Whales as sentinels in a changing marine environment in the Gulf of Alaska

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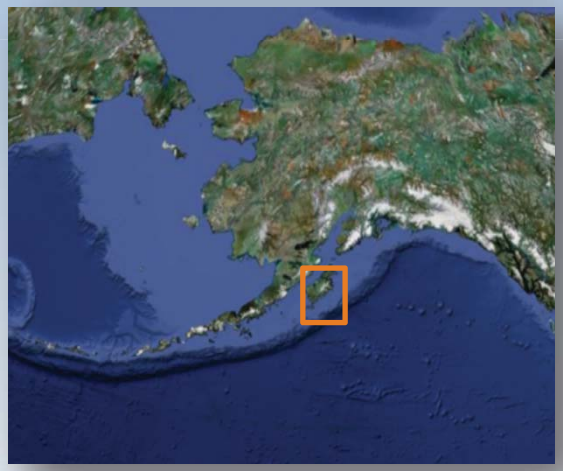
Outline

- The GAP project
- GAP Whales
- Three examples
  1. Monitoring of index sites
  2. Spatial and temporal trends in habitat use
  3. Consumption modeling

The Gulf Apex Predator-prey Project GAP

- Initiated in 1999 to address questions of biologic and economic concern triggered by dramatic declines in Steller sea lions



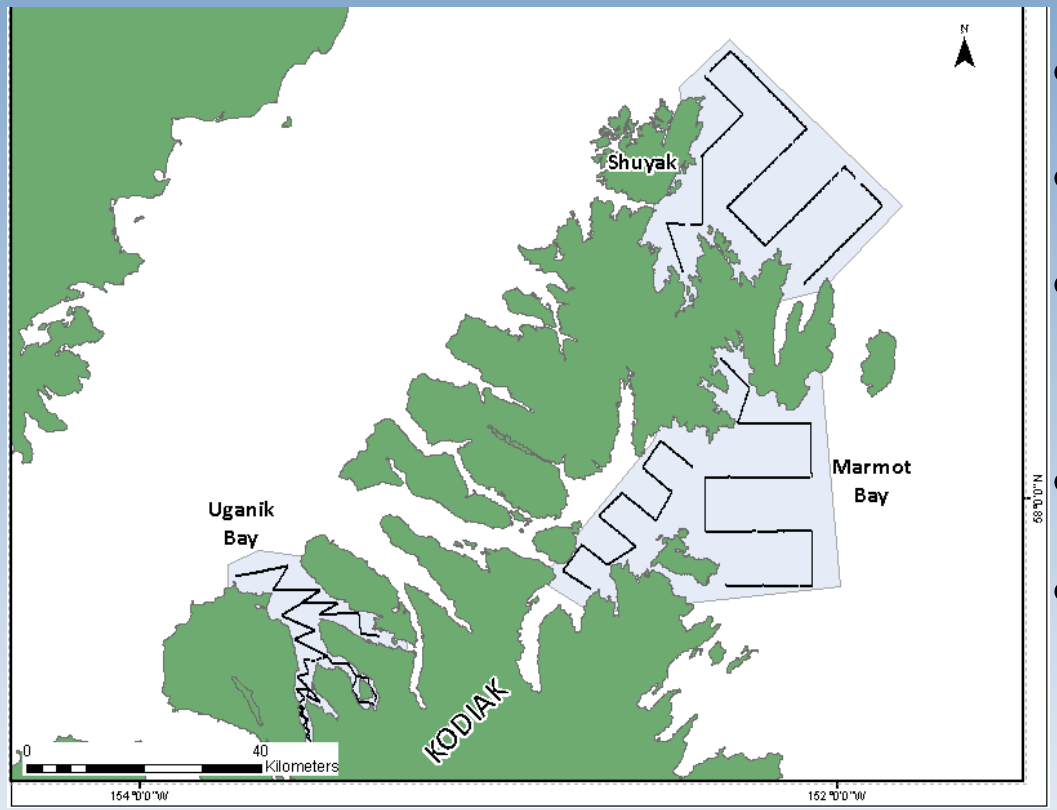
GAP Whales

- Apex predators that consume massive amounts of prey
- Major population fluctuations
- Recovery is occurring during times of significant environmental change
- Given the breadth of GAP and related data, we now seek to explore the use of whales as sentinels

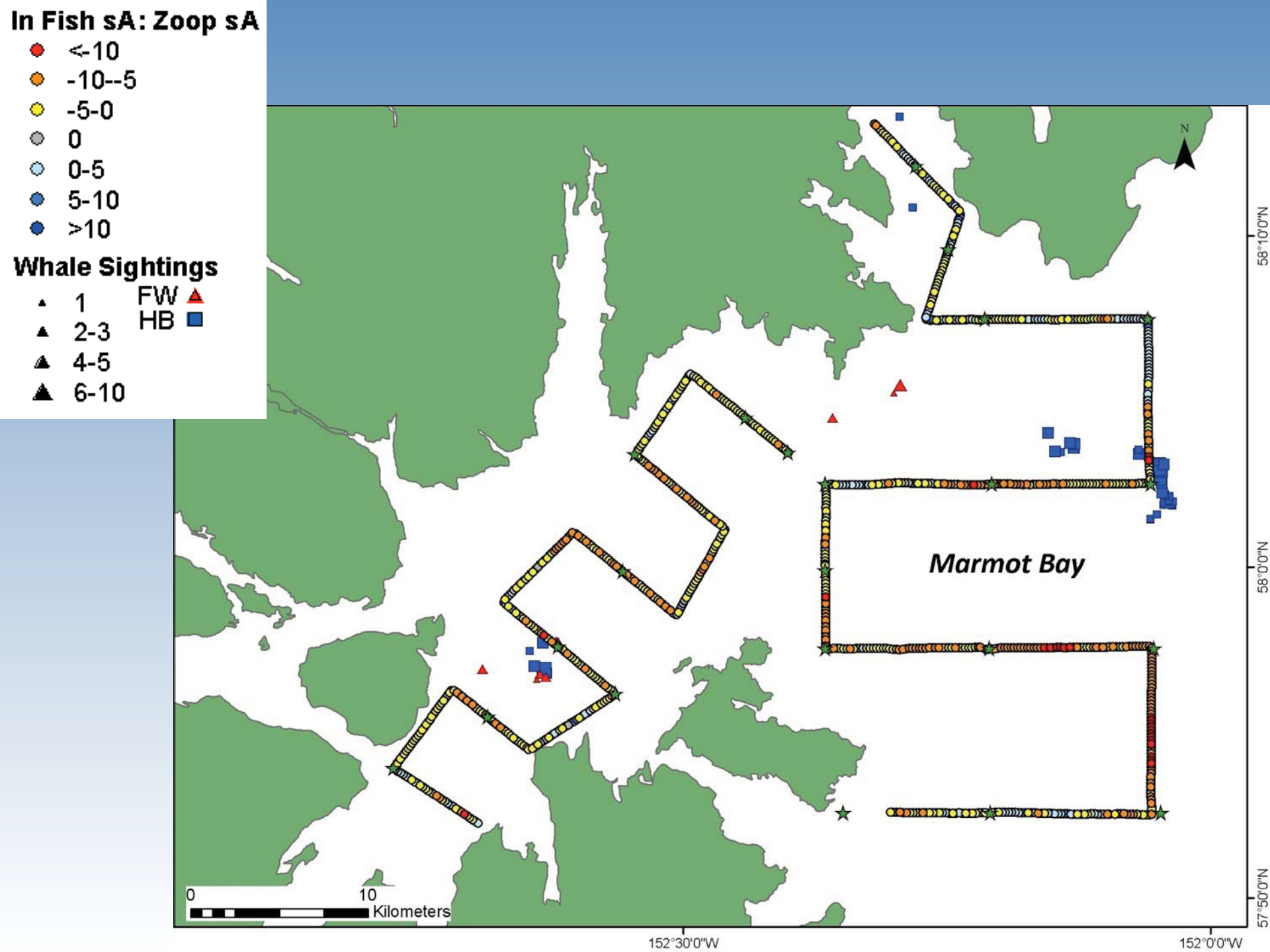
Monitoring

- Established three VIS
- Each suited for MTL and UTL monitoring
  - Prey data
  - Known importance to foraging whales
  - Near SSL haulouts
  - Commercial fisheries

