Paradigm or Paradox: Can we attribute species changes to environmental variables in central California?

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Summary
Sea Surface Temperature (SST) gradually increased from 1920s to the 1980s in central California.
Since the late 1990s, water temperatures have cooled along the central California coast.
Strengths and trends of correlations among SST and abundances of fishes are highly variable and depend on species and data set used.
The high variability of fish abundance and climate data makes it difficult to detect patterns in species-climate relationships.
Basin-scale indices are better predictors of fish abundance than SST and dissolved oxygen for most species.

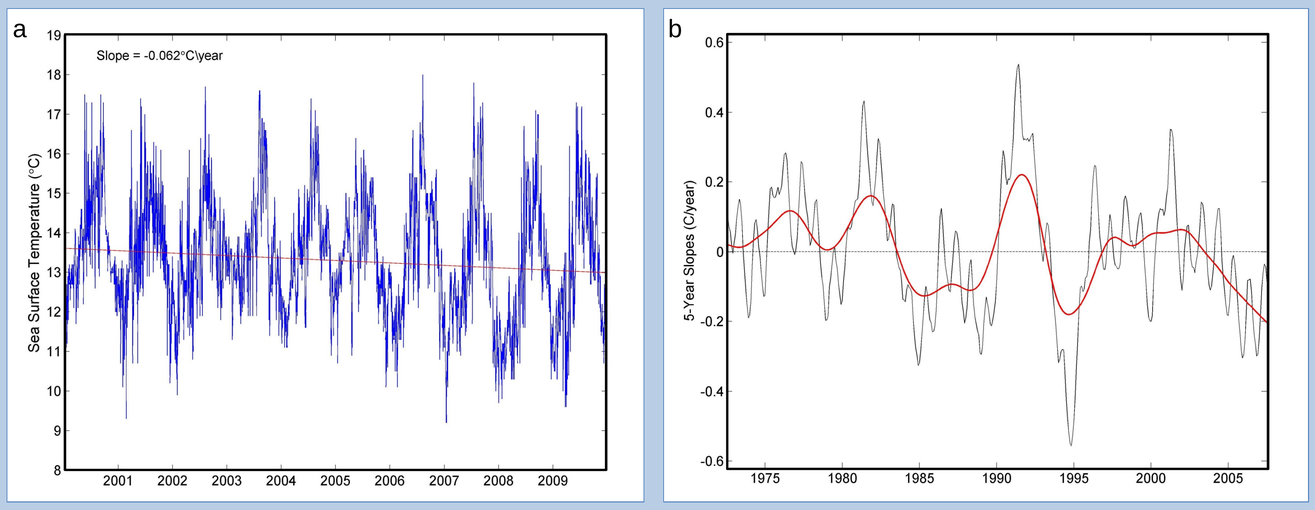
Introduction

Basin-wide fluctuations in temperature and productivity have occurred over the past 100 years in the Pacific with many more predicted in the future.

Global warming is expected to raise ocean temperatures worldwide, although not evenly across the globe.

On the central California coast, a cooling trend in SST over the past 12 years has been observed.

Given these environmental conditions, it is unclear how marine fishes will respond to climate change.



Data from Pacific Grove, CA showing (a) SST and (b) 5-year running slope of SST using data from 1950-2009.

Project Goals

Refine our understanding of trends in SST in central California.

Determine if it is possible to detect relationships between environmental variables and changes in demersal fish assemblages in central California

Quantify changes in the distance of warm isotherms off the central California coast to determine potential relationships between temperature changes and abundance of pelagic species

Results

Cooling of SST has been greater in winter, probably due to increased intensity and frequency of winter storms.

Generalized linear model (GLM) analyses revealed trends in fish abundance were highly dependent on the data set and type of survey data originated from.

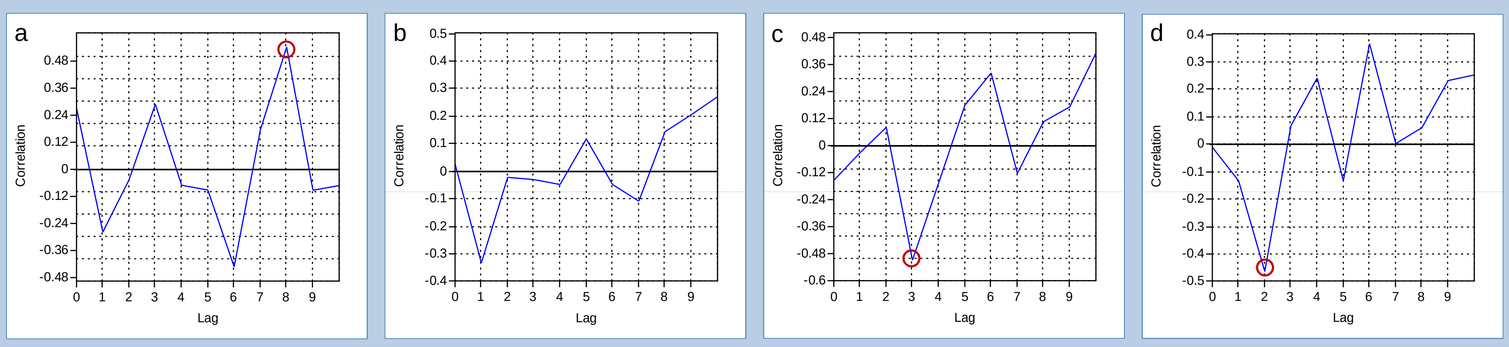
Linear and logistic regressions provided little insight into trends in fish abundance.

