COLLABORATIVE FISHERIES RESEARCH PROJECT

Surveys of Nearshore Fishes in and Near Central California Marine Protected Areas

Final Report Submitted to the Ocean Protection Council
and
California Sea Grant College Program

by

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Project Summary

We worked with the fishing communities of Half Moon Bay, Monterey, Morro Bay, and Port San Luis, California to develop monitoring protocols for the use of hook and line fishing gear, and to collect baseline information for three Marine Protected Areas that were established in September 2007. We completed a total of 34 fishing trips in the Fall of 2007 in the Año Nuevo, Point Lobos, and Point Buchon State Marine Reserves, and in corresponding reference sites. Within these areas, we used a stratified random sampling design to determine sampling locations. At each location, experienced volunteer anglers fished with standardized gear for a specified amount of time. We worked with a total of five Commercial Passenger Fishing Vessels (CPFV) and 174 volunteer anglers, and caught a total of 7,928 fishes, comprised of 27 species. Caught fishes were identified, measured, tagged with external T-bar anchor tags, and released at location of capture.

Key Words

Collaborative research, monitoring, Marine Protected Areas, Central California, nearshore fishes

Introduction

On September 21, 2007, 29 Marine Protected Areas (MPAs) were established along the central California coast from Pigeon Point to Point Conception. The 1999 Marine Life Protection Act that led to the formation of the new MPAs specifically required MPAs in California to be monitored and evaluated (Weber 2000). In the Spring of 2007, we conducted workshops with fisheries scientists and the fishing communities of Half Moon Bay, Monterey, Morro Bay, and Port San Luis, California to develop protocols for monitoring MPAs using hook and line fishing gear. Our goal was to develop protocols for collaborative fishing research that could be used to monitor MPAs and also serve to provide valuable information for fisheries management. In the Summer and Fall of 2007, we implemented the protocols developed at those meetings with scientists and fishermen to collect information about species composition, catch rates, and sizes of nearshore fishes in the Año Nuevo, Point Lobos, and Point Buchon State Marine Reserves (SMR), and corresponding reference sites. We conducted standardized fishing surveys to assess species composition, length frequency, and catch rates in these MPAs and associated reference sites.

A key component of our project is that it was conducted collaboratively, incorporating fishermen knowledge and expertise in the development and application of the study protocols. In addition, non-governmental organizations, resource managers (NOAA Fisheries and the Department of Fish and Game), and academic scientists were involved in the development of this study and in the evaluation of the sampling design. The resource managers and Fisheries scientists who evaluated the survey protocols agreed that the sampling we initiated, if continued, would provide useful information for both MPA monitoring and fisheries management.

The objectives of this study were to:

- Develop rigorous scientific protocols to monitor Central California MPAs
- Engage the fishing community in the monitoring of MPAs
- Evaluate differences between MPAs and reference sites at the time of closure
- Generate baseline data for future evaluation of changes in species and size composition and relative abundance of fishes associated with shallow rock habitats inside and outside MPAs
- Create a sampling design that can be used to collect data for state and federal stock assessments

Methods

Workshops

During the planning phase of this project, a series of five workshops were held in Morro Bay, Moss Landing, and Santa Cruz, California to obtain ideas about protocols for this study from the fishing, science, and management communities. During the later workshops, boat captains used their experience and knowledge to assist us in choosing sampling locations. Additional workshops were held after the field sampling season in Morro Bay, Moss Landing, and Half Moon Bay, at which members from these communities offered suggestions on how to improve upon this project.

Sampling Locations and Nomenclature

Areas

The Año Nuevo, Point Lobos, and Point Buchon State Marine Reserves (SMR) (Figure 1) were chosen as sampling locations for this study because the nearshore rocky habitat within the selected MPAs is extensive and representative of the rocky habitat in the central California coastal region, and the sites have long been popular fishing areas for both recreational and commercial fishermen. Additionally, a portion of the Point Lobos MPA has been closed since 1973. Including this area allowed us to compare fish communities from an area that has been closed to fishing for more than three decades to the newly established MPAs and their corresponding reference sites. The Año Nuevo, Point Lobos, and Point Buchon SMRs encompass areas of 10.2 mi^2, 5.4 mi^2, and 6.7 mi^2 respectively. Reference sites were based on the criteria that they shared similar size, habitat, and oceanographic conditions with the nearby MPAs.

Grid Cells

Within each MPA and reference site, 500 m x 500 m grid cells were created and used to delineate sampling locations. A total of 22 grid cells in Año Nuevo, 18 in Point Lobos, and 22 in Point Buchon were generated (Figure 2), with equal numbers of grid cells located in both the MPA and reference sites. The grid cells were positioned in nearshore rocky habitats, in water less than 40 meters deep (to limit fishing mortality from barotrauma), in areas that had previously been identified by fishermen as having suitable habitat for nearshore fishes.

Sampling Protocols

We planned to sample four days a month in each of three months in each area to account for temporal variability in the late summer months. We scheduled four days of sampling in each study area (Año Nuevo, Point Lobos, and Point Buchon) in August, September, and October for a total of 12 days in each area. Half of the days were spent in the Marine Protected Area (MPA) sites and the other half in the reference sites. During each day of sampling, four of the grid cells (in a given MPA or reference site) were chosen at random and sampled. In the morning, the captain was provided with the coordinates of the sampling cell and asked to fish in each cell in locations where he thought he could best catch fish. A total sampling time of 1½ hr was allotted for each grid cell. In order to account for the variability within each cell, the captain was instructed to locate three suitable fishing locations within each grid cell and complete a fishing drift in each for 15 minutes (location terminology is explained in Figure 3). If a single 15-minute drift was not possible, due to strong currents or other reasons, the captain could choose to make several drifts in the same location for a combined total of 10-15 minutes. The objective was to fish in three discrete locations within the grid cell for a total of at least 30 minutes, but no more than 45 minutes.

We recruited volunteer anglers to fish in this study. Anglers were recruited from various fishing clubs, online fishing websites, and from previous collaborative studies. Some anglers called us to volunteer after they heard of the project through local media. We required that all volunteer anglers were experienced with rockfish fishing, over the age of 16, and capable of fishing consistently for six hours.

At the beginning of the trip, each angler was assigned to a fishing station, which was

organized by gear type. All anglers on the bow fished with hard tackle (i.e., lingcod bar) at the terminal end of the fishing gear with a shrimp fly teaser (a smaller lure used in addition to the main tackle to entice and catch fish) higher on the line. Only anglers experienced in fishing lingcod bars were assigned to these stations. Lingcod bars ranged in color and weight (4, 6, 7, 8, or 10 oz). The deckhand rigged the poles with the lightest sinker or lingcod bar that could counteract the current and would get the line to the bottom as fast as possible. The hooks on the lingcod bars were single and barbless (except for four trips where some double hooks were occasionally used in addition to the singles). Anglers on the starboard side of the vessel fished with two shrimp fly lures without bait, and anglers on the port side fished with two shrimp fly lures, baited with frozen squid (in strips 2-4 inches long). The shrimp fly lures were made of mylar, had single barbless 4/0 hooks, 30 lb hook line, and 60 lb main line. Both red and white shrimp flies were used in order to accommodate preferences of anglers in both the northern and southern regions of the study area. Anglers used sinkers of 4-12 oz depending on the currents. Skippers chose the weights based on the criterion of using the least amount of weight that would enable an angler to fish on the bottom.

Once on station, the captain signaled the start of the drift, and the anglers would commence fishing. During a drift, between six and twelve volunteer anglers fished using rod and reel fishing gear. The number of anglers that fished at a given time was always divisible by three so that each gear type was fished with equal effort. A member of the science crew fished at one of the stations if there were not enough volunteer anglers to achieve a balance of sampling among gear types. If there were extra anglers, they were rotated into the stations. For each drift, the number of anglers fishing, and the names of persons recording and tagging were noted on a data sheet. The start and end latitude and longitude were also noted and the start and end times were recorded to the second. If at any time during the drift an angler had a problem with their gear, the deckhand or a member of the science crew would give them a new rod so that they were fishing during the entire drift. If the angler stopped fishing for more than a minute, however, the time the lure was out of the water was noted on the data sheet and the time was subtracted from the overall effort.

When a fish was caught, it was identified to species, measured (total length) on a wooden v-board (Año Nuevo and Point Lobos) or a flat plastic measuring board (Point Buchon), tagged with an external T-bar anchor tag (unless the fish was in poor condition or was too small), and released. The location (latitude and longitude) and depth where a fish was released were recorded. In order to reduce incidental mortality, care was taken when handling the fishes, and the effects of barotrauma were ameliorated with venting needles and descending devices, and the duration of time that the fishes were on board the vessel was minimized. If a high catch rate precluded rapid processing of the captured fishes, anglers were instructed to stop fishing so that the fish on board could be processed and the number of anglers was reduced before fishing recommenced.

If a fish exhibited signs of barotrauma, its swim bladder was vented with a hypodermic needle and/or was released at depth with a fish-descending device (either the Ace Calloway Barotrauma Reversing Fish Release or a weighted milk crate). A coded number system was used to describe the condition of the fish upon release (Table 1). Caught fishes were released after processing, except for a sub-sample of gopher rockfish, which were retained for a diet study that will be completed later. The retained fish were measured, tagged, euthanized, put in an ice chest, and later bagged and frozen.

At each grid cell that was sampled in Año Nuevo and Point Lobos, we measured water

temperature at depth using a sensor that continuously recorded temperature and pressure readings. Water clarity was measured with a secchi disc in each cell. Also, during each drift we recorded surface water temperature, observations on the weather, wind speed and direction, swell height and direction, presence of harbor seals and/or seal lions and/or kelp beds, and, if possible, current direction and speed and amount of relief.

Collaboration

Correspondence with Volunteer Anglers

At the end of each sampling day, an email was sent out to the volunteer anglers to thank them for their participation, to report how many fishes were caught, and to ask for feedback on the trip. At the end of each sampling month, every volunteer was mailed a flyer summarizing the trips that month, including the number and species of fish that were caught, and the number of volunteers that participated. Also, some of the largest catches were listed next to photographs from the trips. A brief description was given about the project, our objectives, and appreciation to the volunteers was expressed. The objective of the update flyers was to acknowledge the anglers for their contribution to the project and to further engage them in the monitoring process.

Website Posting

Two websites were created for this project, one through a San Luis Obispo Science and Ecosystem Alliance domain (http://www.slosea.org/collaborative) and one through a Moss Landing Marine Laboratories, domain (http://seagrant.mlml.calstate.edu/crmpamonitor.php). On these websites, information about the study was posted, including a project overview, background information, a description of the study areas (including maps), sampling results, volunteer sign up information, media related to the project, and information on what to do with a recaptured tagged fish. In addition, information about the project was posted periodically on well-known fishing websites.

Tag Returns

Posters illustrating a tagged rockfish, with a summary of the objectives of this study, and an explanation of how and where to report a tagged rockfish were disseminated to all of the volunteer anglers, to local fishing websites, on the websites for this project, and were placed in key fishing areas along the central coast (Figure 4). These posters spread awareness about the project and will increase tag returns and participation in further collaborative projects.

Results

Collaboration with the Fishing Community

Fishing community involvement was substantial throughout the course of this study. Volunteers were of both genders and encompassed a broad range of ages and backgrounds. Several volunteers fished multiple times; four volunteers came out on 5 separate trips, four fished on 6 trips, one angler on 7 trips, one on 8 trips, one on 12 trips, and one angler (who went out in each of the three areas) came out on 15 trips. Volunteers for the trips in Año Nuevo and Point Lobos came from 70 different cities in California, two different cities in Utah, and one city in Texas. Feedback from the anglers was positive. On several occasions, we received emails

from anglers, sending us photographs from the trips and thanking us for the opportunity to participate. Also, during the course of this project we had the opportunity to work with five different Commercial Passenger Fishing Vessel (CPFV) captains and ten deckhands.

Trip Information

Sampling was completed during 12 days in both Point Lobos and Point Buchon. Due to poor weather, only 10 days were spent fishing in Año Nuevo (4 ½ days in the MPA, 5 ½ days in the reference site). In the days sampled, a total of 96 hours were spent fishing (all areas combined) and a total of 7,928 fishes were caught. A total of 174 discrete volunteers participated for a total of 366 volunteer days (Table 2). There were between 5 and 18 volunteer anglers aboard the boat during each survey trip and 6, 9, or 12 anglers fishing at a given time. During the course of this project, we worked with five captains aboard five different vessels. In Año Nuevo, we fished with Tom Mattusch aboard the F/V *Huli Cat* (Huli Cat Sport Fishing & Charter Boat; Half Moon Bay, CA) and in Point Lobos with David Lemon aboard the F/V *Caroline* (Chris' Fishing; Monterey, CA). Sampling in Point Buchon was with Michele Leary aboard the F/V *Fiesta* (Virg's Landing; Morro Bay, CA), Sal Rocha aboard the F/V *Patriot* (Patriot Sportfishing; Avila Beach, CA), and Dustin Selck aboard the F/V *Pacific Horizon* (Patriot Sportfishing; Avila Beach, CA).

