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Descriptive analyses and extended distribution records of macroinvertebrates based on remotely operated vehicle surveys offshore of the northern Channel Islands

Rebecca E. Flores Miller*, Daniel W. Gotshall, John J. Geibel, and Konstantin A. Karpov

California Department of Fish and Wildlife, Marine Region, 20 Lower Ragsdale Drive, Suite 100, Monterey, CA 93940, USA (RFM)

California Department of Fish and Wildlife (retired), 4 Sommerset Rise, Monterey, CA 93940, USA (DWG)

California Department of Fish and Wildlife (retired), 425 Central Avenue, Menlo Park, CA 94025, USA (JJG)

California Department of Fish and Wildlife (retired) and *Karpov Marine Biological Research, 24752 Sashandre Lane, Fort Bragg, CA 95437, USA (KAK)*

**Correspondent: rebecca.floresmiller@wildlife.ca.gov*

In 2003, marine protected areas (MPAs) were established offshore of the northern Channel Islands, California. The MPAs are surveyed by remotely operated vehicle (ROV) as part of a larger, ongoing effort to evaluate their effectiveness. To determine macroinvertebrate species distribution and richness, we analyzed the ROV video data collected at five paired sites during 2007–2009. Percent occurrence was used to estimate species richness. Macroinvertebrates observed included harvested species and species with structure-forming potential. Fifty-three invertebrate species were identified along with 20 higher taxonomic complex level classifications when identification to species level was not possible. Two of the five site-pairs formed clusters in two different cluster analyses. Site clustering suggested an island effect or clinal change in the biogeographic regions from the Oregonian Province through the Transition Zone to the Californian Province. The ROV surveys yielded new depth records for three invertebrate species. In addition, the cnidarian *Stylaster californicus* was found offshore of Santa Rosa Island, expanding its documented distribution within the northern Channel Islands.

Key words: California, Channel Islands, Channel Islands National Marine Sanctuary, macroinvertebrates, marine invertebrates, marine protected areas, remotely operated vehicle

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In 2003, marine protected areas (MPAs) were established within the Channel Islands National Marine Sanctuary (CINMS) located in the coastal waters off southern California. The MPAs were expanded into federal waters in 2006 and 2007. The northern Channel Islands within the CINMS consist of San Miguel, Santa Rosa, Santa Cruz, and Anacapa islands. These islands reside in a unique geographical setting influenced by two major currents, the southerly flowing California current and the northerly flowing Davidson current, with corresponding faunas resulting in three distinct biogeographic regions—the Oregonian Province, Californian Province, and a Transition Zone (Airame et al. 2003). During planning for the MPAs, representative habitat groups were identified based on the type of coastline and exposure, depth, substrate, and dominant plant communities, along with areas of coastline appropriate for nesting seabirds and haul-out areas for pinnipeds (Airame et al. 2003). Between 30 and 50% of the identified representative habitat in each biogeographic region was placed into the northern Channel Island MPAs (Airame et al. 2003). The MPAs include State Marine Reserves (SMRs) where take, damage, injury or possession of any marine resource is prohibited, and State Marine Conservation Areas (SMCAs) that allow limited recreational or commercial take. Biological monitoring within MPAs and their control sites was designed to measure MPA effects in terms of changes in populations, ecosystem structure, habitats, and spillover (CDFG 2004). Marine protected area effects are expected to occur from increased species reproduction and growth inside MPAs, with spillover of individuals to adjacent areas (Russ et al. 2004). Monitoring activities were prioritized to target habitats defined during the design of the MPAs. The highest priority was given to shallow (0–30 m) and deep (31–100 m) hard-substrate habitats.

Remotely operated vehicles (ROVs) have proven to be a useful tool to survey benthic invertebrates (Tissot et al. 2006, Tissot et al. 2007, Lundsten et al. 2009, Hannah et al. 2010). Beginning in August 2003, the California Department of Fish and Wildlife (CDFW)—formerly California Department of Fish and Game—conducted exploratory video sampling using a ROV in the deep zone at four paired MPA and control sites adjacent to San Miguel, Santa Rosa, Santa Cruz, and Anacapa islands. Monitoring began in 2004 and expanded in 2005 to five site-pairs. Sites were quantitatively sampled using a video strip of known length and width. Three site-pairs were located in the Oregonian Province, one in the Transition Zone, and one in the Californian Province (Figure 1, Table 1).

