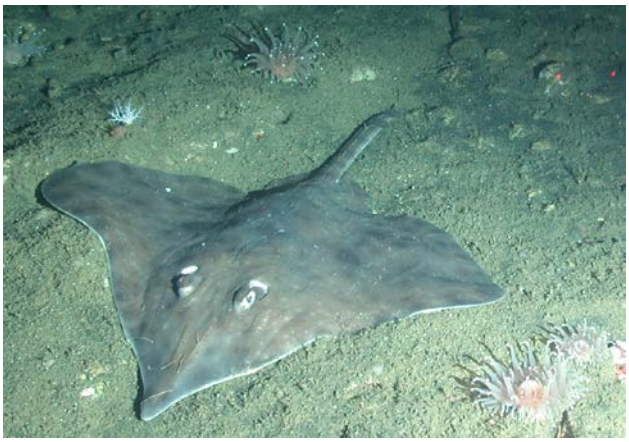
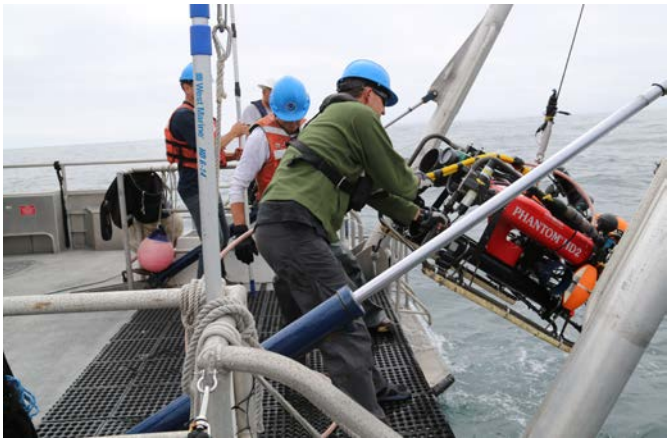


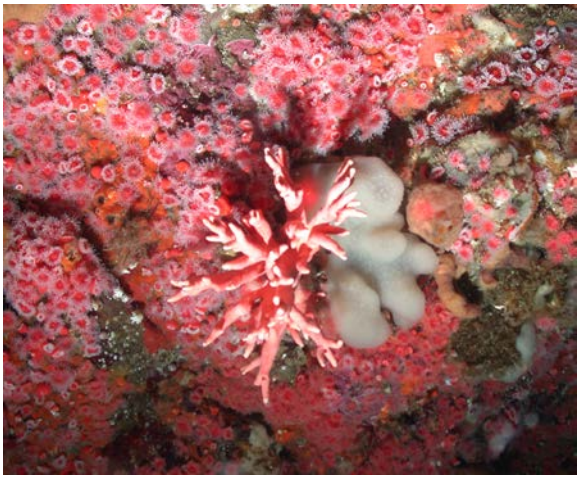

Report from the Workshop on Benthic Sampling at Cordell Bank National Marine Sanctuary

June 20-21, 2016

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Purpose: Solicit expert advice to aid Cordell Bank National Marine Sanctuary (CBNMS) in design of long term benthic monitoring sampling strategy

Invited Participants:
Ben Becker, Point Reyes National Seashore
Tom Laidig, NOAA Southwest Fisheries Science Center (Santa Cruz)
James Lindholm, California State University, Monterey Bay
Kevin Stierhoff, NOAA Southwest Fisheries Science Center (La Jolla)
Brian Tissot, Humboldt State University

ONMS Staff:
Dani Lipski, CBNMS Research Coordinator, facilitator
Kaitlin Graiff, CBNMS Research Specialist
Dan Howard, CBNMS Superintendent
Michael Carver, CBNMS Deputy Superintendent and Resource Protection Coordinator
Jan Roletto, Gulf of the Farallones National Marine Sanctuary (GFNMS) Research Coordinator, note-taker

Executive Summary

Background:
The research staff at CBNMS is evaluating the future direction of its benthic science program and aims to develop a long term monitoring strategy in 2016-2017. There is a history of benthic surveys at CBNMS using various technologies and approaches. The goals and strategies of the historic surveys have varied – some have been multi-year approaches, others were one time surveys; some were led by CBNMS and others by partners. All the surveys have resulted in a wealth of information about the sanctuary and particularly the bank itself but there is no current long term strategy for benthic surveys. CBNMS needs a long term strategy for characterization and monitoring to guide planning, implementation, and fundraising so that information is available to understand and protect the resources of the sanctuary and inform management efforts.

In late 2015 and early 2016 members of the CBNMS staff engaged in an exercise to identify the research and monitoring issues, stressors, metrics of interest, and time line as a first step in identifying the needs of a benthic monitoring program. CBNMS then invited experts in benthic sampling to a workshop to discuss our needs and identify possible approaches for sampling techniques and strategies. Participants were identified who have expertise in benthic sampling and analysis and have worked at Cordell Bank or similar areas and were able to attend a workshop at Point Reyes National Seashore from June 20-21, 2016. In addition to those who attended, Mary Yoklavich (NMFS SWFSC) and Dr. Rick Starr (California Sea Grant, Moss Landing Marine Lab) were invited but were unable to attend.

Workshop Goal:
The stated goal of the workshop was to, “Solicit expert advice to aid CBNMS in design of long term benthic monitoring sampling strategy”.

Workshop Results:
At the workshop, participants were presented with background information on CBNMS as an organization and place-based marine conservation area, the history of benthic sampling at CBNMS, and the interests and goals identified by CBNMS staff. The group then discussed the factors to consider in designing a benthic sampling strategy including sampling design, sampling units, data collection, analysis, and technology. The experts provided advice on these factors and made recommendations on strategies to consider as CBNMS develops the long term plan.

