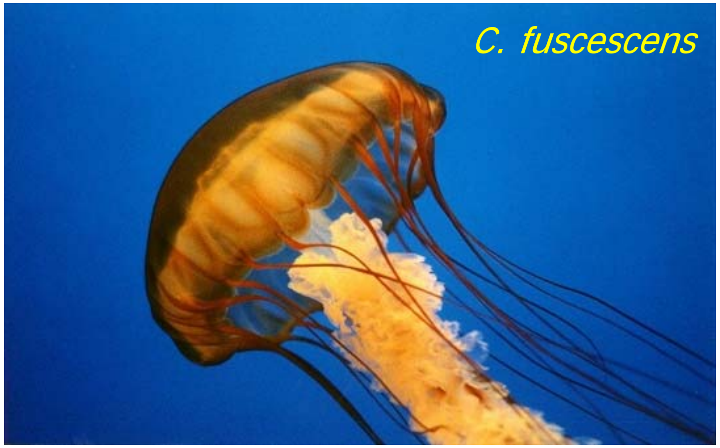
A Tale of Two *Chrysaora*: Pivotal Roles in Contrasting Marine Ecosystems

Richard D. Brodeur[1], Mary Beth Decker[2],
Elizabeth A. Daly[3], Caren Barcelo[4],
James J. Ruzicka[3], and Kristin Cieciel[5]

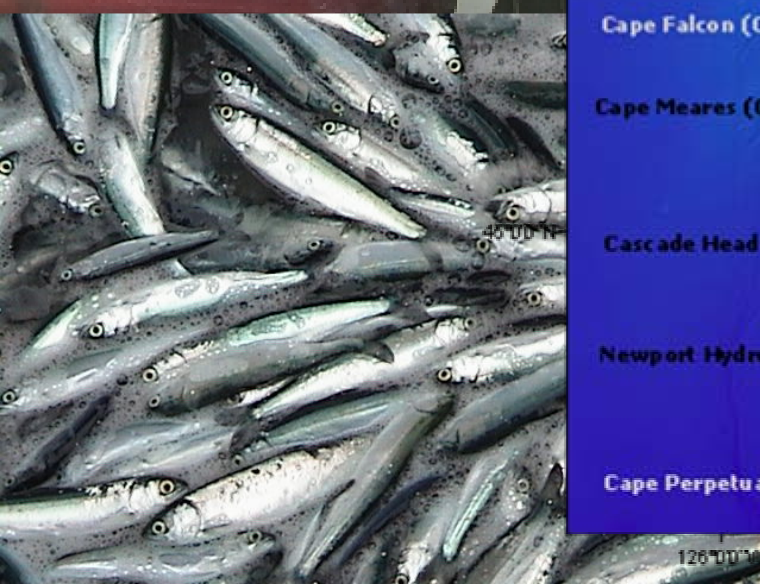
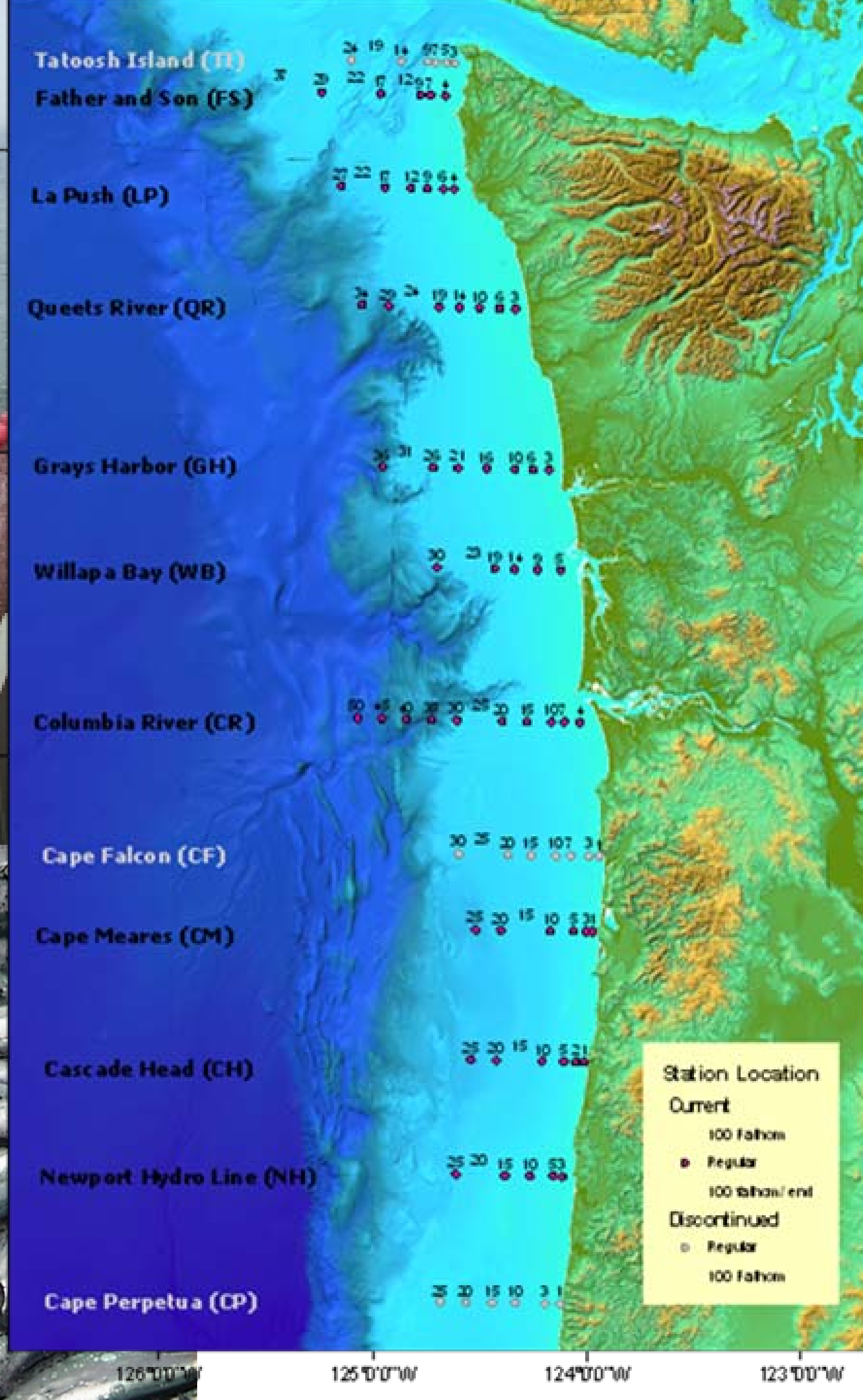
[1] NOAA Northwest Fisheries Science Center, Hatfield Marine Science Center, Newport, OR 97365 USA
[2] Department of Ecology and Evolutionary Biology, Yale University, New Haven, CT, 06520 USA
[3] Cooperative Institute for Marine Resources Studies, Oregon State University, Newport, OR 97365 USA
[4] College of Earth, Ocean and Atmospheric Sciences, Oregon State University, Corvallis, OR 97331 USA
[5] NOAA Alaska Fisheries Science Center, Auke Bay Laboratory, Juneau, AK 99801 USA



Introduction

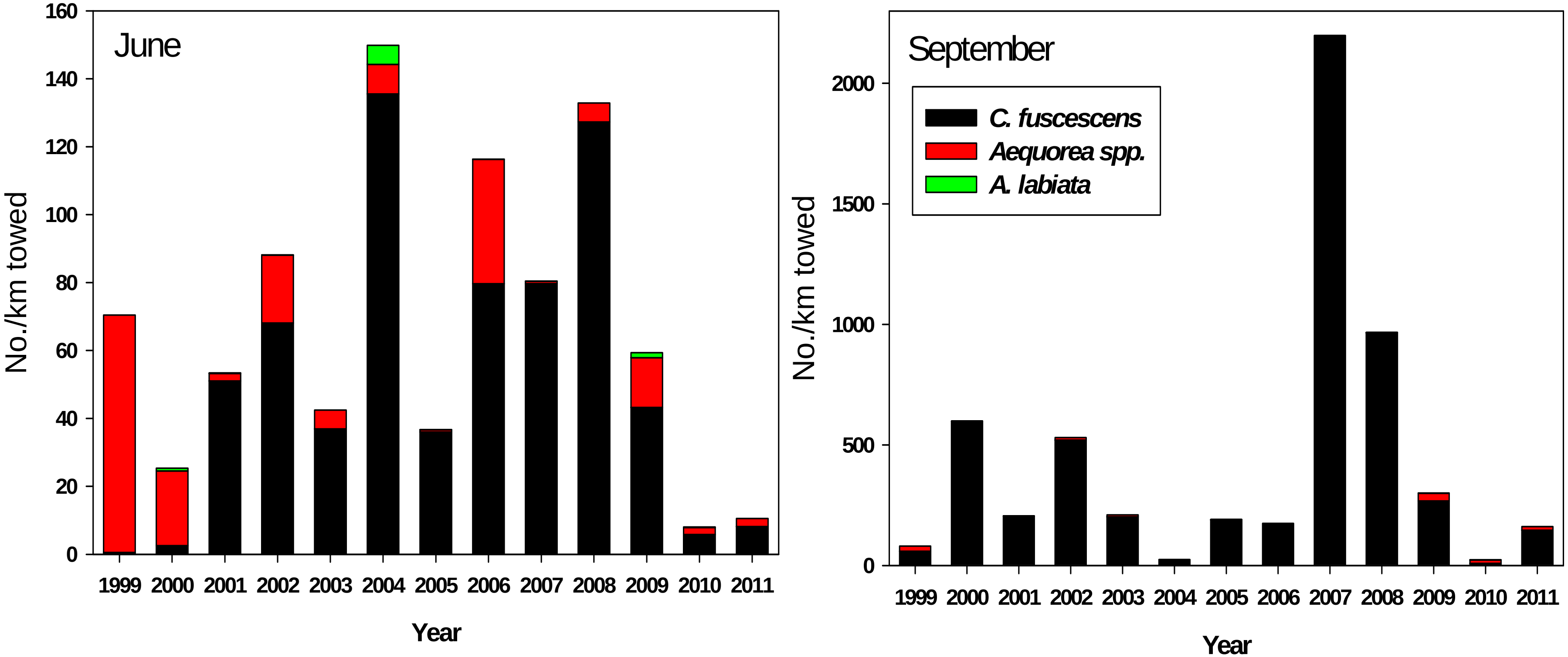
- Large medusae make up a large proportion of the biomass and are major planktivores in pelagic ecosystems
- Forage fishes, including juveniles of midwater and demersal fishes, are also important pelagic planktivores in these systems and may be negatively affected by jellyfish when their distributions overlap
- High overlap could limit food resources available to forage fish, possibly affecting their size or recruitment, but this overlap has not been examined in detail in most ecosystems
- We examine the spatial overlap of the dominant jellyfish species with the important forage fish over multiple years and seasons from a dynamic upwelling area (California Current) and a productive Subarctic ecosystem (Bering Sea) in order to determine which species/years may be most impacted by jellyfish blooms

