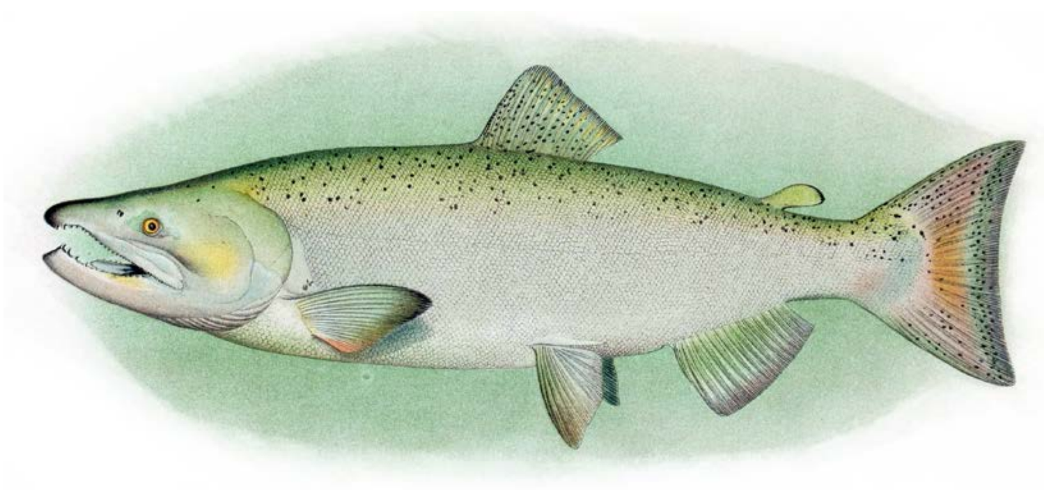
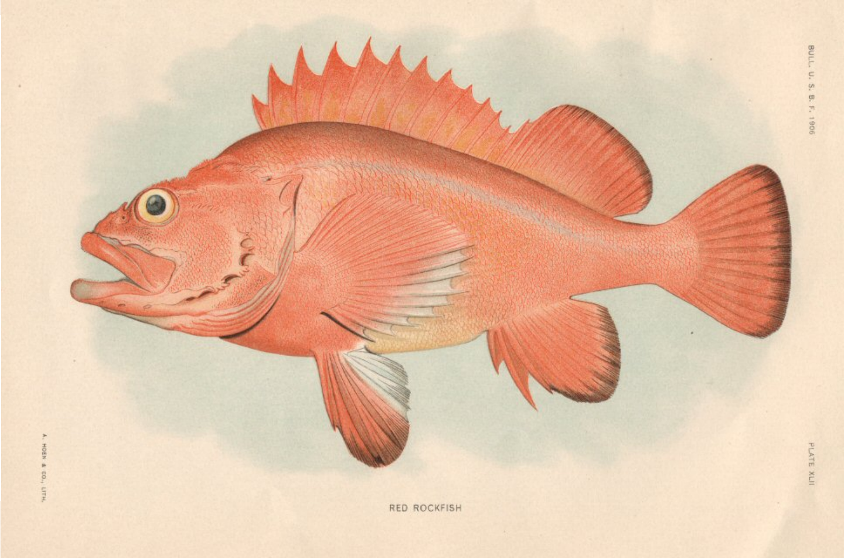
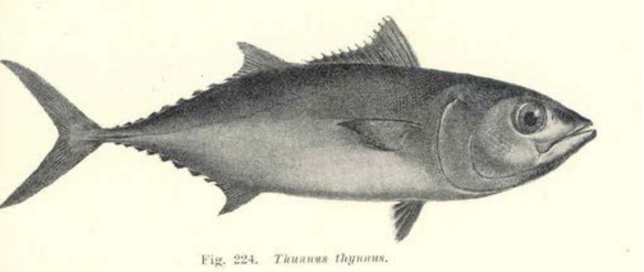
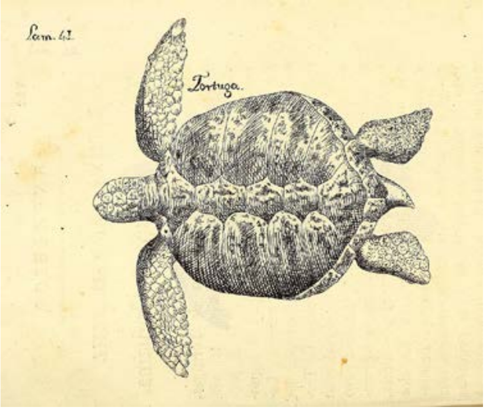
Distributional changes of west coast species and impacts of climate change on species and species groups







Elliott Hazen[1]
Ole Shelton[2]
Eric Ward[2]
[1]NOAA Southwest Fisheries Science Center
[2]NOAA Northwest Fisheries Science Center



OUTLINE

Introduction: Context

Review part of Jacox et al.

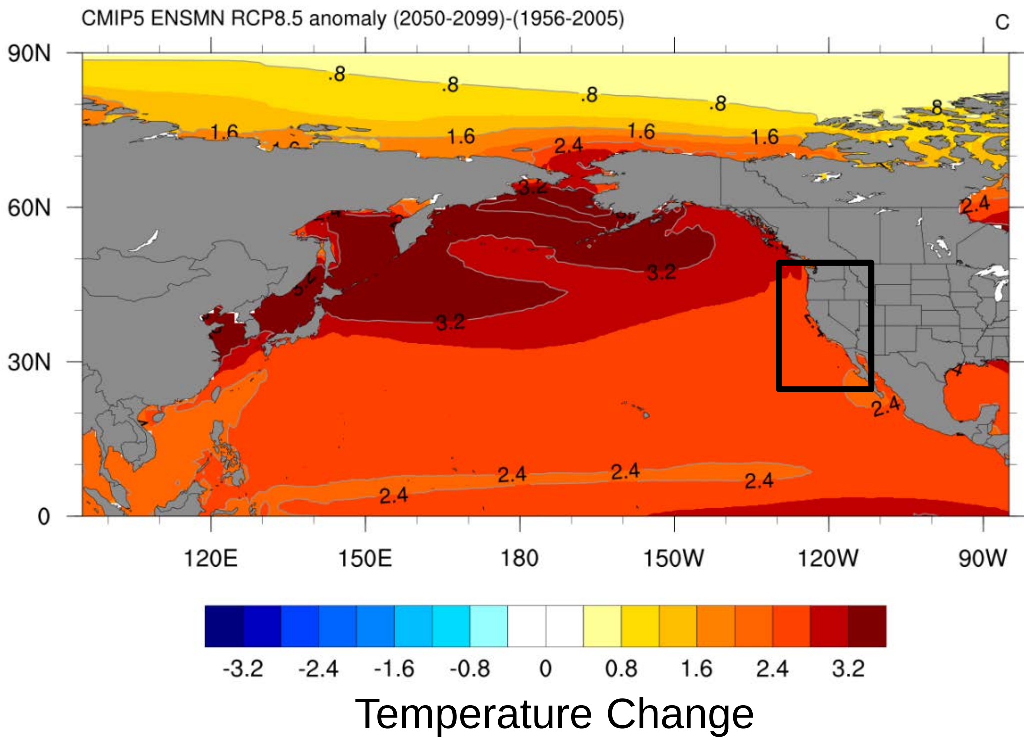
"What do we expect to happen in the California Current under climate change?

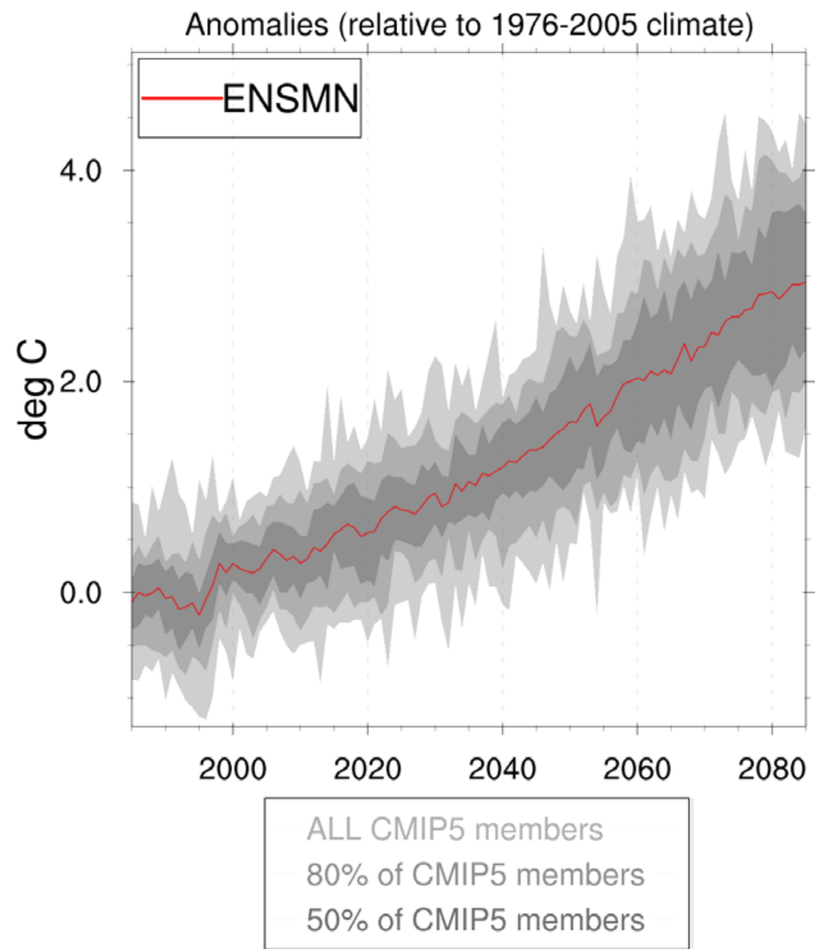
Part 1: Chinook Salmon

Part 2: Groundfish

Part 3: Large Pelagic Species

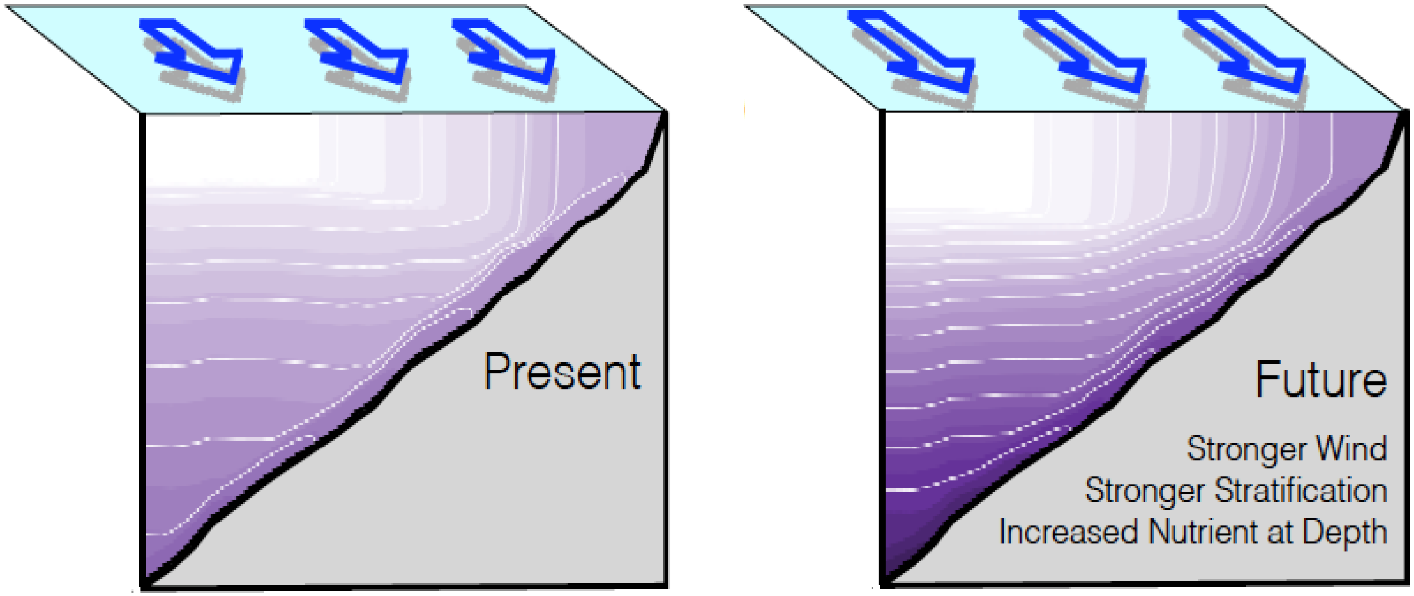
Climate Projections: Sea Surface Temperature





(Jacox et al. FEP Webinar 1)

ANTICIPATED CHANGES IN UPWELLING SYSTEMS



Jacox *et al.* (2015)

- Changes in upwelling?
- Changes in stratification?
- Changes in nutrient content of source waters?
- Increased hypoxia and ocean acidification?

(Jacox et al. FEP Webinar 1)

Oceanography will not solely determine distributions

Distributions are a function of finding physiologically suitable habitat

AND

Surviving in that habitat.

California sea lions:	~10,000 (1950s)	>150,000 (current)
Harbor seals:	<10,000 (1950s)	> 50,000 (current)
Humpback whales:	+6-7% annually in WA, OR, CA	

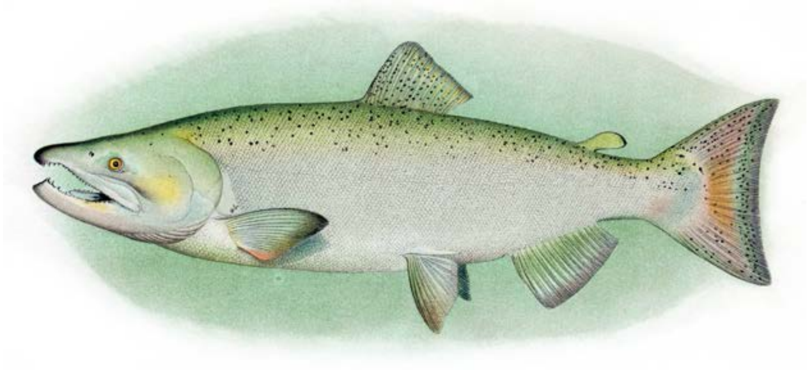
(Carretta et al. 2015)

Predators matter

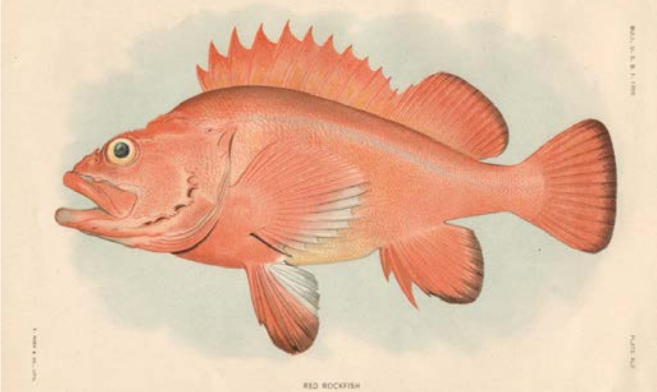
Need to be better incorporated into distribution and survivorship models

USE AVAILABLE DATA TO TALK ABOUT OBSERVED SHIFTS IN SPECIES DISTRIBUTIONS OVER RECENT DECADES

Part 1: Chinook Salmon
Ole Shelton

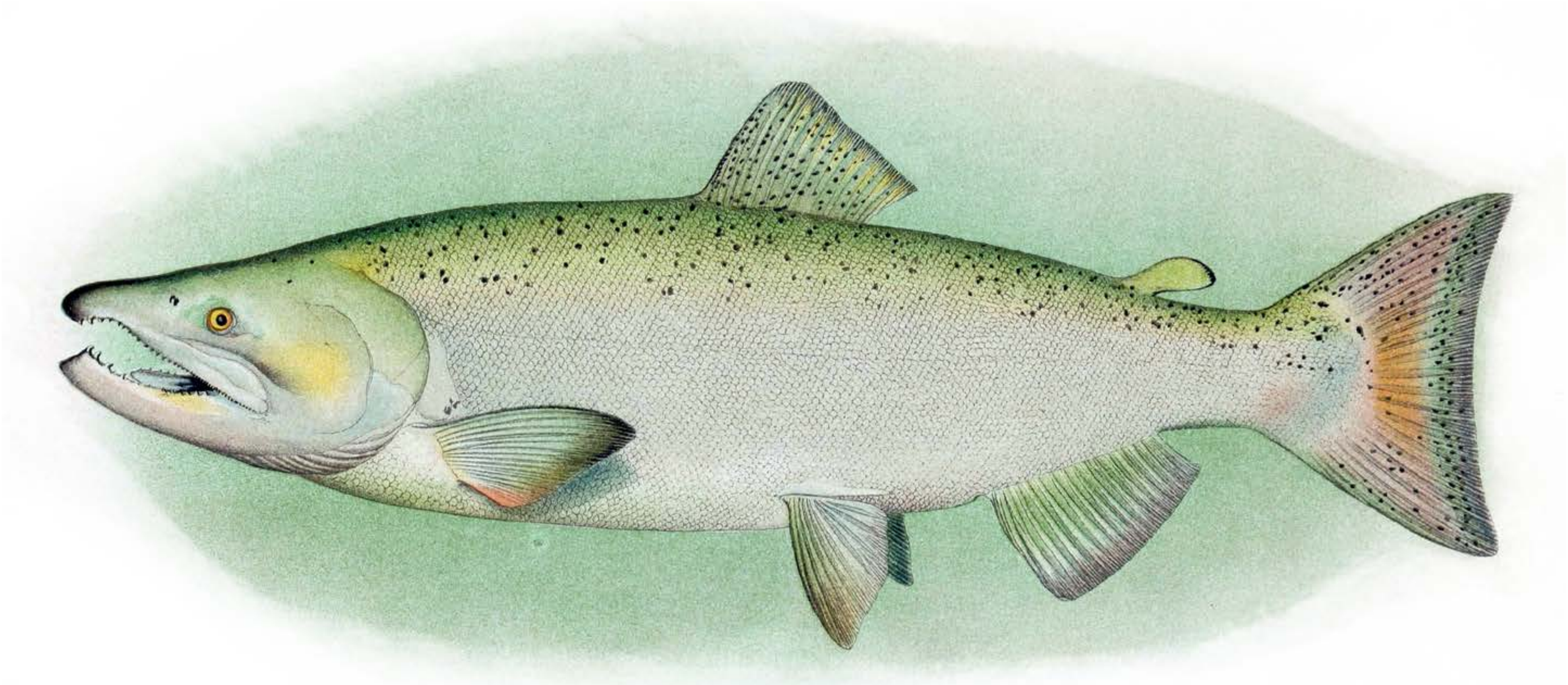


Part 2: Groundfish
Eric Ward



Part 3: Large Pelagic Species
Elliott Hazen

Fall Chinook salmon

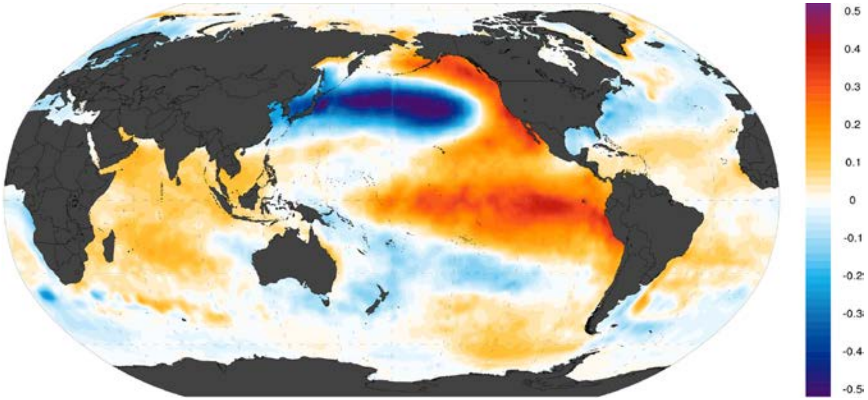


Ole Shelton[1], Will Satterthwaite[2], Eric Ward[1], Blake Feist[1], Brian Burke[1]
[1]NOAA Northwest Fisheries Science Center
[2]NOAA Southwest Fisheries Science Center

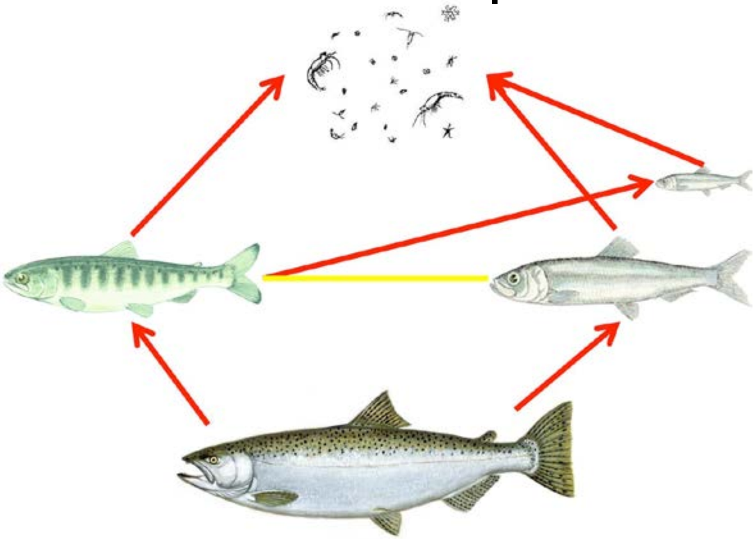
Salmon are central to riverine and coastal ecosystems

Fisheries

Climate



Predators & Competitors



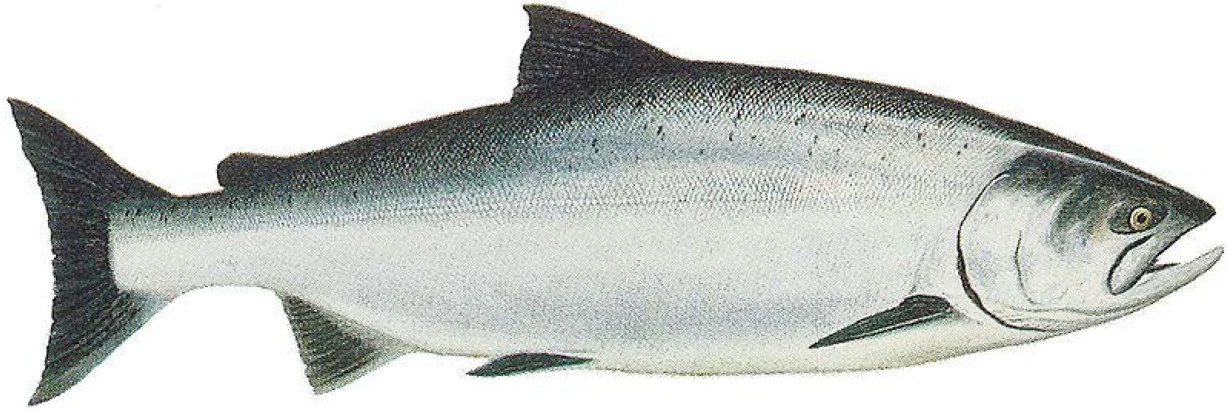
Prey

Where are fall Chinook in the ocean?

