Linkages between climate variation and the pelagic ecosystem of the CA current.

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Objectives

Show recent trends in Central California atmospheric and oceanographic conditions. We focus, here, of variability in ***wind structure*** along the coast and offshore as it relates to productivity and retention of food resources.

Show population and community responses to environmental variability.

Region of interest

Introduction: Upwelling

Production within the California Current system is driven by upwelling. This is simplified however. What is important is the ***quality of upwelling***. For upwelling to lead to improved production in the system it must:

1. Be ***intense enough*** to bring deep enriched waters to the surface ***but not so intense*** as to create turbulence and drive production offshore,

2. Be ***timed correctly to start and persist*** through critical times (e.g., recruitment events).

and

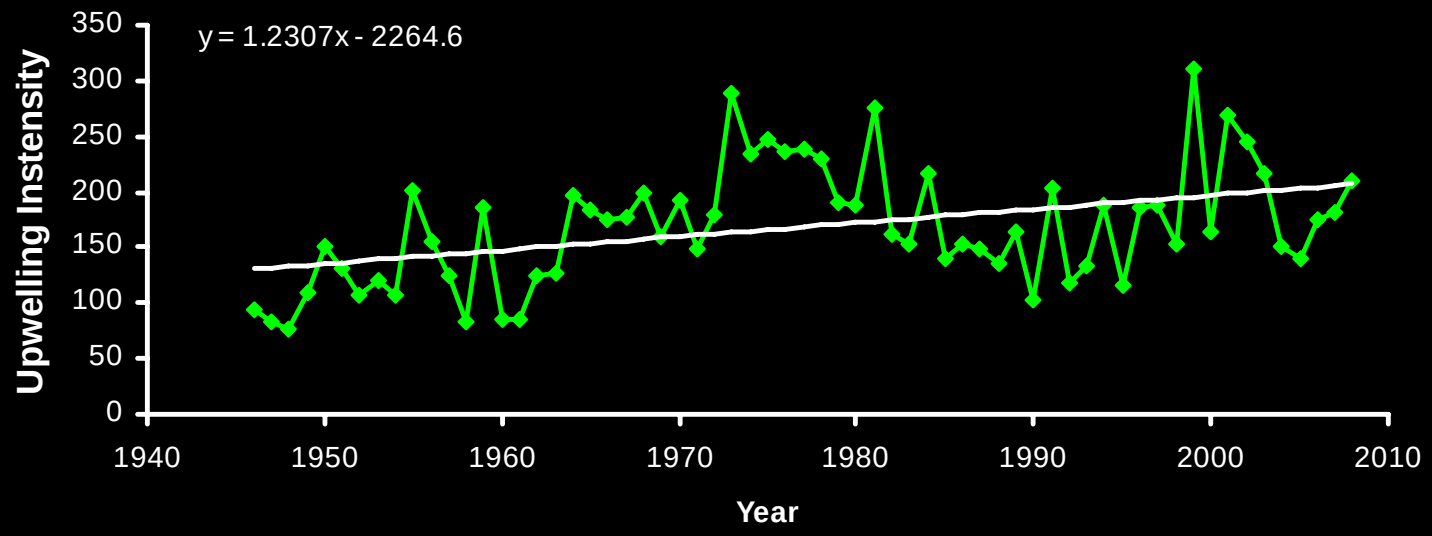
3. ***Be associated with a wind structure that retains production locally along the coast***.

Introduction: Upwelling

The first two aspects of upwelling have been studied relative to their relationship to probable climate change.

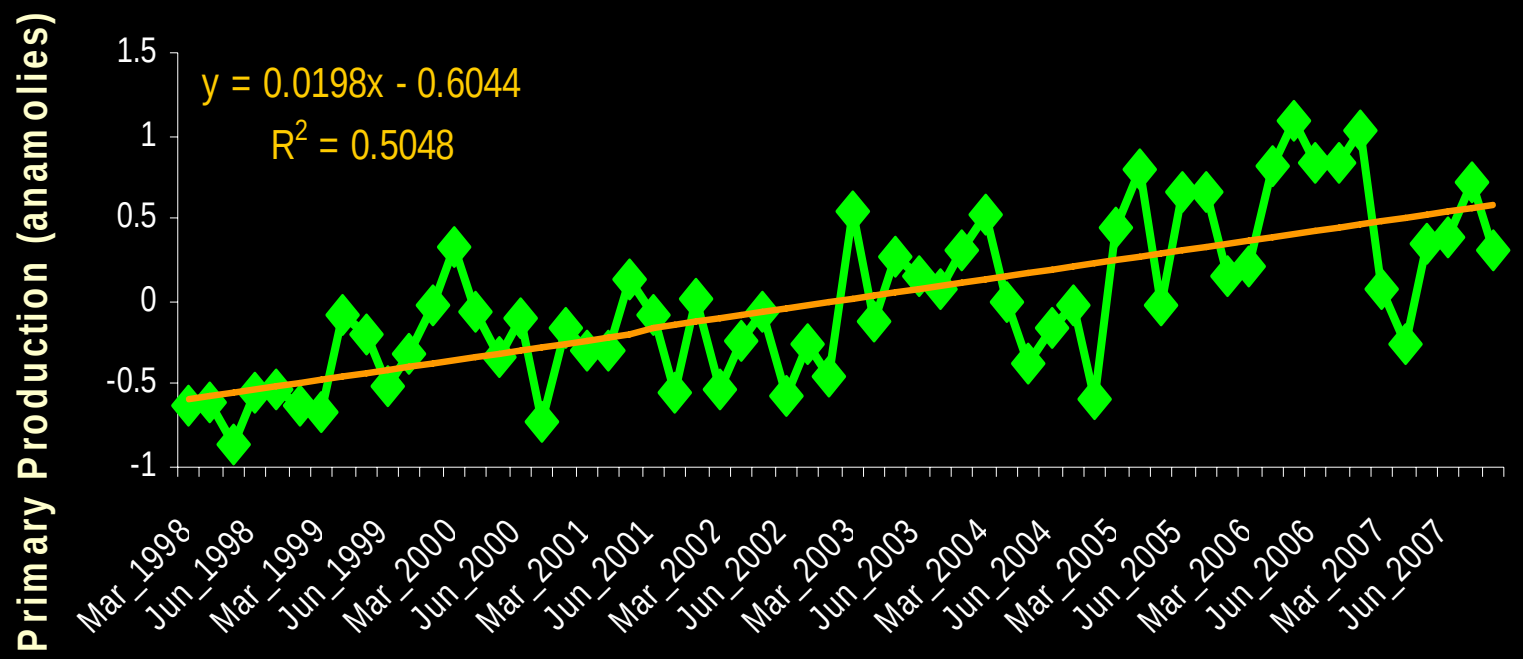
1. ***Intensity***

Over the last 60 years there has been a substantial increase in upwelling favorable winds. It is believed this is associated with the difference between land mass and ocean heating.