Study Areas

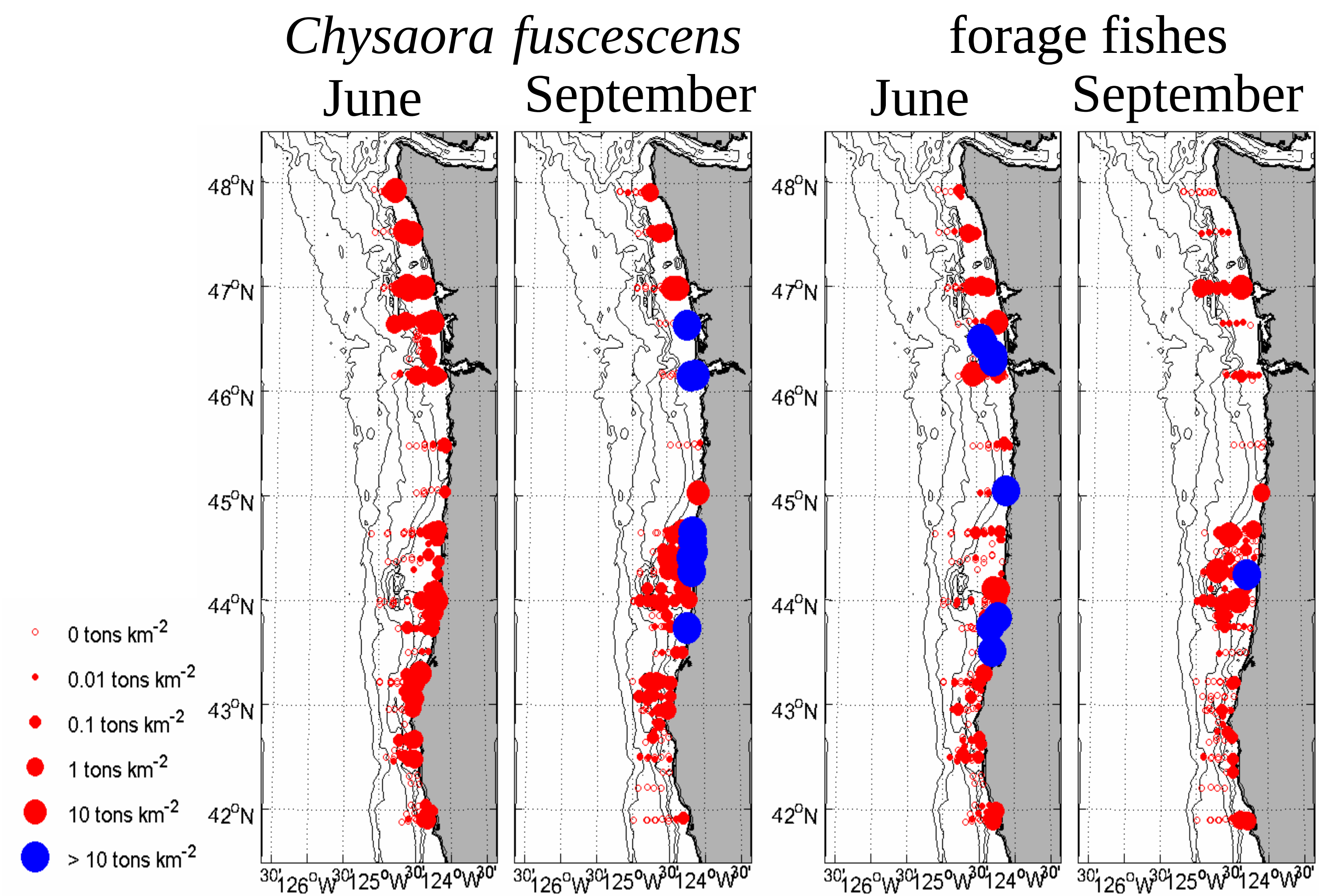



Tatoosh Island (TI)
Father and Son (FS)
La Push (LP)
Queets River (QR)
Grays Harbor (GH)
Willapa Bay (WB)
Columbia River (CR)
Cape Falcon (CF)
Cape Meares (CM)
Cascade Head (CH)
Newport Hydro Line (NH)
Cape Perpetua (CP)
Station Location
Current
100 Fathom
Regular
100 fathom/ end
Discontinued
Regular
100 Fathom
48°0'0"N
47°0'0"N
46°0'0"N
45°0'0"N
126°0'0"W
125°0'0"W
124°0'0"W
123°0'0"W

West Coast Jellyfish Species Composition by Year

- Abundance varies interannually and seasonally
- Catch dominated by *Chrysaora* overall (>83%) and especially in September (>91%)

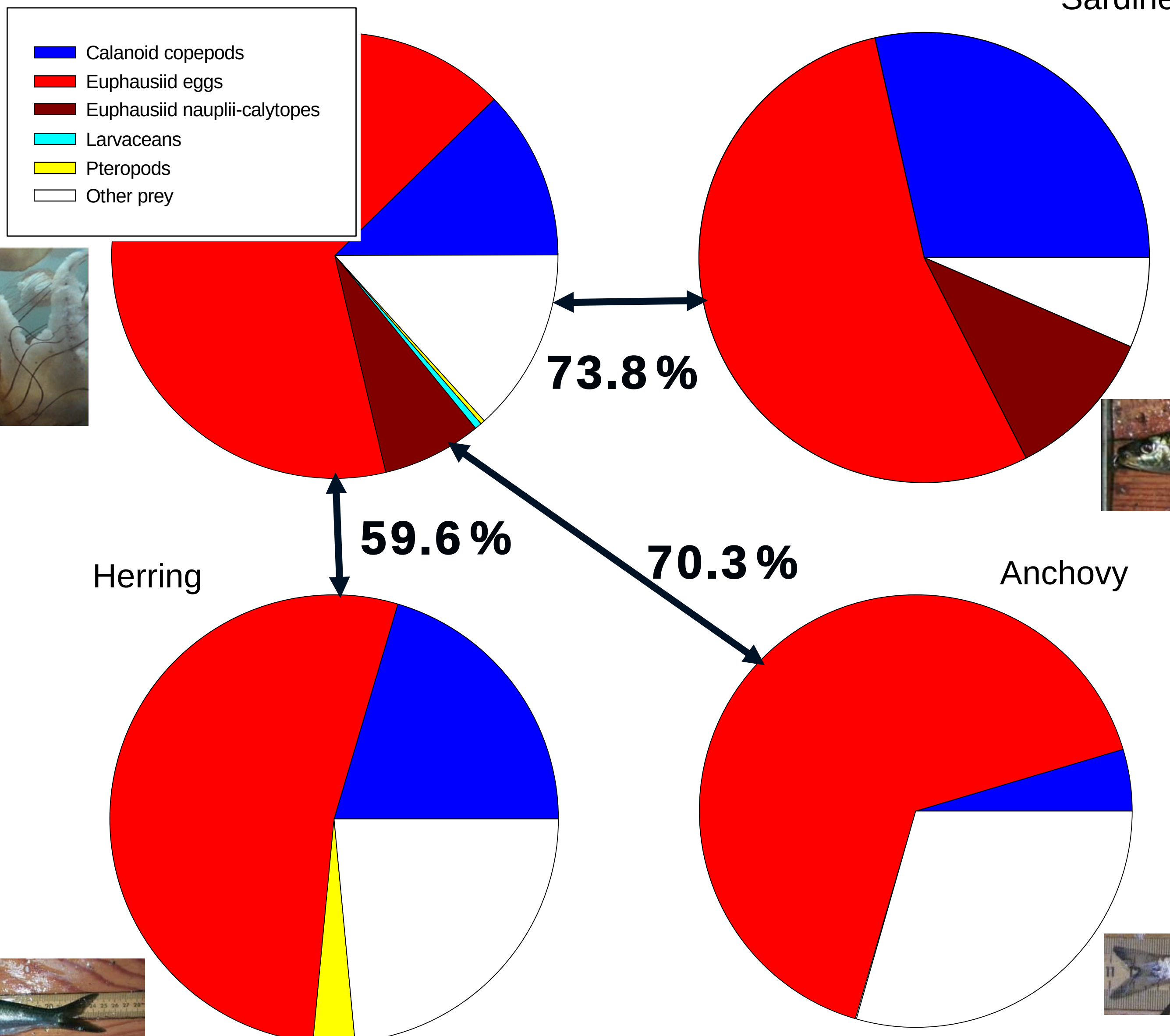


Biomass of Forage Fish vs. *Chrysaora*



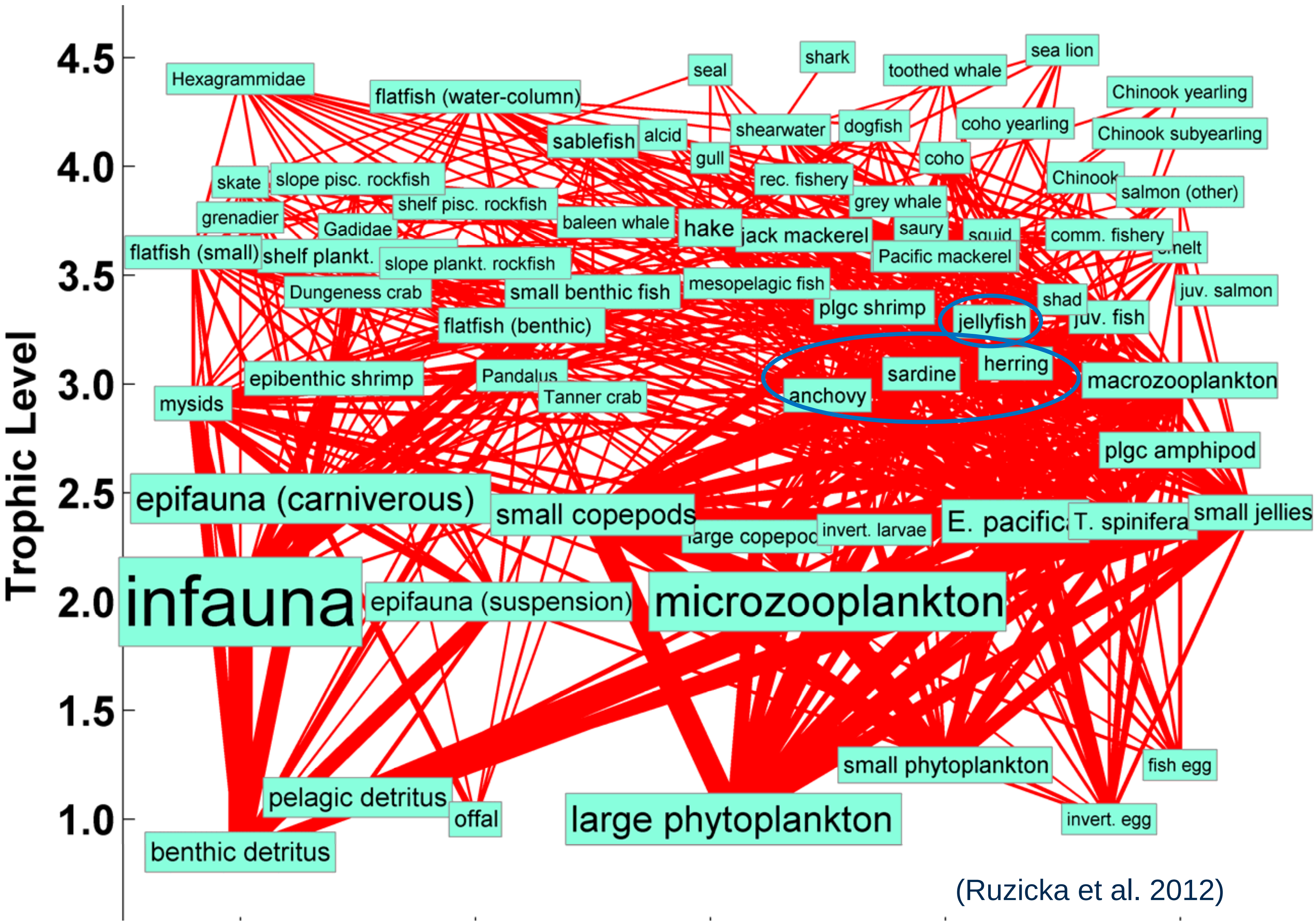
(Ruzicka, Brodeur and Wainwright. 2007. CalCOFI Rep.)