Conclusions: Workshop participants provided excellent recommendations and advice to CBNMS on designing a long term benthic sampling strategy. Recommendations on survey design, sampling strategies, image and statistical analysis, and operations will be useful as CBNMS drafts a long term strategy. Advice included the best way to divide the sanctuary into strata, using a combination of a stratified random survey design with some fixed long term sites, maximizing area surveyed and bottom time with long transects that can be subsampled, ideas for data summarization and factors to consider in statistical analysis. The participants provided valuable insights based on their experiences with long term monitoring and managing data as technologies change. The group also discussed their preferences and experiences with technology, vehicle configurations, data management, and operations.

Acknowledgements:
We thank the workshop participants for generously sharing their time and advice, Cordell Marine Sanctuary Foundation for providing support for the workshop, and Point Reyes National Seashore for providing the meeting room. Kevin Stierhoff provided significant edits that greatly improved the report.

Proceedings:
Day 1

Morning Session: Introduction to CBNMS, history of benthic sampling at CBNMS, and benthic science needs at CBNMS

Late morning and afternoon: Discuss sampling strategies, sample design, analysis, and long term planning.

See Appendix I for agenda.

Introduction to CBNMS:
Dan Howard, CBNMS Superintendent, provided an introduction to CBNMS and the Office of National Marine Sanctuaries (ONMS) organization, when CBNMS was designated, the ONMS mission, and our program areas: Science, Education, Resource Protection, and Community Engagement. Dan pointed out that we have a history of being engaged in benthic sampling in a variety of ways, and we participate in and sustain a long term science and monitoring program for the pelagic environment, as well as other research and monitoring efforts. The program areas are connected, with science activities informing resource protection efforts, and information and visuals being used in education and outreach efforts.

History of benthic sampling:
Kaitlin Graiff, CBNMS Research Specialist, presented the history of benthic sampling at CBNMS which includes scuba surveys by Cordell Expeditions in the 1970s and 1980s that provided information that ultimately led to the designation of the area as a national marine sanctuary. More recently, other divers have visited the bank to collect samples and imagery, including a group of NOAA technical divers in 2010 and the Bay Area Underwater Explorers in 2013 and 2014. The *Delta* submersible was used for surveys on Cordell Bank from 2001-2005 in partnership with NMFS and resulted in several publications about rockfish and habitat on the bank. Remotely-operated vehicles (ROVs) and autonomous underwater vehicles (AUVs) have also been used on the bank. The Kraken ROV conducted one ROV dive in 2010 and the NMFS NWFSC SeaBED AUV conducted some surveys in the sanctuary in 2011. The CBMNS-owned *Phantom* ROV was used in 2014 for surveys on the bank and in the expansion area. The CBNMS also owns a camera sled which has been used to survey soft sediment habitat. Kaitlin showed maps of the sanctuary, the extent of multibeam bathymetry data, and the location of the historic visual surveys.

See Appendix II for this presentation.

Benthic Science Needs:
Dani Lipski, CBNMS Research Coordinator, presented the goals of the workshop and the management issues the sanctuary faces or could face, the stressors, species, habitats, time frame, research questions, and the capacity of CBNMS to conduct these surveys including staffing, funding, vessel, and technology. These are the factors that will drive the design of the long term sampling plan. Dani explained that the goal was to receive input that will help us develop a plan

within the next year. We want to develop a 20-year plan and we think we can reasonably expect to acquire the resources to conduct a survey every one to three years.

See Appendix III for outline of CBNMS benthic science needs provided to the workshop participants.

Discussion Part 1: Survey Design

The group began with a discussion around general ideas for designing surveys for CBNMS. These comments, as well as some that were brought up throughout the workshop, are summarized here:

- Conduct additional multibeam bathymetric mapping to complete mapping datasets so entire sanctuary has high quality multibeam data
- Use data collected on previous benthic surveys to inform future sampling design
- Concentrate effort on intense sampling when possible (conduct fewer surveys with intense sampling versus numerous surveys with sparse sampling; quality versus quantity)
- Consider conducting intensive characterization surveys early on, and then follow-up surveys can be less frequent.
- Use habitat type and depth as strata: 1) Soft sediment/continental shelf, 2) Cordell Bank, 3) Shelf/Slope Transition, 4) Slope and Bodega Canyon. These subsets of CBNMS were defined by looking at depth contours and locality of seafloor features within CBNMS boundaries
- Survey multiple strata in a single mission
- Stay focused on the level of detail and the types of questions that you want to answer, keeping in mind the scale, time horizon, etc. that you expect to see change in community structure. Design your long term monitoring strategy with realistic goals in mind, based on what resources you think you may have or will be able to acquire, and what management questions you are interested in.
- Detecting a percentage of change will be different for different habitats (i.e., it may be harder to detect changes in soft sediment habitat) so it will be necessary to vary the amount of change we can detect depending on habitat type and consider these differences during analysis.
- Consider collecting acoustic data for fish during any survey. This will provide data on fish that you aren't targeting with the ROV but additional sampling (trawl, visual, other) would be needed to identify species.

The group decided to focus on looking at the different habitat types in the CBNMS as strata and address each habitat separately. Below are summarized comments and recommendations from workshop participants on approaches to sample each stratum.

<u>Soft sediment on Continental Shelf:</u>

- The CBNMS ROV, camera sled, or both could be used to survey this stratum. The benefits of the ROV are that you have better control of the camera platform, which could result in better imagery. The camera sled may be used as a simpler and quicker way to get bottom imagery, but the quality may not be as good.

