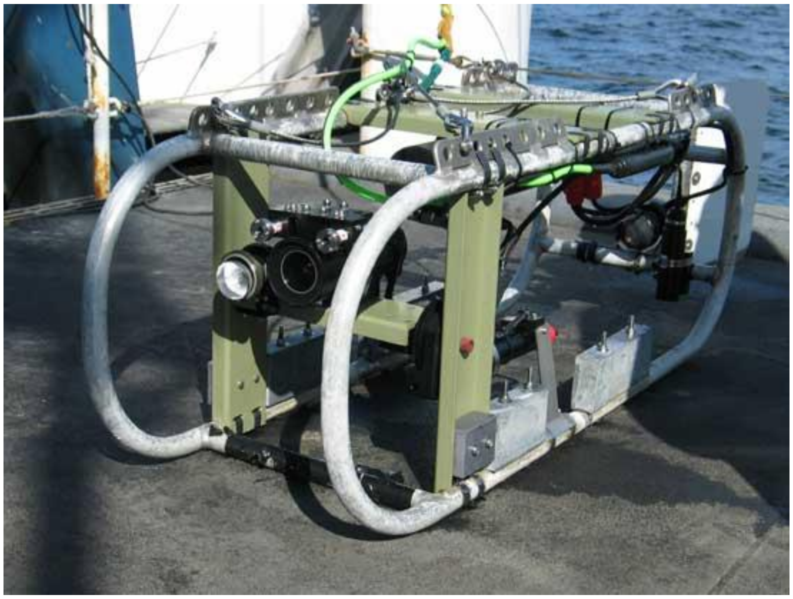
Identification, Counts, and Behavior of Demersal Fishes along the Central Coast of California Using a Towed Camera Sled



A Capstone Project
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by

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To the SEP Faculty:

Advances in imaging technologies have led to improvements in population sampling and habitat characterizations in the marine environment. Optimum applications for such technologies should be assessed in order to produce robust data in support of management. Towed camera sleds are one such technology needing assessment for its application to the study of mobile fauna.

This is a scientific inquiry capstone exploring the effects that fish behavior and seafloor habitat associations have on the identification of demersal fishes using towed camera sled technology. In spring 2008, I began viewing a random sampling of 20 video transects collected as part of a collaborative effort between the Monterey Bay National Marine Sanctuary and the Institute for Applied Marine Ecology at CSUMB. Ten transect videos were collected over hard bottom habitats and 10 were collected over soft bottom habitats. Behavioral and taxonomic identification data were recorded for every fish observed for each transect. These data were then used to analyze the effect of seafloor habitat and fish behavior on the identification of fishes using a towed camera sled.

Various types of management in the MBNMS could benefit from an enhanced understanding of the camera sleds application to the study of demersal fishes. The CDFG works in collaboration with the National Marine Fisheries Service to regulate and enforce fishing activities. Studies on fish abundance and distribution can directly inform and influence fishing regulations. Therefore, an enhanced understanding of the utility of a towed camera sled could serve to enable the collection of more robust data. These data can then help to create a more informed decision-making process for fishing regulations.

My most significant bias in this project was that I am not an expert at fish identification. Though I bought books and did my best, my results would be understated for species identification. To account for this, I made a category for fishes that I could not identify, but were represented clearly enough for an expert to identify. I then included this category in my species analysis.

Overfishing is an obvious problem around the globe. I do not hope for fishing to stop. However, I do hope for more effective management strategies that insure sustainable fishing practices. Population sampling is the most basic requirement for resource management. This capstone provided me the opportunity to examine ways to facilitate more efficient population sampling of demersal fishes.

Abstract: Advances in imaging technologies have led to improvements in animal population sampling and habitat characterizations in the marine environment. Optimum applications for such technologies should be assessed in order to produce robust data. Towed camera sleds are one such technology needing assessment for its application to the study of demersal fishes. This study explores the effects of behavior and habitat on identification using towed camera sled technology. Hard bottom habitats had higher proportions of species identified than soft bottom habitats. Soft bottom behaviors did not significantly affect identification, while station keeping bottom behavior in hard bottom habitats led to significantly higher proportions of species identification. Overall, the towed camera sled was more effective for studying demersal fishes in hard bottom habitats over soft bottom habitats and stationary behaviors may lead to more refined levels of taxonomic identification.

Introduction:

Our ability to sample and observe marine communities has improved dramatically with the development of underwater research platforms and imaging technologies such as camera mounted underwater vehicles. Russell (1986) reported occurrences of net avoidance in large fishes when a camera was mounted on an epibenthic sledge. However, the same study showed camera selectivity against small camouflaged fishes. While the camera enabled the observation of large fish avoidance, it was not well suited for observing some smaller fishes. This study illustrates that data collection methods vary in efficacy from one application to another. It is critical to understand the limits and capabilities of data collection techniques such that the data that directly inform management are as robust as possible.

