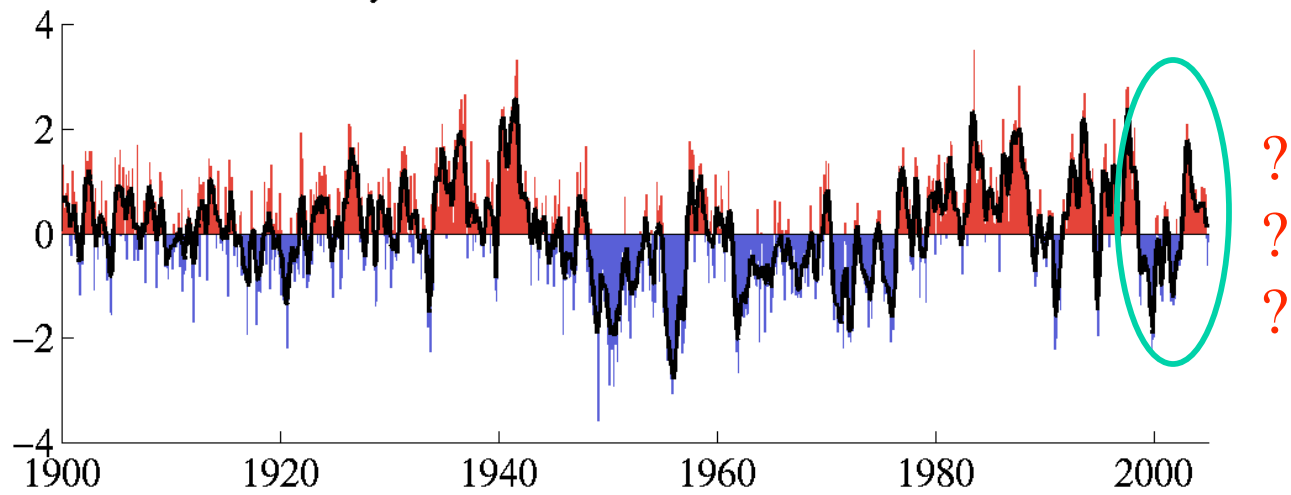


Pacific Decadal Oscillations

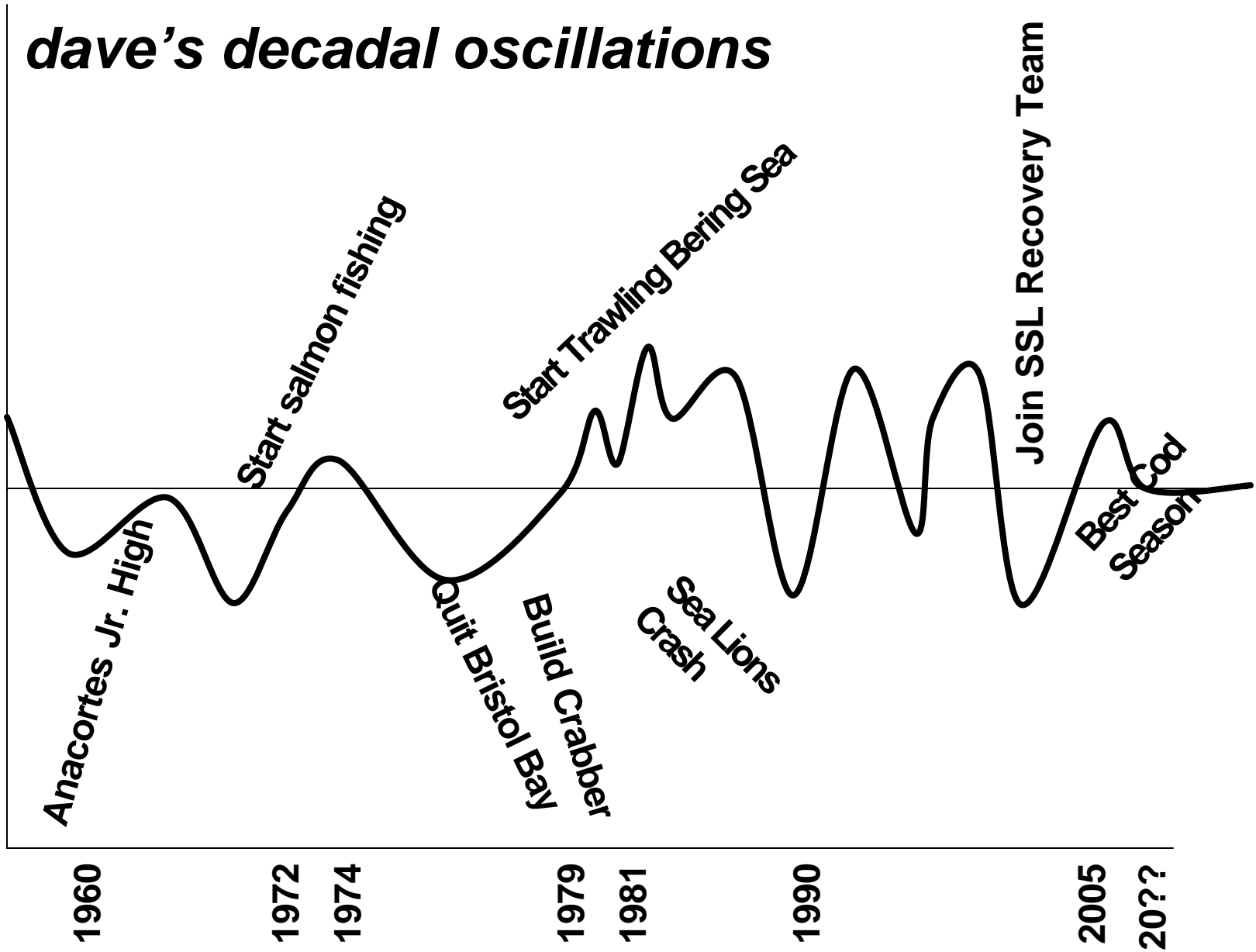
PDO
vs.
DDO

dave's decadal oscillations

monthly values for the PDO index: 1900–2004



dave's decadal oscillations



1972 ... In the Beginning - West Coast Salmon



1974 ... West Coast Salmon



...and on to Bristol Bay

1979...Let's Build a Crabber



1981...Luckily it's also a Trawler



Bering Sea Ecosystem Study Program

- **The Goal:**

...develop a fundamental understanding of how climate change will affect the marine ecosystems of the eastern Bering Sea, the continued use of its resources, and the economic, social and cultural sustainability of the people who depend on it.

