ROCKS AND FISHES: SUBMERSIBLE OBSERVATIONS IN A SUBMARINE CANYON

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A multi-disciplinary study to assess the importance of small-scale refugia to species of large rockfishes in deep water was undertaken recently in Monterey Bay. Isolated rock habitat at depths suitable for rockfishes in Soquel Canyon (up to 300 m) was identified using fine-scale bathymetry and sidescan sonar imaging, verified with visual observations from a manned submersible, mapped and quantified. Species composition, size, and habitat specificity (type and depth) of fishes associated with these features were estimated using a video camera and parallel laser system along transects made from a submersible. High numbers of large (up to 1 m) rockfishes were locally associated with rock ledges, small caves, crevices, and overhangs. Two distinct assemblages of rockfishes were obvious from clustering analysis; small species were associated with mud and cobble substrata of low relief, while larger species were found under ledges or near large structures on vertical walls, ridges and boulder fields. Relative abundance and size of the largest species were higher and larger, respectively, when estimated from submersible surveys than from partyboat catch records from adjacent areas. We suggest that discontinuous rock outcrops of high relief are inaccessible fishing areas and thereby provide natural refuge for commercially and recreationally important fishes in Soquel Canyon.

INTRODUCTION

Rockfishes (Sebastes sp.) are heavily exploited in recreational and commercial fisheries along the west coast of the United States. These fisheries in California are worth over $1 billion, considering all associated industry, with recreational value far exceeding that of the commercial fisheries (Lenarz 1987). Rockfishes have been harvested

continuously in California with various types of gear (e.g., hook and line, gill net, and trawl) since the early 1900's. Historically, rockfish landings have been especially high in Monterey (Phillips 1939).

Many species of rockfishes are slow-growing, long-lived, and older at maturity. Because of these life history characteristics, as well as patchy distributions and likely residentiality, local stocks of rockfishes are particularly vulnerable to over fishing. Indeed, decline in abundance and size of large species of rockfishes has been noted in recent recreational catches landed in the Monterey area. As local stocks within the bay become depleted, the Monterey fleet has expanded its range to greater distances from port.

Commercial and recreational fisheries can affect the sustainability of coastal rockfish populations by changing their distribution, abundance, and diversity. Accurate assessment of these factors is critical for effective management, protection, and restoration of this resource. Because California is considering the use of marine harvest refugia, and is in the process of designating four marine ecological reserves, it is important to identify and describe the extent of naturally-occurring refugia.

There is little information on the distribution, abundance, and other ecological characteristics of mature rockfishes associated with deep-water rocky habitat in the Monterey Bay area. This type of habitat is beyond SCUBA capabilities, and the rocky substrata prohibit accurate estimates of fish abundance using conventional trawl surveys. Despite this lack of knowledge, deep-water rocky features are important rockfish habitats. Using the submersible *Delta* for two exploratory dives in 1991, we observed high numbers of mature rockfishes and lingcod (Ophiodon elongatus) associated with an isolated rocky outcropping surrounded by a field of mud along the side of a submarine canyon in Monterey Bay. Our observations of species of large rockfishes in deepwater in the Monterey Bay submarine canyon system were somewhat surprising because they represent very low numbers in the hook and line fisheries in the area and are rarely observed during shallow water surveys by scuba divers. Geologists were likewise surprised at the incidence of such variable habitat in a canyon that was thought to be dormant and without the influence of erosion processes.

Our general objective is to assess rockfish resources and their potential habitat in the Monterey Bay submarine canyon system by combining geophysical techniques and submersible observations. Our working hypothesis is that rocky outcrops along the headward sides of these canyons serve as refugia for deep-dwelling rockfishes. We are evaluating rockfish species composition, abundance, and species-specific size distribution within heavily-fished and lightly-fished areas of the same depth and habitat. Because most of the shallow and more accessible rocky areas in Monterey Bay have been heavily fished continuously for most of this century, fishes in these areas expectedly would be fewer in number, smaller, and not yet reproductively active when compared with less accessible areas. Exposed rocky habitat in relatively deep water outside the depth range of recreational fishing could serve as spawning and birthing grounds for larger, and perhaps older individuals of some species, and may produce a significant number of recruits.

