NMFS Southwest Fisheries Science Center

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

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Edited by Melissa Monk

With contributions from John Field, Tom Laidig, Nick Wegner, and William Watson

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 the Acting Deputy Director is Dr. Toby Garfield. All SWFSC divisions have supported 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. Lisa Ballance), and the Fisheries Resources Division (led by Dr. Gerard DiNardo). 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 four of the six research branches conduct studies focused on groundfish. Dr. Steve Lindley is currently the acting supervisor of the Early Life History and Habitat Ecology teams. The Early Life History team focuses on early life history of fishes, salmonid ocean and estuarine ecology, habitat ecology, and the molecular ecology of fishes. The Habitat Ecology utilizes a number of survey tools, e.g., visual surveys conducted with remotely operated vehicles (ROV), human-occupied submersibles, autonomous underwater vehicles (AUV), scuba, etc., to study deep-water demersal communities. The Molecular Ecology team (led by Dr. Carlos Garza) studies the molecular ecology and phylogeny salmonids and groundfish. The Fisheries Assessment group (led by Michael Mohr) conducts research and stock assessments in salmon population analysis, economics, groundfish, and fishery oceanography of salmonids and groundfish. Dr. John Field leads the Groundfish Analysis team within the Fisheries Assessment group, which supports the needs of NMFS and the Pacific Fishery Management Council, one of which is groundfish stock assessment. The Groundfish Analysis team also conducts the annual pelagic juvenile rockfish recruitment and ecosystem assessment survey along the West Coast. 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. A scientist from Fisheries Resource Division in La Jolla currently represents the SWFSC on the Pacific Council's Groundfish Management Team, and several scientists from the Fisheries Ecology Division in Santa Cruz currently serve on the Pacific Council's Scientific and Statistical Committee.

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)

Over the past year (2017-2018) the Ichthyoplankton Ecology and Molecular Ecology labs within the Fisheries Resources Division in La Jolla completed a project that used molecular methods to identify larval rockfishes collected from winter core CalCOFI stations between 1998 and 2013. The overall aim of this research was to develop a species-specific larval rockfish time-series and then use this data to evaluate how spawning patterns of different rockfishes responded to

environmental factors and the presence of rockfish conservation areas in Southern California between 1997 and the present. We found that the mean abundances of 6 of 8 rockfishes targeted by fishers and 3 of 7 non-targeted species increased significantly between 1998 and 2013 throughout southern California. We also found that 75% of targeted species increased at a greater rate within the CCA than at locations with similar environmental conditions outside of the reserves. By contrast, there was no difference in rate of change for the untargeted species within or outside the CCA. Results from this research were published in a University of San Diego MS thesis (Chen 2017) and in an article in the Royal Society Open Science (Thompson et al. 2017).

Moving into the next year we are going to expand on the rockfish genetic identification by similarly identifying rockfish larvae from the Trinidad Head Line, northern California and the Newport Line, central Oregon in collaboration with Eric Bjorkstedt and Ric Brodeur, respectively. This project should enable us to understand rockfish spawning dynamics at the California Current scale.

We continued a project to extract otoliths from the genetically-identified rockfish larva and measure otolith band widths and core size. We have removed otoliths from six rockfish species annually between 1998 and 2013. We are in the process of measuring otolith core width and the width of the 3 outer bands. We will then test the hypothesis that higher maternal investment (larger core) and recent growth (wide outer bands) correlate positively with recruitment success between 1998 and 2013 in southern California. This project is being led by Noah Ben-Aderet, a FATE-funded postdoctoral fellow.

We continued a project that is using next generation sequencing to bulk-identify rockfish (and other fish) species presence/absence from plankton samples. We collected plankton samples for this research from CalCOFI stations, in the Santa Barbara Channel, in Santa Monica Bay and along transects spanning northern California, Oregon and Washington. We first manually identified fish eggs and larvae under the microscope and by sequencing small amounts of tissue from individuals. We then returned the ichthyoplankton into the appropriate plankton sample and extracted DNA from the sample in two ways. First, we conducted DNA extraction using as template the ethanol in which each sample was stored. Second, we masticated the entire sample and extracted DNA from this mush. After extracting DNA we conducted Mi-seq metabarcoding runs to sequence part of the mitochrondrial 12S gene. Comparison of metabarcoding sequence to reference sequences available on GenBank indicated that metabarcoding was able to identify with high precision which fish species, including rockfishes, which were present in each sample. Because reference sequences were not available for some species we constructed a 12S reference library using tissue from fishes of known identity. We have completed the Mi-seq runs and are currently running bioinformatics analyses to determine which species were found in each sample. This research is being led by Dovi Kacev, a NRC postdoctoral researcher.