Diet overlap between *Chrysaora* and Dominant Forage Fishes



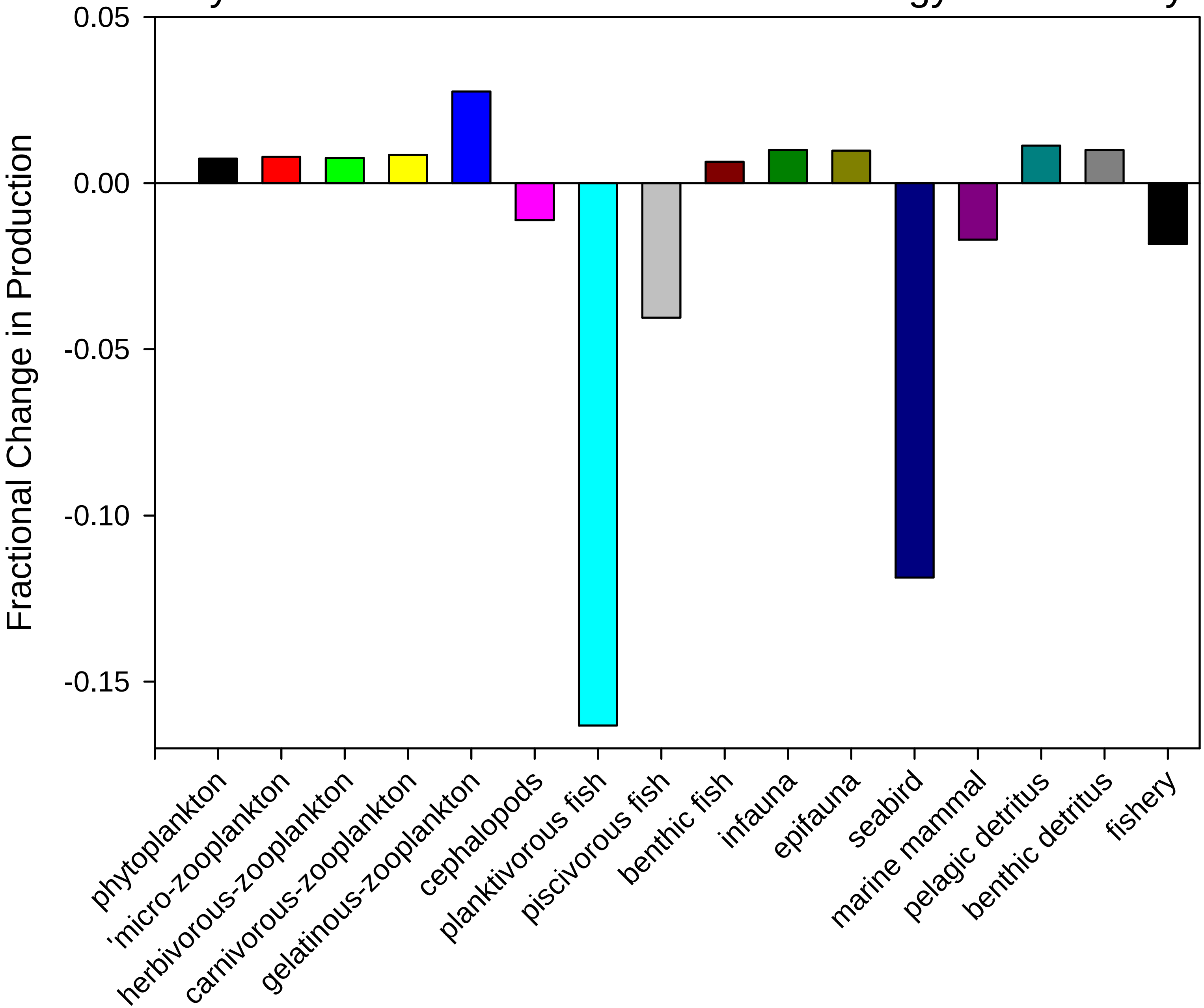
(Brodeur et al. 2008 *Mar. Biol.*)

Model of Northern California Current Ecosystem (2007)



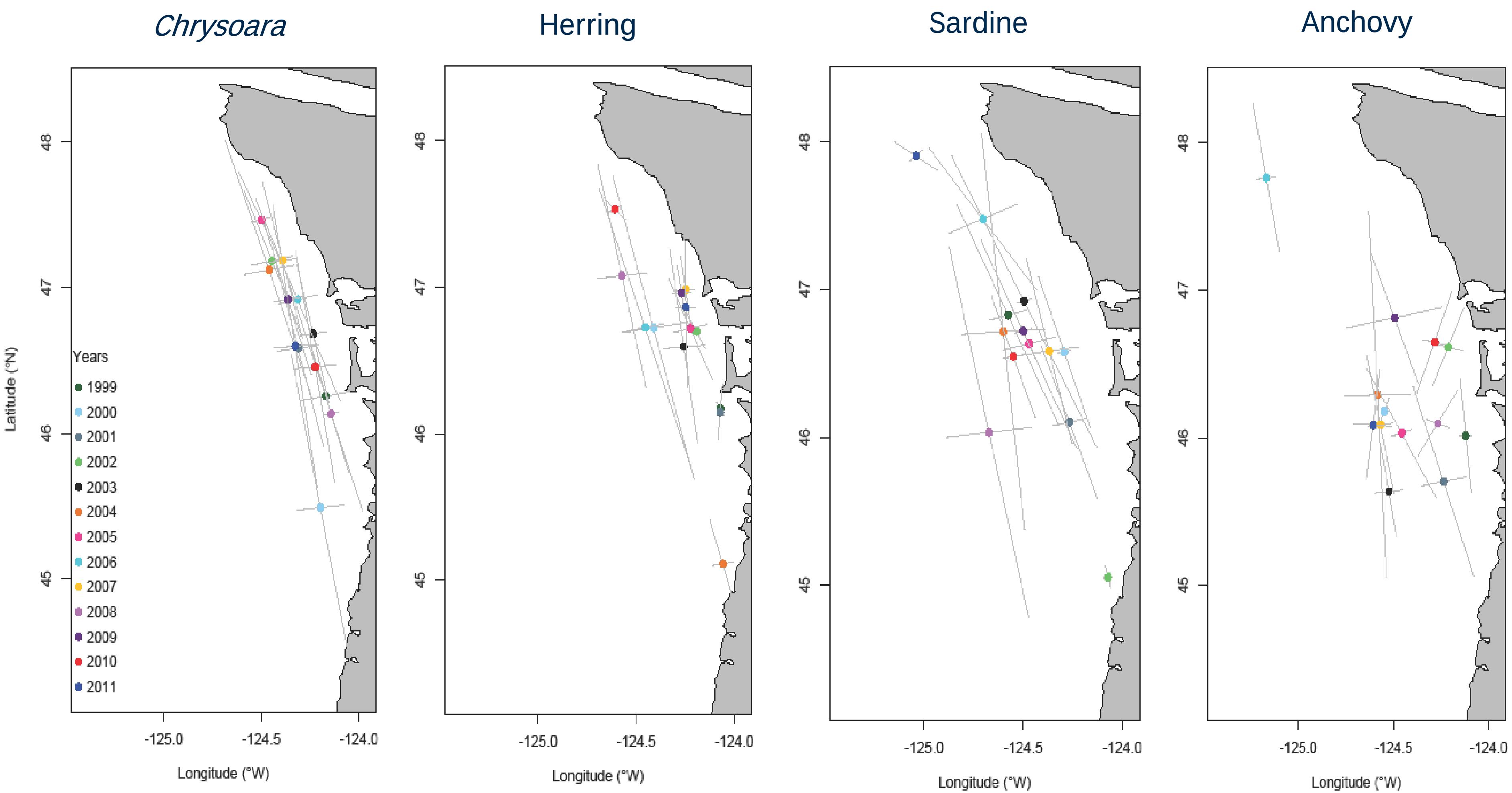
(Ruzicka et al. 2012)