METHODOLOGY

This represents preliminary findings during the first year of a multi-year study supported by NOAA National Underseas Research Program (NURP), and conducted by

fisheries biologists from NOAA, National Marine Fisheries Service's Pacific Fisheries Environmental Group (PFEG), Moss Landing Marine Laboratories (MLML), the California Department of Fish and Game (CDFG), and the Marine Science Institute at University of California, Santa Barbara, and geologists from the U.S. Geological Survey (USGS) and MLML.

Our approach to assess rockfish assemblages and their habitat in inaccessible, lightly fished areas included three methodologies performed as three phases of the 1992 pilot study. First we conducted a survey of the bathymetry in our Soquel Canyon study site using a 3.5 kHz echo sounder integrated with Global Positioning System (GPS) navigational data along track lines. From this survey we produced a fairly fine-scale bathymetric map of the area (Fig. 1), with depth contours at only 20 m intervals. We identified areas of high relief and potential slumping, and used this map to select our submersible dive sites.

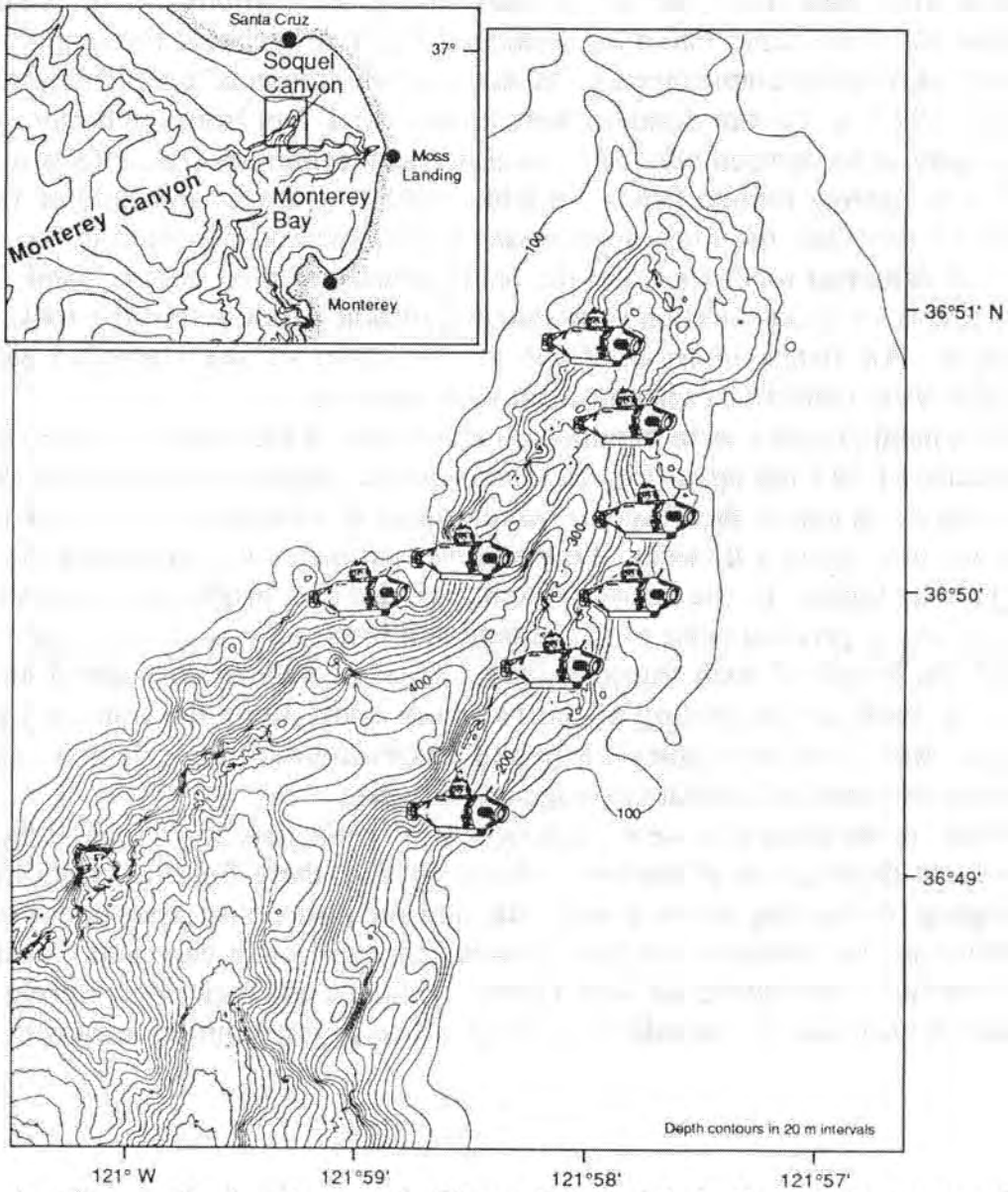

Figure. 1. Fine-scale (contours at 20 m intervals) bathymetric map of Soquel Canyon and sites of submersible dives.

During the second phase of our study, eight sites (Fig. 1) were evaluated as potential rockfish habitat using the *Delta* submersible in water from 80 to 305 m. at the head of the canyon. The *Delta* is a relatively small submersible, accommodating one scientific observer and one pilot, has a maximum operating depth of about 350 m, and a cruise speed of 1.5 knots. An acoustic track-point system on board the support vessel monitors the underwater location of the submersible. Most of the dives were made during daylight to avoid potential bias due to diel activity patterns of the fishes. Each dive was documented continuously with a high-8 mm video camera and associated lights that were externally mounted to the starboard side of the submersible; the scientific observer verbally annotated each video tape. A hand-held high-8 mm video camera and voice recorder were used as back-up data recorders. Divers de-briefed themselves after their dives, including transcribing observations on fishes and habitat from audio and video tapes into a computerized database on board the support vessel.