Monitoring



- Sampling grids
- CTD casts
- Dual frequency backscatter
- Zooplankton samples
- Whale counts, photos & biopsies


In Fish sA: Zoop sA
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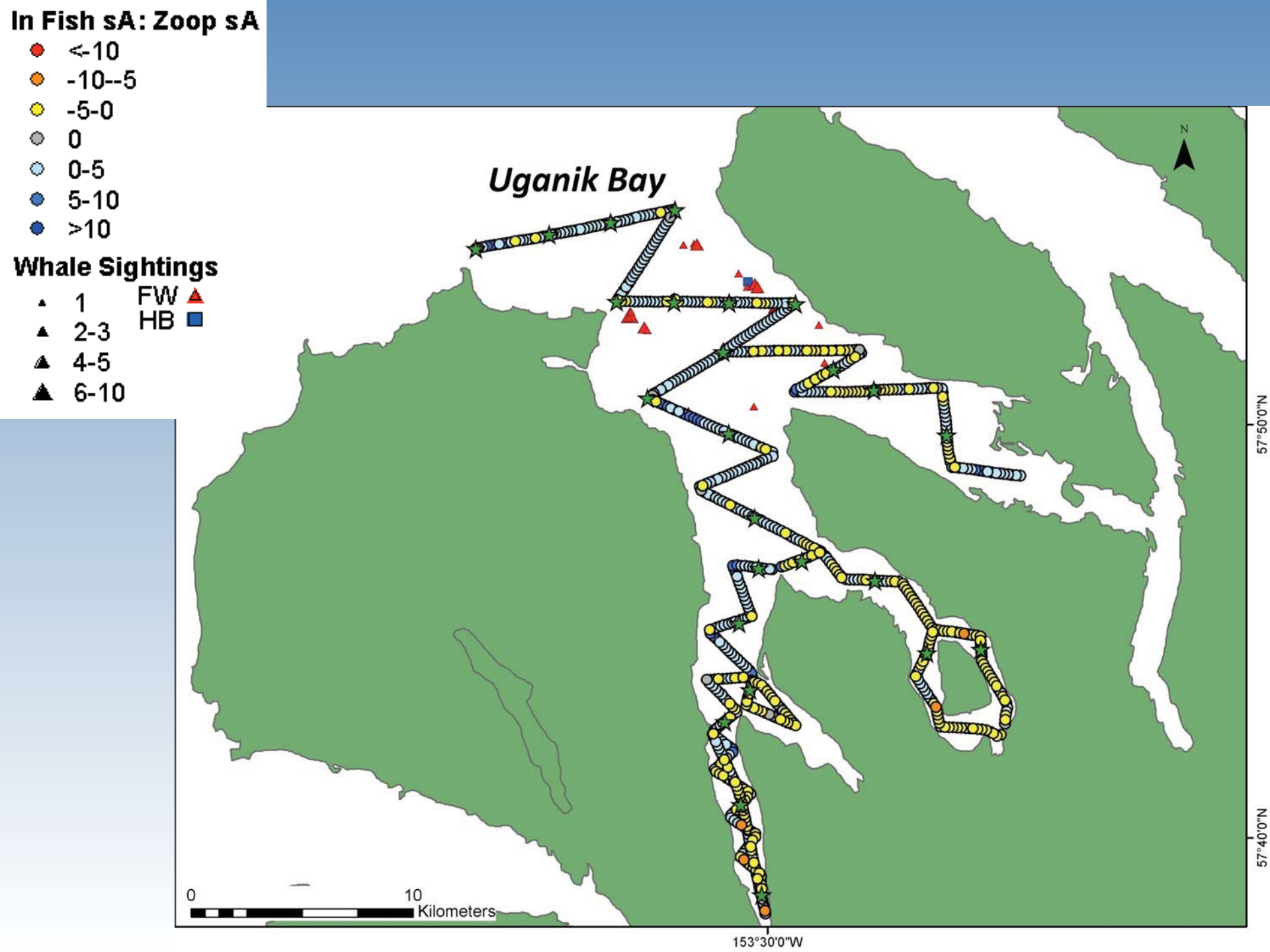
-5-0
0
0-5
5-10
>10
Whale Sightings
1
2-3
4-5
6-10
FW
HB
Marmot Bay
N
0
10
Kilometers
58°10'0"N
58°0'0"N
57°50'0"N
152°30'0"W
152°0'0"W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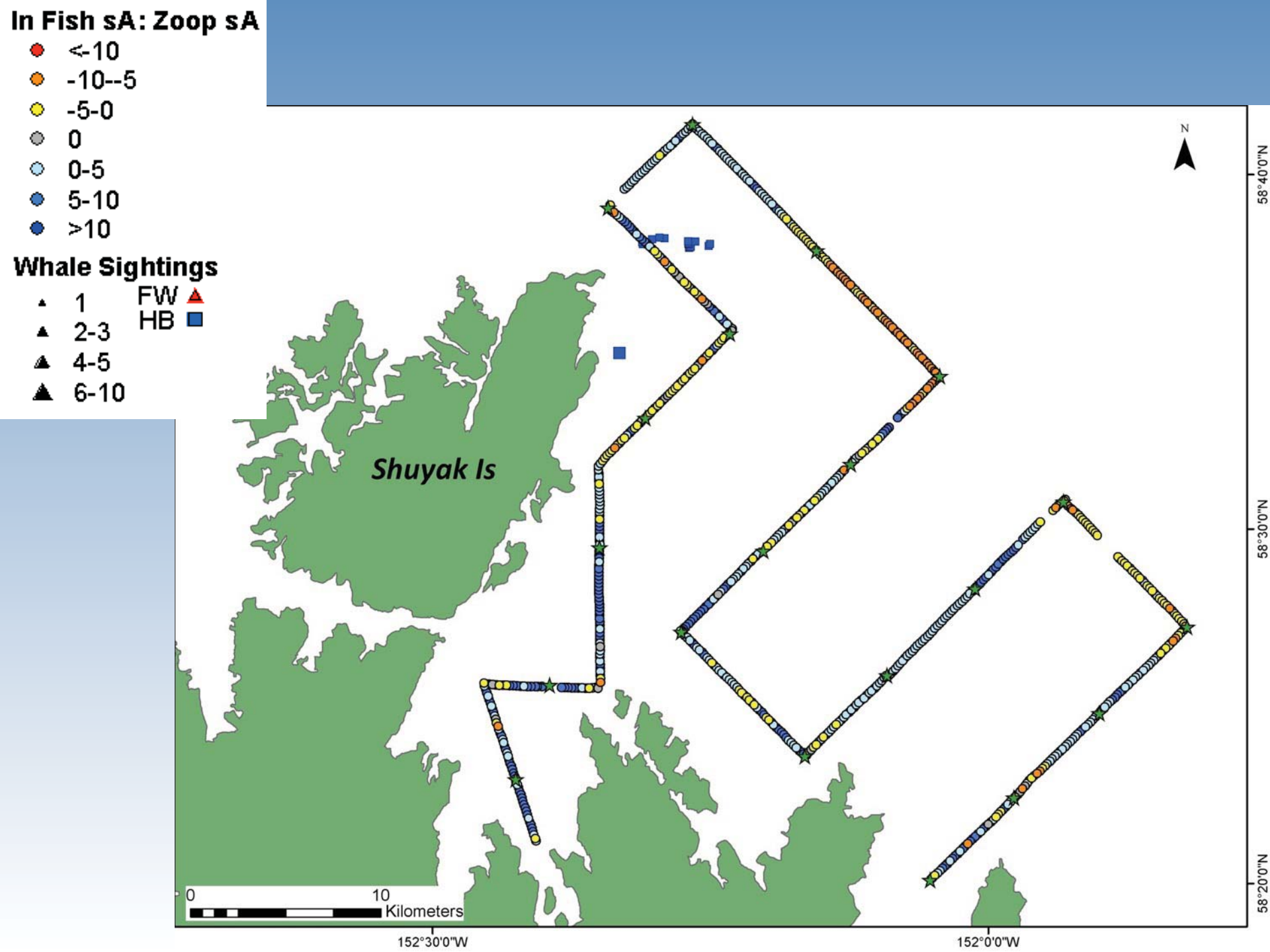
Kilometers
153°30'0"W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58°40'0"N
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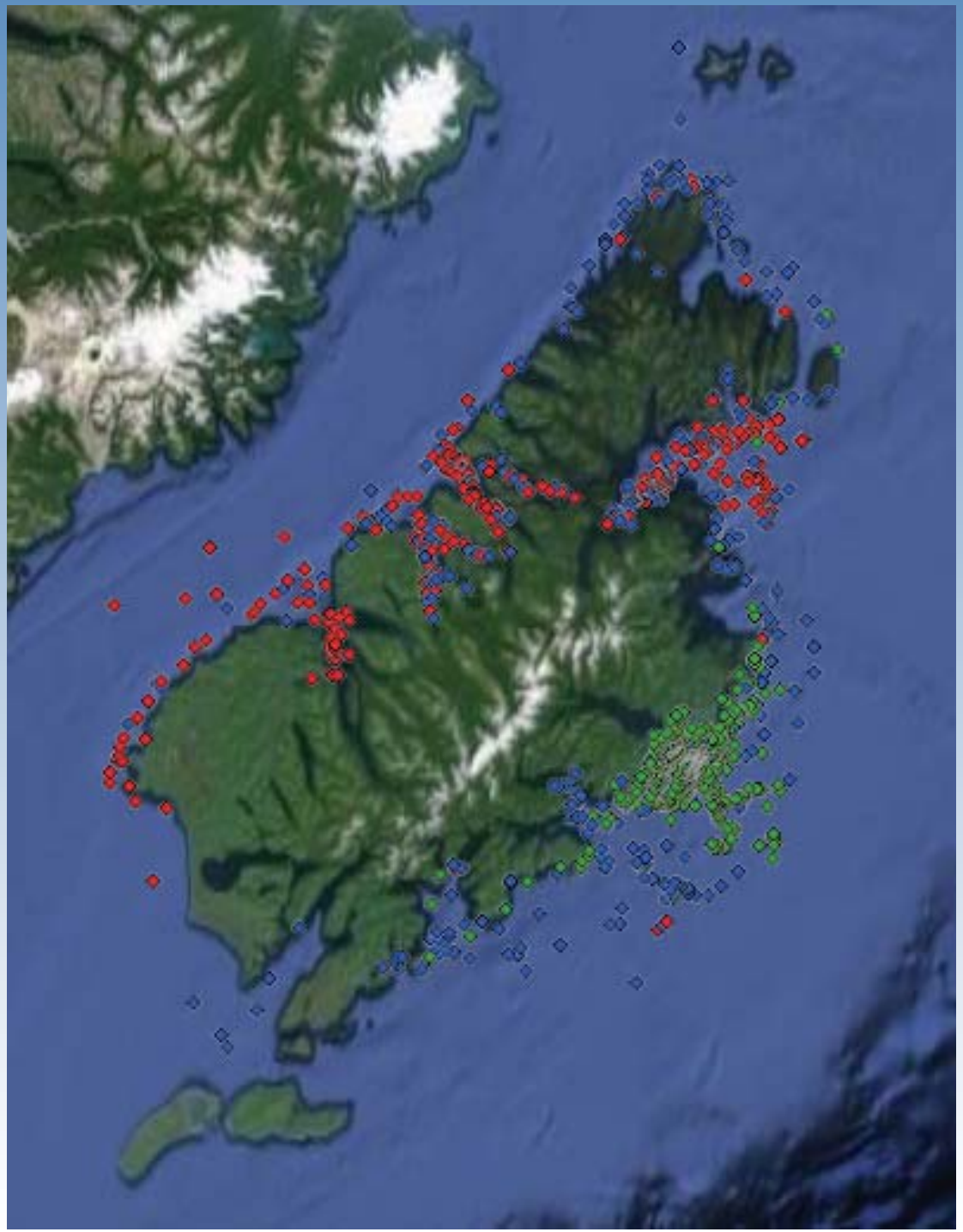
58°20'0"N
152°30'0"W
152°0'0"W