Following guidance from the monitoring plan for the Channel Islands MPAs (CDFG 2004), the ROV surveys focused on rocky substrate in depths ≥20 meters; however, the average depth of two of the 393 transect lines was between 19.1 and 19.95 meters (Table 2). Control sites were selected for comparable habitat, depth (if practical), and exposure to their associated MPA site. The entire north side of Anacapa Island contains MPAs; therefore, the Anacapa Island SMR MPA site was paired with an Anacapa SMCA control site (Karpov et al. 2012). The Anacapa Island SMCA prohibits all take of living marine resources except for the recreational take of California spiny lobster (*Panulirus interruptus*) and pelagic finfish, and the commercial take of California spiny lobster (CDFG 2013).

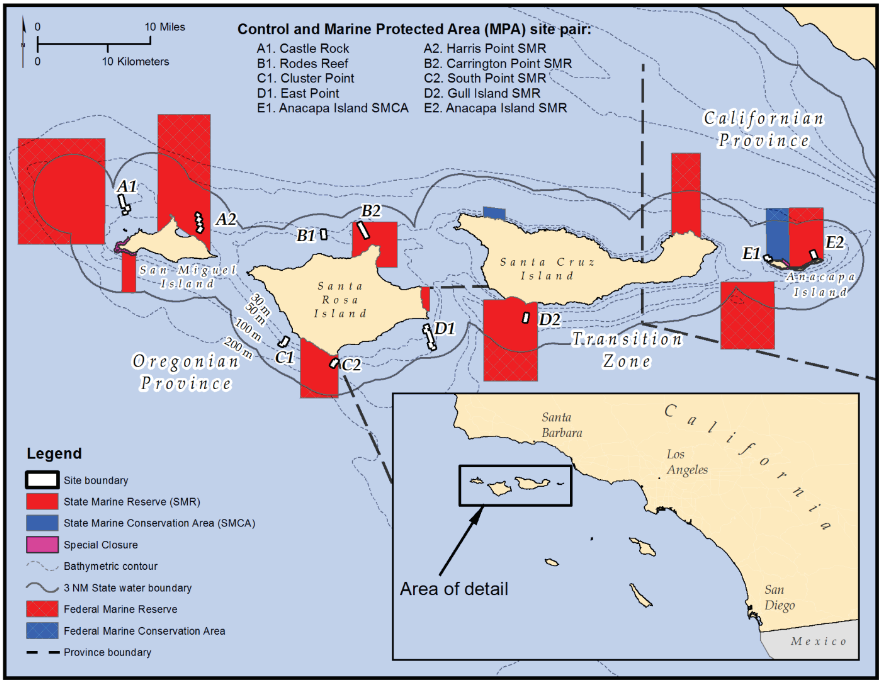

Figure 1.—Marine protected area (MPA) and control sites monitored by remotely operated vehicle offshore of the northern Channel Islands, California, 2007–2009.

Biogeographic Province	Island/ Site	Number of Transect Lines Surveyed[a] 2007	2008	2009	Total	Species/ complexes[b]
Oregonian						
San Miguel						
MPA	Harris Point SMR	13	13	11	37	40
Control	Castle Rock	8	8	7	23	38
Santa Rosa						
MPA	Carrington Point SMR	13	13	14	40	39
Control	Rodes Reef	12	12	11	35	40
MPA	South Point SMR	13	15	16	44	39
Control	Cluster Point	11	9	5	25	39
Oregonian Total Transect Lines		70	70	64	204	
Transition						
Santa Cruz						
MPA	Gull Island SMR	21	21	19	61	44
Santa Rosa						
Control	East Point	18	11	18	47	45
Transition Total Transect Lines		39	32	37	108	
Californian						
Anacapa						
MPA	Anacapa Island SMR	17	13	12	42	37
Control	Anacapa Island SMCA	13	14	12	39	31
Californian Total Transect Lines		30	27	24	81	

[a]Does not include transect lines excluded from analysis.
[b]Total species/complexes compiled by site.

