NMFS Southwest Fisheries Science Center

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Agency Report to the Technical Subcommittee of the Canada-U.S. Groundfish Committee

April 2021

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With contributions from John Field, Tom Laidig, Nick Wegner, Sabrina Beyer and Joe Bizzarro

A. AGENCY OVERVIEW

The Southwest Fisheries Science Center (SWFSC) conducts fisheries and marine mammal research at three laboratories in California. Activities are primarily in support of the Pacific Fishery Management Council, the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), as well as a number of international fisheries commissions and conventions. The Science and Research Director is Kristen Koch and John Crofts is the Deputy Director. All SWFSC divisions support the essential needs of the NMFS and the Pacific Fishery Management Council (PFMC) for groundfish, including as active members of the PFMC's Scientific and Statistical Committee (SSC), the Groundfish Management Team, and other management teams and advisory bodies.

The Center is headquartered in La Jolla, which hosts three divisions that conduct research on a wide range of Pacific and Antarctic fish, marine mammals, sea turtles, and marine habitats; the Antarctic Ecosystem Research Division (led by Dr. George Watters), the Marine Mammal and Turtle Division (led by Dr. David Weller), and the Fisheries Resources Division (led by Dr. Annie Yau). The Fisheries Resources Division (FRD) conducts research on groundfish, large pelagic fishes (tunas, billfish and sharks), and small coastal pelagic fishes (anchovy, sardine and mackerel), and is the only source of groundfish research at the La Jolla facility. The Fisheries Research Division is also the primary source of federal support for the California Cooperative Oceanic Fisheries Investigations (CalCOFI) surveys that have taken place along much of the California coast since 1951. Researchers at FRD have primary responsibility for ichthyoplankton collections, studies of species abundance and distribution (including responses to climate variability), systematics, and the application of early life history information to stock assessments.

The Fisheries Ecology Division (FED) in Santa Cruz is directed by Dr. Steve Lindley, and three of the four research branches conduct studies focused on groundfish. The FED recently underwent a reorganization due to supervisor retirements and new hires. Dr. Steve Lindley is currently the acting supervisor of the Fisheries Economics team. The Molecular Ecology team (led by Dr. Carlos Garza) studies the molecular ecology and phylogeny salmonids and groundfish. Dr. John Field now oversees a larger Fisheries Assessment Group with three teams, Fisheries and Ecosystem Oceanography (led by Dr. John Field), Habitat and Groundfish Ecology (led by Dr. E.J. Dick) and Fisheries Assessment Modeling (led by Dr. Michael O'Farrell).

All of the teams within the Fisheries Assessment Group support the needs of NMFS and the Pacific Fishery Management Council, one of which is groundfish stock assessment. Specific objectives of the FED groundfish programs include: (1) collecting and developing information useful in assessing and managing groundfish stocks; (2) conducting stock assessments and improving upon stock assessment methods to provide a basis for harvest management decisions at the PFMC; (3) characterizing and mapping biotic and abiotic components of groundfish

habitats, including structure-forming invertebrates; (4) disseminating information, research findings and advice to the fishery management and scientific communities; and (5) providing professional services (many of which fall into the above categories) at all levels, including inter-agency, state, national and international working groups. Dr. Xi He from FED was the most recent SWFSC representative to the Pacific Council's Groundfish Management Team, however that seat is currently vacant since Dr. He's retirement earlier in 2021. Several scientists from the Fisheries Ecology Division in Santa Cruz currently serve on the Pacific Council's Scientific and Statistical Committee.

There is also much collaboration among the three teams within the Fisheries Assessment Group. The Fisheries Assessment Modeling team primarily conducts stock assessments for both groundfish and salmon, focusing on research to advance fisheries assessment methods. The Habitat and Groundfish Ecology team utilizes a number of survey tools, e.g., visual surveys conducted with remotely operated vehicles (ROV), human-occupied submersibles, autonomous underwater vehicles (AUV), scuba, hook-and-line fishing and captive rearing, to study deep-water demersal communities and groundfish ecology. The Fisheries and Ecosystem Oceanography team within the group is responsible for leading the annual pelagic juvenile rockfish recruitment and ecosystem assessment survey along the West Coast.

The Environmental Research Division (ERD) is led by Dr. Toby Garfield and has researchers located in both Monterey and Santa Cruz. The ERD is a primary source of environmental information to fisheries researchers and managers along the west coast, and provides science-based analyses, products, and information on environmental variability to meet the agency's research and management needs. The objectives of ERD are to: (1) provide appropriate science-based environmental analyses, products, and knowledge to the SWFSC and its fishery scientists and managers; (2) enhance the stewardship of marine populations in the California Current ecosystem, and other relevant marine ecosystems, by understanding and describing environmental variability, the processes driving this variability, and its effects on the production of living marine resources, ecosystem structure, and ecosystem function; and (3) provide science-based environmental data and products for fisheries research and management to a diverse customer base of researchers, decision-makers, and the public. The ERD also contributes oceanographic expertise to the groundfish programs within the SWFSC, including planning surveys and sampling strategies, conducting analyses of oceanographic data, and cooperating in the development and testing of environmental and biological indices that can be useful in preparing stock assessments.