Video footage has been used to characterize marine communities and the landscapes in which they occur for more than two decades (Uzmann et al. 1977, Hecker 1994, Lauth et al. 2004, Singh et al. 2004, Busby et al. 2005, Auster et al. 2008). Some commonly used technologies for acquiring video footage include camera sleds, remotely operated vehicles (ROVs), autonomous underwater vehicles (AUVs), and human-occupied submersibles. Each of these technologies is optimally suited for specific applications and conditions. For example, human-occupied submersibles have been used to observe deepwater fish assemblages and habitat associations (Yoklavich et al. 2000, 2002; Auster and Lindholm 2005; Anderson and Yoklavich 2007). Submersibles allow scientist to make direct observations on fauna and habitat from more than one angle. AUVs with orthogonally configured cameras have been widely and successfully used to study sessile fauna and seafloor geology (Singh et al. 2004). However, data suggest that ROVs are superior to AUVs for collection of data on mobile fishes (Auster et al. 2008). Camera sleds have been a valuable tool for many benthic studies (Hecker 1994, Lauth et al. 2004, Lindholm et al. 2004, Spencer et al. 2005). Often mobile fauna are studied with the use of ROVs, which are also beneficial in areas of high topographic relief (Whitmire et al. 2004, Busby et al. 2005, Auster et al. 2008). These evaluative studies enable future applications of the data collection methods to be more effective. This increased effectiveness will produce more robust data in support of management, while possibly saving time and conserving funds.

Demersal fishes include, but are not limited to many species of rockfish. Rockfish and some other demersal fishes such as flatfish are commercially valuable and therefore subject to over-fishing. Some populations of rockfish along the coast of California have been depleted to only a fraction of their original size (Love et al. 2002). In order to support the sustainable management of these species, it is necessary to accurately estimate abundance and determine habitat associations. While camera sleds have been used to study abundance of sedentary species of fishes such as flatfish, more mobile species can be more problematic (Lauth et al. 2004, Spencer 2005). As mentioned already avoidance due to many factors can reduce data accuracy (Koslow et al. 1995, Auster et al. 2008).

This study quantified the utility of a towed-camera sled for the identification, count and behavioral observations of demersal fishes along the continental shelf of central California. Videographic data were analyzed from multiple sled transects from 2006-2008. All observed fish were identified to the lowest taxonomic level, counted, and their behavior (such as position relative to the seafloor) was characterized. Results inform both the on-going efforts in the region to characterize fish communities and the approaches used to monitor fishes in the context of management.

Methods

Study Site

Research cruises aboard the NOAA R/V *Fulmar* are conducted annually in the Monterey Bay National Marine Sanctuary (MBNMS) as part of a collaborative effort between the MBNMS and the Institute for Applied Marine Ecology at CSU Monterey Bay. A total of 20 randomly selected one hour camera sled transects were used for the study from across the Sanctuary. Transects were selected from two different habitat types, hard and soft bottom. Hard and soft bottom delineation was derived from Greene et al. (1999) subclassifications for macro and microhabitats. Hard bottom refers to any habitat primarily composed of bedrock, boulder, cobble or pebble. Soft bottom refers to habitats primarily composed of gravel, sand, mud, or organic debris. Figure 1 shows the four study areas at which transects were collected.