Variability Index Sites

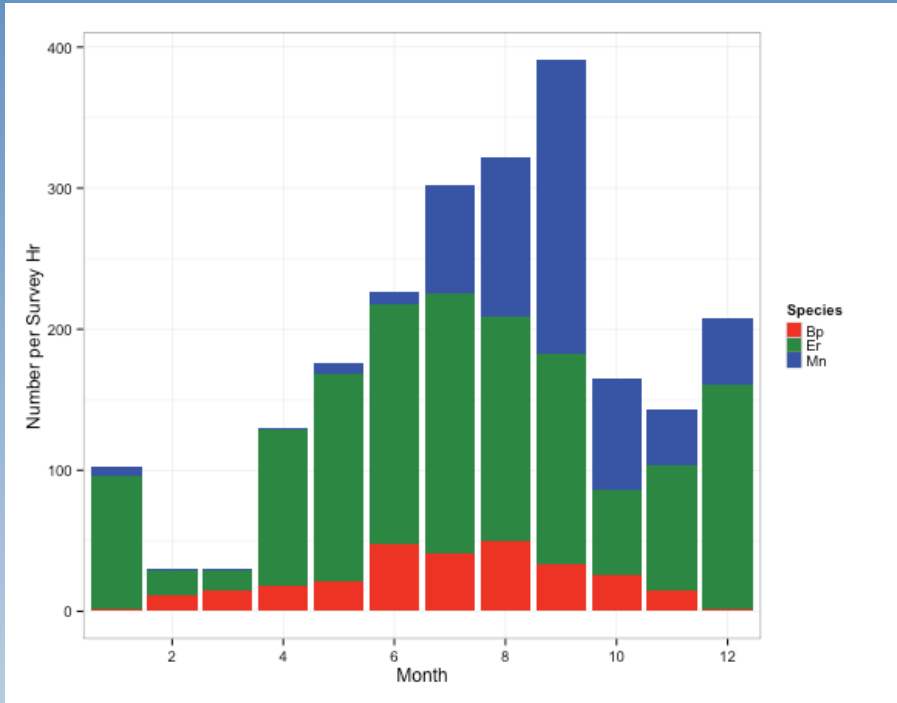
- Monitoring of index sites has already shown substantial differences between just two years
- Replicate surveys provide a means of documenting change
- Returning to Marmot Bay in 2014

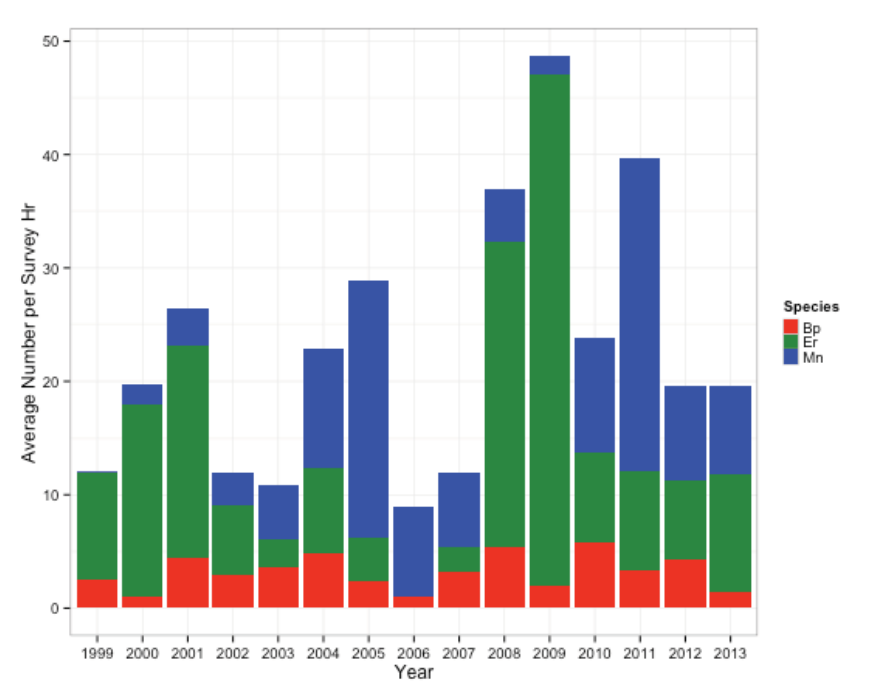
Aerial Surveys

- Data: Sightings from Aerial Surveys
  - Opportunistic : 1997 – mid 2007
  - Directed : mid 2007 to Present
- Explore data for spatial and temporal trends and habitat preferences