To quantify fish abundance and habitat use, belt transects (e.g., Pearcy et al. 1989, Stein et al. 1993) of 10-min duration were conducted 1-2 m from the bottom at 0.4-0.9 knots. In spite of recognized biases of visual transect techniques (i.e., effects of observer and lights, resighting mobile fishes, variable width of transect and field of view), belt transects are probably the most appropriate survey method considering the sedentary behavior of demersal rockfishes and the heterogeneity of their environment. Transects were purposely of short duration to maintain constant depth within the rock habitat at each station. All fishes in front of the viewing port on the starboard side of the submersible were identified (when possible) and counted.

Two parallel lasers were mounted on either side of the external video camera at a fixed distance of 39.5 cm apart (Fig. 2). The projected reference spots on the video tape, and also visible in situ to the observer, were critical in estimating the size of fishes and distance traveled along a transect. We made measurements by comparing the size of a fish or habitat feature to the known spacing of the two bright laser spots when the object was nearly perpendicular to the camera and lasers (Davis and Tusting 1991). We estimated the length of each transect, independent of submersible speed and bottom currents, by tracking the spacing of the two laser spots along the transect's path. The video tapes were used to supplement in situ observations of the scientist and provide independent estimates of habitat coverage and fish size.

Submersible dives also were made by marine geologists at six sites. Relief, habitat type, size and depth range of features were described; these field descriptions assisted the biologists in planning dives at each site and for post-cruise assessment of habitat. Microhabitat of the dominant fish species was characterized at each site. Substrata type included various combinations of mud, cobble, boulders, and rock ridge. Species-specific abundance at each site was standardized by distance covered during a transect.

