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Trophic ecology of the Gopher Rockfish (*Sebastes carnatus*): providing baseline
information for monitoring marine protected areas

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Project Hypothesis

Gopher Rockfish diets will differ inside vs. outside of marine protected areas (MPAs) due to higher Gopher Rockfish densities inside MPAs.

Project Goals and Objectives

The goal of this study was to characterize the diet of Gopher Rockfish in central California and investigate the effects of increased conspecific densities on diet in MPAs. Specific objectives were to:

- 1) Describe the diet of the Gopher Rockfish in taxonomic detail to better characterize the role of this fish as a predator;
- 2) Assess the long-term effects of fishing exclusion and increased conspecific density on feeding ecology by comparing Gopher Rockfish diets inside and outside of an MPA that has been established for 35 years (Point Lobos);
- 3) Assess the short-term effects of fishing exclusion and increased conspecific density on feeding ecology across the central California region by comparing Gopher Rockfish diets inside and outside of four newly-established MPAs;
- 4) Investigate environmental factors that could potentially contribute to variation in Gopher Rockfish diet.

Briefly describe project methodology

Gopher Rockfish were collected from four marine protected areas (MPAs) and four corresponding reference areas surveyed by the California Collaborative Fisheries Research Program. These MPA and reference area pairs were located in four geographic locations: Ano Nuevo, Point Lobos, Piedras Blancas, and Point Buchon. Gopher Rockfish were collected with hook and line and trapping gear in the summer and fall of 2007–2009.

Gopher Rockfish diets were investigated using traditional stomach content analysis. Prey were identified to the lowest possible taxonomic groups, enumerated, and weighed wet to the nearest 0.001 g. The contribution of each prey type to the diet was determined using percent prey-specific number (%PN), percent prey-specific weight (%PW), and percent occurrence (%O). Overall importance of each prey type was then calculated using a modified prey-specific version of the Index of Relative Importance: $PSIRI = (%PN + %PW) * \%O$.

Diets were compared inside and outside of the old Point Lobos MPA and inside and outside of four new central California marine protected areas using the following metrics: 1) richness; 2) evenness; 3) composition; 4) trophic level and 5) individual specialization. Prey richness, evenness and composition were compared at two levels of classification, which included 18 taxonomic groups, and 7 ecological feeding guilds. All metrics were compared inside and outside of MPAs using Randomized Complete Block Analysis of Variance or Randomized Complete

Block Multivariate Analysis of Variance. Geographic location (Ano Nuevo, Point Lobos, Piedras Blancas and Point Buchon) was used as the blocking factor in all cases.

To investigate the potential influence of environmental variables on diet that could contribute to differences among geographic locations, a Canonical Correlation Analysis was conducted using environmental and dietary variables. Environmental variables included depth of fish collection, temperature at depth, area of hard substrate in each sampling grid cell, and latitude. Dietary variables consisted of prey weights of 18 prey taxonomic groups.

Describe progress and accomplishments toward meeting goals and objectives.

The stomachs of 1,018 gopher rockfish were collected, of which 710 contained prey items. The contents of these 710 stomachs were identified, and included over 10,500 individual prey items that comprised at least 60 unique species. All of the project objectives were completed using these data (see Project Outcomes).

PROJECT MODIFICATIONS:

Due to time constraints, the proposed stable isotope analysis to examine long-term dietary variation was postponed for future investigation.

PROJECT OUTCOMES:

The Gopher Rockfish was found to be a generalist predator that ate a wide variety of prey types. This project resulted in the most taxonomically detailed description of Gopher Rockfish diet to date. Similar to previous studies, major prey groups included Cancer crabs, spider crabs, brittle stars, and shrimp. Unlike previous studies, fishes were not found to be a highly important prey group, which may be attributable to low rockfish recruitment during the time frame of this study. Furthermore, mysids were found to be important prey that were not documented in previous studies. The mean Gopher Rockfish trophic level calculated from stomach contents was 3.57 and no significant relationship was observed between trophic level and total length.

Diets did not differ inside versus outside the old Point Lobos MPA in terms of prey richness, evenness, and composition at the prey taxonomic and guild levels. Trophic level and individual specialization also did not differ. No consistent differences in these metrics were observed inside versus outside the four new MPAs, although prey evenness and composition did differ significantly among geographic locations. Diets at Ano Nuevo, the most northern and shallow collection location, were dominated by Cancer crabs and porcelain crabs, while diets from southern, deeper locations were dominated by brittle stars.

In the environmental analysis, depth of fish collection was found to have a very strong relationship with prey composition. However, depth was also confounded with geographic location, with collection sites at Ano Nuevo being shallower than the other locations. Thus, there may be other factors.