- by stock, account for confounding factors

How do abundance and distribution change with shifts in climate?

What does this mean for fisheries and ecosystems?



Builds on previous work

Weitkamp 2010

MARINE DISTRIBUTIONS OF CHINOOK SALMON 153

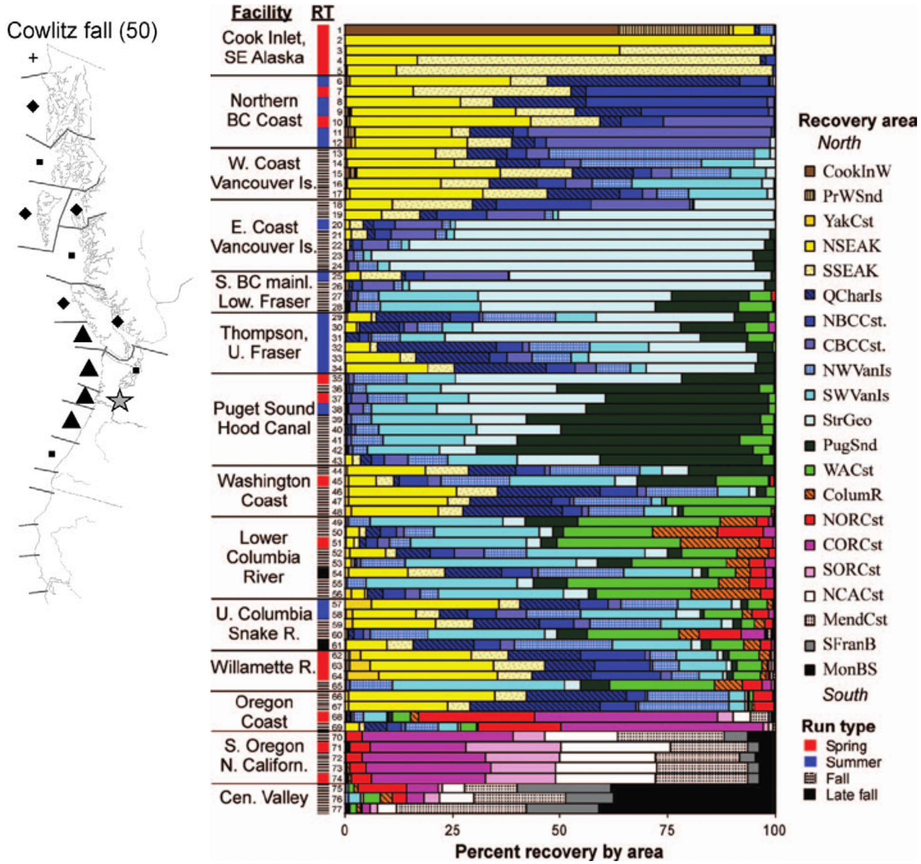
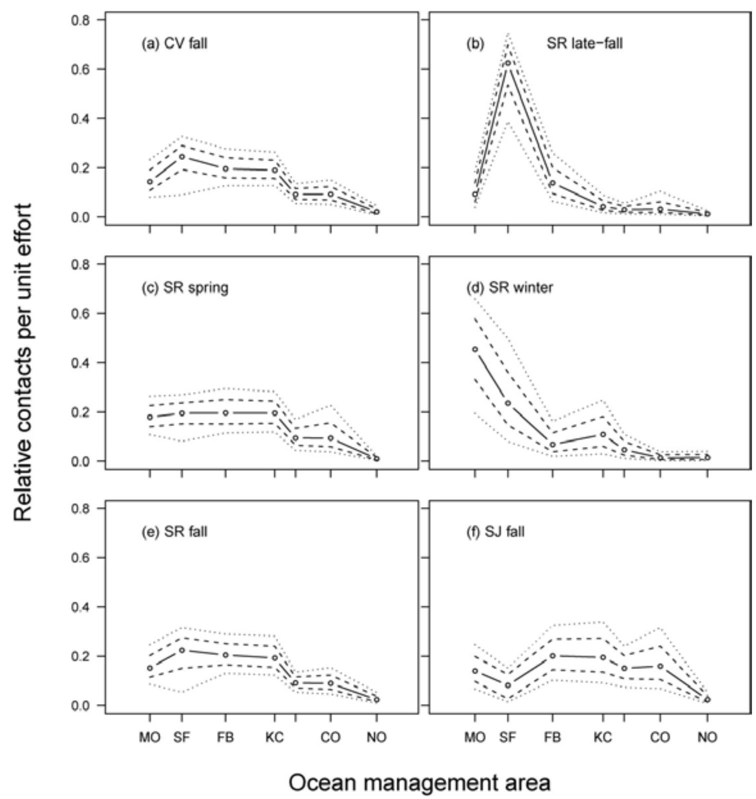


FIGURE 2.—Recovery patterns for coded-wire-tagged Chinook salmon by HRG, arranged by geographic region from north (top) to south (bottom). Each horizontal bar represents the percentages of recoveries in the 21 marine recovery areas for a single HRG; recovery area abbreviations and boundaries are provided in Figure 1. Run timing (RT) and HRG numbers are indicated to the left of the bar chart. See Figure 1 for HRG locations and Table A.1 for HRG names and recovery statistics.

Satterthwaite et al. 2014



Pacific Salmon Commission's
Chinook Technical Committee

Coded Wire Tags

Releases and Recoveries

Releases between 1977 - 2006

>50 hatcheries,

>230 million released fall Chinook

~ 900,000 fish recovered

Reliant on Fisheries recoveries

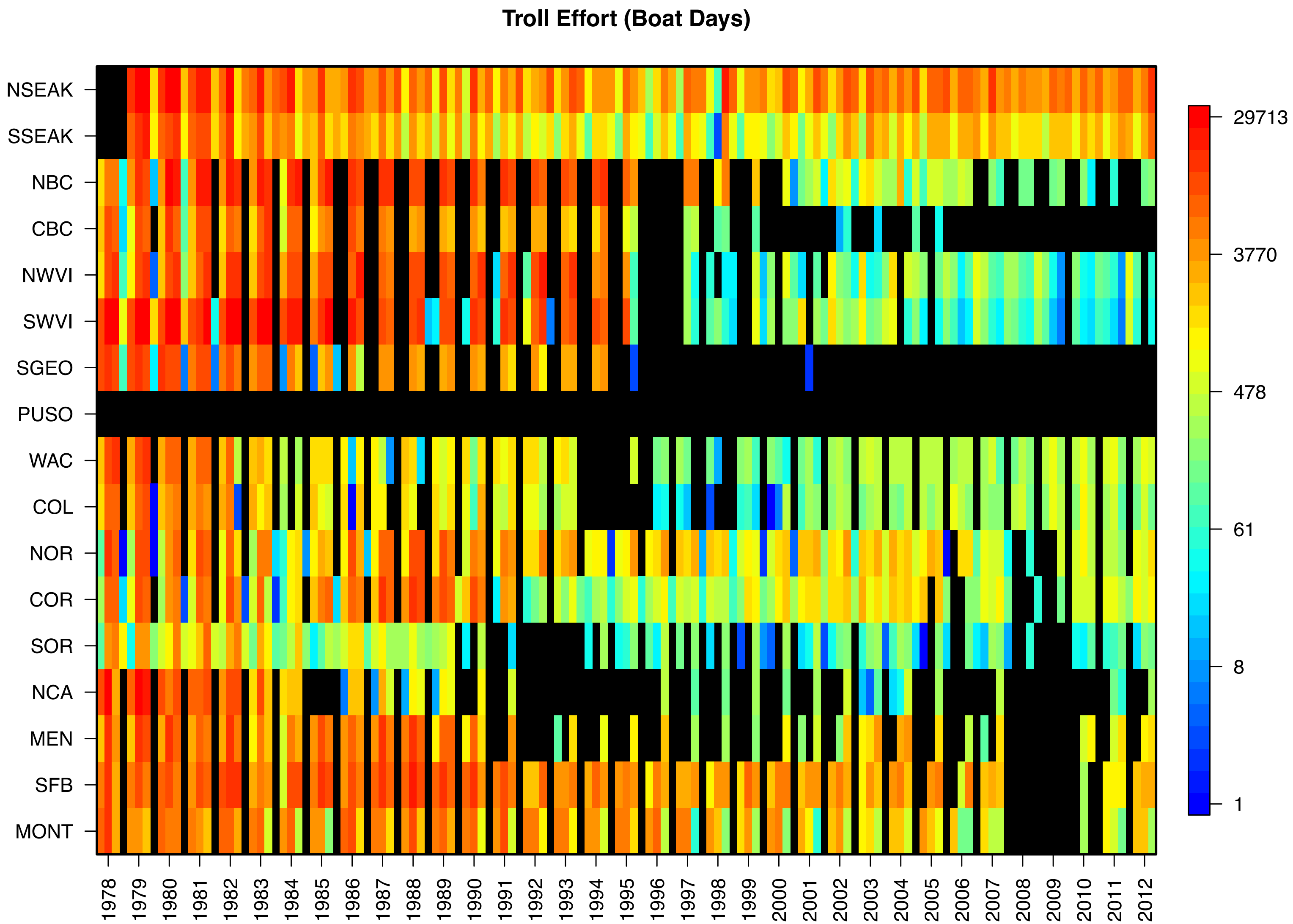
<u>Focus on Summer distribution for:</u>

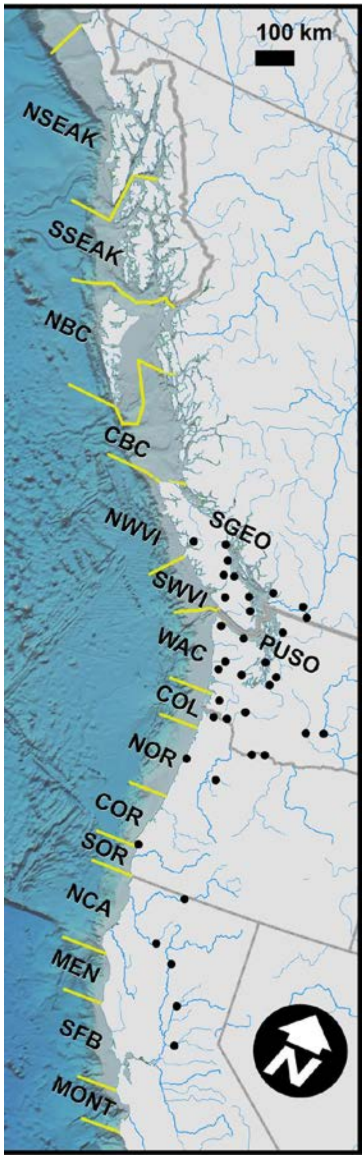
Central Valley, California

Klamath-Trinity River

Columbia River

Fishing Effort (commercial troll fishery)

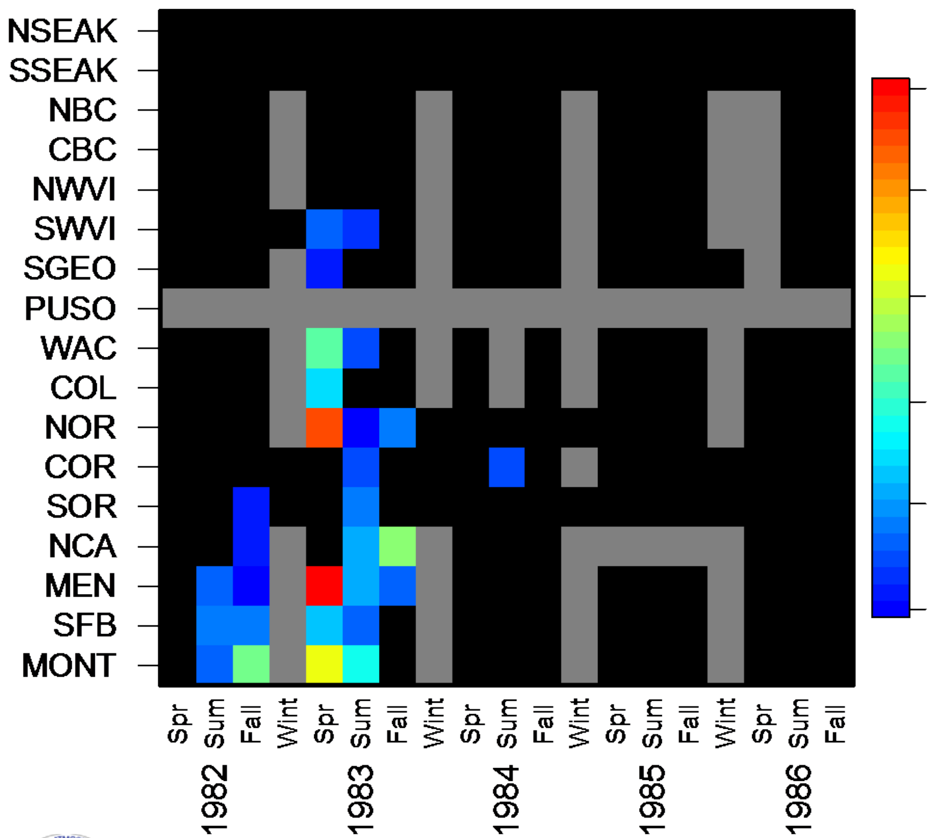




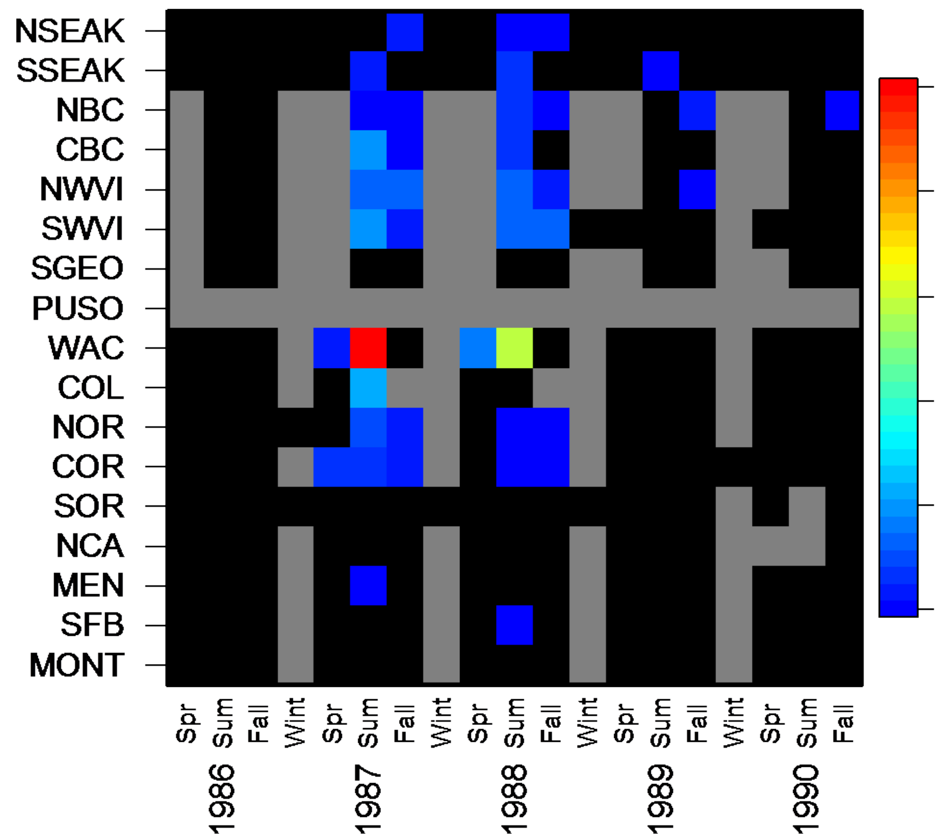
Marine Recoveries

(commercial troll CPUE)

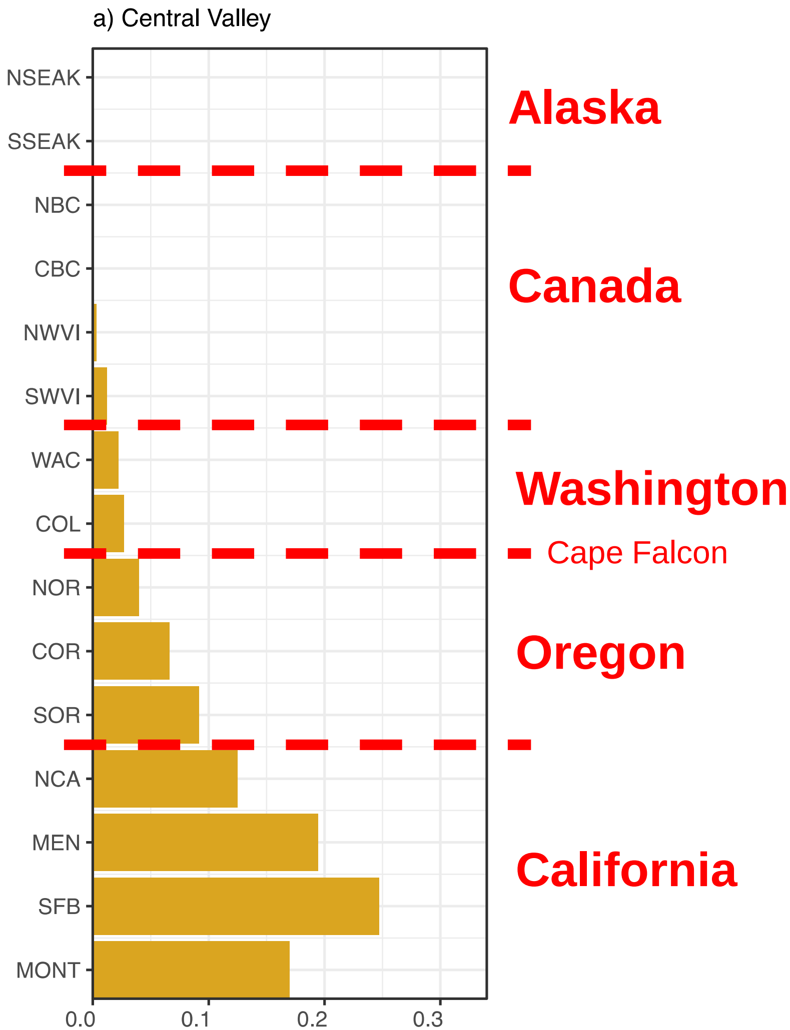
Sacramento River (origin=SFB)
(Coleman NFH,1980)

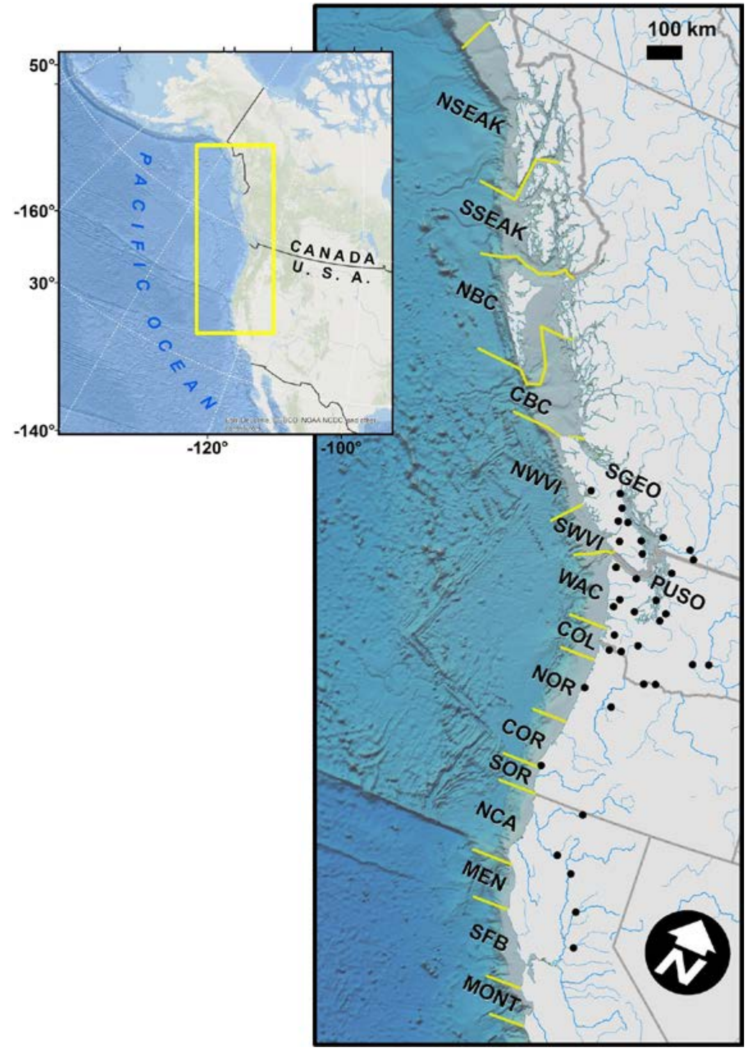


Snake River (origin=SNAK)
(Lyons Ferry,1984)