- Gray Whales
- Humpback Whales
- Fin Whales



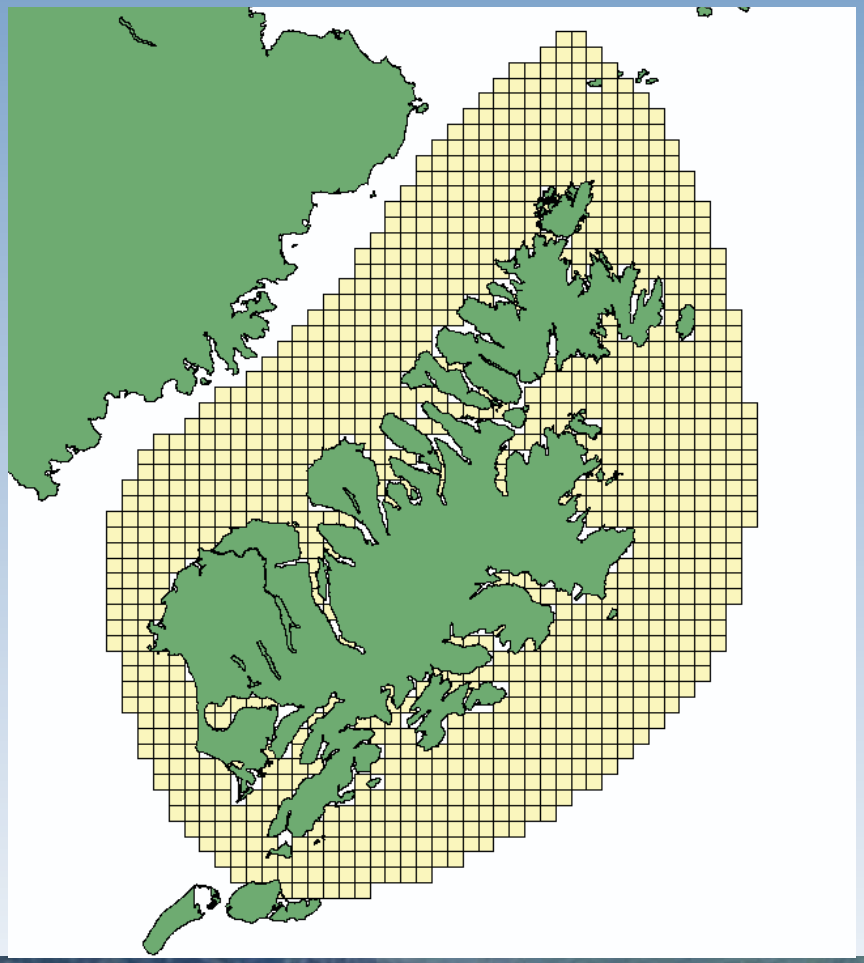


Month

Year

	ER	MN	BP
Month	6.7*	40.0***	4.1
Year	16.6***	80.1***	0.5
Month * Year	7.8**	67.7***	0.3

Modeling the data



- Grid – 5km^2
- Variables
  - SST (mean & var)
  - Chl *a* (mean & var)
  - Depth
  - Month
  - Year
  - Latitude
  - Longitude
  - ???

Consumption modeling

- In the CGOA, multiple ecosystem drivers have been suggested
  - Fishing and climate change cannot explain majority
  - Leads to the importance of trophic interactions, including whales

Consumption modeling

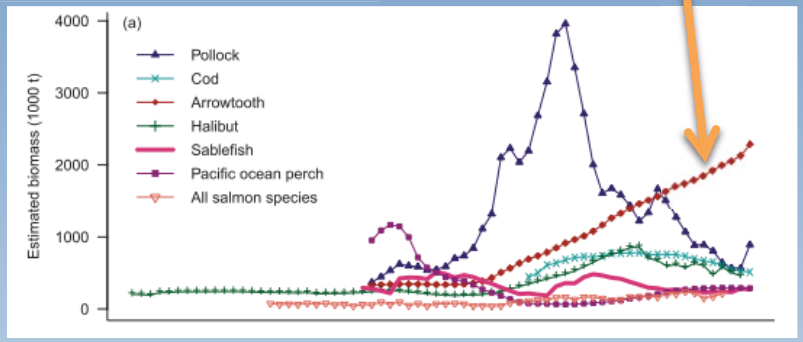
- Current ecosystem models estimate baleen whales having small roles
- But…models have low resolution
  - Spatial: regional (GOA) vs. mesoscale (10's to 100's km)
  - Temporal: annual vs. seasonal

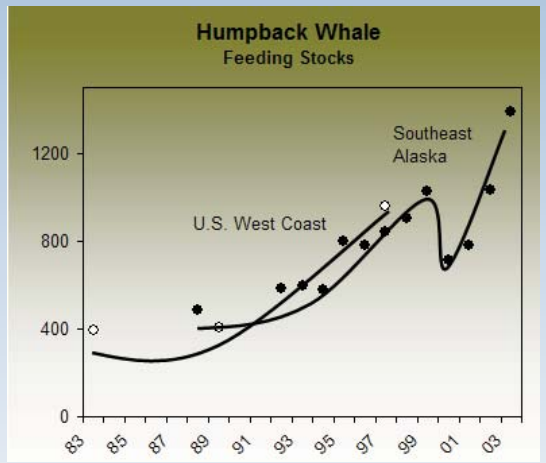
The GAP Approach

- Bioenergetic model
- Summer consumption estimates only
- Meso-scale (near-shore Kodiak)
- Example: ATF vs. Humpback whales

Comparing impacts
ATF vs. Humpback whales

- Similarities
  - Population trends
  - Low exploitation rates
- Differences
  - Mobility
  - Seasonality
  - Life span
  - Consumption ratios (Q:B; 6 vs 1.5)