Table 1.—Biogeographic provinces, islands, sites, number of transect lines surveyed, and species or complexes observed per site at marine protected area (MPA) and control sites offshore of the northern Channel Islands, California, 2007–2009.

Average Depth Bin[a] (meters)	MPA/ Control	Transect Lines per Year 2007	2008	2009	Years Combined Transect Lines	Percent Occurrence
15	MPA	0	0	0	0	n/a
	Control	0	2	0	2	12.3
20	MPA	8	4	1	13	12.9
	Control	19	3	7	29	16.1
25	MPA	10	11	9	30	15.1
	Control	12	19	20	51	18.3
30	MPA	6	6	8	20	19.6
	Control	10	8	6	24	17.6
35	MPA	8	5	5	18	18.2
	Control	7	8	4	19	14.6
40	MPA	10	14	12	36	19.0
	Control	6	4	5	15	18.2
45	MPA	8	14	11	33	18.5
	Control	4	2	6	12	13.7
50	MPA	10	7	11	28	17.1
	Control	4	5	5	14	14.0
55	MPA	10	10	6	26	16.1
	Control	0	3	0	3	9.6
60	MPA	7	4	7	18	14.2
	Control	0	0	0	0	n/a
65	MPA	0	0	2	2	16.4
	Control	0	0	0	0	n/a

[a]Depth bin 15 contains transect lines ≥15<19.9 meters in depth (average); subsequent depth bins follow the same parameters.

Table 2.—Number of transect lines by depth bin, marine protected area (MPA) and control site, year, and years combined and invertebrate percent occurrences by years combined at locations surveyed offshore of the northern Channel Islands, California, 2007–2009.

Finfish monitoring methods developed and used by CDFW for ROV video transect sampling include precision and accuracy of strip transect protocols (Karpov et al. 2006), statistical power by transect size and area sampled (Karpov et al. 2010), and MPA effects on finfish abundances at six of the ten sites (Karpov et al. 2012). Previous analyses of these video recordings, however, have not focused on invertebrate abundances.

The primary purpose of our study was to identify macroinvertebrates within five paired MPA and control sites during 2007–2009 using percent occurrence (PO) as a measure of species richness. Secondarily, we examined species distribution by depth, location, and year.

Materials and Methods

Study area.—The northern Channel Islands are located off the coast of Santa Barbara, California. The sites are within the CINMS and offshore of San Miguel, Santa Rosa, Santa Cruz, and Anacapa islands (Figure 1).

Site selection.—Sites were selected using sonar and exploratory ROV surveys. Sites were delineated by a rectangle 500 meters wide and parallel to shore across varying depths (Figure 1). Transect lines within the rectangle were randomly placed 20 m apart per each survey year (lines were 10 m apart at Anacapa Island SMCA and Gull Island SMR).

Depths reported were averaged across the 500-m transect lines. The number of transect lines per rectangle varied each year in order to insure the targeted rocky substrate was adequately sampled. Therefore, sites with higher amounts of soft-only substrate resulted in more transect lines than those with greater hard substrate.

Video collection.—The 2007 and 2008 surveys were conducted in August; the 2009 survey was conducted in July. All sampling was collected using a Deep Ocean Engineering (DOE) model Phantom® HD 2+2 ROV equipped with a video camera (for methods, see Karpov et al. 2006, Karpov et al. 2010, and Karpov et al. 2012). A DOE 460 TVL camera was used in 2007 and 2008. A downward video camera was used for the 2007 invertebrate identifications. ROV modifications in 2008 resulted in the removal of the downward facing camera. A forward-facing video camera was used during the 2008 and 2009 surveys. In 2009 a higher resolution camera, the Sidus 800 TVL, was used. All surveys were conducted during daylight hours between 0730 and 1700, with ROV lighting consistent throughout the survey years.

Habitat assessment.—Substrate was interpreted using a simplified version of a classification scheme detailed by Greene et al. (1999). Rock, boulder, cobble, or sand substrates were logged into the database independently. Each substrate was considered continuous until a break of ≥2 m occurred, or the substrate fell below 20% of total combined substrates for ≥3 m. Following processing, substrates were combined into three habitat types described by Karpov et al. (2010) as hard (consisting of rock or boulders or a combination of both), soft (cobble or sand or a combination of both), or mixed (combination of hard and soft habitat), and were recorded as percentages (Table 3).