Ecosystem Effects of a 5% Increase in Energy Flow to Jellyfish

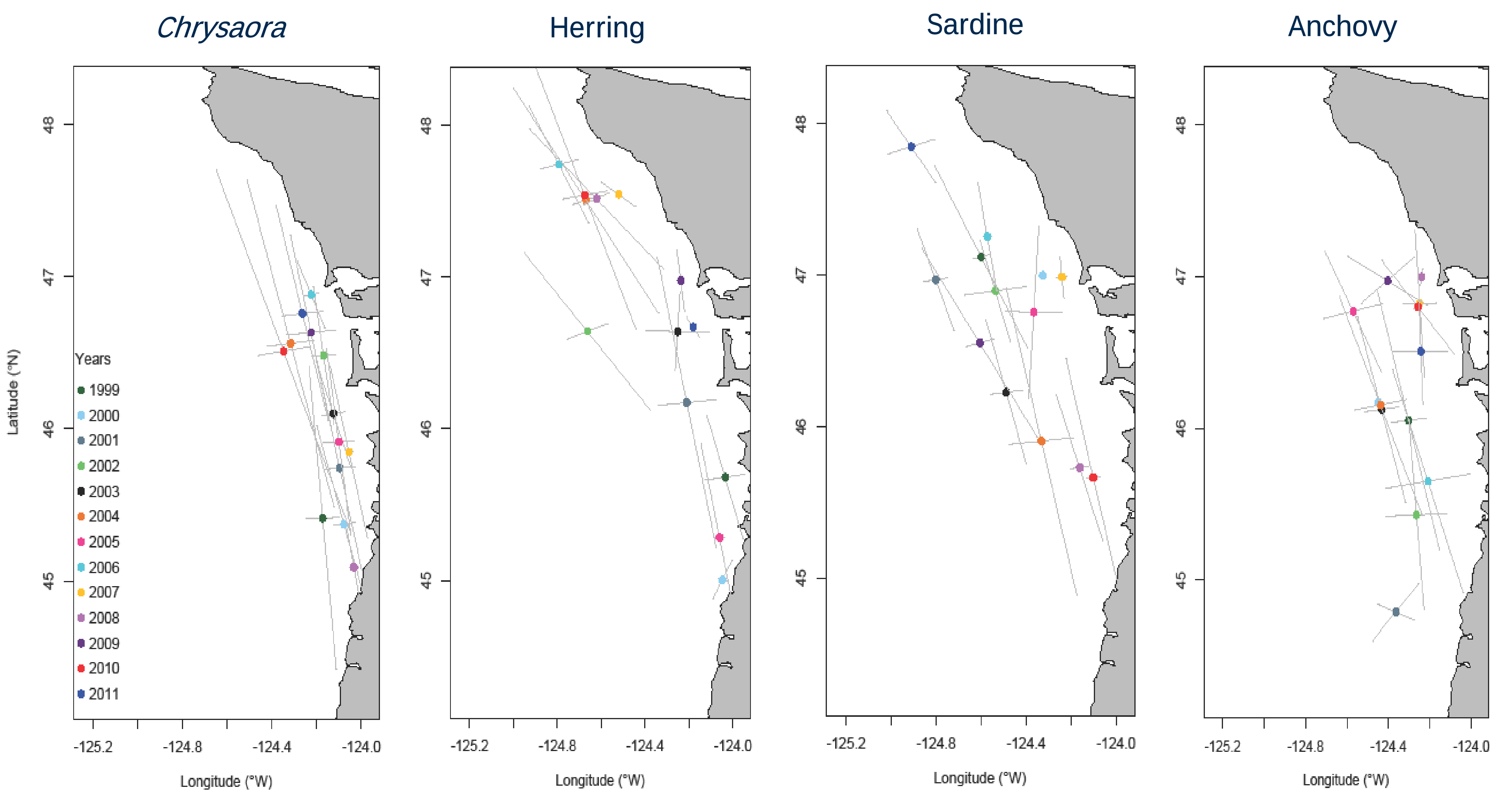


(Brodeur et al. 2010)

Distributions of centers of gravity and variation for June cruises from 1999-2011



Distributions of centers of gravity and variation for September cruises from 1999-2011

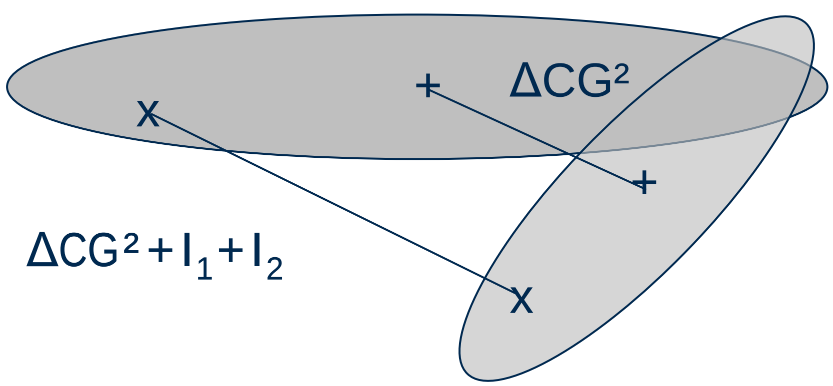


Global index of collocation (GIC)

Calculates the extent to which two populations are geographically distinct, by comparing the distance between their *CGs* and the *mean distance* between individual fish taken at random and independently from each population.

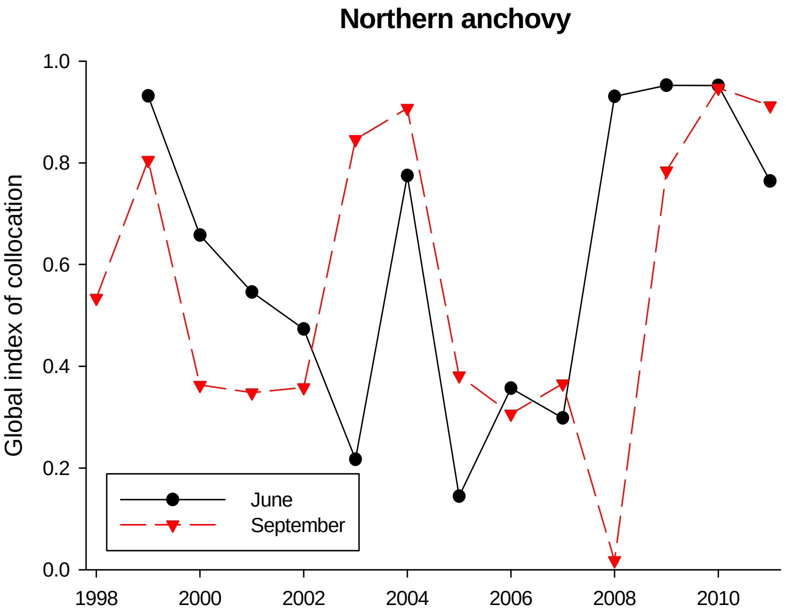
$$\mathrm{GIC} = 1 - \frac{\Delta CG^2}{\Delta CG^2 + I_1 + I_2}$$

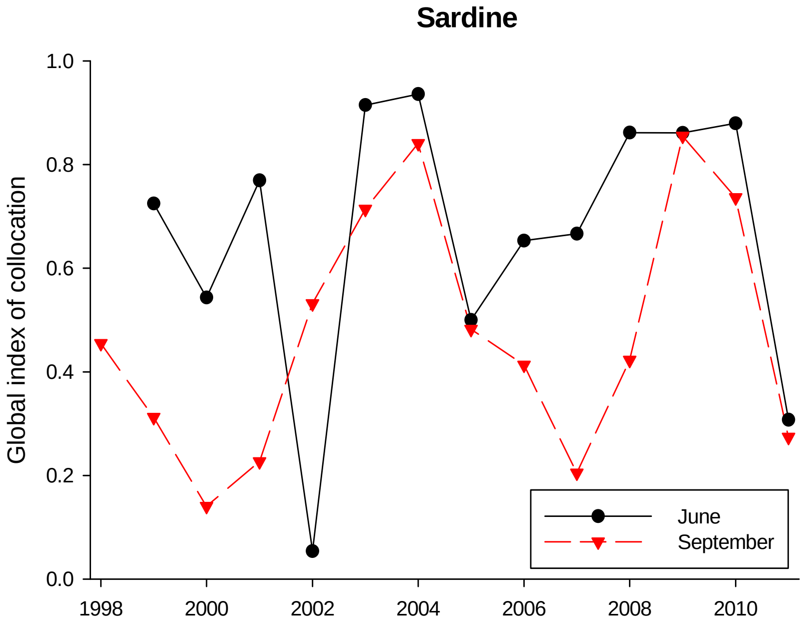
Ranges between 0, in the extreme case where each population is concentrated on a single but different location, and 1, where the two CGs coincide.

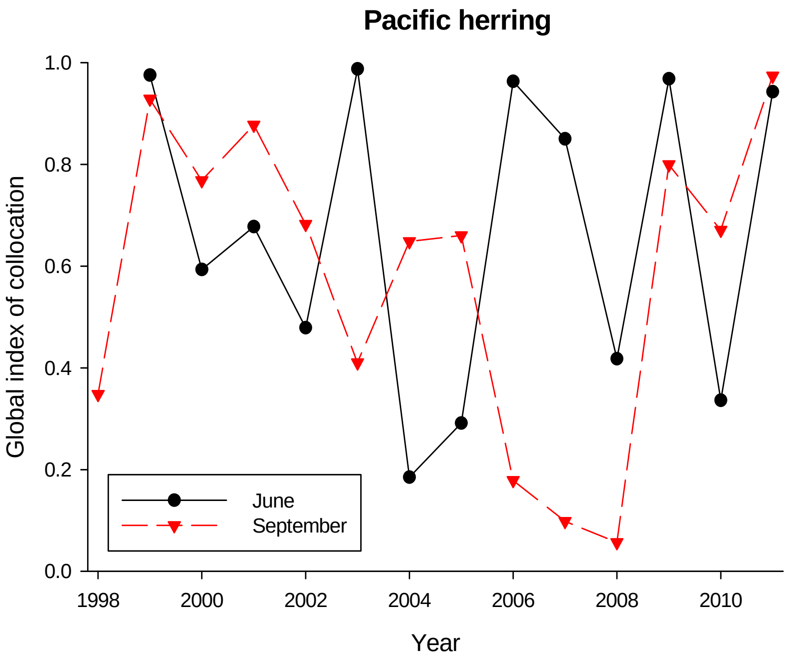


(Woillez et al. 2009)

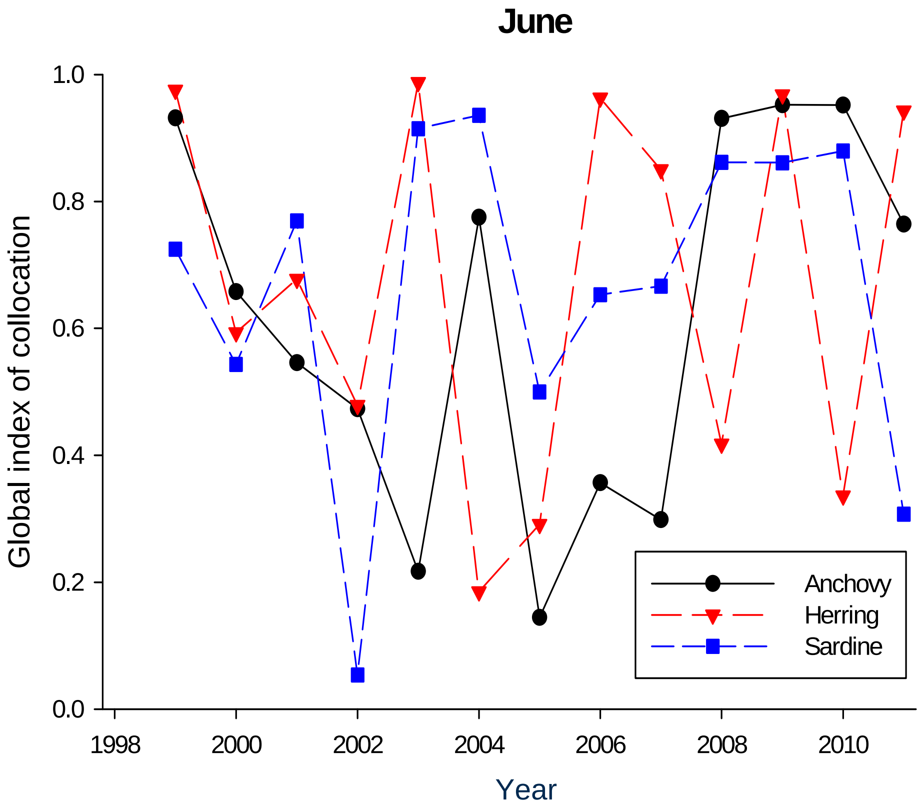
Seasonal and interannual variability in the Global Index of Collocation between *Chrysaora* and forage fishes