We sampled 21 of the 22 grid cells in the Año Nuevo area, 17 of the 18 grid cells in the Point Lobos area, and 19 of the 22 grid cells in the Point Buchon area (Table 3). On average, each cell was sampled, 2.2 times in 2007 (all three areas combined), 1.7 times in Año Nuevo, 2.7 times in Point Lobos, and 2.2 times in Point Buchon. On average, the drifts in Point Buchon had the longest duration, whereas those in the Año Nuevo area were the shortest (Table 4). On average, if a grid cell was sampled, there were 5.0 drifts within the cell per day. The number of drifts per cell per day averaged 7.6 in the Año Nuevo area, 3.4 in the Point Lobos area, and 3.4 in the Point Buchon area. In the Año Nuevo area, on average, there were also fewer anglers fishing at a given time, fewer fishing hours, fewer angler hours, and fewer total fishes caught than the other two areas (Table 5).

Catch information

During the course of this study, 27 different species of fishes from 10 genera were caught. The majority (97%) of the caught fishes were rockfishes, from the Genus *Sebastes* (Table 6). For all areas combined, blue rockfish were the most frequently caught (38% of the total catch), followed by gopher rockfish (27%), black rockfish (11%), and olive rockfish (10%). The Shannon diversity index (H) value was 1.80 for all areas and sites combined and for the individual sites values ranged from 1.35 to 1.82 (Table 6). Out of the 7,928 fishes caught, we retained 61 gopher rockfishes from the Año Nuevo area, 76 from the "OLD" Point Lobos reserve (the section of the Point Lobos MPA that has been closed to fishing since 1973), 48 from the "NEW" Point Lobos reserve (the section of the Point Lobos MPA that was closed in September 2007), 53 from the Point Lobos reference site, and 44 from the Point Buchon area for a diet study that will be completed later. Of the remaining 7,646 fishes, 83% were tagged and released and 17% were released without tags.

In Año Nuevo, 19 species of fishes were caught, the majority being black rockfish (43%), blue rockfish (33%), and gopher rockfish (11%). In Point Lobos, 20 species of fishes were caught. Blue rockfish (48%), gopher rockfish (19%), and olive rockfish (17%) dominated catches from this area. In Point Buchon, 21 species of fishes were caught, primarily gopher

rockfish (48%) and blue rockfish (24%). On average, 79 fishes were caught each day in the Año Nuevo MPA and 167 in the reference site; 79 fishes were caught in the NEW section of the Point Lobos MPA, 421 in the OLD, and 209 in the reference site; 258 fishes were caught in the Point Buchon MPA and 155 in the reference site.

Results presented in this report focus on the ten species most frequently caught (those species that were greater than or equal to 1.5% of the total catch in any area). Within each area, species composition was relatively similar between sites; however, small differences were observed. In Año Nuevo, nine of the ten most frequently caught fishes in both sites (MPA and reference) were the same, although not in the same order. For MPA and reference sites, the three most frequently caught species were the same (blue rockfish (#1), gopher rockfish (#2), and black rockfish (#3)). In Point Lobos, nine of the ten most frequently caught species were the same in both the MPA and reference sites, although in different orders. In both MPA and reference sites, blue rockfish were caught most frequently, but in the MPA site, olive rockfish were second in abundance and gopher rockfish were third. In the reference site, gophers were second in terms of catch and olives were third. In Point Buchon, in both the MPA and reference sites, the most frequently caught species were gopher rockfish (#1), blue rockfish (#2), black rockfish (#3), and olive rockfish (#4). Out of the ten most frequently caught fishes in each site at Point Buchon, eight were the same, but were in different rank orders.

Over the three study months, species composition within each area was also relatively similar. In October, however, the percentage of blue rockfish caught in all areas decreased. In Año Nuevo, the percentage of black rockfish caught in October increased, and in Point Lobos the percentage of gopher rockfish caught in October also increased (Table 7).

Incidental Mortality

In order to maximize the survival of caught fishes, we restricted fishing to locations with water depths than 40 meters and we removed the barbs from all hooks. Additional measures were also taken to increase survival. Fishes that suffered from inflated air bladders were vented with a hypodermic needle and released. If the fishes struggled to get down, a fish-descending device (either the Ace Calloway Barotrauma Reversing Fish Release or a weighted milk crate) was used. The deeper-dwelling fishes such as gopher, china, and vermilion rockfishes are more likely to sustain injury due to barotrauma, including crystallized eyes, inflated air bladders, and extruded stomachs, thus were more likely to be vented and/or descended with a device and/or more likely to float upon being released. To maximize the survival of fishes, we minimized handling and took great care while processing each fish. The time on boat was minimized by rapid processing, and if fish were being caught at a rate that prevented rapid processing, anglers were asked to stop fishing so that the science crew could catch up. If the catch rate was exceptionally high in a particular area, the number of anglers was reduced.

Of the 27 species caught, 13 species had zero mortality. One species (Rosy rockfish) had 12 mortalities out of 72 fish (16.7%). Vermilion rockfish experienced 5.6% mortality. Mortality of all other species was less than 3.5%. A small number of fish floated away after being released and did not swim down. Mortality of these fishes is uncertain. Not including these fishes, overall mortality rate in this study was 2.1%. Although we know from previous tagging projects that not all fish that float away will die, if all floaters are considered mortalities, we would estimate overall mortality to be 3.3%.

Length Analyses

Total lengths (measured to the nearest centimeter) of caught fishes ranged from 8 – 87 cm. Of the ten most frequently caught species, mean lengths of six species were significantly different ($p<0.05$) among areas (Figure 5). Mean lengths of the fishes in Point Lobos (all sites combined) were larger than both of the other areas, with the exception of gopher rockfish, which were largest in Año Nuevo. Average lengths of these species also showed variation between the MPA and reference sites (Table 8, Figures 6 and 7).

In Año Nuevo, of the ten most frequently caught species, lingcod were the largest and blue rockfish were the smallest. We used a two-sample t-test to determine that mean lengths of black, blue, and yellowtail rockfish were significantly larger ($p < 0.001$) in the MPA than in the reference site, and vermilion rockfish were significantly larger ($p < 0.05$) in the reference site.

In Point Lobos, of the ten most frequently caught species, lingcod were the largest and yellowtail rockfish were the smallest. We used a two-sample t-test to determine that mean lengths of black, copper, kelp, and vermilion rockfish were significantly larger ($p < 0.05$) in the MPA than in the reference site, as were blue and china rockfish ($p < 0.001$).

In Point Buchon, of the ten most frequently caught species, lingcod were the largest and blue rockfish were the smallest. We used a two-sample t-test to determine that mean lengths of lingcod and vermilion rockfish were significantly ($p < 0.05$) larger in the MPA than in the reference site; olive rockfish also were significantly ($p < 0.001$) larger in the reference site.

Historic Lengths

For several species, we compared average fish lengths from this study to historic average lengths of fishes caught near our study areas. These values were obtained by compiling unpublished California Department of Fish and Game onboard central California CPFV observer data from 1987 to 1998 (Data courtesy of Deborah Wilson-Vandenberg, Figure 8). For most species that were evaluated, the average lengths from this study fell within the range of historic values. However, the average lengths from this study for copper rockfish in both Año Nuevo and Point Buchon fell in the lower end of the historic length range, olive rockfish tended to be smaller in all three areas, and vermilion rockfish were also smaller in Año Nuevo.

Maturity

Because spawning stock biomass is a metric of fish population health, it is informative to compare the lengths of fishes that are being captured to the lengths at 50% and 100% maturity (the lengths at which 50% or 100% of individuals in a population are mature). For the ten most frequently caught species, we compared the lengths at 50% maturity as determined by Miller and Geibel (1973), Wyllie Echeverria (1987), and Starr et al. (2002) to the lengths at the 75^{th} percentile of catch. At the majority of sampling sites, blue, copper, and olive rockfish were near the length of 50% maturity reported for each species. The 75^{th} percentile lengths of black and yellowtail rockfish were consistently below 50% maturity, and the 75th percentile lengths for vermilion rockfish tended to fall between the 50% and 100% maturity lengths (Table 9). Comparisons were made with the 50% and 100% maturity lengths for the females of each species because males tend to reach maximum length and maturity at younger ages than females (Love et al. 2002).

Catch Rates

Catch rates are reported as the average catch per angler hour and were calculated by dividing

the total fishes caught by total angler hours in a cell in a day. Total angler hours are the sum of all drift times per cell per day multiplied by the number of anglers fishing during those drifts, minus the amount of time anglers were not fishing in each drift (due to gear getting tangled, etc.). Catch rates varied among areas and sites. The highest catch per angler hour was in the OLD portion of the Point Lobos MPA (24.4 total fish per angler hour) and the lowest was in the Año Nuevo MPA (4.1 total fish per angler hour) (Table 10). Within each site, catch rates also varied by species (Table 11). The highest overall catch per angler hour values were for black, blue, gopher, and olive rockfishes. Significant differences in catch rates between sites were observed for several of the ten most frequently caught species in all three areas (Figure 9), based on two sample t-tests of ln (x + 1) transformed data. In the Año Nuevo area, black, blue, and china rockfishes were caught at significantly ($p < 0.05$) higher rates in the reference site than in the MPA. In the Point Lobos area, olive, and copper rockfishes were caught at significantly ($p < 0.001$) higher rates in the MPA site than in the reference site, and blue and vermilion rockfish also were caught at significantly ($p < 0.05$) higher rates in the MPA. In the Point Buchon area, yellowtail and china rockfishes were caught at significantly ($p < 0.05$) higher rates in the MPA than the reference site, as were blue rockfish ($p < 0.001$).

Influences on Catch Rates

In an attempt to understand what factors may affect catch rates, a series of regression analyses were completed on catch rate data. The following variables were regressed against catch per angler hour: the square of the wave height recorded at NOAA buoys near where the fishes were caught (that day and the previous day), the number of seals and/or sea lions near the boat while fishing, the temperature at depth and on the surface and the difference between them, the wind speed at the time of fishing, the secchi depth (measuring light penetration, water clarity), and swell height at the time of fishing. The data are inconclusive with the sample size we have. Some of the potential trends that were observed are: an increase in catch rate with increasing water clarity, a decrease in catch with increasing wave height, and an increase in catch rate with increasing water temperature at depth.

In our scoping meetings, there was concern regarding the abilities of the volunteer anglers about how skill level might influence catch rates. An evaluation of the difference between each individual's catch and the average catch of all anglers resulted in a normal distribution with a mean that is not significantly different from zero. This indicates that the skill of the volunteer anglers in this study is not influencing the results.

Also of concern in the scoping meetings was how the different vessels used in an area might influence catches. Whereas the same boat was used in both Año Nuevo and Point Lobos for all trips, three vessels were used in Point Buchon. With only one year of data, definitive differences between these vessels cannot be proven, although the F/V Fiesta did have higher catch rates within the Point Buchon MPA than did the other vessels (Figure 10).

Gear Effects

Anglers fished an equal amount of time with three different gear types. Generally, more experienced fishermen fished from the bow using lingcod bars (BAR) and a shrimp fly teaser, each with a single hook. Fishermen on the starboard side fished with two shrimp flies (FLY) each with a single hook, and those on the port side fished with two shrimp flies (each with a single hook) baited with squid (BAIT). Of the total catch of fishes (7,928), 34% were caught by BAR, 34% by BAIT, and 32% by FLY. Proportions of BAR, BAIT, and FLY were also similar

by area (Año Nuevo: 26%, 35%, 40%; Point Lobos: 36%, 34%, 30%; Point Buchon: 34%, 35%, 32%, respectively). Catch rates for each gear type were also similar. Catch rates for BAR, BAIT, and FLY were: 3.2, 3.2, and 3.0 fish per angler hour respectively.

Although each gear type caught the same amount of fishes, the species composition caught by each gear was somewhat different. An ANOVA was completed to evaluate differences in catch rates of certain species of fish by gear type. Gophers were caught at significantly ($p < 0.001$) higher rates by BAIT than both BAR and FLY in Point Lobos and Point Buchon, and when all areas are combined. In Point Lobos and when all areas are combined, olive rockfish were caught at significantly ($p < 0.05$) higher rates by BAR than both BAIT and FLY. Also, when all areas are combined, china rockfish were caught at significantly ($p < 0.05$) higher rates by BAIT than by both BAR and FLY (Figure 11).

Lastly, a comparison was made to evaluate whether or not gear type has an effect on the size of fish caught. We compared average lengths of each species by gear type using an ANOVA. Of the ten most frequently caught species, only blue and olive rockfish had significant differences in length among gear types. Blue rockfish caught by BAR were significantly larger than FLY ($p<0.001$), and larger when caught by BAIT than both BAR ($p=0.04$) and FLY ($p<0.001$).Olive rockfish caught by BAR were significantly ($p=0.021$) larger than when caught by FLY.

Point Lobos OLD MPA vs. NEW MPA

Using a two-sample t-test we compared average lengths of the ten most frequently caught species from the OLD and NEW sections of the Point Lobos MPA. Results indicate that black, blue, and gopher rockfishes are significantly larger in the OLD Point Lobos reserve than in either the newly closed portion (NEW) or in our reference sites (Figure 12). A two-sample t-test was also completed on catch rates in these sections. Catch rates were significantly higher in the OLD Point Lobos reserve for blue, copper, kelp, olive, and vermilion rockfishes (Figure 13). When all species were combined, catch rates in the OLD Point Lobos reserve were dramatically (up to 5.7 times) higher than in all other sites and areas (Table 10).