- **The Hurdle:**

...a lack of models that link global climate forcing, through physical oceanography, through the impact on functional groups/communities, and up to the broader ecosystem consequences of these responses, including potential impacts on Bering Sea villagers, commercial fishers, and other people harvesting the Bering Sea for their livelihoods.

- **The Challenge:**

... integrating a social science plan
... influencing the shape of this BEST implementation plan
...seeking research that engages the linkages between marine productivity and the implications for subsistence harvesters, commercial fishing, and cultures around the Bering Sea.

What Are Commercial Fishermen Reading?

- Fishery Management Documents

 - North Pacific Fishery Management Council
Issue specific management documents

 - Alaska Fisheries Science Center
Annual Stock Assessments
Fishery Evaluation Report section on Ecosystem Considerations
contributions from over 100 researchers
assessment of ecosystem responses to recent regime shifts

- Scientific Literature

 - Articles and research reports that are highlighted in:
the popular press
regional symposia

 - Recent Examples;

 - “A new climate regime in northeast pacific ecosystems” by Peterson and Schwing

 - “Is the Bering Sea stuck in a warm phase?” by Overland, Boldt, Hollowed, Stabeno, Hunt, and Wang

 - “Sentinels for change: sites 2 and 4 on the eastern Bering Sea shelf” by Stabeno, Napp, and Whitledge

Some Climate Questions from Commercial Fishermen

1. Has the North Pacific shifted to a different state or regime since the late 1980s?
2. What is the nature of the new state?
3. What are the ecosystem responses?
4. How long can the shift be expected to last?
5. Is it possible to predict when the regime will shift back and what indicators should be used to determine when it happens?
6. What are the implications for the management of marine resources?

Bering Sea Features that Influence Responses of Biota to Climate Forcing

- SEA ICE - which affects underwater light fields, water column temperature structure, and the availability of physical substrate for hauling out (walrus, ice seals);
- STRATIFICATION of the water column - which affects the availability of light and nutrients needed to support primary production, as well as the vertical distribution of many of the smaller planktonic organisms;
- WATER TEMPERATURE - which affects the rates at which physiological processes occur and influences the vertical and horizontal distribution and aggregation of fish.

Some Research Questions from Commercial Fishermen

- **Short Time Scales:** (months)

Pollock roe maturity — When will it happen?

- *likely driven by water temperature*, which influences the seasonal timing at which roe maturation occurs.

- **Intermediate Time Scales:** (a decade)

Pacific cod biomass — How big will it be in ten years?

- *likely affected by stratification of the water column* and by water temperature, winds, and the abundance of larval food and predators.

- **Long Time Scales:** (several decades)

Rockfish biomass — How conservative should management be?

- *likely influenced by changes in climate regimes* and the degree of evolutionary adaptation of these very long-lived fish to alternating favorable and unfavorable reproductive regimes.

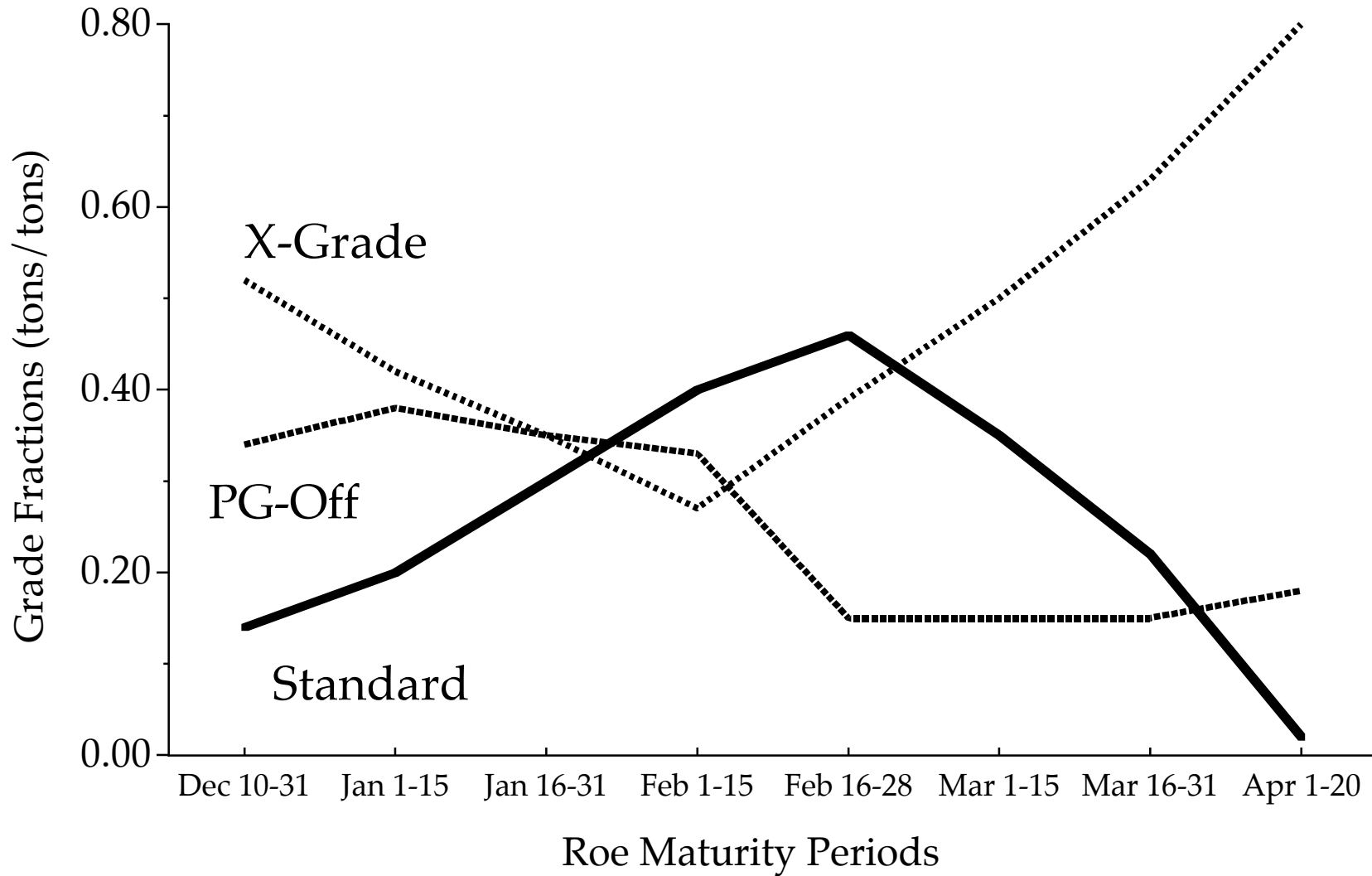
Pollock Roe Maturity Seems to Occur Earlier on the Calendar in Recent Years

