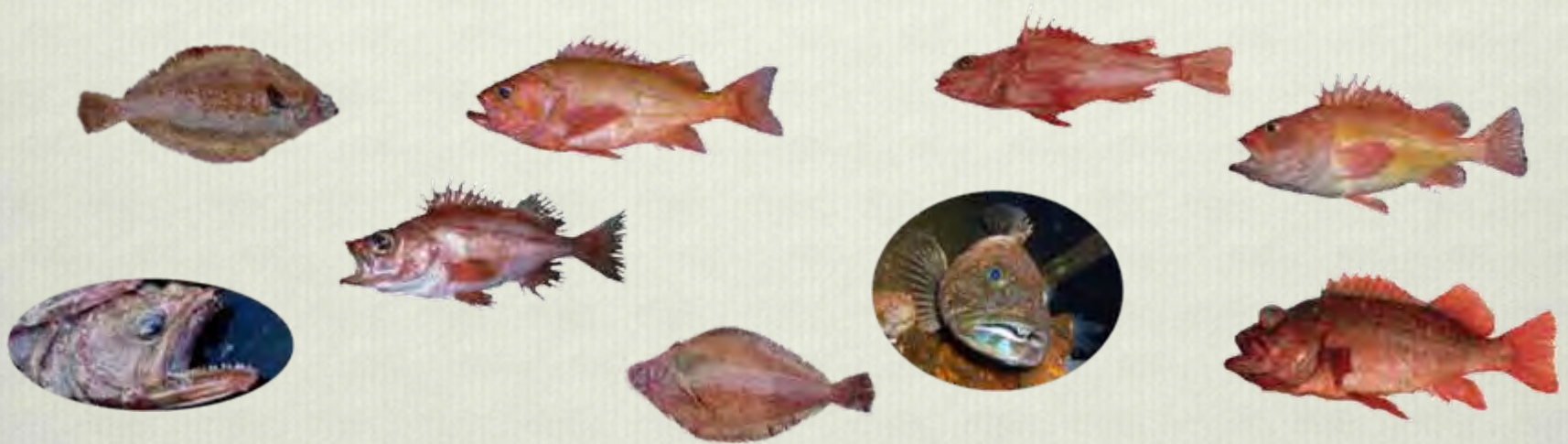


Ecological consequences of a precipitous decline in mean trophic level in the Northern California Current



Nick Tolimieri, Jameal Samhour, Blake Feist, Phil Levin

NOAA Fisheries, Northwest Fisheries Science Center



Ecosystem reorganization means retooling to better benefit from the ocean's bounty