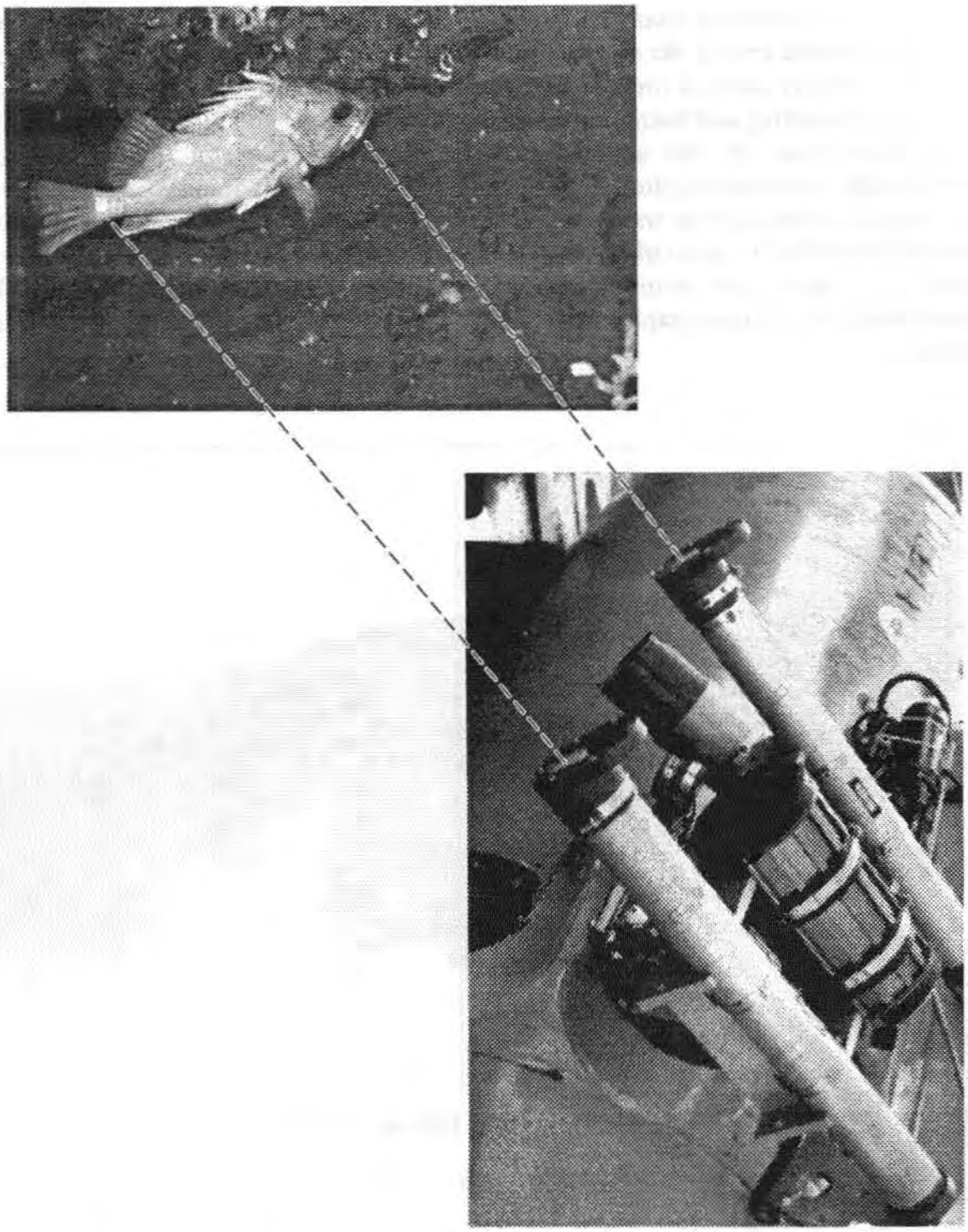

Figure 2. Composite demonstrating (a) the parallel lasers mounted to an underwater camera and used to estimate fish size and distance travelled along transects, and (b) an *in situ* video print of a greenspotted rockfish (*Sebastes chlorostictus*) at interface of boulder and mud substratum (laser spots are evident).

During the third phase, which was concurrent with the submersible operations, we conducted a sidescan sonar survey of Soquel Canyon. Four nights were spent surveying the north end of the canyon, particularly over 80-300 m of water. Side scan sonar is the perfect method for differentiating blocks of hard substrata, which appear dark, from surrounding soft bottom sediments because of their greatly different reflection characteristics (Fig. 3). The sonographs along each track line of the survey were combined with navigational plots from differential Global Positioning System (GPS) to form a mosaic of the canyon walls. When plotted on regional bathymetry, the side scan targets are identified as areas of positive or negative relief. We are using these maps or mosaics to quantify the amount of rocky outcrops available to rockfishes. Our interpretations of the sonographs were verified by observations made from the *Delta* submersible.