Introduction: Primary production

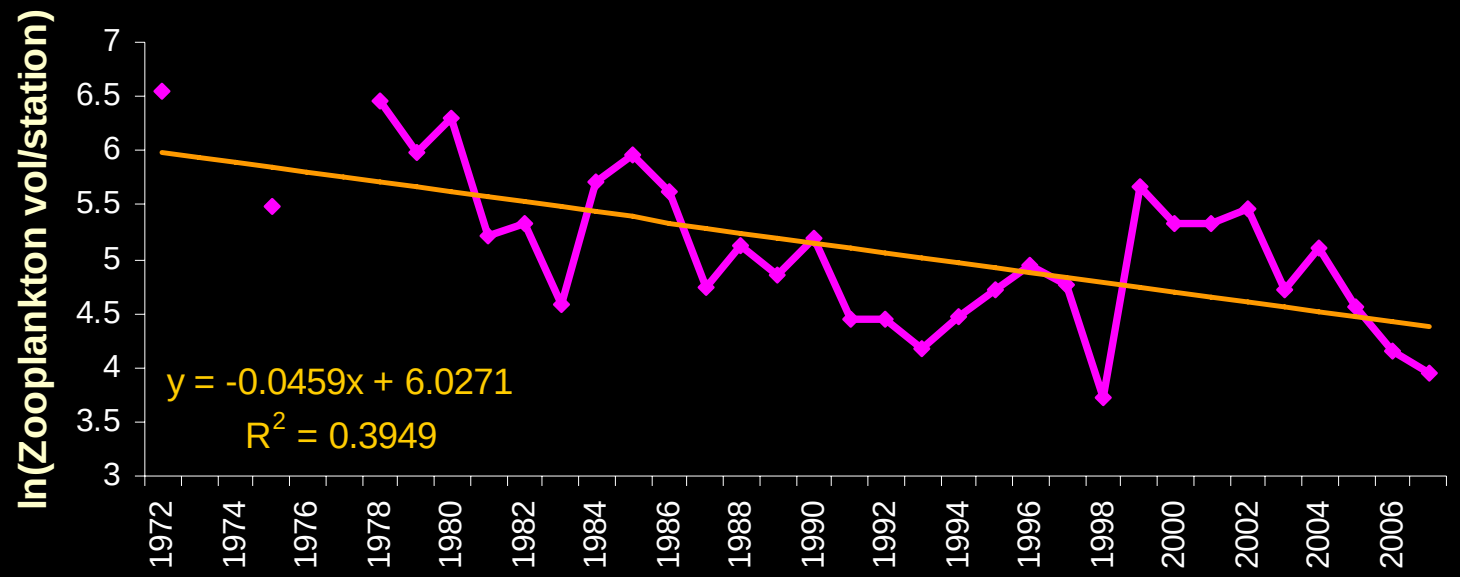
Primary production in central California estimated from satellite data. Notice that production is up in the last decade (or its an artifact of the sampling).



Source: D. Foley, ERD NOAA

Introduction: Krill production

Increased primary production, as Bakun (1990) suggested, does not transfer up the chain.



Source: CalCOFI, Wells et al. 2008

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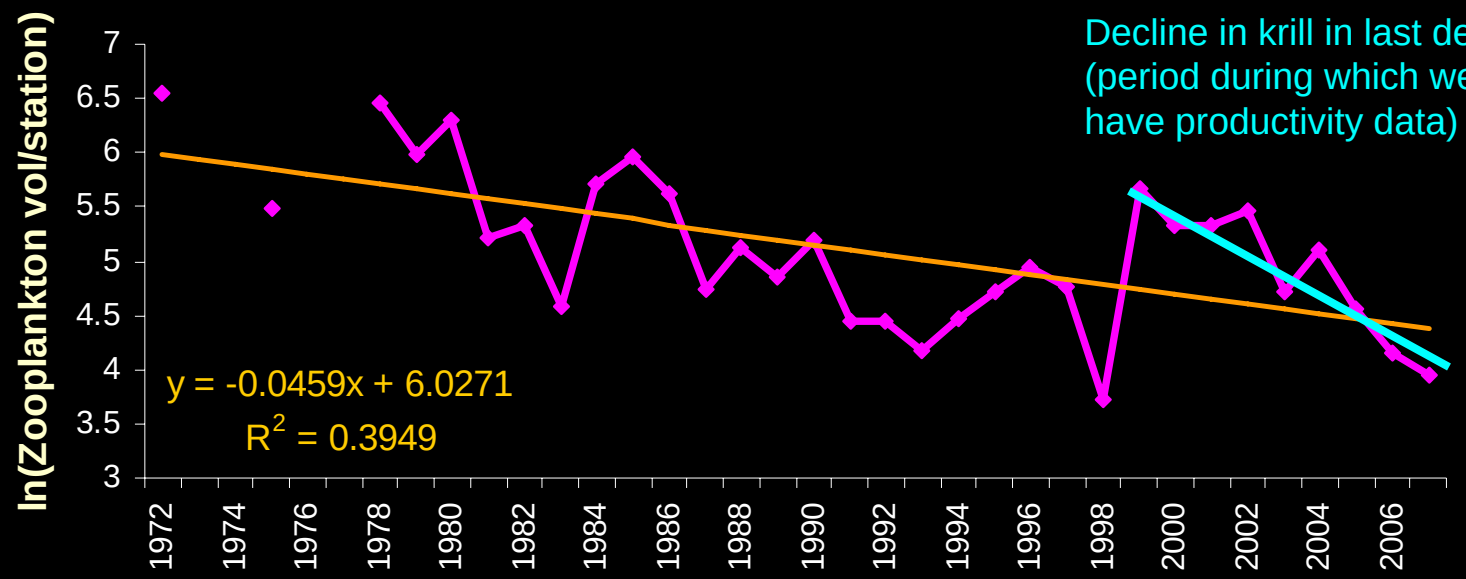

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The first two aspects of upwelling have been studied relative to their relationship to probable climate change.

2. ***Timing***
As global temperature increases, the timing of the most intense upwelling winds occurs later in the season.