Finally, we have continued updating larval fish identifications from historic CalCOFI surveys to current taxonomic standards. We currently have completed all surveys from January 1962 through 2014, and by the end of this year expect to have completed analysis of samples collected in winter and spring of 2015-2018. This will provide a 56-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

The Rockfish Recruitment and Ecosystem Assessment survey completed its 36th survey year in June of 2018. The abundance of most young-of-the-year (YOY) pelagic juvenile rockfish was lower than recent years, following a series of very high abundance years that started in 2013 and persisted through the 2014-2016 large marine heatwave. The exception was fairly high YOY rockfish abundance within the southern California Bight. A manuscript detailing the relationship between pelagic juvenile rockfish abundance and oceanographic conditions was completed in 2018 (Schroeder et al., in press). This study built upon earlier studies of environmental drivers of rockfish recruitment variability, in which it was hypothesized that transport and source waters in the California Current Ecosystem were key factors driving the density independent processes that lead to variable recruitment in adult rockfish populations.

Previous studies focused on relative sea level as a proxy for the transport of Pacific Subarctic Water (PSUW) into the California Current from the Gulf of Alaska region. Most shelf break and slope water in the California Current is composed of a mix of PSUW, which tends to be cooler, lower salinity, and higher in oxygen and nutrients, and Pacific Equatorial Water (PEW), which reflects the poleward reach of the more subtropical waters of the California undercurrent and tends to be warmer, more saline, low oxygen, nutrient poor (spicy). By evaluating a more robust set of data to represent subsurface and offshore environmental conditions, particularly water mass characteristics using the results of a data-assimilative Regional Ocean Model System (ROMS) as well as in-situ data from ARGO array (an observing system of free-drifting profiling floats that measure the temperature and salinity of the upper 2000 m of the world's oceans).

The study demonstrated clearly that high YOY rockfish abundances tend to correspond to greater contributions of Subarctic water, while years of low rockfish abundance are associated with subtropical waters (Figure 1). The analysis was of particularly utility in interpreting observations during the large marine heatwave, which was characterized by warm surface waters and elevated sea levels, but cool, subarctic waters in the subsurface environment. The results are key to understanding mechanisms and drivers of recruitment variability, which in turn are key to understanding productivity of rockfish (and other) populations, and will help to better understand likely consequences of future climate variability and change. Several additional publications (Ainley et al. 2018, Warzybok et al. 2018) were also completed in 2018 that were based on part on the rockfish recruitment survey data and the interactions between pelagic juvenile rockfish and higher trophic level predators.