Few relationships between SST and fish abundance are clear and discernible, despite having the greatest number of significant relationships for the 35 species examined with cross correlation analyses.

More clear relationships were evident with basin-scale indices and fish abundances than with single variable data. Several conflicting results were still observed.

Intrusions of warm isotherms along the California coast showed no clear trend in abundance of pelagic species from commercial landings data.

	# species	# species with significant results	% species showing similar trends
Pacific Grove SST	35	21	21.4
Dissolved Oxygen	35	10	33.3
El Niño Modoki	35	20	41.7
North Pacific Gyre Oscillation	35	19	38.5



Cross correlation results of Vermilion Rockfish from fishery dependent data with environmental variables: (a) Pacific Grove SST, (b) Dissolved Oxygen, (c) El Niño Modoki, and (d) North Pacific Gyre Oscillation. Significant results are denoted by red circle. SST results show a direct relationship with fish abundance at a lag of 8 years. However, basin-scale indices show an inverse relationship at a lag of 2 or 3 years.

Methods

Short frequency variations were filtered to smooth Pacific Grove SST data to obtain clearer trends in central California.

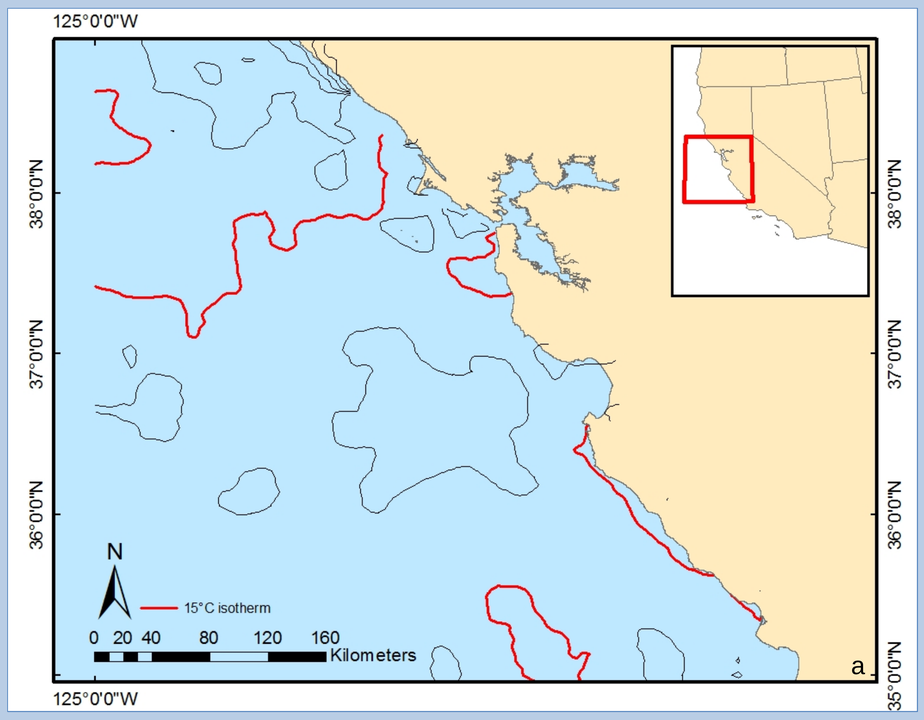
Fish abundance data were from two fishery dependent data sets, commercial landings, and stock assessments. Data analysis with environmental conditions consisted of linear and logistic regressions, Analysis of Variance (ANOVA), and cross correlations.