- Examine what previous camera sled and ROV surveys tell you about the patchiness and persistence of species and community assemblages. Examine that data to inform the selection of sites for future monitoring.
- Depending on your question, consider using other tools, such as the SEABOSS used by the USGS Woods Hole Coastal and Marine Science Center. This is a simple and cost effective tool that can groundtruth sediment type by using cameras and bottom-grab sampling.
- Consider conducting long transects. The habitat is fairly homogenous so you can run long transects and these can be subsampled later if needed, thereby efficiently collecting large amounts of imagery.
- Long transects with a high definition video camera will allow you to collect many hours of video from which you can subsample video frames at user-defined intervals that will provide a large sample size.
- You can create shorter video segments from these longer segments and remove sections where you stop to explore (i.e., when off-effort), and use sections of about 500-750 m for quantitative assessments.
- Consider placing transects so they can be surveyed consecutively without retrieving the ROV and moving the boat, or at least minimizing transit between transects. This will maximize bottom time and can be used in most habitat types.
- Rippled Scour Depressions (RSDs) have been found to be prominent habitat features on the continental shelf (Davis et al., 2013). Existing bathymetric and survey data suggest that RSDs are present in CBNMS (on the east side of Cordell Bank), but additional high-resolution bathymetric mapping should be conducted to determine if they are present and should be considered in the sampling design. You could start by looking at the existing bathymetry maps to identify putative RSD areas to sample. If RSDs are present, they should be considered a different habitat feature among the shelf soft sediment since RSDs move and can influence invertebrate communities.
- Discussion about fixed locations and random sampling strategies:
    - Resampling at fixed locations eliminates the location effect on your sampling and can be used to look at how that location changes over time, but it cannot be used to extrapolate to a wider area.
    - Random sampling allows you to look at a wider area and is good for characterization, looking at extent or movement of organisms, and modeling questions. You may need more samples with random sampling.
    - The best approach would be to combine a stratified-random sampling design with some additional fixed locations.
- The group discussed several options for sample design and ultimately recommended a stratified-random sampling design that includes long transects within blocks where some sites are revisited over time and new sites are sampled randomly.
    - For example, you could use the previous camera sled and ROV data to identify sea pen and brittle star patches, repeatedly sample those locations, and randomize additional sampling locations around them. This would tell you about the extent and persistence of those patches through time, and also about other areas that have not yet been surveyed.
    - You could have several blocks within this stratum (possibly 1-6) and they do not have to be uniform. The transects would be randomly selected from within blocks.
    - This approach could be applied to other strata in CBNMS.

Cordell Bank:

- The CBNMS ROV can be used to survey this habitat to 300 m. The western side of the bank transitions into deeper habitat and the continental slope and a different survey vehicle would be needed for this area.
- The group discussed if and how the bank should be divided up to look at different sections or strata. Previous approaches used a grid or depth zones. The group recommended examining the data from the *Delta* dives to see where natural breaks in community structure occur relative to prominent habitat features (e.g., depth and seabed geology as determined by cluster analysis), to define sampling strata. Anecdotally, demersal fish communities often change below ~100 m depth (T. Laidig), but existing data should be analyzed to determine if this applies at Cordell Bank.
- In addition to depth, other factors may influence community structure, such as the location on the bank (i.e., cardinal direction) and the distance from the boundary between different seabed geology (e.g., rock versus sand) or slope (e.g., shelf versus slope).
- Consider using the transition area at the base of the bank and surrounding habitat as a strata (on the west side of the bank: deep boulder, soft sediment, and steep slope; on the east side of the bank: fine- or coarse-grain unconsolidated sediment on the continental shelf); these areas could be ecologically unique.
- Recommend sampling multiple strata per survey. Try to collect as much data as you can during each cruise. This will allow you to have data on multiple strata each year that you are able to survey and will mitigate impacts of years you get weathered-out or have funding lapses.
- The suggestions regarding stratified-random sampling design and dive logistics described for the continental shelf would also work here. Also plan to revisit some sites (possibly those that were historically sampled) and randomize other sites.

Canyon and Continental Slope:

- The CBNMS's *Phantom* ROV is restricted to ~300 m and cannot survey these areas. A different vehicle and boat would be required, so surveys in these regions will be sampled more opportunistically, and likely rely on multiple survey tools on vessels like *Okeanos Explorer* or *Nautilus*, and on funding secured through RFPs from, for example, the Deep Sea Coral Research and Technology Program (DSCRTP) or Office of Exploration and Research.
- Since very little is known about these regions and resampling will be difficult, the focus of surveys in these regions should be on habitat characterization.
- Examine other sources that can provide information about this region, for example:
    - Trawling and snag data
    - DSCRT database
    - Non-trawl fishery bycatch data
- Review existing information from regions outside of CBNMS with similar habitat characteristics, for example in the Bering Sea, to see what might be inferred about the slopes and canyons within CBNMS.
- The steep slope and high rugosity of this terrain makes surveys challenging. Typically, transect surveys in steep, high-relief areas will run perpendicular to the isobaths from deep to shallow (called "elevator" transects). When surveying in a canyon, be sure to look at the canyon walls where hard substrate may be present, and not just at the canyon floor.

Discussion Part 2: Analysis

Image Analysis:

- Still images vs. Video
    - CBNMS currently has the ability to collect standard-definition (NTSC) video and 3 megapixel (MP) images from a still camera. However, we are purchasing a high-definition (HD) video camera that can capture still images. High-resolution still images (i.e., frame grabs) will be extracted from the HD video.
    - Rather than collecting time-lapse still images at a fixed interval, James Lindholm recommended continuous recording of video with an HD video, from which still images may be extracted as user-defined intervals, to provide a more complete picture of the habitat and allow for changes to the still image interval during post-processing.
    - Video may be better for fish and stills may be better for invertebrates. With video you may be able to see multiple angles of the fish and see movement and behavior which can help with fish identification. This is not as important for invertebrates which are more sessile. Still images can allow you to focus in on invertebrate assemblages.
    - There are a variety of software packages to help with image analysis. James has used ImageJ (free, open-source) or Image Pro (proprietary). Coral Point Count is another option that CBNMS is currently using. Automated detection and analysis programs are under development, but most analysts are manually reviewing and annotating images and logging data into spreadsheets, databases or both.