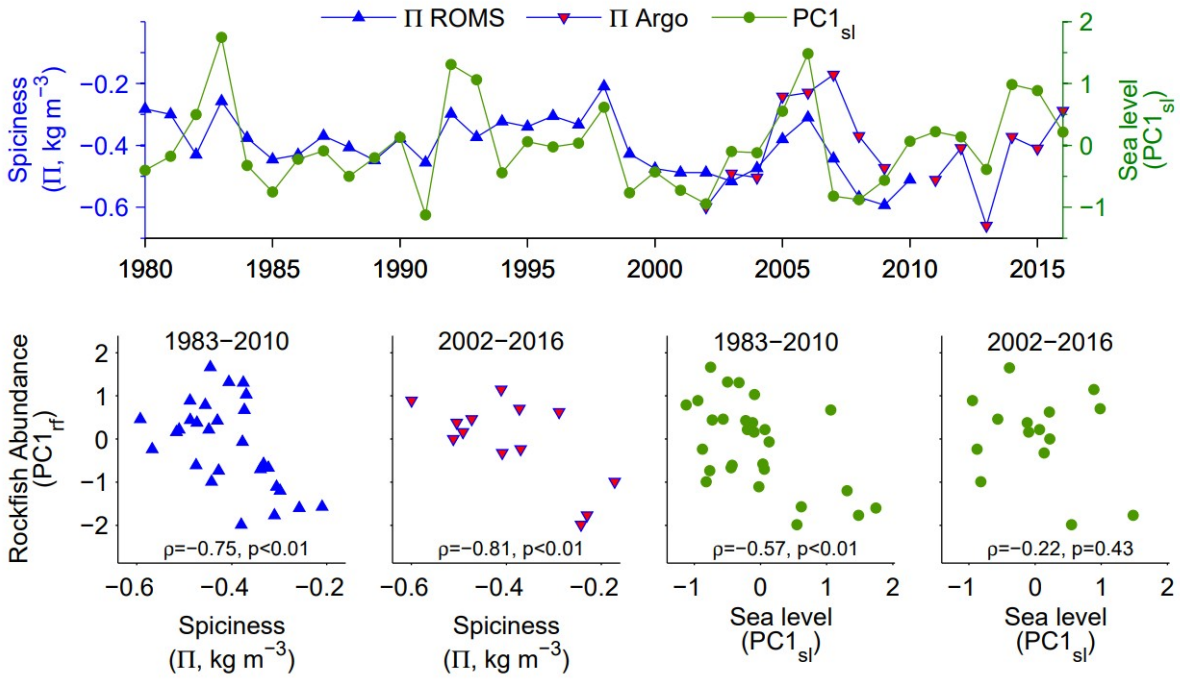

Figure 1: (Top) Time series of April-May averages of spiciness on the 26.0 isopycnal (Π) from ROMS models and Argo profiles and relative sea level anomalies (PC1sl; derived from tide gauge measurements along the California coast). (Bottom) Relationships between rockfish abundance (PC1rf) and the time series displayed in the top plot for two different time periods: 1983-2010 and 2002-2016 (from Schroeder et al., in press).

C. BY SPECIES, BY AGENCY

C2. Shelf Rockfish

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 continues to evaluate post release survival of rockfishes (*Sebastes* spp.) suffering from barotrauma. Over the past few years our groups has used commercially available descending devices to release rockfishes tagged with acoustic transmitters containing depth and accelerometer sensors in order to monitor long-term survival and recovery from barotrauma. This work reveals relatively high survival rates, although there are differences between the five species studied (Bank Rockfish, *S. rufus*, Bocaccio, *S. paucipinis*, Cowcod, *S. levis*, Starry Rockfish, *S. constellatus*, Sunset Rockfish, *S. crocotulus*). Our recent analyses suggest that hypoxia at depth is a major determinate of post

release mortality, with lower levels of dissolved oxygen associated with increased mortality. We hope to continue to assess rockfish movements and behavior in relation to hypoxia to determine rockfish sensitivity pre and post capture. Better understanding how low levels of dissolved oxygen contribute to mortality will allow for refinement of the catch-and-release process and the implementation of release guidelines that maximize survival.

In addition to tagging studies, we have worked with the recreational fishing community in California to measure the effectiveness and angler preference for different types of commercially available release devices. 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. Our 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 (Bellquist et al. 2019).

D. OTHER RELATED STUDIES

D1. SWFSC FED Habitat Ecology Team 2017-18 Research on California Demersal Communities

Contact: Tom Laidig (tom.laidig@noaa.gov)
FED HET Investigators: Joe Bizzarro, Tom Laidig, Diana Watters

The SWFSC/FED Habitat Ecology Team (HET) conducts research focused on deep-water California demersal communities. Our goal 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 rockfish 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 HET 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 HET 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 **EX**panding **P**acific **R**esearch and **E**xploration of **S**ubmerged **S**ystems (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 several research expeditions in 2018 including the 30-day deep sea coral cruise aboard the NOAA ship *Bell M. Shimada* (See D3 below) and multiple west coast mapping surveys aboard the NOAA ship *Rainier*. Six EXPRESS expeditions are currently planned for 2019.