B. MULTISPECIES STUDIES

B1. Research on larval rockfish at the SWFSC

Contact: William Watson (william.watson@noaa.gov)
Larval Rockfish Investigators: Andrew Thompson, William Watson

During the past seven years (2013-2020), the ichthyoplankton and molecular ecology laboratories at the SWFSC, La Jolla, built species-specific larval rockfish time-series by genetically sequencing individual larvae from winter CalCOFI samples between 1998 and 2013. Results of this work are currently published in a master's thesis and two peer-reviewed scientific publications, and time-series from blue rockfish (*Sebastes mystinus*) were used by the Pacific Fisheries Management Council to inform the status of this stock.

In 2019-2020 we are continuing to analyze this data. For example, a SIO master's student (Jessica Freeman) is utilizing nonparametric multivariate and Bayesian analyses to better understand drivers of larval rockfish dynamics. In addition, a postdoctoral researcher (Noah Ben-Aderet) removed otoliths from a subset of six species collected between 1998 and 2013. He has completed measuring otolith core width as a proxy for maternal investment and outer band width as a proxy for growth rate. He is currently conducting analyses to test whether environmental conditions during parturition affect maternal investment and if maternal investment and/or environmental conditions impact rate of growth. The ultimate goal of this project is to identify mechanisms that impact rockfish recruitment and determine if larval condition can predict recruitment success.

In 2019-2020, we initiated another genetics project seeking to identify rockfishes in CalCOFI samples. Rather than sequencing individual larvae, we extracted DNA from the ethanol in which CalCOFI samples are stored. We then used metabarcoding techniques similar to those used for environmental DNA analysis to sequence DNA from all fishes in a sample. It turned out that the traditional primers used for fish metabarcoding (MiFish 12S) discriminated poorly among rockfish species. Hence, we designed rockfish-specific metabarcode primers within the cytochrome *b* gene. We metabarcoded DNA from four stations per year between 1998 and 2019 and used recently developed bioinformatics pipelines to quantify the number of DNA reads for each species in a sample. Initial results demonstrate that we are able to identify most rockfish species from ethanol preservative. The metabarcoding work is led by Zachary Gold, a Ph.D. student from UCLA. The metabarcode work will be one of the chapters of his dissertation thesis. Zack is graduating in 2020 and a manuscript on this effort should be ready for submission to a peer-reviewed journal in late 2020.

We began in 2019-2020 a collaboration with the NWFSC to explore larval rockfish dynamics before, during, and after the 2014-2016 Marine Heatwave. We obtained from Ric Brodeur and Toby Auth rockfish larvae collected annually off the Newport Hydrological Line from 2013-2019. Prior to the closure of the SWFSC due to the coronavirus pandemic, we completed tissue extractions from all larvae (approximately 1800) and sequenced and identified approximately 1000. We were on track to complete identification by the end of April, but had to postpone lab work due the closure of the Center. Once the SWFSC reopens, we should be able to complete the identifications in about a month if we can work at our pre-shutdown pace.

Finally, we continued to update larval fish identifications from historic CalCOFI surveys to current taxonomic standards. We currently have completed all surveys from July 1961 through December 2015, and samples collected during the primary rockfish reproductive seasons, winter and spring, of 2016-2019. This provides a 58-year time series of larval abundances of the

rockfish species visually identifiable as larvae (*Sebastes aurora*, *S. diploproa*, *S. goodei*, *S. jordani*, *S. levis*, *S. macdonaldi*, *S. paucispinis*).

B.2 Research on Juvenile Rockfish at the SWFSC

Contact: John Field (john.field@noaa.gov)

Since 1983 the SWFSC has conducted a Rockfish Recruitment and Ecosystem Assessment Survey in late Spring surveys for pelagic young-of-the-year (YOY) rockfish using a modified Cobb midwater trawl. The survey supports the development of recruitment indices for stock assessments of many winter-spawning rockfish (e.g., chilipepper, bocaccio, and widow rockfishes), and a suite of fisheries and ecosystem oceanography studies. Although the planned 2020 on the NOAA ship Reuben Lasker was cancelled due to COVID 19, the SWFSC managed to complete a small charter survey in the core (Central California) survey area. SWFSC staff joined the charter vessel crew for one night of fishing to train them on basic survey protocols, and for the remaining nights of the charter SWFSC staff would meet fishermen at the dock every 1-2 days to receive catches, where they were returned to the SWFSC lab for processing. Temperature/depth recorders attached to the trawl were used to confirm that the net was fishing at the right depth and for the appropriate duration.

The results of the 2020 survey indicated that total pelagic y indices for total rockfish and sanddab (Citharichthys spp.) were the second lowest on record and continued a decline from record high abundance levels observed during the 2014-2016 marine heatwave (Fig. 1) (25-26). YOY Pacific hake, myctophids, juvenile market squid and pelagic octopus catches were also below average. In contrast, the 2020 index for adult northern anchovy continued a multi-year period of persistently high abundance. A 2021 survey will take place on the NOAA ship Reuben Lasker, beginning in late April 2021. Although the sampling was sparse, with only 15 trawls successfully completed (the average number of trawls conducted in the core area between 1983 and 2019 was 60), the results were rigorously evaluated with model-based estimation approaches, and compared to alternative sources of information, such as seabird diets on the Southeast Farallon Islands, to ensure that catches were consistent with other ecosystem observations (Santora et al. in review). Uncertainty was greater for abundance indices of most taxa in 2020 due to the sparseness of sampling, and a rigorous evaluation of the trade-off between sampling intensity and index uncertainty was developed as part of the evaluation of 2020 data (Santora et al. in review).

