Habitat (RSF) = 2402 km^2

Current Model

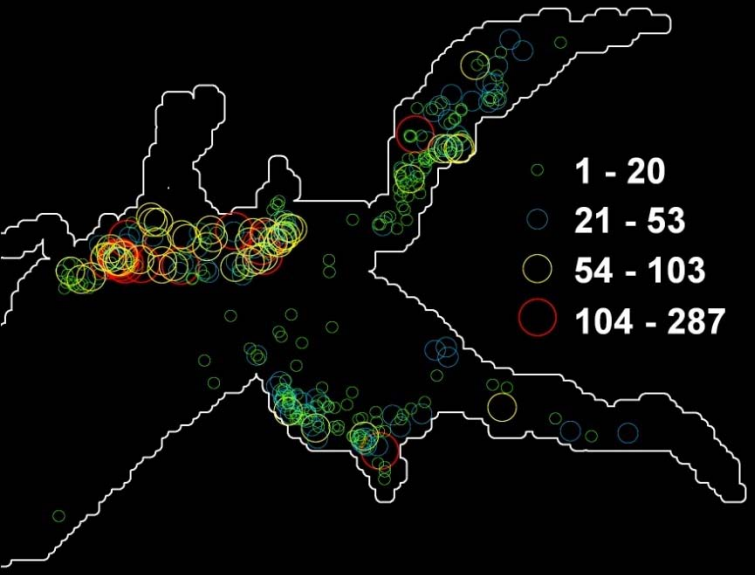


Habitat = 2857 km^2

GLMM - Poisson (Group Size)

Response Variable

Group Size



Start Variables

Bathymetry
Sockeye Salmon
~~Pink Salmon~~
Chinook Salmon
Chum Salmon
Communities
Oil Development
High Flow Acc.
Low Flow Acc.
Med Flow Acc.
Tidal Flats
~~Rock~~
Sand

Fixed Effects

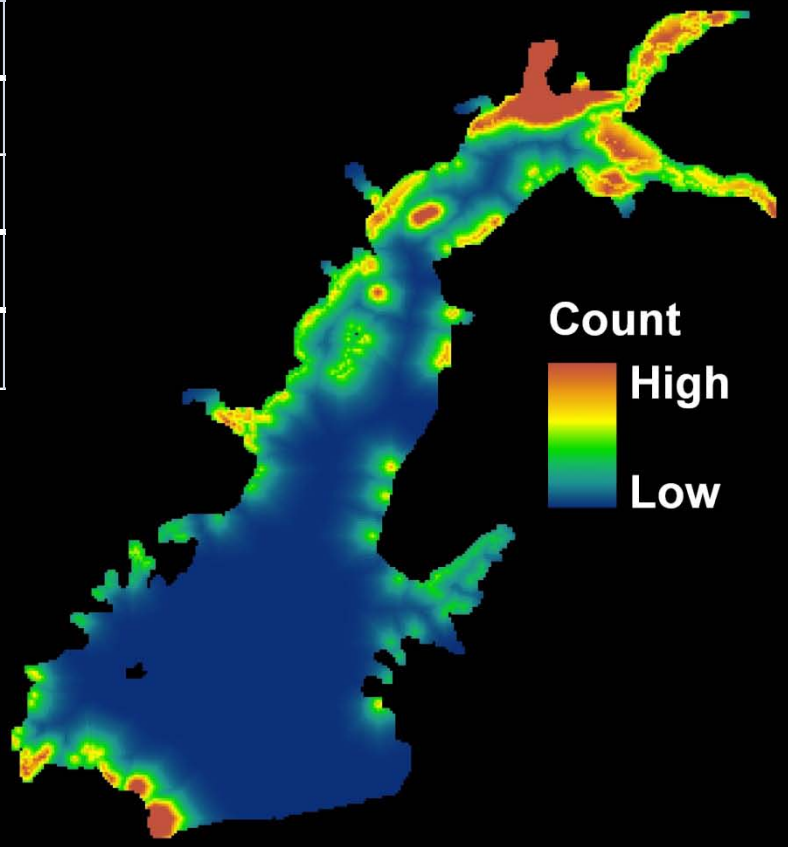
Bathymetry
Sockeye Salmon
Chinook Salmon
Chum Salmon
Communities
Oil Development
High Flow Acc.
Med Flow Acc.
Tidal Flats
Sand
Sample

Random Effect

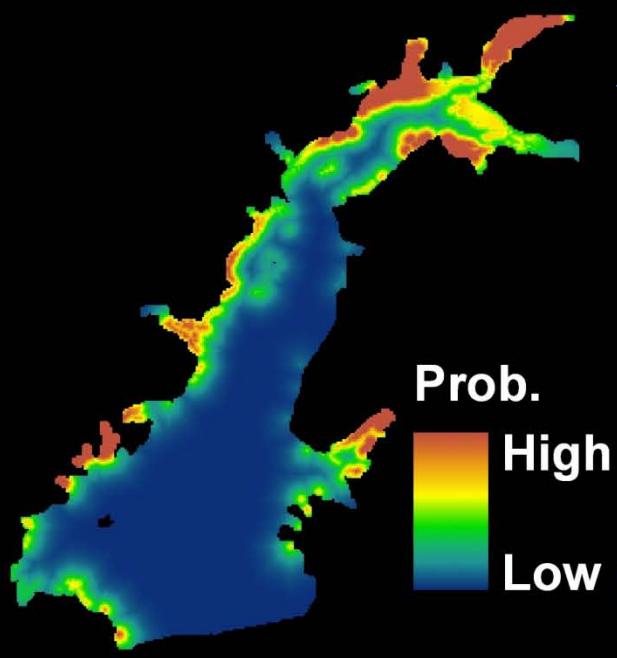
Cell ID (18,083)

