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# Feeding Behavior of the Widow Rockfish (*Sebastes entomelas*), A Diurnally Feeding Rockfish

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## Introduction

Prior to 1978, widow rockfish landings were an insignificant component of the Northeastern Pacific Groundfish Fishery, but since then, these landings have grown from below 1,000 mt to an estimated 28,000 mt in 1981. This dramatic increase in the fishery has more than doubled the commercial landings of rockfish in the area off California, Oregon and Washington (PFMC 1981). Now the immediate question is how these people that are in this highly competitive business could have overlooked this vast resource all this time. There are many reasons but the principal one is that the widow fishery is fundamentally different from traditional rockfish fisheries. The traditional rockfish fishery is a daytime bottom trawl operation while the widow fishery is a nighttime midwater fishery. Obviously it is important to understand these differences in behavior of the widow rockfish (a nocturnal aggregating species) from the traditional commercially important rockfish species which aggregate diurnally. Actually this is really the converse of the question since in most fish species that aggregate into schools and disperse, it is the dispersed stage when the fish is feeding that is the driving force of this day-night cycle (Hobson 1973).

## Diurnal Feeding

Stomach sample data were taken primarily from commercial landings in the Eureka area, supplemented with other samples from Northern California sport and commercial catches. Most were fish taken in the nighttime midwater fishery. The diet of the widow rockfish consists of salps, fish, (primarily myctophids) shrimp and euphausiids (Table 1). These four groups are roughly equal in the diet and make up over 90% of the total diet volume. The only other commonly occurring prey group is hyperiid amphipods. Phillips (1964) felt that these amphipods domnated the diet of widow rockfish. All these prey groups represent organisms that migrate to the surface at night while the widow rockfish is aggregated near the bottom. So probably these prey are taken during the day in their submerged stage (Adams in prep).

The obvious next step is a directed fishing effort to obtain day and night stomach samples from members of the same population. This data would be used to examine their pattern of gut fullness. This was attempted in conjunction with a NWAFC research cruise that was attempting to make biomass estimates of the widow rockfish population off Oregon. The vessel used in the cruise was the R/V Chapman, a new stern end trawler which is equipped with the most recent electronic and mechanical fishing gear, but even using this boat, we were unable to consistently catch fish in midwater. Midwater fishing is very sophisticated. Besides extensive technological gear, it requires a great deal of fishing experience plus current feedback on the local fishes' schooling behavior. It is questionable whether any research vessel, no matter how suitably equipped, can successfully fish in midwater without extensive prior experience. Nevertheless, we need this type of data to answer the day-night feeding question.

## Seasonal Feeding

There are also strong seasonal differences in the diet considering just the four major groups mentioned earlier; euphausiids, shrimp, salps and fish. These four major groups dominate the diet (accounting for between 82 and 97 percent of the quarterly diet volume), but the distribution of diet volume among the four major groups is different during the year (Figure 1). During the fall, fish dominate, while in the winter, the major prey are shrimp. In the summer quarter, the widows are feeding on euphausiids and fish. The spring quarter is the only period when salps are a major part of the diet. This period and summer are the only time of the year when euphausiids are important. The spring quarter is also the period of highest absolute volume of prey per fish and also of the highest number of prey categories per fish.

This pattern is significant since the widows are feeding most heavily just after they have finished partition (release of young) during winter months (T. Echeverria per. comm.). There is a high demand for energy during reproduction, and following this activity stored energy is at its lowest level. In other species, natural mortality is concentrated during this period (Shul'man 1974), and perhaps this is also true for widow rockfish.

## Discussion

Random sampling is rarely possible in feeding studies; therefore it is important to understand the relationship between different types of sampling and the error involved. How stomach samples are gathered cannot be considered independent of the intended questions that are going to be asked of that data. Samples used here were gathered both from research cruises (directed sampling) and from commercial port sampling (incidental sampling). Average values of the amount of a particular type of prey item will differ from true population values because of variation and bias. Variation is the spread (or dispersion) of the observed sampled values around the mean. The enormous variation typical of food habitat data is due largely to its patchy or contagious nature. These types of data have sampling distributions which are skewed and have a large proportion of empty sample elements. That is, it it common for a prey item to occur in only a few fish, but for those few fish to be stuffed with them. In order to evaluate the relative importance of this type of variation in both direct and indirect sampling, I looked at the degree of patchiness in a research trawl versus a commercial landing using Lloyd's (1967) mean crowding index. For the different major prey groups, the patchiness indices are very similar, with the commercial data consistently less patchy (Table 2). Essentially this means that the relationship between the mean and the variances is similar, and although neither of these data sets are normally distributed, there is not a great deal of difference in this aspect of the data between these two types of sampling.

