FISH-HABITAT RELATIONSHIPS AT THE CORDELL BANK (CALIFORNIA) NATIONAL MARINE SANCTUARY

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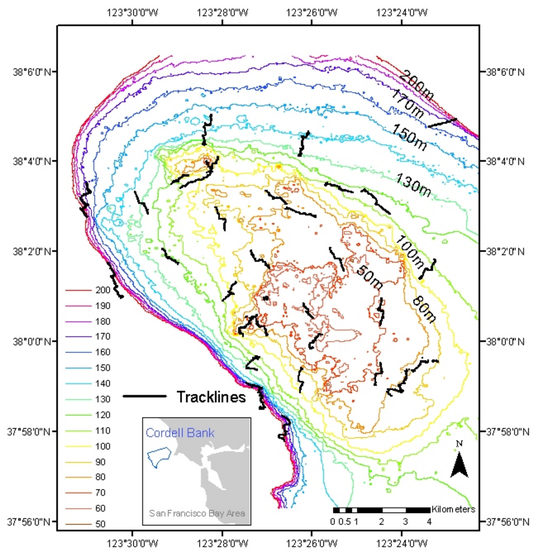
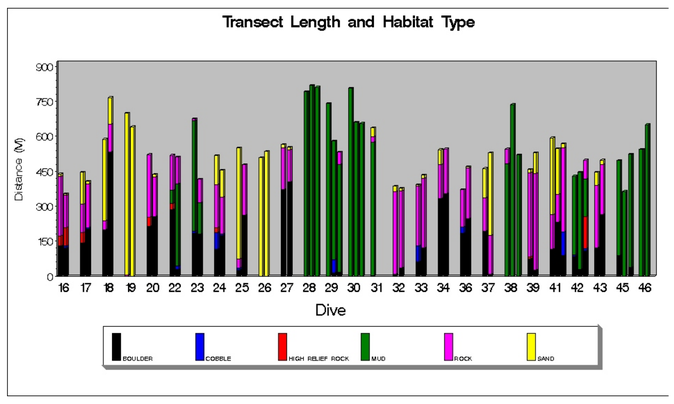
During September 2002 Sanctuary staff and cooperating scientists conducted the first quantitative assessment of the distribution and abundance of demersal fishes using the *Delta* submersible. To characterize the biotic and abiotic resources of the Bank and to lay the groundwork for an anticipated long-term monitoring program, we sampled non-cryptic benthic fishes and habitat along 60 transects, each 2 m wide and 15 minutes in duration, during 28 submersible dives. The dives were broadly allocated over the Bank and surveyed over a seven-day period.



CORDELL BANK NATIONAL MARINE SANCTUARY

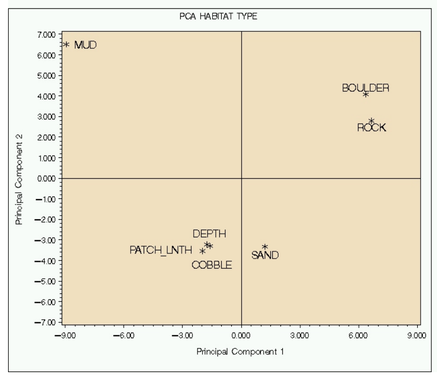
Cordell Bank is a submerged granitic island 8 km wide by 15 km long, which lies on the continental shelf 100 km northwest of San Francisco. A bathymetric contour map over which submersible dive tracks (black squiggly lines) have been laid is shown. Dive locations were chosen to provide a broad representation of the Bank's depths, habitat types, and spatial zones. The inset shows the location of the Sanctuary along the Central California Coast. The blue footprint is the boundary of the entire Sanctuary; the Bank is in the western region of the Sanctuary along the continental shelf break.

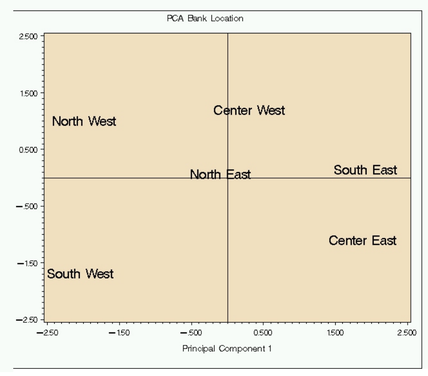


Transects were broadly distributed over the bank to sample all habitats (see contour map). While all transects were 15 minutes in duration, differences in relief and substrate between transect resulted in large differences in transect length which could vary by a factor of two. For this reason, fish density estimates were based on habitat patch size and not time. Habitat hererogeneity varied greatly between transects.