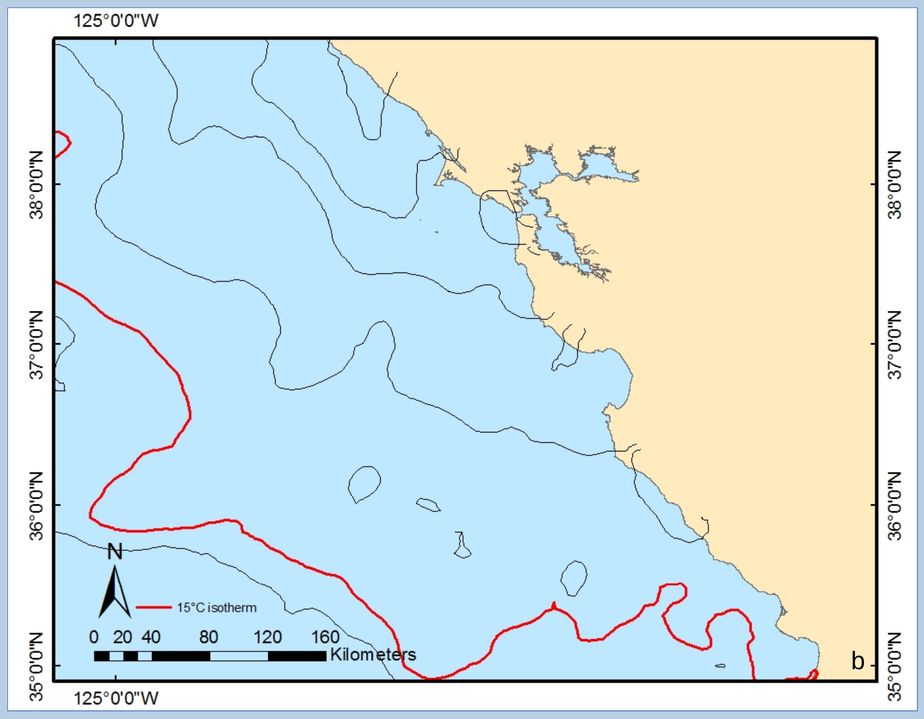
Basin-scale indices were provided by MBARI, dissolved oxygen data from CALCOFI, and SST from Hopkins Marine Station.

GLM was used to smooth abundance data and determine relationships among data sets for species.

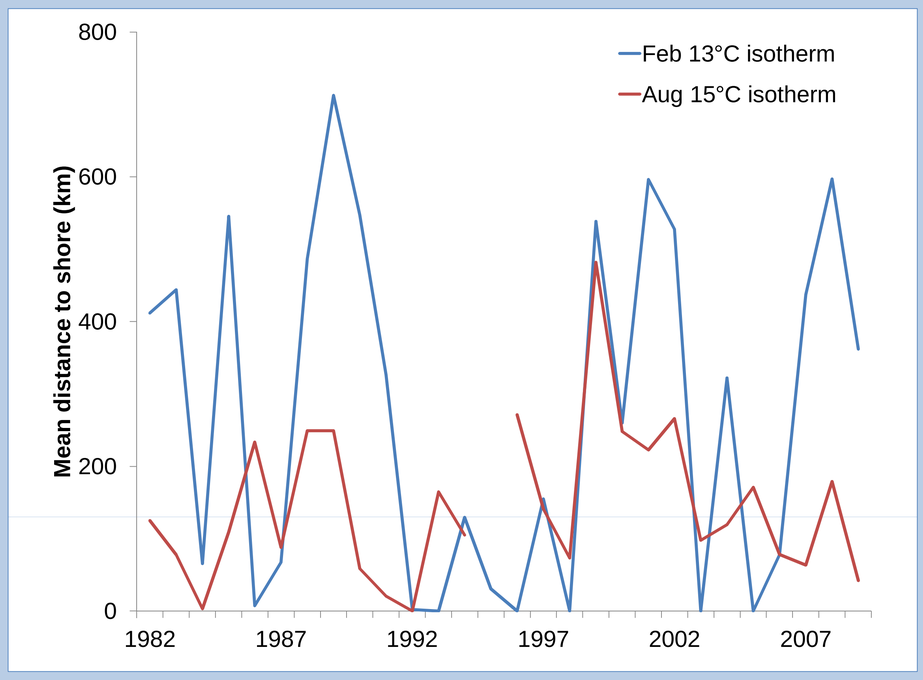
Take Home Messages

1. No single index appropriately describes the variance between fish abundance and climate.
2. Highly variable abundance and SST data make trends difficult to detect.
3. Basin-scale indices are better predictors than localized temperature data for central California.
4. Longer time scales are required to overcome short-term variability.
5. Indices are simply indicators of general trends, not causal relationships with fish abundances.





Map of location of 15° isotherm along the central California coast for (a) August 1984 and (b) August 1986. SSTs were 15°C or greater during August 1984. Two years later in August 1986, temperatures were degrees cooler along central CA.



Mean distance of 13°C and 15°C isotherms to shore between 35.5°N and 37.5°N latitude. Data from August show intrusions of warm, offshore water near to the coast in 1984, 1991, and 1992. Satellite data from August 1995 were unusable.

Acknowledgements
We would like to thank MBARI (Francisco Chavez), PFEL (Dave Foley, Jan Mason, Frank Schwing, and John Petersen), NMFS (John Field), and MLML (Rhett Frantz and the Fisheries and Conservation Biology Lab) for their assistance.