The RREAS survey data have been pooled with data from NWFSC pelagic juvenile cruises, including the PWCC/NWFSC survey from 2001-2009 and the NWFSC Pre-recruit survey from 2011 through 2019. One effort in progress has pooled data from these surveys to describe the variability in the temporal and spatial abundance and distribution patterns of YOY rockfishes along the U.S. West Coast. This analysis indicates that over the scale of the California Current, while there is considerable spatial coherence in these relative abundance patterns over broad spatial scales, there are many years in which abundance patterns are very heterogeneous, particularly to the north and south of major promontories such as Cape Mendocino and Point Conception (Field et al. in review). Results also confirm that the high abundance levels of YOY rockfish observed during the 2014-2016 large marine heatwave were largely coastwide events.

The results of this work will help to inform future pelagic YOY surveys and future indices of recruitment strength used to inform stock assessment models.

C. BY SPECIES, BY AGENCY

C1. Nearshore rockfish stock assessments

C2. Shelf Rockfish

Drs. Melissa Monk and E.J. Dick are currently leading the development of stock assessments for the vermillion/sunset rockfish complex southern and central/northern California to support PFMC management efforts. The stock assessment review panel for these assessments will take place in late June (the NWC will lead development of models for Oregon and Washington). Two models for California waters will be developed, north and south of Point Conception, as there appears to be more mixing of vermillion and sunset in the southern region, while in the northern region vermillion rockfish are more frequently encountered. Far more data are available in the southern area (index and compositional data from the NWFSC hook and line survey will likely be key indices in the southern model) relative to the central/northern California area, where data are more sparse. This assessment represents the first large-scale effort to age vermilion rockfish, and as several aging laboratories are involved, the labs have initiated an official CARE (Center for Age Reading Experts) exchange, with each lab providing 60 fish that are subsequently aged by each lab involved in the age determination effort. The results will provide robust information on ageing error among the aging labs.

C2.a. Rockfish barotrauma and release device research at SWFSC La Jolla Lab

Contact: Nick Wegner (nick.wegner@noaa.gov)

The Genetics, Physiology, and Aquaculture program at the SWFSC in La Jolla continues to evaluate the effects of capture and barotrauma on rockfishes (*Sebastes* spp.) following release in recreational fisheries. This work focuses in three major areas: 1. Acoustic telemetry tagging studies to document the survival rates and sublethal effects of catch and release and barotrauma on important management species such Cowcod (*S. levis*) and Bocaccio (*S. paucispinis*) (Fig A), 2. Laboratory studies examining the sensitivity of rockfishes to hypoxia both before and immediately following laboratory induced barotrauma using hyperbaric chambers, and 3. Working with the recreational fishing community in California to measure the effectiveness and angler preference for different types of commercially available descending devices used to release rockfishes suffering from barotrauma.

Analysis of acoustic tagging work to date has shown species-specific long-term survival rates of 50.0% for Cowcod (n=46, CI= 35.7-70.5%) and 89.5% for Bocaccio (n=41, CI 80.2-99.8%). For

Cowcod (which showed much lower survival rates), fish length, sea surface temperature, and dissolved oxygen levels at depth all significantly affected survival. For fish that survived, general additive models (GAMs) of post-release behavior showed that capture and barotrauma affected Cowcod and Bocaccio for at least 30 days post release. Dissolved oxygen also significantly affected post-release behavior. The modeled impact of dissolved oxygen on both survival rate and post-release behavior have led to on-going laboratory-based studies to examine the effects of hypoxia on Cowcod and Bocaccio behavior and physiology. Specifically this work is examining behavioral avoidance to low oxygen using a custom-built shuttle-box system, and determining the effects of hypoxia on metabolism through respirometry trials. Better understanding how low levels of dissolved oxygen contribute to mortality and rockfish behavior will allow for refinement of the catch-and-release process and the implementation of release guidelines that maximize survival. In addition, such work can provide insight into limits on rockfish suitable habitat.