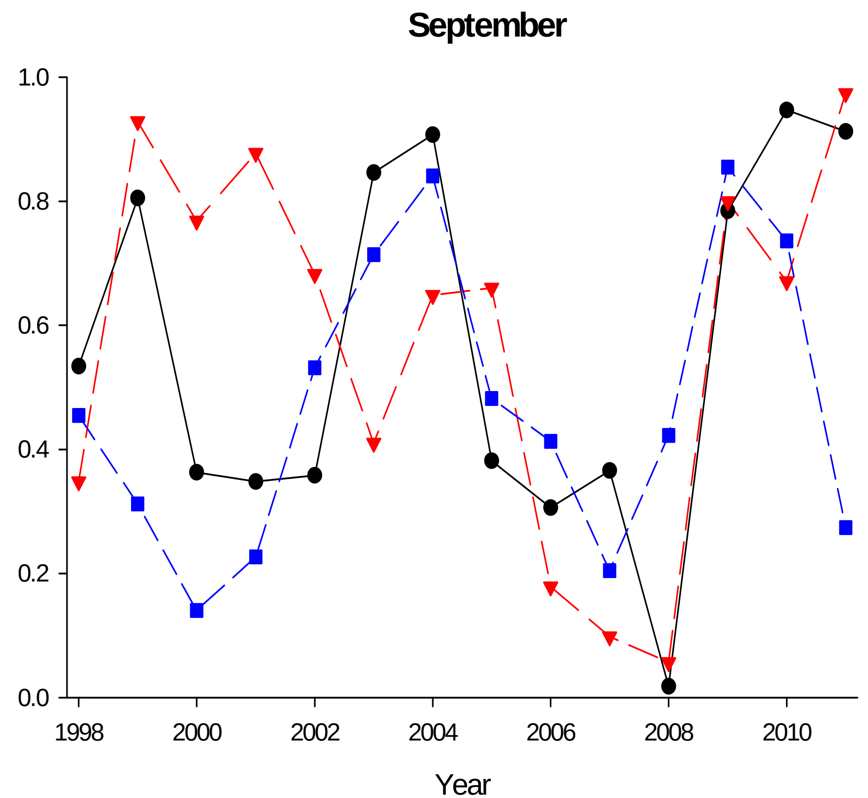






Interannual variability in the Global Index of Collocation between *Chrysaora* and forage species for each month





Cramér-von Mises* p-values for the difference between the spatial distributions of *Chrysaora* and forage fishes in June

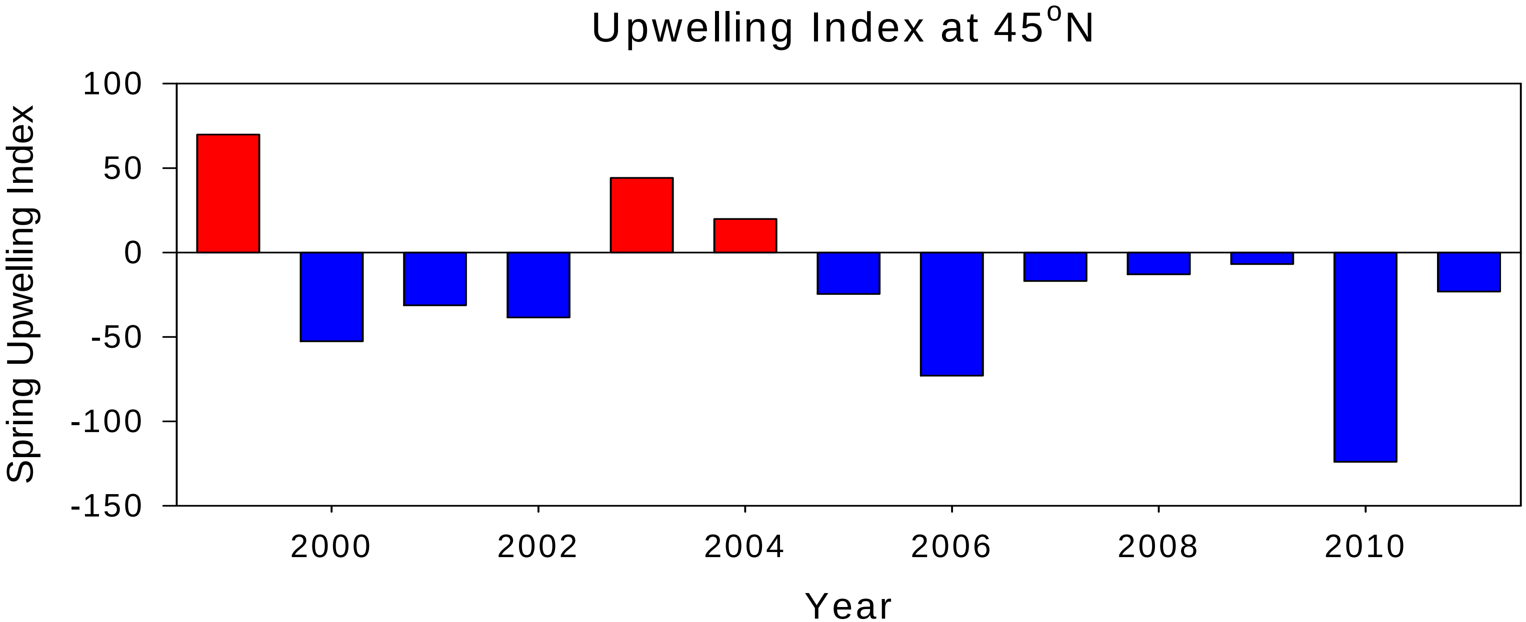
Non-Sig. Diff.	9/13	9/13	7/13	
Year	**Herring**	**Sardine**	**Anchovy**	Regime
1999	n.s.	n.s.	n.s.	Cool
2000	n.s.	n.s.	n.s.	Cool
2001	n.s.	n.s.	n.s.	Cool
2002	< 0.001	< 0.001	0.011	Cool
2003	n.s.	n.s.	< 0.001	
2004	0.006	n.s.	0.038	
2005	n.s.	n.s.	0.031	
2006	n.s.	n.s.	n.s.	Cool
2007	n.s.	n.s.	0.018	
2008	< 0.001	< 0.001	n.s.	Cool
2009	n.s.	n.s.	n.s.	Cool
2010	0.005	0.020	n.s.	
2011	n.s.	< 0.001	0.002	

*From Syrjala (1996) Ecology

Cramér-von Mises* p-values for the difference between the spatial distributions of *Chrysaora* and forage fishes in September

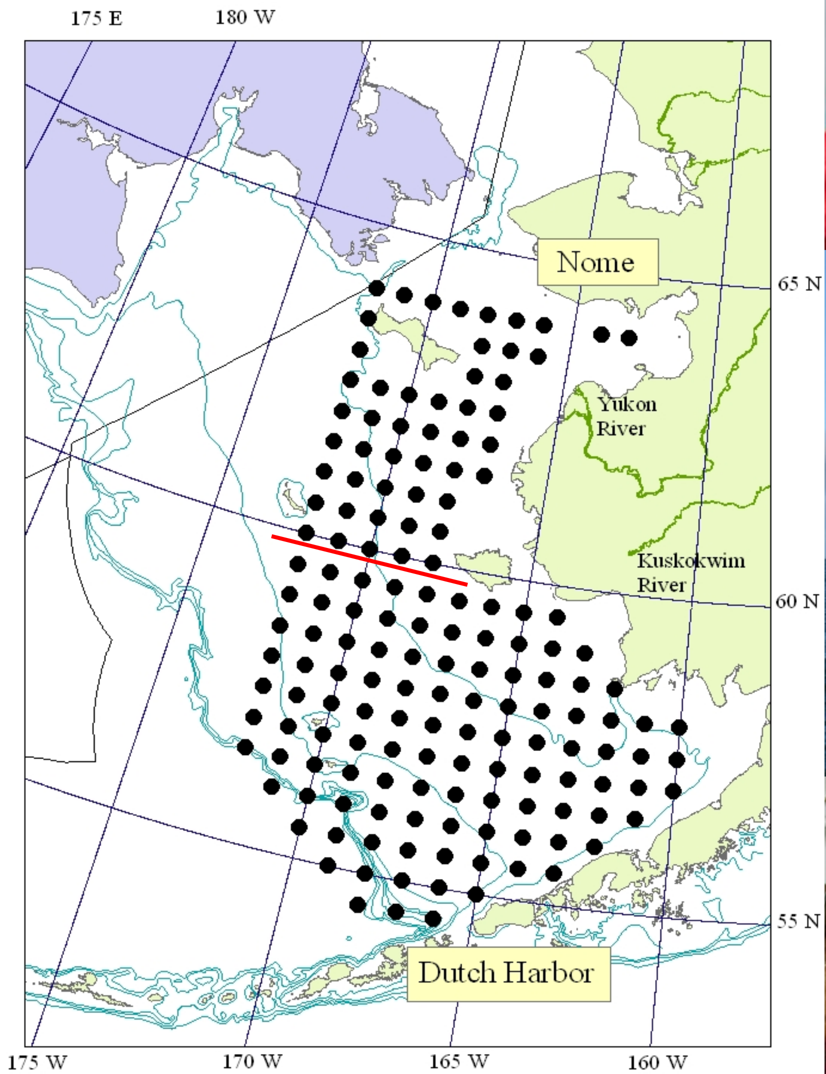
Non-Sig. Diff.	9/13	8/13	10/13	
Year	**Herring**	**Sardine**	**Anchovy**	Regime
1999	n.s.	n.s.	n.s.	Cool
2000	n.s.	n.s.	n.s.	Cool
2001	n.s.	0.001	0.003	Cool
2002	n.s.	0.001	0.025	Cool
2003	n.s.	0.024	n.s.	
2004	n.s.	n.s.	n.s.	
2005	n.s.	0.038	n.s.	
2006	0.004	n.s.	0.006	Cool
2007	0.044	n.s.	n.s.	
2008	0.009	n.s.	n.s.	Cool
2009	n.s.	n.s.	n.s.	Cool
2010	n.s.	n.s.	n.s.	
2011	0.033	0.003	n.s.	