ABUNDANT
WILDLIFE



CLEAN BEACHES

VIBRANT
COASTAL
COMMUNITIES



RENEWABLE
ENERGY
RESOURCES

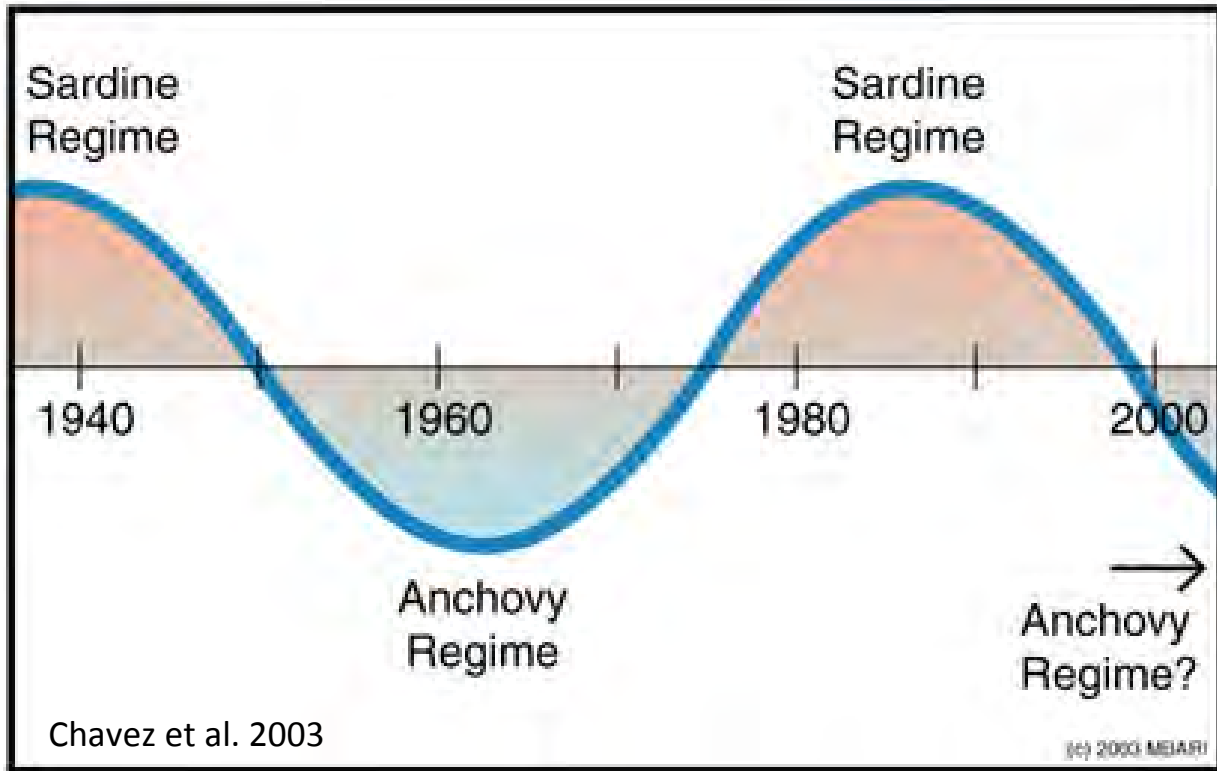
GOOD JOBS



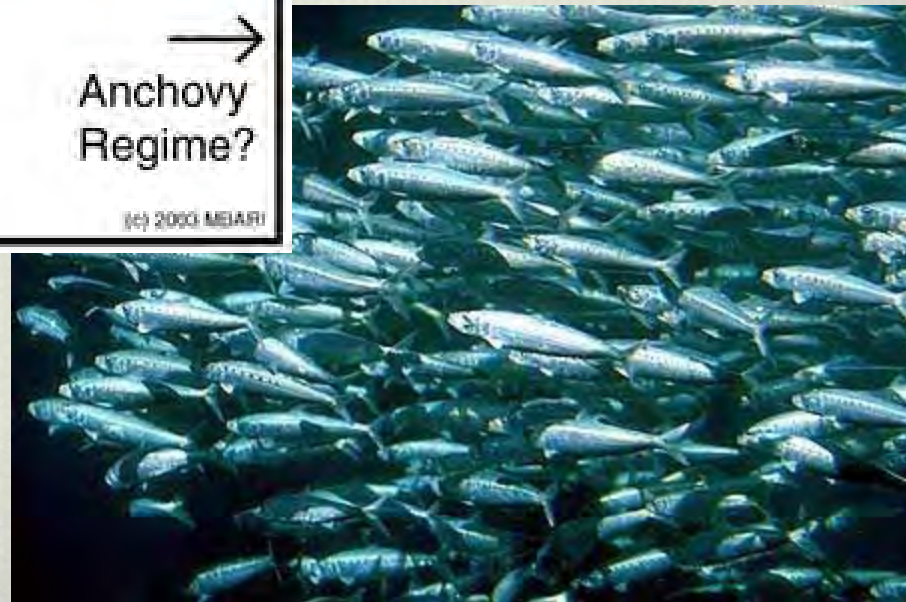
RELIABLE
FISHERIES



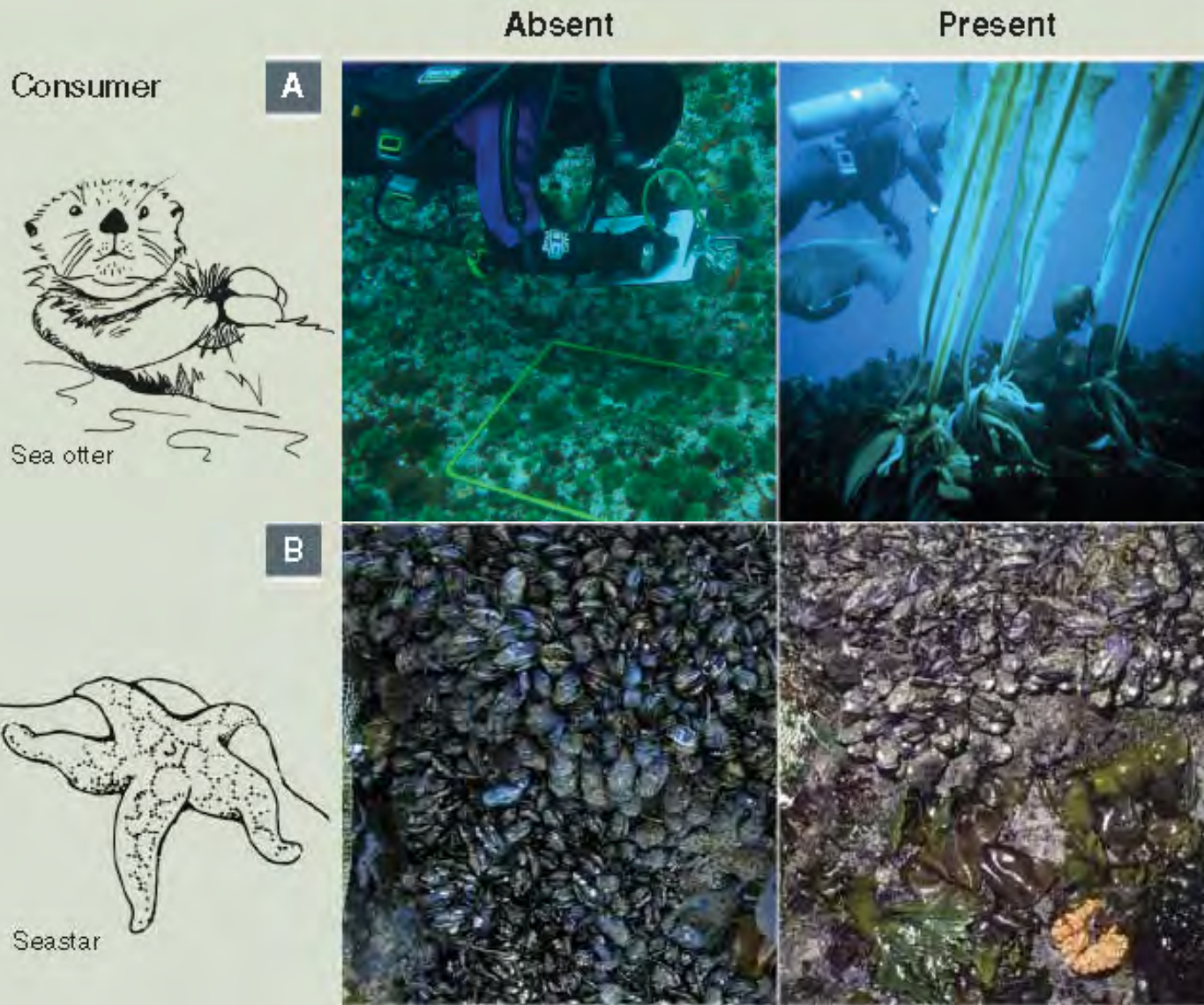
How does reorganization happen?



Bottom-up
& climatic
drivers

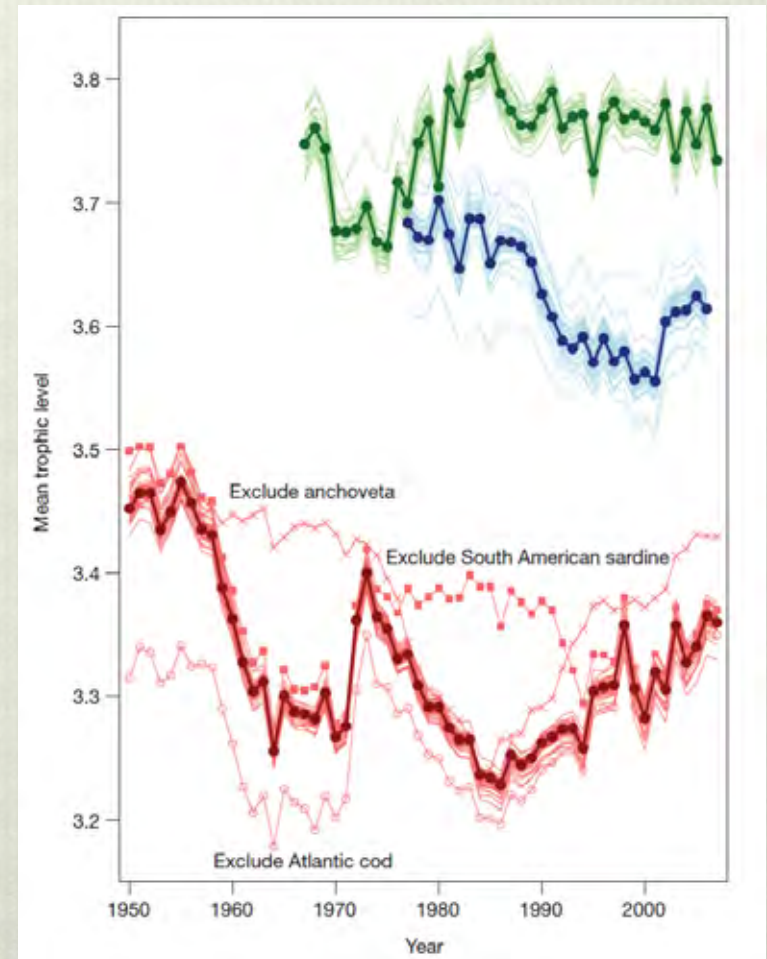
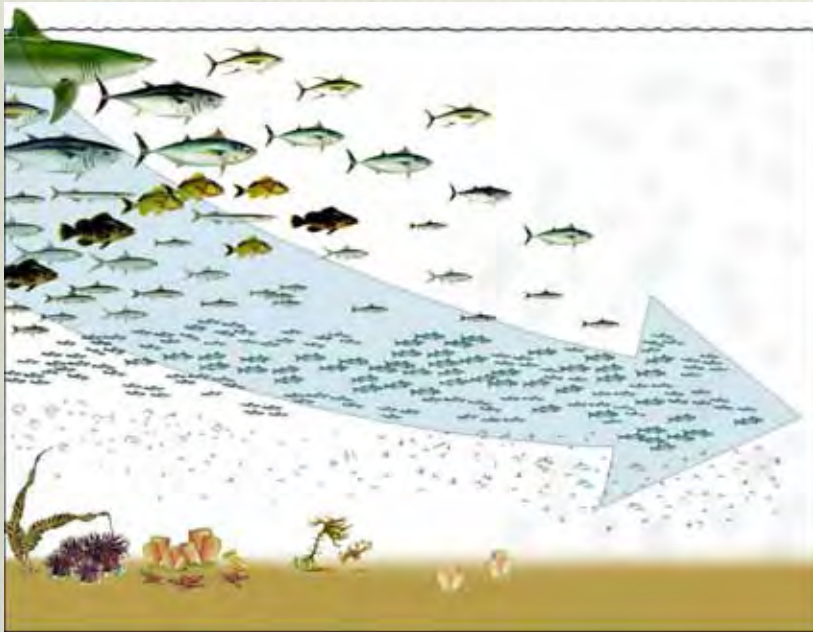


How does reorganization happen?