Issue Background

Pollock roe is by weight, and in absolute dollar terms, one of the highest-valued products produced from the Bering Sea. Quality and therefore price is determined by the stage of maturity, with both immature or over-mature roe significantly discounted by the market.

In 2001 and again in 2003 Bering Sea pollock roe maturity seemed advanced, with large amounts of over-mature roe harvested soon after the season opened on January 20th. In “normal” years, roe maturity peaks several weeks later, in February. While its possible to advance the season start date, its not an easy thing to do because of concerns over the endangered Steller sea lion. On the other hand, if the season start date is advanced but the maturation cycle is “normal,” then significant amounts of immature roe would likely be harvested.

Pollock Roe Grade Fractions Over the Annual Maturation Cycle



Source: Traditional ecological and economic knowledge.

Catcher-Processor Roe Values by Grade, US Dollars, 2003-2004.

Year	Roe Grade	Tons	Value (\$)	Average Value (\$/lb)	Range (\$/lb)
2003	Standard	3,909	\$67,025,021	<u>7.78</u>	6.50 - 8.91
	PG-Off	998	\$12,252,761	5.63	4.92 - 7.13
	X-Grade	1,106	\$6,694,657	<u>2.75</u>	1.58 - 4.45
		<hr style="width: 100%; border: 0.5px solid black;"/>	6,002	<hr style="width: 100%; border: 0.5px solid black;"/>	\$85,972,439
2004	Standard	4,299	\$81,999,172	8.65	7.27 - 9.79
	PG-Off	1,975	\$26,476,736	6.08	4.10 - 7.74
	X-Grade	2,423	\$17,669,083	3.31	1.36 - 5.67
		<hr style="width: 100%; border: 0.5px solid black;"/>	8,698	<hr style="width: 100%; border: 0.5px solid black;"/>	\$126,144,990

Source: Bill Atkinson's New Report 990, 991, 995, 996, 1039, 1041, and 1045.