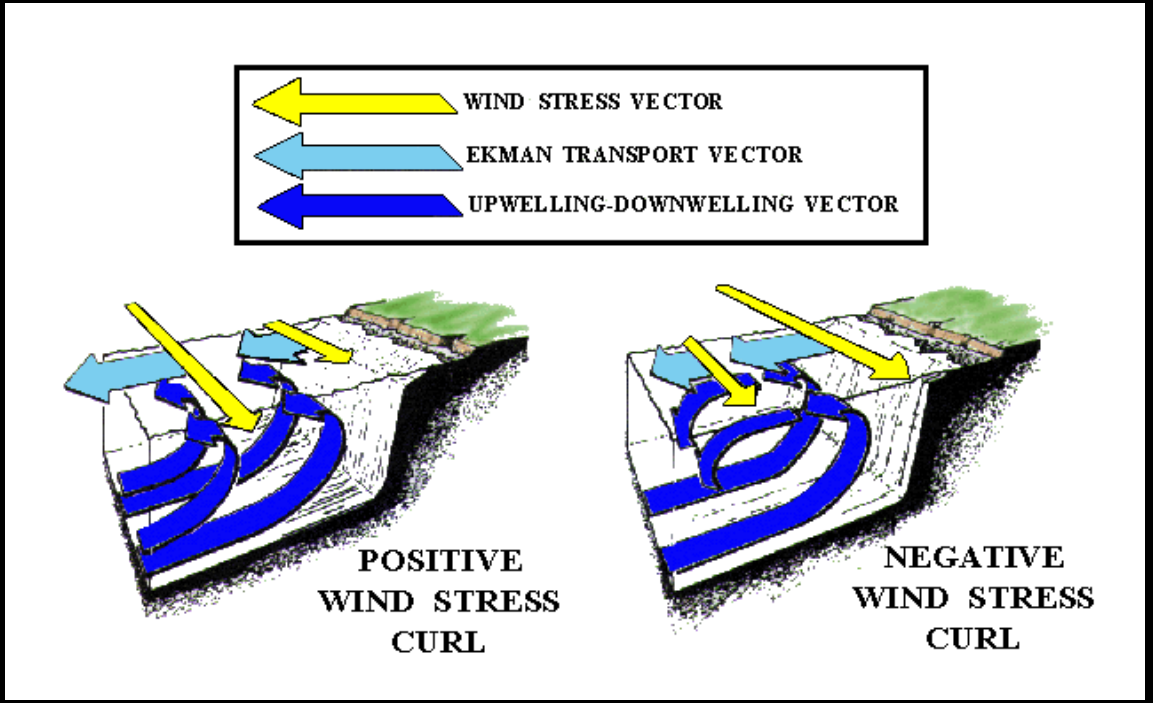
Third Upwelling Characteristic: Wind Structure

The third feature related to upwelling quality, ***wind structure***, has been discussed but not explored.

Along with more intense upwelling winds may be associated stronger off-shore winds relative to inshore winds.

If winds off-shore are substantially stronger than winds inshore any production that may result from upwelling will be moved off-shore and/or mesoscale features, such as fronts along the coast, will be altered. (simplified interpretation)

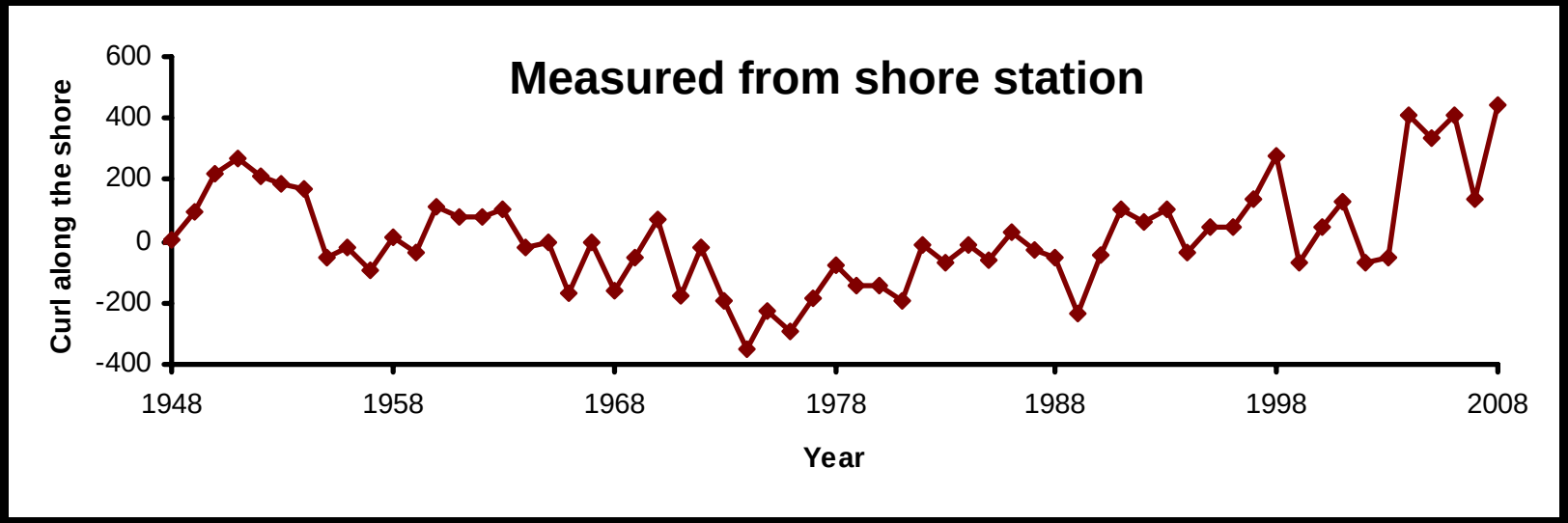
Wind structure and upwelling

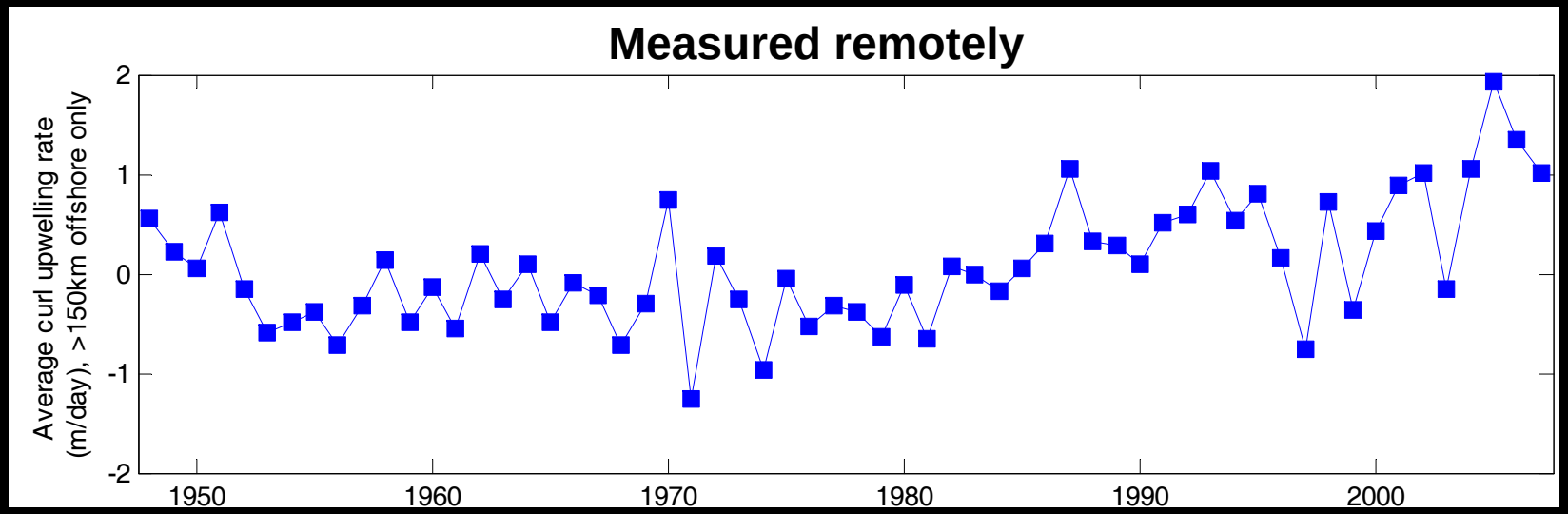


We are going to focus on wind structure. Figure represents curl-driven upwelling and retention along the shore but similar behavior occurs in open waters. Specifically, wind shear can cause upwelling.