Data Analysis:

The group advised that the data analysis will ultimately be driven by the sampling plan that is adopted, the data that is collected, and specific questions to be answered. However, a few general guidelines should be considered:

- Basic data summaries and visualization
    - Summary analyses that describe community structure and habitat characteristics that may affect observed patterns
    - Some potential summary statistics:
        - Numbers of species or taxa groups
        - Density of frames with organisms present
        - Density of animals in known area
    - Georeferencing of still images and video annotations allows for the visualization of observations relative to the areas sampled.
    - Photomosaics can be useful for visualizations and outreach, and also for estimating percent cover.
    - Represent major taxa groups (fish, corals, sponges) on a map (i.e., species distribution maps)
    - Linear referencing method can be used to represent locations of animals along a transect.
    - Extract information that may delineate various seabed habitats (e.g., slope, rugosity, TPI, etc.) from multibeam bathymetric surfaces, and generate maps that illustrate the distribution of various taxa relative to those potential seabed habitat types.

- Pie charts can illustrate the community composition at different locations.
- See examples:
  - Monitoring MPAs in Deep Water Off Central California: 2007 IMPACT Submersible Baseline Survey. 2008. California Sea Grant College Program Publication No. T-067. https://caseagrant.ucsd.edu/sites/default/files/R_MPA-3%20Starr-Yoklavich.pdf
  - North Central California Coast Marine Protected Areas Baseline Characterization and Monitoring of Mid-Depth Rock and Soft-Bottom Ecosystems (20-116). 2014. James Lindholm et al. Final Report to California Sea Grant. http://www.csgc.ucsd.edu/RESEARCH/RESEARCH_PDF/NCCMPA/Final/RMPA-8_Lindholm_FinalReport.pdf

Statistical Analysis:

- Again, this will be driven by the sampling plan that is adopted, but it is well worth thinking about ahead of time so that you collect the correct data.
- Various multivariate statistical packages (e.g. PRIMER, the 'vegan' and 'mvpart' packages in R) can be used to examine relationships between organisms and their habitats (e.g., cluster analysis, multidimensional scaling (MDS), and multivariate regression trees (MRT)).
- Predictive modeling based on habitat followed by non-parametric model selection criteria (e.g., Akaike's information criteria (AIC) may also be used to generate maps predicting species distributions.
- If you have time series data and before-after-control-impact (BACI) design you can look at before and after comparisons.
- CBNMS will need to address this in more detail as the sampling plan is developed.

Succession:

With any long-term monitoring plan, it is necessary to plan for changes in technology and personnel over time to ensure that data is accessible and understandable into the future.

- Many have seen the succession from 8 mm video (Hi8), to VHS, to miniDV tapes, and now digital media. Video footage should be archived in a way that remains accessible as hardware and software technology changes. Tape media breaks and hard disk drives fail; plan accordingly.
- Look ahead as new technology is adopted. Update old media formats while the outgoing media technology is still available.
- Documentation (i.e., metadata) is key. Each survey should have good documentation of the vehicle configuration, data management, personnel, etc.
- Be sure to securely archive documents and data. The CBNMS server is backed up nightly and data stored there should be safe. We might also consider saving copies to a hard drive stored in another building or off-site, or using cloud-based storage, if available to NOAA.
- Retain written documentation. Even printed versions of documents can be helpful. Digitization (e.g., scanning to PDF with optical character recognition) of written documentation would provide an additional layer of redundancy and allow for more efficient searching.

How to deal with gaps in data from missed surveys:
Surveys may be missed because of funding gaps, poor weather, technology failures, or other reasons. Instead of depending on data collected at every planned interval, keep this in mind:

- Manage expectations of what you can realistically do.
- Ask questions appropriate to the level of data that you have.
- Repeated monitoring over a long time period is more important than ensuring you have data every year.
- A small amount of data collected repeatedly over a long time period can be valuable

Research Questions:
While the focus of the workshop was on designing a monitoring plan, the CBNMS presented a list of research questions (see Appendix III), some of which were briefly discussed.

- The group discussed how we might compare historic and more current data to examine changes over time. The experts agreed that this is possible depending on how you frame the question. They suggested that we could compare the community assemblages and sizes but may not be able to compare densities. As long as you are straightforward about the differences in the technologies and caveats and are looking at an appropriate spatial scale then it is possible.

Day 2:

Discussion Part 3: Long term planning

Half day session: discuss operations, collaborations, and any other outstanding topics

Operations:
The group discussed ROV operations and vehicle configurations. The goal was for CBNMS staff to learn how others are operating equipment and if there are methods or equipment we should adopt, particularly as we prepare to integrate a new HD video camera system.

- Camera configurations
    - Most have used the Scorpio (Insite Pacific) 3MP still camera in varying configurations, but usually with one camera mounted oblique/forward facing and 1 or 2 mounted downward.
    - GoPro cameras can be used as a second HD camera for forward or downward facing still or video imagery.
- Laser calipers
    - Parallel high-intensity lasers are often installed as a size-reference.
    - Many vehicles have paired lasers spaced 10-cm apart.
    - The SWFSC (La Jolla) HDHV-ROV (https://swfsc.noaa.gov/hdhv-rov/) has red lasers spaced20- and 40-cm apart, plus a green crossing laser (on the same plane as the 20-cm pair) to measure range from the camera.
    - Color of lasers does not seem to matter too much in terms of fish avoidance or attractions. Green lasers are becoming more common and red lasers are getting harder to purchase. Depending on the color of the seabed in the survey area, green lasers may be easier to see in post-processing (e.g., Cordell Bank has a lot of red organisms and red lasers can be hard to see in post-processing).