D3. FY19 NMFS Deep-sea coral EXPRESS expedition, 9 Oct-8Nov 2018

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

A 30-day deep sea coral expedition was conducted 9 Oct - 8 Nov, 2018 off the coast of Oregon and California. The expedition was supported by NMFS' Deep Sea Coral Research and Technology Program and was jointly planned and staffed by NOAA (CINMS, NWFSC, SWFSC), BOEM, and USGS under the EXPRESS campaign (See D2 above). 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 Essential Fish Habitat baseline information at 12 sites proposed for modification the Pacific Fishery Management Council, 2) Revisit previously surveyed sites to document if changes have occurred over time, 3) Collect information to validate BOEM supported cross-shelf habitat suitability models, and 4) Collect samples to help in identifying west coast corals and sponges and expand use of new technologies.
The expedition began off Newport, OR and worked its way south to the southern California Bight. Two underwater survey vehicles were used; the NWFSC and PIFSC's autonomous underwater vehicle (AUV) and the Mare remotely operated vehicle (ROV). Benthic habitats were surveyed for the presence of deep-sea corals (DSC), sponges, and fishes. Water chemistry, DSC, sponge, and geologic samples were collected for a variety of researchers along the west coast.

Eighteen unique areas were sampled along the coast at depths from 50 - 650 m. A total of 37 ROV and 24 AUV dives were completed along with 123 water samples. Forty one DSC, 54 sponge, and 10 geologic samples were collected. Over 110 fish, 35 coral, and 34 sponge taxa were identified including some potential new species of DSC and sponges (Fig. X, XX). At least 3 DSC species had southern range extensions. A newly discovered, yet undescribed species of

yellow-colored *Swiftia* previously found only around the Farallon Islands was observed as far south as Anacapa Island in southern California.