Source: ERD NOAA

Wind structure and upwelling



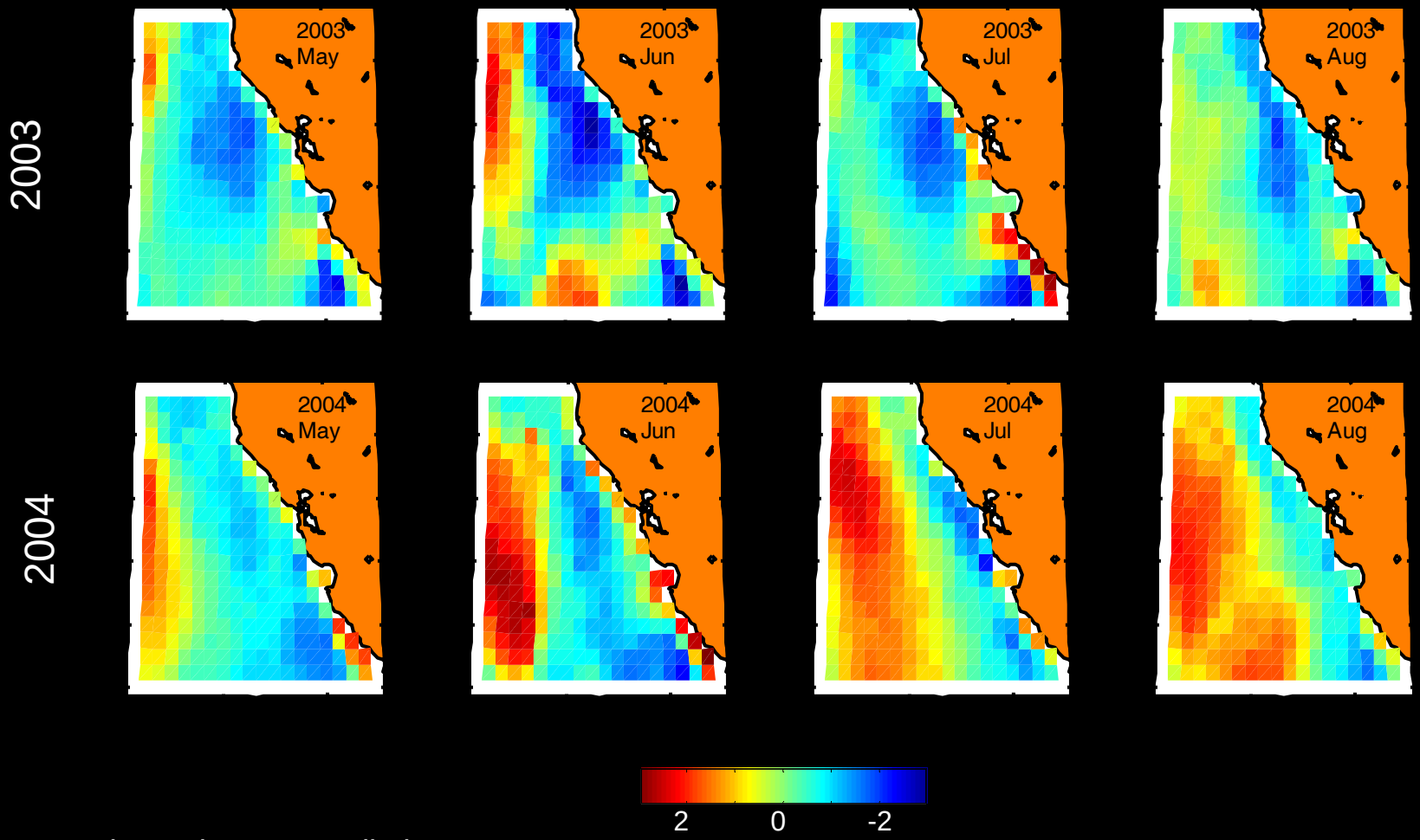


*These data are preliminary.

Source: ERD NOAA; Ryan Rykaczewski

Wind structure and upwelling

Curl-derived upwelling anamolies*



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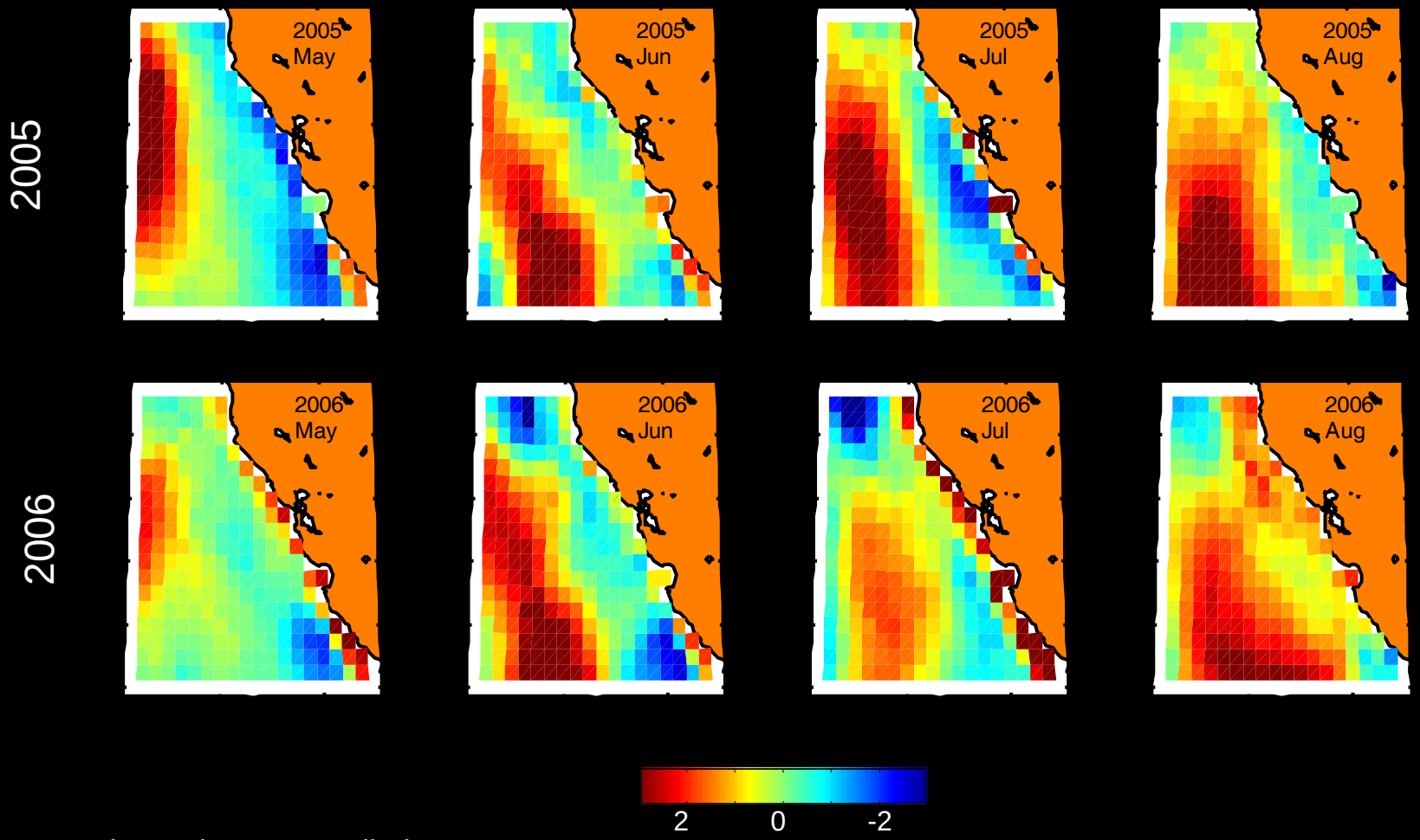