- Overlay
    - Overlay can be applied in post-processing using systems such as Vigra, if it is not recorded to the video in real time.
    - SWFSC records two data streams: one with no overlay (for education and outreach purposes) and one with an overlay (for analysis).
    - Variables to consider including in overlay include: depth, altitude, vehicle pitch/roll, camera pitch/roll, speed (SOG), heading, date/time, temperature, oxygen concentration. To facilitate the extraction of date/time during video analysis, a time code generator (e.g., Horita) may be used.
    - Time is the critical variable that links the multiple data streams (images, tracking)
- X-keys input devices
    - X-keys programmable keyboards may be used during surveys to record observations in real time.
    - Pros - Minimizes time required to enter information about commonly occurring species and events while minimizing data input errors.
    - Cons – identifications are made on the fly so it is best if it is used as qualitative data only, unless you are confident you can capture everything with a correct identification. The data type is presence data, not counts.
- CTD
    - Most vehicle configurations are now incorporating a CTD (conductivity, temperature and depth) sensor.
    - CBNMS does not currently have a CTD but would like to incorporate one into their ROV system.
- Altimeter
    - For visual survey methods, it is important to know the height of the camera above the bottom, and usually surveys try to maintain a consistent height from the bottom. An instrument that measures altitude is valuable, and many are available. Commonly used instruments include the Teledyne Benthos Model PSA-916 sonar altimeter, and the Teledyne RD Instruments Workhorse Doppler velocity log (DVL).
    - Altitude data should be recorded, if possible, and perhaps used during post-processing to estimate transect area (see Stierhoff et al. 2016).
    - During the survey, use the altimeter and judge by eye to maintain consistent height
    - If mounted in line with the axis of the video camera, an altimeter may be used to estimate the distance to the center of the camera image.
- Data recording
    - Record navigation and ROV variables data to file at least every 1-2, video is recorded continuously
    - Record new Winfrog file configuration for each dive and ensure that settings are kept
- Tracking vehicle positions
    - Several options for tracking the position of subsea vehicles are available, including: Ultra Short Baseline (USBL) acoustic positioning systems tracking (e.g., ORE Trackpoint-II and LinkQuest TrackPoint systems) and Doppler velocity logs (DVLs). Both systems are reasonably accurate and both are expensive (~$30,000). Typically, a USBL system is used to track the vehicle from a surface vessel, estimate the location of video/still camera observations, and estimate transect distance. A DVL provides precise and accurate estimates of speed (from which distance can be estimate) and

displacement, but must be provided with a starting location from which estimates of the position in earth coordinates (i.e., latitude/longitude) may be derived.
    - If you can, calibrate your tracking system in advance with a target on the bottom.
    - Hull-mounting the USBL hydrophone will improve data quality by providing a more consistent installation among surveys.
    - Remember that you don't need to over-engineer the tracking – consider the resolution that you need for the analysis you plan to conduct. However, it may be difficult or impossible to rectify poor quality or low-resolution tracking data after collection. Careful installation of tracking equipment and precise measurements of instrument offsets is time well spent.
- Lights
    - HMI lights have been popular in the past and continue to be used. They provide good light quality but some find them to overexpose images in some situations.
    - Many are adopting LED lights instead of HMIs.
    - Can use LEDs in a variety of configurations such as 2 fixed and 2 that can be moved around the ROV as needed. Can be operated at less than full power. SWFSC uses 4 LEDs operated at half power.
    - A strobe is still needed for still photographs, typically mounted above the camera to minimize over-exposure.
- Equipment calibrations and configuration testing
    - Do calibrations and configurations of camera, lights, strobe, and any other equipment that can be tested on deck and in a tank in advance of the surveys if you can.
    - Document your settings. Once you are in the water, work to ensure you maintain those settings (if you can) or assume they stay the same (if you can't control them).
- Area Calculations
    - If amount of area surveyed or density estimates are an important part of your analysis, be sure to know how you will calculate the area of your imagery in advance of the survey. Several techniques were discussed and are not described in detail here. In short, at a minimum you will need to know: transect distance; the pitch, roll, and altitude of the camera; and the camera viewing angles.
- Piloting the ROV
    - The ROV should be operated "low and slow". Most researchers recommend targeting an altitude between 0.6-1 m above the seafloor and a speed of 0.5-1 knot. It is important to understand how the altitude and speed affect the imagery collected and pilot the vehicle in accordance with the type of survey being conducted. Recognize that the seabed type and relief may impact the way that a vehicle is piloted, and may affect estimates of transect width and area.

Collaborations:
Participants presented their interests, capabilities, and potential collaborations

Jan Roletto, GFNMS:

- GFNMS benthic surveys are driven by management questions such as essential fish habitat (EFH) proposals. These needs are determined up to five years in advance. A high priority is to map and characterize the Point Arena Biogenic Areas that is within GFNMS boundaries. Also, shipwrecks are now a focus. GFNMS does not have in-house capability to conduct surveys and analyze data so they rely on working with other partners in NOAA (NMFS, NCCOS) and external partners like Marine Applied Research and Education (MARE).

Brian Tissot, Humboldt State University

- Brian has been working on deep sea ecosystems since the 1980's. His expertise is in habitat and invertebrate interactions and he has worked extensively on Heceta Bank, on the Central CA MPA project, and in other systems. He is currently the Director of the Marine Lab at Humboldt State and will be taking on graduate students soon. They have a small ROV (*Phantom* XL) but currently do not have the personnel to operate it. They also have a research vessel, the R/V *Coral Sea*, available for charter (~$4K/day plus fuel). Brian is open to having students work on projects and to write proposals for collaborative projects. HSU undergraduates get good field experience and could be good to have in the field on projects.

Kevin Stierhoff, NMFS/SWFSC

- The SWFSC had originally focused on white abalone and had done a lot of collaborative work on rockfish and other species. Now they are focused on sustainable fisheries and are doing coastwide surveys, as well as surveys focused in Southern CA. They have about five people in their lab and routinely take on interns. Projects they are doing that focus on technology development for acoustics and automated detection are good areas for collaboration.

James Lindholm, CSUMB

- James' interests are in fish and habitat associations, trawl impacts, and training students for careers in marine science. He has done trawl impacts surveys in Stellwagen Bank NMS and Morro Bay, as well as many subtidal surveys along the California coast. James is the head of the Institute for Applied Marine Ecology at CSUMB, whose goal it is to work with agencies on science for resource management needs and to train students for careers in marine science. CSUMB has 500 undergraduates in the marine science program. James has masters-level graduate students in his lab and is willing to collaborate on projects and have students develop projects on data collected on surveys. James is also on the board of COAST, which collaborates with agencies to provide internships for students.