Research testing the effectiveness of descending devices released 2,275 rockfish from 32 species. While there were some significant differences between device types, all devices were effective for releasing rockfishes back to depth. Initial post-release mortality (defined as all mortality events observable from the vessel while fishing) across all devices was relatively low (7.5%) in capture depths less than 100 m. These results suggest that rockfishes should be released at least half-way to the bottom (preferably directly to the bottom) for the device to be effective in minimizing post-release mortality. Although all descending devices work, at-sea conditions, vessel type, and fish size tend to influence effectiveness and user preference of different device types. This work was recently published in *Fisheries Research* (Bellquist et al. 2019)

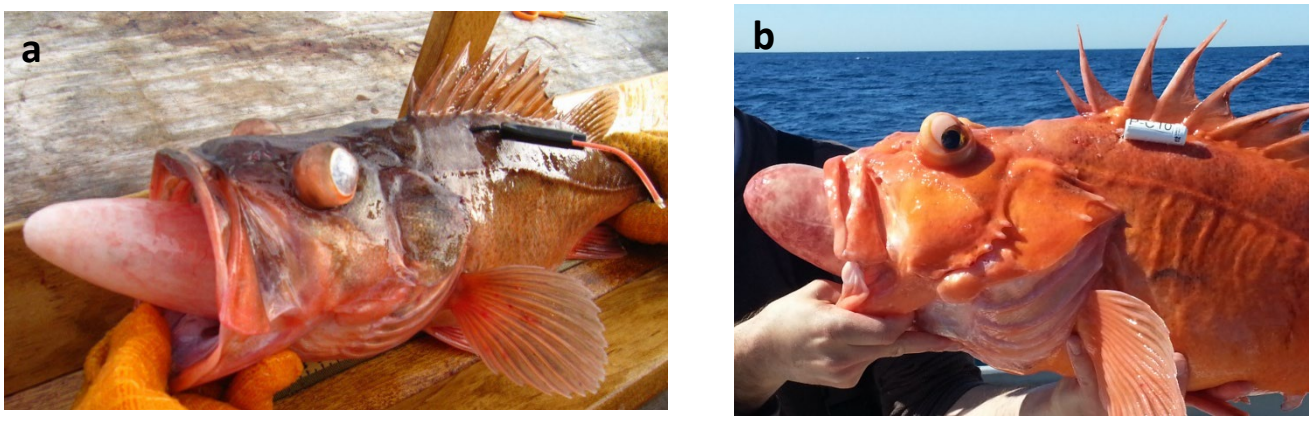

Figure A: Acoustic transmitter attachment and external barotrauma indicators for a) 47.5 cm FL Bocaccio tagged with a V9 single-anchored transmitter displaying a bloated body, everted esophagus, exophthalmia, and ocular emphysema. b) 64.0 cm Cowcod tagged with a double anchored V13 transmitter showing a bloated body, everted esophagus, exophthalmia, and the first onset of ocular emphysema (anterior-dorsal portion of eye).

D. OTHER RELATED STUDIES

D1. SWFSC FED Habitat and Groundfish Ecology Team 2019-20 Research on California Demersal Communities

Contact: EJ Dick (edward.dick@noaa.gov) FED HAGE Investigators: Joe Bizzarro, Tom Laidig, Melissa Monk, Diana Watters

The SWFSC/FED Habitat and Groundfish Ecology Team (HAGE) completes stock assessments on groundfish species and conducts research focused on deep-water California demersal communities. The goal for the deep-water component is to provide sound scientific information to ensure the sustainability of marine fisheries and the effective management of marine ecosystems, with objectives to: (1) improve stock assessments, especially of groundfish species in untrawlable habitats; (2) characterize fish and habitat associations to improve EFH identification and conservation; (3) contribute to MPA design & monitoring; and (4) understand the significance of deep-sea coral (DSC) as groundfish habitat. The HAGE uses a variety of underwater vehicles to survey demersal fishes, macro-invertebrates (including members of DSC communities), and associated seafloor habitats off northern, central, and southern California. These surveys have resulted in habitat-specific assemblage analyses on multiple spatial scales; fishery-independent stock assessments; baseline monitoring of MPAs; documentation of marine debris on the seafloor; and predictive models of the distribution and abundance of groundfishes and deep sea corals. The following are a few examples of recent projects conducted by the HAGE and collaborators.

D2. Expanding Pacific Research and Exploration of Submerged Systems Campaign

Contact: Tom Laidig (tom.laidig@noaa.gov)

In 2018, a team of federal and non-federal partners initiated a new phase of collaborative ocean science off the western United States. The EXpanding Pacific Research and Exploration of Submerged Systems (EXPRESS) campaign targets deepwater areas off California, Oregon, and Washington. The core focus of campaign activities is the collection of spatially explicit deepwater habitat information including multibeam, backscatter, and visual data on continental shelf, shelf edge, and slope habitats. This goal will be attained through partnerships between NOAA (NOS and NMFS), BOEM, USGS, and MBARI. From initial successes, this nascent interagency effort quickly evolved into a major field program engaging and exciting scientists and marine resource managers spanning numerous disciplines and organizations. EXPRESS members were involved in 4 research expeditions in 2020 including the 10-day deep-sea coral cruise aboard the E/V *Nautilus* (see D3 below). Three EXPRESS expeditions are currently planned for 2021.