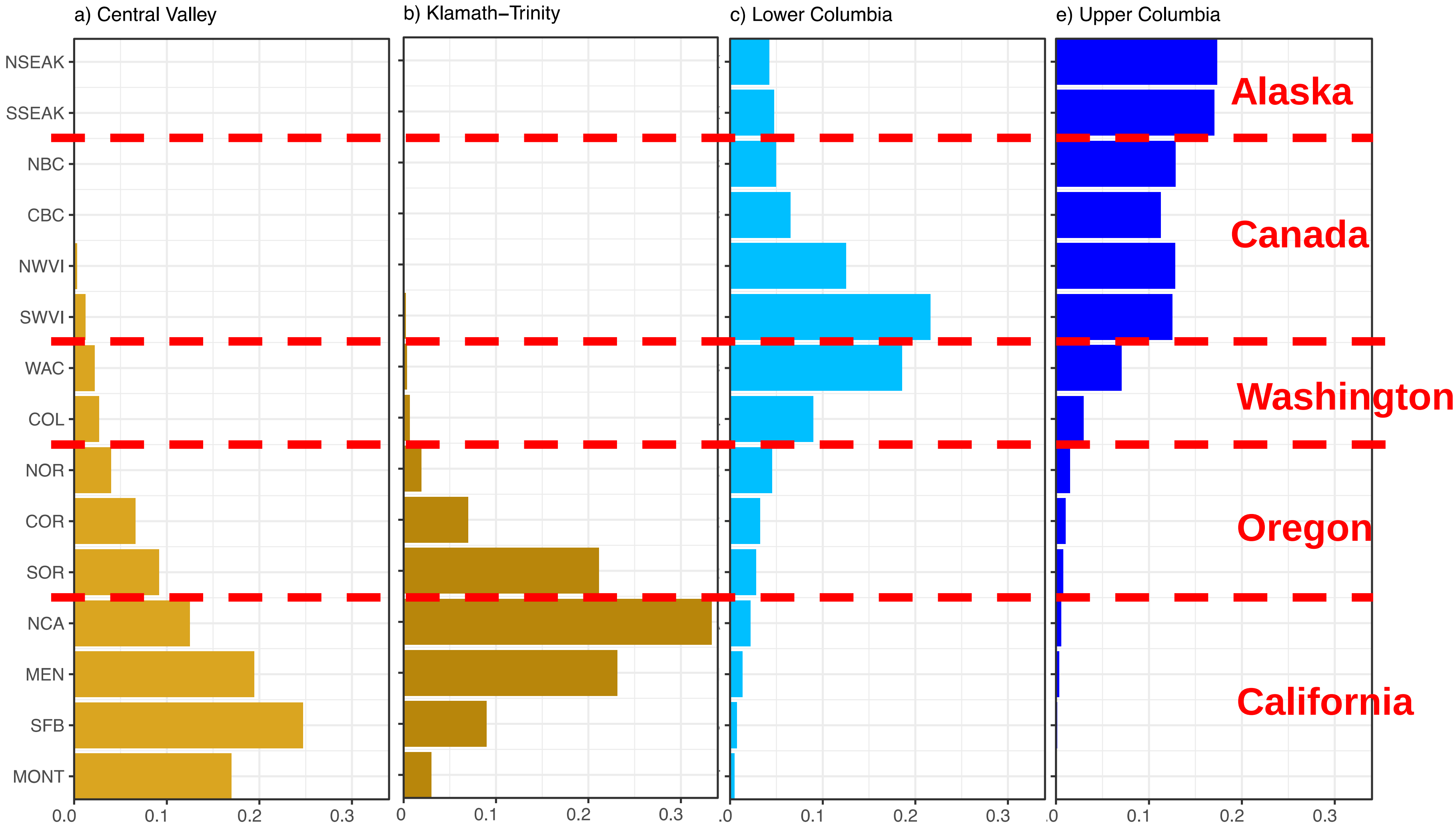


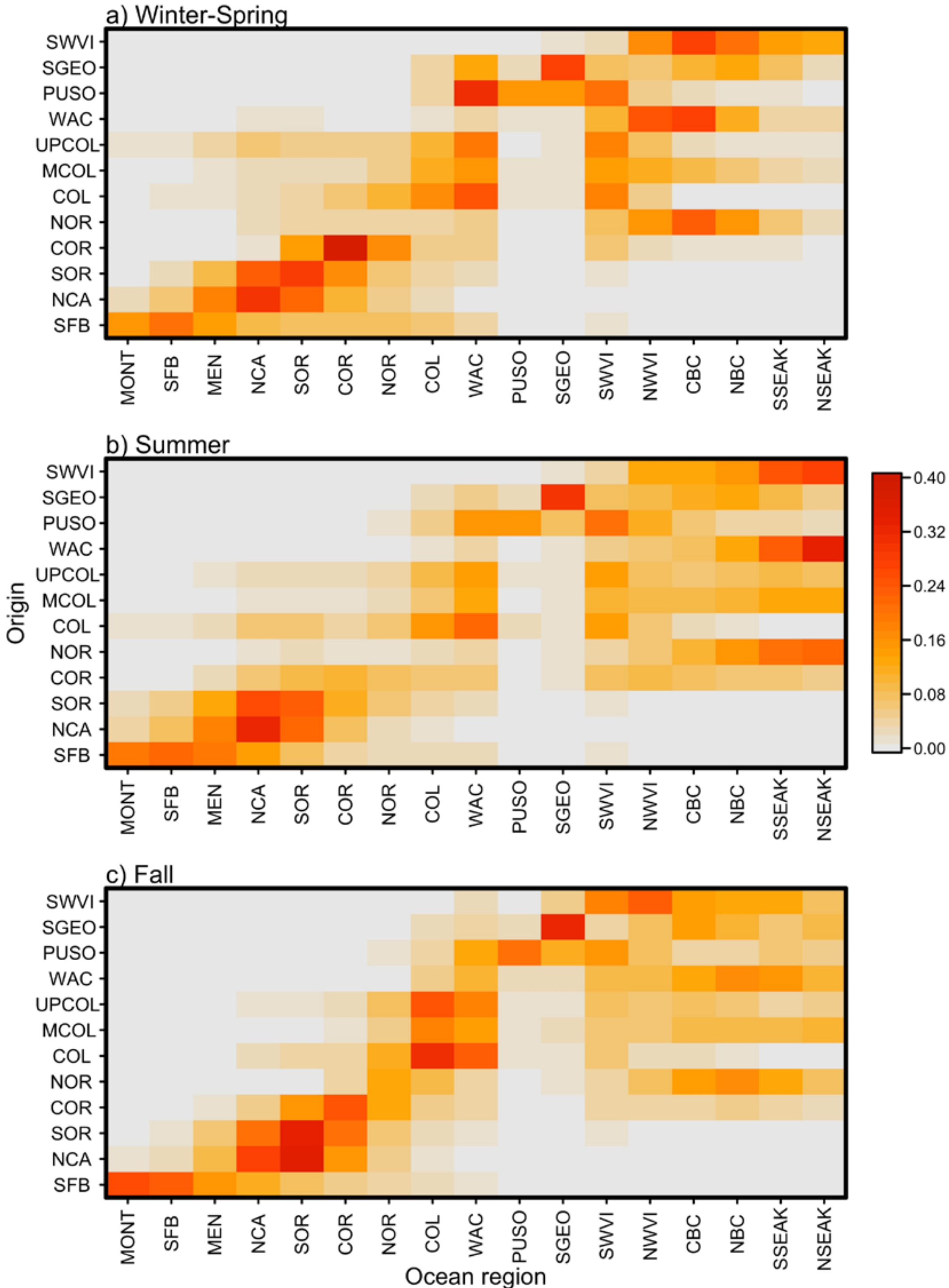
Ocean Distribution (summer, avg. ocean)





Ocean Distribution (summer; avg. ocean)





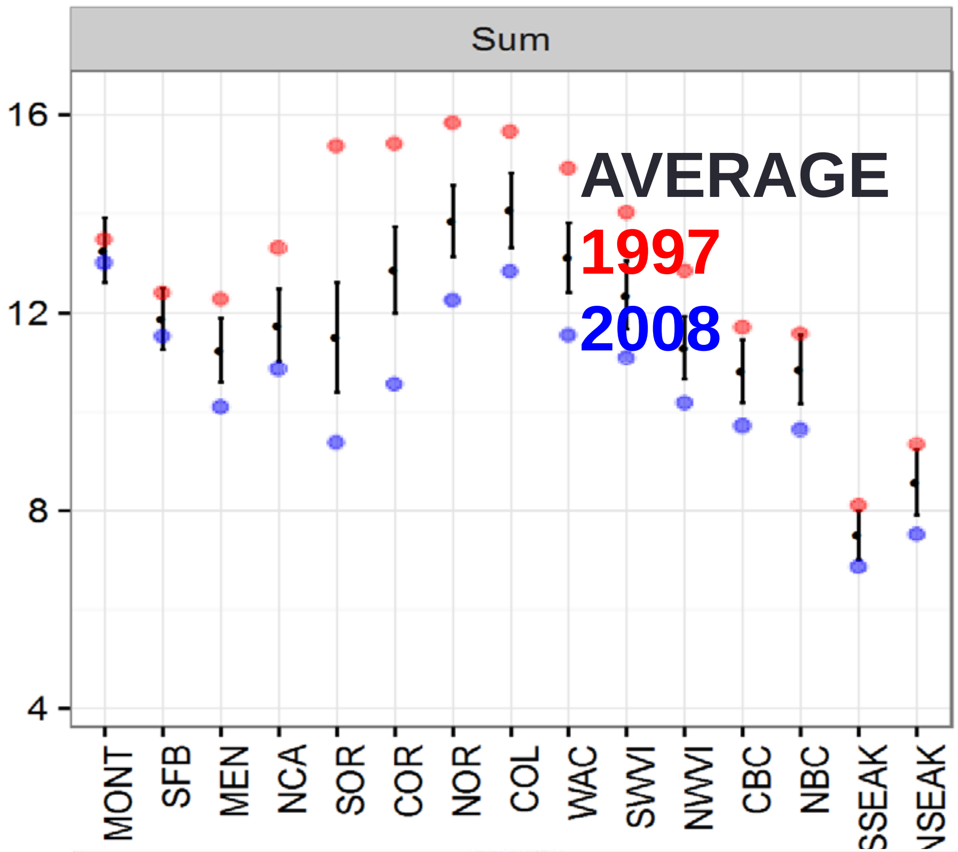
There are strong seasonal patterns

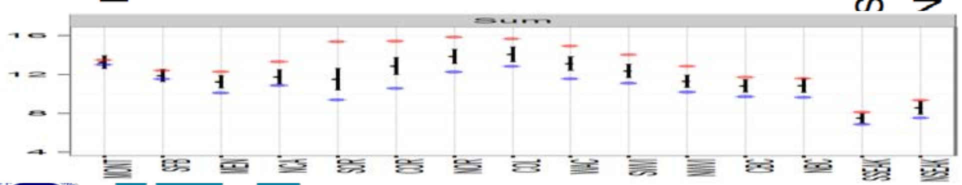
Proportional Distribution
(each row sums to 1)

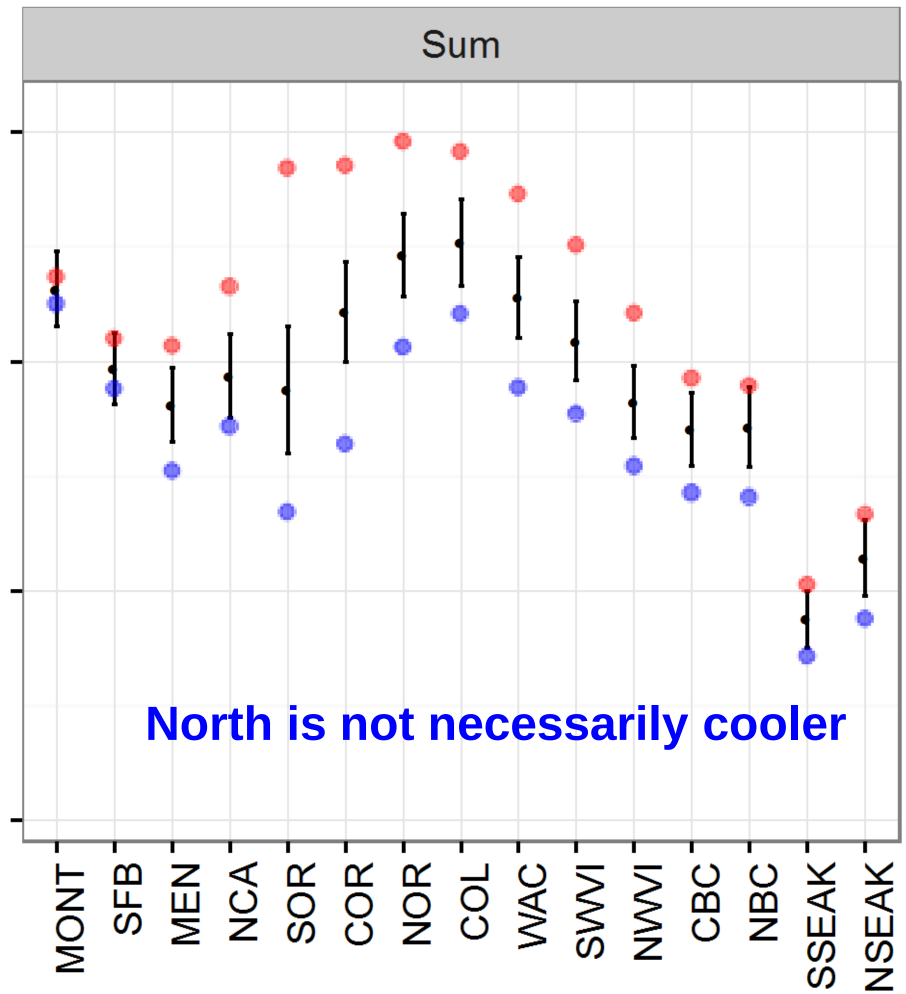
Do distributions change with sea surface temperature?

Sea Surface Temperatures

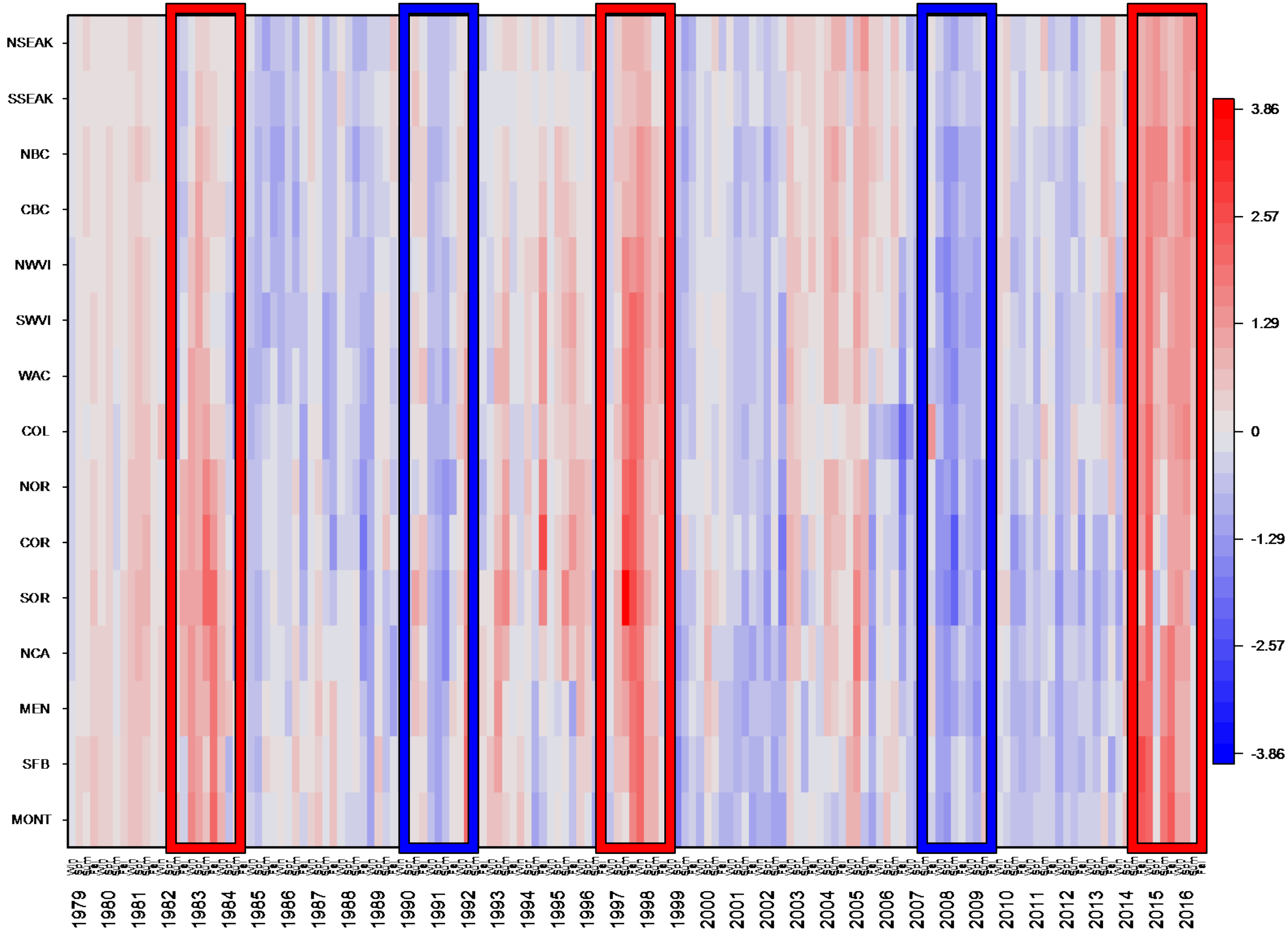
(Shelf, <400m depth, OISST)