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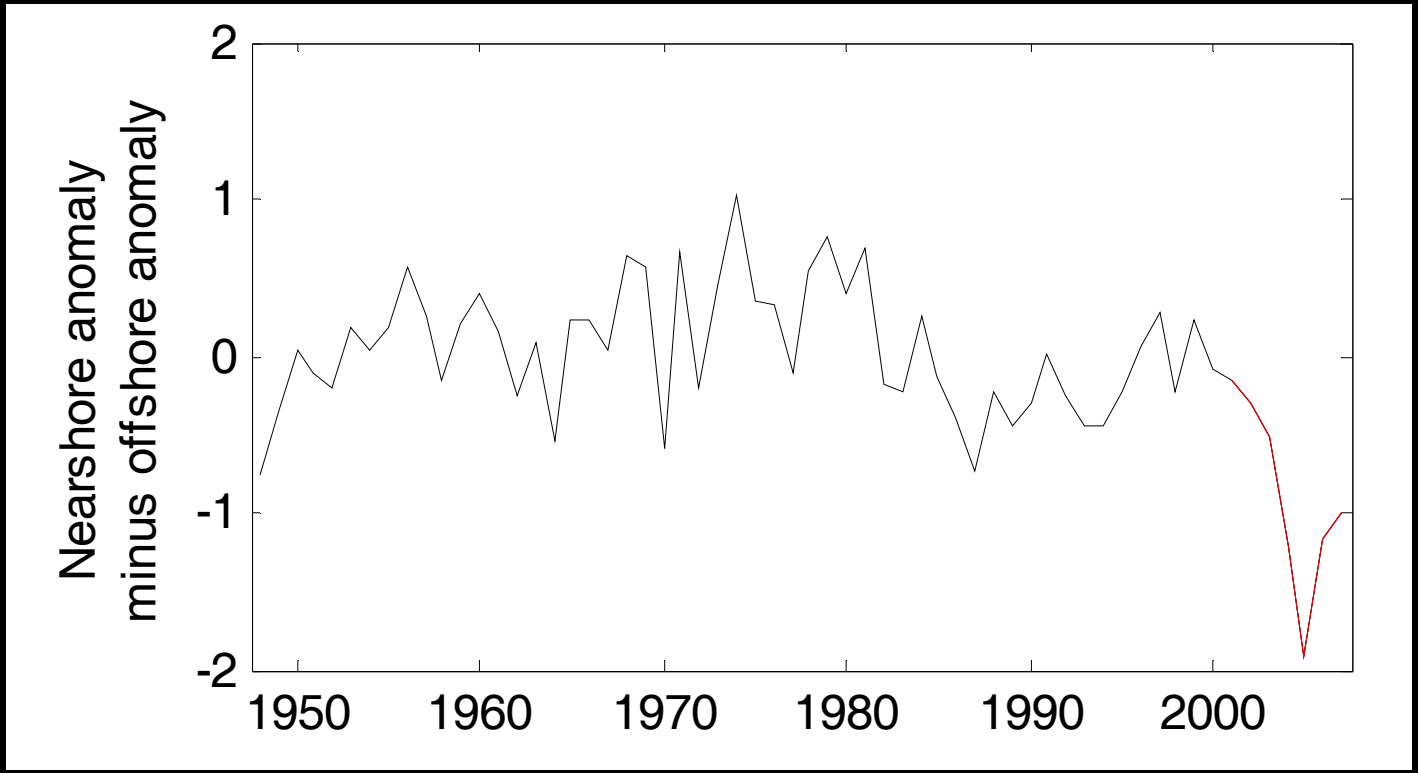
Wind structure and upwelling

Difference between curl-derived upwelling along coast and off the continental shelf*.



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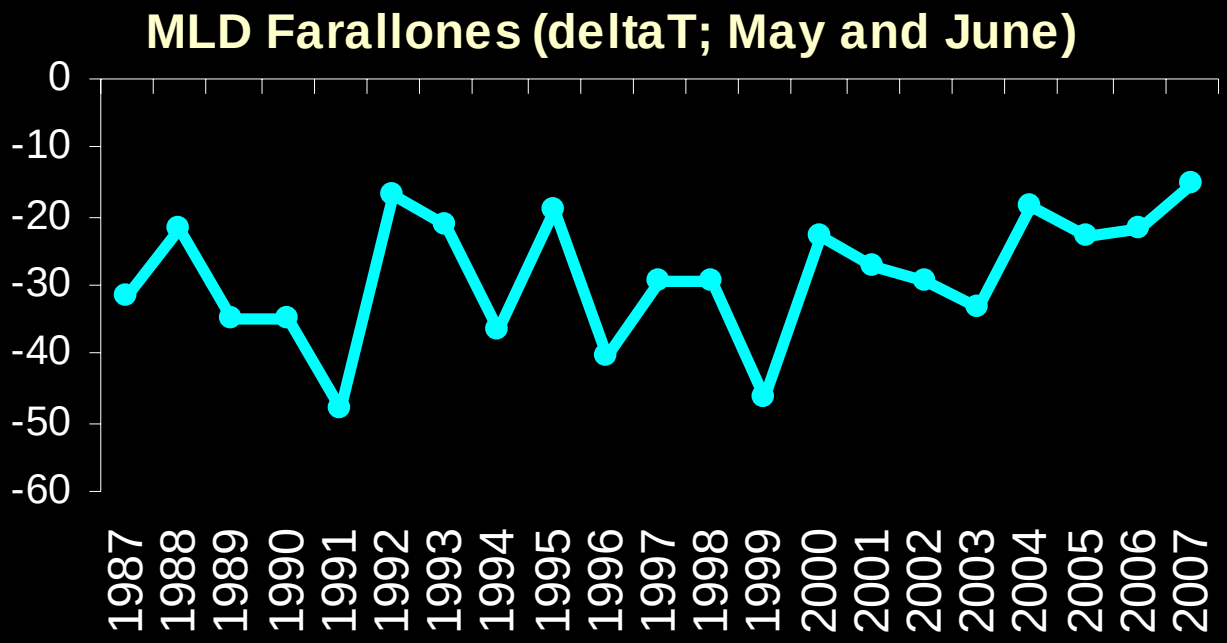
Source: Ryan Rykaczewski