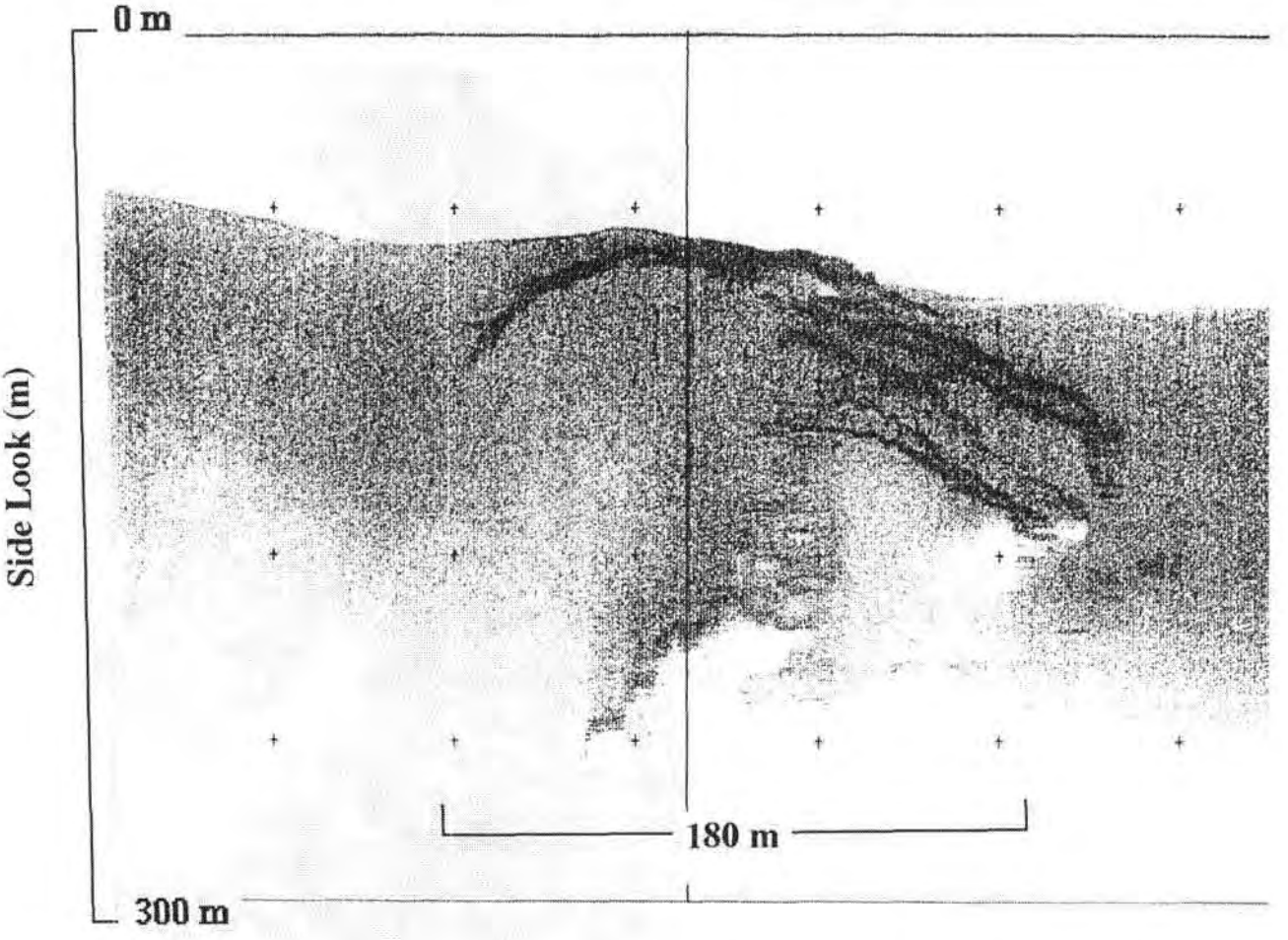

Figure 3. Side scan sonograph of outcrop on wall of Soquel Canyon. Strong acoustic reflectors are from exposed bedding faces, white areas are shadows behind faces, and gray areas are the result of non-reflective muds. These beds, primarily sandstone and mudstone, compose the rockfish habitat. These interpretations were verified by direct observations from submersible.

RESULTS AND CONCLUSIONS

From the geophysical surveys and observations made during seven geological dives at six sites, Soquel Canyon is characterized by extensive erosion, with sharp, steep relief in much of the headward part. This particular geomorphology is thought to have been created by marine and river erosion during the last low-stand of sea level (H. G. Greene, USGS, Menlo Park, CA, pers. comm.). This canyon is made of many isolated rock outcrops that provide ideal shelter for large fishes.