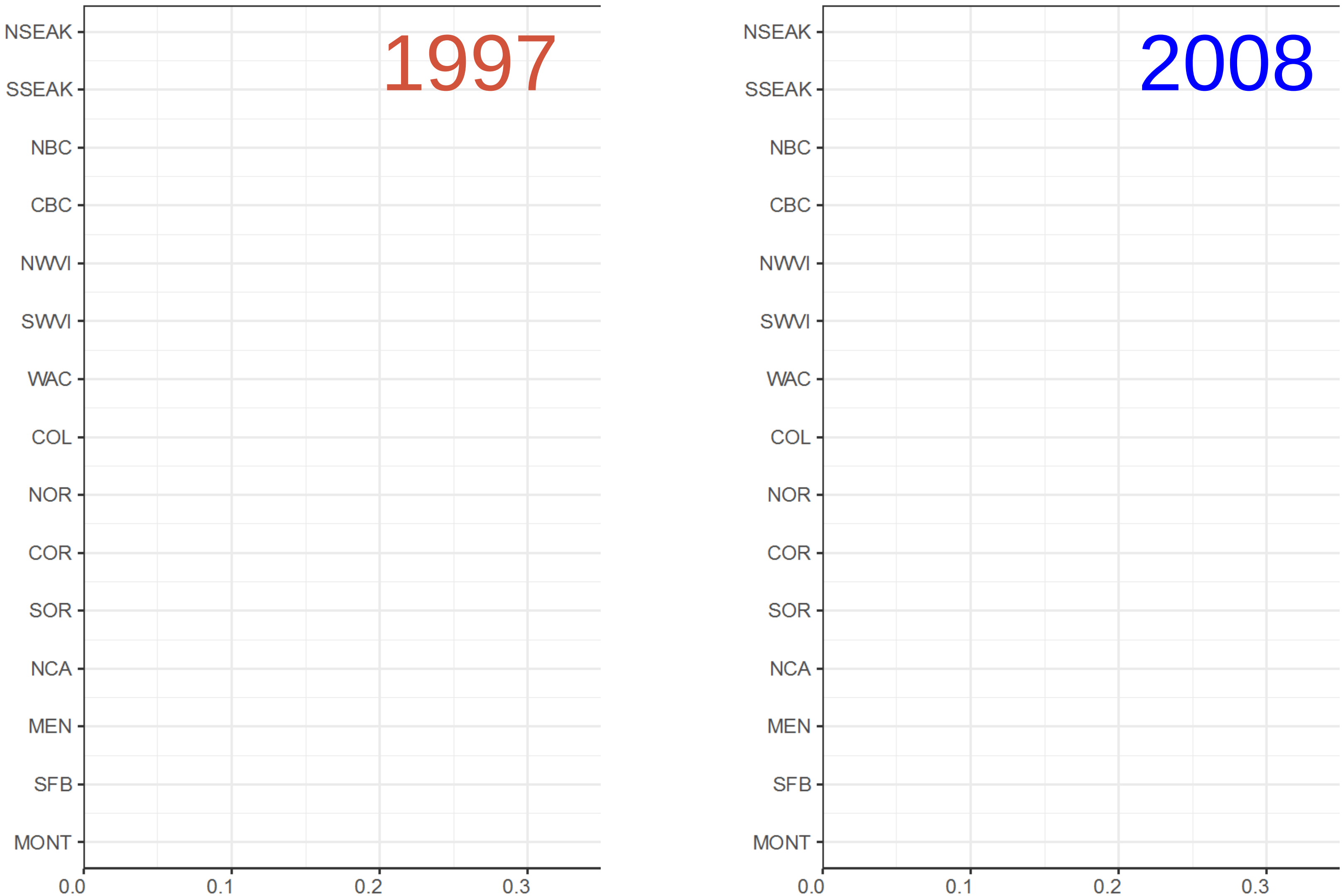


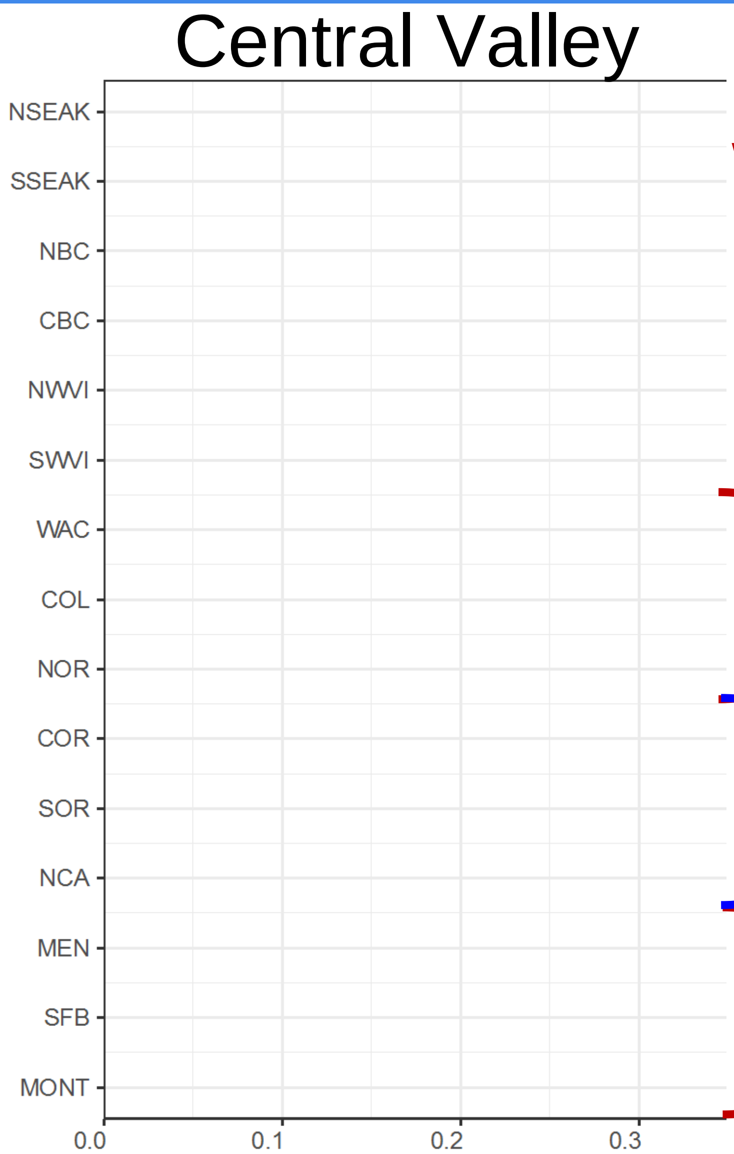


Sea Surface Temperature Deviations



Central Valley, California. Fall Chinook salmon





Compare warm (1997) vs. cold (2008) year

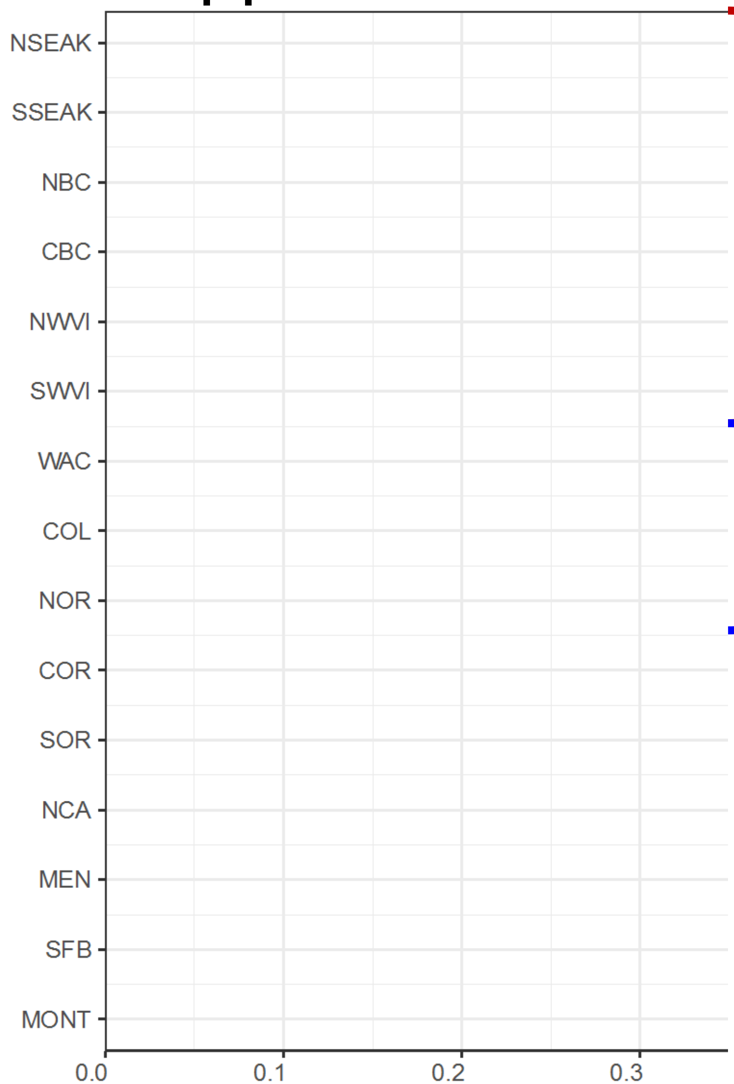
In a warm year:

More Chinook in N. Oregon, Washington (+6%)

Fewer Chinook in N. California, S. Oregon (-13%)

More Chinook in Mendocino and South (+7%)

Upper Columbia



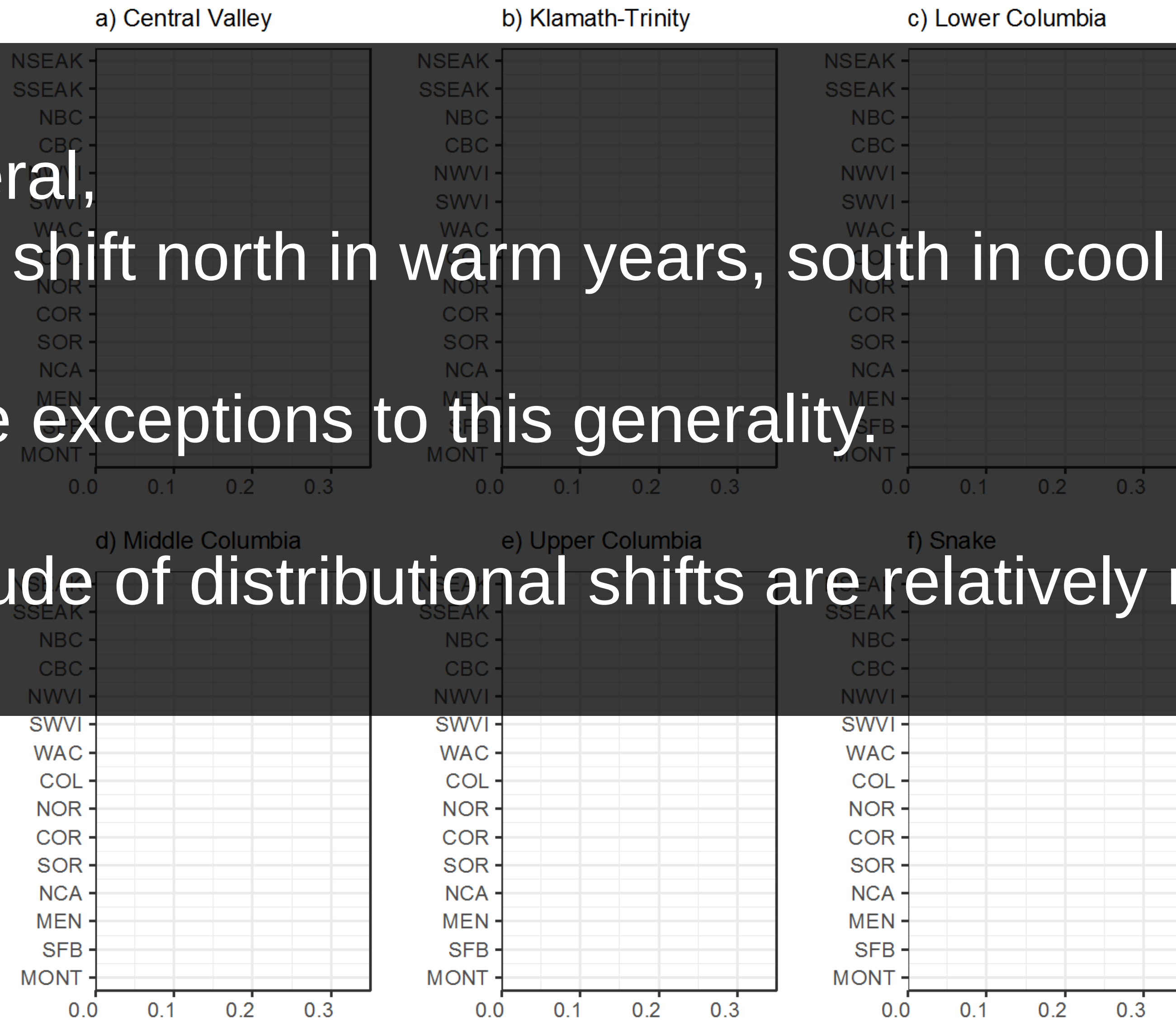
In a warm year:

More Chinook in Canada and Alaska (+3%)

Fewer Chinook in Washington, Oregon (-3%)

Compare
warm (1997) vs. cold (2008)
year

Each region has a distinct response to SST



In general,

Fish shift north in warm years, south in cool years

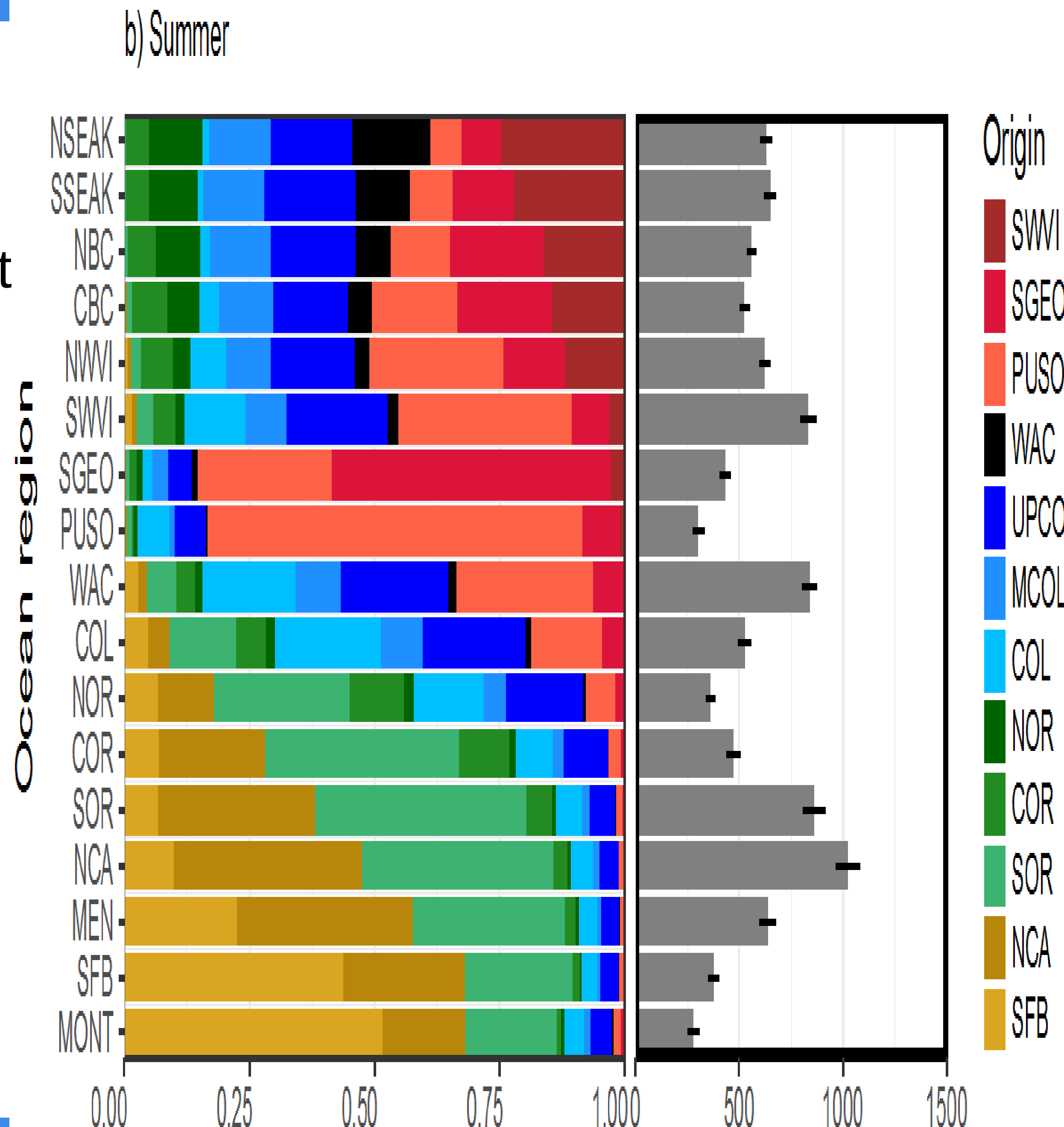
Multiple exceptions to this generality.

Magnitude of distributional shifts are relatively modest

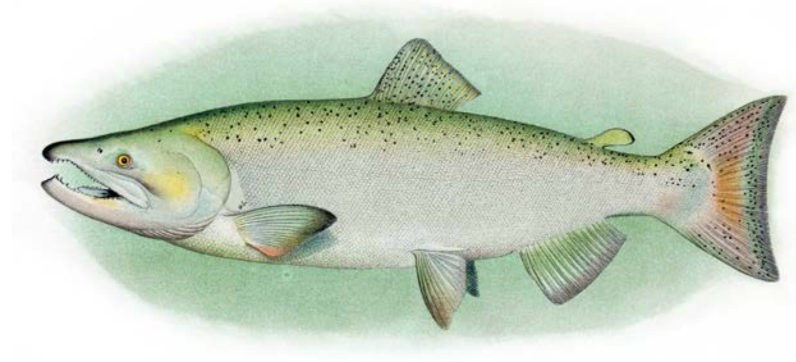
Next:

Combine information across stocks to project composition and total abundance

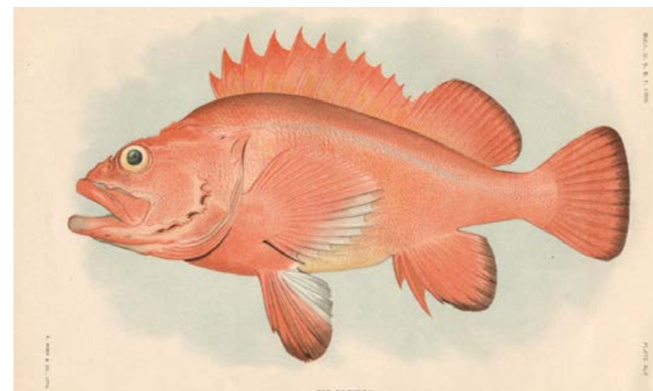
Incorporate climatic effects on salmon survival.



USE AVAILABLE DATA TO TALK ABOUT OBSERVED SHIFTS IN SPECIES DISTRIBUTIONS OVER RECENT DECADES



Part 1: Chinook Salmon
Ole Shelton



Part 2: Groundfish
Eric Ward

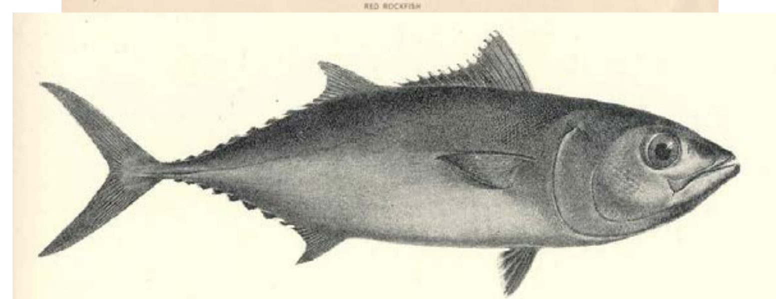
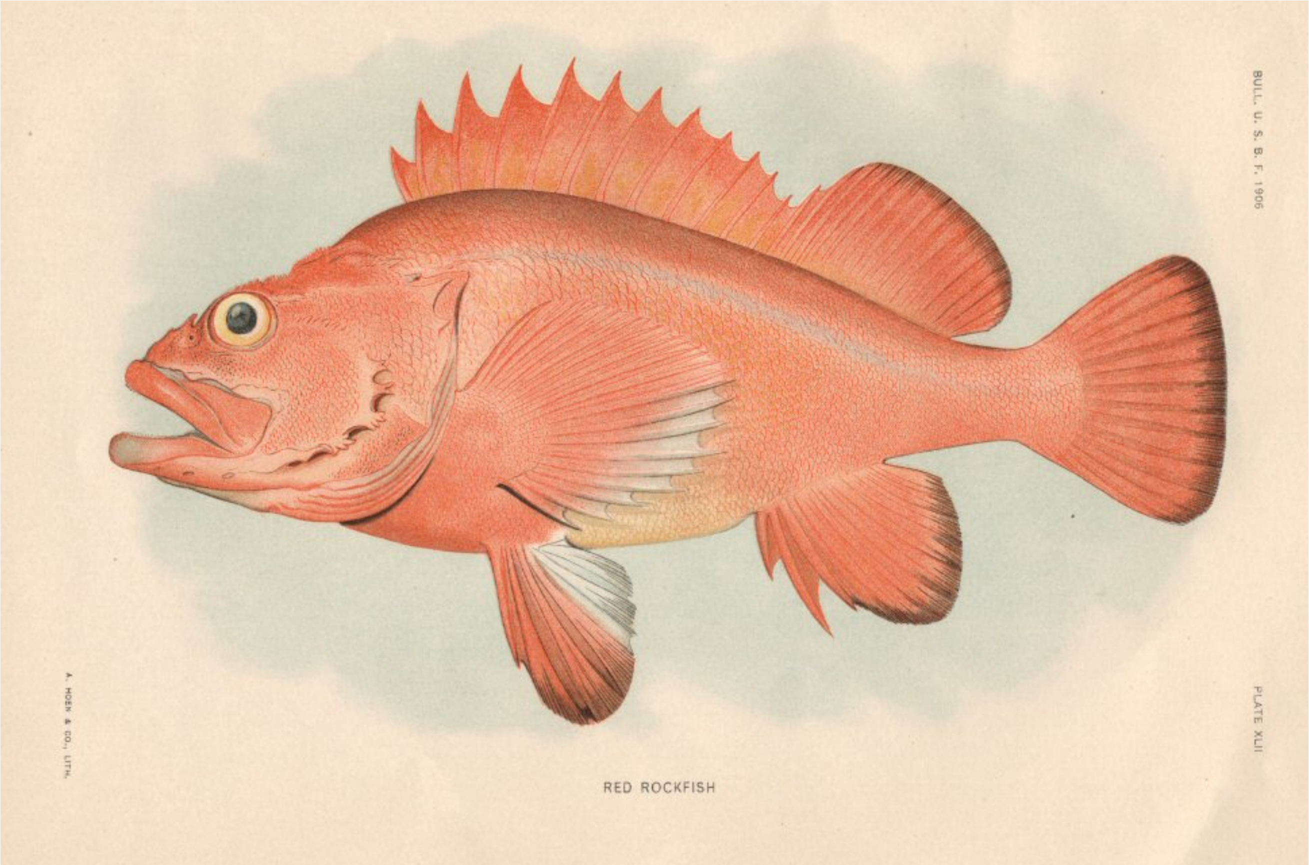


Fig. 224. *Thunnus thynnus.*

Part 3: Large Pelagic Species
Elliott Hazen

GROUNDFISH



Eric Ward[1], Jim Thorson[1], Ole Shelton[1], Lewis Barnett[1], Sean Anderson[2]
[1]NOAA Northwest Fisheries Science Center
[2]Fisheries and Oceans Canada, Nanaimo BC