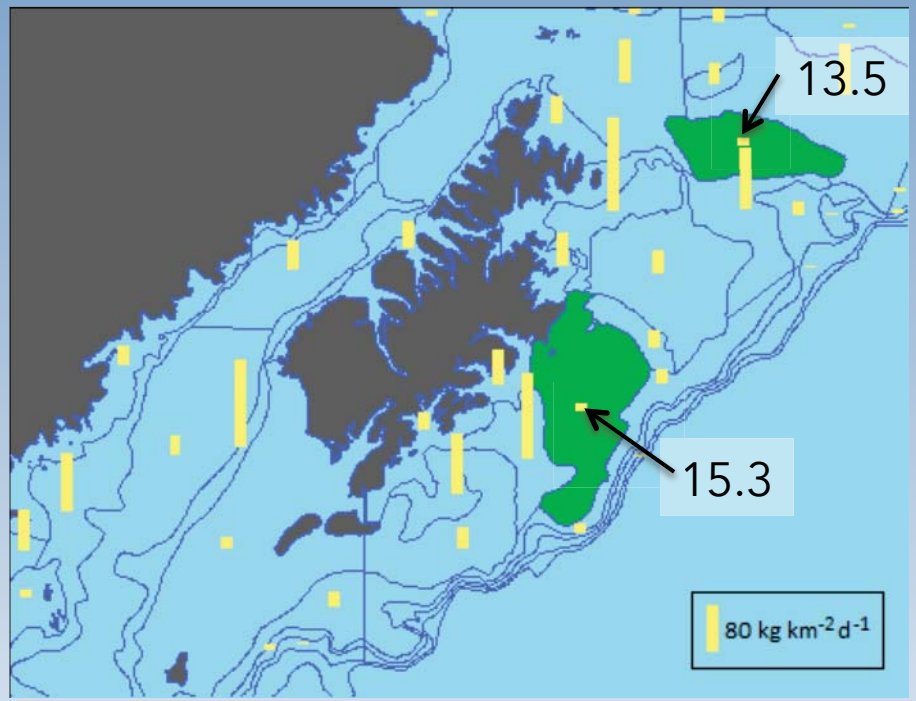




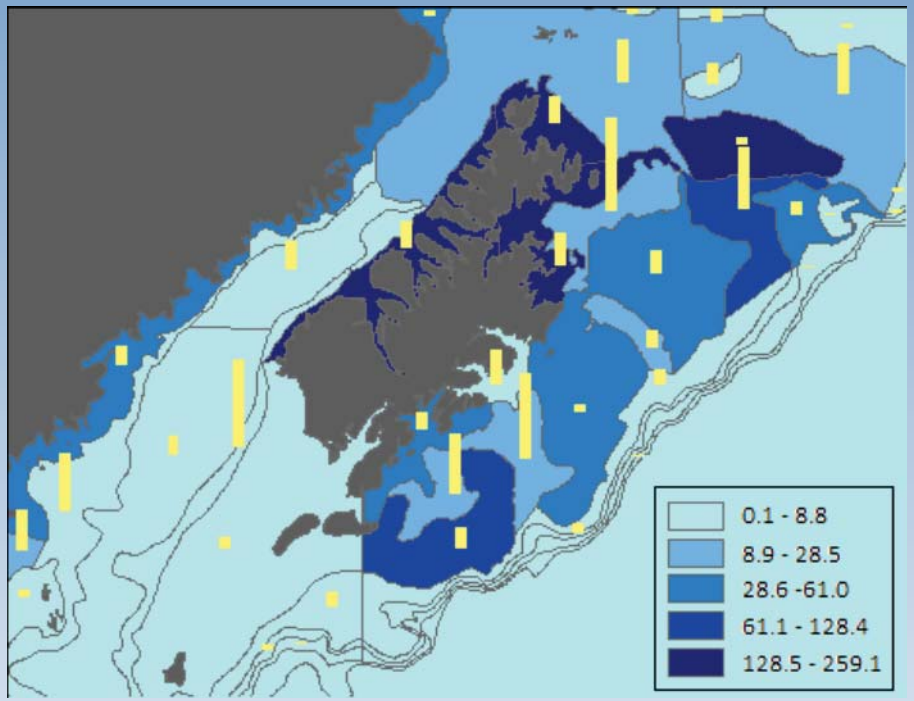
Comparing impacts
ATF vs. Humpback whales

- Humpback whales ~ 10.7 kg $km^{-2}day^{-1}$
- ATF ~28.9 kg $km^{-2}day^{-1}$
  - shows great spatial variation
- High for ATF and low for whales?
- Essential to consider in the context of spatial variation

Avg humpback whale consumption = 10.7 kg km^{-2} day^{-1}
Avg ATF consumption = 28.9 10.7 kg km^{-2} day^{-1}



Avg ATF consumption by spatial strata



Avg ATF consumption & capelin biomass

Next steps

- Use existing framework and hypothetical scenarios
  - Change abundance, diet, prey availability
- Improve whale spatial component using results from habitat model
- How will local energy pathway(s) be modified?
- How much potential impact on SSL?

Looking ahead

- Results have the potential to shed unique insights into roles of whales in marine ecosystems on fine scales
- Diverse methodologies take advantage of GAP's long time-series data
- Design of future studies and data collection
- Use other available data
  - Stable isotopes, dive behavior

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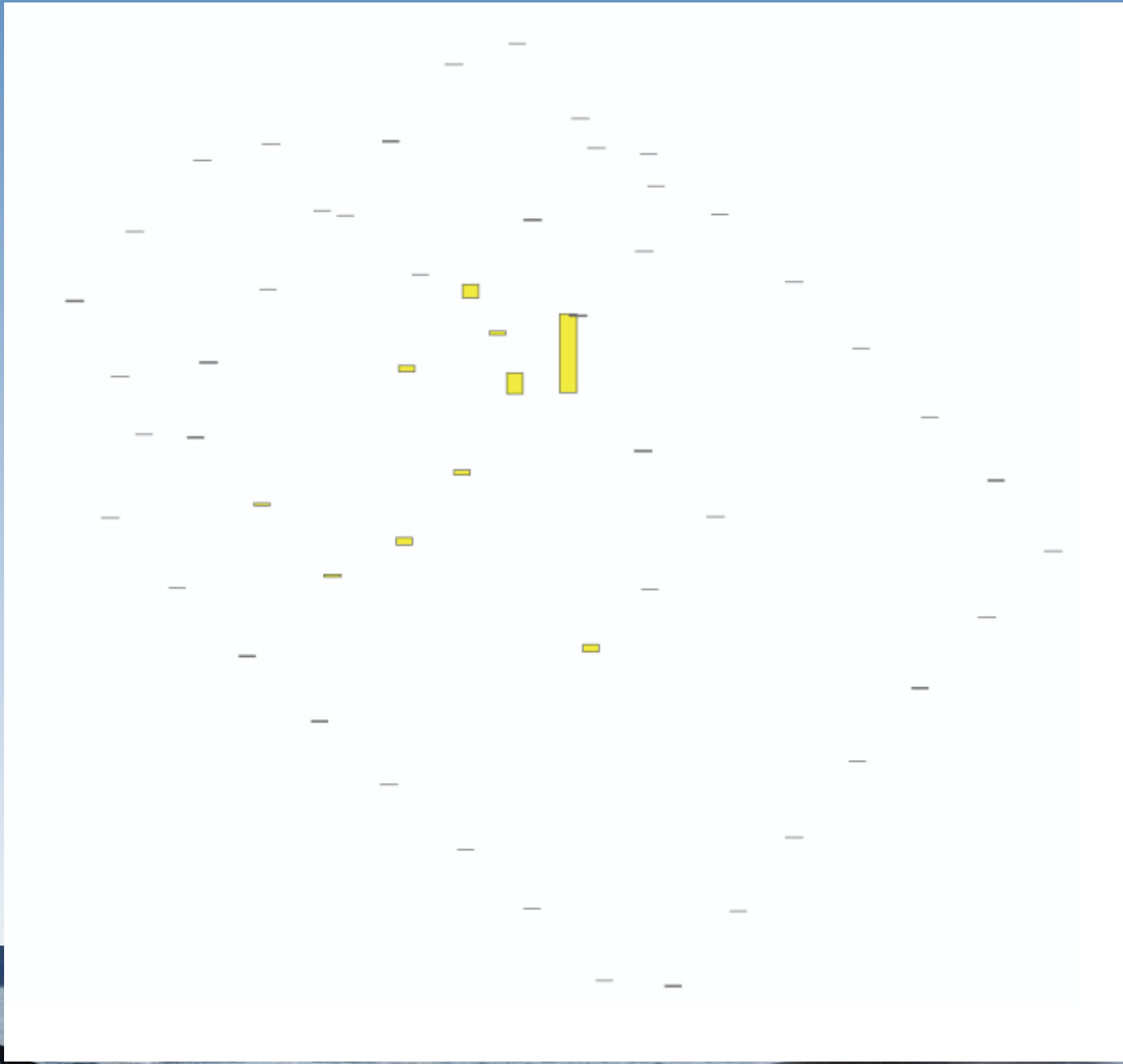