The other possible source of error, sample bias is simply when certain individuals in the population have a greater chance of being included than others. Bias is unrelated to variation. Confidence limits can be very narrow, but still strongly biased. Bias usually results when the sample coverage of the population is inadequate in some area. In Figure 2, the large distribution is the lengths of fishes used in all of stomach samples from port sampling; the small distribution is the lengths of all widows taken in midwater hauls during the April research cruise. Even though the research cruise sample represents almost 200 fish versus around 500 for the port sampling, the range of lengths in the research survey data covers only a small portion of the length range of the port samples. Both of these samples are biased in different ways. In common usage, the term bias, in common usage, has negative connotations implying a faulty sampling design. But bias is really a problem only when it is unrecognized. Attempts to identify bias must be independent of attempts to reduce variance.

Of the two types of sampling, port sampling has the advantage of much lower costs. Incidental sampling of this sort can provide descriptive information about the target population, an example being the seasonal distribution of food of the widow rockfish. However, except in unusual circumstances, this type of data is not adequate for hypothesis testing. When data are needed to detect differences between subgroups of the target population to verify hypothesis, a directed sampling effort is needed.

The widow rockfish offers a typical example of the evolution of management of a species. Usually, a fishery develops explosively. As with the widow rockfish, usually little or no previous information is available prior to the onset of the fishery. Management plans based completely on age and growth studies are developed after intense fishing has taken place. Traditionally feeding studies had no impact on these plans. I have thought about why this is so and there are two possible reasons. The first is that feeding is an unimportant aspect of the fishes' biology. My studies and the views expressed at this workshop, indicate this is untrue. This leaves the second reason that feeding studies have failed to provide the kind of information that is necessary for management. If this is so, the obvious question is: What kind of information is needed by management?

My idea of the kind of food habit data needed for management is related to how fish communities are structured. Ecological theory concerning community structure has been dominated by the Hutchinson-

MacArthur school of thought. In its simplest form, this type of theory views a community of animals as a unidimensional resources axis upon which species occupy some area or breath. When there are multiple species, a zone of overlap exists where species co-occur. The underlying assumption of this theory is that direct competition is the principal force in determining community structure and therefore controls these patterns of niche breath and overlap. This view regards feeding studies as simply a means of identifying potential competitors. When the diets of offshore fishes are found to be widely overlapping, direct competition for food, and therefore feeding studies, is considered unimportant in management strategies. In the terrestrial communities for which these concepts were developed, this theory has been widely accepted, but in aquatic communities, predation has been found to be one of the most powerful integrating concepts (Hobson 1968; Lowe-McConnel 1975; Paine 1966). An alternative to the Hutchinson-MacArthur model is to view the community as a lattice, then the vertical connections would represent predation and the horizontal connections would be competition. Using this model, predator-prey relationships can be an important factor in community interactions. If there is ever going to be true multi-species management, feeding studies are going to have to focus more toward these vertical connections both above and below the managed species and the mechanisms which control them.

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Table 1. The diet of widow rockfish from Northern California (Average TL = 464 mm, min. Size = 361 mm, Max. Size = 543 mm, n = 365).

| | Number | Volume | Min. Size | Max. Size | Freq. of Occurrence |
|---|---|---|---|---|---|
| Hydromedusae | 1.28 | 3.90 | 1.00 | 4.00 | 0.06 |
| Ctenophora | 0.10 | 0.84 | 0.50 | 3.00 | 0.01 |
| Oligochaeta | - | 0.27 | 90.00 | - | 0.01 |
| Pelagic Polychaeta | 0.07 | 0.56 | 2.50 | 2.70 | 0.01 |
| Pelagic Gastropoda | 0.13 | 0.79 | 7.00 | - | 0.02 |
| Cephalopoda | 0.14 | 0.91 | 50.00 | - | 0.03 |
| Mysidacea | 0.01 | 0.01 | 1.00 | - | 0.01 |
| Isopoda | 0.01 | 0.28 | 1.50 | - | 0.01 |
| Gammaridea | 0.07 | 0.34 | 1.00 | - | 0.03 |
| Hyperiidea | 1.45 | 3.77 | 0.70 | 10.00 | 0.18 |
| Caprellidea | 0.01 | 0.01 | 1.00 | 35.00 | 0.01 |
| Euphausiacea | 30.88 | 21.05 | 6.00 | 36.00 | 0.37 |
| Natantia | 11.78 | 12.78 | 0.30 | 7.00 | 0.20 |
| Ascidiacea | 0.02 | 0.22 | 1.50 | 2.00 | 0.01 |
| Larvacea | 0.11 | 0.03 | 0.30 | 0.68 | 0.01 |
| Thaliacea | 22.98 | 16.74 | 1.00 | 80.00 | 0.370 |
| Chaetognatha | 0.01 | 0.55 | - | - | 0.01 |
| Fish | 5.38 | 24.80 | 1.50 | 90.00 | 0.403 |
| Undet. Gelatinous material | - | 10.22 | 6.00 | - | 0.02 |
| Sand | - | 0.91 | - | - | 0.01 |