TABLE 3.—Percent composition of habitat type by island, marine protected area (MPA) and control site, and year at locations surveyed offshore of the northern Channel Islands, California, 2007–2009.

		2007			2008			2009		
Island/		Percent Habitat Type								
Site	Site Name	Hard[a]	Mixed[b]	Soft[c]	Hard[a]	Mixed[b]	Soft[c]	Hard[a]	Mixed[b]	Soft[c]
San Miguel										
MPA	Harris Point SMR	23	34	43	27	29	44	28	23	49
Control	Castle Rock	55	40	5	60	30	10	76	22	3
Santa Rosa										
MPA	Carrington Point SMR	6	39	45	18	34	47	19	43	38
Control	Rodes Reef	16	46	38	32	39	29	31	40	30
MPA	South Point SMR	15	29	56	18	22	60	13	23	64
Control	Cluster Point	27	44	29	36	32	32	42	30	28
Santa Cruz										
MPA	Gull Island SMR	9	27	64	12	22	66	14	18	68
Santa Rosa										
Control	East Point	17	25	58	22	27	51	27	18	55
Anacapa										
MPA	Anacapa Island SMR	14	37	49	21	29	50	20	26	53
Control	Anacapa Island SMCA	23	34	43	21	31	48	28	28	44
	Average	22	35	43	27	30	44	30	27	43

[a]Rock and/or boulder.
[b]A combination of rock and/or boulder with cobble and/or sand.
[c]Cobble and/or sand.

Video processing.—Invertebrate occurrences were identified to the lowest taxon possible using available literature (Behrens and Hermosillo 2005, Gotshall 2005, Lamb and Hanby 2005, Lee et al. 2007) and by consulting established experts in their respective fields. Identifications did not include data from transect lines removed due to prolonged poor visibility resulting from lighting, mysid swarms, dense algae, or kelp.

The 2007 observations were entered into a spreadsheet and then compiled into a Microsoft Access® database. The 2008 and 2009 observations were processed using an X-keys Pro programmable key pad to log the invertebrate identifications into an Access® database. The X-key system was linked to a DVD player and to a Horita II TCW-50 time code wedge. The X-key and Horita linked together with the database. Once an identified invertebrate reached the bottom of the video monitor, the reviewer used the X-key system to record the invertebrate. This process maintained consistency with species recording and time notations among reviewers. The database automatically logged species-encounter time along with the species Taxonomic Serial Number (ITIS 2010). These data can be cross-referenced with substrate type, depth, and water temperature for future analysis.

Statistical analyses.—All statistical tests were *a posteriori*. The PO of invertebrates was used as a measure of species richness, and was calculated by summing the number of lines on which a species was observed and then dividing by the total number of lines examined at each site per survey year. Percent occurrence is a method of normalizing to reduce the effect of different sample sizes among sites and years.

Using PO, we looked at year effects, MPA and control sites, species distribution by depth, the influences of oceanic regimes on species distribution, island comparisons, and the effect of sample size on the number of observed species. Site comparisons were made using cluster analysis from the statistical package "R" (R Project Contributors 2011). For cluster analysis, both the agglomerate and the divisive procedures in R were used with Euclidean and Manhattan metrics. The agglomerative clustering method (R function "agnes") begins by calculating a number of clusters that are then combined into larger clusters until only a single cluster remains. The divisive clustering method (R function "diana") begins with all data in one cluster and then systematically divides the data into smaller clusters. Kaufman and Rousseeuw (1990) described both methods of clustering. The Euclidean distance is derived from computing the square root of the sum of squares of absolute differences, whereas the Manhattan distance is the sum of the differences (Data Analysis Products Division 1999). All years were combined for the cluster analyses.

Percent occurrence was reviewed by sites. To estimate adequate sample size, we ran a regression of sample size using the mean number of species and complexes observed for the ten sites across three years (n=30). Two ANOVAs were run, one using the number of species and complexes per transect line with year and site as independent variables, and the other using year and site type (MPA and control sites separated) as factors to determine year, site, and MPA and control effects on the number of species observed by transect line.