Pollock Roe Maturity Seems to Occur Earlier on the Calendar in Recent Years

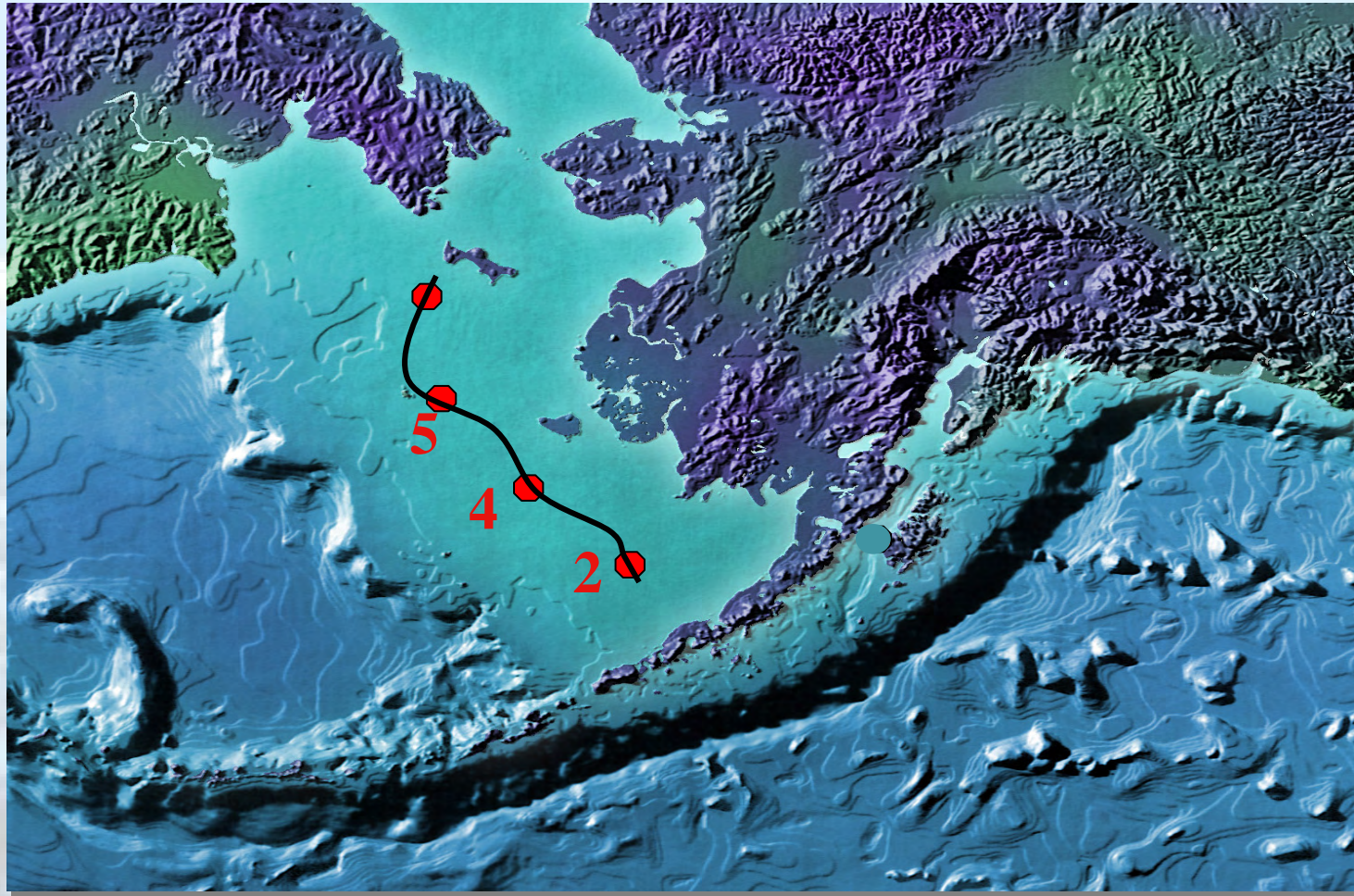
Potential Research Topic

The industry suspects that pollock roe maturation is influenced by water temperature on the eastern Bering Sea shelf, and that ***it may be possible to forecast the position of the roe maturation schedule in advance*** based on water temperature developments during the preceding fall period. Recent research on temperature changes tracked at Mooring Two indicates that water-column temperatures may prove useful as an index of pollock roe maturation changes, but the data is not available in real time.

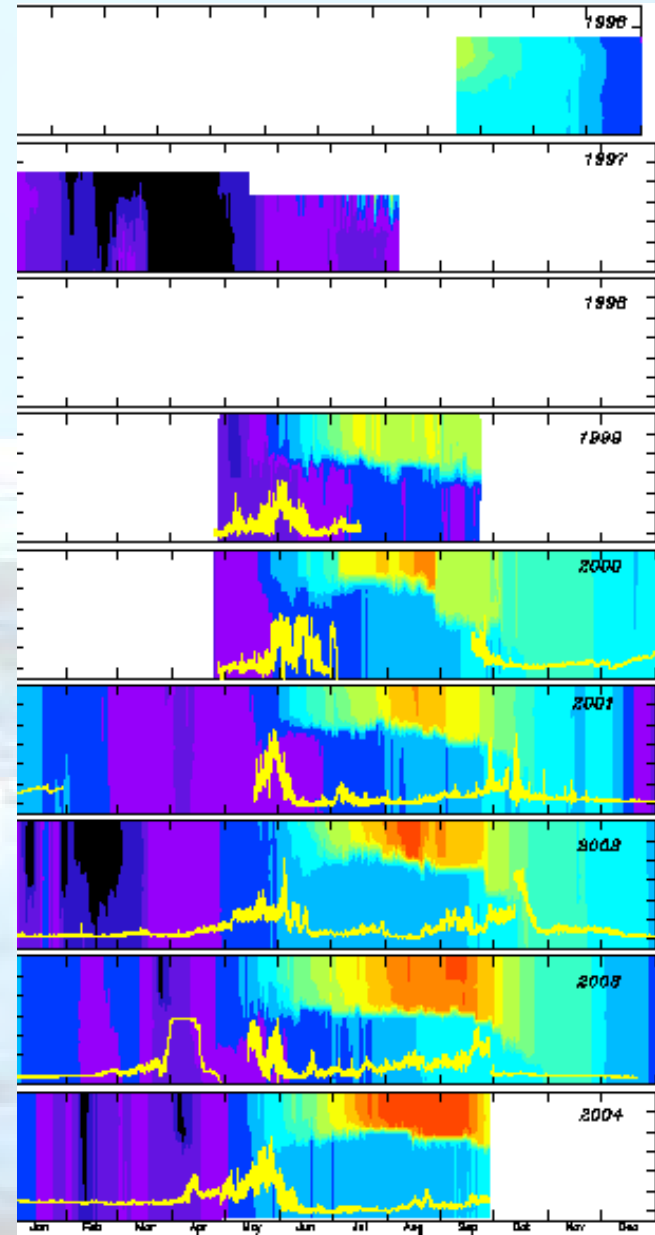
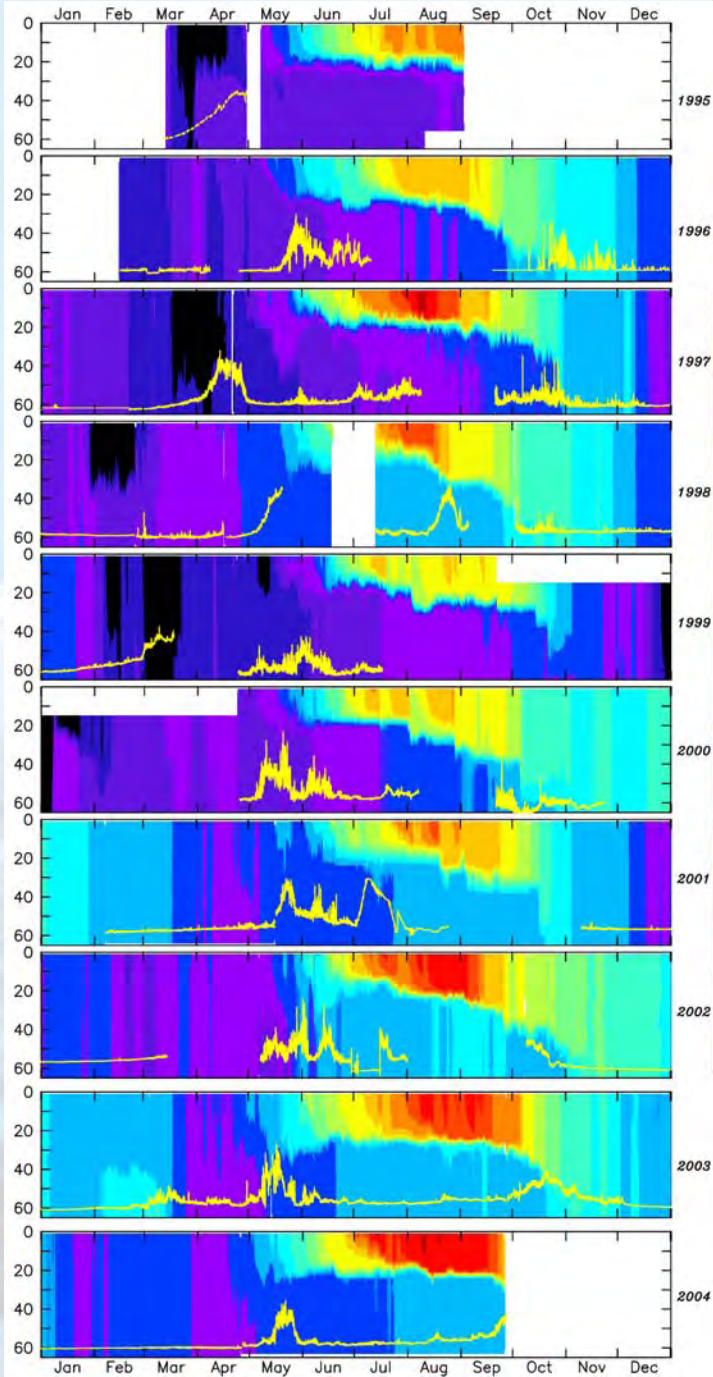
What would it take to increase the availability of eastern Bering Sea water temperature data and to begin research on its relationship to pollock roe maturity?