Table 2. Lloyd's (1967) index of patchiness for major prey categories from research trawls versus commercial landings.

| Prey Categories | Commercial Landings | Research Trawls |
|---|---|---|
| Euphausiids | 2.72 | 2.30 |
| Salps | 3.94 | 1.34 |
| Shrimp | 10.15 | 10.36 |
| Fish | 10.71 | .24 |

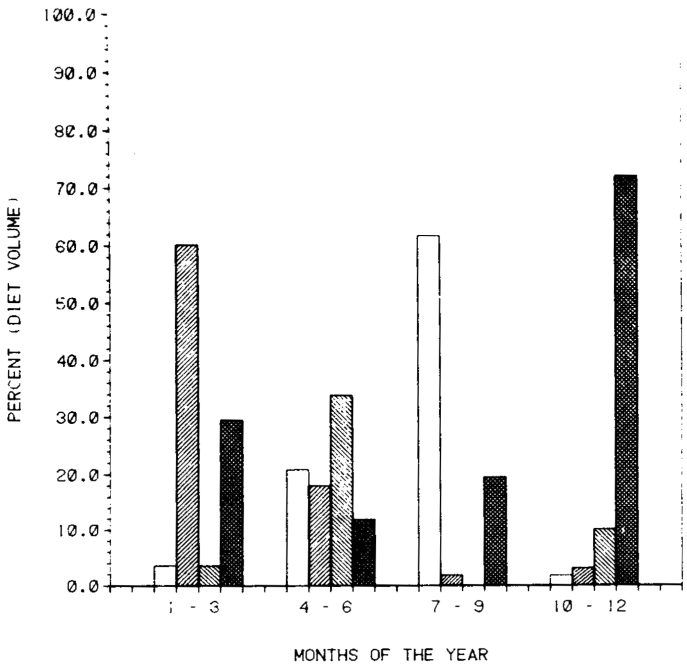


Figure 1. Seasonal feeding of the widow rockfish on salps (clear bar), shrimp (left-hatched bar), euphausiids (right-hatched bar) and fish (cross-hatched bar).

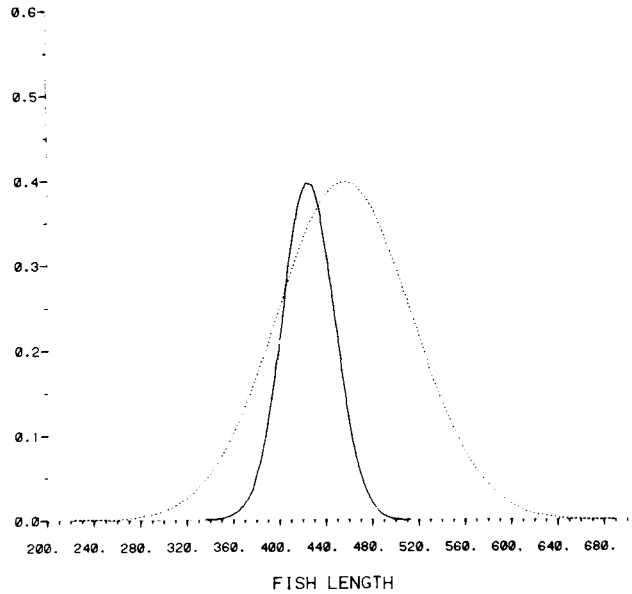


Figure 2. This distribution of lengths of widow rockfish from port sampling (dashed line) and from the April research cruise (solid line).