Discussion

Comparisons between Areas

The number of fishes caught in each area varied, probably because of habitat differences. Of particular note, the catches in Año Nuevo were much lower than the other two areas. This can be attributed, in part, to the difference in effort between areas; however, average catch rates in Año Nuevo were also lower than in the other two areas. This could be a function of the strong currents that were often encountered while fishing, other environmental conditions, or because the sites in Año Nuevo have lower fish abundance. Additional years of data will help to determine the reason for the reduced catch rates. The high catch rate in Point Lobos is attributed mostly to the very high catch rates in the OLD MPA. If the OLD section is excluded, Point Lobos and Point Buchon had relatively similar catch rates, although catch rates in Point Lobos are still higher.

Species composition also varied between areas. Variations reflected known geographic ranges of the fishes. For example, black rockfish were found in the highest abundance in Año Nuevo, and were less abundant further south. This agrees with their spatial distribution along the coast, which extends from western Alaska to southern California, and the fact that they are found most commonly north of northern California (Love et al. 2002). The geographic range for gopher rockfish is from Oregon to southern Baja California, yet they are uncommon north of northern California (Love et al. 2002). During this study, gophers were found in the highest abundance in Point Buchon.

Comparisons between Point Lobos OLD and NEW

At the time of closure in 2007, we expected that the NEW section of the Point Lobos reserve would be more similar to the reference site than the OLD section of the reserve, which has been closed to fishing since 1973. We expected that the OLD section would yield higher density, biomass, average length, and diversity of species, based on a summary of reserve effects from existing MPAs in other parts of the world (Halpern 2002). Data from our study indicate that the characteristics of the fishes in the OLD reserve are different from those outside the reserve. Overall catch rates in the OLD section were substantially higher than in the NEW section and the reference sites (Table 10) and catch rates of four of the ten most frequently caught fishes were significantly higher in the OLD section of the reserve than outside (Figure 13). Additionally, average lengths of three of the ten most frequently caught fishes were significantly larger in the OLD section (Figure 12). The number of species found in the OLD section, however, is not different from the NEW section or the reference sites. The results imply that the reserve has promoted growth and abundance. However, there was no baseline survey of the OLD section of the Point Lobos reserve, therefore we are inferring the reserve benefits from the differences between fishes inside and outside the OLD section. This highlights the importance of having a thorough baseline survey when a reserve is established. The surveys that we conducted this year will serve as a baseline to evaluate future changes.

Comparisons with Other Data

We compared catches from the trips completed in Año Nuevo to CPFV landings on the same day from the same general area. The catches were similar in species composition and abundance, indicating that our survey is representative of what is being caught by other recreational anglers.

Likewise, for Point Buchon, catch rates, sizes, and species composition were similar to that reported by Stephens et al. (2006) in their analysis of catch on commercial passenger fishing vessels for the south central coast from 1988-2006. For the majority of fish species that were evaluated, the average length data from this study fall within the ranges of recent historic data. This implies that there have not been dramatic changes in fish lengths over the past decade.

Maturity

Whereas the mean length of several species was at or above their lengths at 50% maturity, most frequently the mean lengths of species were below the length at which half the population is mature. This comparison is a good metric by which to gauge the efficacy of MPAs when future data are collected.

Role of Gear Type

The choice to use three different types of terminal tackle was based on the objective to make the study representative of the recreational industry, encompassing as many angler preferences as possible. For example, fishermen in the northern extent of our study preferred the use of red shrimp flies, whereas those in the southern extent preferred white. It was for this reason that a mixture of the two colors was used in both areas. Because each type of terminal tackle caught approximately the same number of fishes, at approximately the same rate, we can assume that gear type is not influencing the overall quantity of catch. However, because average lengths varied by gear type, it is important that all three types of terminal tackle be used in future studies.

Survey Objectives

Collaboration

We were successful in engaging the fishing community with the monitoring of the central California MPAs. Overall community participation and interest in this project was substantial. This interest was fostered by continual dissemination of information to the volunteer anglers and to the fishing community as a whole via emails, updates flyers, and website posts. Several fishermen contacted us through these websites with questions and expressed interest in the study. Since the completion of the study, interest from the fishing community has remained high and many fishermen have expressed a desire to participate in future years.

This study has provided an opportunity to involve the fishing community in the monitoring of MPAs and in the collection of data for fisheries management. Their expertise has also been invaluable in the creation and execution of the survey protocols. This study has also benefited from the involvement of members from both the science and fisheries management communities. Making this project truly collaborative has allowed it to benefit from the suggestions of knowledgeable people from a wide range of backgrounds.

Monitoring Protocols

We successfully created coast-wide fishing protocols that can be used to monitor MPAs using a collaborative design. The protocols incorporate environmental, temporal, and spatial variability, and are sufficiently robust to enable us to detect significant differences among sampling sites. Also, the protocols are easily replicated and have the flexibility to work in other areas along the coast. Members of the fishing, science, and fisheries management communities have collectively given support to the protocols and agree that they have the potential to contribute to state and federal stock assessments and to the evaluation of MPAs.

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Tables

Table 1. The codes used to express the condition of a caught fish upon release.

Condition	Description
1	The fish had eye damage due to barotrauma (crystallized eyes)
2	The fish was vented (swim bladder) with a hypodermic needle
3	The fish showed signs of marine mammal or fish predation, but was not a mortality
4	The fish showed signs of hook damage (including eye damage) or body cuts/scale loss, but was not a mortality
5	The fish was released using a fish descending device (either the Ace Calloway Barotrauma Reversing Fish Release or a weighted milk crate)
6	The fish was floating (did not swim down) upon release, but mortality was uncertain
7	The fish was a morality due to mammal or fish predation
8	The fish was a mortality due to causes other than mammal or fish predation (e.g., mortality due to barotrauma, handling injuries, etc.)

Table 2. General information regarding the trips completed during this study, including: number of discrete volunteers ("No. Volunteers") (Año Nuevo and Point Lobos are combined) that participated, number of volunteer days, number of vessels used, and total number of fishing days in each area. An even number of days were spent in the reference and MPA sites except in Año Nuevo where 5 ½ days were spent in the Reference sites and 4 ½ days were spent in the MPA sites.

	Año Nuevo	Point Lobos	Point Buchon	Total
No. Volunteers	112		62	174
No. Volunteer Days	117	128	121	366
No. Vessels Used	1	1	3	5
No. Fishing Days	10	12	12	34

Table 3. The number of grid cells within and sampled in each site (Marine Protected Area (MPA) and reference (REF)) in each area (Año Nuevo (AN), Point Lobos (PL), and Point Buchon (PB)). "OLD" refers to the section of the Point Lobos MPA that has been closed since 1973 and "NEW" refers to the section that was closed in September 2007.

Site	No. Grid Cells	No. Grid Cells Sampled
AN MPA	11	10
AN REF	11	11
PL OLD	6	5
PL NEW	3	3
PL REF	9	9
PB MPA	11	9
PB REF	11	10

Table 4. The average, minimum, and maximum number of minutes per drift (End Time - Start Time) and the average drift distance (meters) by area (Año Nuevo (AN), Point Lobos (PL), and Point Buchon (PB)) and site (Marine Protected Area (MPA) and reference (REF)). "OLD" refers to the section of the Point Lobos MPA that has been closed since 1973 and "NEW" refers to the section that was closed in September 2007.

Location	Drift Time (minutes)			Drift Length (meters)
	Average	Minimum	Maximum	Average
AN	6	1	18	122
AN MPA	6	1	18	122
AN REF	6	1	15	121
PL	11	2	27	107
PL MPA	10	2	24	87
PL OLD	10	2	24	65
PL NEW	11	2	24	142
PL REF	12	2	27	134
PB	13	3	23	161
PB MPA	13	3	23	146
PB REF	13	5	23	176

Table 5. The average number of anglers (No. Anglers) fishing at a given time, total hours during which fishing occurred (the sum of all drift times), total angler hours, and total fishes caught in each area (Año Nuevo (AN), Point Lobos (PL), and Point Buchon (PB)) and site (Marine Protected Area (MPA) and reference (REF)). "OLD" refers to the section of the Point Lobos MPA that has been closed since 1973, and "NEW" refers to the section that was closed in September 2007.

Location	No. Anglers	Total Fishing Hours	Total Angler Hours	Total Fishes Caught
AN	7.7	26.9	215.2	1275
AN MPA	7.5	10.5	84.9	356
AN REF	7.9	16.4	130.3	919
PL	9.2	32.7	291.0	4177
PL MPA	9.3	17.1	153.8	2923
PL OLD	9.4	12.2	108.9	2528
PL NEW	9.2	4.9	44.8	395
PL REF	9.1	15.6	137.3	1254
PB	9.2	36.0	330.4	2476
PB MPA	9.5	18.3	172.4	1546
PB REF	9.0	17.6	158.0	930
Total		95.6	836.7	7,928

Table 6. Species composition by site (listed from most to least frequently caught, all areas combined). Values are the percentage of the total catch at each site (Marine Protected Area (MPA) and reference (REF)). "OLD" refers to the section of the Point Lobos MPA that has been closed since 1973, and "NEW" refers to the section that was closed in September 2007. An asterisk (*) indicates a value less than 0.1 when rounded. The Shannon diversity index (H) is also listed for each site.

		Año Nuevo		Point Lobos			Point Buchon	
Common Name	Scientific Name	% MPA (N=356)	% REF (N=919)	% OLD (N=2528)	% NEW (N=395)	% REF (N=1254)	% MPA (N=1546)	% REF (N=930)
Blue rockfish	*Sebastes mystinus*	30.3	34.7	54	31.6	41.6	28.8	14.7
Gopher rockfish	*Sebastes carnatus*	15.7	9.5	13	39	25.7	46.1	51.5
Black rockfish	*Sebastes melanops*	33.1	46.7	1.2	2	8.4	5.7	10.5
Olive rockfish	*Sebastes serranoides*	0.3	0.1	20.1	14.4	10.5	4.3	6.2
Yellowtail rockfish	*Sebastes flavidus*	3.1	2.4	0.3	2.8	1.3	4	2.6
Vermilion rockfish	*Sebastes miniatus*	3.9	1	2.3	1	1.5	1.6	2.3
Lingcod	*Ophiodon elongatus*	3.4	1.1	1.3	1	1.1	1.8	3.8
Kelp rockfish	*Sebastes atrovirens*			2	1	3.3	0.6	0.2
Copper rockfish	*Sebastes caurinus*	0.6	0.1	2.6	1.3	0.7	0.6	0.4
China rockfish	*Sebastes nebulosus*	1.1	2.3	1	1.8	0.8	1	0.3
Rosy rockfish	*Sebastes rosaceus*			0.6	1.3	1.4	2.1	0.4
Canary rockfish	*Sebastes pinniger*	3.7	0.5	0.7	0.3	0.5	0.7	0.1
Kelp greenling	*Hexagrammos decagrammus*	0.6	0.5	0.4	1.3	0.5	0.2	2.4
Treefish	*Sebastes serriceps*						0.9	1.9
Starry rockfish	*Sebastes constellatus*			0.1	0.3	0.2	0.9	0.2
Black-and-yellow rockfish	*Sebastes chrysomelas*	0.8					0.1	1.4
Cabezon	*Scorpaenichthys marmoratus*	0.8	0.1	0.1	0.3	0.1	0.2	0.8
Mackerel	*Scombridae*		0.1	0.2		0.6	0.1	
Brown rockfish	*Sebastes auriculatus*	1.4	0.5			0.1		
Rock greenling	*Hexagrammos lagocephalus*	0.6	0.1	*		0.2		
Sanddab	*Citharichthys sordidus*						0.2	
Grass rockfish	*Sebastes rastrelliger*		0.1		0.3			
Rock sole	*Lepidopsetta bilineata*						0.1	0.1
Pacific sardine	*Sardinops sagax*	0.3	0.1					
Ocean whitefish	*Caulolatilus princeps*			0.1				
Calico rockfish	*Sebastes dalli*						0.1	
Red Irish lord	*Hemilepidotus hemilepidotus*	0.3						
	Shannon Diversity Index (H)	1.82	1.35	1.47	1.63	1.71	1.65	1.71

Table 7. Species composition by month for each area. Values are the percentage of the total catch in a given area each month. An asterisk (*) indicates a value less than 0.1 when rounded.