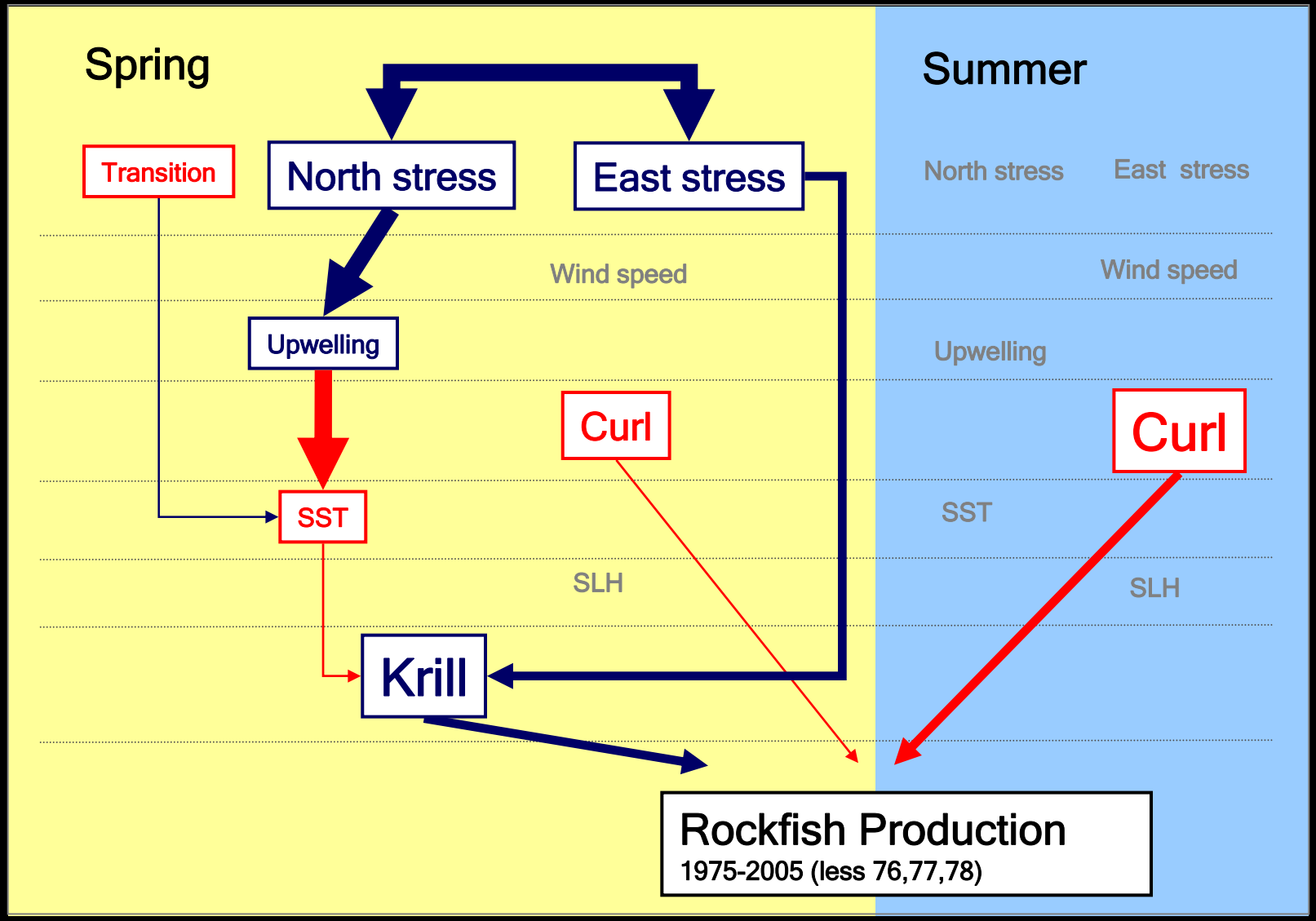
Mixed layer depth (represented here by thermocline)

Reduced upwelling around Farallon Islands can lead to a strongly stratified production layer.



Source: FED NOAA

How important are curl and krill to production of upper trophic levels?



