Relationships of the catch per unit effort of nearshore rockfishes to environmental variables in central California

Corina I. Marks[1], Richard M. Starr[1,2], Dan P. Malone[3], & Dean E. Wendt[4]

1-Moss Landing Marine Labs, 2-California Sea Grant, 3-University of California, Santa Cruz, 4-CalPoly San Luis Obispo

Introduction

- Fishing is a tool used to measure the relative abundance of fishes.
- Wind, swell, depth, and other environmental factors can influence catch rates.
- The California Collaborative Fisheries Research Program (CCFRP) uses standardized sampling protocols to minimize variation in catch per unit effort (CPUE) that may occur due to seasons, weather, and gear type.
- Here, we use 6 years of vessel-based and remotely sensed data to examine how catchability of fishes varies in relation to environmental factors.

Questions

1. How much variation in CPUE is attributed to geographic and temporal factors along the central coast of California?
2. Do environmental factors affect CPUE differently among study sites?

Methods

1. Select meteorological data pertaining to study sites and sampling days from the National Buoy Data Center and calculate 3 hour, 1 day, 2 day, and 3 day averages.
2. Calculate averages for seafloor habitat variables from high resolution (2 m) elevation models.
3. Aggregate variables associated with each fishing drift (Table 1).
4. Use ANCOVA and forward model selection to determine which variables significantly affect variation in catch rates.
5. Conduct bivariate analyses of significant environmental factors at each site.

Table 1. Predictor variables used in modeling total CPUE and species CPUE.

Variable	Range of Values	Variable	Range of Values
Year	2007 - 2012	Obs. wind speed	0 - 20 kt
Site	Año Nuevo Point Lobos Piedras Blancas Point Buchon	Cloud cover	0 - Clear skies 1 - 25-75% clouds 2 - >75% clouds 3 - Fog
MPA	Inside, Outside	**Externally sourced data**	**Range of Values**
Sample Cell	Nominal by site	Wave height - NOAA buoy	0.7 - 3.3 m
Relief	Low (<1 m), Med. (1-3 m), High (>3 m)	Wind speed - NOAA buoy	0 - 13 m/s
Surface water temp.	8.9 - 16.5 °C	Water temp. - NOAA buoy	12.1 - 17.2 °C
Drift depth	6.4 - 50.0 m	Seabed orbital velocity (*U*)	0.004 - 1.010 m/s
No. seals	0 - 15	Slope (mean, range, SD)	0.76 - 79.08 degrees
No. sea lions	0 - 30	Rugosity(mean, range, SD)	0 - 0.39
Obs. swell height	0 - 10 ft	Depth(mean, range, SD)	6.5 - 55.2 m

Results

1. Weather related variables such as wind and swell accounted for a small amount (<2%) of the variance explained in models of total and species specific CPUE.
2. Types of environmental variables correlated with CPUE differed based on site along the Central Coast (Figure 1).

TOTAL CPUE MODEL RESULTS

Total CPUE = Site*MPA + Year*Site*MPA + Sample Cell*Site*MPA + Wind + Relief + Seals + Drift depth + 3 day avg. wind speed

Total proportion of variance explained by model: 0.34, p <0.001, n = 728 drifts.

Variable	Effect on CPUE	Variance explained	MPA sites with correlations	Covarying factors at sites
Year and Geography		0.305		
Relief	+	0.016	All four sites	None
Obs. Wind	-	0.015	Point Lobos, Point Buchon	None
Seals	-	0.003	No individual sites	None
3 day avg. wind	-	0.001	Point Lobos	2 day avg. wind
Drift depth	-	0.001	Point Lobos	None

SPECIES SPECIFIC MODEL RESULTS

Black Rockfish CPUE = Year*site*MPA + Sample Cell*site*MPA + Relief + Clouds + Drift depth + 3 day avg. *U* + 3 hr. avg. wind

Images courtesy of Larry Allen

Total proportion of variance explained by model: 0.56, p <0.001, n = 728 drifts.