	Año Nuevo (N= 1275)			Point Lobos (N=4177)			Point Buchon (N=2476)		
Common Name	% August	% September	% October	% August	% September	% October	% August	% September	% October
Black rockfish	26.8	6.8	9.3	2.0	1.1	0.3	1.9	3.4	2.2
Black-and-yellow rockfish	0.1	0.2					0.2	0.1	0.4
Blue rockfish	22.4	7.1	4.0	20.1	19.9	8.2	12.2	6.6	4.7
Brown rockfish	0.3	0.5		*					
Cabezon	0.3			*		*	0.1	0.1	0.2
Calico rockfish							*		
Canary rockfish	0.5	0.8	0.2	0.1	0.4	0.1	0.2		0.2
China rockfish	1.3	0.2	0.4	0.3	0.5	0.2	0.2	0.2	0.4
Copper rockfish	0.2		0.1	0.7	0.4	0.8	0.1	0.1	0.4
Gopher rockfish	6.5	2.5	2.2	7.1	6.6	5.6	19.3	15.2	13.6
Grass rockfish			0.1		*				
Kelp greenling	0.2	0.1	0.2	0.1	0.3	0.1	0.6	0.2	0.2
Kelp rockfish				0.9	0.9	0.5	0.2	0.1	0.2
Lingcod	1.5	0.2	0.1	0.5	0.3	0.4	0.7	0.5	1.4
Mackerel	0.1			0.2	0.1		*		
Ocean whitefish						*			
Olive rockfish	0.2			8.4	5.1	3.2	1.7	2.1	1.3
Pacific sardine		0.1	0.1						
Red Irish lord		0.1							
Rock greenling		0.2	0.1		*	0.1			
Rock sole									0.1
Rosy rockfish				0.4	0.3	0.2	0.8	0.5	0.2
Sanddab									0.1
Starry rockfish				*	*	0.1	0.1	0.3	0.2
Treefish							0.5	0.3	0.5
Vermilion rockfish	1.2	0.5	0.1	1.0	0.6	0.4	0.6	0.4	0.8
Yellowtail rockfish	1.3	0.7	0.5	0.4	0.2	0.2	1.1	1.6	0.8

Table 8. The average total length (cm) (standard error) and the number of fishes measured (N) of the ten species most frequently caught during this study. Values are listed for: a) Año Nuevo (AN), b) Point Lobos (PL), and c) Point Buchon (PB) Marine Protected Area (MPA) and reference (REF) sites. Significant (*: $p < 0.05$, **: $p < 0.001$) differences between sites were determined using a two-sample t-test.

a)	AN MPA		AN REF		
Common Name	Length (cm)	N	Length (cm)	N	Significance
Black rockfish	32.9 (0.2)	118	30.3 (0.2)	429	** (MPA > REF)
Blue rockfish	25.9 (0.5)	108	23.4 (0.3)	317	** (MPA > REF)
China rockfish	28.3 (2.5)	4	29.7 (0.6)	21	
Copper rockfish	38.0 (3.0)	2	26.0	1	
Gopher rockfish	27.6 (0.3)	56	27.9 (0.2)	87	
Lingcod	56.2 (4.0)	12	61.5 (3.7)	10	
Olive rockfish	28.0	1	25.0	1	
Vermilion rockfish	36.1 (1.3)	14	44.3 (1.8)	9	* (REF > MPA)
Yellowtail rockfish	29.8 (1.0)	11	24.6 (0.9)	22	** (MPA > REF)

b)	PL MPA		PL REF		
Common Name	Length (cm)	N	Length (cm)	N	Significance
Black rockfish	31.4 (0.6)	38	29.7 (0.3)	105	* (MPA > REF)
Blue rockfish	28.2 (0.1)	1489	26.9 (0.2)	521	** (MPA > REF)
China rockfish	30.1 (0.5)	32	26.0 (0.5)	10	** (MPA > REF)
Copper rockfish	38.2 (0.7)	70	30.8 (2.5)	9	* (MPA > REF)
Gopher rockfish	26.9 (0.1)	482	26.7 (0.1)	322	
Kelp rockfish	31.0 (0.3)	55	29.8 (0.4)	42	* (MPA > REF)
Lingcod	62.6 (1.8)	36	58.0 (2.2)	14	
Olive rockfish	35.1 (0.2)	563	34.6 (0.4)	131	
Vermilion rockfish	42.3 (0.6)	63	38.5 (1.7)	19	* (MPA > REF)
Yellowtail rockfish	26.1 (1.2)	19	26.9 (0.9)	16	

c)	PB MPA		PB REF		
Common Name	Length (cm)	N	Length (cm)	N	Significance
Black rockfish	31.2 (0.3)	88	31.0 (0.3)	98	
Blue rockfish	24.1 (0.3)	442	24.6 (0.5)	137	
China rockfish	28.5 (0.7)	16	28.3 (2.2)	3	
Copper rockfish	29.9 (1.2)	10	29.5 (2.5)	4	
Gopher rockfish	26.1 (0.1)	704	26.1 (0.1)	478	
Kelp rockfish	30.8 (0.6)	10	30.0 (4.0)	2	
Lingcod	58.3 (1.5)	28	52.0 (1.6)	35	* (MPA > REF)
Olive rockfish	30.6 (0.5)	65	33.0 (0.4)	58	** (REF > MPA)
Vermilion rockfish	39.4 (0.8)	23	35.1 (1.0)	21	* (MPA > REF)
Yellowtail rockfish	25.7 (0.5)	61	27.4 (0.7)	24	

Table 9. Mean total length (cm) of the 75th percentile of lengths (75% of individuals per species were smaller) of captured fishes for the ten most frequently caught species. Total lengths (cm) and age (year) at 50% maturity and 100% maturity are reported for females of the species in central California (Miller and Geibel 1973, Wyllie Echeverria 1987, and Starr et al. 2002).

					Año Nuevo		Point Lobos			Point Buchon	
Common Name	Length (cm) at 50% Maturity	Age (yrs) at 50% Maturity	Length (cm) at 100% Maturity	Age (yrs) at 100% Maturity	MPA TL (cm) at 75%	REF TL (cm) at 75%	OLD TL (cm) at 75%	NEW TL (cm) at 75%	REF TL (cm) at 75%	MPA TL (cm) at 75%	REF TL (cm) at 75%
Black rockfish	41.0	7	48.0	11	35.0	33.0	34.0	31.0	32.0	34.0	33.0
Blue rockfish	29.0	6	35.0	11	29.0	27.0	32.0	29.3	31.0	29.0	28.3
China rockfish	27.0	4	30.0	6	31.0	31.0	33.0	30.8	27.0	30.5	30.8
Copper rockfish	34.0	6	41.0	8			44.0	41.5	35.0	29.9	33.0
Gopher rockfish	17.0	4	21.0	5	30.0	29.0	29.0	28.0	28.0	28.0	28.0
Kelp rockfish	26.0	4	30.0	6			32.0	32.0	32.0	34.0	32.0
Lingcod	58.0	3	76.5	7	64.0	63.0	71.5	60.0	65.0	57.0	63.5
Olive rockfish	35.0	5	39.0	8			38.0	37.0	38.0	33.0	34.0
Vermilion rockfish	37.0	5	46.0	9	39.0	46.3	45.0	47.5	44.0	38.0	41.8
Yellowtail rockfish	36.0	7	42.0	11	31.8	28.0	33.0	25.0	29.5	30.0	28.0

Table 10. Average catch per angler hour values (standard error) with all species combined by area (Año Nuevo (AN), Point Lobos (PL), and Point Buchon (PB)) and site (Marine Protected Area (MPA) and reference (REF)). "OLD" refers to the section of the Point Lobos MPA that has been closed since 1973, and "NEW" refers to the section that was closed in September 2007.

	Catch per Angler Hour (SE)
AN	5.5 (0.5)
AN MPA	4.3 (0.6)
AN REF	6.4 (0.8)
PL	14.9 (1.6)
PL MPA	19.2 (2.4)
PL OLD	24.4 (3.0)
PL NEW	9.6 (1.3)
PL REF	10.5 (1.6)
PB	7.6 (0.5)
PB MPA	9.0 (0.8)
PB REF	6.1 (0.5)

Table 11. The average catch per angler hour (CPUE) and standard error (SE) for each species by area (Año Nuevo (AN), Point Lobos (PL), and Point Buchon (PB)) and site (Marine Protected Area (MPA) and reference (REF)). "OLD" refers to the section of the Point Lobos MPA that has been closed since 1973, and "NEW" refers to the section that was closed in September 2007. Species are listed from highest to lowest overall catch. An asterisk (*) indicates values less than 0.01 when rounded.

	CPUE										
Species Code	PL	PL OLD	PL NEW	PL MPA	PL REF	AN	AN MPA	AN REF	PB	PB MPA	PB REF
Blue rockfish	7.1 (1.0)	13.3 (2.0)	2.9 (0.4)	9.7 (1.6)	4.3 (0.8)	1.7 (0.3)	1.0 (0.3)	2.3 (0.4)	1.8 (0.3)	2.6 (0.5)	0.9 (0.1)
Gopher rockfish	2.8 (0.3)	3.0 (0.4)	3.6 (0.7)	3.2 (0.4)	2.4 (0.4)	0.7 (0.1)	0.7 (0.2)	0.6 (0.1)	3.6 (0.3)	4.1 (0.5)	3.1 (0.3)
Black rockfish	0.7 (0.3)	0.3 (0.1)	0.2 (0.1)	0.3 (0.1)	1.2 (0.6)	2.4 (0.3)	1.6 (0.5)	3.0 (0.4)	0.6 (0.1)	0.5 (0.1)	0.7 (0.2)
Olive rockfish	2.5 (0.4)	5.0 (1.0)	1.6 (0.4)	3.8 (0.7)	1.1 (0.2)	*	*	*	0.4 (0.1)	0.4 (0.1)	0.4 (0.1)
Yellowtail rockfish	0.1 (*)	0.1 (0.1)	0.2 (0.1)	0.1 (0.1)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)	0.3 (0.1)	0.4 (0.1)	0.2 (0.1)
Vermilion rockfish	0.3 (0.1)	0.6 (0.1)	0.1 (*)	0.4 (0.1)	0.1 (*)	0.1 (*)	0.1 (0.1)	0.1 (*)	0.1 (*)	0.2 (*)	0.1 (*)
Lingcod	0.2 (*)	0.3 (0.1)	0.1 (0.1)	0.2 (0.1)	0.1 (*)	0.1 (*)	0.1 (*)	0.1 (*)	0.2 (*)	0.2 (*)	0.2 (*)
Kelp rockfish	0.3 (0.1)	0.5 (0.1)	0.1 (0.1)	0.4 (0.1)	0.3 (0.1)				*	0.1 (*)	*
China rockfish	0.1 (*)	0.2 (0.1)	0.1 (0.1)	0.2 (0.1)	0.1 (0.1)	0.1 (*)	*	0.1 (*)	0.1 (*)	0.1 (*)	*
Rosy rockfish	0.1 (*)	0.1 (*)	0.1 (0.1)	0.1 (*)	0.1 (0.1)				0.1 (*)	0.2 (0.1)	*
Copper rockfish	0.2 (0.1)	0.6 (0.1)	0.1 (*)	0.4 (0.1)	0.1 (*)	*	*	*	*	0.1 (*)	*
Canary rockfish	0.1 (*)	0.1 (0.1)	*	0.1 (*)	*	0.1 (0.1)	0.2 (0.1)	*	*	0.1 (*)	*
Kelp greenling	0.1 (*)	0.1 (*)	0.1 (0.1)	0.1 (*)	*	*	* (*)	*	0.1 (*)	*	0.1 (*)
Treefish									0.1 (*)	0.1 (0.1)	0.1 (*)
Starry rockfish	*	*	*	*	*				0.1 (*)	0.1 (*)	*
Brown rockfish	*				*	0.1 (*)	0.1 (0.1)	*			
Black-and-yellow rockfish						*	*		*	*	0.1 (0.1)
Cabezon	*	*	0.1 (0.1)	*	*	*	*	*	*	*	*
Calico rockfish									*	*	
Grass rockfish	*		*	*		*		*			
Mackerel	*	*		*	0.1 (*)	*		*	*	*	
Ocean whitefish	*	*		*							
Pacific sardine						*	*	*			
Red Irish lord						*	*				
Rock greenling	*	*		*	*	*	*	*			
Rock sole									*	*	*
Sanddab									*	*	

Figures

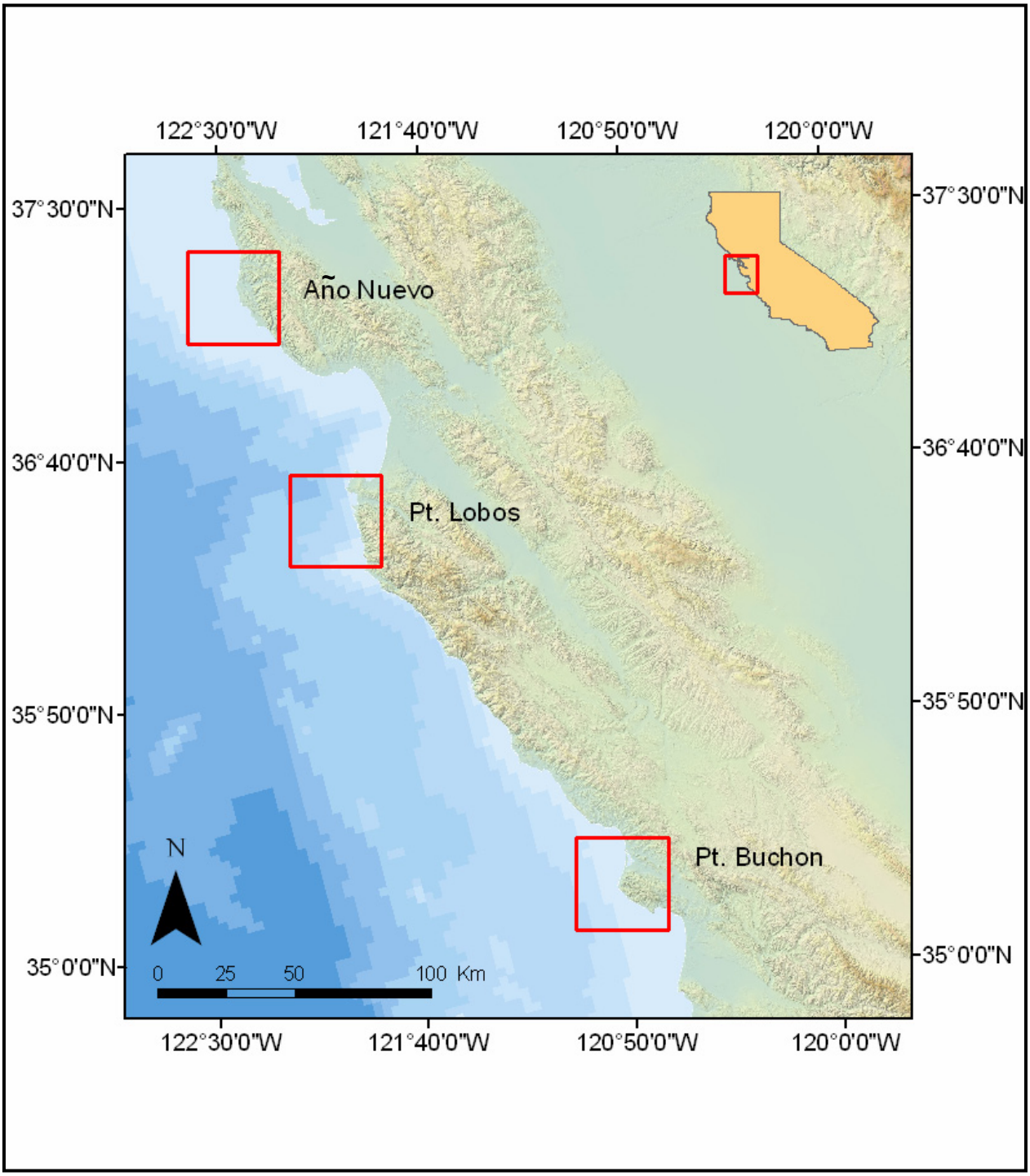


Figure 1. The three areas surveyed during this study: Año Nuevo, Point Lobos, and Point Buchon. Within these areas, both the Marine Protected Areas and reference sites were sampled.