*From Syrjala (1996) Ecology


Upwelling Index at 45°N
100
50
0
-50
-100
-150
Spring Upwelling Index
2000
2002
2004
2006
2008
2010
Year

BASIS Survey

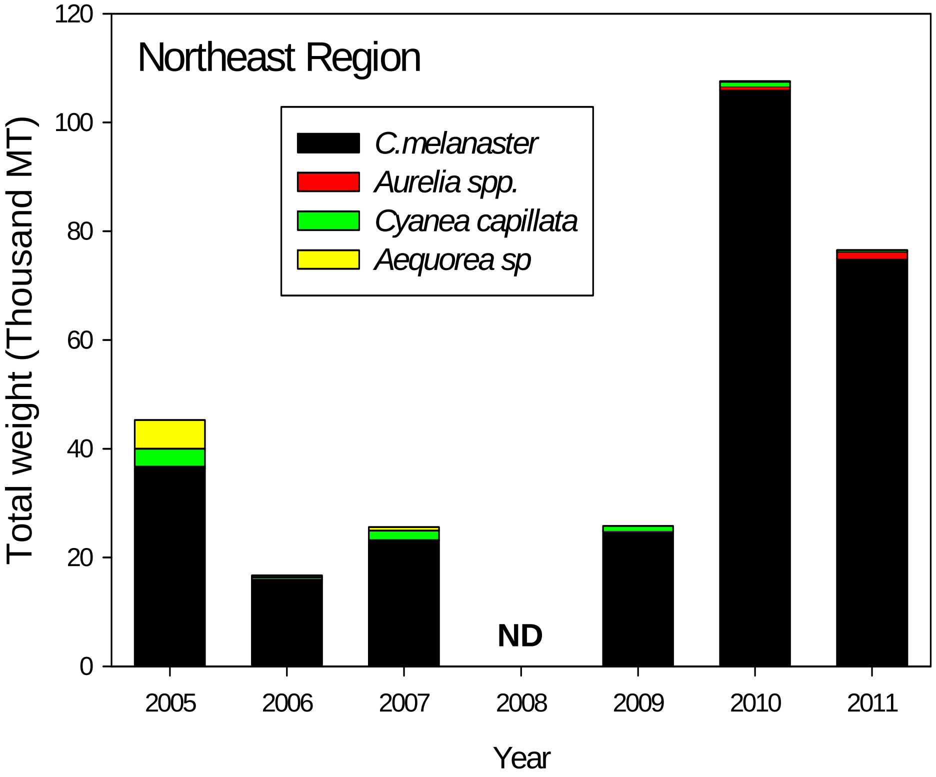
2004-2011

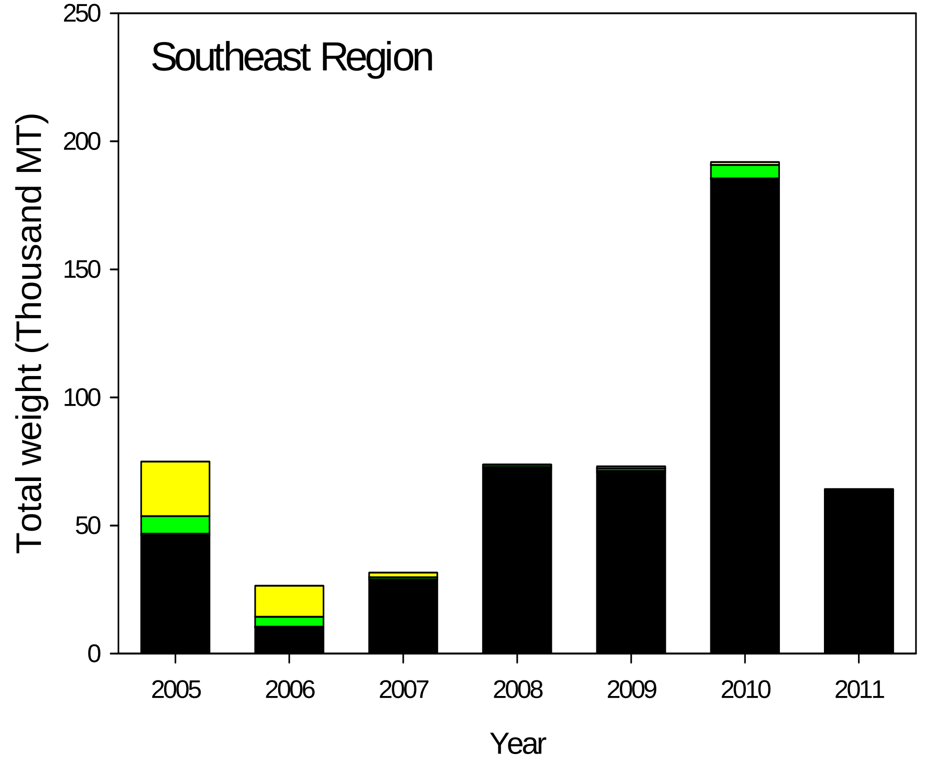


BASIS Jellyfish Species Composition by Year

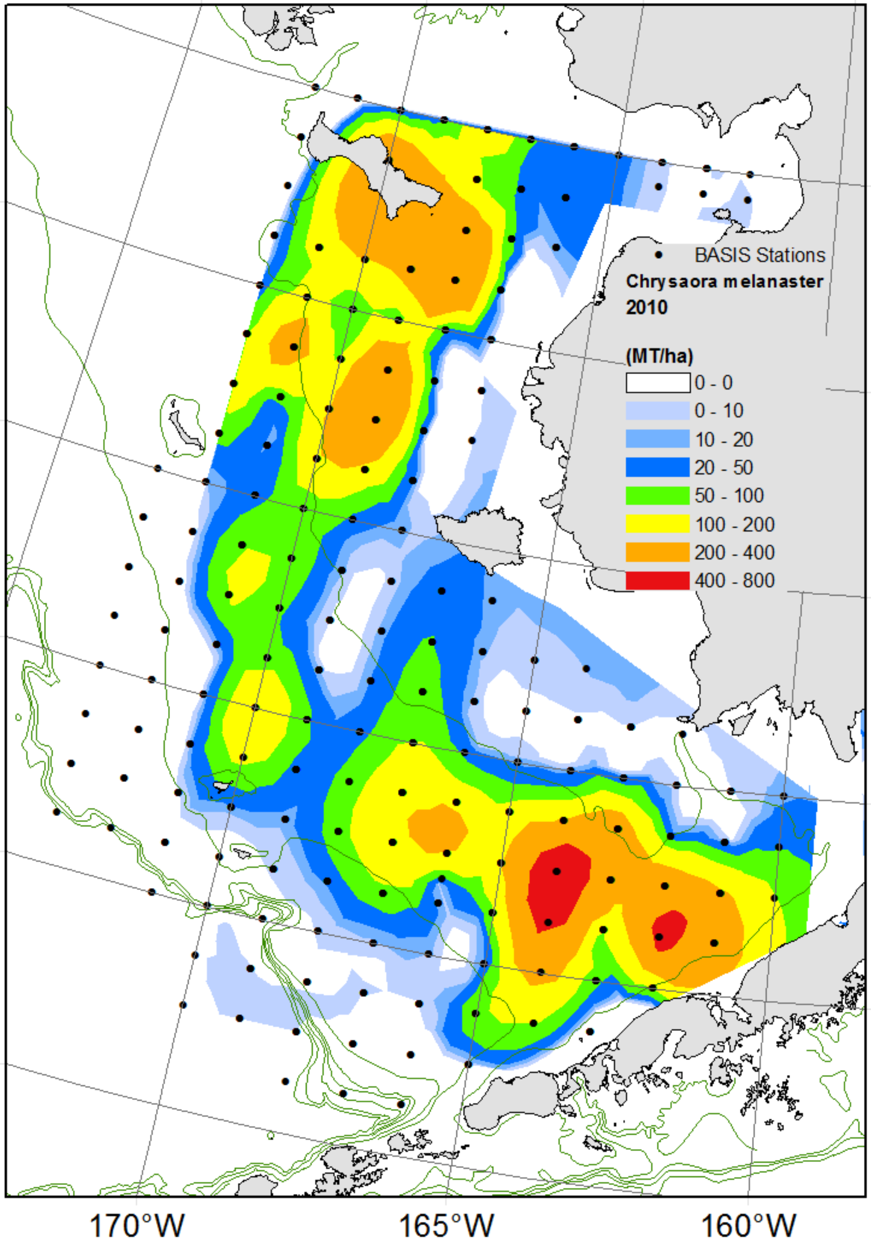
- Abundance varies interannually and geographically

- Catch dominated by *Chrysaora* in Northeast (>94%) and in Southeast (>89%)

