The Effects of Climate Regimes on the Pacific Cod Longline Fishery

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Methods

Data are NMFS observer records from summer 2002-winter 2010 (when VMS data enable trip identification). Warm years are 2002-2005; cold years 2007-2010.

We test the following:

(1) What is the relationship between survey abundance and fishery CPUE?
- Mean standardized (vessel and season) CPUE is compared to estimated fishable abundance (age 3+, estimated using age-length keys from B. Lauth, AFSC)

(2) What is the relationship between climate regime and fishery CPUE?
- Compare mean standardized CPUE between warm and cold climate regimes
- Differences may be caused by cod avoidance of the cold pool
- Compare mean standardized CPUE by month as the cold pool dissipates

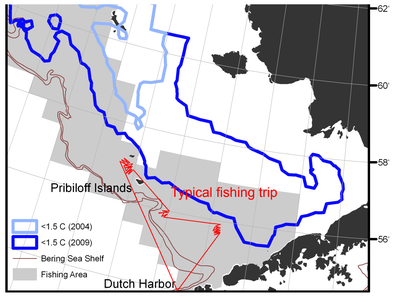
How do vessels respond to different fishery (CPUE) conditions?
- Longline vessels fish in a particular way: they take trips typically characterized by multiple sets in a location, followed by multiple sets in another location.
- We define a "move" as travel between sets >40 km.
- Theoretically, a vessel should fish in one location until CPUE declines such that the benefits of moving are greater than the cost. Barring cost data, we test:

(3) Do vessel moves lead to increased CPUE in new fishing grounds?
- Calculate the change in CPUE ($CPUE_{t+1}$-$CPUE_t$) for consecutive sets. Compare "non-moves" to "moves"

If vessels move in response to CPUE, and CPUE is affected by climate, we can identify the relationship between climate and the fishery response.

(4a) The cold pool dissipates from June-August. Does the persistence of vessels in an area (as measured by number of moves) decrease as the cold pool dissipates within a cold year, when a large cold pool is present?

(4b) Is persistence greater in cold years when the cold pool is larger?
- Compare the kernel densities of the frequency of moves during a trip, over months and over temperature regimes



A longline vessel typically takes trips characterized by multiple sets in one location, followed by multiple sets in another, distinct location.

Introduction

An important part of the Bering Sea Aleutian Islands (BSAI) Pacific cod fishery is the "freezer longline" sector which in 2008 accounted for $220 million of the Pacific cod first wholesale value of $435 million. Climate change in the North Pacific is likely to affect the distribution Pacific cod. A retrospective examination of fishery response to inter-annual climate variability can improve our ability to predict future fishery distributions under warmer climate conditions.

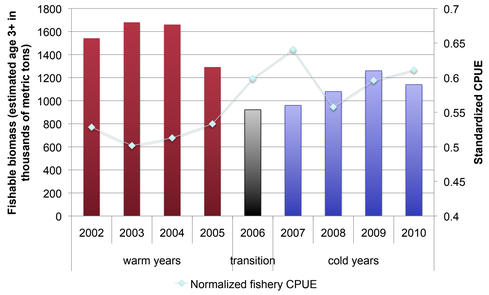
What is the relationship between climate regimes and fishery behavior?

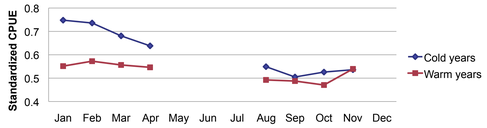
To answer this question, we investigate:
- **The relationship between survey abundance and fishery CPUE**
- **The relationship between climate regime and fishery CPUE**
- **How vessels respond to different fishery (CPUE) conditions, in particular,**
- **How vessel trips change in relation to abundance and CPUE changes that are driven by climate.**

Vessels fish to maximize their net revenue. Higher CPUE increases net revenue, while the cost associated with greater travel decreases it. Here, we explore how climate factors affect CPUE, and how the nature of longline fishing trips (specifically, travel) changes in response. Other factors that make up net revenue will be modeled in detail in future work.