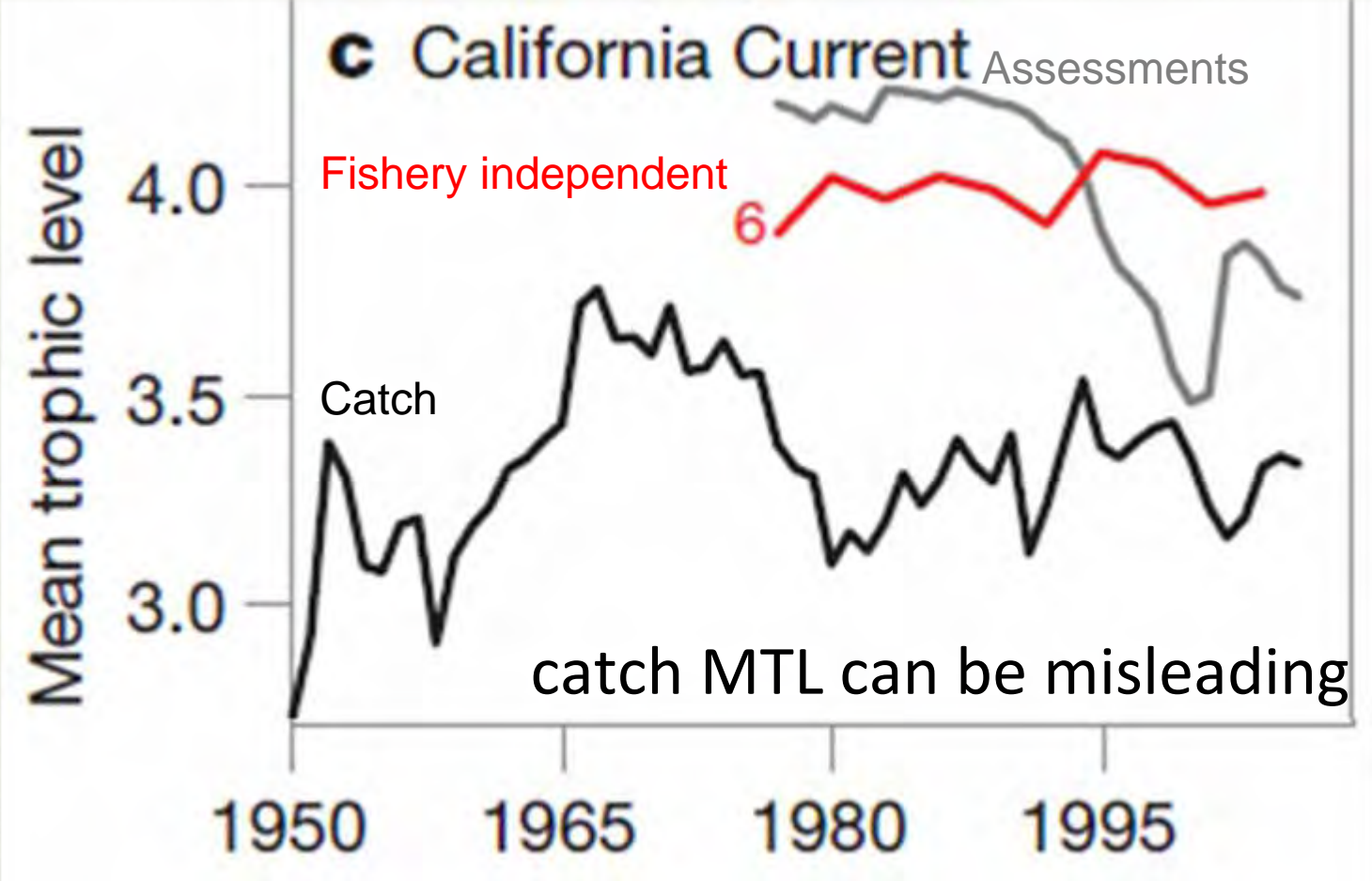


Top-down drivers

Mean trophic level as an indicator of reorganization



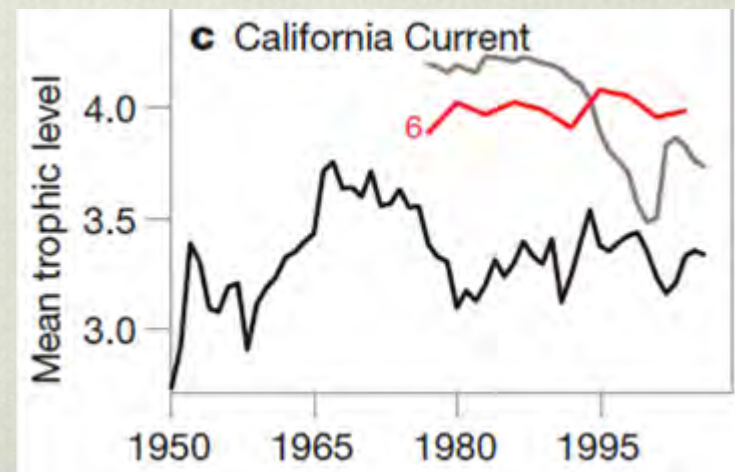
Mean trophic level as an indicator of reorganization



Ecosystem reorganization in the California Current

1) What's happening to trophic structure?

2) What are the ecological consequences?