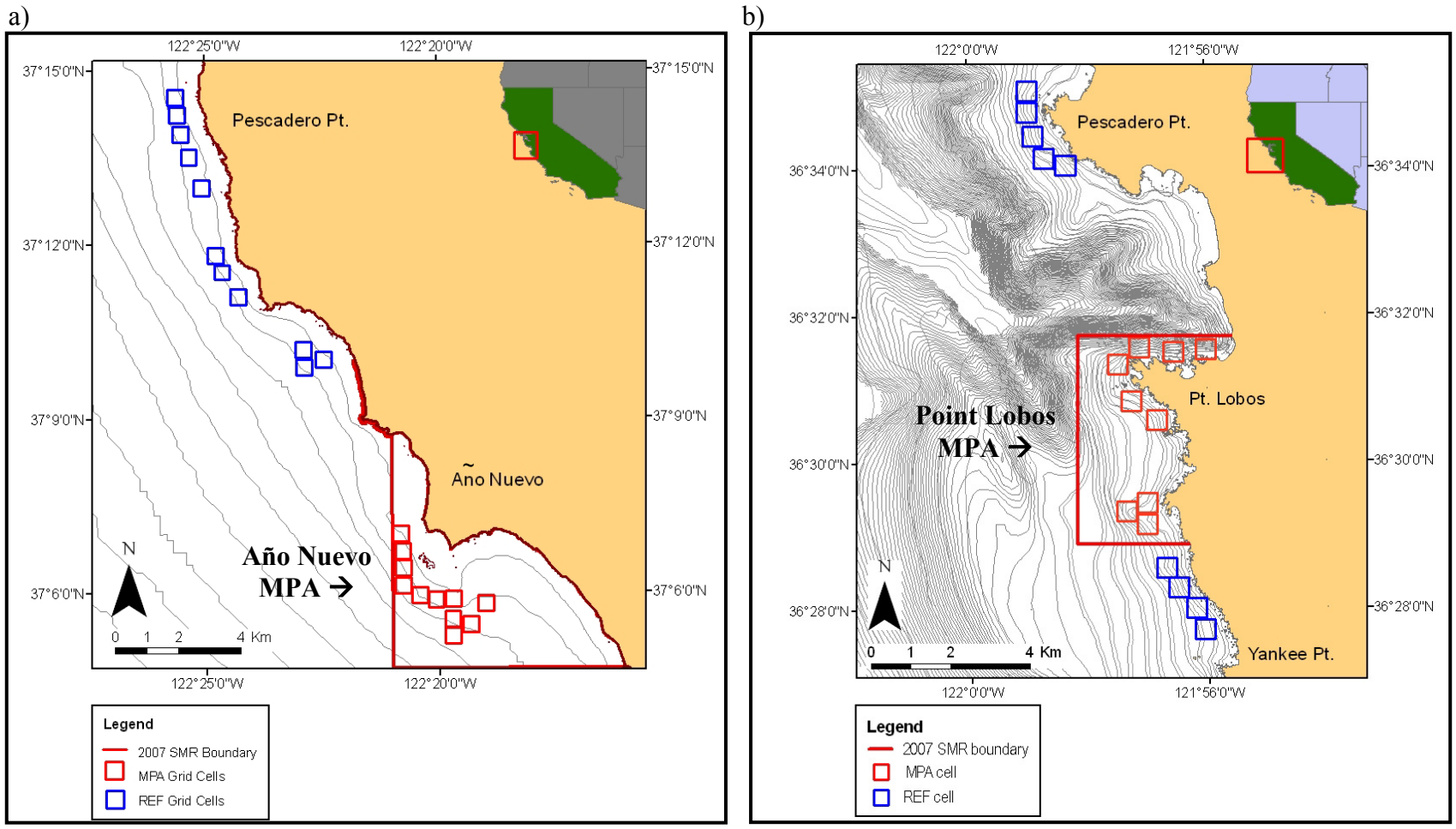
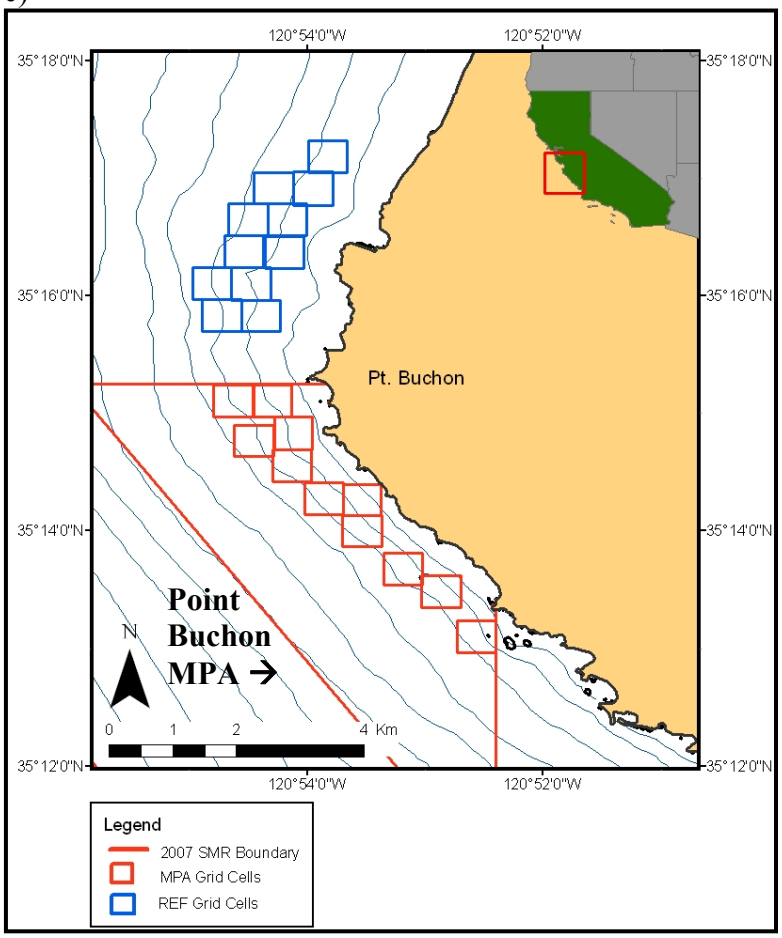


Figure 2. The 500m x 500m grid cells in which sampling was completed in the a) Año Nuevo, b) Point Lobos, and c) Point Buchon Marine Protected Areas and in corresponding reference sites.

Figure 2 continued.

c)



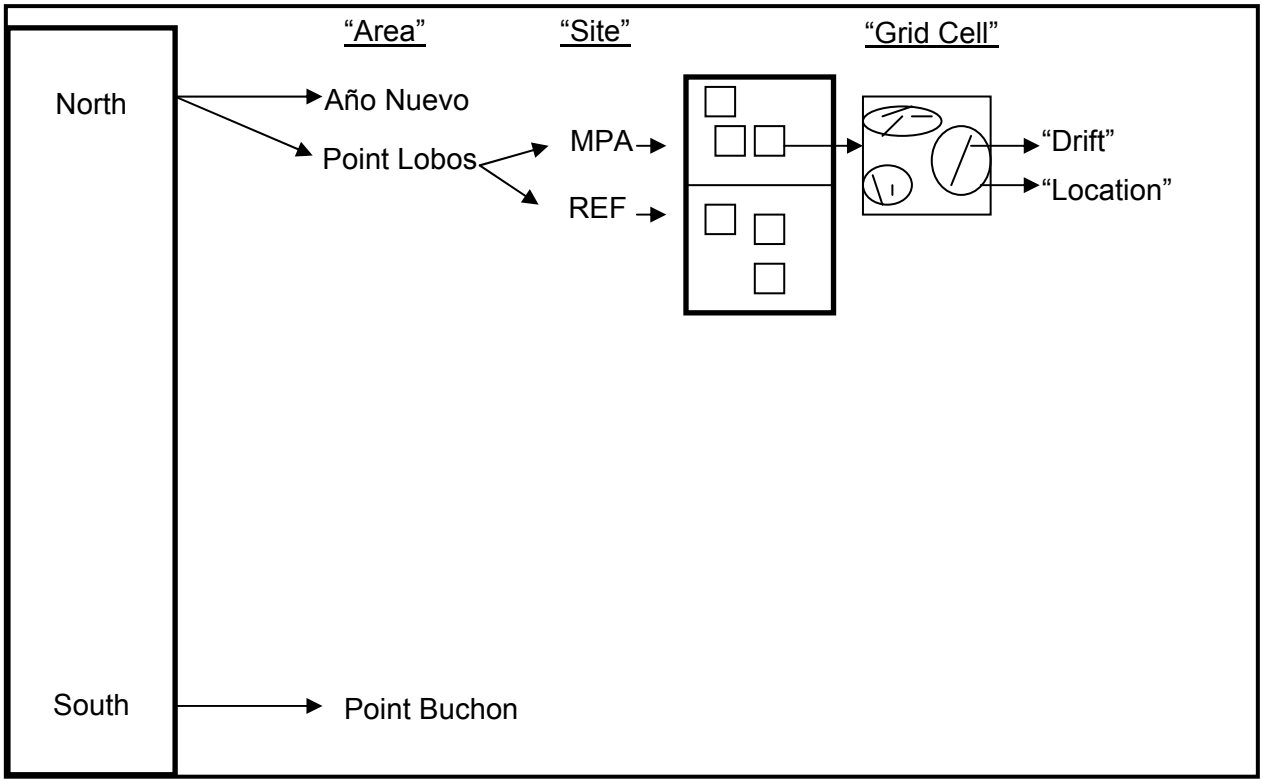


Figure 3. Terminology used to identify various levels of location information. Sampling was completed in three "Areas." In the north, there are two areas: Año Nuevo and Point Lobos. In the south, there is one area: Point Buchon. Within each of these areas, there are two different "Sites:" either Marine Protected Area (MPA) or reference (REF). Within these sites are "Grid Cells," which delineate the sampling boundaries. In each of the grid cells "Drifts" were completed in three distinct "locations."

SLOSEA

CAL POLY
Center for Coastal Marine Sciences

Have You Seen This Tag???

Rick Starr of the UC Cooperative Extension Sea Grant Program and Dean Wendt of California Polytechnic State University, San Luis Obispo have been working with Commercial Passenger Fishing Vessels and recreational anglers to catch and tag fish out of Morro Bay, Monterey, Pillar Point and San Luis Harbors. The purpose of this collaborative research is to collect baseline information about the Point Buchon, Point Lobos, and Año Nuevo Marine Protected Areas.

If you catch a tagged fish, please record the tag number, date caught, latitude and longitude and depth where the fish was caught, and call, email or mail the information to:

Noelle Yochum
Moss Landing Marine Labs
8272 Moss Landing Road
Moss Landing, CA 95039
831.771.4479
nyochum@mlml.calstate.edu

Leslie Longabach
California Polytechnic State University
1 Grand Avenue
San Luis Obispo, CA 93407
805.756.2950
llongaba@calpoly.edu

For more information about this study go to:
www.slosea.org/collaborative and http://seagrant.mlml.calstate.edu/crmpamonitor.php

Please report information even if you decide to release the fish!

Thank you for your help!

October 2007

Figure 4. The tag-return flyer that was disseminated to encourage the return of fish tags.