Perhaps there are other resource issues (***salmon bycatch***) that would benefit from real-time data on temperature changes on the Bering Sea shelf?

Mooring Sites



Temperature and fluorescence at Sites 2 (left) and 4 (right)



Fishermen Want to Know Whether the Pacific Cod Biomass Will Increase or Decrease

Issue Background

Pacific cod is a valuable species that inhabits the Bering Sea and Aleutian Islands. The fishery is extremely diverse with a wide range of user groups dependent on benefits obtained from selling or consuming cod. The Alaska cod fisheries are now in the process of being rationalized, with some form of harvest privilege the most likely route to rationalization. With secure use rights, the privilege to harvest cod takes on increased value — in theory a value equal to the net present value of the “stream” of future benefits associated with its harvest.

But how big will be the pie that a harvest share is calculated from?
And where is cod fishing likely to take place?

In Atlantic Canada and the North Sea, cod stocks have plummeted with the cause attributed largely to overfishing. But recent studies have also implicated global warming, with the possibility that cod abundance may not recover due to changes in the location and composition of the phytoplankton and zooplankton that form the base of the food chain.

Fishermen Want to Know Whether the Pacific Cod Biomass Will Increase or Decrease

Potential Research Topic

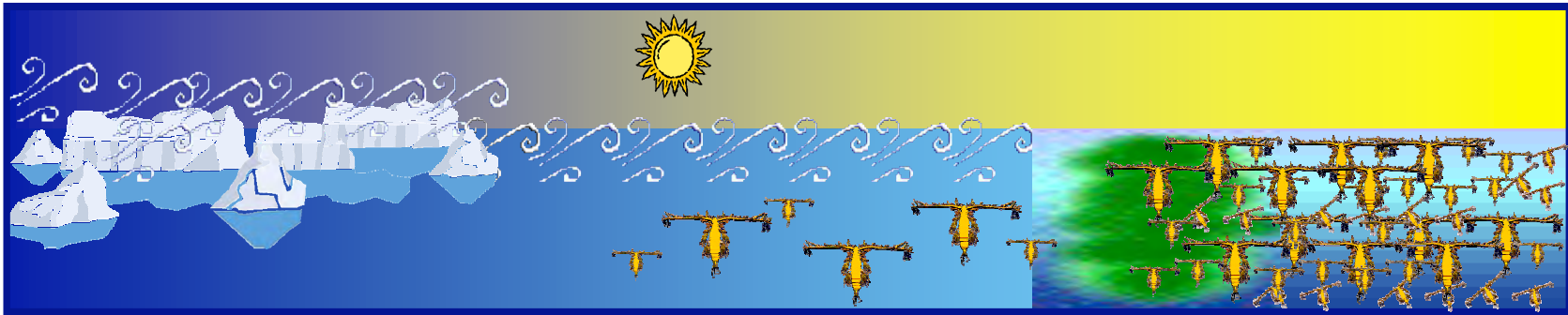
The industry suspects that Pacific cod abundance and distribution is influenced by ice cover and water temperature on the eastern Bering Sea shelf, and that it may be possible to combine climate data with data from the fisheries on abundance and distribution to examine the effects of climate forcing on fish stock abundance in the Bering Sea.

What would it take to begin a research effort that seeks to ***link together cod-stock abundance and distribution data with data on climate forcing as a way to assess the likely future size and location of Pacific cod in the Bering Sea?***

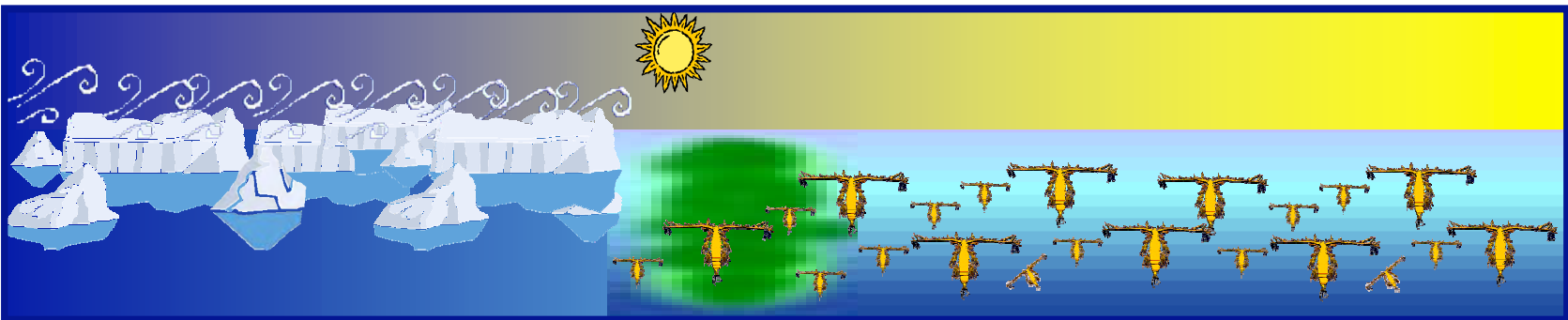
Perhaps there are other fish stocks (***yellowfin sole***) whose future conditions could be related to factors that describe climate forcing throughout the Bering Sea and Aleutian Islands?