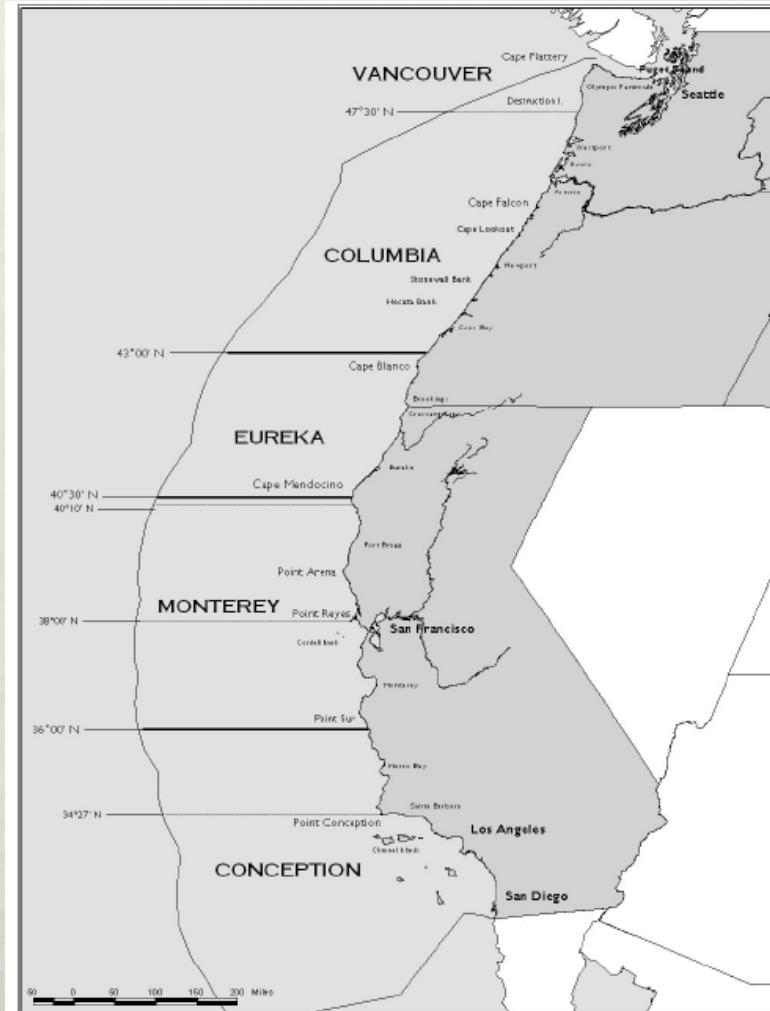


Focus: the groundfish community

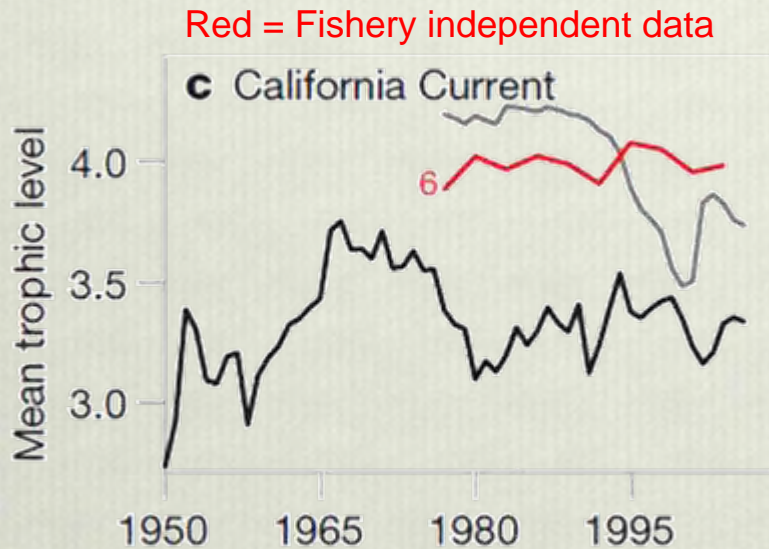
NOAA Northwest Fisheries Science Ctr

West Coast Trawl Survey

- ❖ 2003- 2010
- ❖ ~50 - 1200 m
- ❖ ~32.5 - 48.3° N
- ❖ >4,000 trawls
- ❖ TL info from fishbase.org



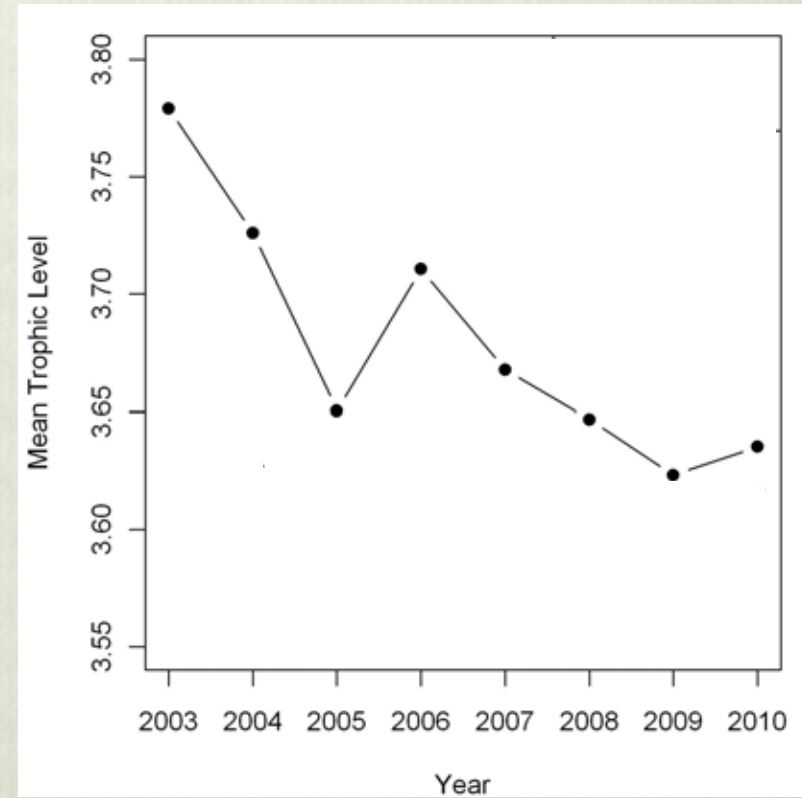
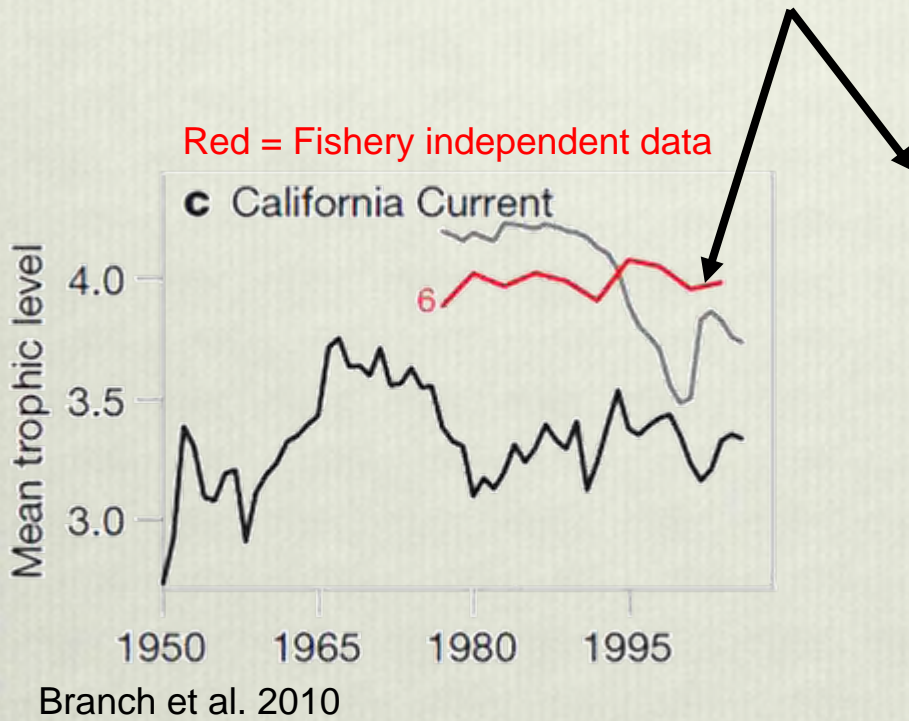
Previously stable trophic structure



Branch et al. 2010



Previously stable trophic structure has declined rapidly

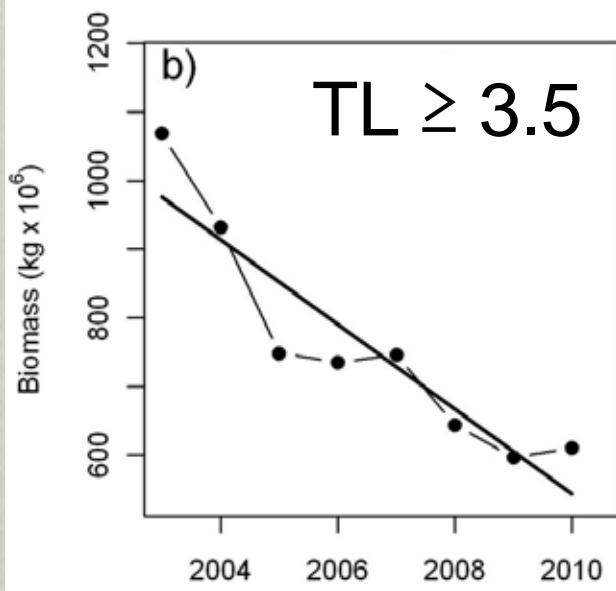
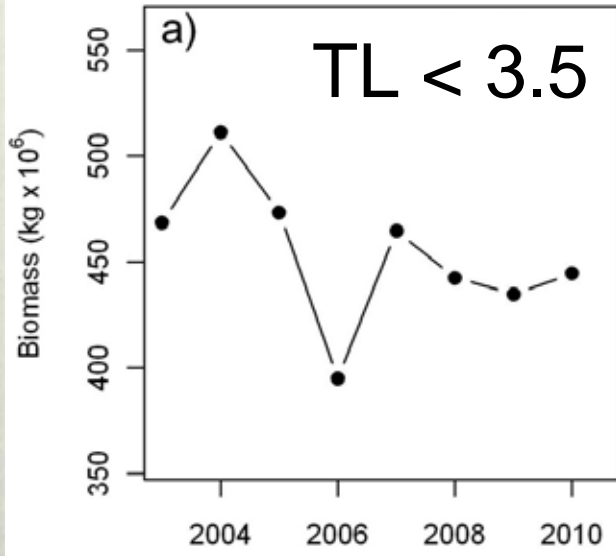


Have higher trophic level
species been lost?