Twenty-three biological dives were made at eight sites during the pilot study in Soquel Canyon. Five of these sites, in particular, have been verified as excellent rockfish habitat from visual observations using the submersible *Delta*. From post-cruise analysis of 42 10-min transects representing 7.1 km total distance covered, we observed 2,470 individual fishes from 37 species, of which over 2,000 from 21 species were rockfishes. The major rockfish habitat types in Soquel Canyon include vertical cliffs with joints, fractures, and overhangs, small and large ledges, talus slopes and boulder fields of exposed sandstone and mudstone interspersed with soft mud and crinoid fields.

Clustering analysis of all bottom types based on relative abundance of fish species indicates habitat partitioning. Small species, such as sharpchin (S. zacentrus), stripetail (S. saxicola) and halfbanded rockfish (S. semicinctus), were associated with mud and cobble substrata of low relief. Mud-rock combinations were dominated by greenspotted rockfishes (S. chlorostictus; Fig. 2) and an assortment of larger species (e.g., bocaccio, S. paucispinis). The largest species up to 1 m in length, such as cowcod (S. levis) and yelloweye rockfish (S. ruberrimus), were closely associated with larger structures such as rock ledges, small caves, crevices, and overhangs. Many rockfishes of all sizes were associated with some structure, including boulders, cobble, invertebrates such as crinoids and sea anemones, debris, and simple shallow depressions in the mud. In seeking shelter near rock outcrops, large rockfishes may be excavating the friable semi-consolidated mudstone; this type of bioerosion could result in some of the geologic characteristics of the habitat.

From our pilot study, the preliminary conclusion is that heterogeneous, rocky habitat of high relief surrounded by soft mud in deep water of submarine canyons supports viable adult rockfish populations. These fishes are likely protected from excessive harvest because these habitat characteristics make them difficult to target. Indeed, species and size composition of rockfishes in the catch of the recreational fisheries in the Soquel Canyon area are very different from assemblages described from our submersible observations at similar depths and locations (Fig. 4). The more mobile species (e.g., chilipepper, S. goodei, and yellowtail rockfishes, S. flavidus) that tend to aggregate off the bottom may be more vulnerable to the hook-and-line fisheries, whereas the larger benthic species (cowcod, yelloweye rockfish, and lingcod) are relatively more abundant in the submersible observations.

Because of the many canyon systems in or near Monterey Bay, deep-water rocky habitats are accessible relatively close to heavily-fished areas, making comparisons among sites possible. From our fishery-independent estimates of rockfish abundance and habitat availability and characterization, we can evaluate the need for protecting populations of rockfishes on small-scale refugia. These areas could serve as sources of recruitment for fish populations being reduced by fishing, and identifying critical habitat for mature adults could prevent further declines in population numbers of some species.