Climate affects the ecosystem through sea ice

Early Ice Retreat → Late Bloom, Warm Water - Large Copepod Biomass



Late Ice Retreat → Early Bloom, Cold Water - Small Copepod Biomass



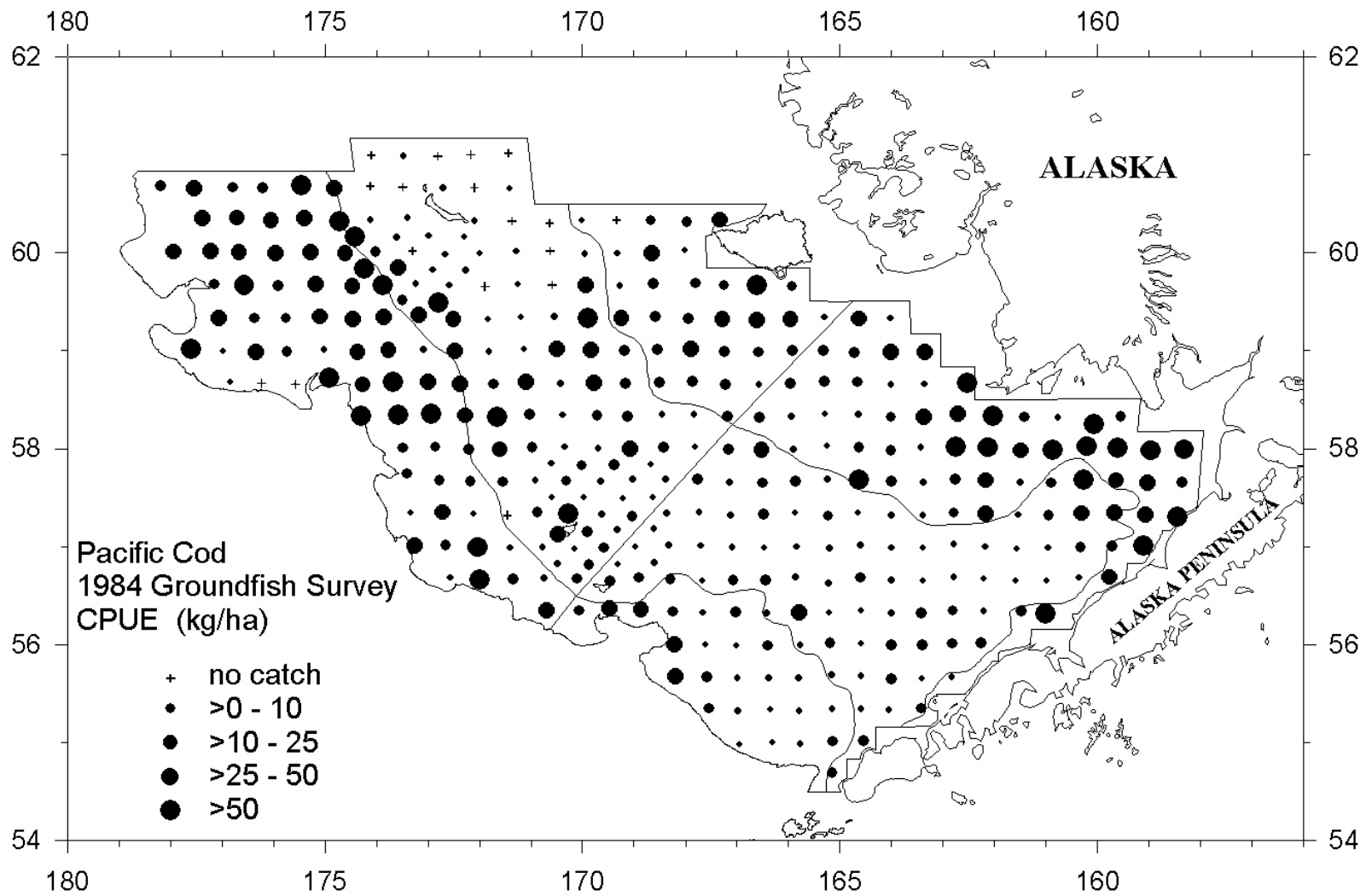
February

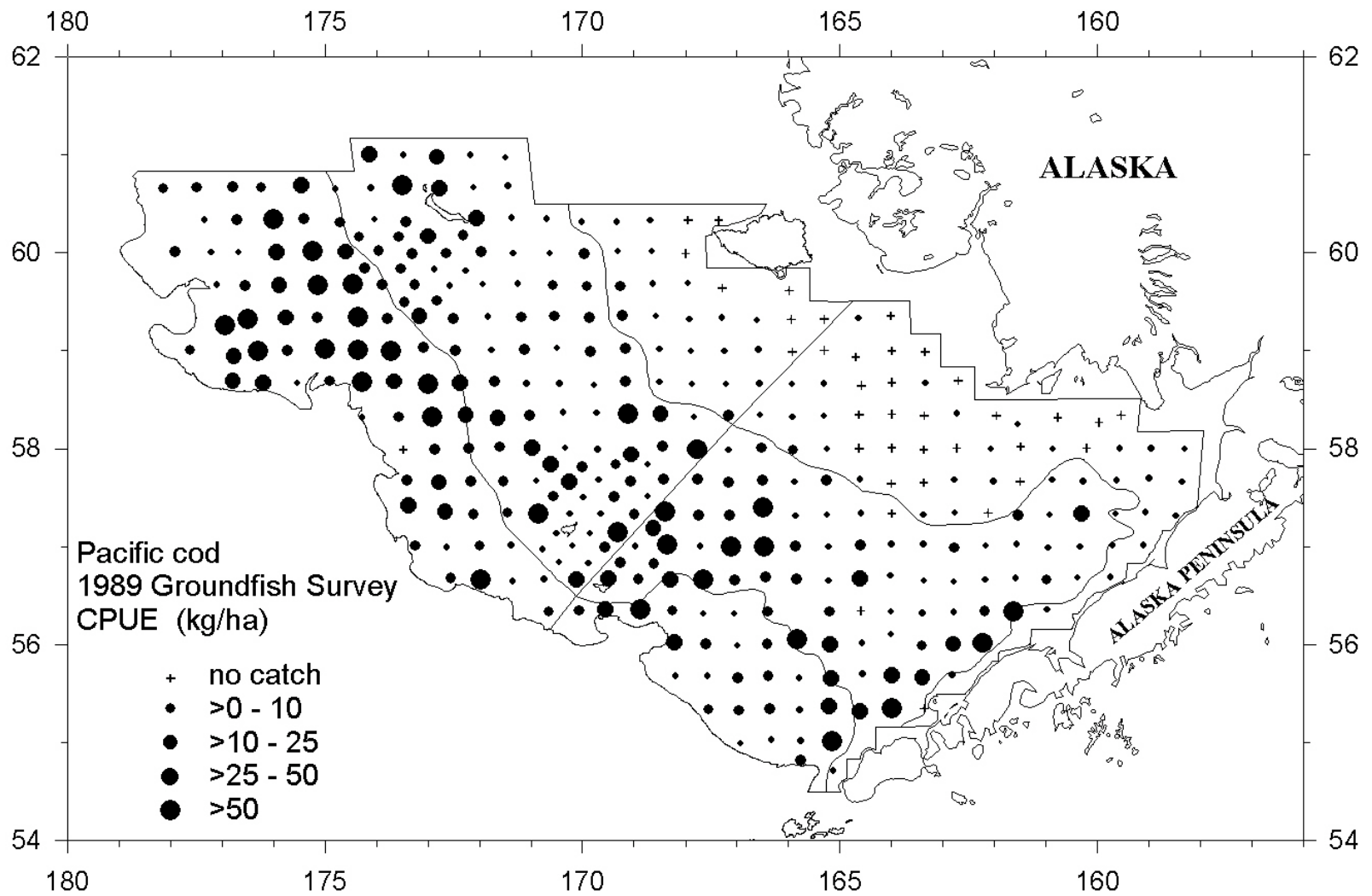
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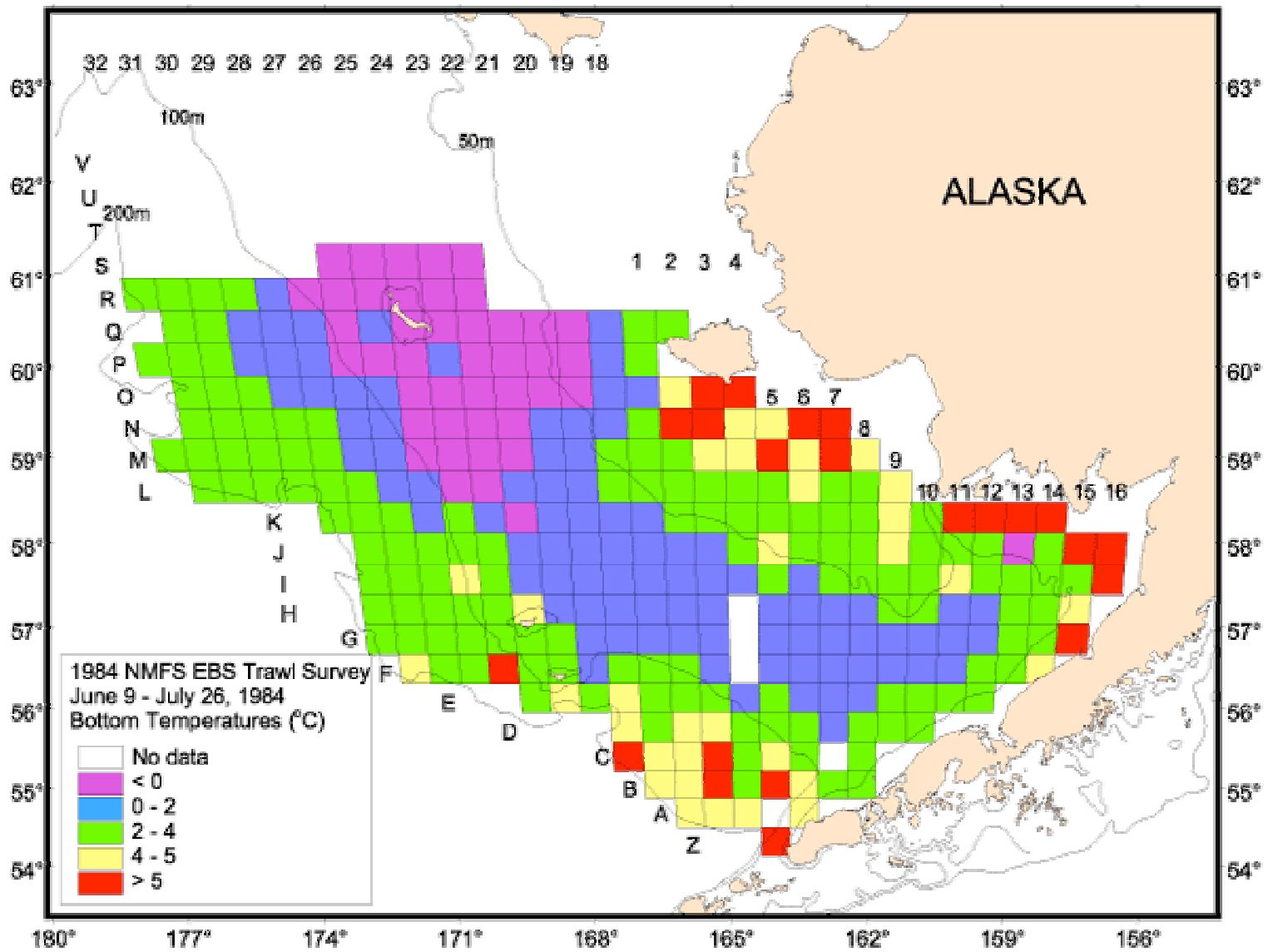
April