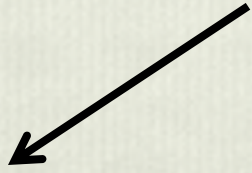


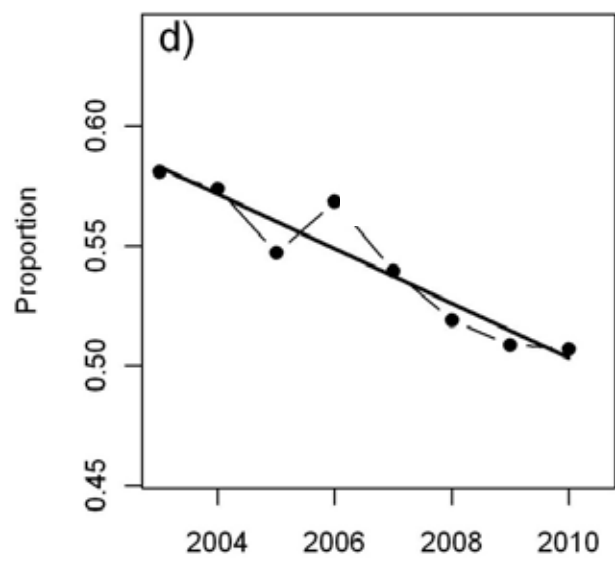
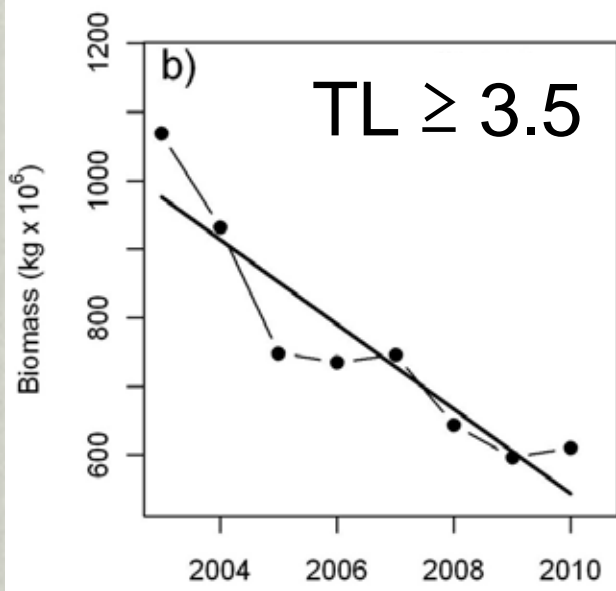
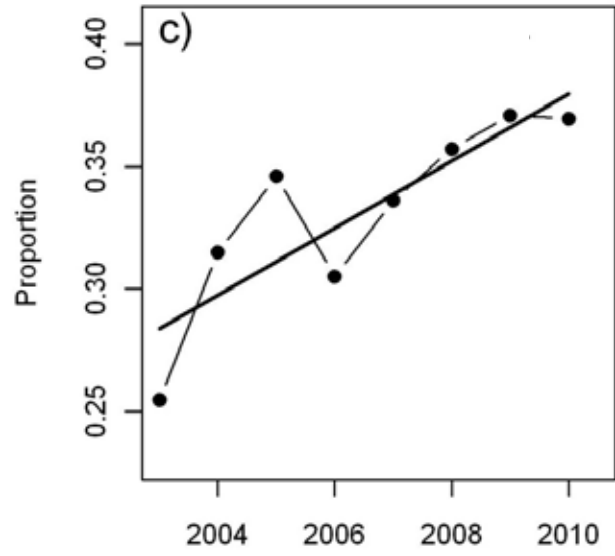
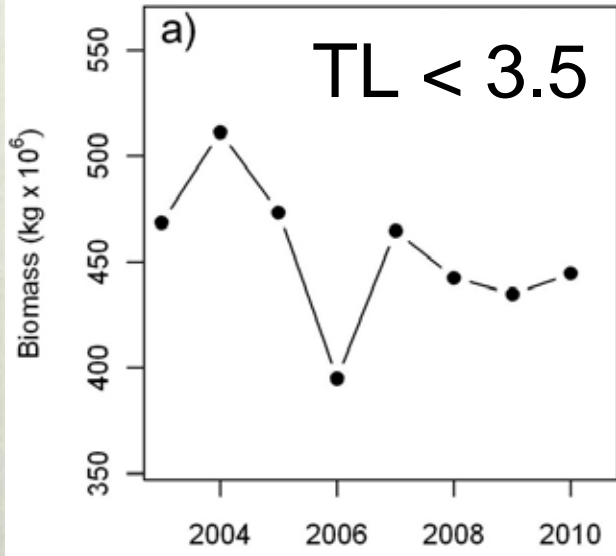
Have lower trophic level
species become more
abundant?





Higher TL groundfish biomass declined by 43% since 2003





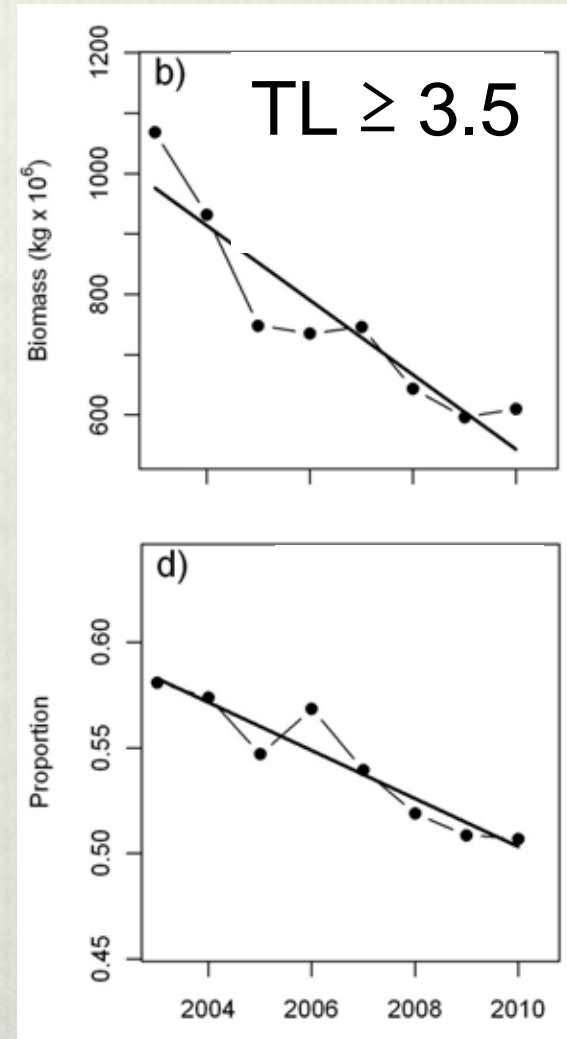
← Lower TL groundfish make up a greater proportion of total biomass



Ecosystem reorganization from the top down in the California Current?