IMPACTS OF PROJECT:

This work shows that generalist predators such as Gopher Rockfish can serve as samplers of the benthic environment, and can provide information about the presence of many cryptic prey species that are not otherwise surveyed. Our finding of no differences in diet inside and outside of a 35-year-old MPA informs expectations of trophic shifts, by demonstrating that trophic changes not guaranteed in all cases, or may take many decades to manifest. The finding of no difference in diets inside and outside of new MPAs indicates that, despite

greater Gopher Rockfish densities inside the MPAs, Gopher Rockfish populations are likely not at critically high densities where changes in diet would be expected. The central California region is highly productive, and may be capable of supporting many more Gopher Rockfish than it currently does. Differences in diets among geographic locations emphasize the importance of regional habitat types in shaping the local invertebrate community, and thereby the food web structure.

BENEFITS, COMMERCIALIZATION, AND APPLICATION OF PROJECT RESULTS:

The Gopher Rockfish dietary information provided on over 60 prey species can help better characterize the ecosystem players inside and outside of the MPAs surveyed in this project. The baseline diet data that we collected for several new MPAs will make it easier to detect and track changes over time in these locations if they do occur. Differences among geographic areas like those observed here should also inform the analysis of MPAs as a network. Although these MPAs were all established as part of the Central Coast region, it is important to recognize that differences among the areas within a region could influence how MPAs perform. It may be necessary to group MPAs at a finer geographic scale when looking for overall MPA effects.

ECONOMIC BENEFITS generated by discovery

Using fish collected as part of a larger MPA monitoring survey (Sea Grant project RRMPA-4) provided a cost-effective means to investigate the effects of MPAs on Gopher Rockfish feeding ecology. Furthermore, using Gopher Rockfish as benthic samplers of the marine environment provides information about the presence of many small and cryptic invertebrates that would otherwise require costly and labor-intensive benthic surveys.

In a broader context, the results of this study increase the available knowledge of the ecological function of MPAs, which are being used as tools to protect natural resources and the long-term sustainability of fisheries resources. MPAs have many economic benefits, including tourism and recreation, ecosystem goods and services, improved economic outlook for recreational and commercial fisheries, and the non-market value of healthy marine ecosystems.

Issue-based forecast capabilities

The case study of Point Lobos State Marine Reserve provides evidence that trophic changes in MPAs are not guaranteed, and may take several decades to occur. Despite greater fish density inside the Point Lobos MPA, Gopher Rockfish diets were not significantly from nearby reference areas after 35 years of protection. Thus, changes to trophic structure or species composition that result from changes in fish density may take many years to manifest in the central California MPAs, if they occur at all.

Tools, technologies and information services developed

N/A

PUBLICATIONS

Peer-reviewed journal articles or book chapters

Loury, Erin K. 2011. Fishing with a mission: Collaborating to monitor California's marine protected areas. *Fisheries* 36(3):141-142

DOI: 10.080/03632415.2011.10389089

URL: <http://dx.doi.org/10.080/03632415.2011.10389089>

Thesis:

Diet of the Gopher Rockfish (*Sebastes carnatus*) inside and outside of marine protected areas in central California. Erin K. Loury August 2011, Moss Landing Marine Laboratories

Blog Post:

Loury, Erin. 3/30/11. The Colors of Nature in Cancer Crabs and Stunning Sunsets (<http://mlmlblog.wordpress>).

DISSEMINATION OF RESULTS:

The results of this project have or will be disseminated through:
2 peer-reviewed manuscripts, in preparation (one on MPA trophic effects and one detailed diet description of the Gopher Rockfish);
2 oral presentations at conferences;
2 public seminars;
2 poster presentations;
1 Master's thesis

COOPERATING ORGANIZATIONS:Academic

Moss Landing Marine Laboratories
Cal Poly San Luis Obispo

Other

California Collaborative Fisheries Research Program/Teacher Enhancement Program at Moss Landing Marine Laboratories

INTERNATIONAL IMPLICATIONS:

This project provides data on the ecological function of marine protected areas (MPAs) that are part of California's statewide MPA network. Resource managers around the world are increasingly implementing MPAs as tools to protect and manage natural marine resources. Thus, the results of this project can help increase international understanding of the potential ecological effects of MPAs

AWARDS:

Stoye Award for best student oral presentation in Ecology & Ethology (JMIH)

KEYWORDS:

Gopher Rockfish, marine protected areas, diet, feeding ecology, benthic invertebrates

PATENTS:

None

Volunteer Count = 6

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