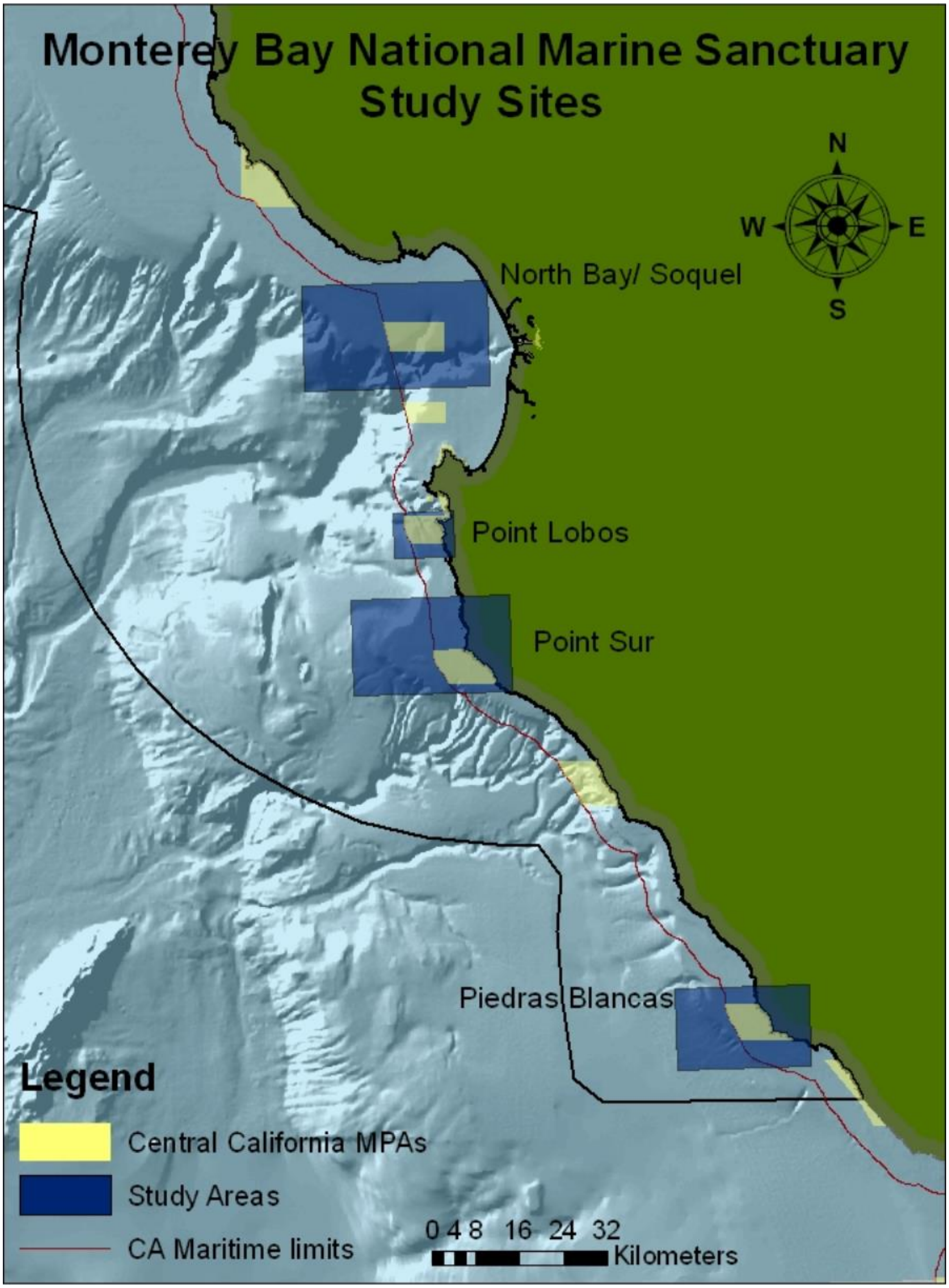

Figure 1. Map shows the study areas in within the Monterey Bay National Marine Sanctuary at which transect footage was collected. Transects were randomly selected from each study area.

Towed Camera Sled

All transect video footage was obtained by a towed camera sled (Figure 2). This sled is equipped with a 10:1 optical zoom, high-resolution color camera. The camera has a motorized tilt of +/-90°. Two Deep Sea Power and Light Inc. 250W Tungsten/ Halogen lights are mounted on the sled for illumination. Two 500 mW lasers spaced 10 cm apart are used for spatial reference. The sled is also equipped with an altimeter, compass (accuracy+/-1%), and depth gauge (+/1%). The sled will be deployed from the 67' NOAA vessel, R/V *Fulmar*.

Objectives, Hypotheses, and Data Analysis

The primary objective of this study was to characterize the utility of the towed camera sled for the study of demersal fishes of central California with respect to identification, count and behavior. There were two specific hypotheses tested in this study to address this objective:

HO1: The proportion of fish species identified over hard bottom substrates will be greater than was observed over soft bottom substrates.

HO2: Stationary behaviors observed with a camera sled would have a higher rate of species identification than non-stationary behaviors.

To test these hypotheses, ten transects were randomly selected from each of these two habitat types. Video of each transect was advanced to the first fish, which was identified to the lowest possible taxonomic level. For ease of sorting data, fish were assigned to a numeric category representing its level of identification (table 1.). The