The effect of depth on the number of species and complexes observed was examined by combining all years and sites and regressing the transect line-depth against the number of species and complexes observed on each line. We also ran an ANOVA of the number of species or complexes observed by site, year, and depth. All ANOVAs and the multiple regression were run using R (R Project Contributors 2011). The multiple regression was run using species count as the dependent variable and year, site, and depth as the independent variables. This approach was used to obtain a slope for depth when the site and year effects were accounted for.

Results

Sites combined.—During the 2007–2009 surveys, 413 transect lines were examined. Twenty lines were excluded from analysis due to poor visibility, including two from 2007, ten from 2008, and eight from 2009. The total number of transect lines included in the analysis was 393, with depths ranging from 19 m to 67 m (Table 1, Table 2).

Members of some genera could not consistently be assigned to species level due to the inability to see finer structures resulting from camera resolution, lighting, or water clarity. When this occurred, these invertebrates were assigned to a higher taxonomic complex level. Fifty-three invertebrates were identified to species along with 20 higher taxonomic complex level classifications (Table 4). The 2008 survey yielded 47% fewer invertebrates or complexes than the 2007 survey (Table 4), whereas, the 2009 survey yielded 64% more invertebrates or complexes when compared separately to the 2008 and 2007 surveys (Table 4).

Most of the poriferans observed were low-profile encrusting forms. Seven sponges were identified to species and seven complexes (Table 4). Two species of the genus *Polymastia*, *P. pachymastia* and *P. pacifica*, are found in the northern Channel Islands (Lee et al. 2007). *Polymastia* observed are only identifiable to species by close examination; therefore, they were recorded as *Polymastia* spp. Occurrences of *Rhabdocalyptus* spp. likely included *R. dawsoni, R. nodulosus, R. asper*, and *R. tener*. *Xestospongia* spp. included *X. edapha* and *X. diprosopia* (Lee et al. 2007). *Staurocalyptus* spp. observations included *S. dowlingi, S. solidus,* and *S. fasciculatus*.

Seventeen cnidarian genera were identified to species and four were recorded as complexes (Table 4). Gorgonians placed in the Gorgonacea complex were individuals that could not be identified further because they were completely covered with zoanthids or were dead. *Muricea* spp. likely included *M. fruticosa* and *M. californica*. Red gorgonians observed in this study likely included two genera, *Swiftia* and *Chromoplexaura* (G. Williams, California Academy of Sciences, personal communication); these are indistinguishable in the field and were recorded together as the Family Plexauridae. Four *Urticina* species were observed, along with an *Urticina* complex likely including *U. columbiana, U. lofotensis*, *U. mcpeaki*, or *U. piscivora*, when identification to species was not possible.

Three genera of molluscs were identified to species, including market squid (*Doryteuthis opalescens*) egg cases, along with two complexes (Table 4). The unknown Dorididae (nudibranch) complex consisted of white dorids (likely the genus *Doris*) and yellow dorids (genus *Doris* or *Peltodoris*) (Behrens and Hermosillo 2005). The *Octopus* complex likely included *O. bimaculatus* or *O. rubescens.*

Four arthropod species were identified, along with one arthropod complex (Table 4). The Cancridae complex may contain *Romaleon antennarium*, *Metacarcinus anthonyi*, and *Cancer productus*.

The phylum Echinodermata was represented by 12 sea star species, 3 urchin species, and 5 complexes (Table 4). Echinoderms identified to the complex level consisted of three sea stars, one brittle star, and one sea cucumber. The *Pisaster* complex consisted of *P. giganteus* and *P. brevispinus*. The *Henricia* complex included *H. leviuscula* and *H. aspera*. The *Astropecten* complex likely consisted of *A. armatus* and *A. verrilli*. *Parastichopus californicus* and *P. parvimensis* were recorded as *Parastichopus* spp. All brittle stars encountered were recorded as Ophiurida. In addition to the above, three species of bryozoans were recorded, four chordates were identified to species, and the genus of one chordate was determined (Table 4).

Table 4.—Percent occurrence by invertebrate species and complex, year, and years combined at locations surveyed offshore of the northern Channel Islands, California, 2007–2009.