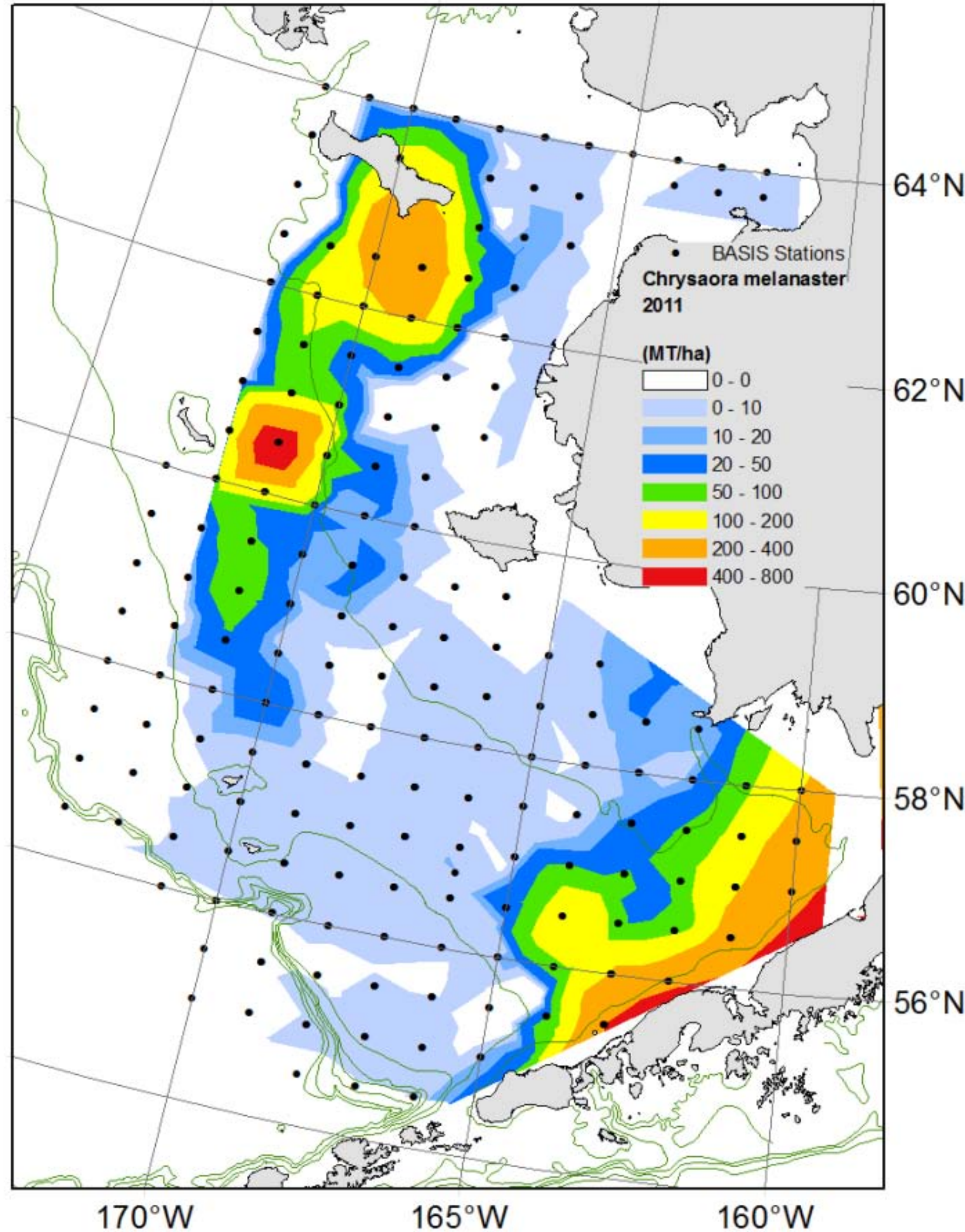




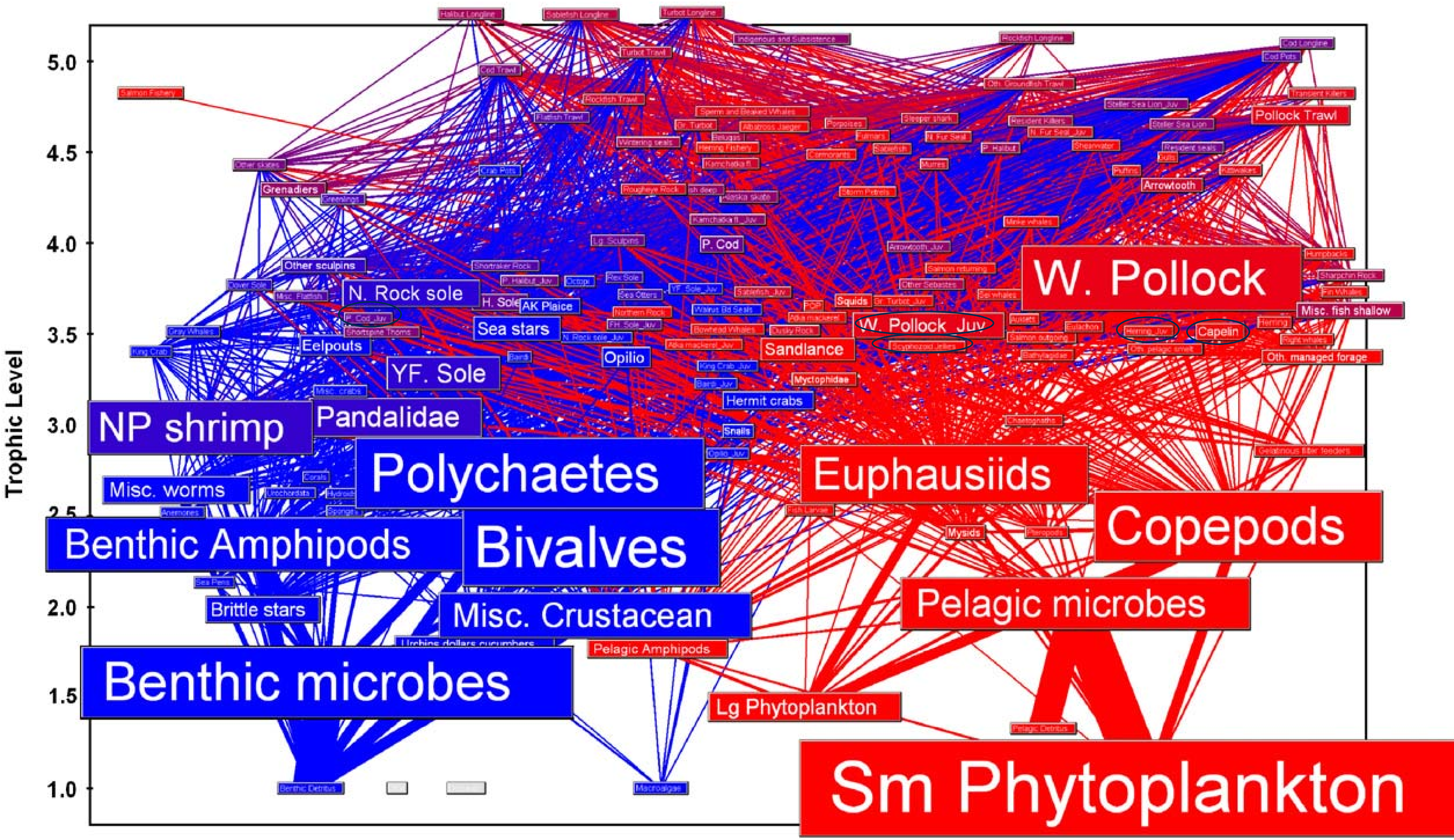
2010


BASIS Stations
Chrysaora melanaster
2010
(MT/ha)
0 - 0
0 - 10
10 - 20
20 - 50
50 - 100
100 - 200
200 - 400
400 - 800
170°W
165°W
160°W

2011

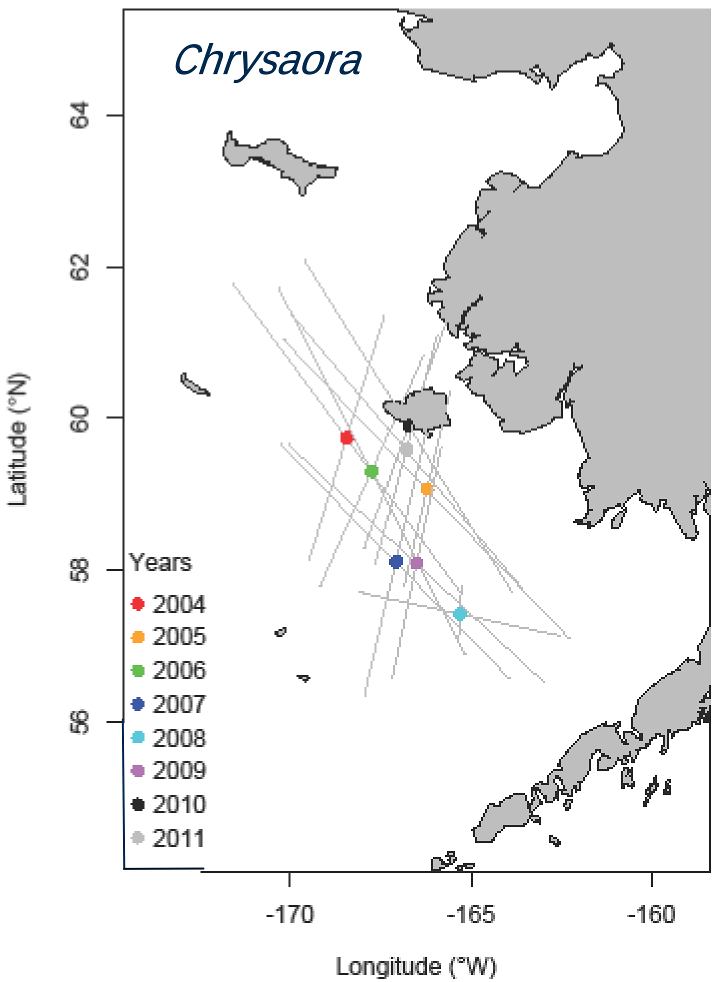

BASIS Stations
Chrysaora melanaster
2011
(MT/ha)
0 - 0
0 - 10
10 - 20
20 - 50
50 - 100
100 - 200
200 - 400
400 - 800
64°N
62°N
60°N
58°N
56°N
170°W
165°W
160°W