Next Steps:
The workshop provided CBNMS with invaluable input to begin development of a long term benthic sampling strategy. CBNMS will begin drafting the strategy with the goal of having it completed before the 2017 field season. CBNMS has a list of follow up action items from the workshop, listed in a separate document.

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Appendices:

- Agenda
- History of benthic surveys at CBNMS ppt
- CBNMS benthic science program goals

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Suggested citation:

Lipski, D., 2016, Report from the Workshop on Benthic Sampling at Cordell Bank National Marine Sanctuary. NOAA Cordell Bank National Marine Sanctuary. 13 pp.

Appendix I: Agenda

CBNMS Benthic Sampling Workshop Agenda

Purpose: Solicit expert advice to aid CBNMS in design of long term benthic monitoring sampling strategy

Participants:
Ben Becker, Point Reyes National Seashore
Tom Laidig, NOAA Southwest Fisheries Science Center (Santa Cruz)
James Lindholm, California State University, Monterey Bay
Rick Starr, CA Sea Grant & Moss Landing Marine Lab
Kevin Stierhoff, NOAA Southwest Fisheries Science Center (La Jolla)
Brian Tissot, Humboldt State University

CBNMS Staff:
Dani Lipski, Research Coordinator, facilitator
Kaitlin Graiff, Research Specialist
Dan Howard, Superintendent
Michael Carver, Deputy Superintendent and Resource Protection Coordinator

Jan Roletto, GFNMS Research Coordinator, note-taker

Travel to Olema, CA: June 19
Workshop Dates: June 20-21

Address: 1 Bear Valley Road, Point Reyes Station, CA 94956

Itinerary:

Day 1	June 20, Red Barn Classroom
9:00	Arrival, coffee
9:15	Welcome, introductions (Dani)
9:30	Review goals and agenda (Dani)
9:40	CBNMS introduction (Dan)
10:00	History of benthic surveys in CBNMS (Kaitlin)
10:30	Break
10:40	Goals of workshop and CBNMS benthic science program (Dani)
11:20	Discussion Part 1: Survey Design • Survey type • Survey scheme • Survey strata (e.g., depth, substrate) • Site selection strategy • Sampling units (e.g., type, size) • Resampling interval

12:30 Lunch Break

1:30 Continue Discussion Part 1

2:00 Discussion Part 2: Analysis

- Metrics
- Image Analysis
- Summary Analysis and Characterization
- Statistical Analysis and Visualizations
- Considerations for data gaps in space and time
- Comparisons with other surveys using various survey tools

3:30 Break

3:40 Discussion Part 3: Long term planning

- Evaluation for monitoring goals
- Planning for future succession
- Considerations for opportunistic surveys and funding shortages (adding or missing surveys)

4:30 Summarize, discuss
5:00 Adjourn

6:30 Assemble at Station House bar
7:00 Dinner at Station House (hosted)

Day 2: June 21, CBNMS Office Conference Room
9:00 Arrive for Coffee

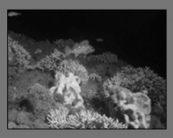
9:15 Discussion Part 4

- Continuation of Day 1 topics as needed
- Research topics
- New technology, software, products
- Operational details
- Partnerships and opportunities

11:00 Wrap up, next steps
12:00 Meeting Adjourns

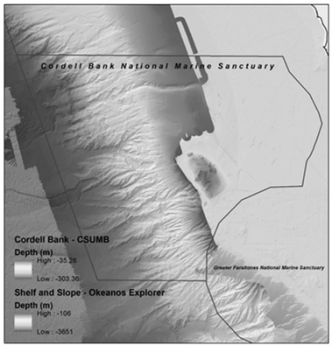
Appendix II. History of Benthic Surveys

History of benthic research and monitoring at CBNMS

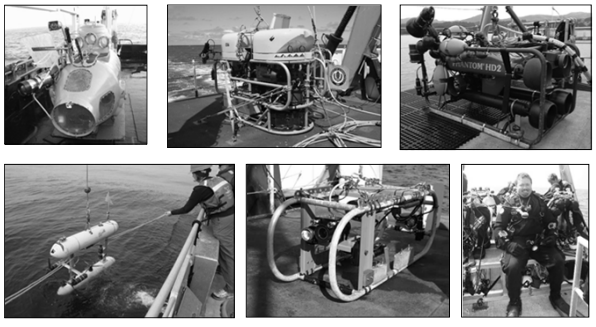



ROV Workshop -- June 20, 2016

Multibeam Data



Survey Tools



SCUBA

1977–1986

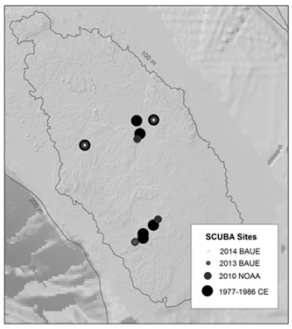
- Cordell Expeditions

2010

- NOAA Technical divers

2013 and 2014

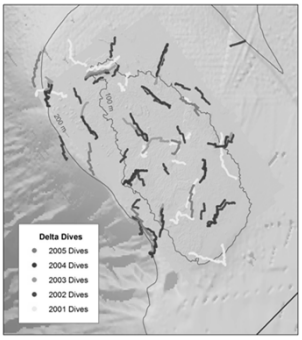
- Bay Area Underwater Explorers



Delta Submersible

2001-2005

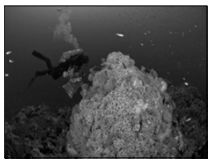
- Purpose:
  - Classify habitats and monitor fishes and invertebrates on and around Cordell Bank
- Partners:
  - U.S. Geological Survey
  - National Marine Fisheries Service
  - California Department of Fish and Wildlife