Phylum	Species/complexes	2007	2008	2009	All Years
Porifera					
	Acarnus erithacus	23.7	13.2	40.8	25.7
	Craniella arb	18.0	24.8	47.2	29.5
	Geodia mesotriaena	5.8	54.3	60.0	38.9
	Halichondria panicea	0.0	0.0	8.0	2.5
	Neopetrosia zumi	0.0	0.8	0.8	0.5
	Polymastia spp.	35.3	28.7	56.8	39.9
	Red sponge	0.0	0.0	4.8	1.5
	Rhabdocalyptus spp.	3.6	4.7	3.2	3.8
	Spheciospongia confoederata	2.2	0.0	3.2	1.8
	Staurocalyptus spp.	1.4	0.0	0.8	0.8
	Tethya aurantia	52.5	54.3	62.4	56.2
	White sponge	29.5	0.0	0.0	10.4
	White sponge branching	0.0	8.5	3.2	3.8
	Xestospongia spp.	0.0	7.0	8.8	5.1
Cnidaria					
	Adelogorgia phyllosclera	12.9	10.9	8.8	10.9
	Aglaophenia struthionides	0.7	0.8	0.8	0.8
	Balanophyllia elegans	1.4	0.8	0.8	1.0
	Coenocyathus bowersi	9.4	4.7	8.8	7.6
	Corynactis californica	52.5	36.4	53.6	47.6
	Epizoanthus scotinus	0.0	0.8	0.0	0.3
	Eugorgia rubens	43.2	39.5	36.8	39.9
	Gorgonacea	0.0	5.4	0.8	2.0
	Halipteris californica	36.0	39.5	38.4	37.9
	Muricea spp.	12.2	8.5	6.4	9.2
	Pachycerianthus fimbriatus	0.0	11.6	11.2	7.4
	Parazoanthus lucificum	0.0	4.7	14.4	6.1
	Plexauridae	73.4	78.3	87.2	79.4
	Ptilosarcus gurneyi	7.9	6.2	11.2	8.4
	Stylaster californicus	5.0	1.6	0.8	2.5
	Stylatula elongata	20.9	38.0	45.6	34.4
	Urticina columbiana	59.7	59.7	60.8	60.1
	Urticina lofotensis	0.0	2.3	13.6	5.1
	Urticina mcpeaki	0.7	0.0	0.0	0.3
	Urticina piscivora	1.4	2.3	1.6	1.8
	Urticina spp.	1.4	0.0	0.8	0.8
Bryozoa					
	Diaperoforma californica	36.0	3.1	12.0	17.6
	Heteropora pacifica	20.9	34.1	53.6	35.6
	Hippoporina insculpta	3.6	24.8	27.2	18.1

Table 4.—Continued

Phylum	Species/complexes	2007	2008	2009	All Years
Mollusca					
	Dorididea	3.6	7.0	9.6	6.6
	Doryteuthis opalescens (eggs)	0.0	0.8	1.6	0.8
	Leopecten diegensis	2.2	0.0	0.0	0.8
	Megathura crenulata	5.8	4.7	5.6	5.3
	Octopus spp.	0.0	0.0	0.8	0.3
Arthropoda					
	Cancer productus	0.0	0.0	0.8	0.3
	Cancridae	0.0	0.0	3.2	1.0
	Loxorhynchus crispatus	0.0	0.0	0.8	0.3
	Loxorhynchus grandis	5.8	0.8	0.0	2.3
	Panulirus interruptus	0.0	0.0	0.8	0.3
Echinodermata					
	Astrometis sertulifera	2.9	0.0	0.0	1.0
	Astropecten spp.	7.2	7.0	6.4	6.9
	Ceramaster patagonicus	0.0	2.3	0.8	1.0
	Dermasterias imbricata	19.4	8.5	19.2	15.8
	Henricia spp.	34.5	33.3	51.2	39.4
	Luidia foliolata	28.8	10.1	32.0	23.7
	Lytechinus pictus	0.0	1.6	0.0	0.5
	Mediaster aequalis	77.0	66.7	75.2	73.0
	Ophioderma panamensis	0.0	0.0	2.4	0.8
	Ophiopsila californica	0.0	0.0	0.8	0.3
	Ophiothrix spiculata	29.5	24.8	19.2	24.7
	Ophiurida	0.0	4.7	34.4	12.5
	Orthasterias koehleri	17.3	10.9	11.2	13.2
	Parastichopus spp.	87.8	87.6	82.4	86.0
	Patiria miniata	95.0	89.9	96.0	93.6
	Pisaster spp.	54.0	60.5	56.8	57.0
	Poraniopsis inflata	4.3	0.8	4.8	3.3
	Pycnopodia helianthoides	64.0	57.4	67.2	62.8
	Strongylocentrotus franciscanus	23.7	14.0	19.2	19.1
	Strongylocentrotus purpuratus	0.7	0.0	0.0	0.3
Chordata					
	Ascidia paratropa	0.0	0.0	0.8	0.3
	Botrylloides spp.	0.0	0.0	1.6	0.5
	Cystodytes lobatus	1.4	0.8	3.2	1.8
	Polyclinum planum	9.4	10.1	14.4	11.2
	Styela montereyensis	0.0	7.8	8.0	5.1
Number of Species/complexes		49	54	65	73
Number of Transect Lines[a]		139	129	125	393