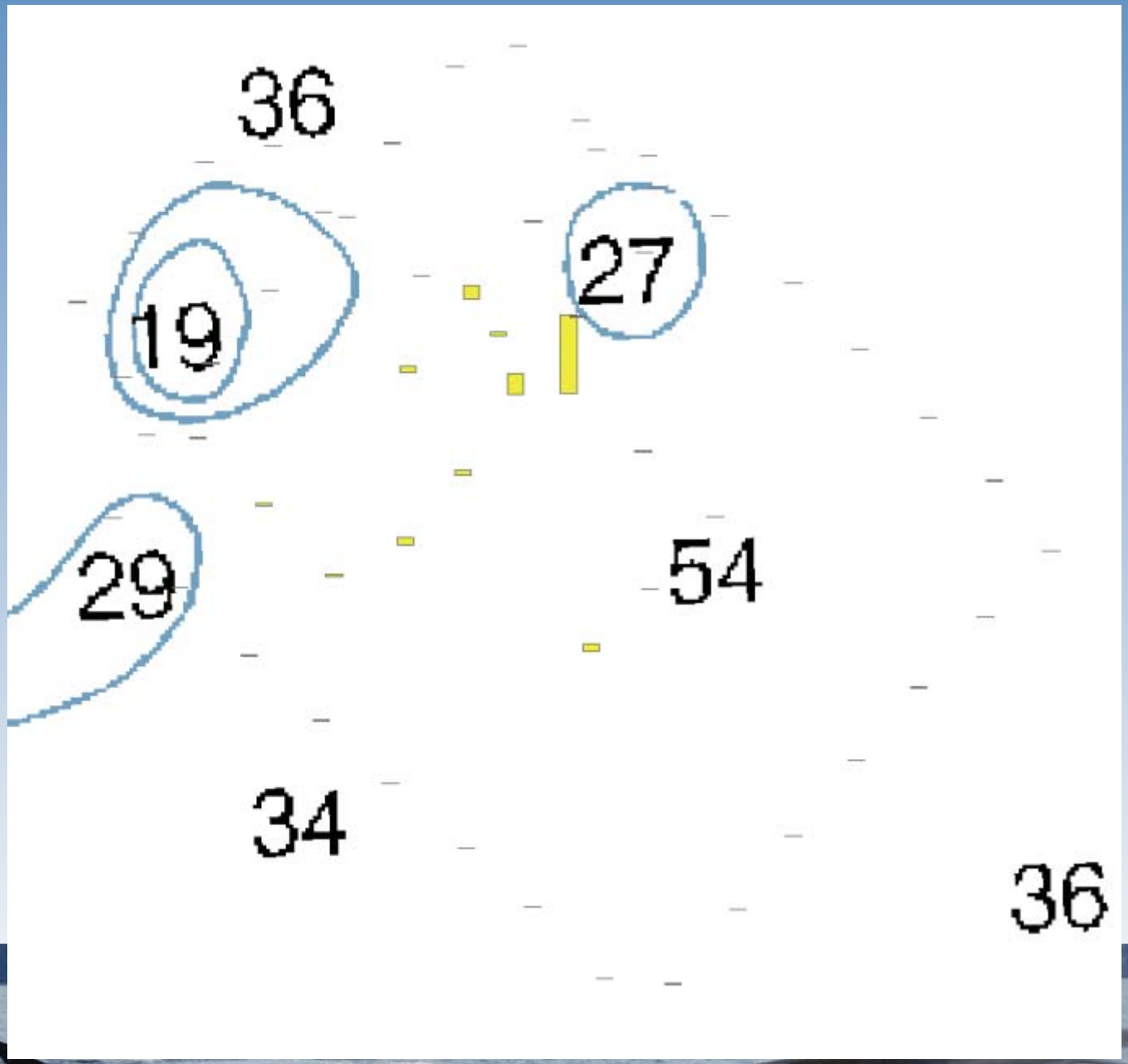
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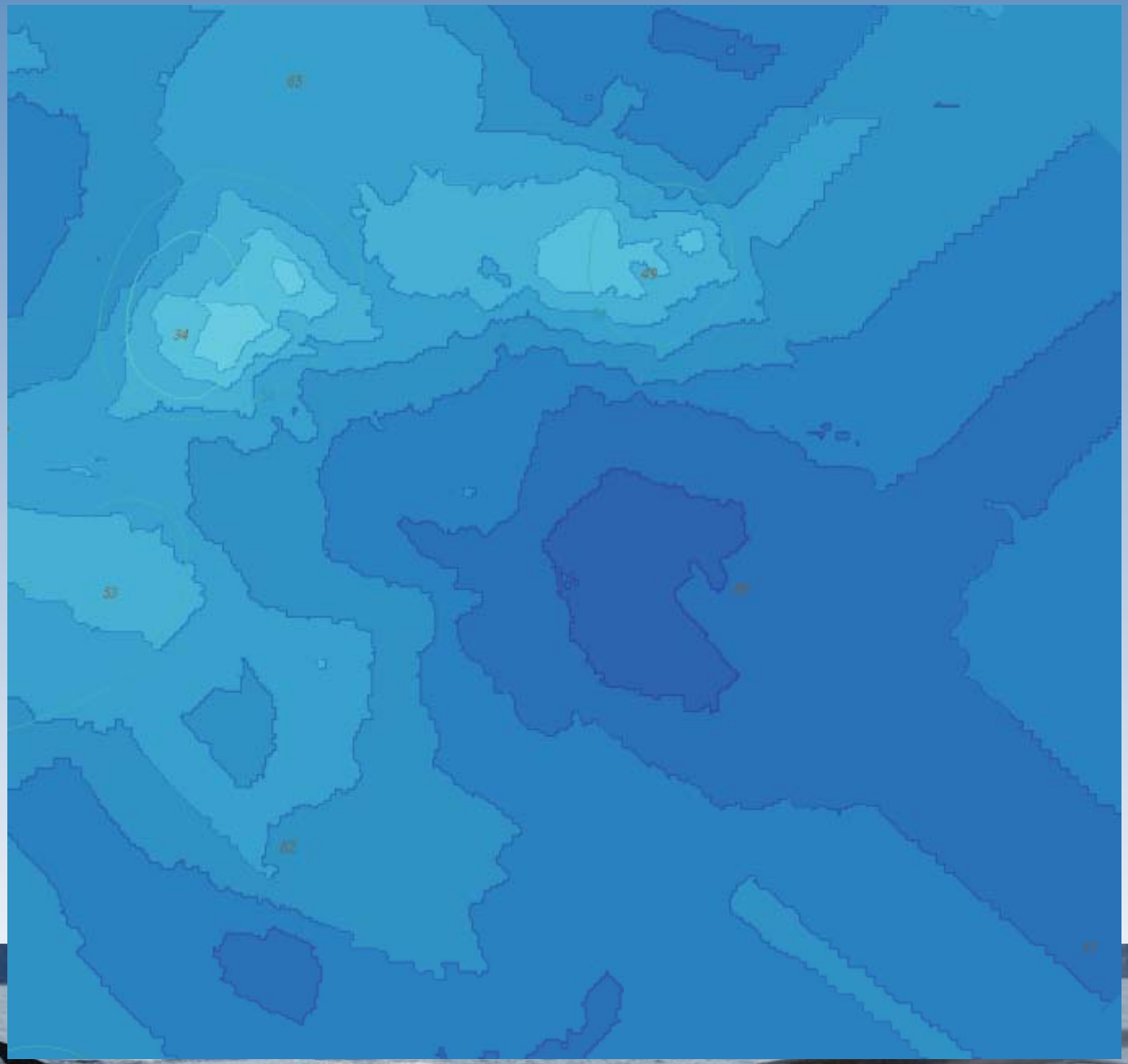
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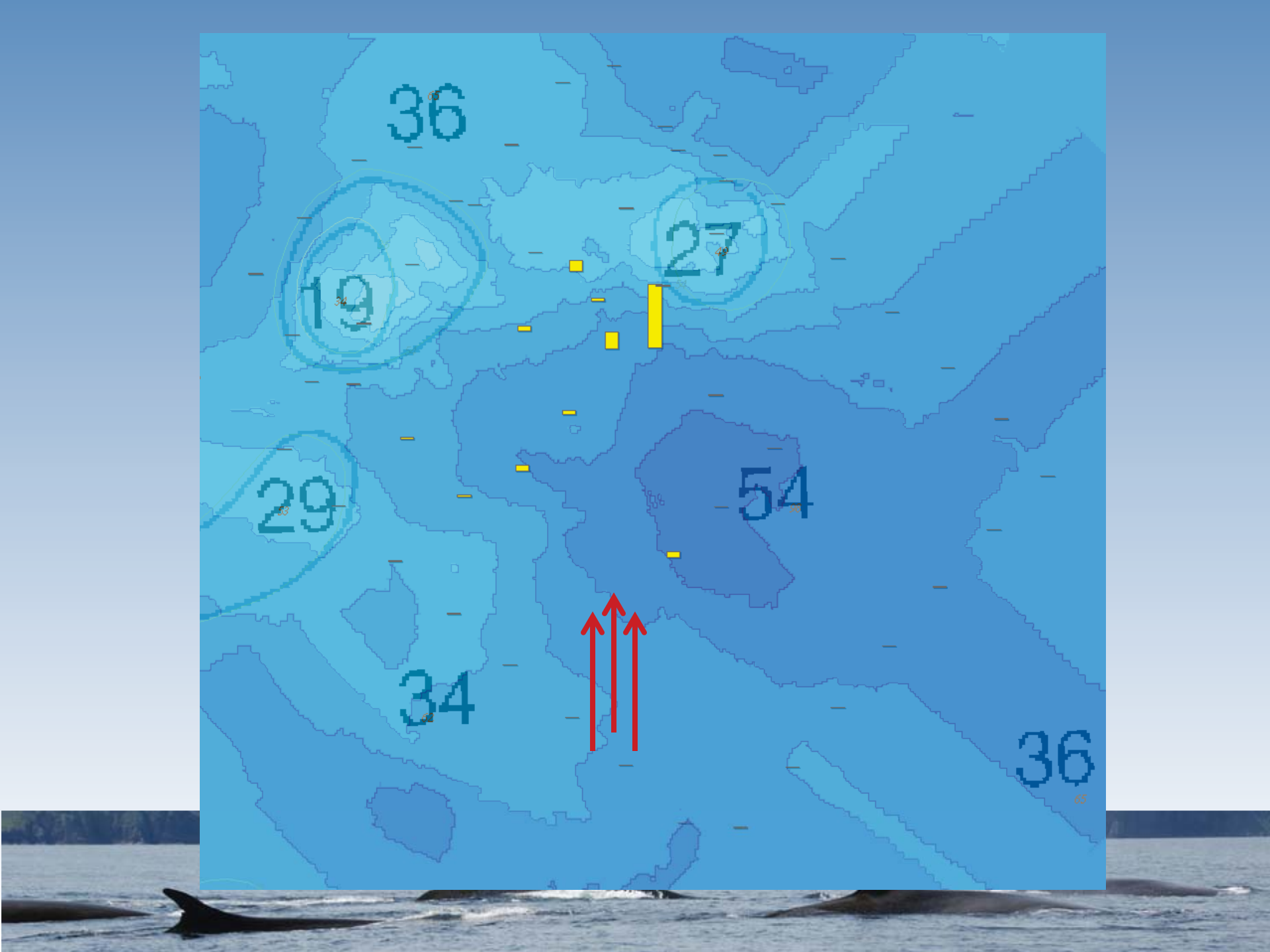