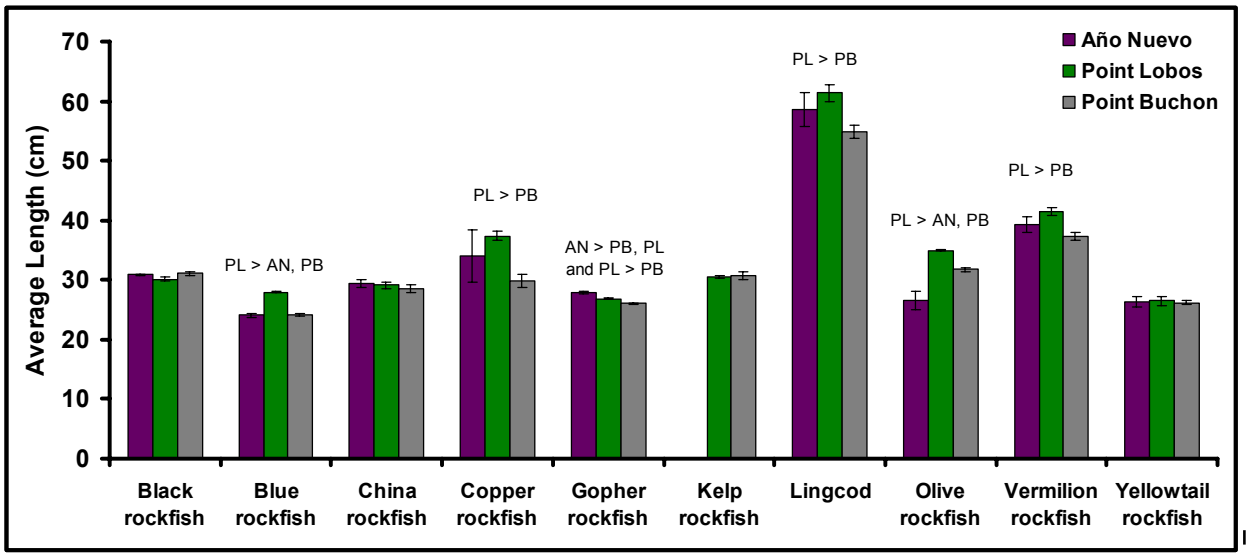
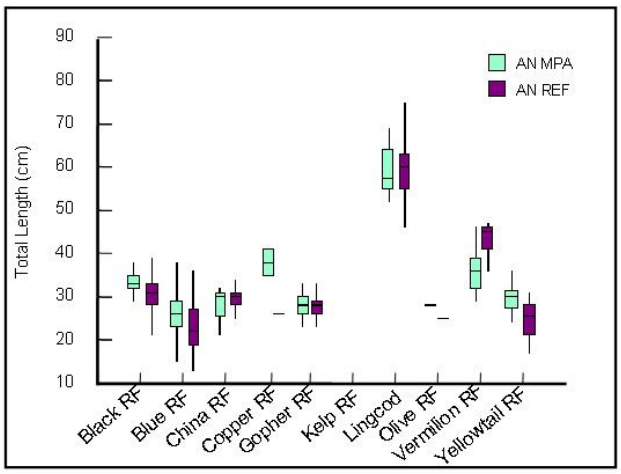


Figure 5. Average total lengths (cm, with standard error bars) of the ten most frequently caught species by area. An ANOVA was completed to evaluate significant differences by area. Significant ($p<0.05$)

a)



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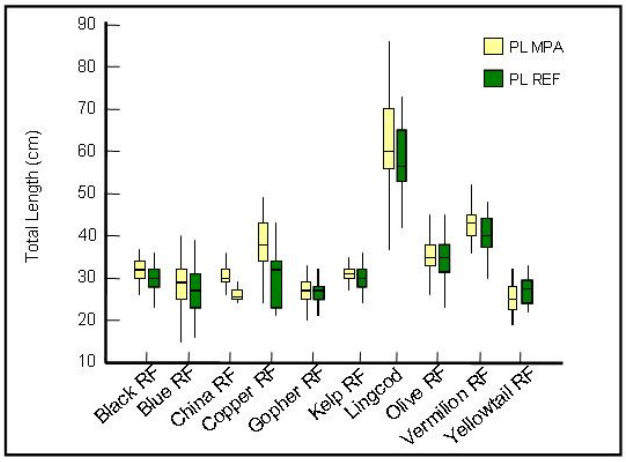

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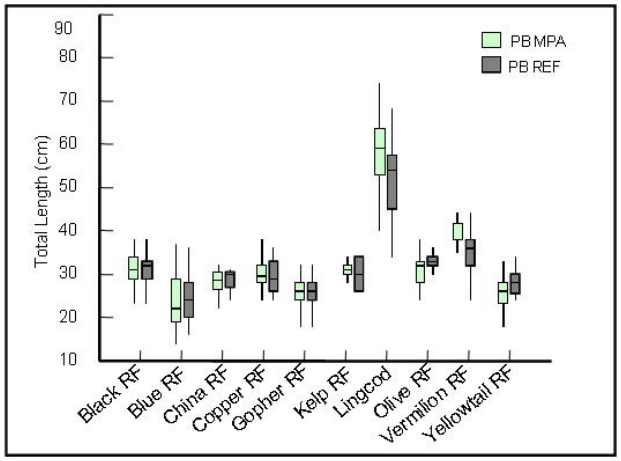
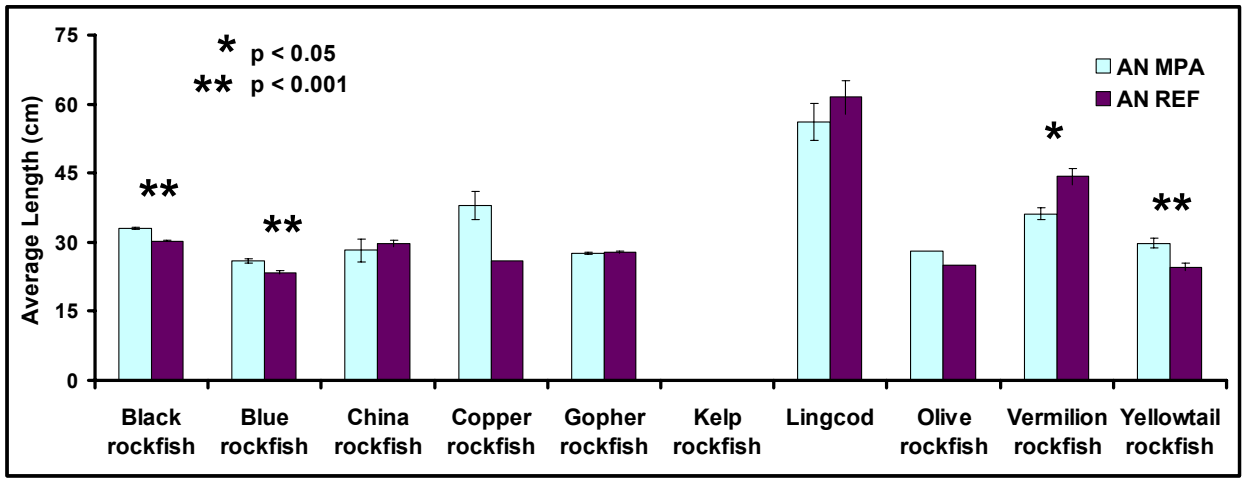
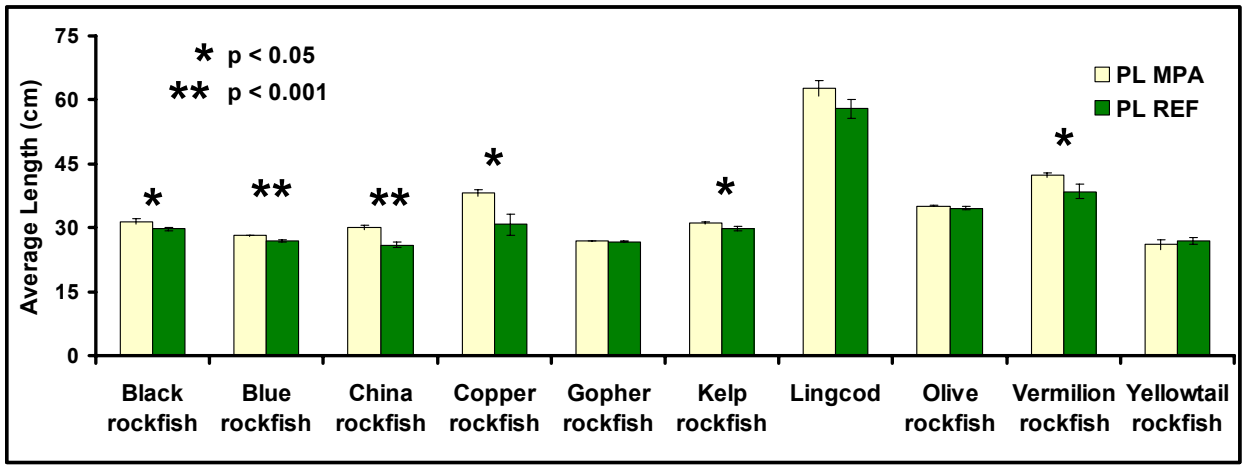


Figure 6. Box plots of total length (cm) for the ten most frequently caught species (RF: rockfish) comparing values between the Marine Protected Area (MPA) and reference (REF) sites in: a) Año Nuevo (AN), b) Point Lobos (PL), and c) Point Buchon (PB). The top of the box is the 75th quartile and the bottom is the 25th. The midline in the box is the median value.

a)



b)



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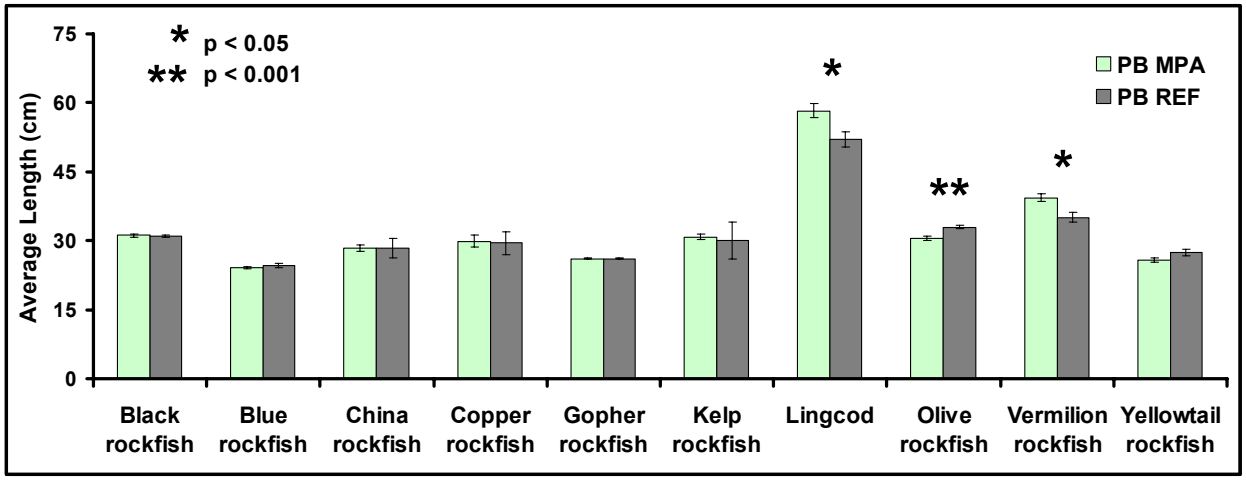


Figure 7. Average total lengths (cm, with standard error bars) for the ten most frequently caught species by site (Marine Protected Area (MPA) and Reference (REF)) in a) Año Nuevo (AN), b) Point Lobos (PL), and c) Point Buchon (PB). Significant differences between sites were determined using a two-sample t-test. Significance is indicated with asterisks (*).