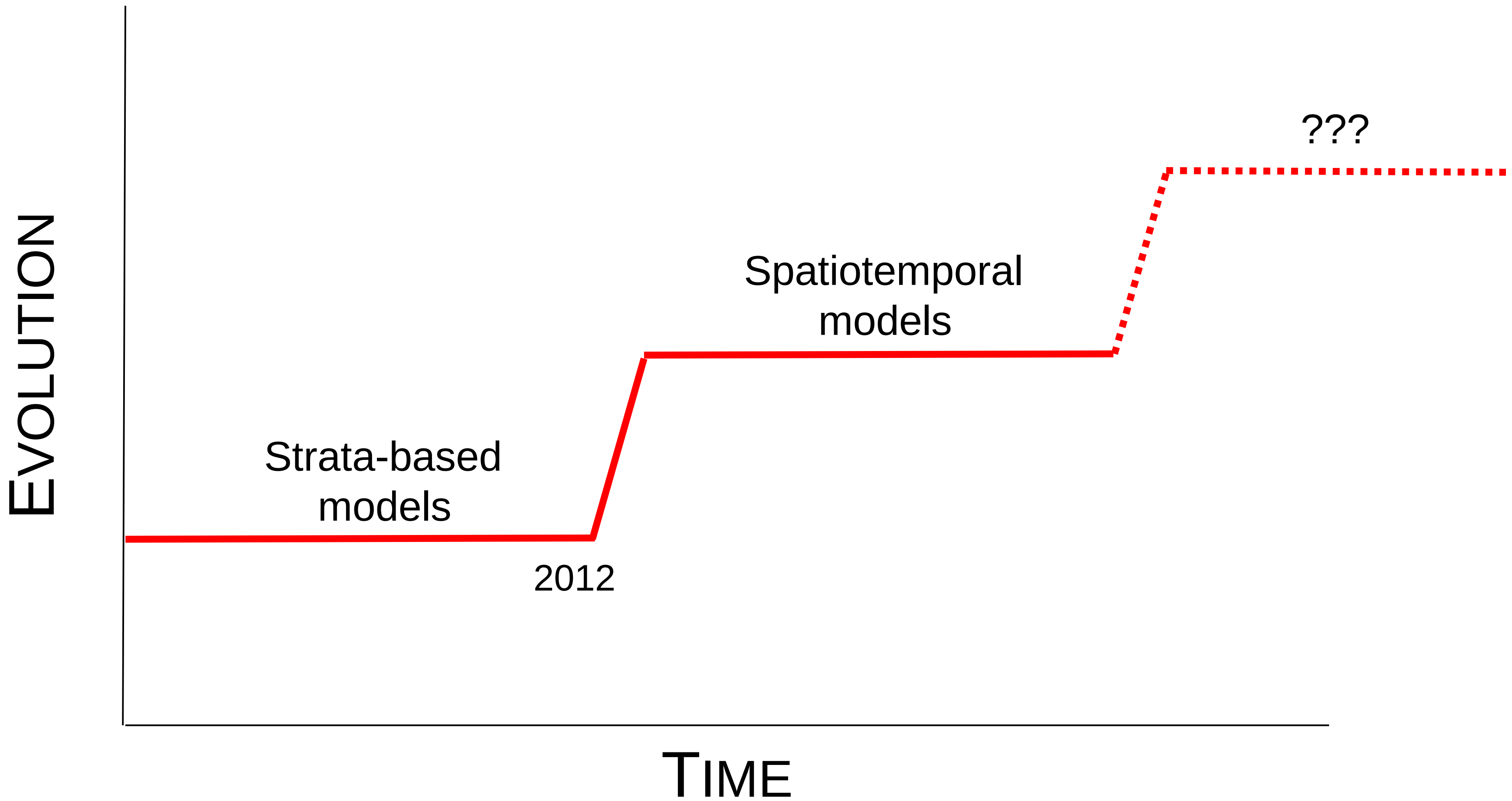
OUTLINE

Part 1: Spatially explicit modeling of fish biomass

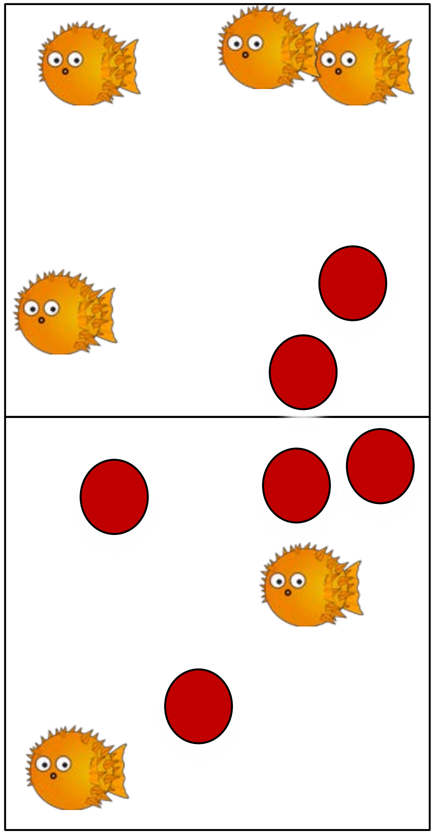
Part 2: Associations with habitat, multispecies modeling

Part 3: Relationships between climate and forecasting

Strata based estimation to spatially explicit models

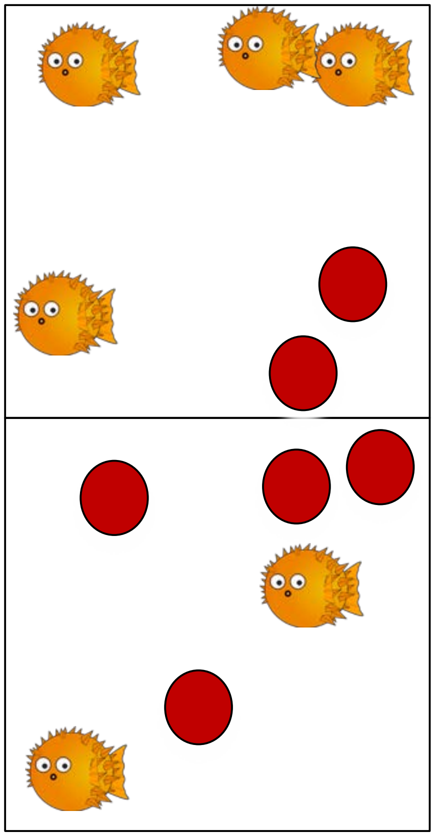


Strata based models can perform well



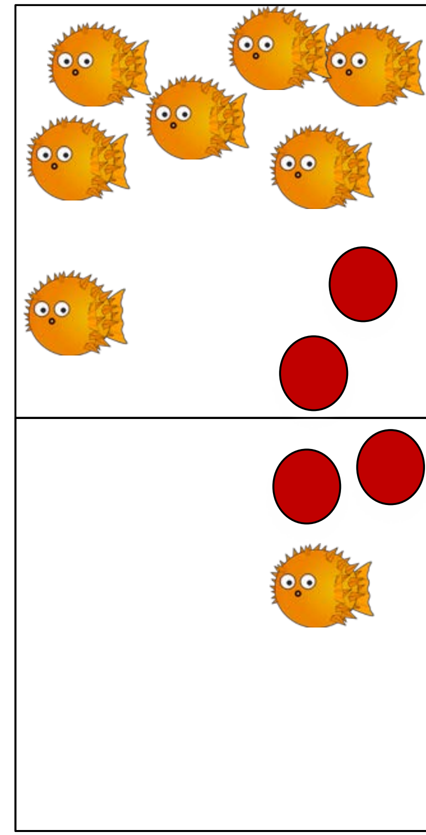
- Density assumed constant in each stratum
- Sensitive to shifts in effort or movement of stock

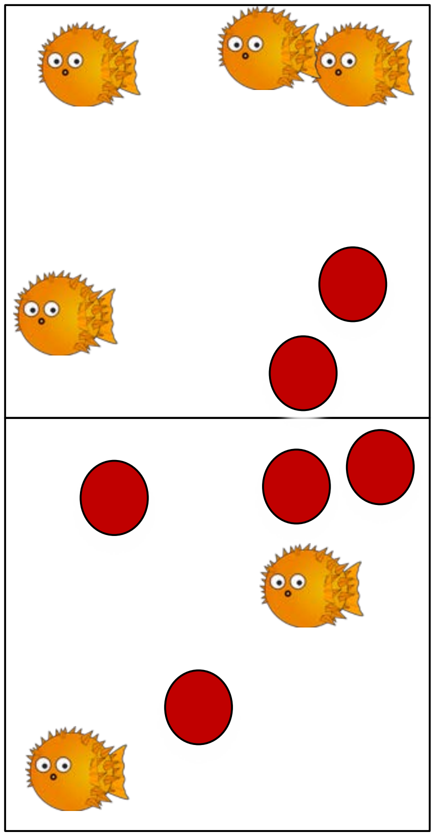
BUT QUANTIFYING CHANGE CAN BE DIFFICULT



- EFFORT INCREASES IN NORTH

- CHANGE IN UNCERTAINTY

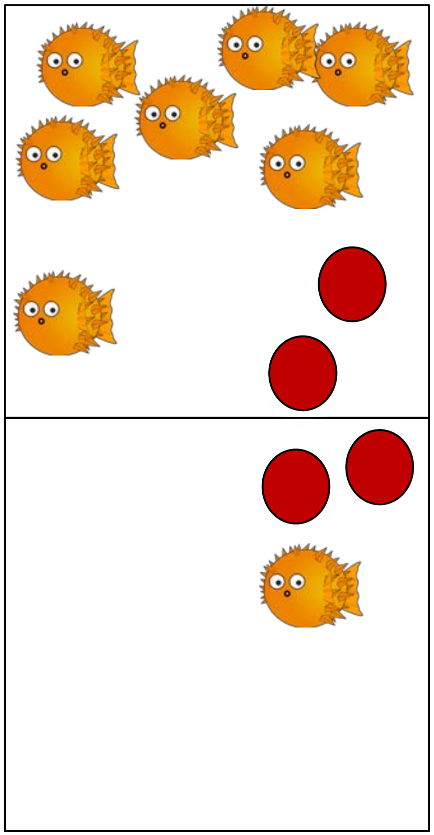




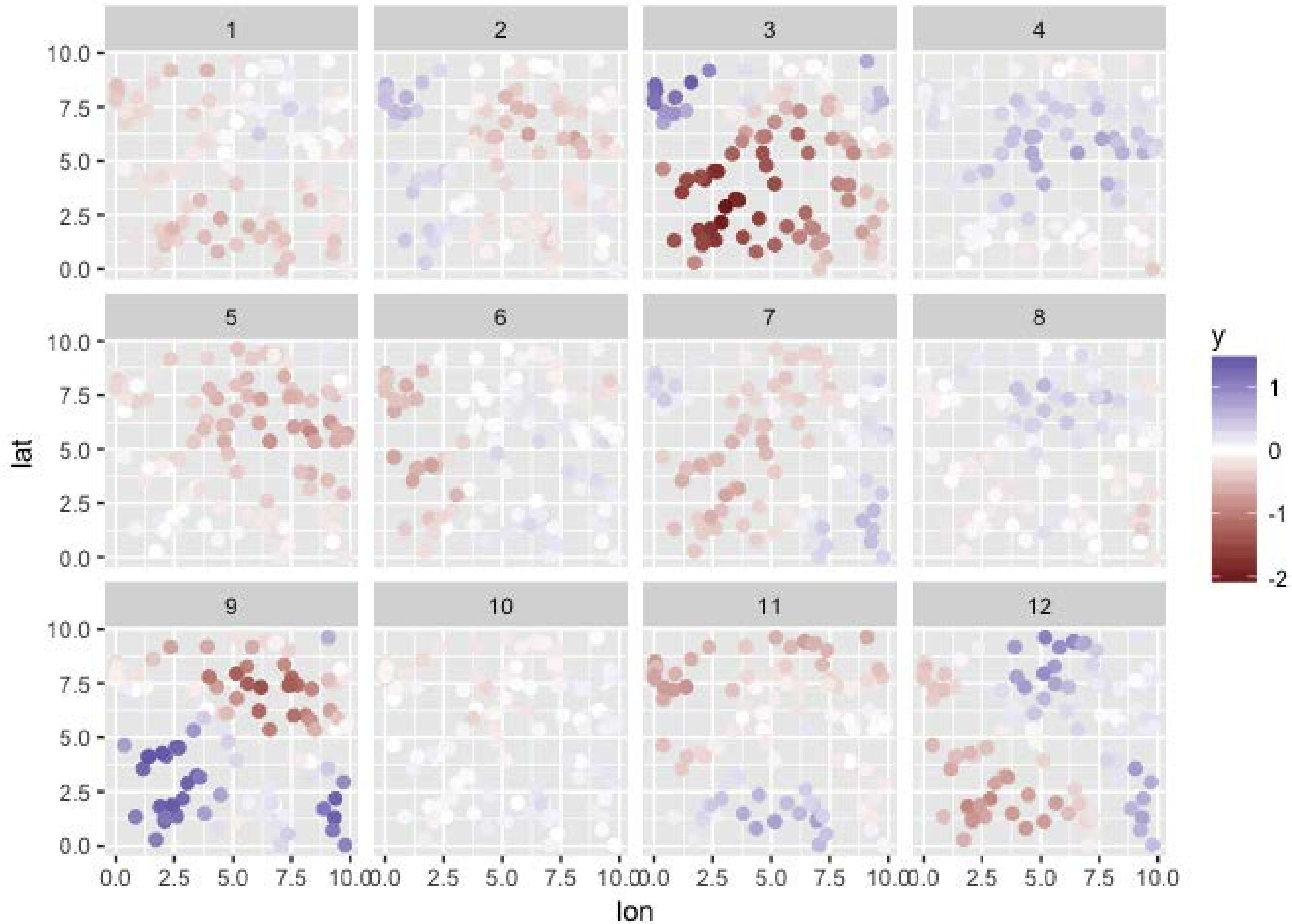
CENTER OF GRAVITY:

COG = $\text{sum}(\text{lat}_i \times \text{weight}_i)$

Would suggest northward movement when it really didn't occur

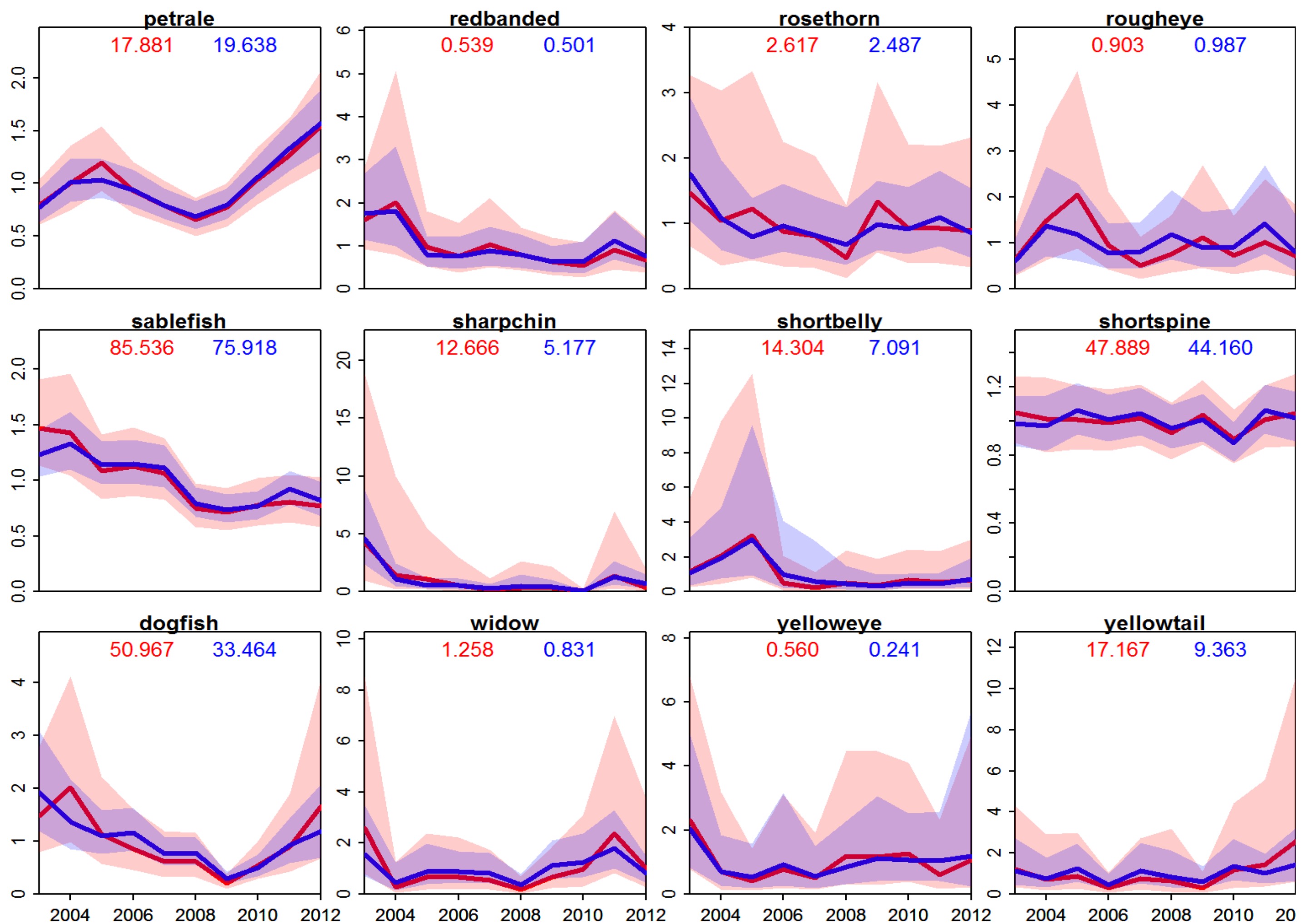


SPATIALLY EXPLICIT MODELS



SPATIAL MODELS YIELD SIMILAR TRENDS, HIGHER PRECISION

Papers:
Thorson et al. (2015)
Shelton et al. (2014)



Strata model
Spatial model

VERY FLEXIBLE MODELS CAN ALSO BE APPLIED TO OTHER DATA OR QUESTIONS

Extreme spatial events: dissolved oxygen, chlorophyll blooms

New events: species invasions

Mechanisms: species interactions, density dependence

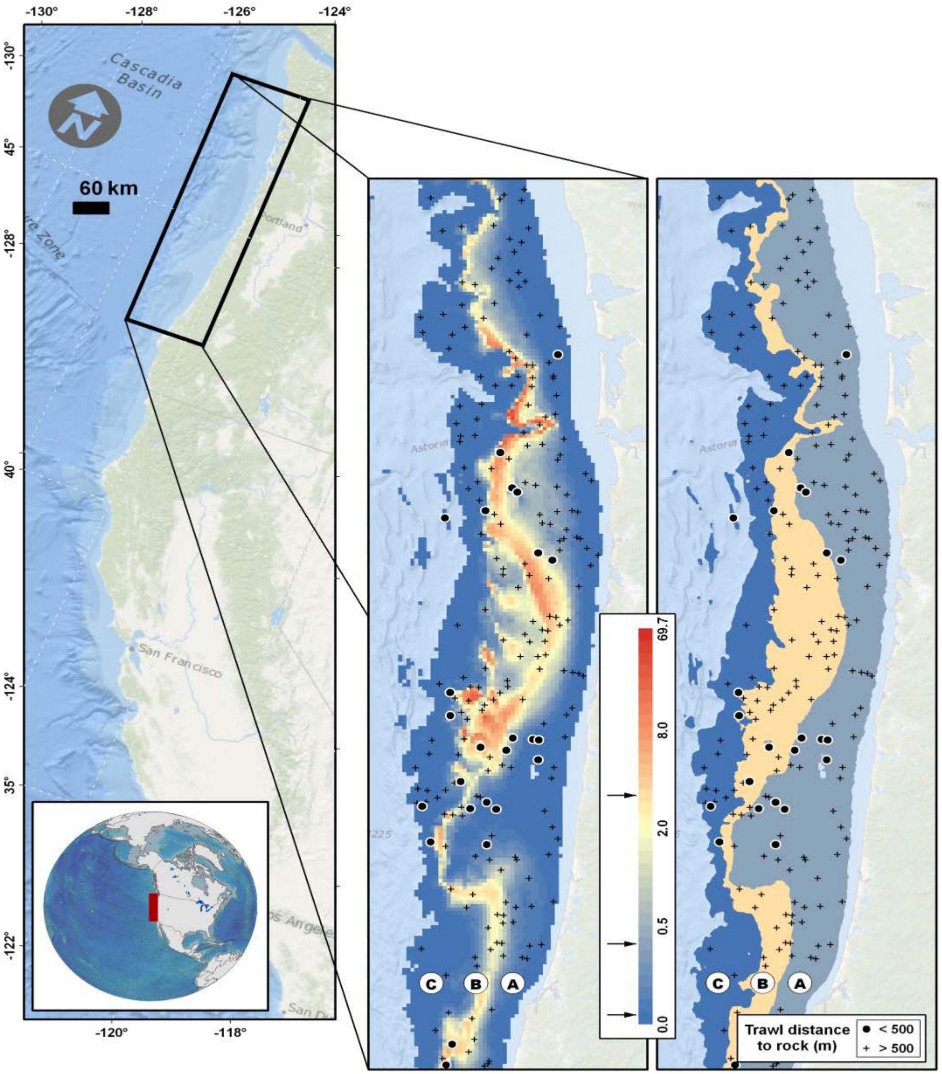
2. Improved understanding of habitat relationships

<u>Shelton et al. 2014</u>

- Fine scale depth and habitat features used as predictors of occurrence, density

- Improved precision of annual estimates and trend for darkblotched rockfish

- Instead of moving northward, might certain species move deeper instead? Time or temperature: depth interactions



MULTISPECIES MODELING IMPROVES UNDERSTANDING OF HABITAT RELATIONSHIPS

Can biogenic habitat (corals, sponges) be a proxy for rockfish habitat

6 rockfish, 2 thornyheads, soft corals, sponges

Covariance for spatio-temporal components of encounter probability and positive catch rates

- Encounter probability shows two groups
  - SFI + Thornyheads VS rockfishes
- Positive catch rate shows three groups
  - SFI + Thornyheads VS Northern rockfishes VS Coastwide rockfishes