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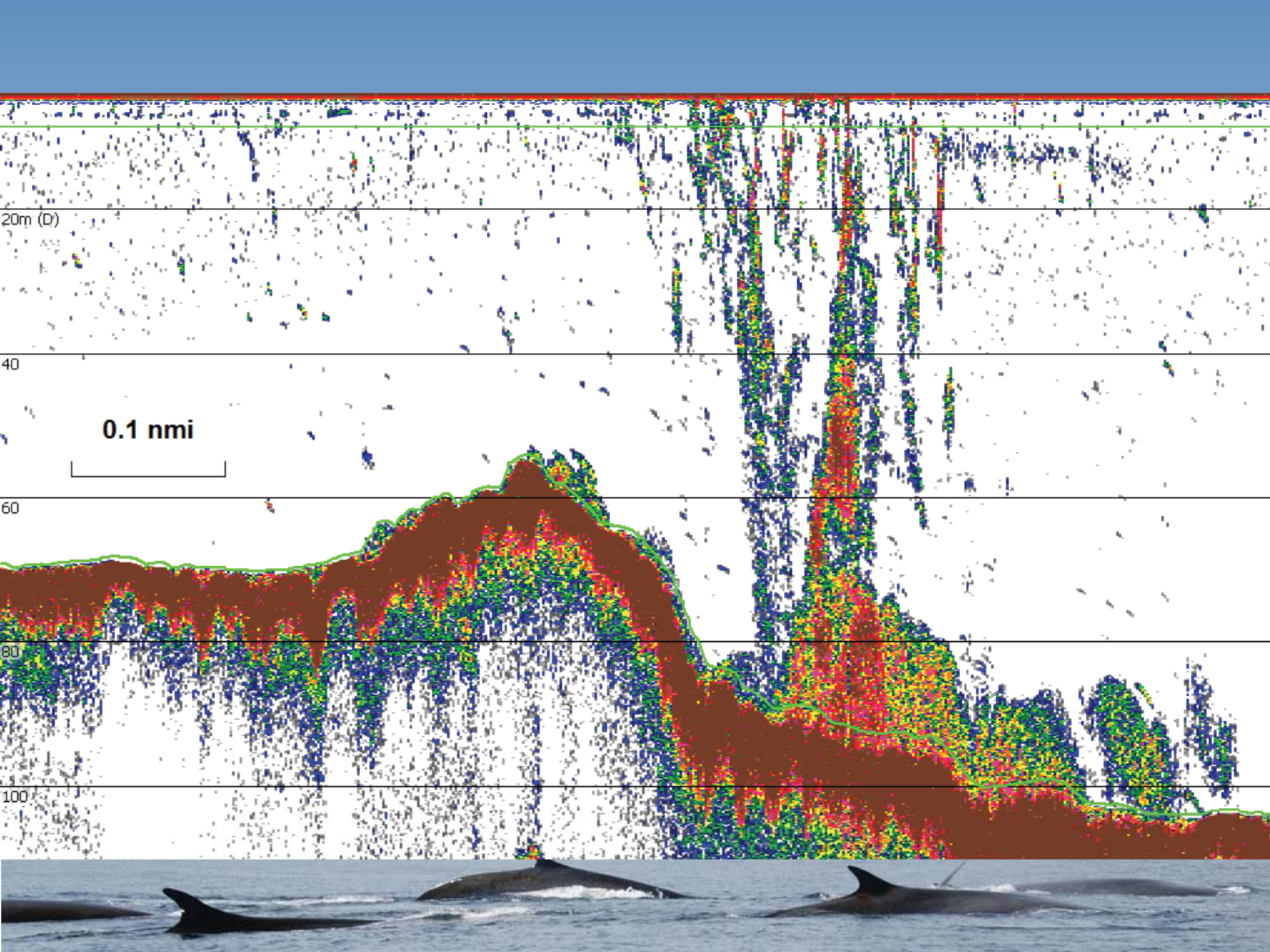
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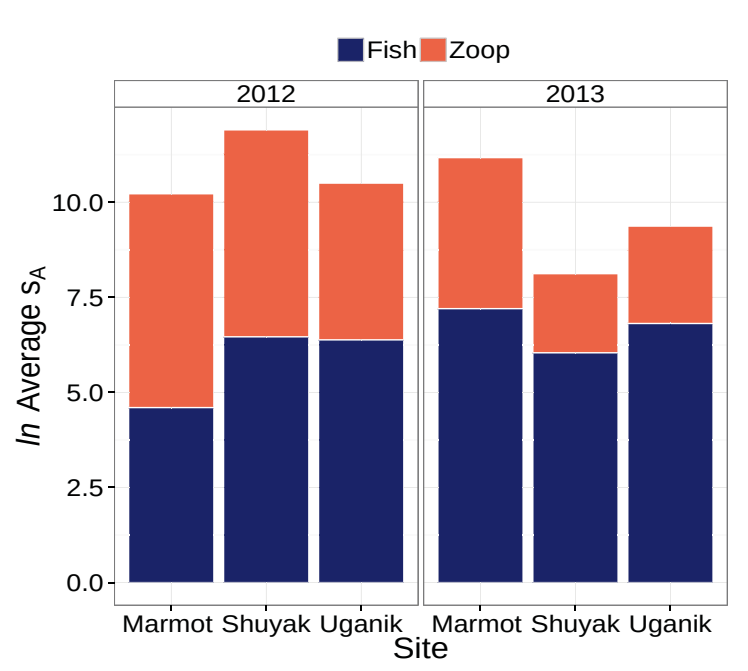
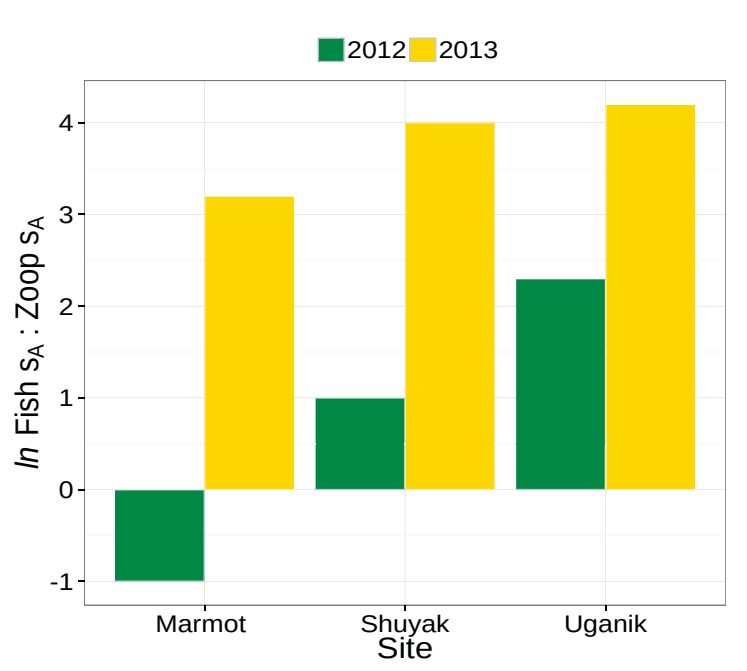
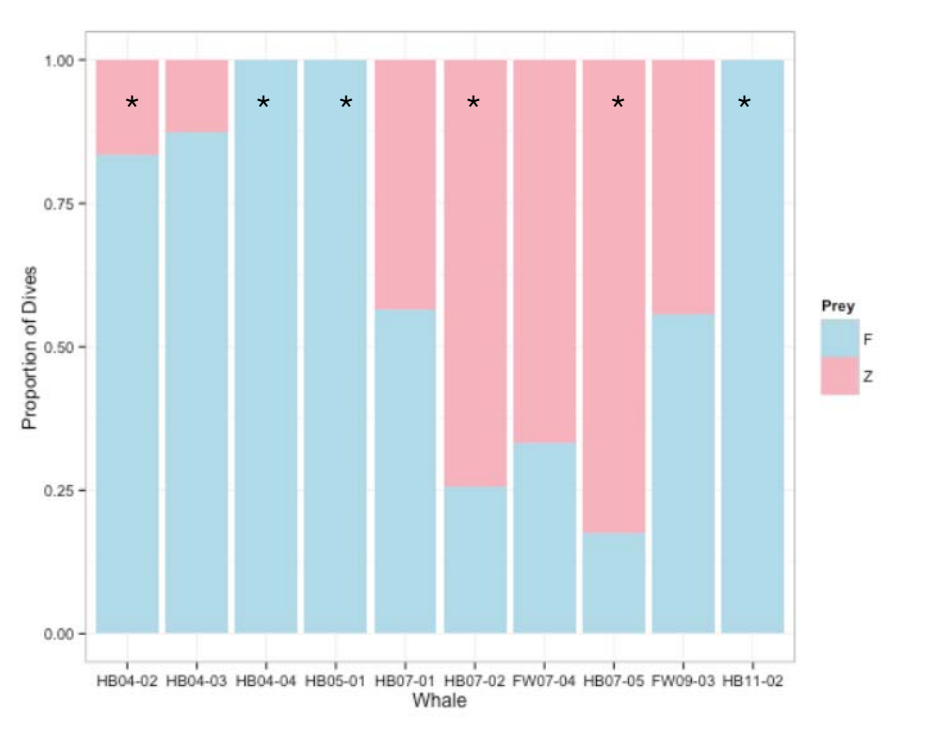