Results

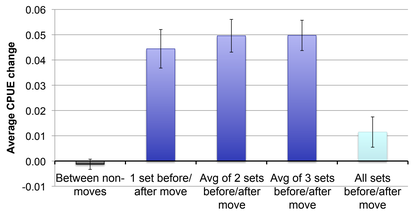
(1 and 2) Relationship between survey abundance and fishery CPUE, and climate regime and fishery CPUE





Very little fishing occurs in May-July (only some CDQ sets) so the mean CPUE for this period is not shown. The biological surveys (EBS bottom trawl and acoustic surveys) occur during June-July, when fishing for Pacific cod was closed, Hilborn and Walters (1992) and others have noted the issues with fishery-dependent data as an index of abundance.

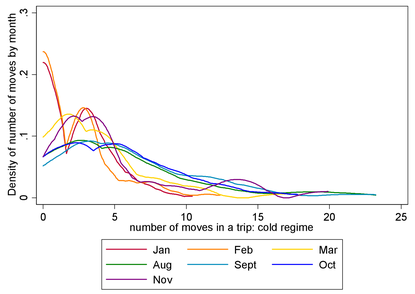
(3) Do vessel movements lead to increased CPUE?



The mean CPUE for all sets is 0.63 kg/hook. CPUE does not change, on average, when a vessel does not move. However, it increases, on average, when a vessel moves to a new location and this increase is sustained throughout the entire sequence of sets after a move.

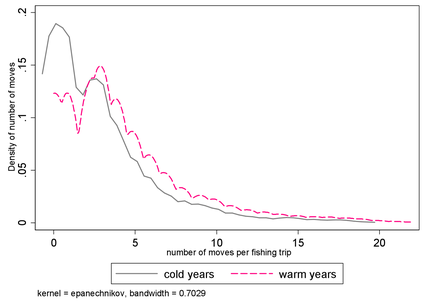
Relationship between vessel behavior and climate

(4a) Monthly difference in frequency of moves for cold years



Persistence of vessels in a fishing area decreases as the cold pool dissipates in cold years. Given (1 and 2), we interpret this as a decrease in the quality of fishing opportunities due to a decrease in CPUE as the cold pool dissipates.

(4b) Differences in the frequency of moves in warm vs. cold years



Persistence of vessels in a fishing area is greater in cold years when the cold pool is larger. We interpret this as a lower quality of fishing in warm years, due to a lower CPUE. This may be due to lower concentration of fish from cold pool avoidance by Pacific cod.

Preliminary Conclusions

(1) Fishery CPUE during the period of study is *higher* when total abundance is lower.

(2) Fishery CPUE is *higher* in cold regime years. It is also higher in months when there is a cold pool, and decreases as the cold pool dissipates.

(3) Vessels make costly moves when the CPUE declines such that the increase in CPUE from moving is greater than the cost.

(4a) The frequency of moves increases as the cold pool dissipates in cold years.

(4b) The frequency of moves is lower in cold years when the cold pool is larger.

Vessels move less when the cold pool is large. Unsurprisingly, vessels are also less likely to move when CPUE is high, thus we posit that the concentration of fish is greater when the cold pool is large.

Costs, in terms of the total distance traveled in a trip and the average number of sets/trip, are higher in warm years.

	cold years	warm years	Difference significant?
Km traveled/ trip	608.7	788.4	yes
km/ton of catch	3.5	4.5	
number of sets	33.0	39.4	yes

IMPLICATIONS and NEXT STEPS

Under future, warmer climate conditions, we expect Pacific cod to be less concentrated over the fishing grounds, which all other things equal, will increase the costs that cod harvesters face.

Modeling work in progress will allow more specific predictions about the increased costs to the fleet of a warmer environment.

References

Hilborn, R. and C. J. Walters (1992). "Quantitative fisheries stock assessment: choice, dynamics, and uncertainty." Reviews in Fish Biology and Fisheries 2: 177-178.

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