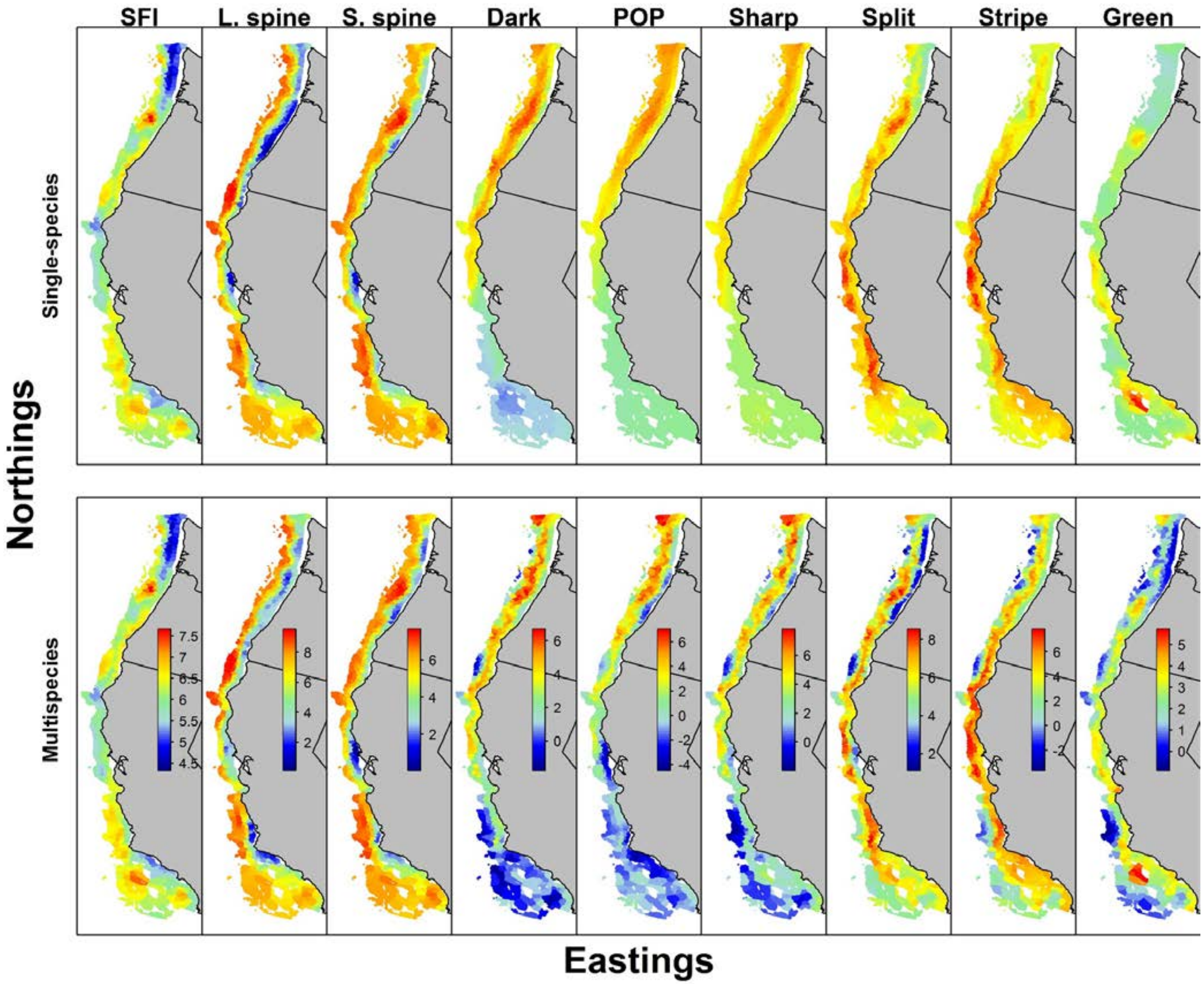
Correlation: Encounter probability

SFI	1.0	0.9	0.4	–0.8	–0.7	–0.9	–0.8	–0.9	–0.9
L. spine	0.9	1.0	0.7	–0.8	–0.5	–0.7	–0.6	–0.9	–0.8
S. spine	0.4	0.7	1.0	–0.1	0.2	–0.1	0.1	–0.4	–0.5
Dark	–0.8	–0.8	–0.1	1.0	0.9	0.9	0.9	0.9	0.7
POP	–0.7	–0.5	0.2	0.9	1.0	0.9	0.9	0.8	0.5
Sharp	–0.9	–0.7	–0.1	0.9	0.9	1.0	0.9	0.9	0.8
Split	–0.8	–0.6	0.1	0.9	0.9	0.9	1.0	0.9	0.6
Stripe	–0.9	–0.9	–0.4	0.9	0.8	0.9	0.9	1.0	0.9
Green	–0.9	–0.8	–0.5	0.7	0.5	0.8	0.6	0.9	1.0

Correlation: Positive catch rates

SFI	1.0	0.1	0.3	0.1	0.2	0.0	0.2	–0.3	0.6
L. spine	0.1	1.0	0.5	0.5	0.6	0.6	0.4	0.3	0.4
S. spine	0.3	0.5	1.0	0.5	0.5	0.3	0.4	0.0	0.4
Dark	0.1	0.5	0.5	1.0	0.9	0.9	0.6	0.5	0.7
POP	0.2	0.6	0.5	0.9	1.0	0.9	0.4	0.2	0.7
Sharp	0.0	0.6	0.3	0.9	0.9	1.0	0.3	0.3	0.7
Split	0.2	0.4	0.4	0.6	0.4	0.3	1.0	0.6	0.5
Stripe	–0.3	0.3	0.0	0.5	0.2	0.3	0.6	1.0	0.2
Green	0.6	0.4	0.4	0.7	0.7	0.7	0.5	0.2	1.0

MULTISPECIES MODELING IMPROVES FINE-SCALE PREDICTION



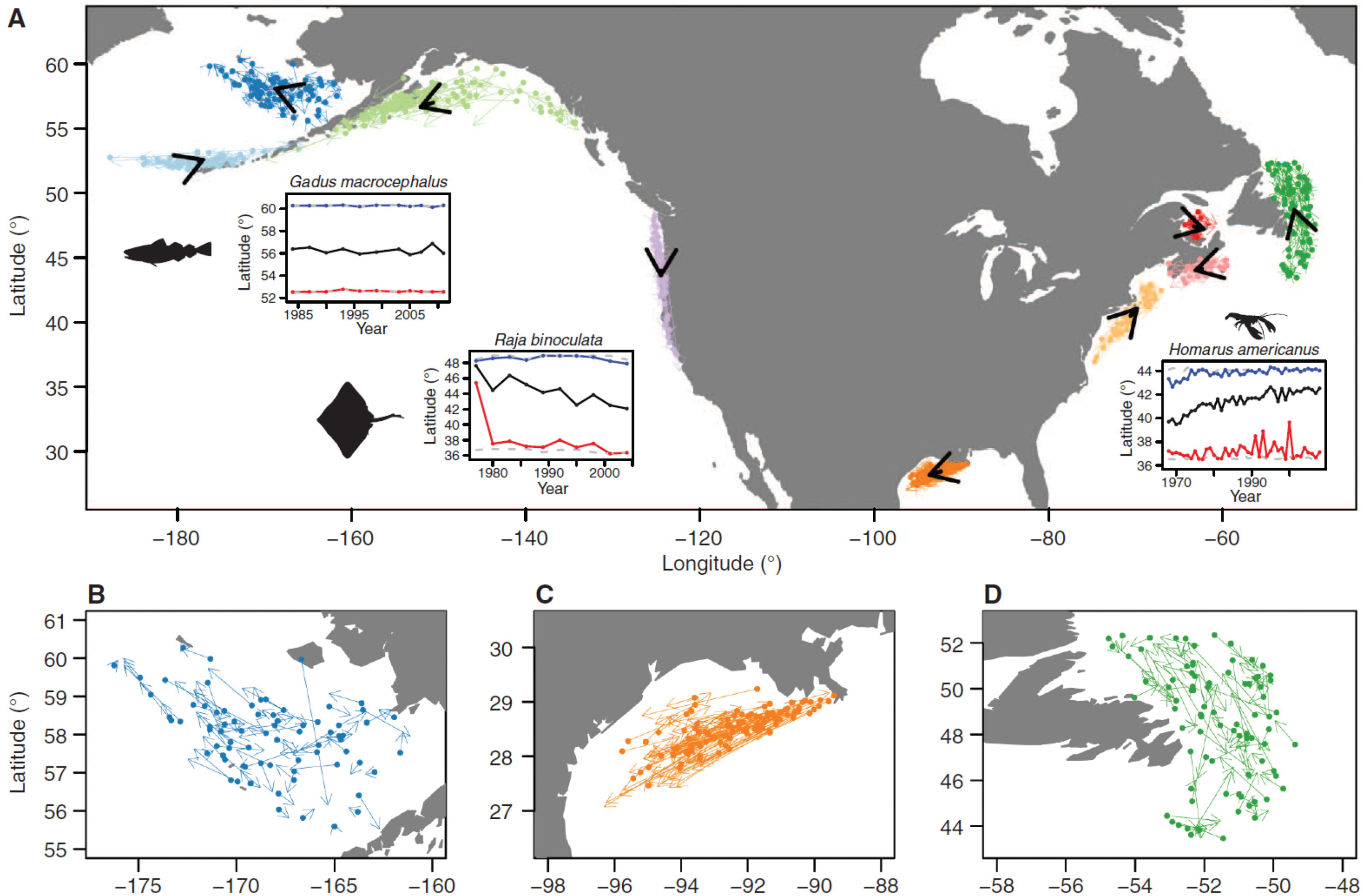
Multispecies model is useful for…

1. Understanding covariation among species
    - Useful information ecologically
2. Essential fish habitat designation
    - Improves density predictions

Multispecies model is not useful for…

1. Index standardization for stock assessment
    - Adds complexity without improvement in precision

3. Improved understanding of climate impacts



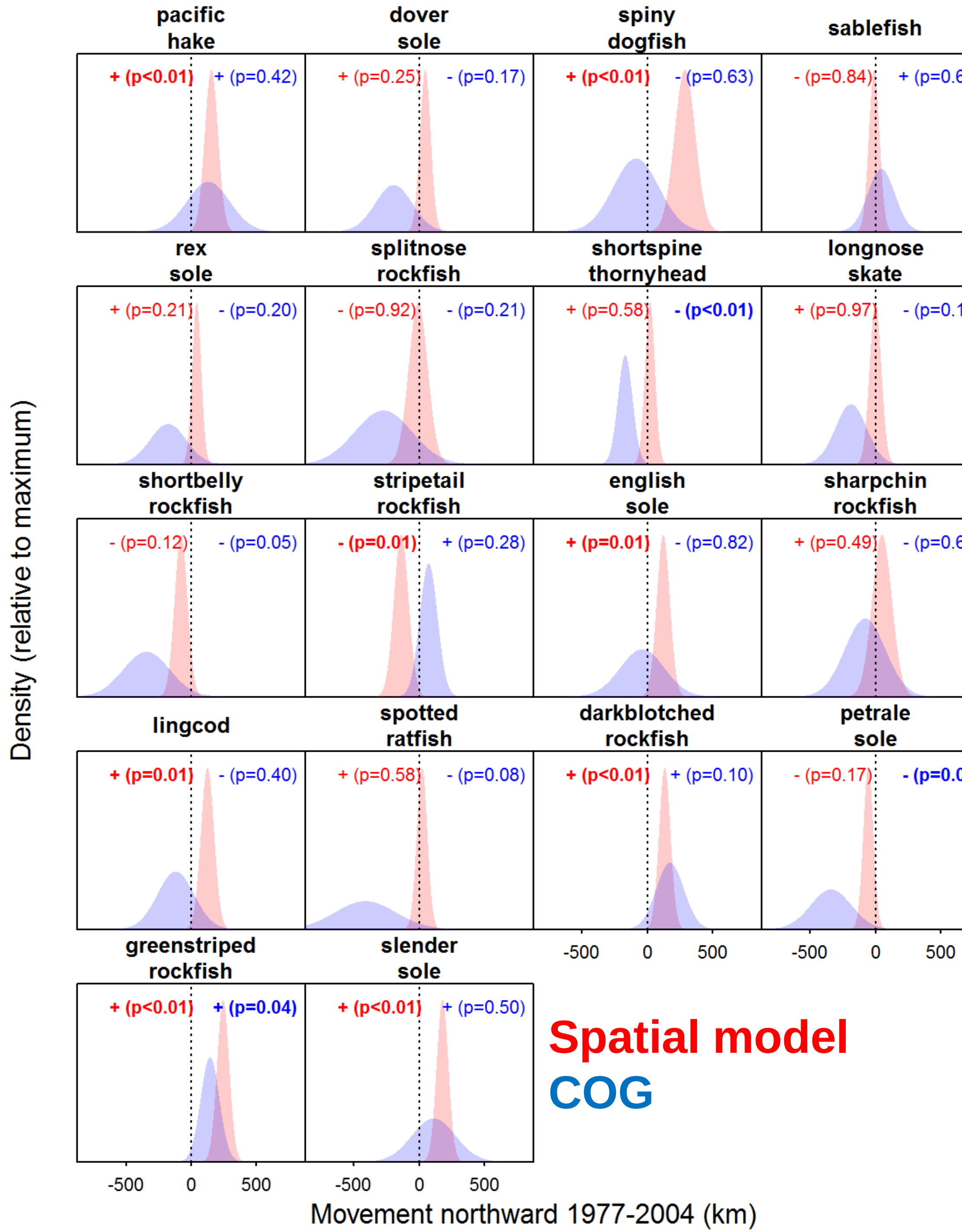
Pinsky et al. 2013 *Science* “Marine taxa track local climate velocity”

But velocities estimated from Center of gravity

1. Applying spatiotemporal models, are there groundfish species that suggest a northward shift?

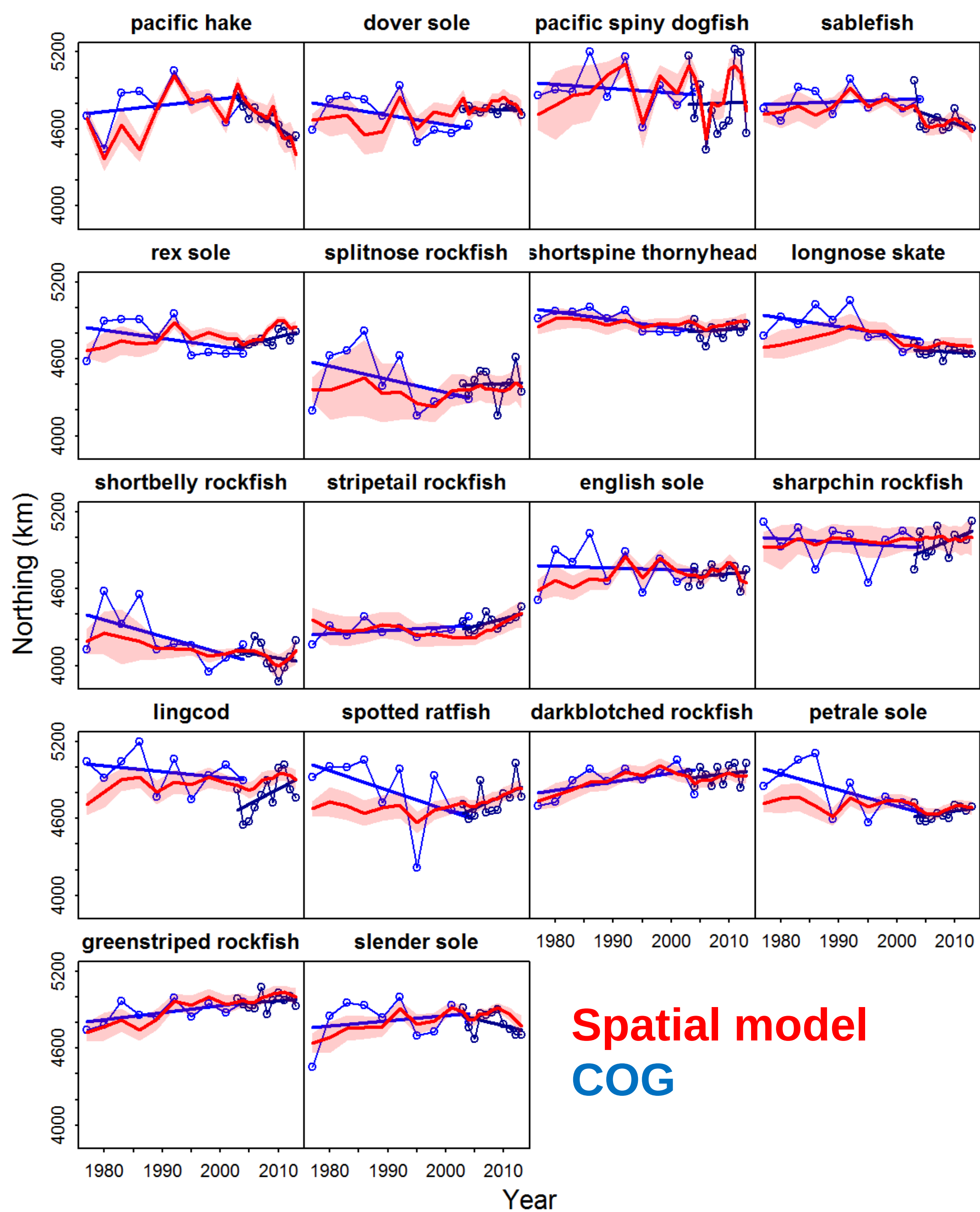
2. Have any species in the California Current increased or decreased their ranges?

- **Spatial model** estimates northward shift in 7/18
- **COG** generally estimates more southward shift
  - Caused by southward shift in sampling over time



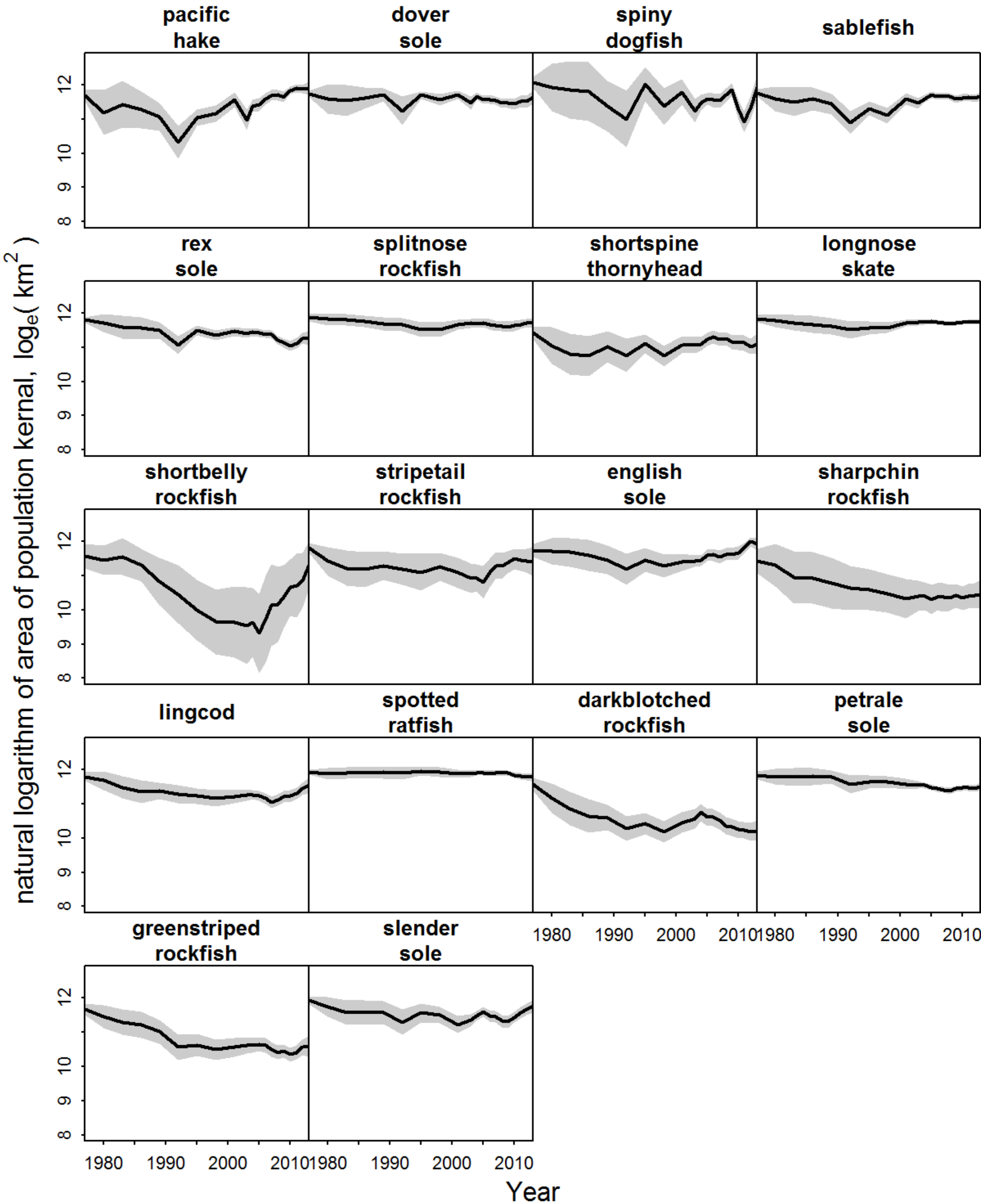
West coast results

- Large differences in trend from 1980-2004 vs. 2003-2013
- Highly variable for semi-pelagic species
  - Dogfish
  - Sablefish
  - Hake

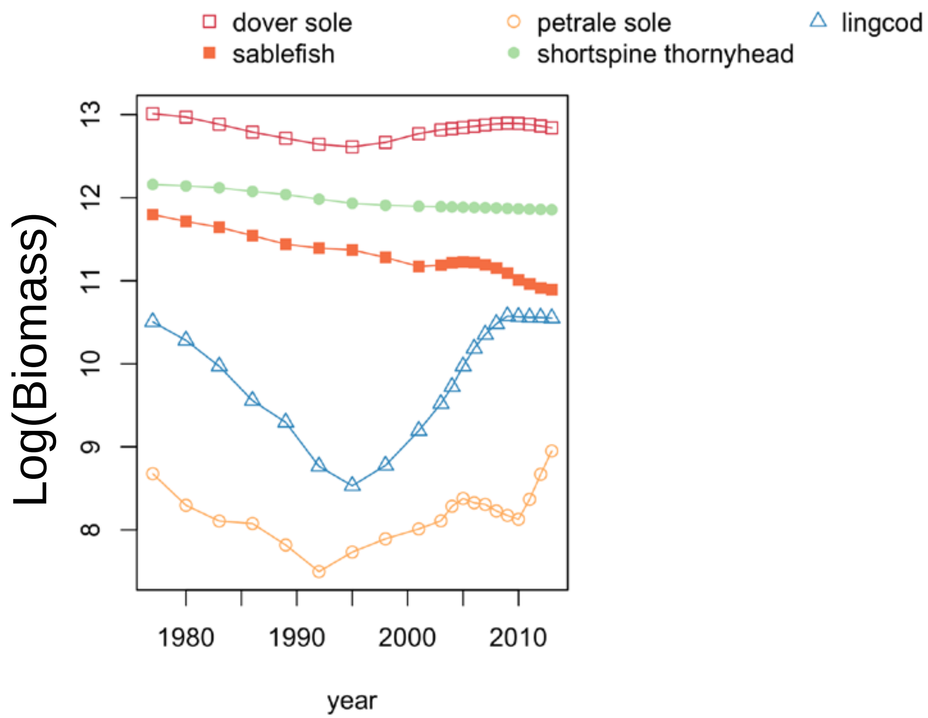


Range contraction

- Decrease in area occupied for several species
  - Darkblotched
  - Sharpchin
  - Greenstriped
- Possibly reduced density in southern region for these spp.