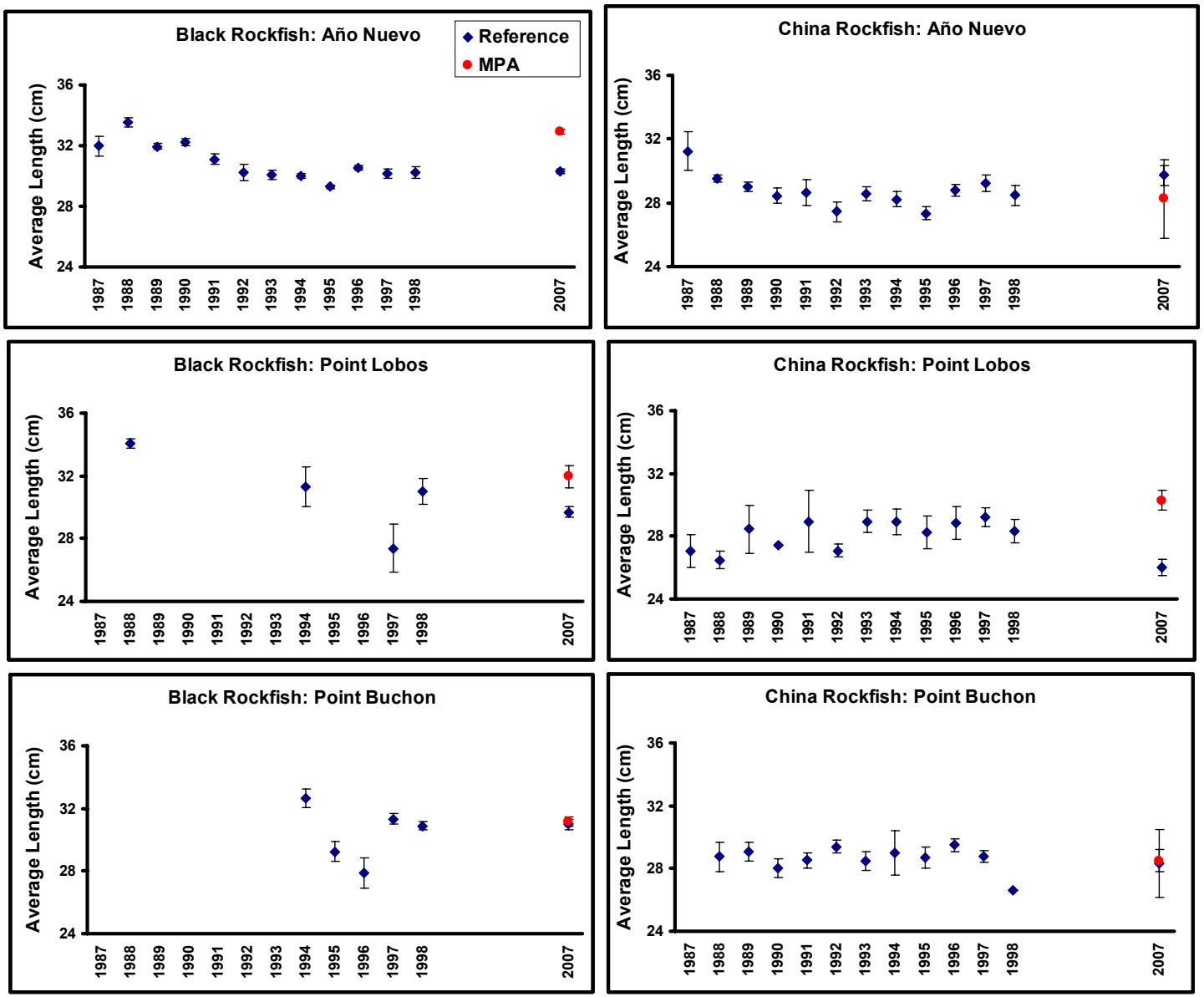


Figure 8. Average total lengths (cm, with standard error bars) from this study (2007 data points show MPA (Point Lobos shows the OLD section only) and reference sites) compared to historic mean lengths of selected rockfishes. Previous data were compiled from unpublished California Department of Fish and Game (DFG) onboard central California CPFV observer data (years 1987-1998) in locations near our collaborative research fishing areas. Data courtesy of Deb Wilson-Vandenberg (DFG).

Figure 8 continued.

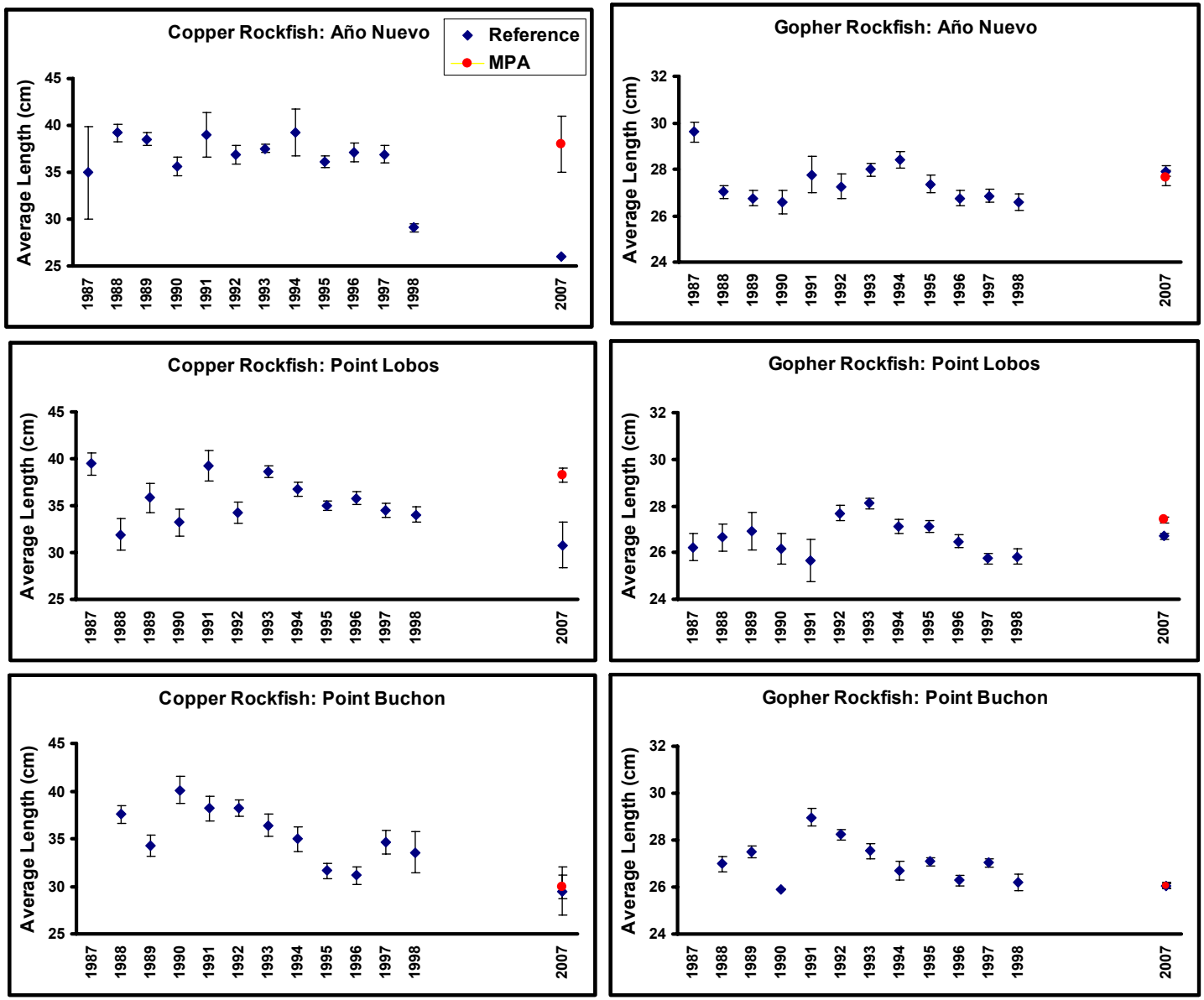
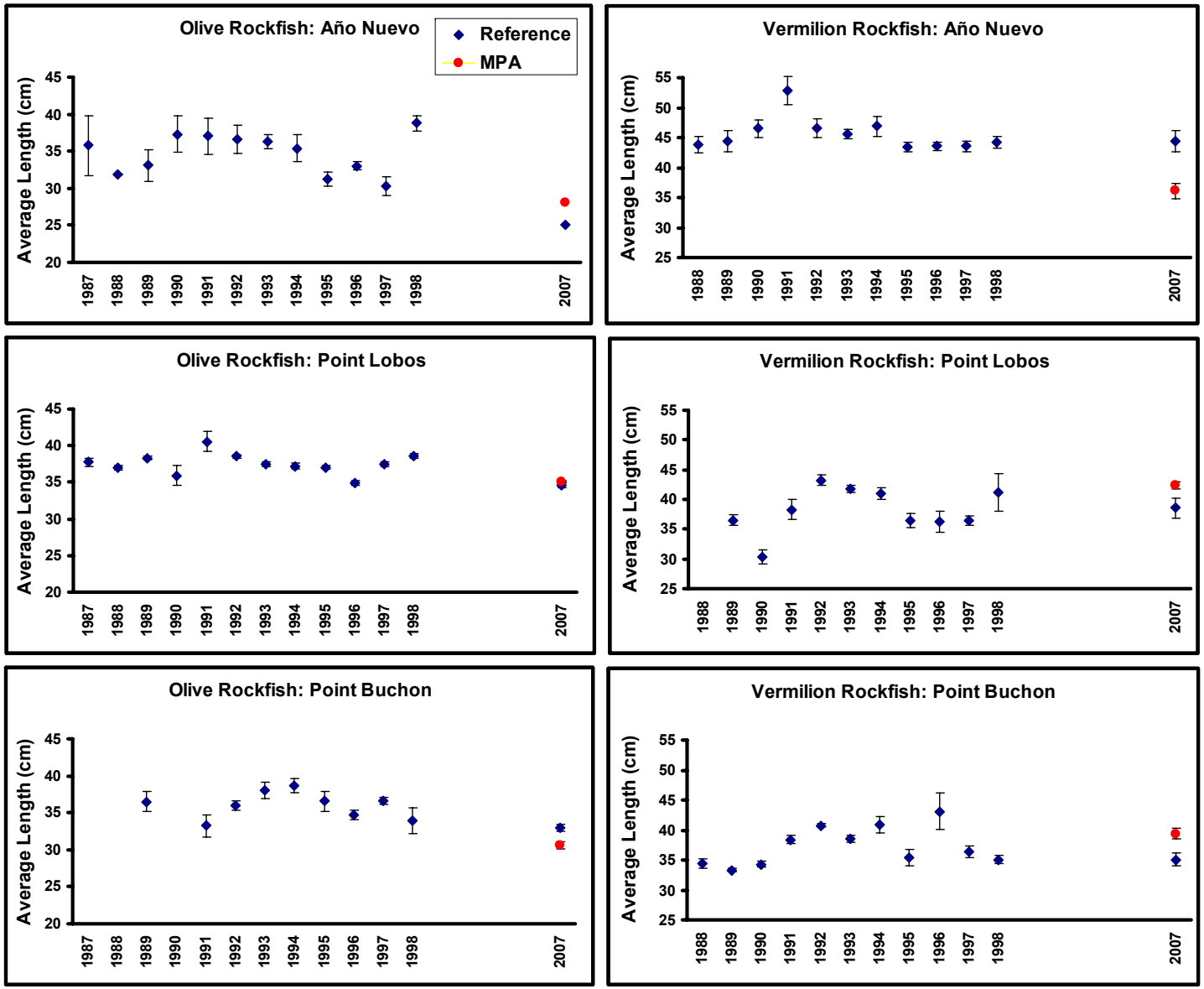
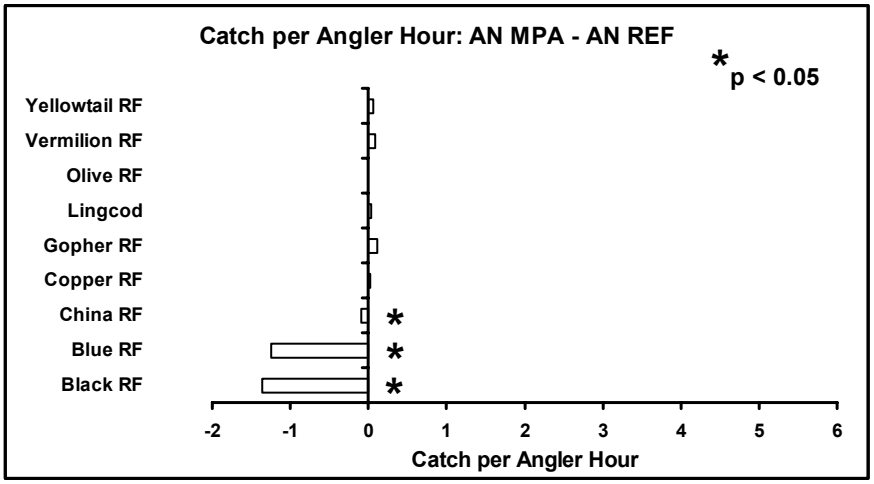


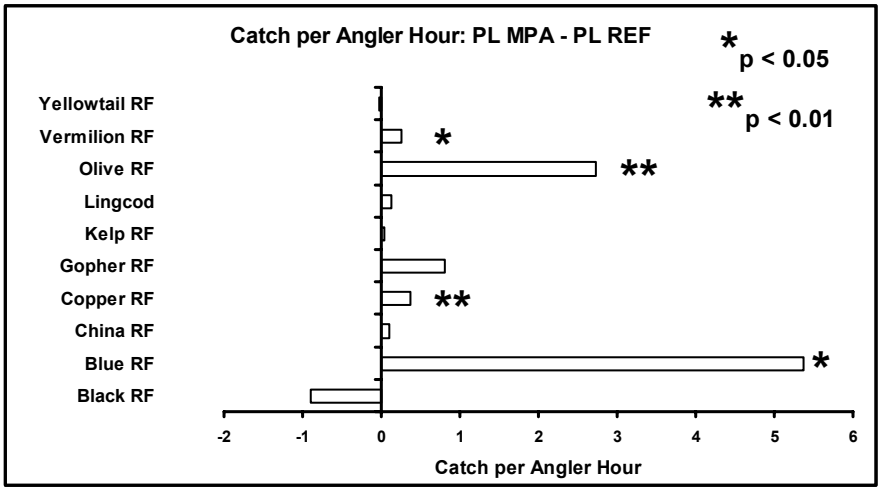
Figure 8 continued.



a)



b)



c)

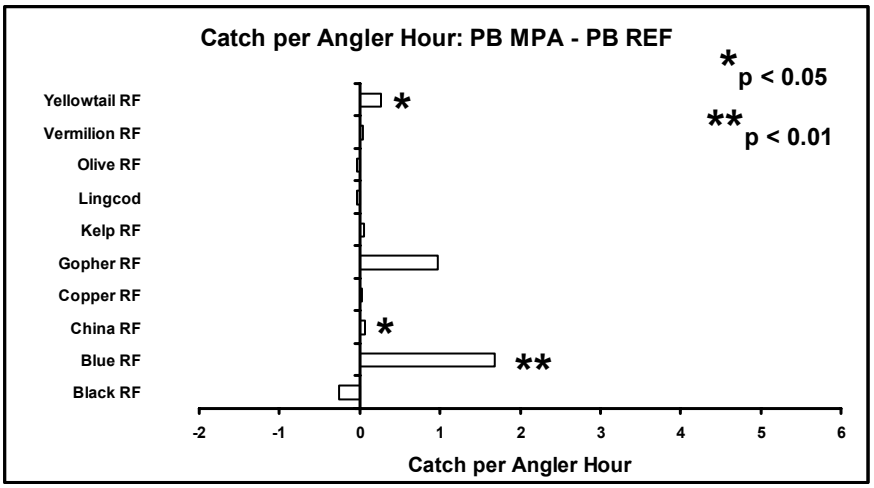


Figure 9. The difference in the average catch per angler hour values between sites (Marine Protected Area (MPA) minus reference (REF)) in Año Nuevo (AN), Point Lobos (PL), and Point Buchon (PB) for the ten most frequently caught species. Significance (indicated with asterisks, *) is based on results from a two-sample t-test on natural log transformed (ln (x+1)) data.