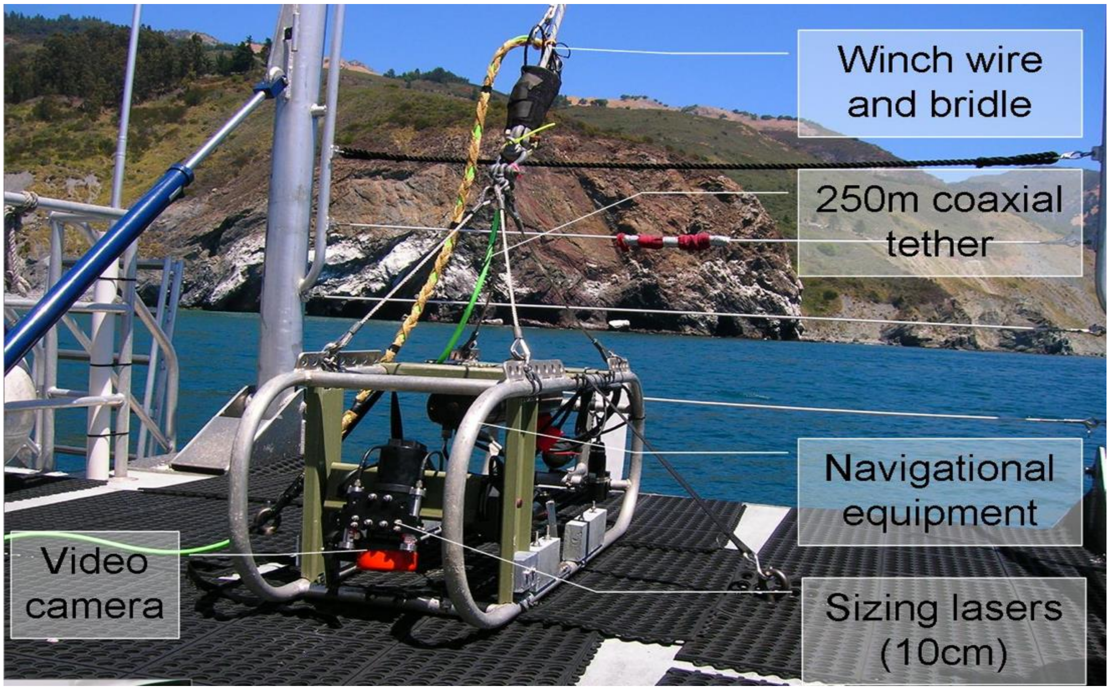

Figure 2. This is a photo of the camera sled used in this study. The major components are labled.

Table 1. List of taxonomic categories used for sorting.

Taxon ID	Description
1	Unidentified
1.5	Young of the year
1.75	Flatfish
2	Genus identification
2.5	Eye side identification for flatfish (i.e. right or left eyed)
3	Sebastomus group
3.5	Split decision between 2 similar species (e.g. olive/ yellowtail rockfish)
4	Species identification
√	Possible identification by expert

fish's relative position to the seafloor and behavioral observation were recorded as well. Table 2 lists and describes the behavior categories used. Video was then advanced to the next fish and the process was repeated until end of transect.

Fish Abundance and Proportion Identified by Habitat Type

Once data acquisition was complete, statistical analysis was performed within and between habitat types. Initially, a comparison between the total abundance of fishes recorded was conducted. To account for unequal transect distances, the total number of fish per transect was divided by the length of transect in meters. This gave a value of fish per meter. A Mann-Whitney U test was performed to determine, if there was a significant difference in fish per meter between hard and soft bottom habitats. Due to a significant difference in the abundance of fishes observed between habitat types, proportions were used to make comparisons between habitats. Proportions of species identified per habitat type were determined by dividing the number of species identifications by the total number of fish observed per transect. When comparing proportions of species identified between habitats, the soft bottom values failed the assumption of normality. An arcsin transformation failed to produce normal data, so a Mann-Whitney U test was used.

Fish Behavior by Habitat Type

Arcsin transformed data were used for pair wise behavior comparisons within each habitat type. Proportions of fishes identified to species were compared with proportions of fish not identified to species to determine, if behavior influences identifcation.

Table 2. List of behavioral characteristics for demersal fishes.

Behavior	**Code**	**Description**
Station-keeping Swimming	SS	Maintaining position over a seafloor feature using active fin movements.
Station-keeping Cover	SC	Maintaining position behind or alongside structure using active fin movements.
Station-Keeping on Bottom Position	SB	Direct contact with or adjacent to structure using little or no fin movements to maintain position.
Continuous Swimming	CS	Direct swimming in single direction with no movements directed at obvious prey and no attempts at predation.

Fishes identified to species proportions included the √ taxonomic category to reduce biases due to a lack of identification expertise. Unidentified proportions included all other identification categories. Each proportion was calculated by dividing the behavior total for an ID group by the total number of observed fishes in that group per transect. Mann Whitney U tests were used for all pair wise behavior comparisons except for the station keeping cover and station keeping swimming behaviors for hard bottom transects, which used T-tests.

Results:

Hard bottom transects had considerably higher abundances of fish than soft bottom transects. There was a significant difference in the abundance of fish per meter between habitats (z=-3.402, p=0.001). Figure 3 shows fish per meter mean values for each habitat.

There was a significant difference in the proportion of fishes identified to species between habitats (z=-3029, p=0.002). Species identification was far more successful in hard bottom than soft bottom habitats. Figure 4 shows the mean proportion of fishes identified to species per transect for hard and soft bottom habitats.

Pair wise comparisons results of species identified and unidentified behavior are summarized in Table 3. Hard bottom transects showed significantly more species identification for station keeping bottom behavior (z=-2.004, p=0.045). No other behaviors for hard or soft bottom transects showed a significant difference between identification groups. Figures 5 and 6 show the mean proportions per behavior for identification groups in hard and soft bottom habitats respectively.