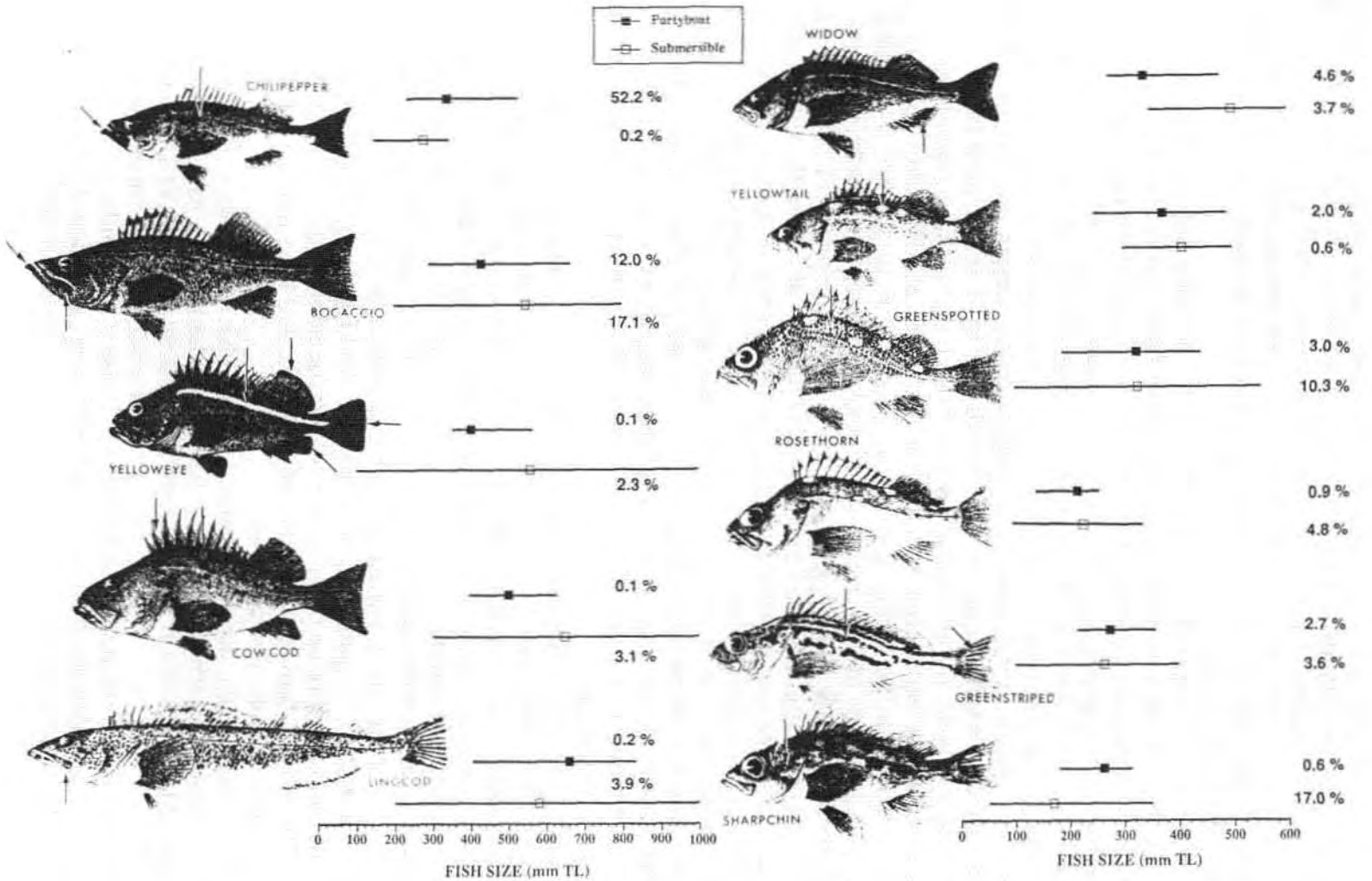

Figure 4. Many species of rockfishes are relatively more abundant and larger in Soquel Canyon than indicated in catch records. Percent abundance, mean and range of sizes are indicated for fishes caught by partyboat fleet and observed during submersible surveys at 90-209 m in Soquel Canyon. Illustrations are from Eschmeyer, Herald, and Hammann (1983).

Our observations demonstrate the utility of submersibles for evaluating fish populations that are closely associated with deep-water rocky areas and unavailable to other methods of evaluation. Manned submersibles provide the scientists with superior field of view to directly quantify abundance and size, and identify difficult species. The high resolution video camera produces a continuous record of observations and allows observers to review their rockfish identifications. Submersible techniques are ideal for surveying potential small-scale refugia without altering the population parameters being quantified.

FUTURE RESEARCH

We are continuing our study of submarine canyons in the Monterey area to compare fish assemblages in lightly- and heavily-fished habitats of similar type and depth. From our recent geophysical survey, we are identifying likely rockfish habitat along the south edge of Monterey submarine canyon and on isolated outcrops in the bay. These ledges have been accessible to substantial and continuous fishing pressure in Monterey Bay for several decades. Using transect techniques and the *Delta* submersible, we will survey fish populations, and compare species and size composition to those from catch records collected by CDFG observers on board Commercial Partyboat Fishing Vessels in the area.

We are currently assessing the likelihood that submarine canyons having structure similar to Soquel Canyon represent significant habitat for rockfishes. Geologic characterization of the headward parts of Monterey, Ascension, Ano Nuevo and Carmel Canyons (particularly from 100-350 m water depth) is in progress, with direct observations from a submersible planned for summer of 1994.

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