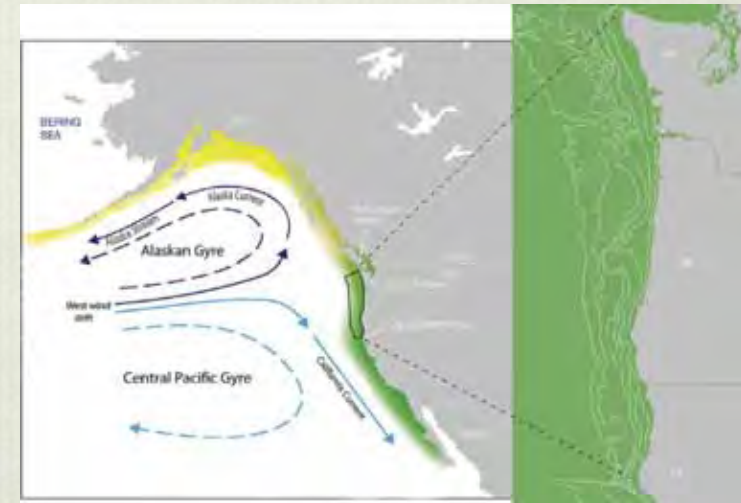
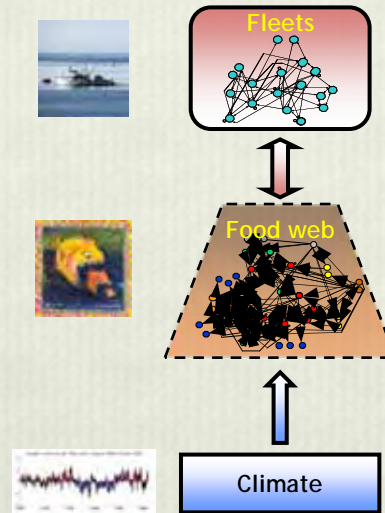
- 1) What's happening to trophic structure?
 - ❖ Higher TL groundfish declined

- 2) What are the ecological consequences of top predator decline?



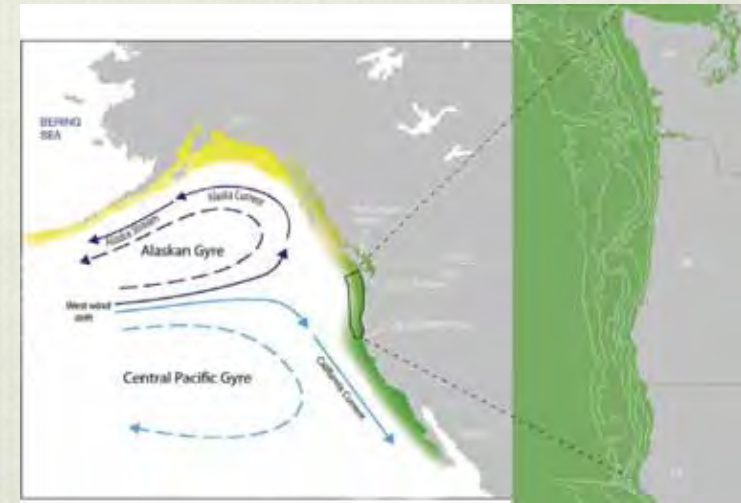
Modeling potential ecosystem responses

CA Current ecosystem model
Ecopath with Ecosim
Field et al. 2006



Modeling potential ecosystem responses

CA Current ecosystem model
Ecopath with Ecosim
Field et al. 2006



- ❖ Introduced a 40% decline in higher TL groundfish biomass
- ❖ Tested instantaneous and dynamic ecosystem responses
 - ❖ Structural
 - ❖ Functional (trophic and bioenergetic processes)

Structural changes

(Instantaneous)



Structural changes

Initially, prey species responded positively

| <u>Species group</u> | Instantaneous | <u>Change over 10 years</u> |
|-------------------------|---------------|-----------------------------|
| phytoplankton | | nr: <10% |
| small zooplankton | | +: 10-20% |
| carnivorous zooplankton | ++++ | ++: 20-50% |
| amphipods | ++++ | +++: 50-100% |
| krill | ++++ | ++++: >100% |
| jellies | ++++ | |
| pandalid shrimp | ++++ | |
| crabs | +++ | |
| squid | ++++ | |
| forage fish | ++++ | |
| salmon | +++ | |
| lower TL groundfish | ++ | |
| albacore | | |
| seabirds | | |
| harbor seals | | |
| whales | | |



Functional changes

Trophic processes changed, bioenergetics did not

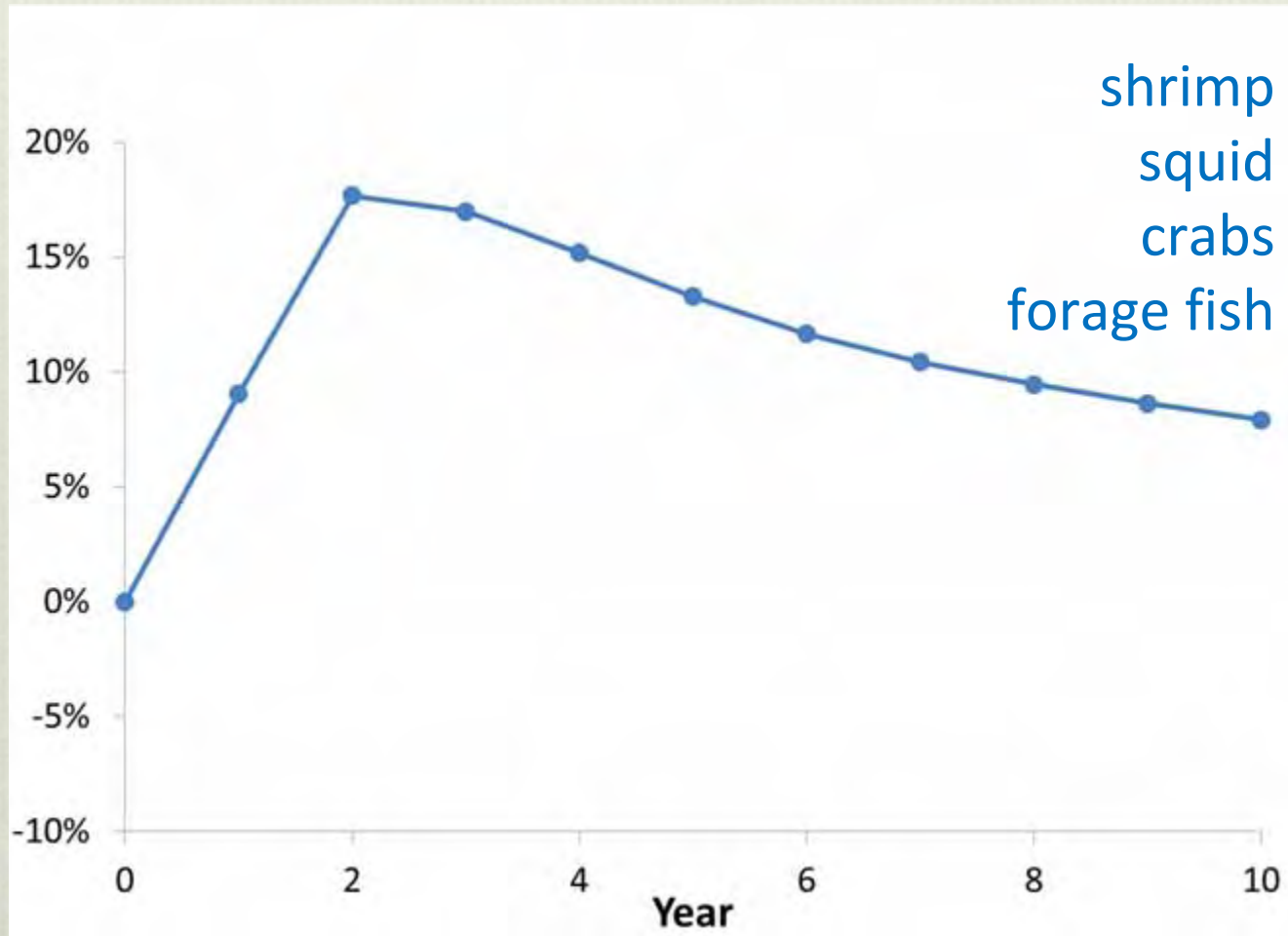
| | Instantaneous | |
|---------------------|---------------|-----------------------------|
| <u>Trophic</u> | | <u>Change over 10 years</u> |
| herbivores | ++++ | nr: <10% |
| zooplanktivores | ++++ | +: 10-20% |
| macroinvertivores | ++++ | ++: 20-50% |
| scavengers | ++++ | +++: 50-100% |
| <u>Bioenergetic</u> | | ++++: >100% |
| biomass | --- | |
| consumption | nr | |
| respiration | nr | |
| throughput | nr | |
| production | nr | |
| NPP | nr | |