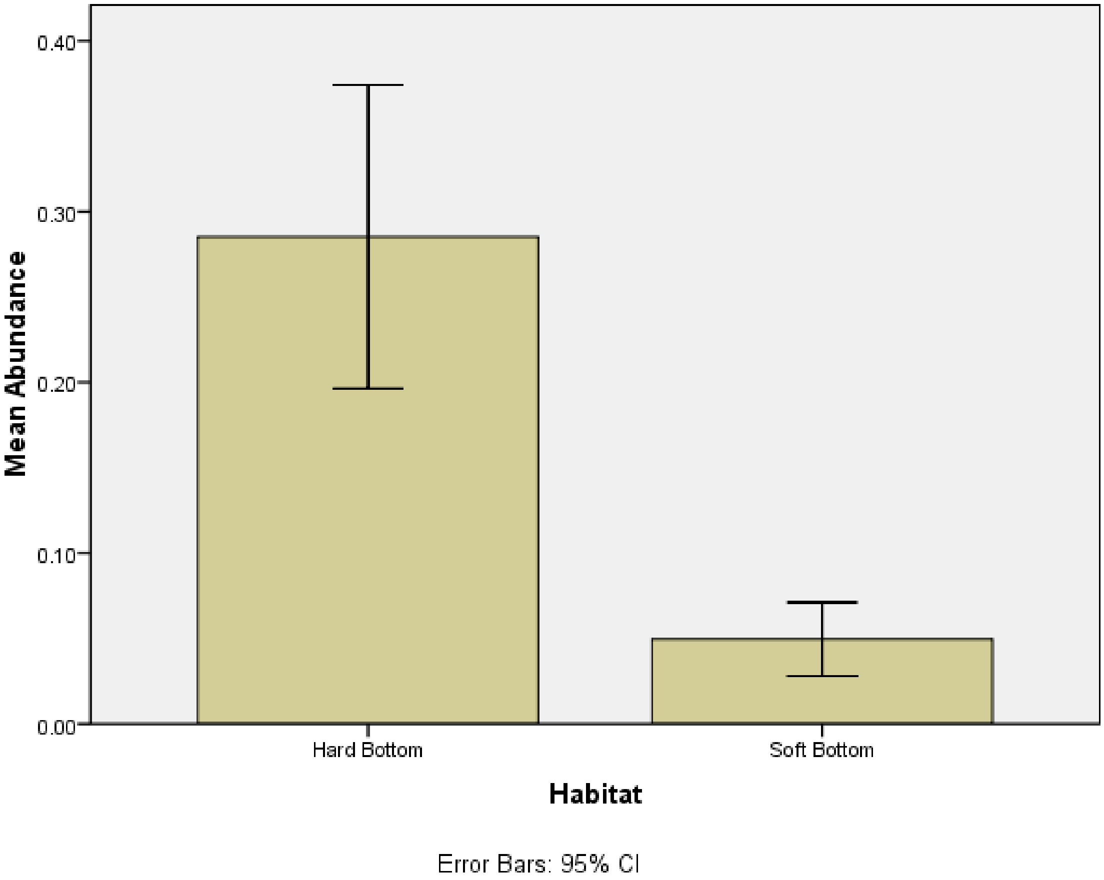

Figure 3. This graph shows mean abundance in fish per meter for hard and soft bottom transects. Hard bottom transects had significantly higher abundances of fish per meter than soft bottom transects (z=-3.402, p=0.001).