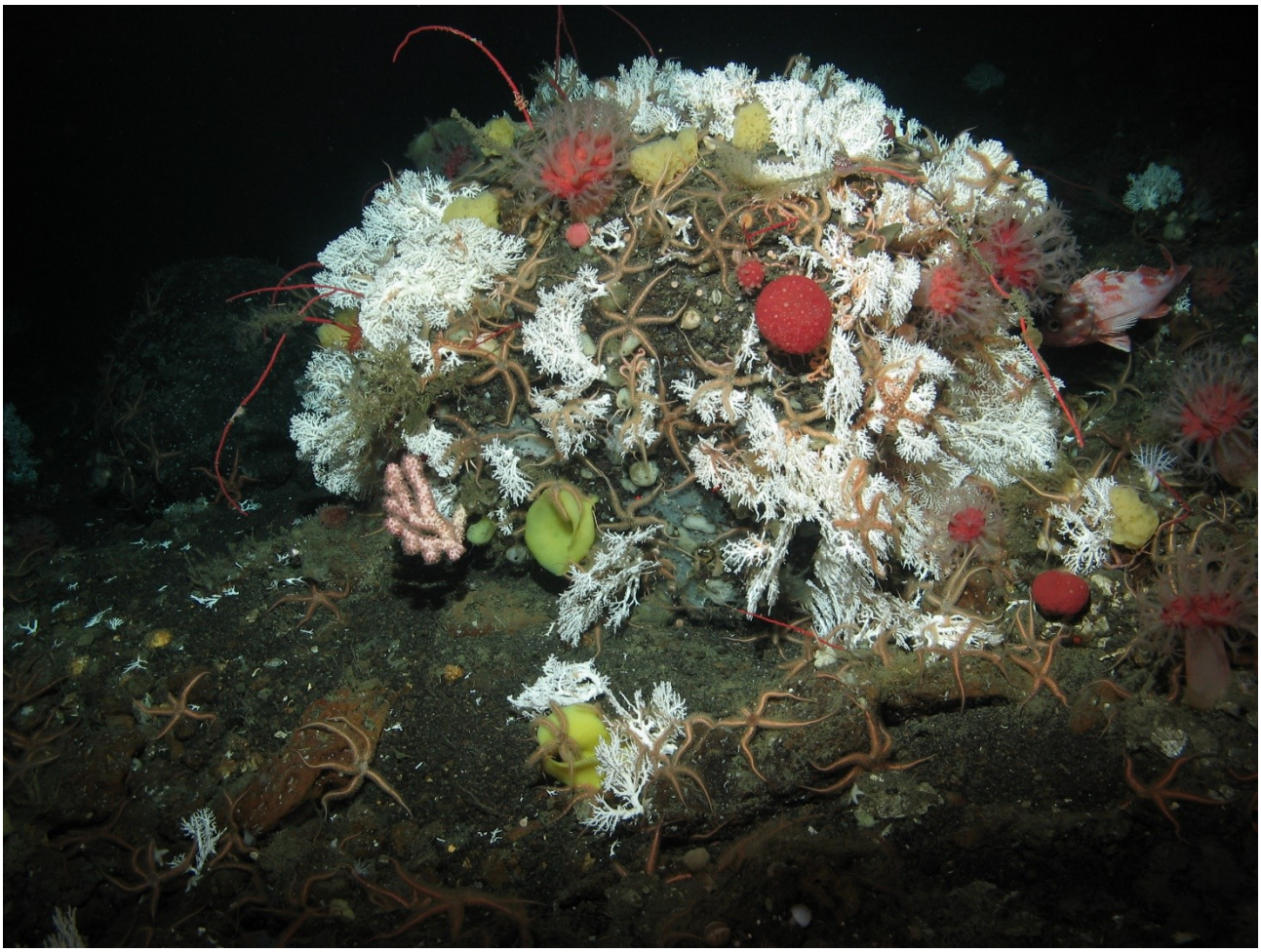

Figure X. A boulder covered in corals of at least 4 different species (white *Stylaster* spp. [possibly *S. parageus*], pink *Paragorgia* spp., red mushroom corals [*Heteropolypus ritteri*], and red stick corals (*Swiftia* spp.). Image taken on Mendocino Ridge at ~430 m.