Gopher Rockfish CPUE = Year*site + Sample Cell*site*MPA + Obs. wind speed + 2 day avg. *U* + 3 day avg. wind speed

Total proportion of variance explained by model: 0.36, p <0.001, n = 728 drifts.

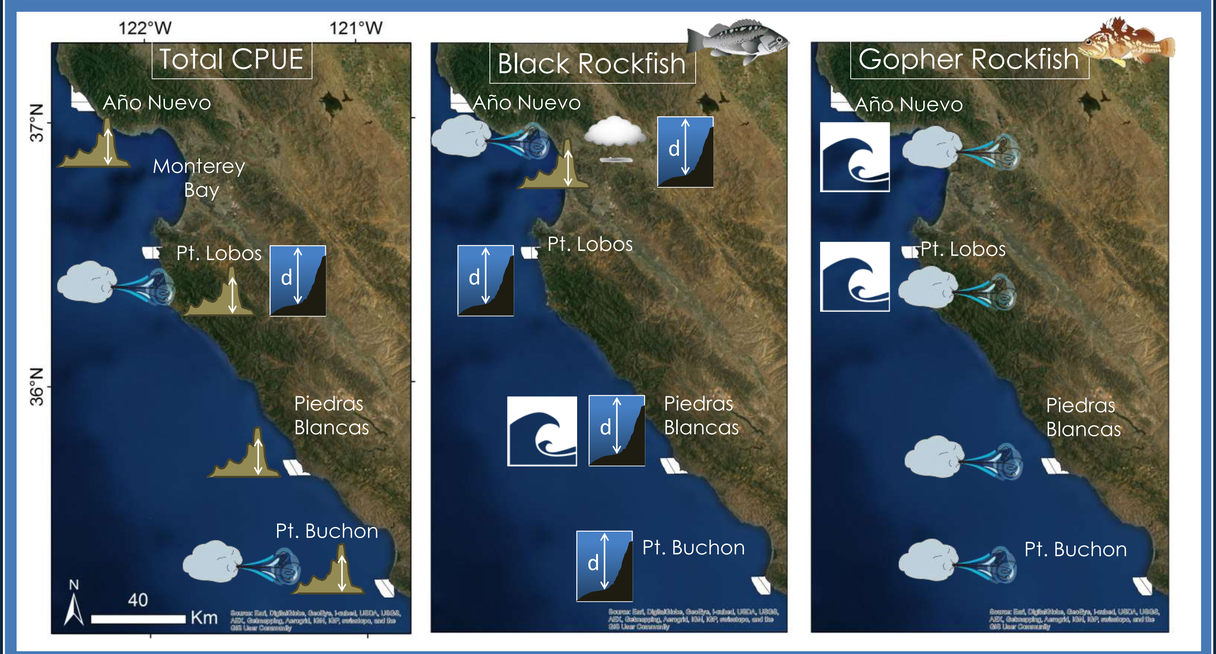

Figure 1. Graphical depictions of environmental variables correlated with CPUE at study sites along the central coast of California.

= Relief = Wind = Depth = Cloud cover = Waves

Discussion

- Swell, temperature, seabed orbital velocity, and predators accounted for little or no variation in CPUE across our study sites on the central coast of California.
- Data here reflect seasonal and daily conditions within the CCFRP sampling design. Greater swell height, wind, and temperature differences may affect catch rates.
- Other factors that could influence catchability of fishes but are not captured in our models include: current, primary productivity, kelp habitat availability, large scale movement patterns of fishes, and competitive behaviors among species.

Acknowledgements

This project has been made possible by funding and/or support by California Sea Grant, the Ocean Protection Council, National Oceanic and Atmospheric Administration, Santa Monica Seafood's Responsible Sourcing Vendor Partner Program, California Department of Fish and Wildlife, the captains and crews of F/Vs Admiral, Caroline, Chubasco, Fiesta, Huli Cat, New Captain Pete, Pacific Horizon, Patriot, Princess, Queen of Hearts, Rita G, Salty Lady, and Tigerfish, as well as our many volunteers.