D3. FY19 NMFS Deep-sea coral EXPRESS expedition, 1 Oct-7 Nov 2019
Contact: Tom Laidig (tom.laidig@noaa.gov)

A 10-day deep-sea coral expedition was conducted 17 Oct - 26 Oct, 2019 off the coast of California. The expedition was supported by NOAA's Marine Sanctuary Program, and staffed by NOAA personnel (CINMS, SWFSC, SWFSC). The cruise was planned through the EXPRESS campaign (See D2 above) with experts from CINMS, SWFSC, NWFSC, USGS, BOEM and MBARI. Research conducted during this cruise is part of the four-year West Coast Deep Sea Coral Initiative. The goals of the expedition were to 1) Collect information on corals, sponges, fishes, and sea floor habitats at sites around CINMS and Santa Lucia Bank, 2) Survey potential wind energy sites off Santa Lucia Bank, 3) Revisit a previously documented potential petrale sole spawning site on Santa Lucia Bank, 4) Create 3-D maps of high coral density areas for CINMS outreach activities, 5) Collect samples to help in identifying west coast corals and sponges. The expedition used two underwater remotely operated vehicles (ROVs), *Hercules* and *Argus*, in tandem. The ROVs were launched from the support vessel E/V Nautilus. Working from home, the science team narrated throughout dives, and directed quantitative transect surveys and specimen collections via telepresence technologies, which also provided live video and audio transmission to the public. Over one hundred hours of video were recorded and analysts are currently reviewing these files for identification and abundances of organisms. Many species of deep-sea corals, sponges and fishes were observed (Figure X). The Petrale sole spawning area was rediscovered but the dive ended too soon (due to travel time to next location) to map the entire aggregation site (Figure XX). A vast, previously unknown reef of dead *Farrea* sponges was discovered just south of Santa Cruz Island (Figure XXX). Additional surveys are being planned to map the extent of this reef. Many samples were collected for identification, however, due to Covid-19 restrictions to laboratory access, they have not been analyzed.

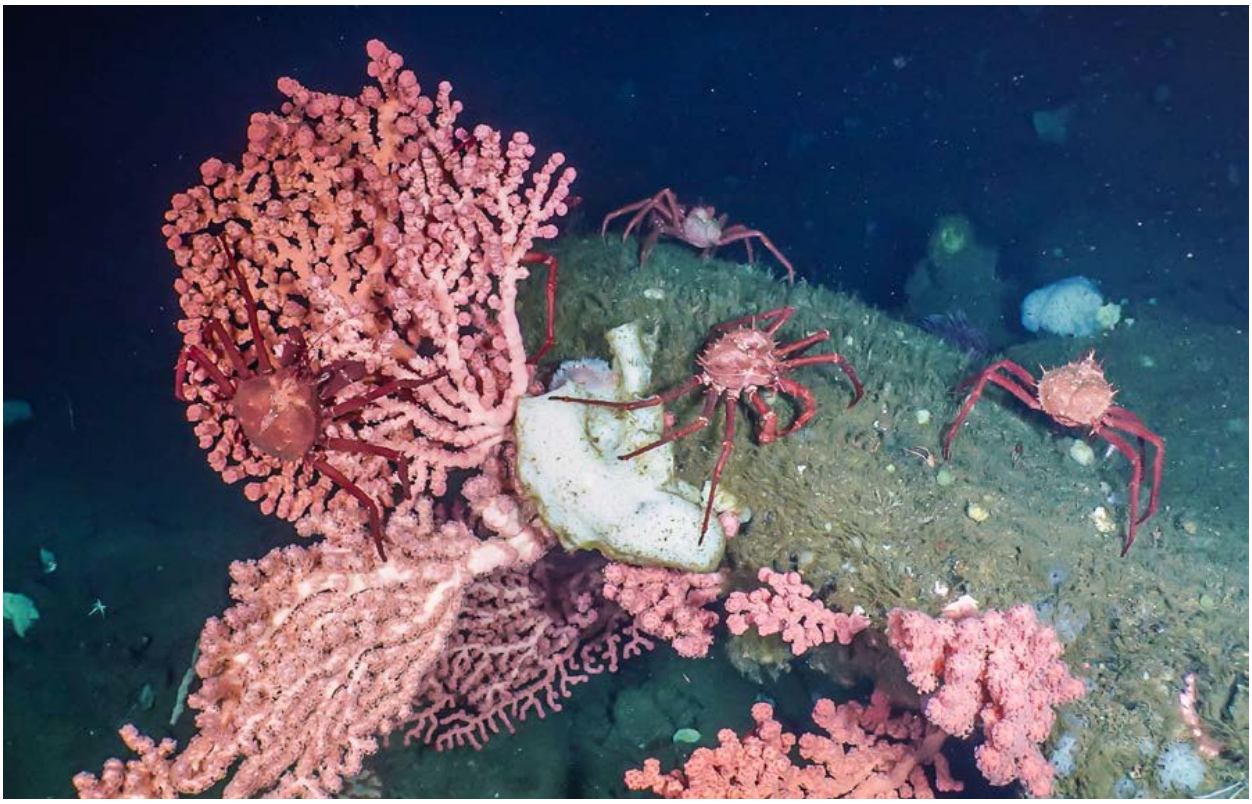

Figure X. Bubblegum corals (*Paragorgia pacifica*) and scarlet king crabs (*Lithodes cousei*) at Santa Lucia Bank.