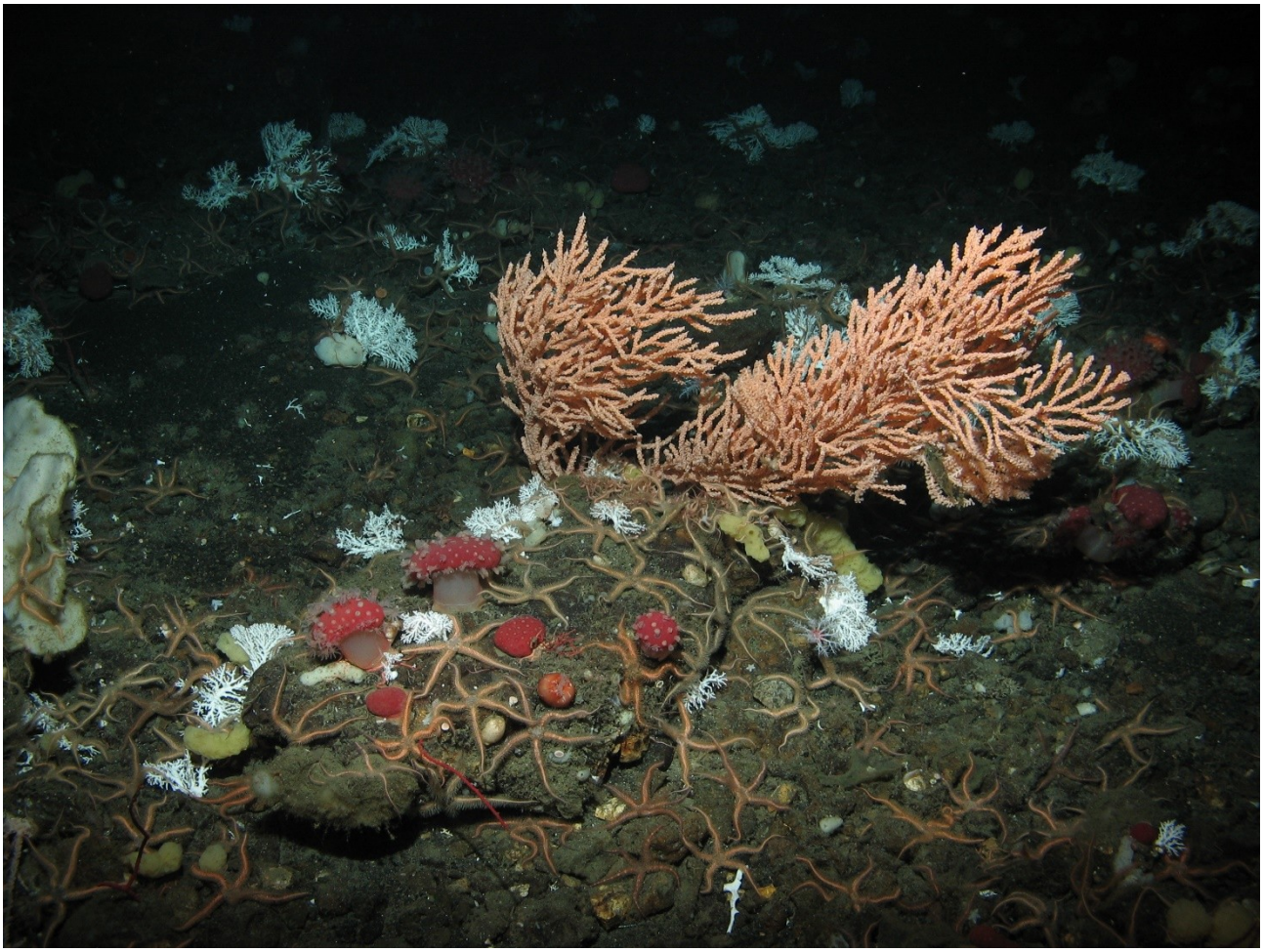

Figure XX. A red tree coral, *Primnoa pacifica*, observed on Mendocino Ridge at ~350 m. This is a southern range extension for this species.

D4. Anthropogenic noise generated by mobile survey vehicles
Contact: Tom Laidig (tom.laidig@noaa.gov)

During our UHSI cruise in southern California in 2017, HET members and researchers at Moss Landing Marine Laboratories placed acoustic devices on each surveillance platform to record ambient sound. The sounds created by each survey vehicle and support vessel were distinct and could be identified from the acoustic sonogram. This data will be examined in conjunction with the DIDSON and imagery data to determine how sound may influence rockfish behavior. These data also help to corroborate vehicle position and when each vehicle made its nearest pass to the surveillance platforms. Three times the platforms were left overnight due to poor sea conditions for retrieval. Interestingly, during these overnight times, the hydrophones picked up calls from *Sebastes paucispinis*.

D5. Revise Habitat Use Database (HUD) for 5-Year Essential Fish Habitat Review
Contact: Joseph J. Bizzarro (joe.bizzarro@noaa.gov)

During 2017, a final draft of the HUD was completed for all 117 species of groundfish identified in the current PFMC Groundfish Fishery Management Plan (FMP). The updated draft version of the HUD was then reviewed by West Coast EFH Coordinator, John Stadler, and retired NWFSC-FRAM fisheries research biologist, Waldo Wakefield. At their requests, several additions and modifications were made during 2018. A final, updated version of the HUD will be completed in mid-May (2019) and made publicly available through the NWFSC/FRAM Data Warehouse (https://www.nwfsc.noaa.gov/data/map) soon thereafter.

D6. Conduct Habitat Suitability Probability Modeling for 5-Year Essential Fish Habitat Review
Contact: Joseph J. Bizzarro (joe.bizzarro@noaa.gov)

Support was provided to Waldo Wakefield (NWFSC, retired) and Bran Black (Oregon State University) to inform Habitat Suitability Modeling efforts for adult life stages of the 92 groundfish species that are directly managed under the PFMC Groundfish Fishery Management Plan. Using information contained in the updated HUD (see D5 above), input data were provided for latitude, depth, and habitat association inputs for Bayesian analysis. Model outputs were then displayed graphically in GIS on a scale of 0-1 that estimates the probability that any particular location (i.e., 25 m x 25 m pixel in the output map) is suitable habitat for a particular species. Modeling efforts continued throughout 2018, with a target completion date of May 2019.