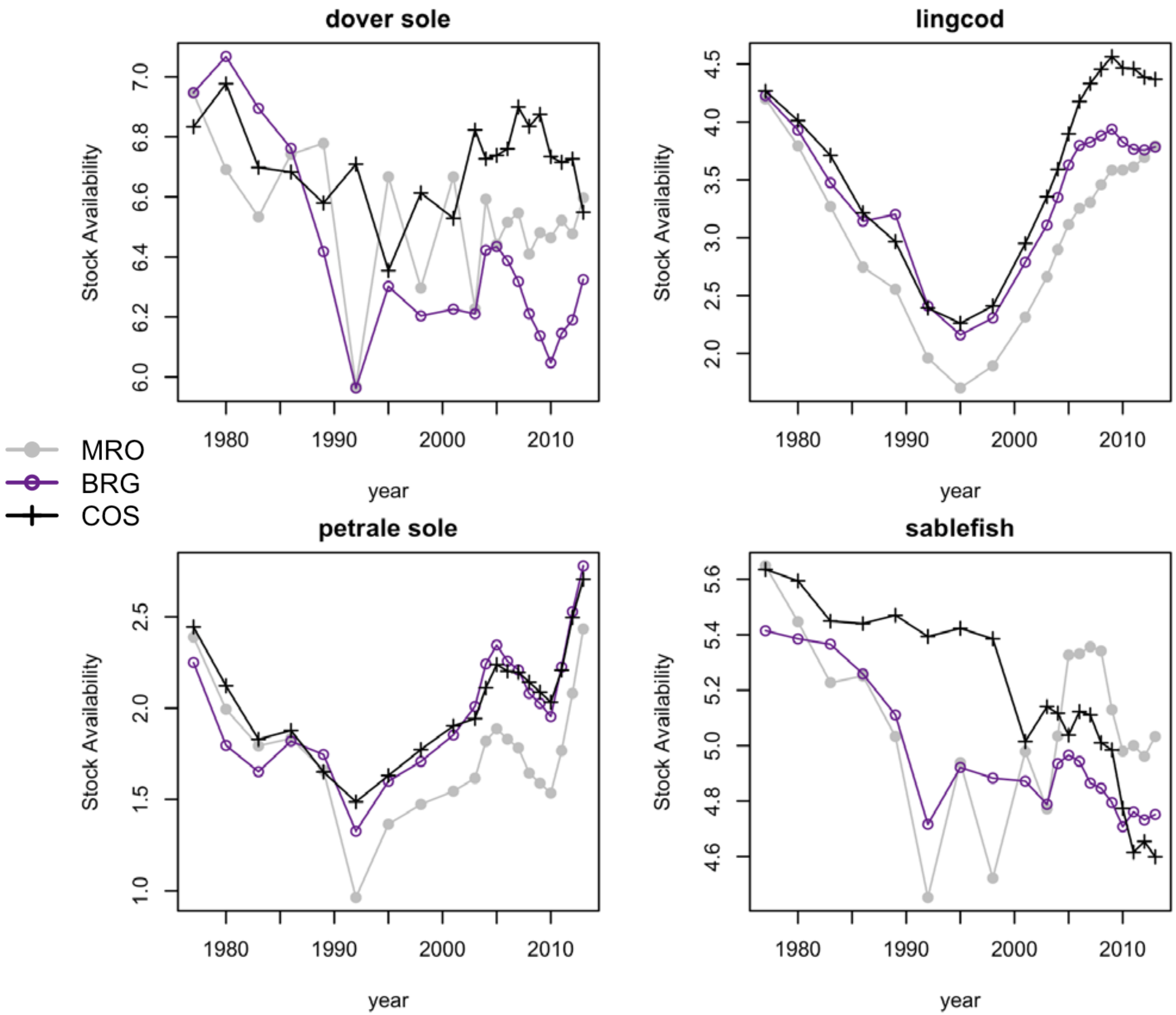


Availability of fish to west coast communities



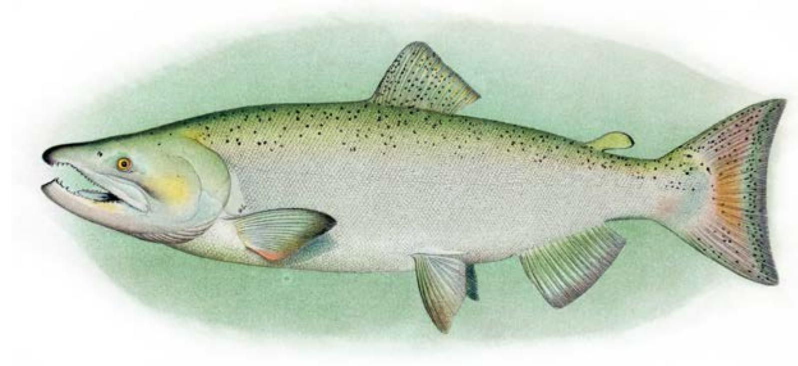
Selden, Samhouri, et al. *in prep*

Shifts can mask or exacerbate declines

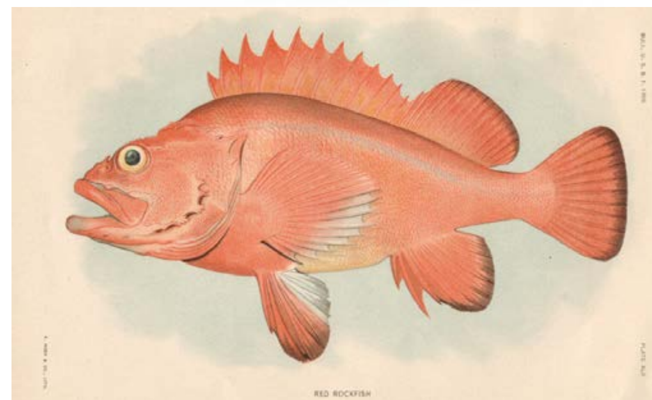


Selden, Samhouri, et al. *in prep*

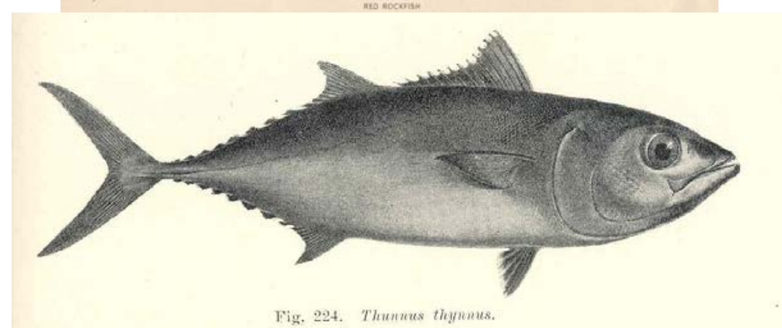
Use available data to talk about observed shifts in species distributions over recent decades



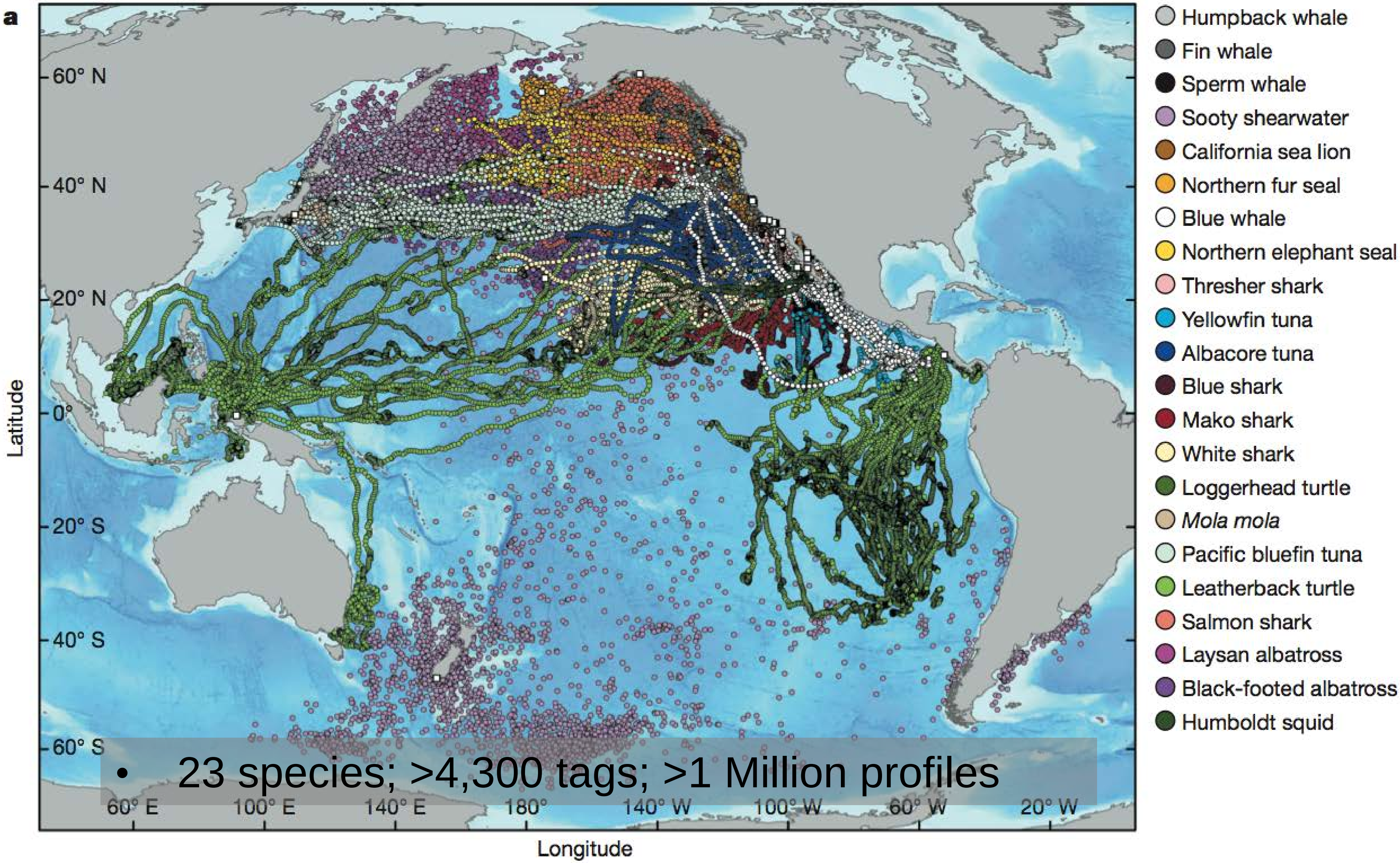
Part 1: Chinook Salmon
Ole Shelton



Part 2: Groundfish
Eric Ward



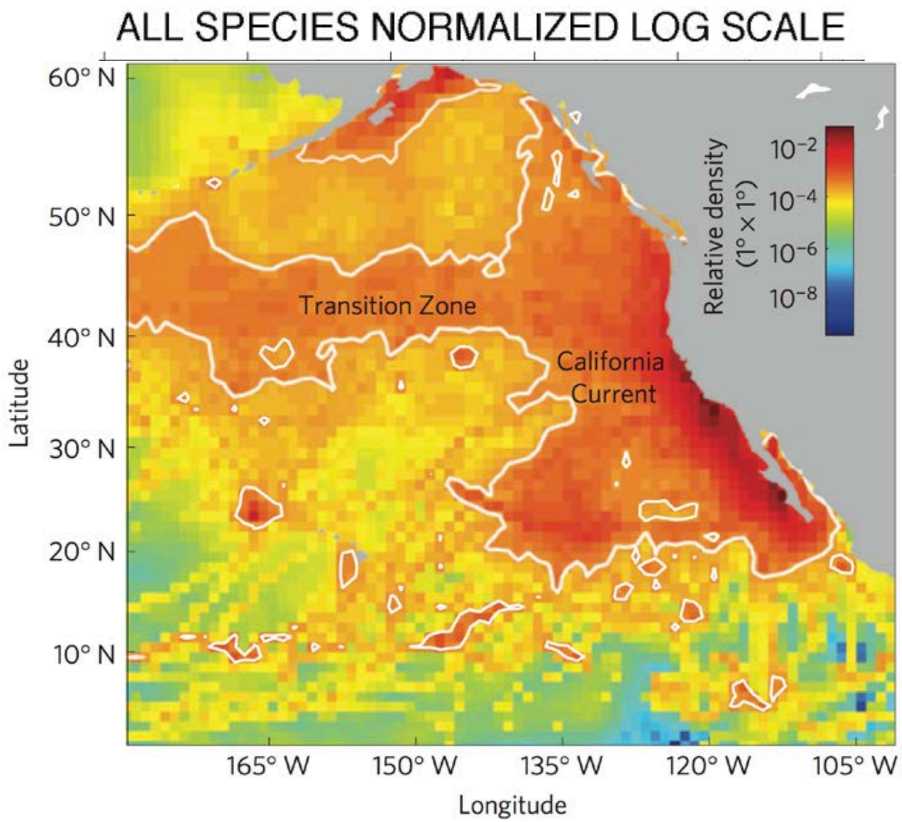
Part 3: Large Pelagic Species
Elliott Hazen

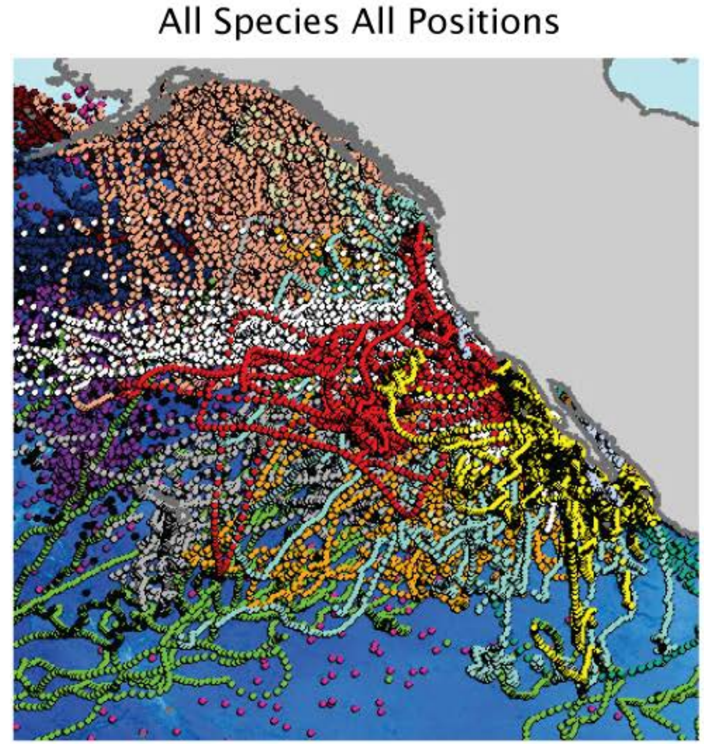


- 23 species; >4,300 tags; >1 Million profiles

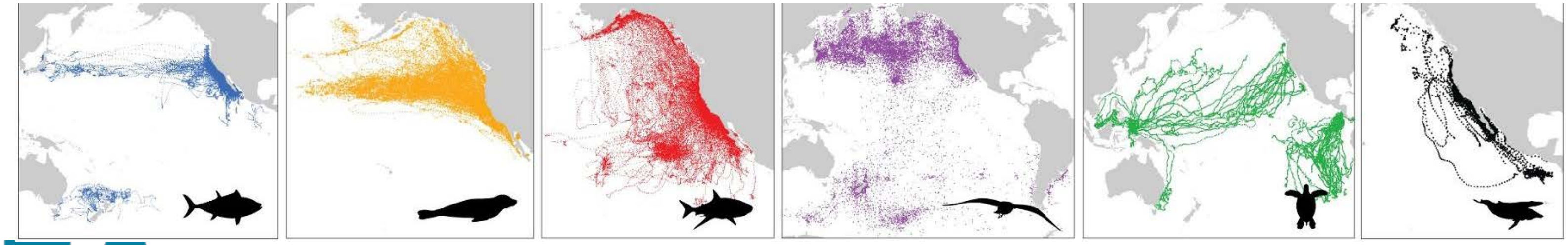
Block et al. *Nature* 2011

Top predator "hotspots"

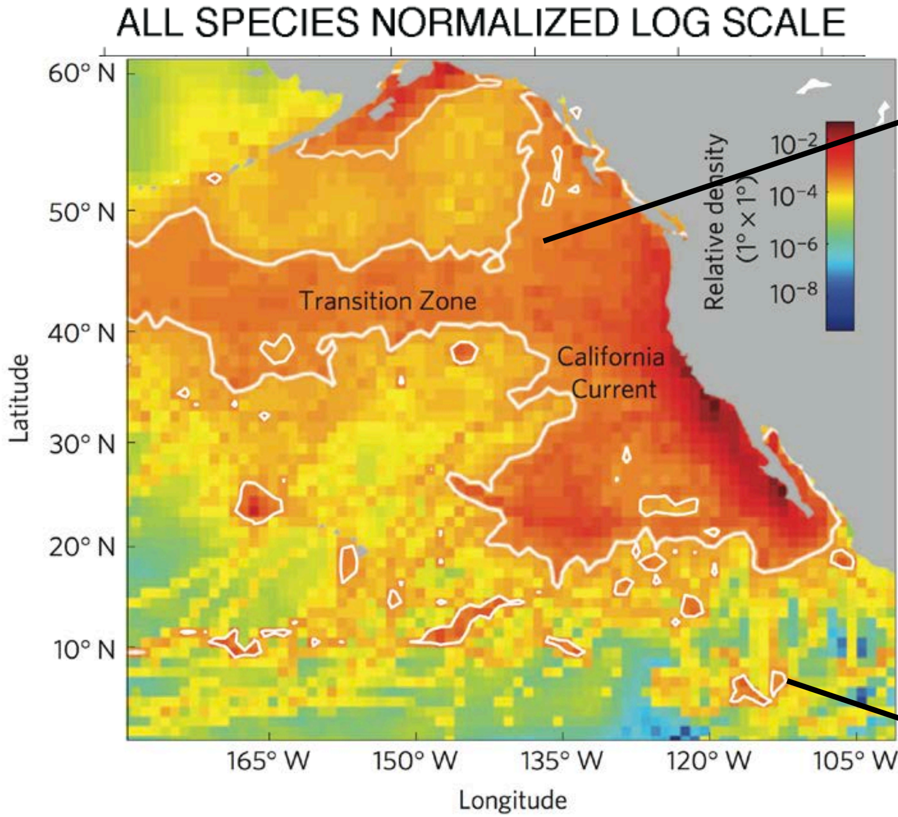


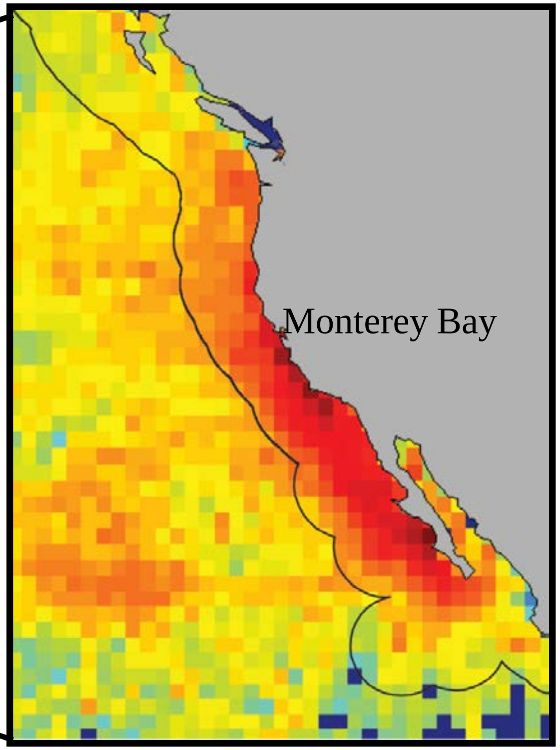


Block et al. *Nature* 2011

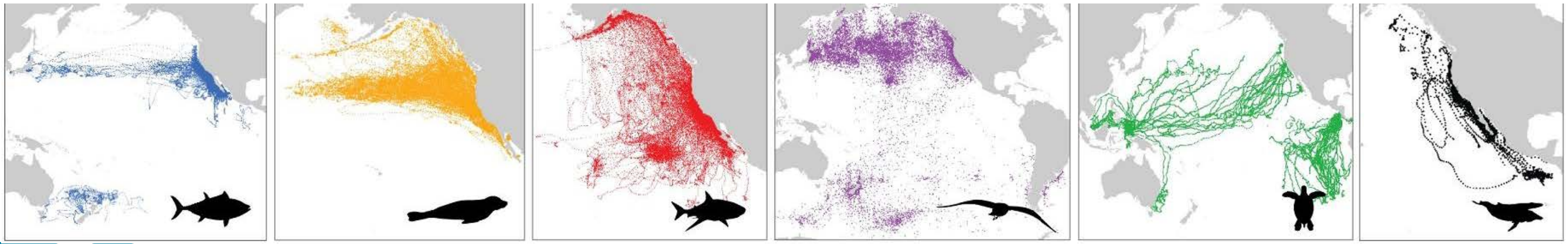


Top predator “hotspots”