Source: Wells et al. 2008

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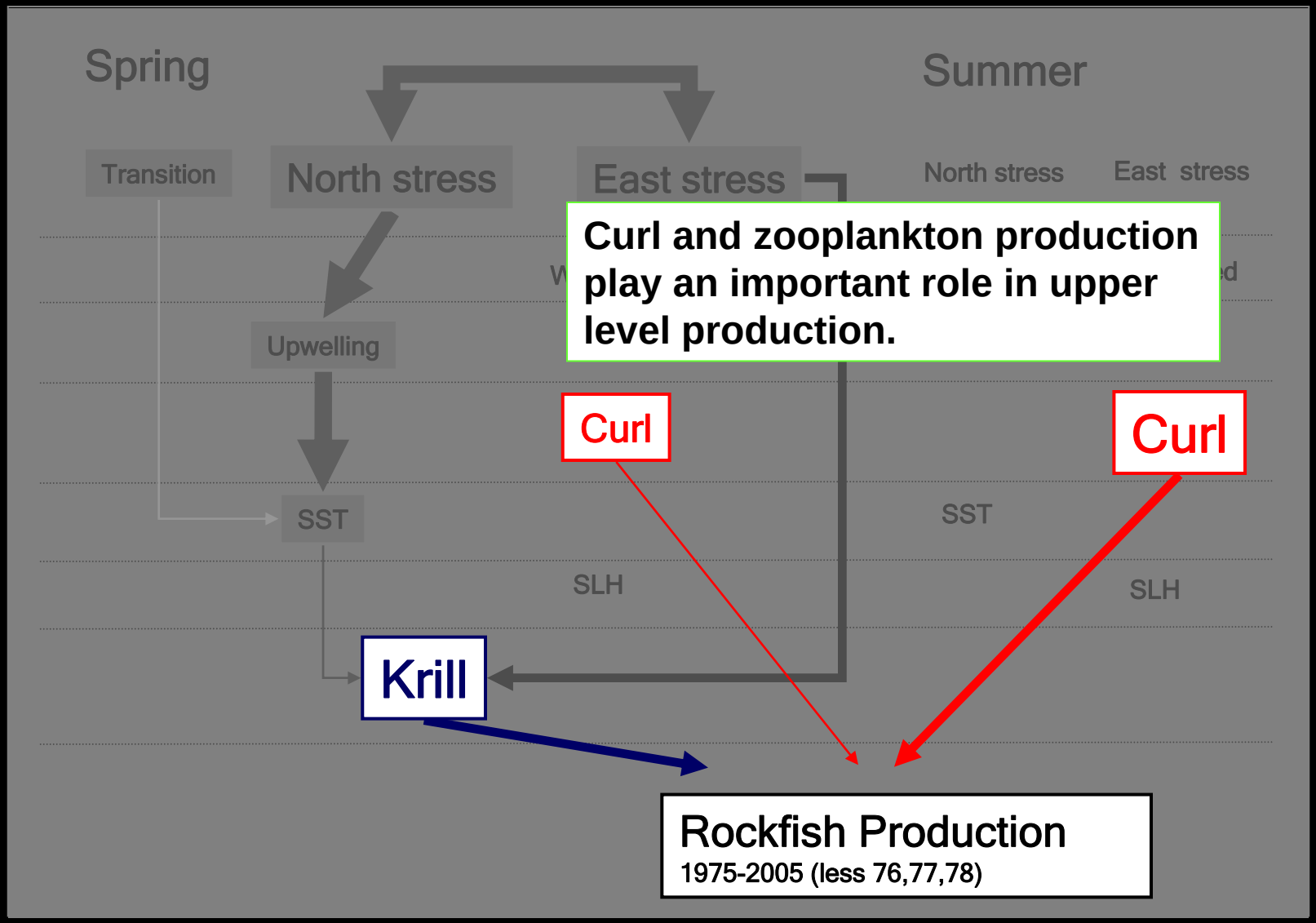

Source: Wells et al. 2008

We can go the next step of fitting trophic chain to the environment.

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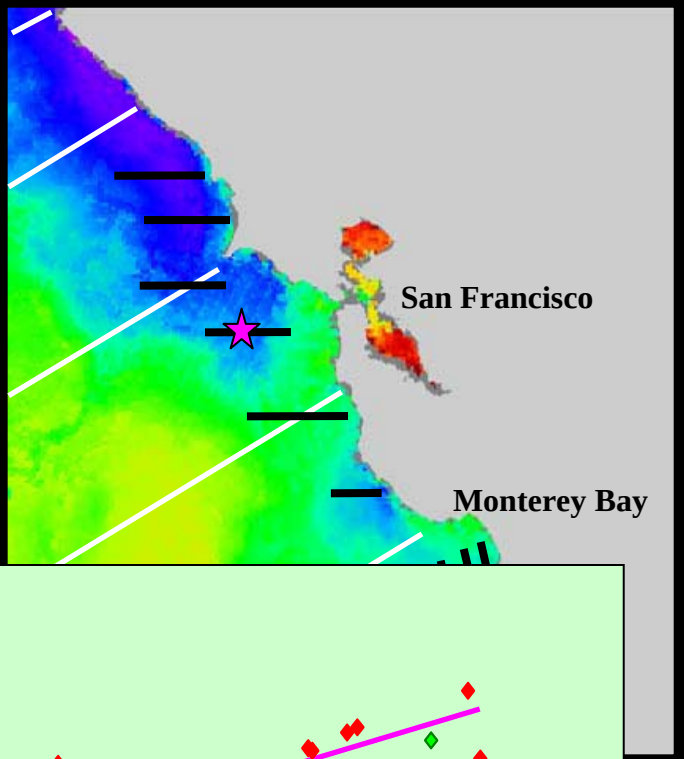
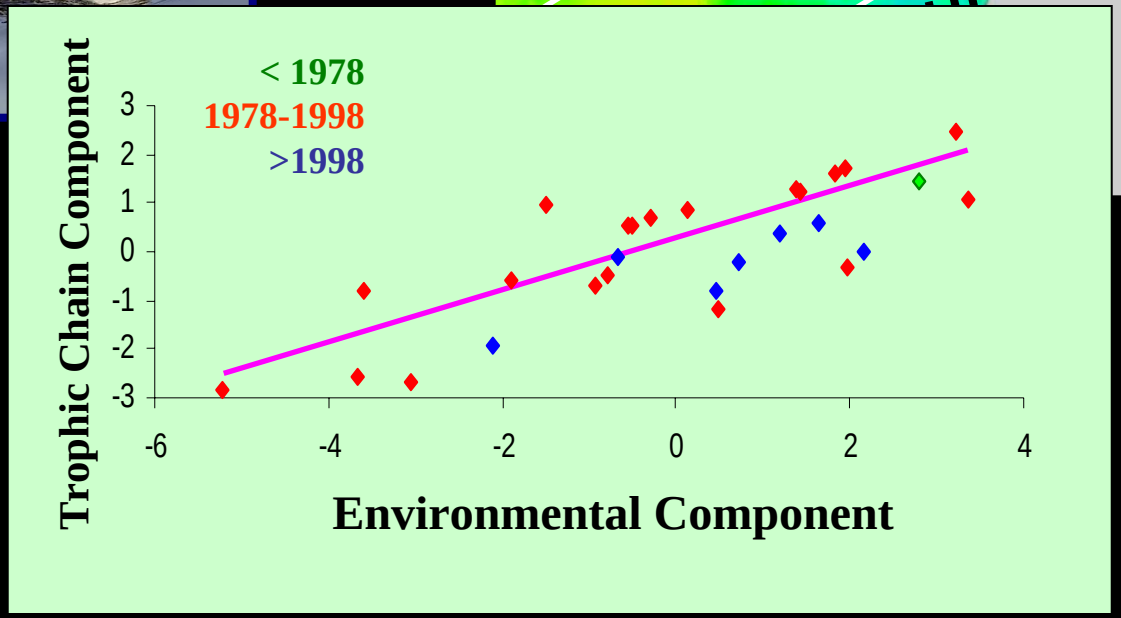
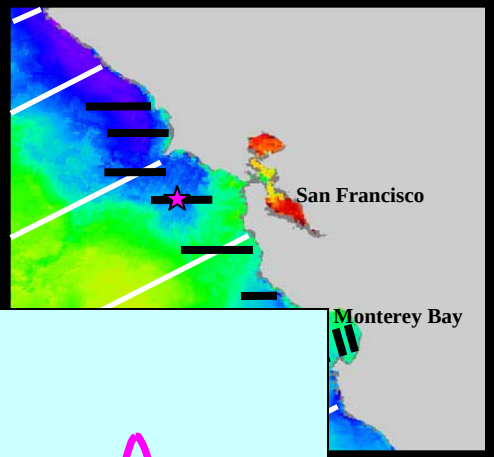