D7. Complete Data Quality layer for Cross-Shelf Benthic Habitat Suitability Modeling Project
Contact: Joseph J. Bizzarro (joe.bizzarro@noaa.gov)

A collaborative effort between NOS, NMFS, and BOEM personnel was initiated in 2016 to create habitat suitability models for corals and infaunal invertebrates and is ongoing. During 2017, a coastwide substrate map, initially created for the 2005 PFMC review of EFH for West Coast groundfishes, was updated to include all newly acquired seafloor induration collected since the last such effort during the 2012 EFH synthesis, and to include hard, mixed, and soft habitat types in California waters. During 2018, a data quality layer was compiled to improve the utility of the map for modeling purposes by weighing the reliability of various seafloor induration data. This updated substrate map and companion data quality layer were then used as an environmental input in coral and infauna modeling efforts. Metadata are now being created for the GIS products, and appropriate sections of the final report will be written and submitted during the spring of 2019.

D8. Organize and Host West Coast Groundfish Food Habits Workshop
Contact: Joseph J. Bizzarro (joe.bizzarro@noaa.gov)

With support from the West Coast Region office and Office of Sustainable Fisheries, a Groundfish Food Habits Workshop was conducted at NMFS-FED in Santa Cruz during September 24-25, 2018 with over 20 participants from 4 different NMFS Science Centers, academics, CDFW biologists, and NGOs. The main goals of the Workshop were to 1) become informed of past and current research on groundfishes, as well as pelagic fishes, sea birds, and marine mammals, 2) learn how to initiate a focused food habits program from Centers that have established programs (i.e., AFSC, NEFSC), and 3) bring together SWFSC and NWFSC scientists to plan and coordinate future work. This Workshop was highly effective in achieving its goals and helped to inform the development of the SWFSC's Center for Ecosystem Science Committee. A final report from the Workshop is currently being prepared and will be submitted to all Workshop participants, the West Coast Region and Office of Sustainable Fisheries, and SWFSC-CESC.

D9. 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. The review panel provided several recommendations for additional work, and indicated that subsequent to a future review, it would be feasible to recommend that this approach for estimating the species composition of California rockfish landings be recommended as the best available science to inform stock assessments in the 2021 stock assessment cycle.

D10. Plasticity in reproductive output in the chilipepper rockfish
Contact: Lyndsey Lefebvre (Lyndsey.Lefebvre@noaa.gov)

An understanding of the reproductive biology of a species is fundamental to successful management of fish stocks. Rockfish (*Sebastes* spp.) have complex reproduction, being

viviparous and generally late to mature, often with extended adolescent periods characterized by abortive maturation events. Furthermore, whereas the majority of *Sebastes* species in the California Current region produce one brood of larvae annually, several are known to produce more than one, though no stock assessments have yet considered the impact multiple brooding may have on population spawning potential for these species. We documented abortive maturation and examined the prevalence and size-dependent and regional patterns of multiple brooding using macroscopic evaluation and detailed histological analysis of ovaries from a model species, chilipepper (*S. goodei*), collected off Central and Southern California (Lefebvre et al. 2018). We modeled the size-related maternal effect on the probability of multiple brooding, and quantified size-dependent fecundity relationships. Our results indicate that the most robust estimation of reproductive output, as a function of the fecundity-length relationship, is improved for chilipepper when multiple brooding is incorporated, due to the greater probability of additional broods, and thus greater spawning potential, in larger females.

E. GROUNDFISH PUBLICATIONS OF THE SWFSC, 2017 – PRESENT

E1. Primary Literature Publications

Ainley, D.G., Santora, J.A., Capitolo, P.J., Field, J.C., Beck, J.N., Carle, R.D., Donnelly-Greenan, E., McChesney, G.J., Elliott, M., Bradley, R.W. and Lindquist, K. 2018. Ecosystem-based management affecting Brandt's Cormorant resources and populations in the central California Current region. Biological Conservation 217: 407-418.

Baetscher, D. S., E. C. Anderson, E.A. Gilbert-Horvath, D.P. Malone, E.T. Saarman, M.H. Carr, and J.C. Garza. In press. Dispersal of a nearshore marine fish connects marine reserves and adjacent fished areas along an open coast. Molecular Ecology. DOI: https://doi.org/10.1111/mec.15044

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. Fisheries Research 215:44-52.