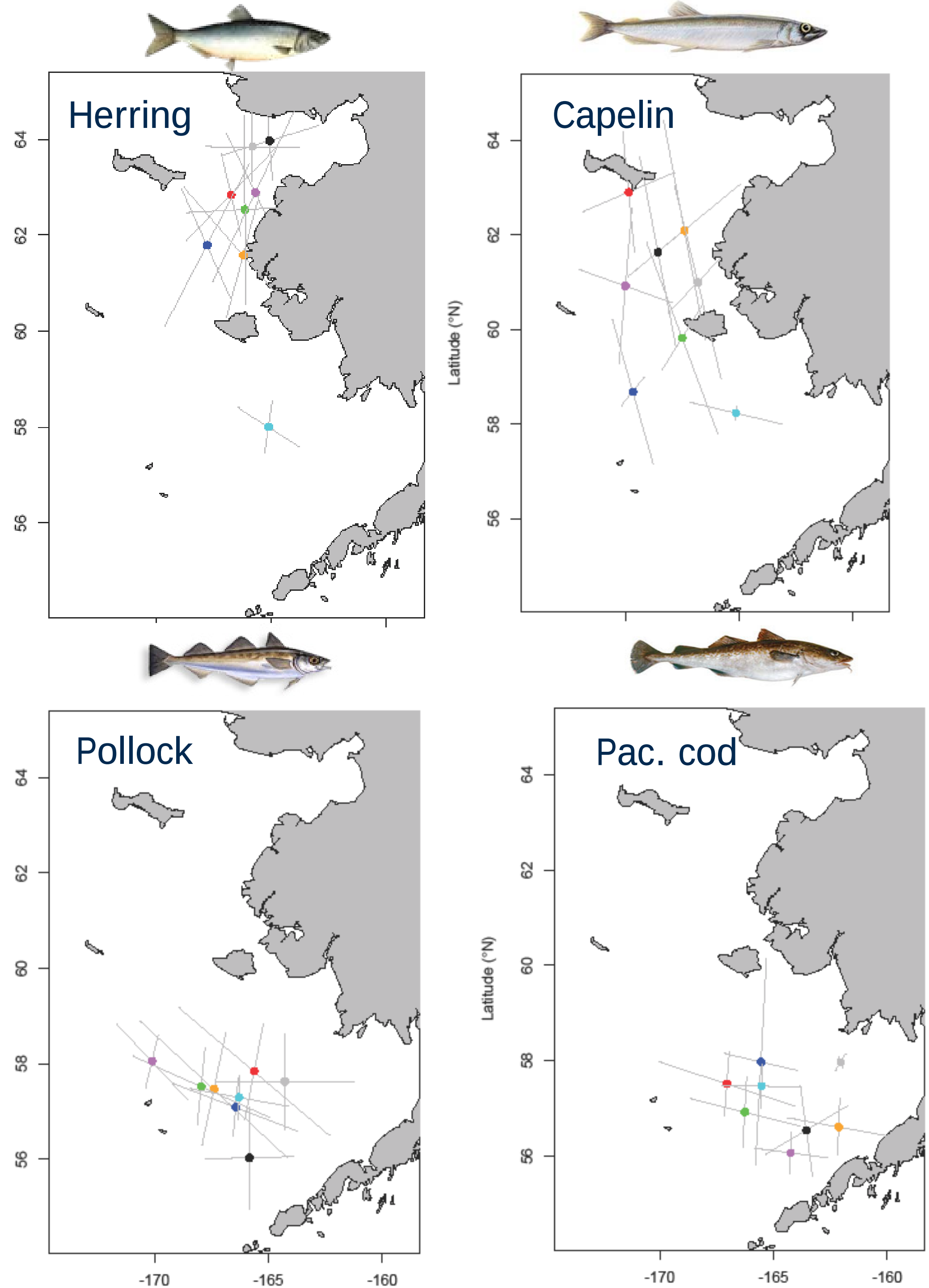
Model of Bering Sea Ecosystem



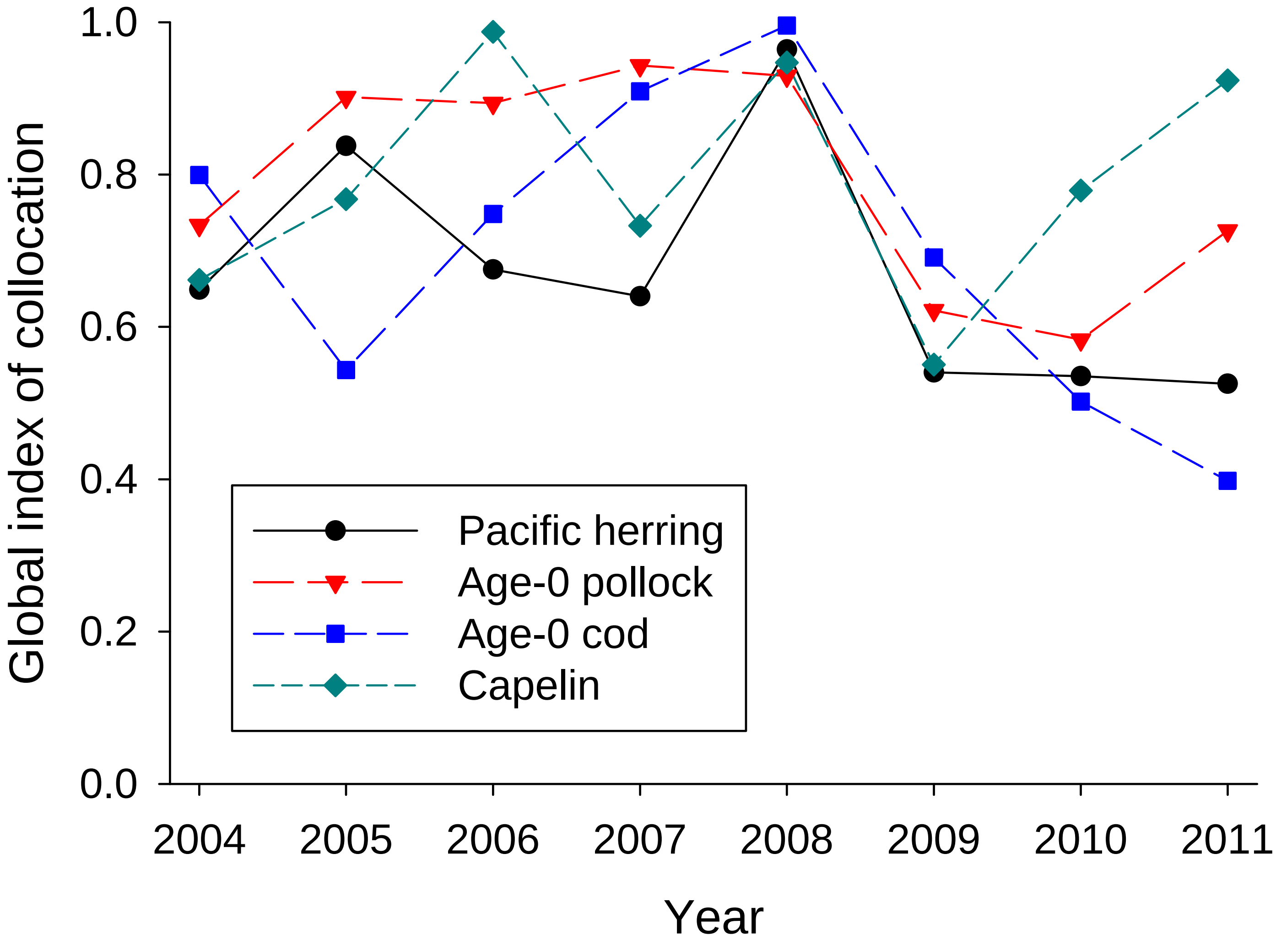
(Aydin and Mueter 2007)

Distributions of centers of gravity and variation for BASIS cruises from 2004-2011





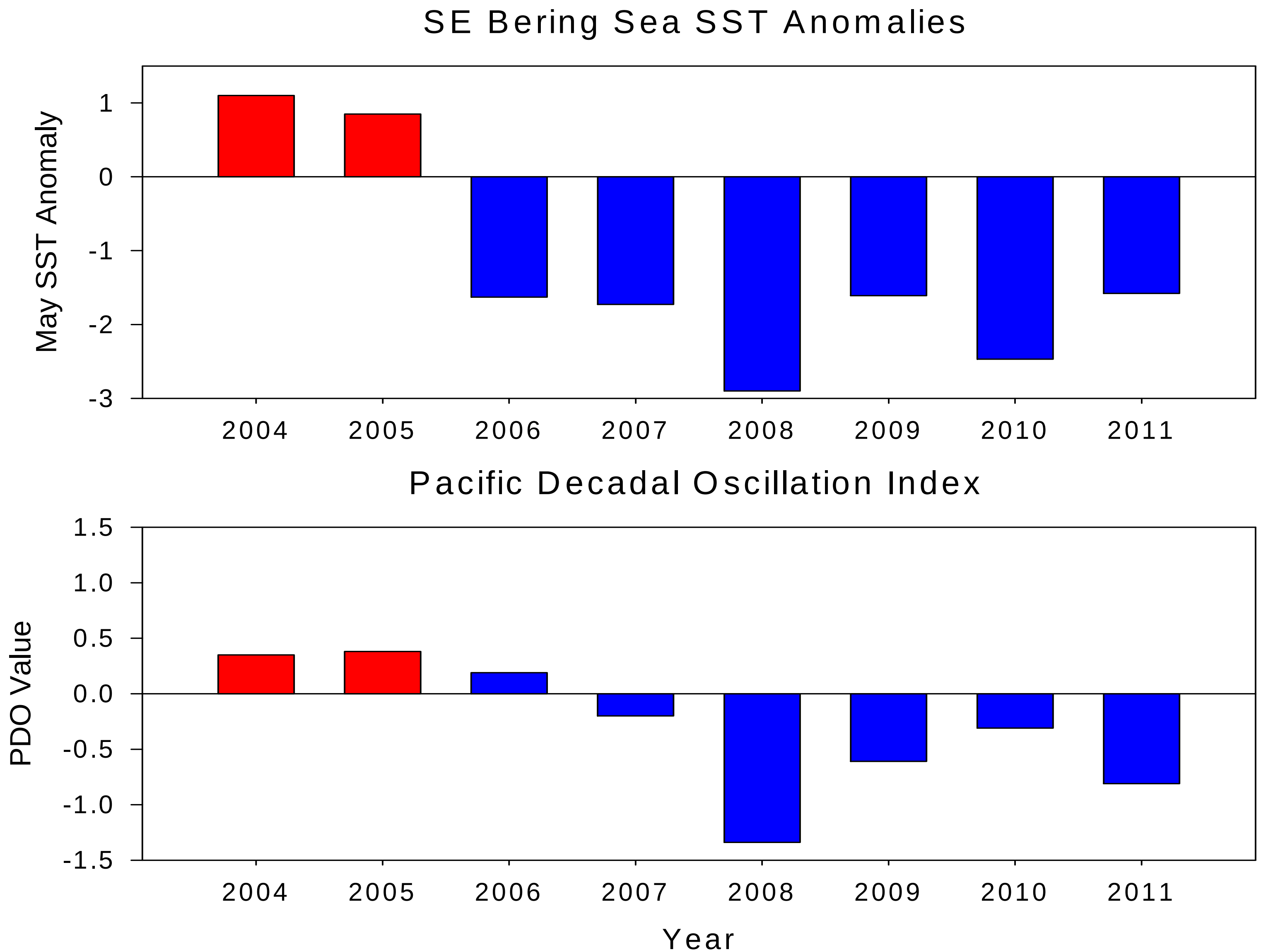
Comparison of Global Index of Collocation between *Chrysaora* and forage fishes in the Bering Sea



Cramér-von Mises* p-values for the difference between the spatial distributions of *Chrysaora* and forage fishes in the Bering Sea

Non-Sig. Diff.	1/8	3/8	1/8	4/8
Year	**Herring**	**Pollock**	**Pacific cod**	**Capelin**
2004	< 0.001	< 0.001	< 0.001	< 0.001
2005	< 0.001	< 0.001	< 0.001	0.018
2006	0.014	< 0.001	< 0.001	n.s.
2007	< 0.001	n.s.	< 0.001	n.s.
2008	n.s.	n.s.	n.s.	n.s.
2009	< 0.001	n.s.	0.003	< 0.001
2010	< 0.001	< 0.001	< 0.001	n.s.
2011	< 0.001	< 0.001	0.002	0.020

*From Syrjala (1996) Ecology


SE Bering Sea SST Anomalies
May SST Anomaly
1
0
-1
-2
-3
2004
2005
2006
2007
2008
2009
2010
2011
Pacific Decadal Oscillation Index
PDO Value
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
2004
2005
2006
2007
2008
2009
2010
2011
Year

Conclusions

California Current

- *Chrysaora* had relatively high spatial overlap with dominant forage fishes for most years (>> 50% significant)
- Herring and sardine showed the highest overlap with *Chrysaora* distributions in May and anchovy had the highest overlap in September

Bering Sea

- *Chrysaora* had relatively low spatial overlap with dominant forage fishes for most years (≤ 50% significant)
- Capelin and pollock showed the most similar distributions to *Chrysaora*
- During 2008, the coldest year, *Chrysaora* distributions were shifted south and overlapped with all forage species

Future Studies

•Examine diets of *Chrysaora* and forage fish in areas with high spatial overlap to see if they are potentially competing for the same prey resources

•Do detailed analysis of environmental factors related to high and low overlap years

• Conduct multivariate community analysis by cruise to look for other species that may have high spatial overlap with *Chrysaora* and other jellyfish species

Acknowledgements

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We wish to thank everyone who went to sea for diligently collecting the jellyfish data in the trawl surveys

Thank you!


Questions?