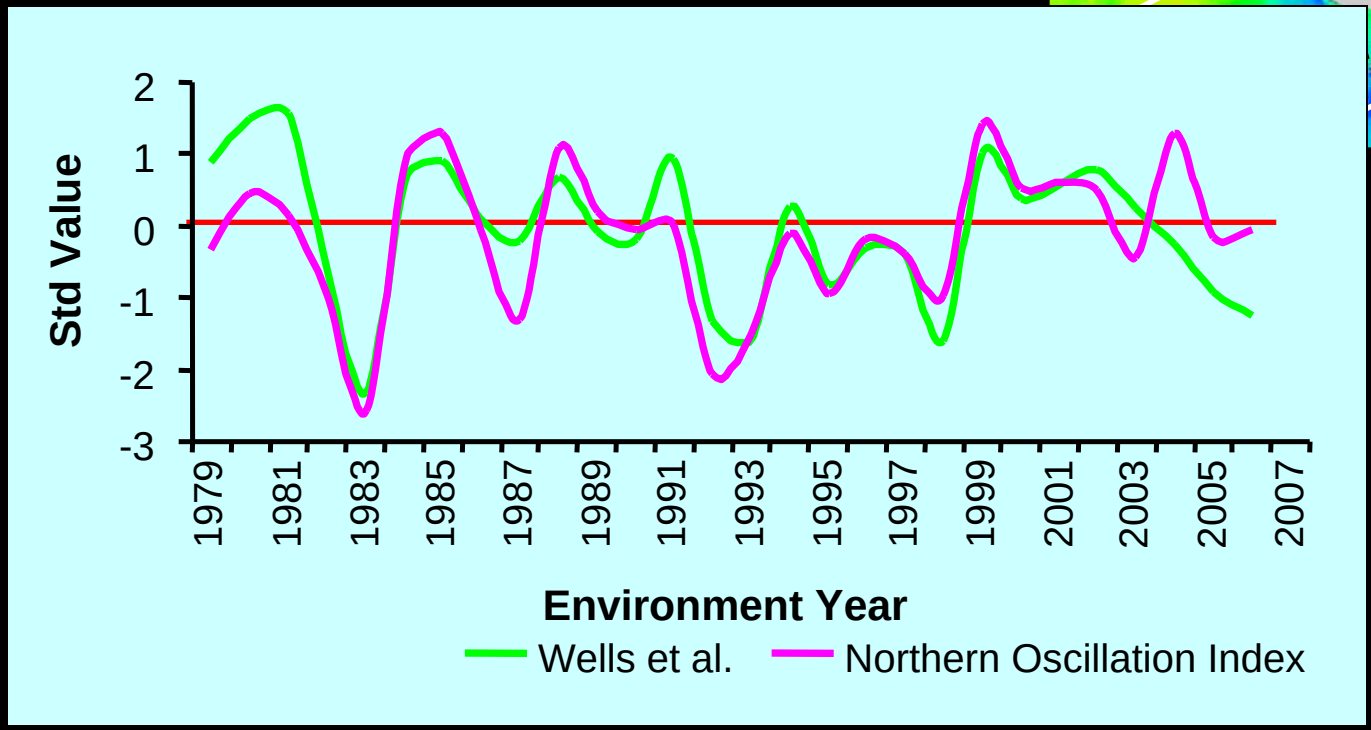


Source: Wells et al. 2008

From this comes an environmental index of production

The environmental component tracks well with other indices of California Current conditions but is driven by local conditions. Note the divergence in recent years.



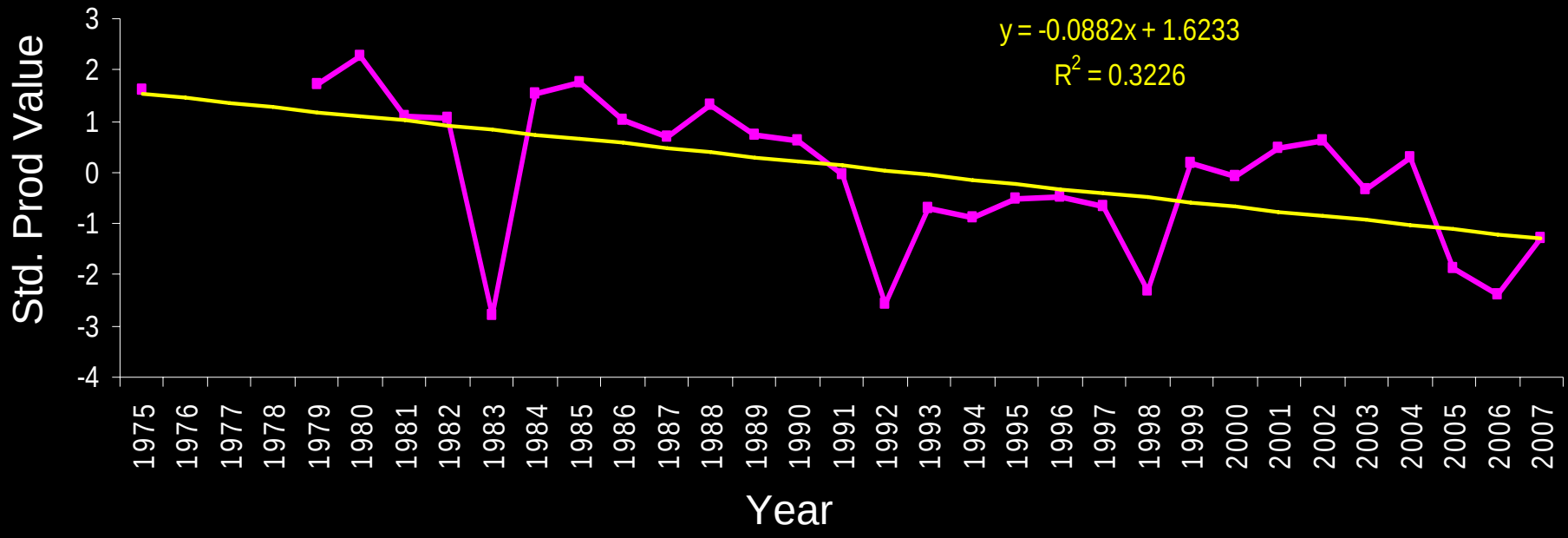


Source: Wells et al. 2008

If we plot that community production over time we see a decline in production

The productivity component can be used to examine the trends in productivity over time.

Murre Chain



Conclusions

We demonstrate that there has been trend in wind structure and derived upwelling along Central California.

Intensification of off-shore winds relative to in-shore winds has setup a dynamic for possibly improved primary production but reduced production of higher trophic levels.

There has been a decline in the community production over the past three decades.

It is unclear if our observations relate to climate change but they do fit well into the predicted trends put forward by the existing literature.

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