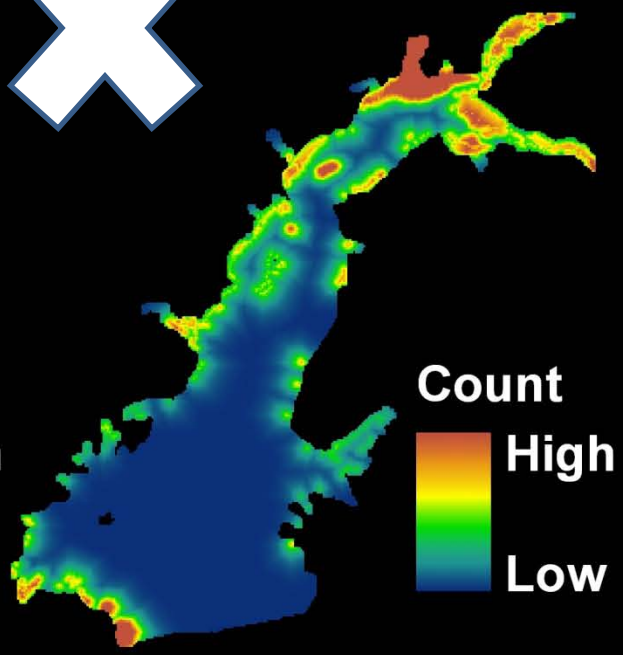
GLMM - Poisson (Group Size)

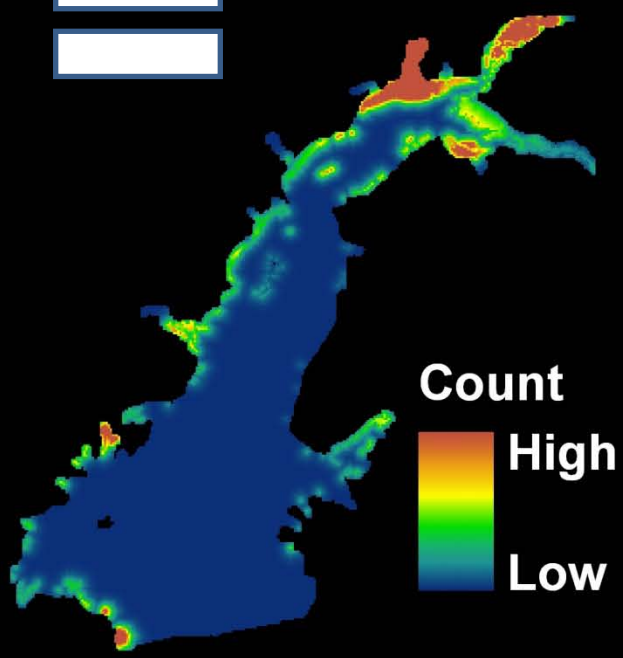
Variable	Coefficient	p-value
(Intercept)	3.192	< 0.001
High Flow	-0.010	0.025
Tidal Flats	-0.243	< 0.001
Sand	0.071	< 0.001



Summary







GLMM - Binary (Presence/Absence)

GLMM - Poisson (Group Size)

Expected Group Size when present

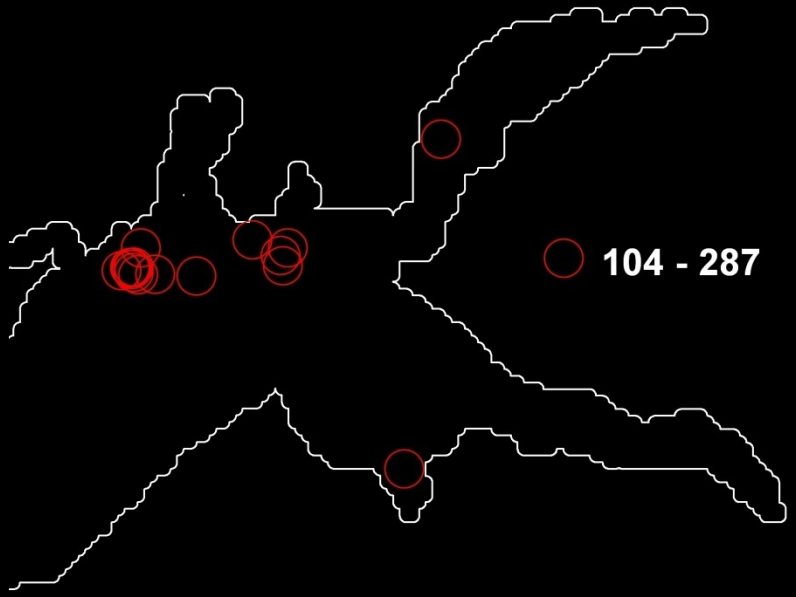
Summary

GLMM – binary (Presence/Absence)

Chinook Salmon	Near
Chum Salmon	Far
Community	Far
Oil Development	Far
High Flow Acc.	Far
Med Flow Acc.	Near
Tidal Flats	Near
Rock	Far
Sand	Near

GLMM - poisson (Group Size)

High Flow Acc.	Near
Tidal Flats	Near
Sand	Far



Conclusions

1. **The same areas seem to be important**
2. Useful tools for informing management
3. Difficult to obtain parameter estimates using GLMM
4. Direct measures of prey
5. Correlation versus causation

Acknowledgements

NMML

- David Rugh
- Kim Shelden
- Phil Clapham
- Field Crews

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- Pat Halpin
- Andy Read
- Ben Best
- Ari Friedlaender

UCSC

- Costa Lab
  (Gitte, Patrick, Jen, Sam)
- Pete Raimondi

Final Words of Wisdom:

"All models are wrong, some models are useful"