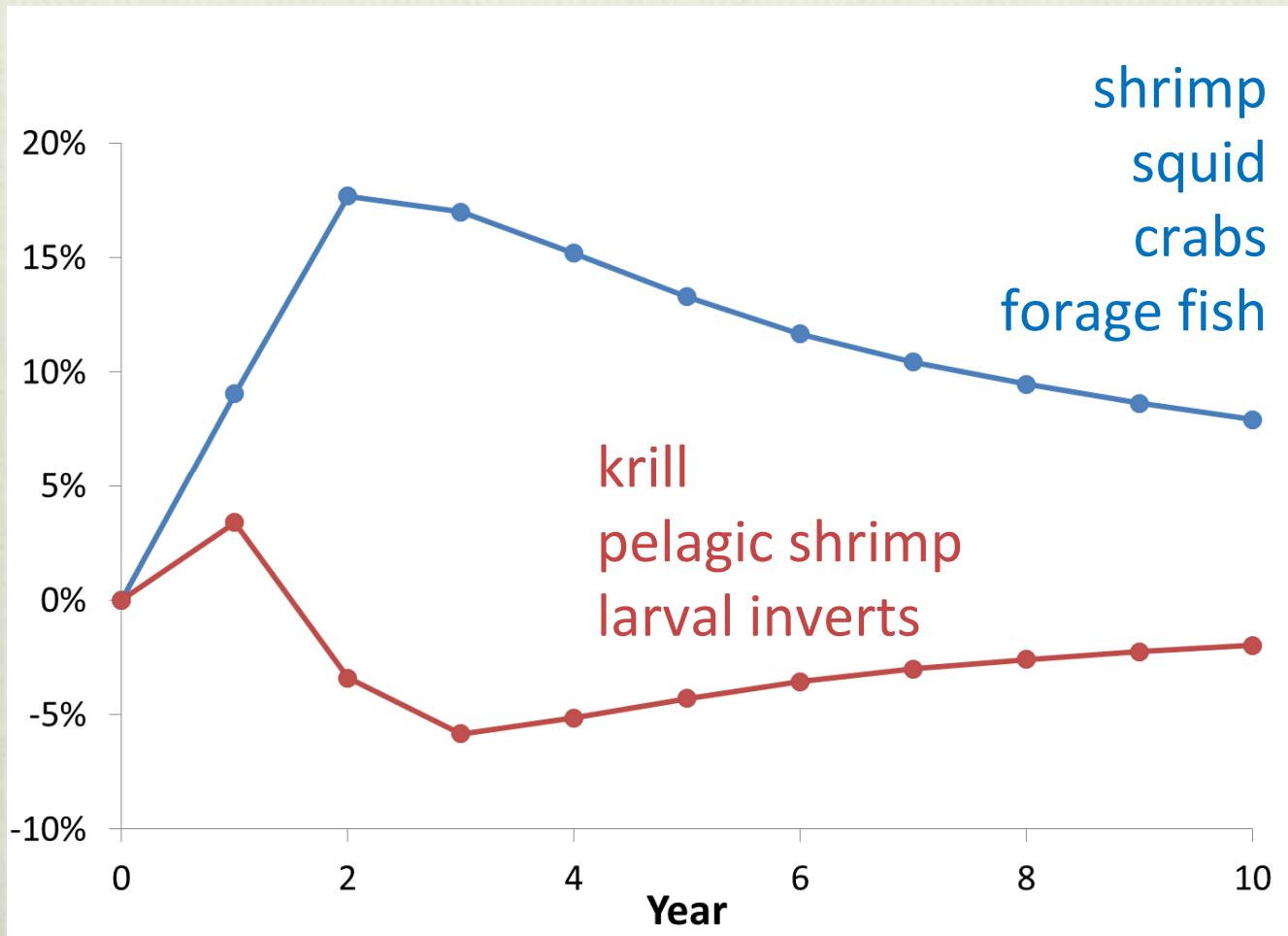
How might predator-prey interactions play out over time?



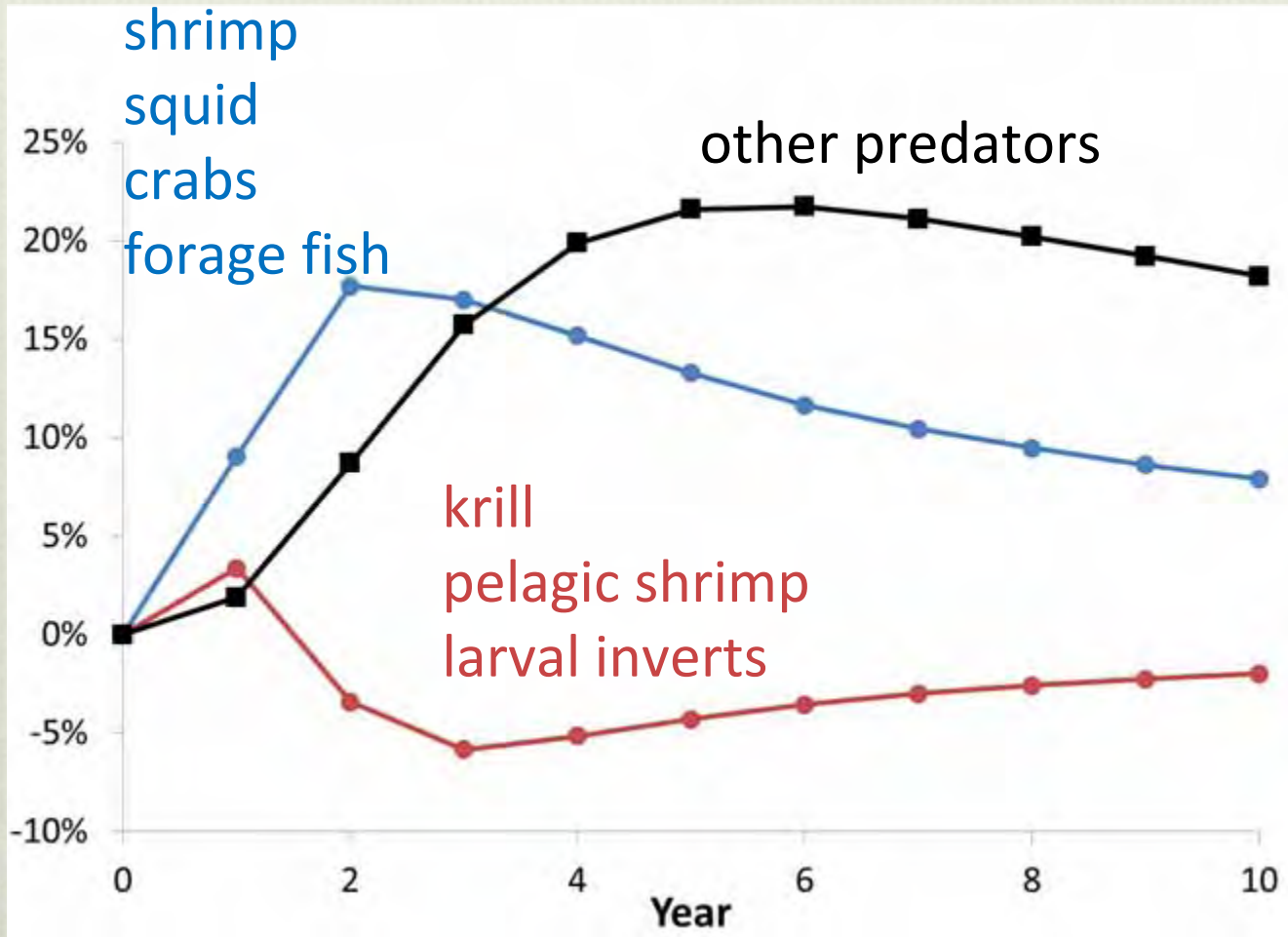
Ecological consequences of top predator decline: initial prey release