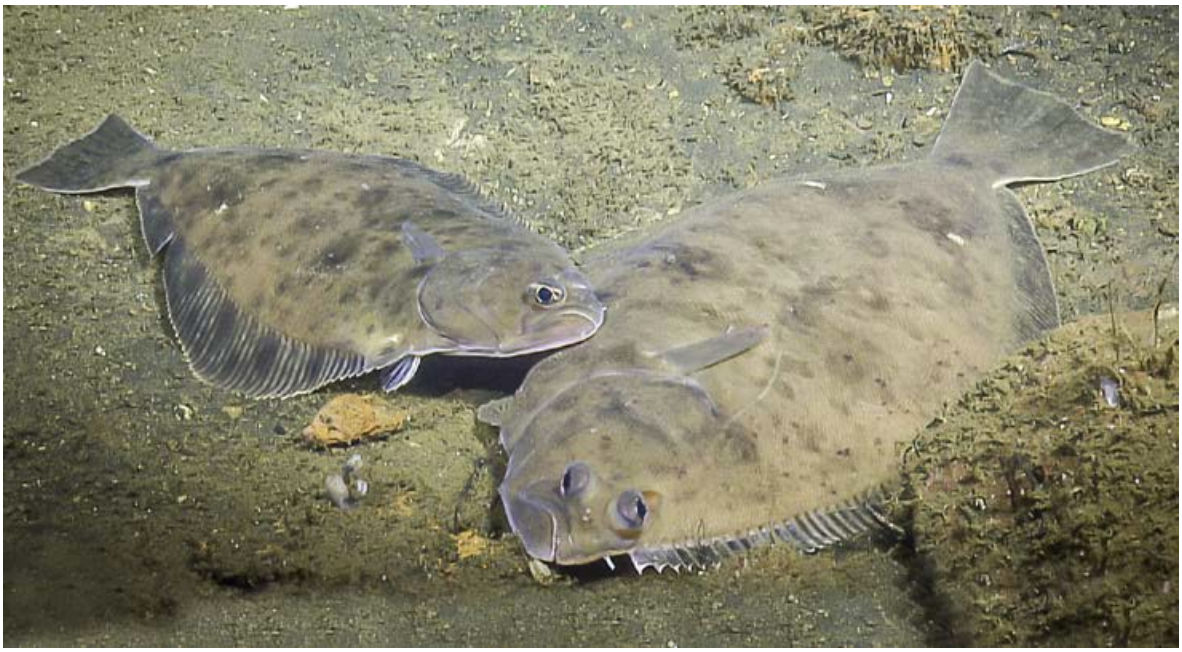

Figure XX. A smaller, presumed male petrale sole (*Eopsetta jordani*) laying on a larger female waiting to spawn.

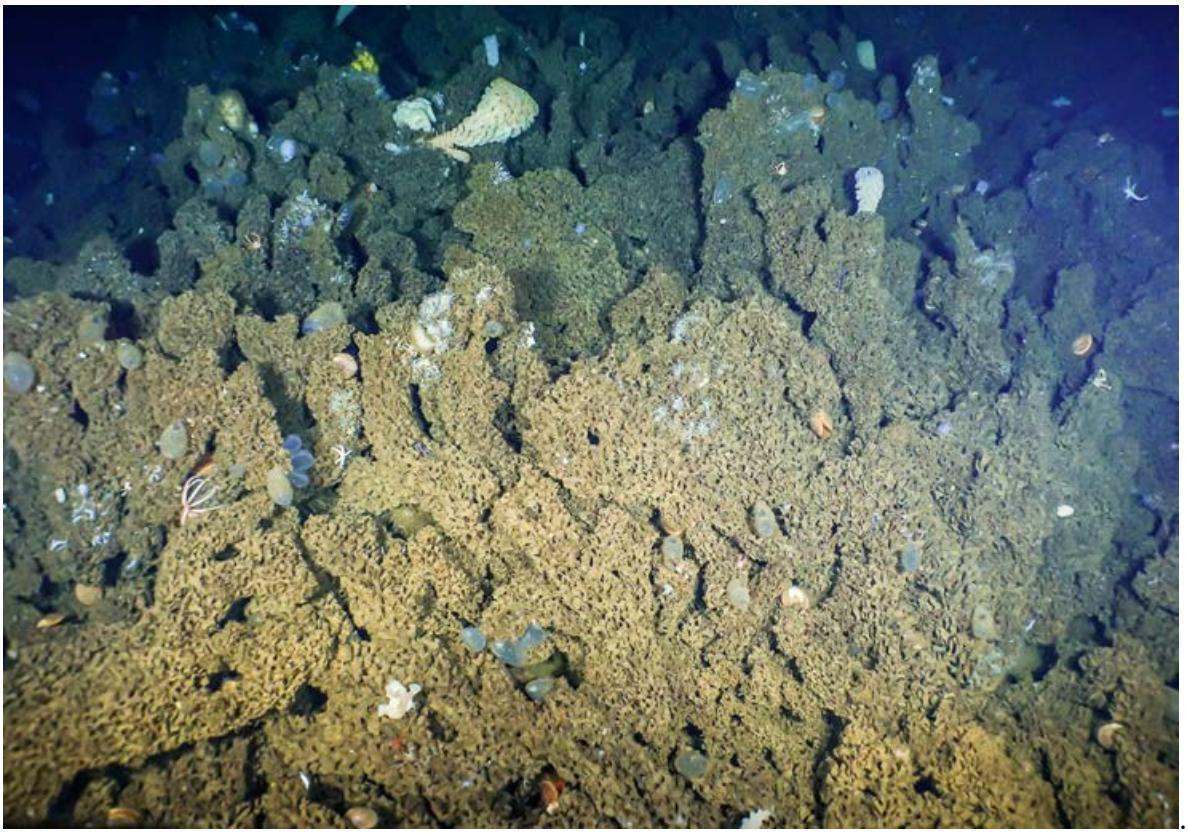

Figure XXX. Large reef of dead sponge (thought to be *Farrea* spp.) found southeast of Santa Cruz Island at ca. 575 meters depth in Footprint Marine Reserve.