Bizzarro, J.J., E.A. Gilbert-Horvath, E.J. Dick, A.M. Berger, K. Schmidt, D. Pearson, C. Petersen, L.A. Katutzi, R.R. Miller, J.C. Field, and J.C. Garza. In review. Addressing cryptic species issues in stock assessments as exemplified by blue rockfish (*Sebastes mystinus*) and deacon rockfish (*S. diaconus*).

Haskell, N., A. Mamula, and T. Collier. In press. Competition or cooperation? Peer effects in the Pacific Coast groundfish fishery. Land Economics.

He, X., and J.C. Field. In press. Effects of recruitment variability and fishing history on estimation of stock-recruitment relationships: Two case studies from U.S. West Coast fisheries. Fisheries Research.

Lefebvre, L., C. Friedlander, and J.C. Field. In press. Reproductive ecology and size-dependent fecundity in the petrale sole, *Eopsetta jordani*, in California, Oregon and Washington waters. Fishery Bulletin.

Lefebvre, L. S., S.G. Beyer, D.M. Stafford, N.S. Kashef, E.J. Dick, S.M. Sogard, and J.C. Field. 2018. Double or nothing: Plasticity in reproductive output in the chilipepper rockfish (*Sebastes goodei*). Fisheries Research 204:258-268.

Schroeder, I., J. Santora, S. Bograd, E. Hazen, K. Sakuma, A. Moore, C. Edwards, B. Wells, and J.C. Field. In press. Source water variability as a driver of rockfish recruitment in the California Current Ecosystem: implications for climate change and fisheries management. Canadian Journal of Fisheries and Aquatic Sciences.

Sogard, S. M., and S.A. Berkeley. 2017. Patterns of movement, growth, and survival of adult sablefish (*Anoplopoma fimbria*) at contrasting depths in slope waters off Oregon. Fishery Bulletin 115(2):233-251.

Warzybok, P., Santora, J.A., Ainley, D.G., Bradley, R.W., Field, J.C., Capitolo, P.J., Carle, R.D., Elliott, M., Beck, J.N., McChesney, G.J. and M.M. Hester. 2018. Prey switching and consumption by seabirds in the central California Current upwelling ecosystem: Implications for forage fish management. Journal of Marine Systems 185: 25-39.

Watters, D. L., and E.J. Dick. 2018. A comparison of length distributions of rockfishes (*Sebastes* spp.) from submersible and trawl surveys off central California. Fishery Bulletin 116(3):291-301.

E2. Other Publications

Baetscher, D. S. 2019. Larval dispersal of nearshore rockfishes. Ph.D. dissertation, University of California, Santa Cruz. 173 p.

Dick, E.J., A. Berger, J. Bizzarro, K. Bosley, J. Cope, J. Field, L Gilbert-Horvath, N. Grunloh, M. Ivens-Duran, R. Miller, K. Privitera-Johnson, and B. T. Rodomsky. 2018. The combined status of blue and deacon rockfishes in U.S. waters off California and Oregon in 2017. Pacific Fishery Management Council, Portland, Oregon. 377 p.

Field, J.C., and X. He. 2018. Stock assessment update of blackgill rockfish, *Sebastes melanostomus*, in the Conception and Monterey INPFC areas for 2017. Pacific Fishery Management Council, Portland, Oregon. 96 p.

He, X., and J. C. Field. 2018. Stock assessment update: Status of bocaccio, *Sebastes paucispinis*, in the Conception, Monterey and Eureka INPFC areas for 2017. Pacific Fishery Management Council, Portland, Oregon. 224 p.

Monk, M. H., X. He, and J. Budrick. 2018. Status of California scorpionfish (*Scorpaena guttata*) off southern California in 2017. Pacific Fishery Management Council, Portland, Oregon. 217 p.

Sakuma, K.. 2018. Cruise report, NOAA Ship Reuben Lasker RL-18-02, May 8 - June 21, 2018: Rockfish recruitment and ecosystem assessment. NOAA National Marine Fisheries Service, SWFSC Fisheries Ecology Division, Santa Cruz, California. 18 p.