SCUBA

Products:

- Cordell Expeditions was instrumental in the designation of CBNMS



- Underwater images and extensive specimen collections –archived at California Academy of Sciences
- Piloted fixed transect survey with BAUE

Delta Submersible

Products:

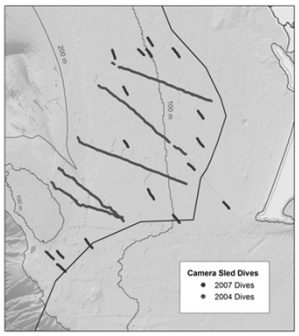
- Species inventory of fishes and benthic invertebrates associated with the bank
- Observations of derelict fishing gear supported 2006 EFH designation and marine debris removal with a ROV in 2008
- Analyses to date have examined fish-habitat relationships, the role of structure-forming invertebrates as habitat for fish and predictive habitat modeling for deep sea corals

  - Pirtle, J.L. 2005. Habitat-based assessment of structure-forming megafaunal invertebrates and fishes on Cordell Bank, California. M.S. Thesis, Washington State University. 64 pp.
  - Anderson, T.J., C. Syms, D.A. Roberts, D.F. Howard. 2009. Multi-scale fish-habitat associations and the use of habitat surrogates to predict the organization and abundance of deep-water fish assemblages. Journal of Experimental Marine Biology and Ecology 379(1-2): 34-42.
  - Young, M.A., P. J. Iampietro, R.G. Kvitek, and C.D. Garza. 2010. Multivariate bathymetry-derived generalized linear model accurately predicts rockfish distribution on Cordell Bank, California, USA. Marine Ecology Progress Series 415:247-261.
  - Etherington, L., P. van der Leeden. K. Graiff, D. Roberts, and B. Nickel. 2011. Summary of deep sea coral patterns and habitat modeling results from Cordell Bank, CA. Report to NOAA Deep Sea Coral Research and Technology Program. 24pp.

Camera Sled

2004 and 2007

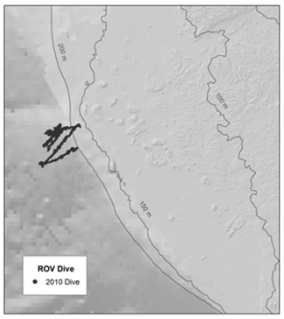
- Purpose:
  - Characterize the soft bottom habitats and biological communities on CBNMS continental shelf.
  - Ground-truth seafloor habitats that were mapped using side-scan sonar
- Partners:
  - U.S. Geological Survey



K2 ROV

2010

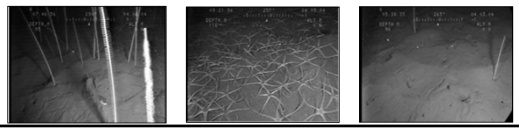
- Purpose:
  - Exploration for deep-sea corals and sponges on CBNMS continental slope
  - Ground-truth habitat classification mapped with multibeam
- Partners:
  - Deep-sea Coral Research and Technology Program
  - National Marine Fisheries Service
  - Pacific Marine Environmental Laboratory
  - National Center for Coastal and Ocean Science



Camera Sled

Products:

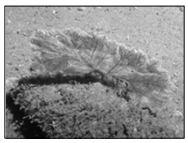
- Species inventory of fishes and invertebrates associated with the continental shelf
- Internal cruise reports
- Presence data of sea pens used in proposals for EFH review



K2 ROV

Products

- Information on the presence, abundance, and habitat associations of deep-water sensitive species, such as corals and sponges, and their associated communities
  - Graiff, K., D. Roberts, D. Howard, P. Etnoyer, G. Cochrane, J. Hyland, and J. Roletto. 2011. A characterization of deep-sea coral and sponge communities on the continental slope west of Cordell Bank, Northern California using a remotely operated vehicle. Final report to NOAA Deep Sea Coral Research and Technology Program. 21pp.
- Refined seafloor habitat classification has been used for future expedition planning
- Observation of large rockfish hotspot used in proposed addition to EFH on slope



AUV

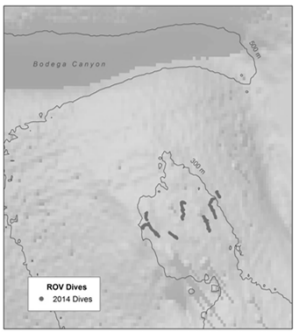
2011

- Project leader: Liz Clarke, NWFSC
- Purpose: Exploration for deep-sea corals and sponges in and near Bodega Canyon
- Partners:
  - Deep-sea Coral Research and Technology Program
  - CBNMS

Phantom ROV

2014

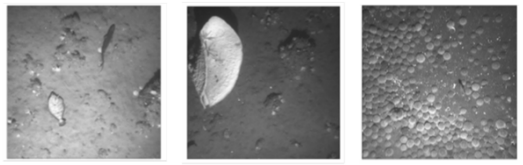
- Purpose:
  - Characterize deep-water habitats in newly expanded areas of CBNMS (Bodega Canyon) and GFNMS (The Football)
- Partners:
  - CBNMS and GFNMS
  - National Center for Coastal and Ocean Science
  - U.S. Geological Survey



AUV

Product:

- A broad-scale characterization of deep-sea coral and sponge habitats and communities
  - Fruh, E., E. Clarke, and C. Whitmire. 2011. A characterization of the deep-sea coral and sponge community in Bodega Canyon off the coast of California from a survey using and autonomous underwater vehicle. Report to NOAA Deep Sea Coral Research and Technology Program. 40pp.