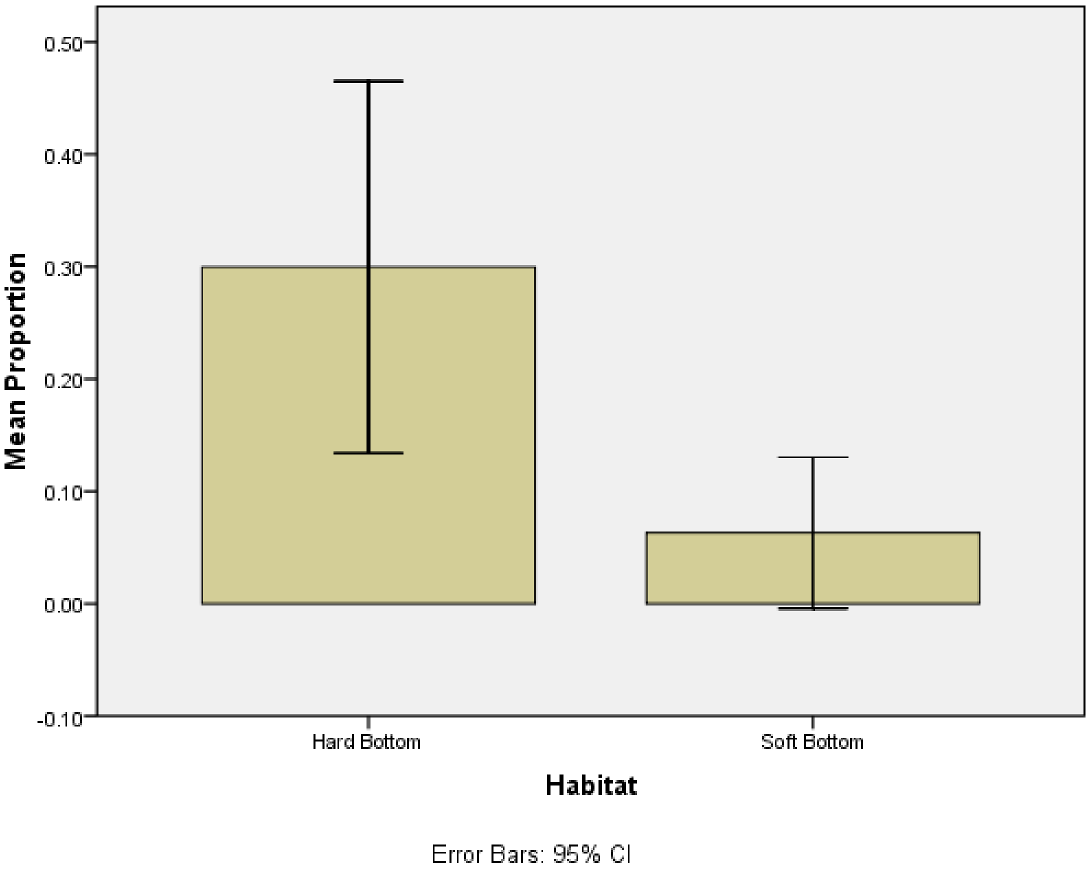

Figure 4. This graph shows the mean proportion of species identified for hard and soft bottom transects. Hard bottom transects had significantly higher proportions of species identification than soft bottom transects (z=-3029, p=0.002).

Table 3. Results of pair wise comparisons of species identified and unidentified behavior.

Habitat type	**Behavior**			
	CS	SB	SC	SS
Hard Bottom Habitat	z=-1.87 p=0.059	z=-2.004 p=0.045	df=18, t=-1.631 p=0.120	df=18, t=-0.182 p=0.857
Soft Bottom Habitat	z=-0.610 p=0.542	z=-0.682 p=0.495	z=-0.795 p=0.427	z=-1.292 p=0.197

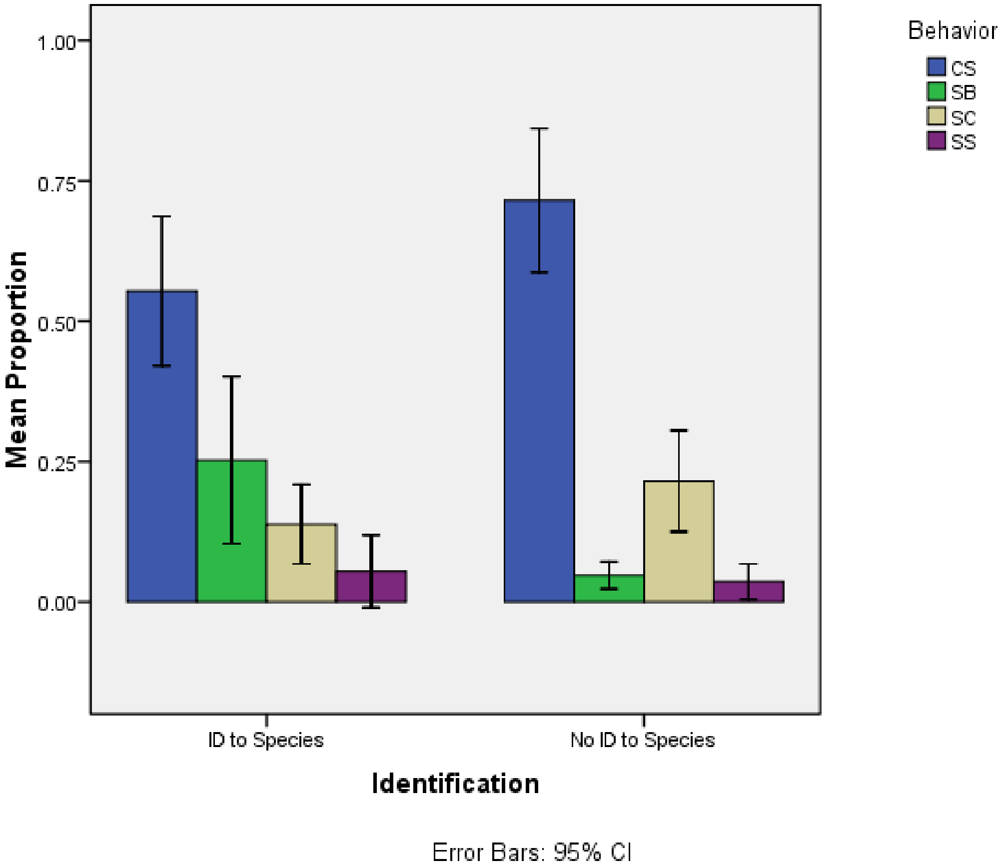

Figure 5. The graph shows the mean proportion of observed behaviors for species indentified and unidentified groups on hard bottom transects. There was a significant difference in station keeping bottom (SB) behaviors (z=-2.004, p=0.045).