HABITAT CHARACTERIZATION

Laboratory analysis of the video transects was performed to classify the substrate. The compound scoring method of Stein et al. (1992) and Yoklavich et al. (1999) was employed. This method involves recording both a 'Primary' (at least 50 % of viewing area) and 'Secondary' (at least 20% of viewing area) habitat type. Classifications used were sand, mud, cobble, boulder, rock or high relief rock. A total of 4225 individual patches were identified in the 60 transects.





Principal Component Analysis was utilized as a summarization tool to investigate the relationships between habitat variables and the distribution of habitats on the Bank. In the figure on the **left**, we analyzed habitat type along with patch length and transect depth. Broad separation along PC 1 is seen from mud=>cobble/sand=>boulder/rock. Patch length and depth cluster together owing to the interaction between depth and substrate type. Deeper transects are generally along less heterogeneous (fewer patches) bottoms. In the figure on the **right** habitat variables were aggregated according to their position on the Bank. The lack of clustering among the six locations indicates that distinct combinations of habitat types are present in the different regions of the Bank.

FISH IDENTIFICATION AND ENUMERATION

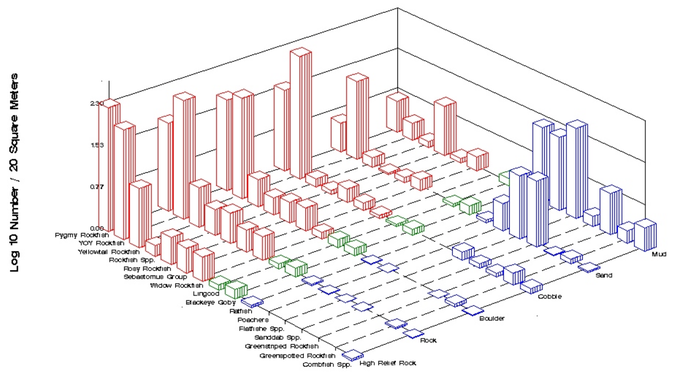
The method described by Yoklavich et al. (1999) was employed to identify, count, and measure fishes. Primary responsibility for fish identification was assigned to the submersible observer because fishes can be much more easily identified from the sub as opposed to video images. Transect images recorded on a digital videotape during each dive were used to support the *in situ* observations. Transect width (2m) was estimated with the aid of a hand-held sonar rangefinder. Fish size was estimated to the nearest 5cm using paired lasers (20cm apart) as a point of reference. The submersible maintained a constant depth (1-2m) above the bottom whenever possible. We employed a protocol which allowed the observer to break and resume transects when visibility or physical impediments precluded quantitative sampling.