D4. The importance of corals and sponges as groundfish habitat off Central and Southern California

Contact: Tom Laidig (tom.laidig@noaa.gov)
FED HAGE Investigators: Joseph J. Bizzarro, Rebecca Miller, Tom Laidig, Diana Watters

The overall goal of this project is to investigate the utilization of corals and sponges as habitat for groundfishes by analyzing extensive, long-term video data sets collected in central and southern California. Fish densities, sizes, diversity, and assemblage structure will be compared among similar seafloor habitat types with varying amounts and types of corals and sponges. Comparisons will be made within and between central and southern California study sites to assess the amount of spatial variability in fish-coral associations. Successful completion of this project will result in quantitative estimates of the relative importance of corals as habitat for a variety of commercially and ecologically significant groundfishes and the spatial consistency of these associations.

The project was initiated during early 2020, with the first year devoted to database standardization, video review, data editing, and new data collection. Using digital seafloor video data collected during human occupied submersible dives, we completed video review and data collection for 110 dive-transects from Central California at depths of 30–320, and 43 dive-transects from Southern California at depths of 44–320. To date, we have documented 402

associations between fishes and corals and 570 associations between fishes and sponges at a distance of < 1 body length and 1521 and 957 associations, respectively, at a distance of < 3 m. There were 64 fishes within 1 body length of a coral or sponge. Species commonly observed with sponges or corals include early juvenile stages of Squarespot, Pygmy, and Halfbanded Rockfishes, and older juvenile and adult Bank, Rosethorn, and Starry Rockfishes. Data collection is nearing completion, and analysis (towards a peer-reviewed publication) will commence during the summer of 2021.

D5. Catch estimation methods in sparsely sampled mixed stock fisheries
Contact: E.J. Dick (Edward.Dick@noaa.gov)

An ongoing project led by Nick Grunloh (UCSC/Center for Stock Assessment Research) and E.J. Dick (FED), with participation by Don Pearson (FED), John Field (FED) and Marc Mangel (UCSC/CSTAR) is focusing on the development of Bayesian hierarchical modeling approaches to be applied to historical and recent rockfish catch data and species composition samples in California fisheries, in order to improve estimates and quantify uncertainty in those estimates. Furthermore, the team has developed a Bayesian model averaging approach for inferring spatial pooling strategies across the over-stratified port sampling system. This modeling approach, along with a computationally robust system of inference and model exploration, will allow for objectively comparing alternative models for estimation of species compositions in landed catch, quantification of uncertainty in historical landings, and an improved understand the effect of the highly stratified, and sparse, sampling system on the kinds of inference possible, while simultaneously making the most from the available data. The methodology, currently a work in progress, was reviewed by a PFMC SSC methodology review panel (which included reviewers from the Center for Independent Experts) in March of 2018.

D6. Rockfish Reproductive Ecology Laboratory and Field Studies

Contact: sabrina.beyer@noaa.gov (Affiliate)/ **sbeyer@ucsc.edu**

Ongoing studies at the SWFSC Fisheries Ecology Division in partnership with the University of California Santa Cruz highlight spatiotemporal variability in reproductive output, including fecundity and the production of multiple annual larval broods in California rockfishes (*Sebastes* spp). Laboratory work continued in 2020 to process egg and larval samples collected in Central California in order to document interannual variability in reproductive effort correlated with oceanographic conditions in a range of economically important rockfishes. Samples of gravid Chilipepper (*S. goodei*), Bocaccio (*S. paucispinis*), Yellowtail (*S. flavidus*) and Widow (*S. entomelas*) rockfishes will be incorporated into a nearly three-decade time-series of fecundity data dating back to the 1980s and 1990s and spanning a range of environmental conditions in the Central region of the California Current to better understand environmental drivers of reproductive plasticity and maternal reproductive effort. The autodiametric method of fecundity analysis was developed, tested and implemented for more rapid processing of unfertilized oocytes in Chilipepper, Yellowtail and Rosy rockfish (*S. rosaceus*). The autodiametric method, on average, was five times faster than the traditional gravimetric counting method for unfertilized stages in rockfishes and will increase the efficiency of reproductive data collection.

E. GROUNDFISH PUBLICATIONS OF THE SWFSC, 2020– PRESENT

E1. Primary Literature Publications

Bellquist, L., Beyer, S. Arrington, M., Maeding, J., Siddall, A., Fischer, P., Hyde, J., Wegner, N.C. 2019. Effectiveness of descending devices to mitigate the effects of barotrauma among rockfishes (*Sebastes spp.*) in California recreational fisheries. *Fish. Res.* 215:44-52.