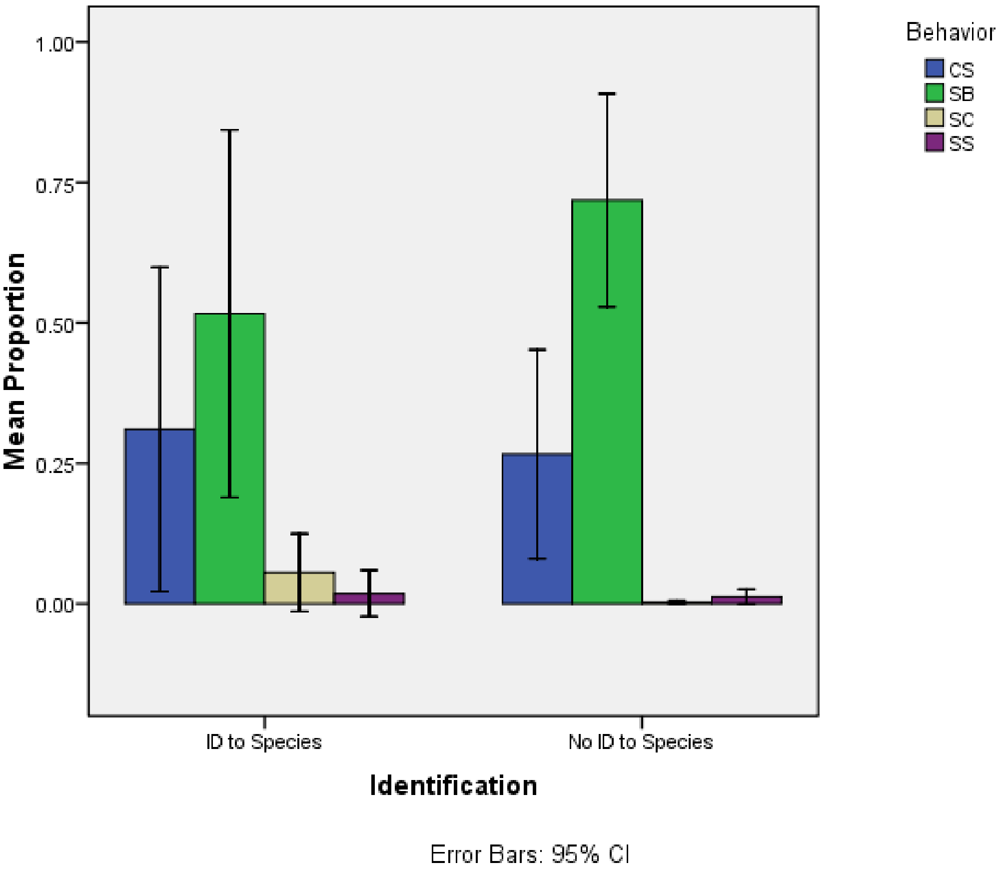

Figure 6. The graph shows the mean proportion of observed behaviors for species indentified and unidentified groups on soft bottom transects. There was no significant difference in behaviors between identification groups.

Species identified in the soft bottom habitats were primarily rockfish (figure 7). Hard bottom transects species identification consisted primarily of rockfish and black-eyed gobies (figure 8). Only a 1.75% of total observed flatfish were identified to species, while 26.37% of total observed rockfish were identified to species.

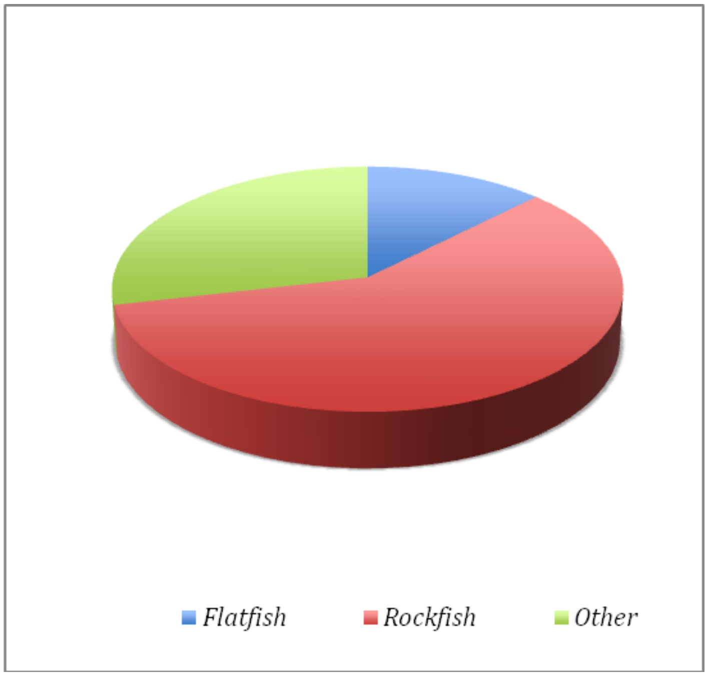

Figure 7. This graph shows percentages of the most common fish identified to species for soft bottom habitats. Rockfish make up over half of the fish identified to species in soft bottom transects.