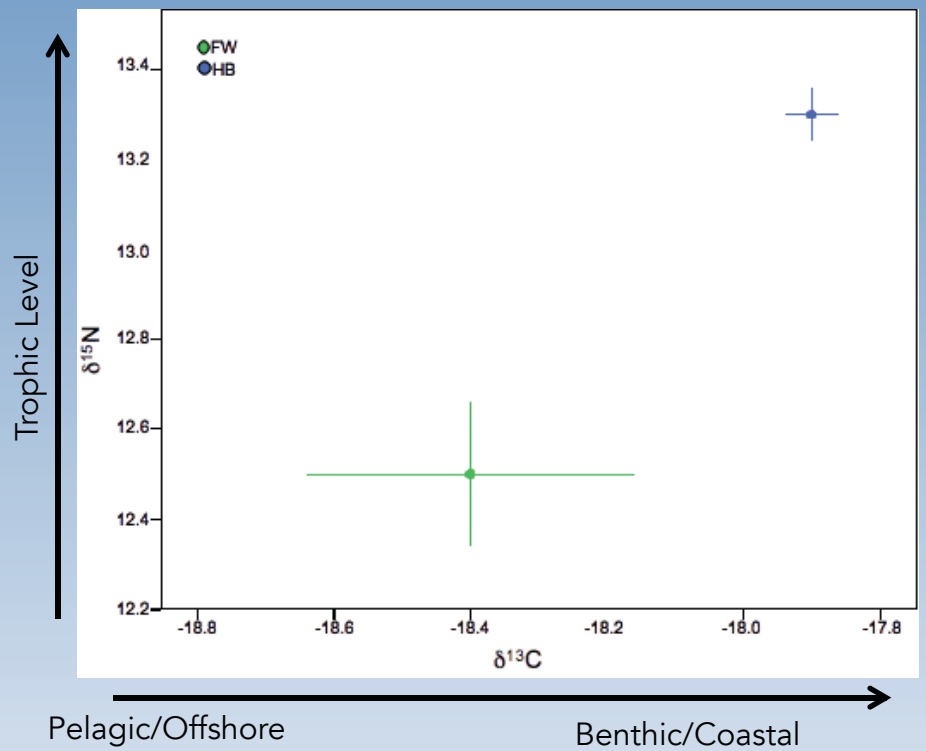


		Average Backscatter (s_A)		Number of Whales	
		Fish	Zoop	Fin	Humpback
2012	Marmot	99	277	18	70
	Shuyak	638	230	0	20
	Uganik	588	62	32	1
2013	Marmot	1345	53	0	0
	Shuyak	420	8	12	52
	Uganik	906	13	1	0

Foraging Ecology



- Fins~ Zooplankton
- Humpbacks~ Capelin
- Overlap when euphausiid density very high


FW
HB
13.4
13.2
13.0
12.8
12.6
12.4
12.2
δ15N
-18.8
-18.6
-18.4
-18.2
-18.0
-17.8
δ13C
Trophic Level
Pelagic/Offshore
Benthic/Coastal