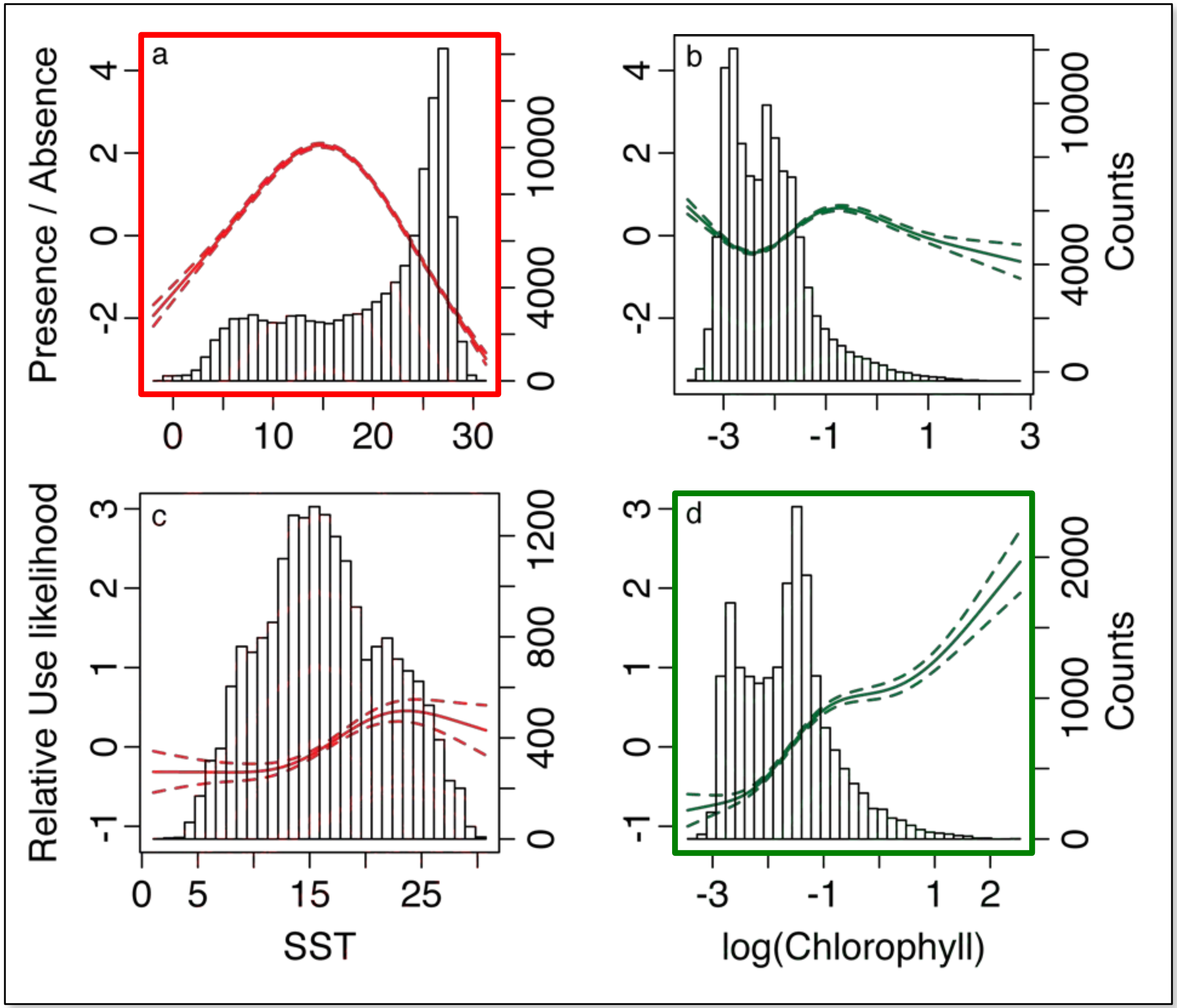


Block et al. *Nature* 2011



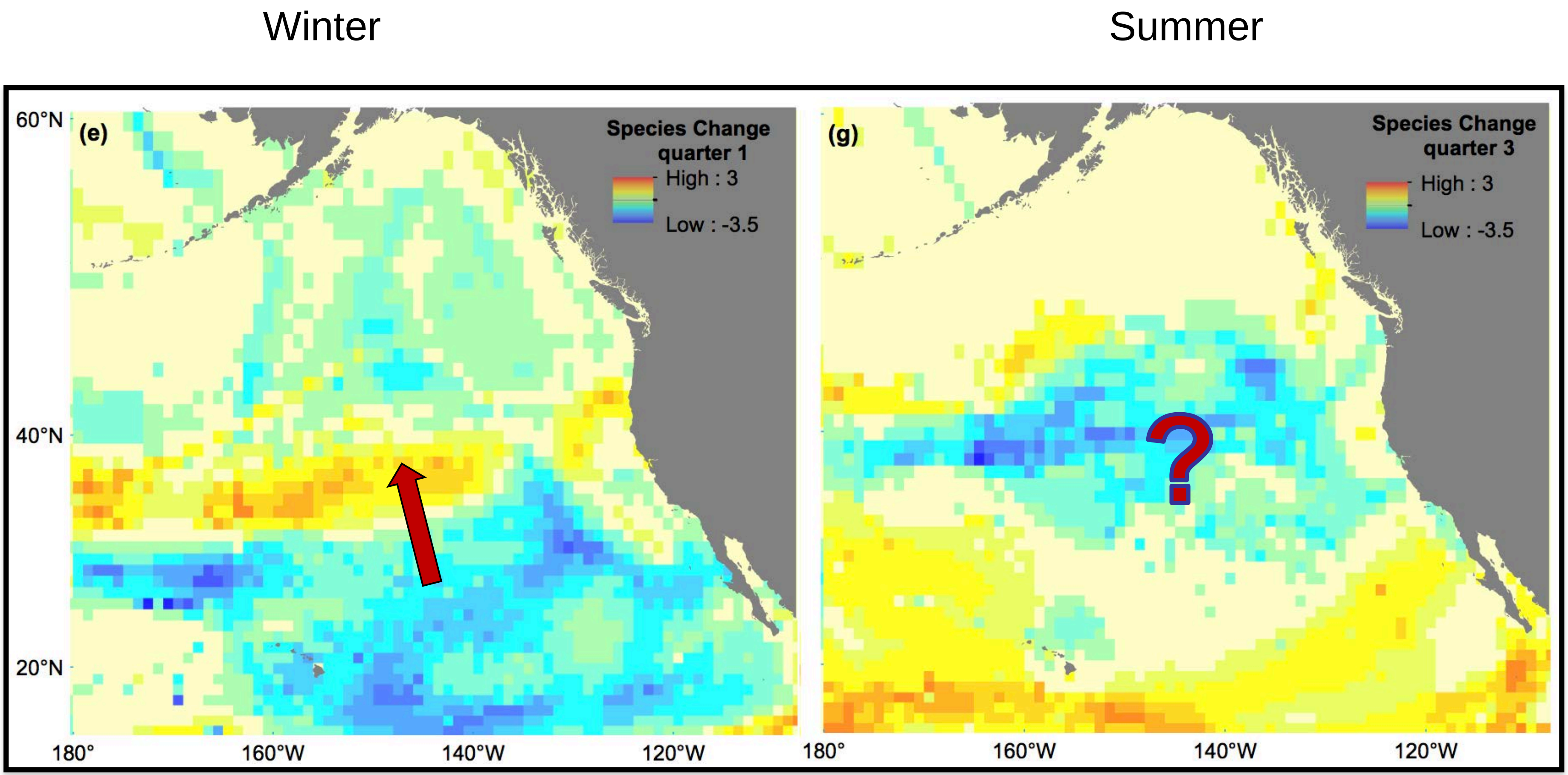
Physical structuring of hotspots

- SST structures habitat
- Chl-a influences use



Block et al. *Nature* 2011

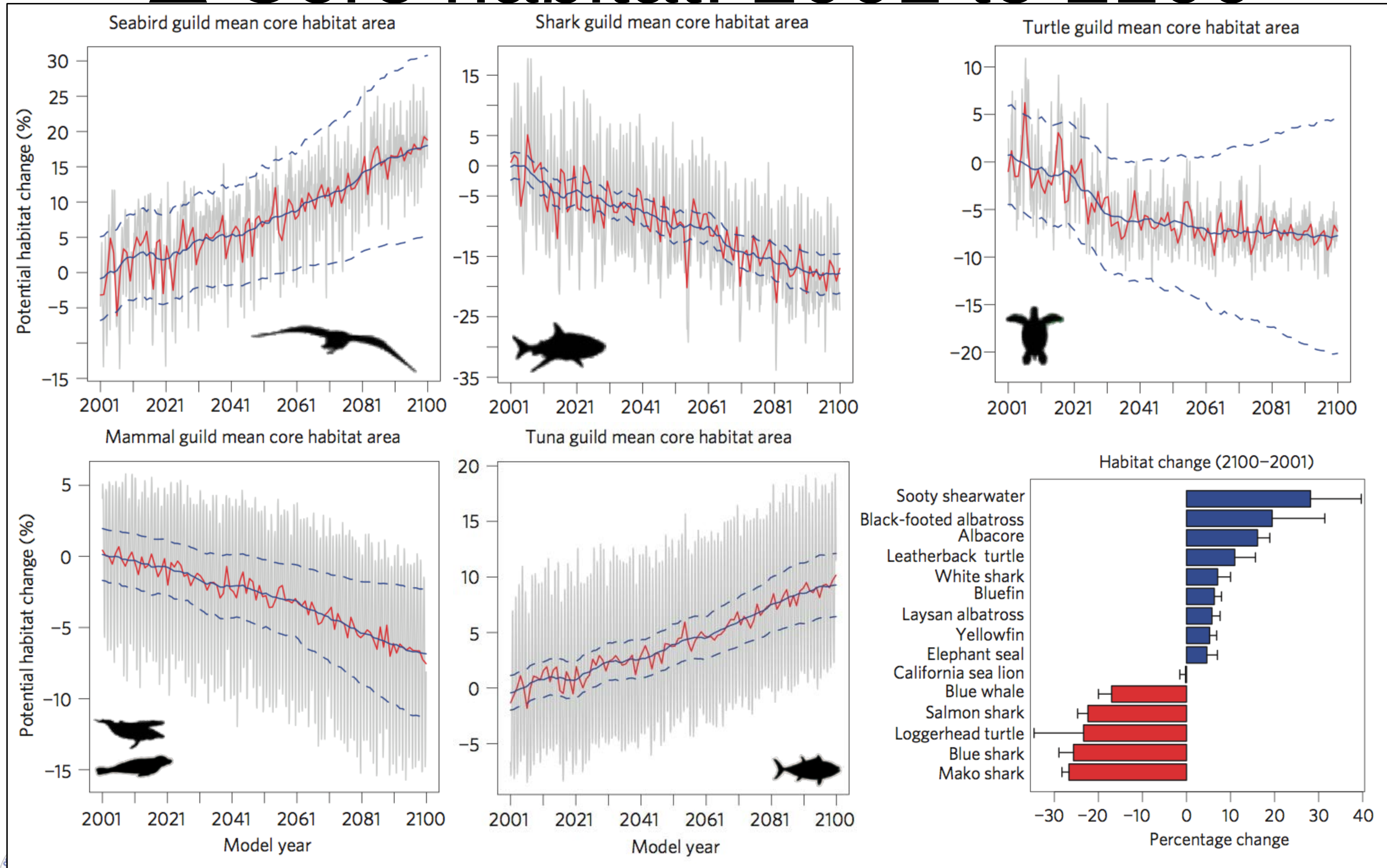
Δ Species Richness: 2001 to 2100



2001-2020 vs 2081-2100

Hazen et al. 2013 *Nature Climate Change*

Δ Core habitat: 2001 to 2100

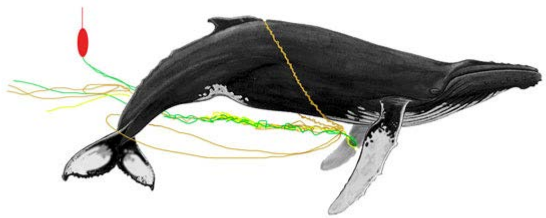


Management for unforeseen

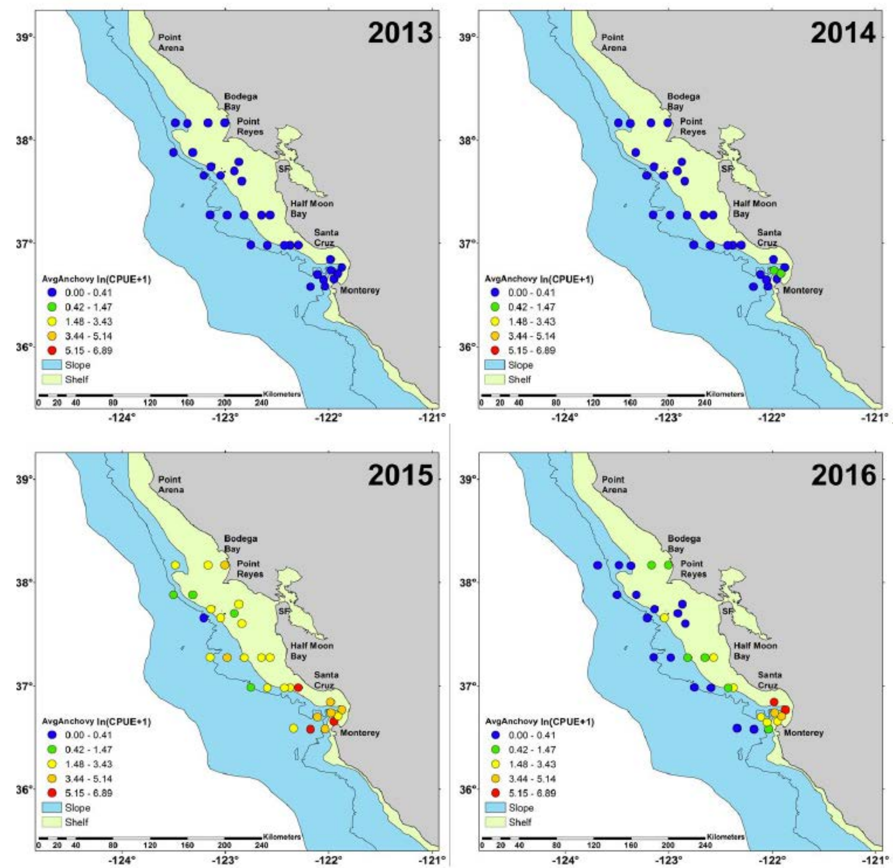
California sea lions left S. California for greener pastures in the Columbia

Source: Bryan Wright, ODFW

Management for unforeseen consequences?



May-June Anchovy CPUE from trawls



Key ecosystem ingredients:

Persistent marine heat wave

Record HAB + domoic acid delayed Dungeness crab fishery

Low krill off shelf break & high concentration of anchovies on shelf

Recovering whale populations

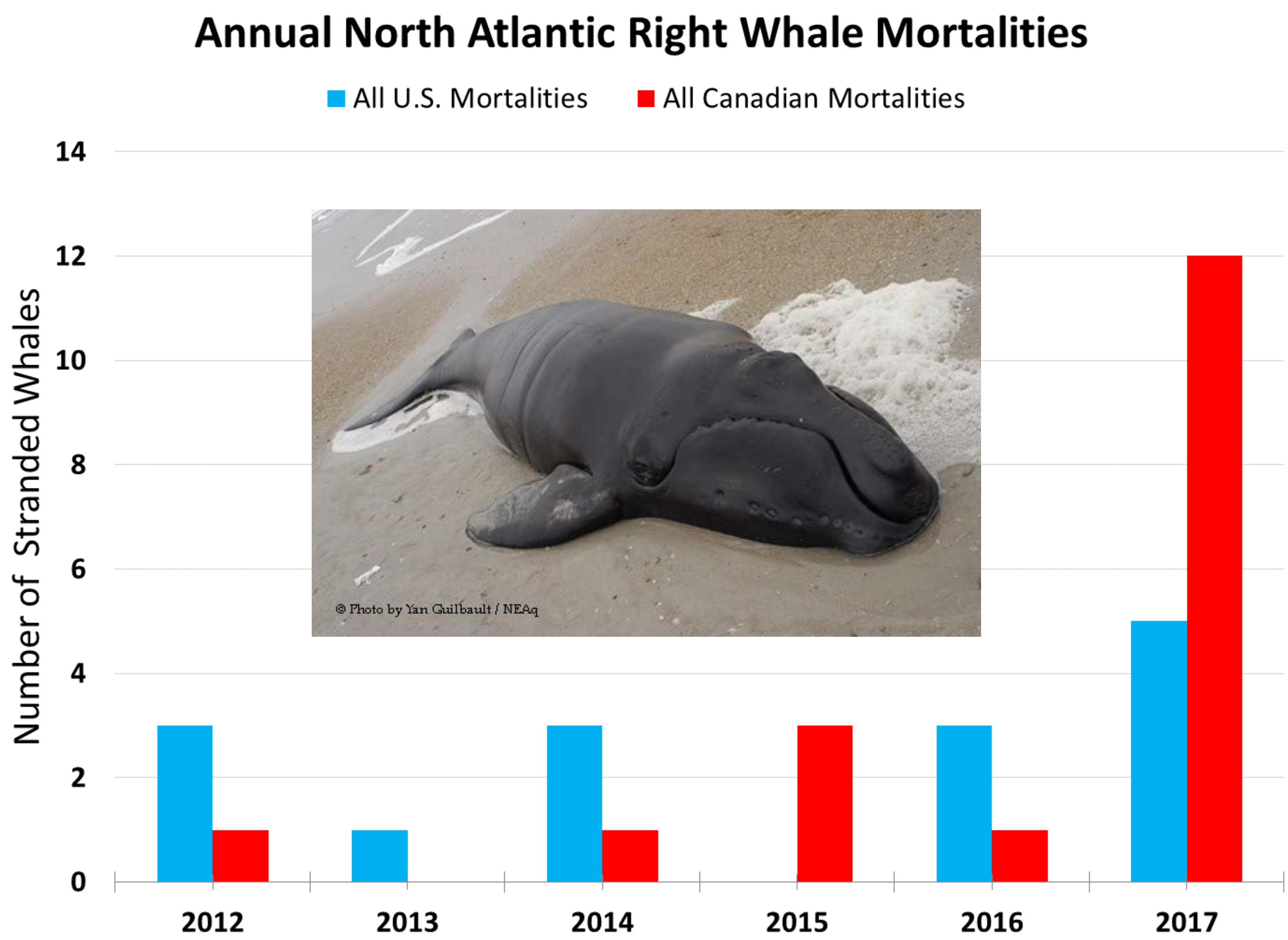
+

Humpback whale prey switching

End result: unusual time-space overlap of large numbers of foraging humpback whales and crab pots/lines (image from Jarrod Santora)

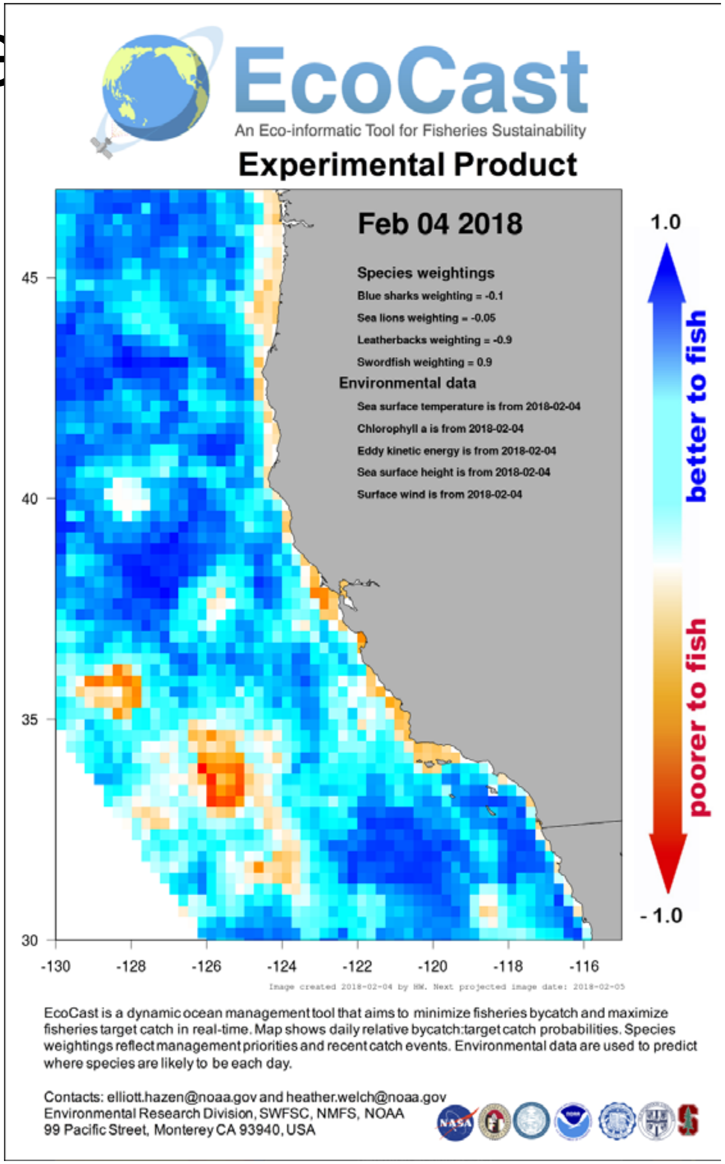
Management for unforeseen

Northward shift to less-stringent management areas



Management for unforeseen consequences

- Daily predictions with weightings set by management concern



http://oceanview.pfeg.noaa.gov/ecocast/