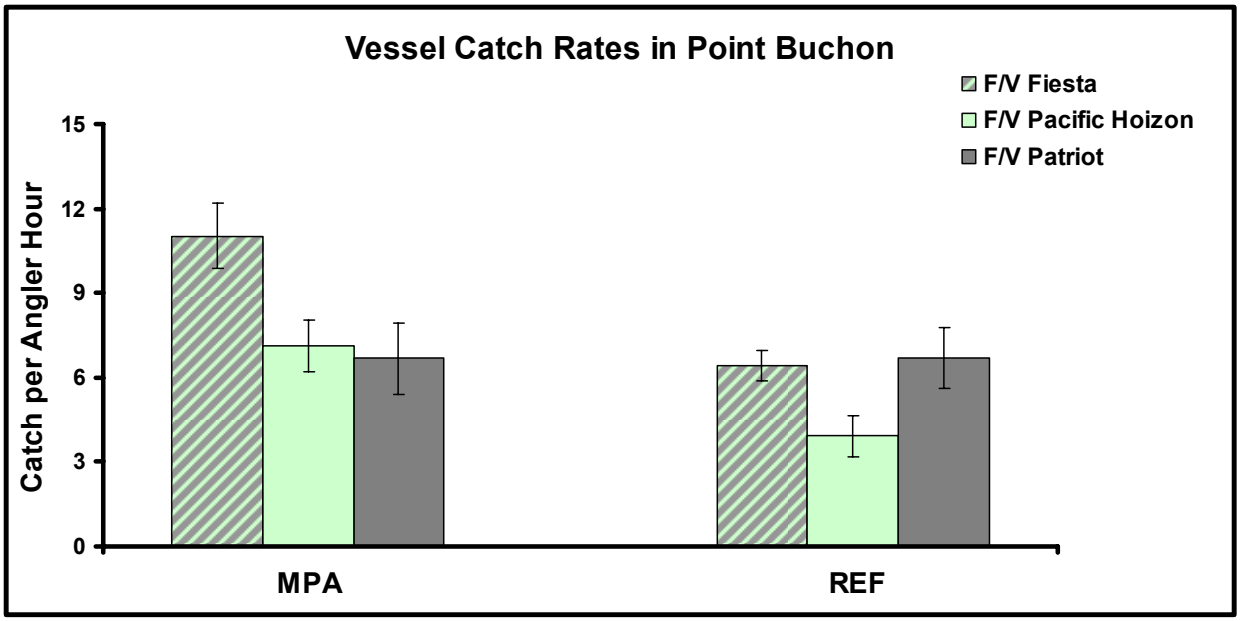


Figure 10. A comparison of the average catch per angler hour values (with standard error bars) for each vessel that was used in the Point Buchon Marine Protected Area (MPA) and reference (REF) sites.

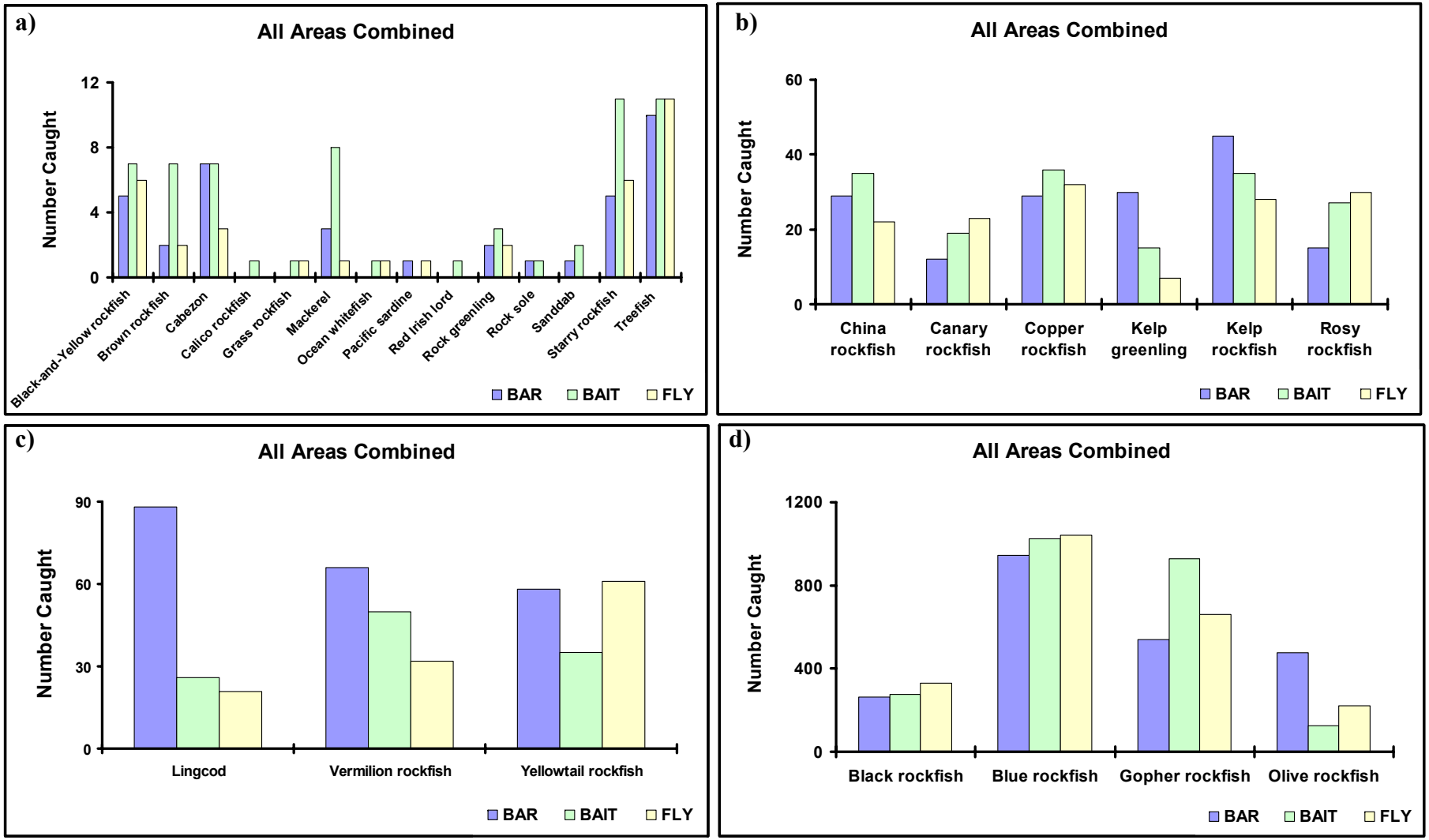


Figure 11. The number of fish for each species (27 species total) caught by the three different types of terminal tackle used in this study (all areas combined). "BAR" refers to single hook lingcod bars (hard tackle) with a single hook shrimp fly teaser, "BAIT" refers to two single hook shrimp flies with a 2 to 4 inch piece of squid bait, and "FLY" refers to two single hook shrimp flies without bait. BAR was fished exclusively on the bow of the vessel, BAIT from the port side, and FLY from the starboard side. The species are grouped by level of abundance (a-d).

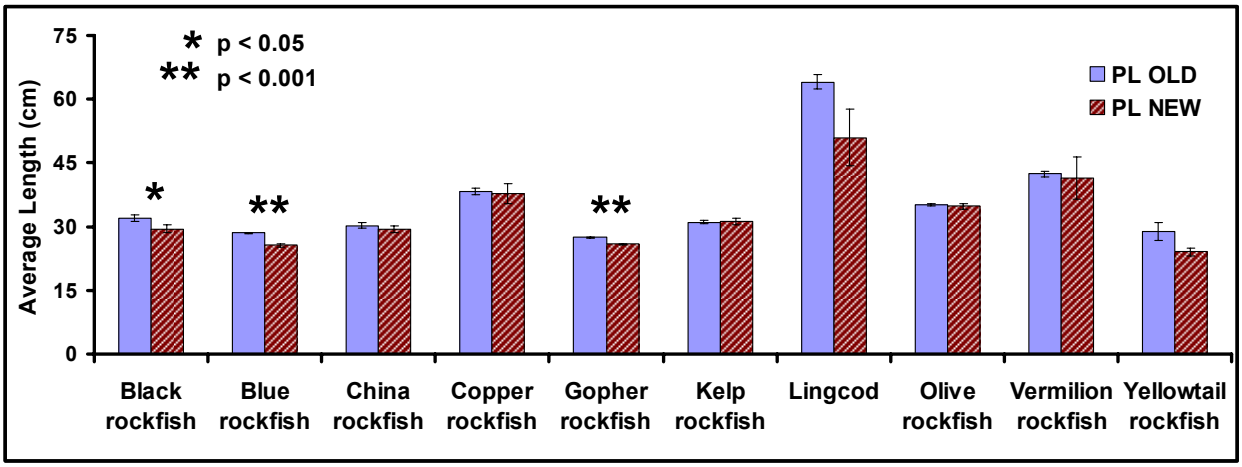


Figure 12. Comparison of the average total lengths (cm, with standard error bars) for the ten most frequently caught species in the "OLD" and "NEW" sections of the Point Lobos Marine Protected Area. "OLD" refers to the section of the Point Lobos MPA that has been closed since 1973, and "NEW" refers to the section that was closed in September 2007. Significant differences (indicated with asterisks, *) were determined with a two-sample t-test.

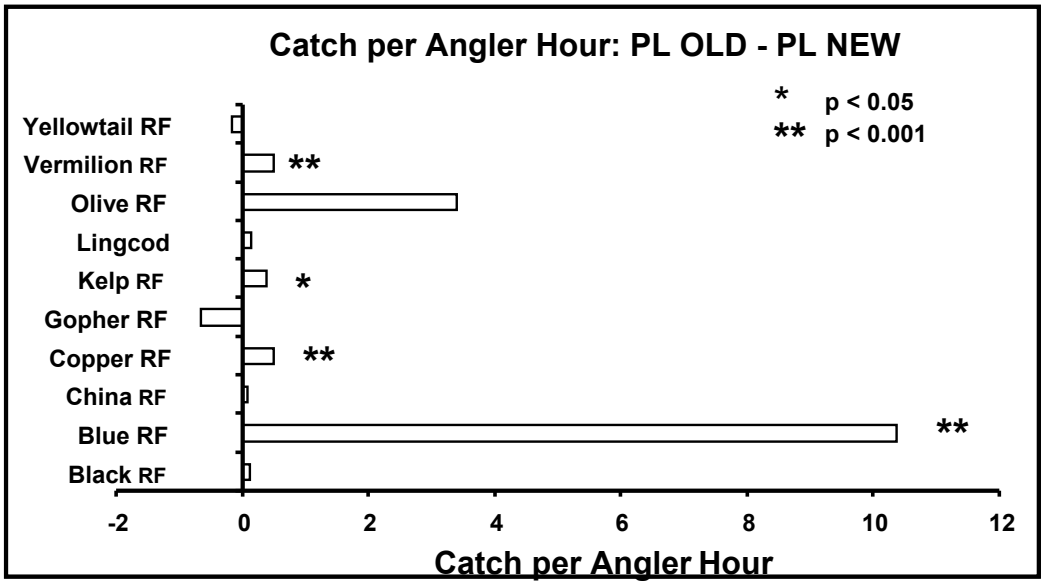


Figure 13. The difference in the average catch per angler hour between the two sections of the Point Lobos Marine Protected Area (OLD minus NEW) for the ten most frequently caught species. "OLD" refers to the section of the Point Lobos MPA that has been closed since 1973, and "NEW" refers to the section that was closed in September 2007. Significance (indicated with asterisks) is based on results from a two-sample t-test on natural log transformed (ln (x+1)) data.