Beyer, S.G., Alonzo, S.H., Sogard, S.M. In press. Zero, one or more broods: Reproductive plasticity in response to temperature, food, and body size in the live-bearing Rosy Rockfish (Sebastes rosaceus). Marine Ecology Progress Series.

Bizzarro, J.J., Gilbert-Horvath, E.A., Dick, E.J., Berger, A.M., Schmidt, K.T., Pearson, D., Petersen, C., Kautzi, L.A., Miller, R.R., Field, J.C., and Garza, J.C. 2020. Genetic identification of blue rockfish (*Sebastes mystinus*) and deacon rockfish (*S. diaconus*) to enable life history analyses for stock assessment. Fishery Bulletin 118:37-50.

Chaumel, J., Schotte, M., Bizzarro, J.J., Zaslansky, P., Fratzl, P., Baum, D., and Dean, M.N. 2020. Co-aligned chondrocytes: zonal morphological variation and structured arrangement of cell lacunae in tessellated cartilage. *Bone* 134: 115264.

Duncan, E., Wooninck, L., Laidig, T., Clarke, E., Powell, A., Whitmire, C., Cochrane, G. and Caldow, C. California Streaming: Exploring Deep-Sea Coral and Sponge Assemblages in Sunny Southern California. 2021. In Raineault, N.A., J. Flanders, and E. Niiler, eds. New frontiers in ocean exploration: The E/V *Nautilus*, NOAA Ship *Okeanos Explorer*, and R/V *Falkor* 2020 field season. *Oceanography* 34(1), supplement, 78 pp

Field, J.C. R.R. Miller, R.R., Santora, J.A., Tolimieri, N., Haltuch, M.A., Brodeur, R.A., Auth, T.D.,Dick, E.J., Monk, M.H., Sakuma, K.M., and Wells, B.K. In review. Spatiotemporal patterns of variability in the abundance and distribution of winter-spawned pelagic juvenile rockfish in the California Current. PLOS One.

Henderson, M.J., Huff, D.D., and Yoklavich, M.M. 2020. Deep-sea coral and sponge taxa increase demersal fish diversity and the probability of fish presence. Frontiers in Marine Science 7:593844 (19 p.).

Lyons, K., Adams, D.H., and Bizzarro, J.J. *In press*. Evaluation of muscle tissue as a non-lethal proxy for liver and brain organic contaminant loads in an elasmobranch, the Bonnethead Shark. *Marine Pollution Bulletin*.

Matich, P., Bizzarro, J.J., and Shipley, O.N. *In press*. Are stable isotope ratios appropriate for suitable for describing niche partitioning and individual variation? *Ecological Applications*.

Mattiasen, E.G., Kashef, N.S., Stafford, D.M., Logan, C.A., Sogard, S.M., Bjorkstedt, E.P., and Hamilton, S.L. 2020. Effects of hypoxia on the behavior and physiology of kelp forest fishes. Global Change Biology 26(6):3498-3511.

Santora, J.A., T.L. Rogers, T.L., Cimino, M.A., Sakuma, K.M., Hanson, K.D., Dick, E.J., Jahncke, J., Warzybok, P., and Field, J.C. In Review. Diverse integrated ecosystem approach overcomes pandemic related fisheries monitoring challenges. Nature Communications.

Shipley, O.N., Kelly, J.B., Bizzarro, J.J., Olin, J.A., Cerrato, R.M., Power, M., and Frisk, M.G. 2021. Evolution of realized Eltonian niches across Rajidae species. *Ecosphere* 12: e03368.

Sosa-Nishizaki, O., García-Rodríguez, E., Morales-Portillo, C.D., Pérez-Jiménez, J.C., Rodríguez-Medrano, M.C., Bizzarro, J.J., and Castillo-Géniz, J.L. 2020. Fisheries interactions and the challenges for target and nontargeted take on shark conservation in the Mexican Pacific, p. 39–62. In: Advances in Marine Biology Vol. 85. Sharks in Mexico: research and conservation, part B (Larson, S, and Lowry, D., eds.). Elsevier. Amsterdam, Netherlands.

E2. Other Publications

Mamula, A., Thomas-Smyth, A., Speir, C., Kosaka, R., and Pearson, D. 2020. Matching Vessel Monitoring System data to trawl logbook and fish ticket data for the Pacific groundfish fishery. NOAA Technical Memorandum NMFS-SWFSC-623. 76 p.

Poti, M., Henkel, S.K., Bizzarro, J.J., Hourigan, T.F., Clarke, M.E., Whitmire, C.E., Powell, A., Yoklavich, M.M., Bauer, L., Winship, A.J., Coyne, M., Gillett, D.J., Gilbane, L., Christensen, J., and Jeffrey, C.F.G.. 2020. Cross-shelf habitat suitability modeling: characterizing potential distributions of deep-sea corals, sponges, and macrofauna offshore of the U.S. West Coast. U.S. Department of the Interior, Bureau of Ocean Energy Management, Camarillo, CA. OCS Study BOEM 2020-021. 267 p.