2002 Delta Submersible Survey
Mean Fish Density and Frequency of Occurrence

SPECIES	GROUP	FISH DENSITY	NUMBER OF PATCHES	FREQUENCY OF OCCURRENCE
YOUNG-OF-YEAR ROCKFISH	ROCKFISH	81.5536	441	28.9941
PYGMY ROCKFISH	ROCKFISH	33.6042	385	25.3123
UNIDENTIFIED FLATFISHES	FLATFISH	9.8032	131	8.6128
UNIDENTIFIED FISHES	UNKNOWN	6.4006	392	25.7725
SPOTTED RATFISH	RATFISH	4.3071	54	3.5503
DOVER SOLE	FLATFISH	4.1990	30	1.9724
POACHERS	POACHER	4.1899	88	5.7857
STRIPETAIL ROCKFISH	ROCKFISH	3.1188	28	1.8409
ROCKFISH SPP.	ROCKFISH	2.3926	225	14.7929
YELLOWTAIL ROCKFISH	ROCKFISH	2.3462	339	22.2880
SCULPIN SPP.	SCULPIN	1.9310	76	4.9967
SANDDAB SPP.	FLATFISH	1.8432	55	3.6160
REX SOLE	FLATFISH	1.5779	16	1.0519
ROSY ROCKFISH	ROCKFISH	1.4280	503	33.0703
SEBASTOMUS	ROCKFISH	1.2966	409	26.8902
GREENSTRIPED ROCKFISH	ROCKFISH	0.8613	71	4.6680
COMBFISH SPP.	COMBFISH	0.8180	94	6.1801
HAGFISH SPP.	HAGFISH	0.6671	17	1.1177
WIDOW ROCKFISH	ROCKFISH	0.6599	64	4.2078
SLENDER SOLE	FLATFISH	0.4227	10	0.6575
THORNYHEAD SPP.	ROCKFISH	0.4119	5	0.3287
BLACKEYE GOBY	GOBY	0.3220	143	9.4017
CALIFORNIA SKATE	SKATE	0.3025	2	0.1315
SHARPCHIN ROCKFISH	ROCKFISH	0.2954	27	1.7751
LINGCOD	GREENLING	0.2914	107	7.0348
SPLITNOSE ROCKFISH	ROCKFISH	0.2825	7	0.4602
PRICKLEBACK SPP.	PRICKLEBACK	0.2748	17	1.1177
SKATE SPP.	SKATE	0.2606	2	0.1315
GREENSPOTTED ROCKFISH	ROCKFISH	0.2376	138	9.0730
EELPOUT SPP.	EELPOUT	0.2252	5	0.3287
SQUARESPOT ROCKFISH	ROCKFISH	0.1849	32	2.1039
LONGNOSE SKATE	SKATE	0.1817	8	0.5260
LONGSPINE COMBFISH	COMBFISH	0.1476	10	0.6575
PETRALE SOLE	FLATFISH	0.1382	5	0.3287
ENGLISH SOLE	FLATFISH	0.0971	7	0.4602
PAINTED GREENLING	GREENLING	0.0921	39	2.5641
CANARY ROCKFISH	ROCKFISH	0.0846	35	2.3011
BLUE ROCKFISH	ROCKFISH	0.0610	12	0.7890
ICELINUS SPP.	SCULPIN	0.0594	8	0.5260
BOCACCIO	ROCKFISH	0.0503	23	1.5122
PACIFIC SANDDAB	FLATFISH	0.0443	1	0.0657
YELLOWEYE ROCKFISH	ROCKFISH	0.0431	28	1.8409
VERMILION ROCKFISH	ROCKFISH	0.0430	11	0.7232
THREADFIN SCULPIN	SCULPIN	0.0425	5	0.3287
KELP GREENLING	GREENLING	0.0418	29	1.9066
STARRY ROCKFISH	ROCKFISH	0.0412	26	1.7094
SHORTBELLY ROCKFISH	ROCKFISH	0.0411	4	0.2630
SHORTSPINE COMBFISH	COMBFISH	0.0405	4	0.2630
BIGFIN EELPOUT	EELPOUT	0.0374	2	0.1315
SPECKLED ROCKFISH	ROCKFISH	0.0367	10	0.6575
SPOTFIN SCULPIN	SCULPIN	0.0302	4	0.2630
SWORDSPINE ROCKFISH	ROCKFISH	0.0295	11	0.7232
SHORTSPINE THORNYHEAD	ROCKFISH	0.0289	2	0.1315
PACIFIC ARGENTINE	ARGENTINE	0.0286	1	0.0657
DIAMOND TURBOT	FLATFISH	0.0262	1	0.0657
PACIFIC COD	COD	0.0222	1	0.0657
PINK SEAPERCH	PERCH	0.0134	1	0.0657
STARRY FLOUNDER	FLATFISH	0.0107	1	0.0657
PACIFIC ELECTRIC RAY	RAY	0.0105	1	0.0657
FLAG ROCKFISH	ROCKFISH	0.0061	2	0.1315
ROSETHORN ROCKFISH	ROCKFISH	0.0057	3	0.1972
PACIFIC HAGFISH	HAGFISH	0.0052	1	0.0657
TIGER ROCKFISH	ROCKFISH	0.0045	1	0.0657
BLUNTNOSE SIXGILL SHARK	SHARK	0.0043	2	0.1315
BLACKTAIL SNAILFISH	SNAILFISH	0.0040	1	0.0657
REDBANDED ROCKFISH	ROCKFISH	0.0040	1	0.0657
GREENBLOTCHED	ROCKFISH	0.0032	2	0.1315
GUNNELS	GUNNEL	0.0032	4	0.2630
RAINBOW SURFPERCH	PERCH	0.0021	1	0.0657
BIG SKATE	SKATE	0.0012	1	0.0657
WOLF-EEL	WOLFFISH	0.0007	1	0.0657
OLIVE ROCKFISH	ROCKFISH	0.0006	1	0.0657
SABLEFISH	SABLEFISH	0.0004	1	0.0657

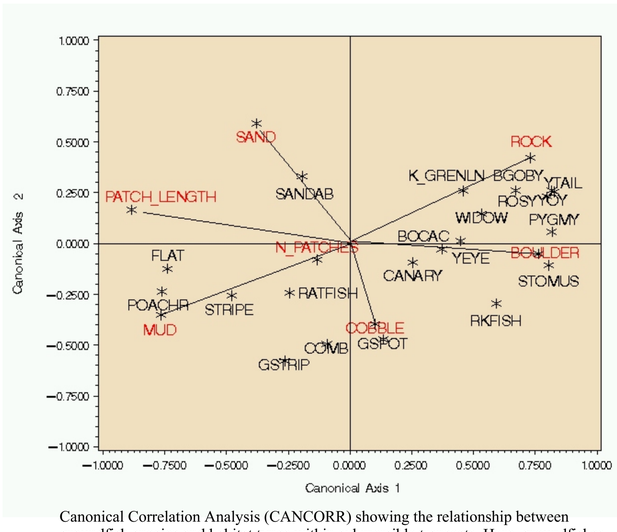
Seventy-three species (including species complexes) were identified on the fall 2002 survey. This list ranks taxa by density (number per 20 m^2). The number of habitat patches and the percent frequency of occurrence in all patches is also presented. The list illustrates the importance of Cordell Bank as habitat for young-of-year rockfish. The high ranking of unidentified fishes is primarily owed to the difficulty of identifying small rockfishes and flatfish.. While Cordell Bank supports a diverse ichthyofauna it is domonated by rockfishes which accounted for over 90% of the enumerated individuals and 30 of the taxa.