Ecological consequences of top predator decline: initial prey release...with a twist



Competitive release tempered prey release over time



Structural changes

Dynamic predator-prey interactions modified structural responses to top predator decline



Structural changes

Dynamic predator-prey interactions modified structural responses to top predator decline

| | Instantaneous | Dynamic |
|-------------------------|---------------|---------|
| <u>Species group</u> | | |
| phytoplankton | | nr |
| small zooplankton | | nr |
| carnivorous zooplankton | ++++ | nr |
| amphipods | ++++ | nr |
| krill | ++++ | nr |
| jellies | ++++ | nr |
| pandalid shrimp | ++++ | + |
| crabs | +++ | + |
| squid | ++++ | + |
| forage fish | ++++ | nr |
| salmon | +++ | ++ |
| lower TL groundfish | ++ | + |
| albacore | | + |
| seabirds | | + |
| harbor seals | | nr |
| whales | | nr |

Change over 10 years

nr: <10%

+: 10-20%

++: 20-50%

+++: 50-100%

++++: >100%



Functional changes

Tempered trophic responses, no changes to bioenergetic processes

| | Instantaneous | Dynamic |
|---------------------|---------------|---------|
| <u>Trophic</u> | | |
| herbivores | ++++ | nr |
| zooplanktivores | ++++ | nr |
| macroinvertivores | ++++ | + |
| piscivores | | + |
| scavengers | ++++ | nr |
| <u>Bioenergetic</u> | | |
| biomass | --- | nr |
| consumption | nr | nr |
| respiration | nr | nr |
| throughput | nr | nr |
| production | nr | nr |
| NPP | nr | nr |



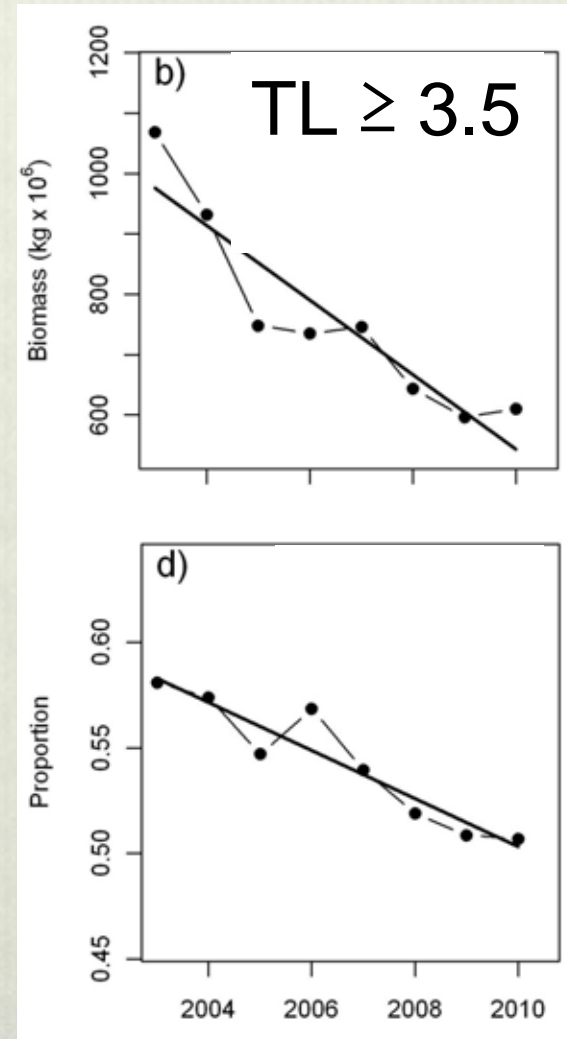
Ecosystem reorganization in the California Current

1) What's happening to trophic structure?

- ❖ Higher TL groundfish declined

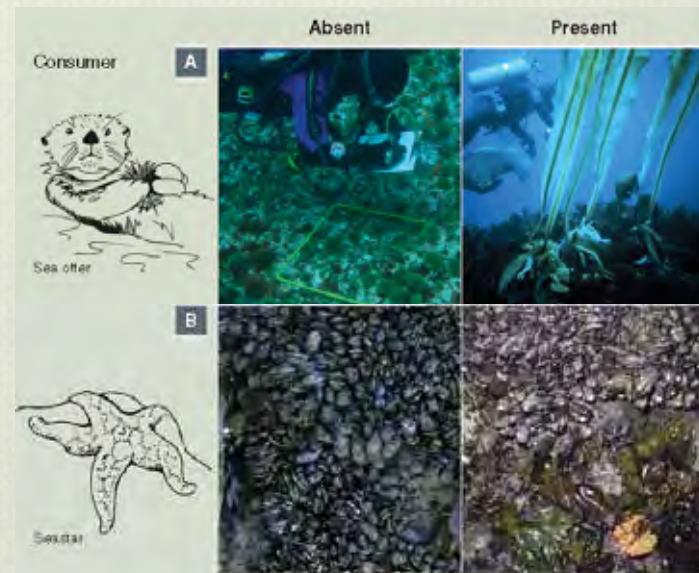
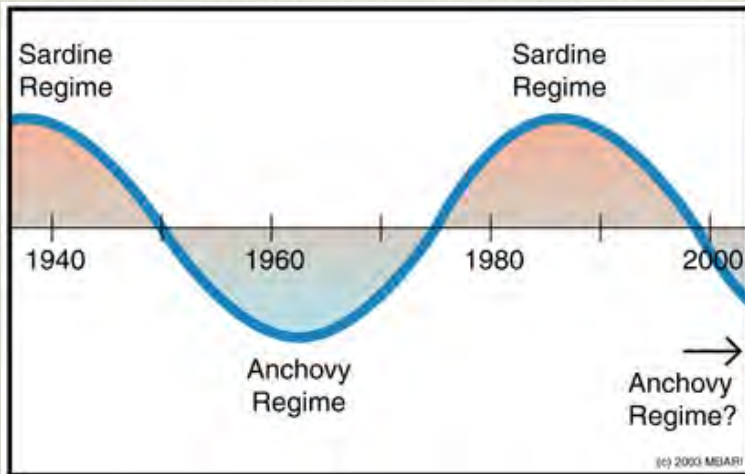
2) What are the ecological consequences of top predator decline?

- ❖ Structural but not functional shifts



Implications

- ❖ Top predator groundfish decline in the California Current underscores importance of both top-down and bottom-up drivers of marine ecosystem reorganization



Implications

- ❖ Reorganization responses contingent on
 - ❖ functional redundancy in predator guild



- ❖ absence of fisheries for forage species



Implications

- ❖ Restructuring of exploited species relative abundances may influence delivery of other ecosystem services