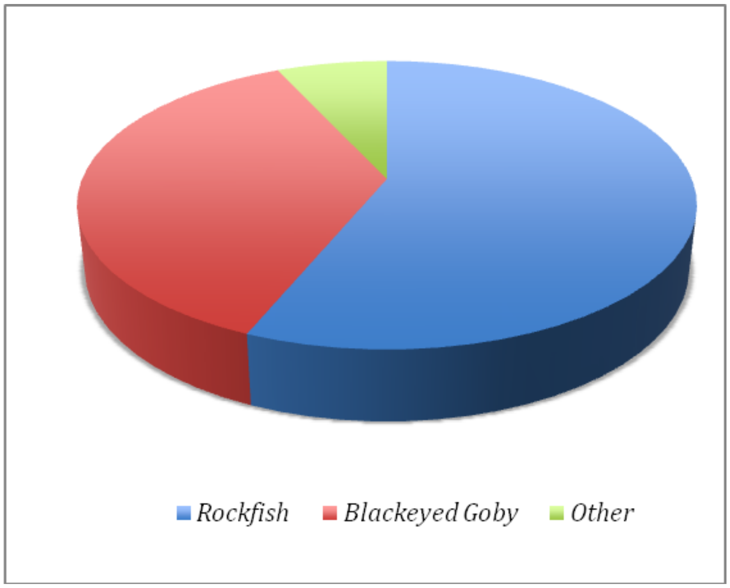

Figure 8. This graph shows percentages of the most common species identified for hard bottom habitats. Black eyed gobies and various rockfish were the most common fish identified to species in hard bottom habitats.

Discussion:

This study supports the hypothesis that more species are identified over hard bottom habitats than soft bottom habitats. Soft bottom species were less identifiable and may also be underestimated due to burial in soft sediments. Inaccurate estimates of populations or habitat associations could compromise management decisions. This indicates some utility of camera sleds for identification of demersal fishes in hard bottom habitats.

The hypothesis that stationary behaviors are more identifiable than moving behaviors is marginally supported by the data for hard bottom habitats. There was a significantly higher proportion of station keeping bottom behavior in the species identified group over the unidentified group. The difference in hard bottom continuous swimming behavior was close to significant ($p=0.059$). In this case it was the unidentified group of fishes that had the higher mean proportion indicating that this behavior may hinder identification. There was no significant difference in station keeping swimming (SS) or station keeping cover (SC) behaviors. However, this does indicate that stationary behaviors could lead to higher species identifications than moving behaviors in hard bottom habitats. Continuously swimming was the most common behavior in hard bottom habitats and is often part of an avoidance response. This could be one of the factors that contributed to lower species identifications in the continuously swimming category. Conversely, large, curious rockfish will often approach the sled. Further study of these camera induced behaviors may shed light on specific species that are more tolerant of camera sled presence (Stoner et. al. 2008).

Soft bottom habitats showed no relationship between behavior and identification. Identification in soft bottom habitats was challenging. Fishes observed with a station keeping bottom behavior in soft sediments were often hard to identify due to partial or total burial in the substrate. In hard substrate habitats on the other hand, fishes observed with a station keeping bottom behavior are often exposed and stationary making identification easier.

Rockfish were the most common type of fish identified to species in both soft and hard bottom transects. They were also far more identifiable than flatfish, which were more abundant in soft bottom habitats. This suggests that the camera sled is more effective at identifying rockfish over flatfish, both of which are part of commercial fisheries in central California. However, Adams et. al. 1995 found that visual surveys for dover sole, *Microstomus pacificus*, had higher than abundances than trawls. Therefore there may be some flatfish studies that could utilize a camera sled.

There are other factors that should be considered when using camera sleds for identification of demersal fishes. Many of the fishes identified to species in this study are morphologically distinct. For example, the long spine combfish has a very distinct dorsal spine making it easy to distinguish from other similar combfish. Blue rockfish, *Sebastes mystinus*, have a very distinct head, which can be identified easily. Pygmy rockfish, *Sebastes wilsoni*, have a distinctive purplish belly. Rosey rockfish, *Sebastes rosaceus*, have faintly purple cheeks distinguishing it from other *sebastomus* rockfish (category 3). *Sebastomus* rockfish all have a red coloration with white dorsal spots making them virtually impossible to distinguish from one another on video. Similarly, there are species such as olive and yellow tail or vermillion and canary rockfish (category 3.5) that share almost identical morphology. Species uniqueness with relation to habitat is another factor that may aid in species identification. Black-eyed gobies are the only goby found in rocky reefs at the depth that transects occurred. This accounts for the large percentage of black-eyed gobies identified. Finally, schooling rockfish such as pygmy and blue rockfish made up a large percentage of the species identified. Schooling fish have a much higher chance of being identified due to sheer numbers.

As stated in the MBNMS Management Plan (1992), commercial fishing is “the most important activity directly dependent on the resources” of the Sanctuary. For this reason there are ongoing efforts to study fish distribution and abundance in the MBNMS. Though the U.S. Coast Guard (USCG) enforces federal laws within the Sanctuary, the primary enforcer of fishing activities within the MBNMS is the California Department of Fish and Game (CDFG). The CDFG works in collaboration with the National Marine Fisheries Service to regulate and enforce fishing activities. Studies on fish abundance and distribution can directly inform and influence fishing regulations. Therefore, an enhanced understanding of the utility of a towed camera sled could serve to enable the collection of more robust data. These data can then help to create a more informed decision-making process for fishing regulations.

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