Density (log10 number of fish / 20 square meters) of fishes observed in each of six primary habitat categories. Blue bars designate species (or species complexes) more commonly observed on sand or mud substrates. Species with red bars are those which occurred on hard substrates. Fish labeled in green are those which had no clear affinity for a particular substrate type.

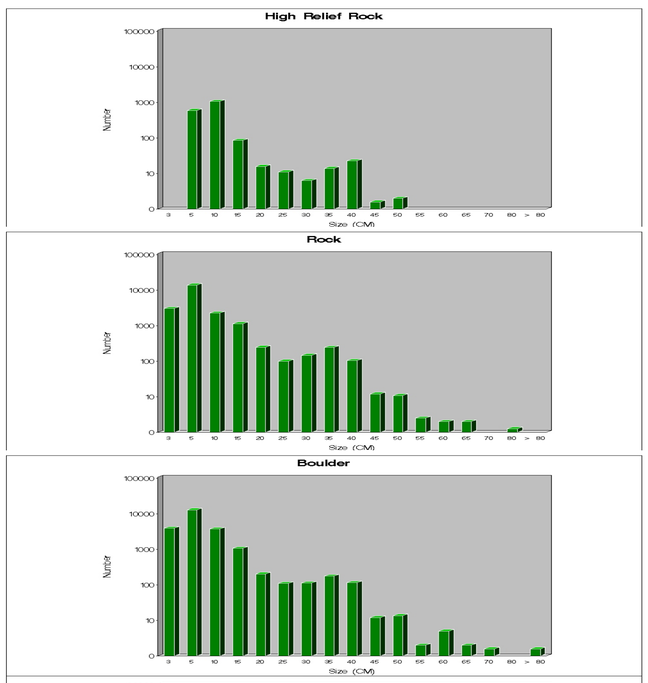


FISH-HABITAT AFFINITY

We examined the fish/habitat relations using data summarization (top figure) and multivariate Canonical Correlation (bottom figure). At the transect-level, five habitat types characterized Cordell Bank. At the scale of transects, hard outcrop areas were characterized by both rocks and boulders. These hard outcrop areas were characterized by a suite of groundfish species (e.g., blackeye goby, pygmy, widow, yelloweye, bocaccio, and young-of-year rockfishes). Sebastomus species were also characteristic of hard outcrop habitats, but were more frequently found in transects dominated by boulders. Cobble habitats were characterized by greenspotted and greenstriped rockfishes and combfish. Transects containing sand habitats were also characterized by sanddabs. In contrast to other habitats, mud habitats were more extensive and continuous and were characterized by flatfishes, poachers, stripetail rockfish, and ratfish.



Canonical Correlation Analysis (CANCORR) showing the relationship between groundfish species and habitat types within submersible transects. Here, groundfishes (black symbols) are plotted in habitat space (red symbols) .



Size frequency histograms are for all taxa combined and summarized separately for each habitat type. Size frequency distributions emphasize the fact that many Cordell Bank habitats harbor high densities of small fishes (NOTE: abscissa is log scale). Most of the fishes <= 5 cm are recently settled YOY rockfish. Small individuals were not found in mud or high relief rock possibly because of the lack of shelter. Rock and boulder habitats, which offer the best cover, had the largest fishes.

SUMMARY

These results represent our first exploratory pass through the data. We have generalized the observed patterns over the entire Bank and have found fish-habitat relationships at this level of resolution to be concordant with those of other investigators. The clear importance of Cordell Bank as a settlement site for YOY rockfishes has been observed and documented. In the future we intend to elucidate differences in fish-habitat relationships between regions of Cordell Bank (finer scale) and between other sites along the West Coast (larger scale). Preliminary observations of the deep boulder habitats at Cordell Bank suggest that this habitat harbors commercially important (and overfished) species such as bocaccio, yelloweye rockfish, vermilion rockfish, and canary rockfish, and that Cordell Bank may be truly essential for the rebuilding the stocks of these species.

REFERENCES

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* A conspiratorial group of plotters.