Phantom ROV

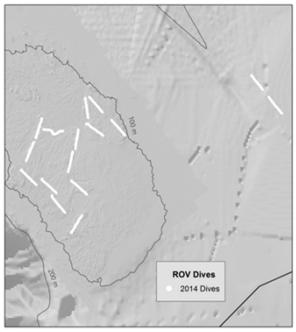
Products:

- Information on the presence, abundance, and habitat associations fishes and invertebrates
  - Graiff, K., D. Lipski, P. Etnoyer, G. Cochrane, G. Williams, E. Salgado. 2016. Benthic Characterization of Deep-Water Habitat in the Newly Expanded Areas of Cordell Bank and Greater Farallones National Marine Sanctuaries. Marine Sanctuaries Conservation Series ONMS-16-01. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 38 pp.
- HD video and still images were used to produce a high school classroom activity: "Deep Coral Communities: Sentinels of a Changing Ocean."

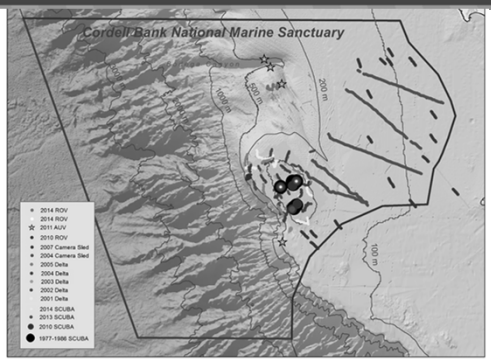
Phantom ROV

2014

- Purpose:
  - Fine scale characterization of invertebrate community on upper reefs (< 70m) of Cordell Bank
  - First year of multi-year monitoring project
- Funded and conducted by CBNMS



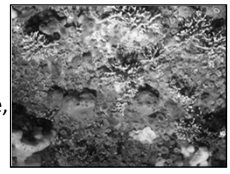
Benthic Survey Locations



Phantom ROV

Future Products:

- Spatial analyses of the invertebrate community and variables such as depth, slope, substrate, and aspect of Cordell Bank



- Data will be used to monitor change in invertebrate abundance and species composition
- Planning for cruise in 2017 to conduct transects >70 meters

Appendix III: CBNMS Benthic Science Goals, developed by CBNMS staff 2016

CBNMS Benthic Science Goals

Overall Goal for Benthic Habitat Project: Benthic communities in the sanctuary are well characterized and monitored so that changes can be detected and information is available to make recommendations to support management.

Regarding *benthic habitat* at CBNMS:

1. What do we want to know about Cordell Bank NMS?
    a. Characterize all habitats at a baseline level, including expansion area
    b. For habitats that are well characterized, monitor to detect change
        i. How are species and habitats changing over time, and in response to stressors and protections
        ii. How are environmental variables changing over time?
2. What stressors or issues are we concerned with?
    a. Climate change, including temperature and ocean acidification
    b. Invasive species
    c. Human impacts, such as fishing
    d. Hypoxia
    e. Disease
    f. Reduced habitat quality
    g. Recovery of habitat and species in response to protections
3. What are our monitoring questions?
    a. How are these metrics changing over time:
        i. Species composition
        ii. Density
        iii. Distribution and Abundance
        iv. Diversity
        v. Health and condition
4. What habitats are we interested in?
    a. We need to consider all habitats in the sanctuary
    b. We will need to catalog the strata such as habitat (continental shelf, slope, rocky, soft), and depth zones so that we can systematically target strata for surveys.
5. What species are we interested in?
    a. Survey for all macro species that we can identify
    b. Specific analyses may focus on rockfish species, *Stylaster*, potential invasive species, crabs, or seastars, depending on what issue we are addressing. We may not be able to anticipate what species will be affected by a stressor, so we need to generally record as many species as we can.
    c. Need to consider that fish and invertebrate surveys may need different technology or survey design.
6. Over what time frame are we considering?
    a. Approximately 20 year planning horizon
    b. The surveys and analyses would take place ideally every year, although resources to do that may be limited.

    c. Some change we would expect to see in the short term (with events like seastar wasting) and some will occur over a longer time period (recovery of populations)
7. What magnitude of change do we want to be able to detect?
    a. More research is needed on this, the general thinking is that we will be able to detect at least a 50% change and would like to be able to detect a 30% change.
8. What types of changes are we interested in?
    a. Species composition
    b. Density
    c. Habitat type or quality
    d. Percent cover
    e. Abundance
    f. Distribution
    g. Health
    h. Changes in temperature, pH, dissolved oxygen and impacts on benthos
9. What are our research questions?
    a. Can we compare current ROV surveys to historic surveys, such as submersible or diver surveys? If so, what does this tell us about change over time?
    b. Have fish populations recovered since protections were implemented?
    c. What are the source-sink dynamics of fish populations at the bank and other nearby areas?
    d. Can we validate and improve the coral predicted habitat model?
    e. What are the interactions of species and habitats?
    f. How does low DO affect organisms in the sanctuary?
    g. How is OA affecting organisms in the sanctuary?
    h. How are changing ocean conditions affecting organisms in the sanctuary?
    i. What is the status of habitat and biological communities in the soft sediment no-trawl zone?
    j. How unique is Cordell Bank compared to other seamounts or offshore habitats along the west coast?

Notes: A few other important points

- Monitoring is a critical component of the work that we do and is part of our responsibility as a federal resource management agency
- Monitoring is the first priority of the CBNMS ROV program, followed by research
- Sampling design needs to be repeatable and statistically rigorous.
- Invasive species is a real threat to CBNMS currently. We need to build relationships with scientists (taxonomists) who work on species and be sure to collect specimens.
- We will consider using other tools and technologies when appropriate (other than our Phantom ROV)
- We have limited resources, limited capabilities, and cannot address all these issues with our ROV. We will look for opportunities to use other vehicles and technology when we can. Our long term strategy should allow for opportunistic surveys.
- The long term planning process should include thinking about succession: after the current team has moved on and technologies have changed. The common metric will probably continue to be photos to track community composition, distribution and abundance.

- Guiding documents include the National Marine Sanctuaries Act, Condition Reports, and Management Plans