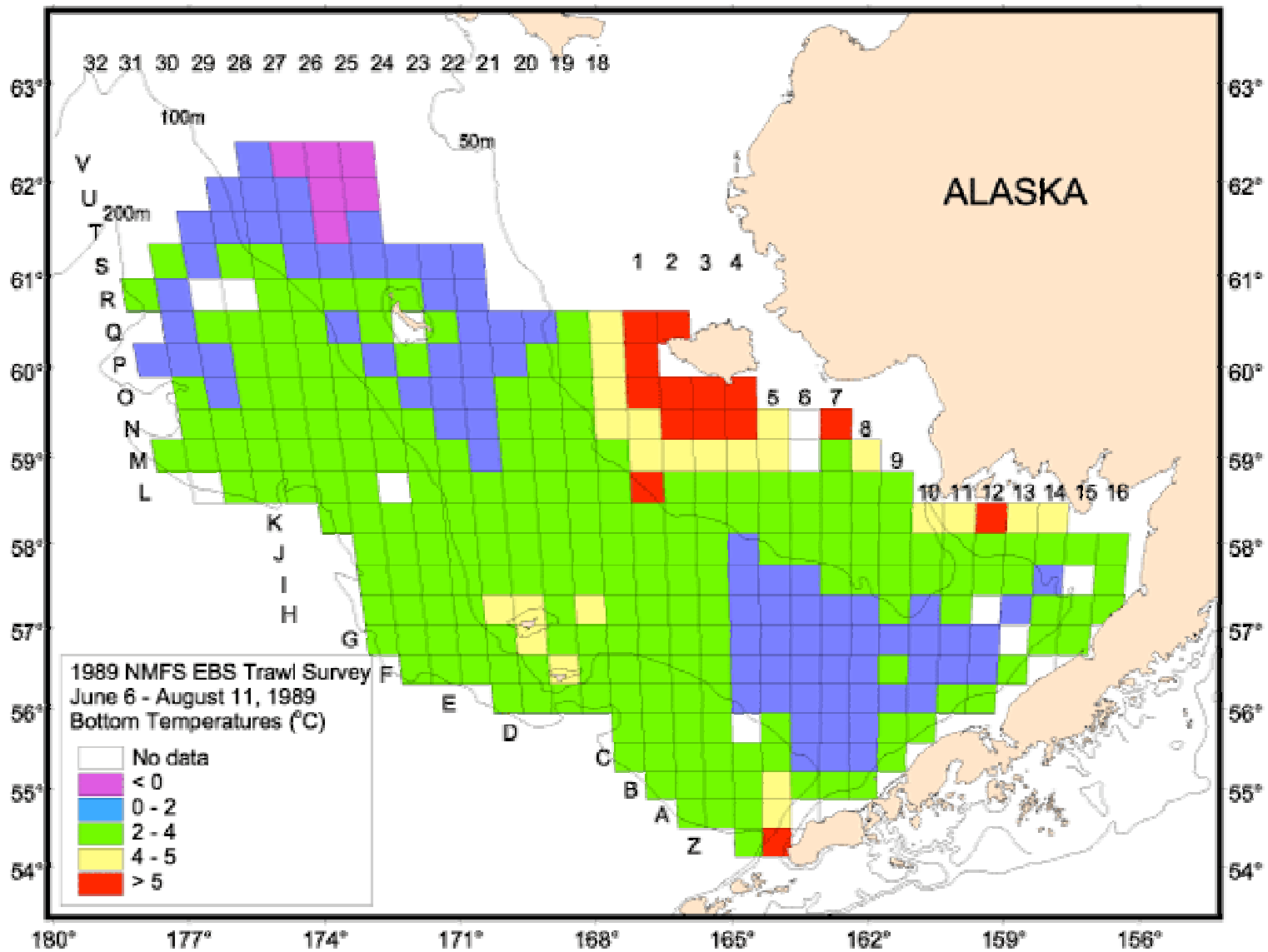
May

June









Yellowfin Sole Effort by Latitude

Year	Count of YFS Hauls	# North of 59 Degrees	% North of 59 Degrees
2003	2051	281	13.7%
2002	1452	221	15.2%
2001	2194	1	0.0%
2000	2666	150	5.6%
1999	1927	55	2.9%
1998	2854	23	0.8%
1997	4759	383	8.0%
1996	2907	278	9.6%
1995	3494	79	2.3%
1994	3794	111	2.9%
1993	3523	572	16.2%
1992	3942	504	12.8%
1991	3182	498	15.7%
1990	505	38	7.5%

Fishermen Want to Know Why Rockfish Live So Long

Issue Background

North Pacific rockfish are a complex of very valuable species that inhabits the deeper waters of the Bering Sea and Aleutian Islands. Commercial fisheries routinely target Pacific ocean perch as well as shortraker, roughey, and thorny-head rockfish. All species appear to be very long lived with a tendency to grow very slowly and to begin reproduction relatively late in life. Recent research indicates that roughey rockfish may live 150 years or more, and there is speculation that the extended life span of rockfish may be an evolutionary response to longer-term climate-regime cycling.

Could this be true? What evidence is there that a reproductive period that lasts for, say, 100 years may increase survival in the face of longer-term climate forcing?

If this were to be true, then is the present climate regime favorable or unfavorable to rockfish reproduction, and why? Should resource management strategies take account of favorable or unfavorable conditions for stock reproduction?

Fishermen Want to Know Why Rockfish Live So Long

Potential Research Topic

Fishery scientists tell us that the rates of reproduction of by many of the zooplankton species are important for the early survival and growth of larval fish. Climate scientists point out that, e.g., ice-induced changes in zooplankton reproduction (timing, species, and magnitude) may propagate as bottom-up forcing, and these bottom-up factors are expected to translate through the marine ecosystem of the Bering Sea, affecting the productivity, distribution, and abundance of fish.

Because rockfish are so long lived, *might it be possible to use Bering Sea rockfish as a means to investigate the influence of longer-term climate forcing on the productivity, distribution, and abundance of fish in general?* That is to say, might it be possible to somehow uncover a record of the effects of previous changes in climate regimes within the populations of Bering Sea rockfish that exist today?

2005... We Still Believe in the One True Cod



But, how long will it last...