[a]Does not include transect lines excluded from analysis.

Data by year, all sites, and MPA and control sites.—Two ANOVAs were run, one with year and all sites as independent variables, the other using year and site type (MPA or control), as factors with the number of species observed by line as the metric. With the first ANOVA we found year and site were significant (P <0.05, df =373). The second ANOVA year was also significant (P <0.01, df =390), site type was not significant (P >0.10, df=390).

Data by MPA and control site.—We reviewed the number of species and complexes observed by the number of lines at each site for all years. A small increase in the number of species and complexes was observed as the number of lines increased (Figure 2). The smallest sample size, 23 transect lines, was at Castle Rock located offshore of San Miguel Island, with 38 species and complexes observed (Table 1). The largest sample size (61 lines) was at Gull Island SMR located offshore of Santa Cruz Island, with 44 species and complexes observed (Table 1). The lowest count of species and complexes was 31 at Anacapa Island SMCA with a sample size of 39 transect lines (Table 1).

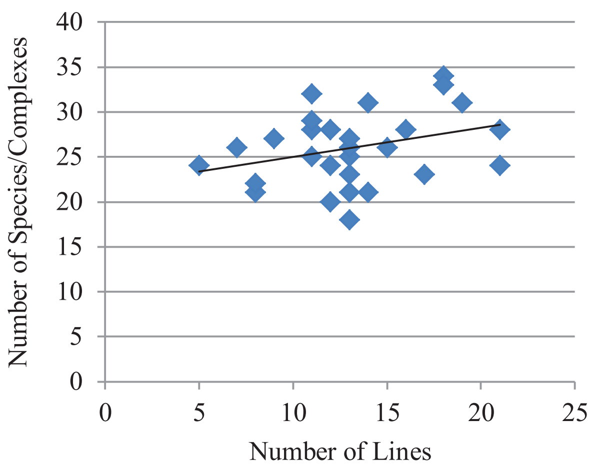

FIGURE 2.—The number of invertebrate species and complexes observed and number of transect lines at all sites each year, offshore of the northern Channel Islands, California, 2007–2009.

While the MPA and control sites were initially addressed separately, combining them provided a broader sample size (number of lines surveyed). The best regression line based on the correlation coefficient for both MPA and control sites was y = 0.153 ln(x) + 33.183 (R^2<0.19, df =28), where x is the number of transect lines surveyed and y is the number of species and complexes observed from 2007 to 2009 (Figure 3).

The results of both agglomerate R agnes and divisive R diana algorithms with Euclidean and Manhattan metrics were fairly consistent, with two site-pairs always clustering (see Figure 4 for R diana method with metric Manhattan). The pairs forming consistent clusters were South Point SMR with Cluster Point, and Anacapa Island SMR with Anacapa Island SMCA. The three remaining site-pairs never clustered together. The five Santa Rosa sites consistently formed their own cluster. Harris Point SMR clustered with the Santa Rosa sites. Although not a site-pair, Gull Island SMR clustered with Castle Rock. Gull Island SMR and Castle Rock clustered with the two Anacapa sites. All of the other clusters more or less fit the actual spatial distribution of the sites.

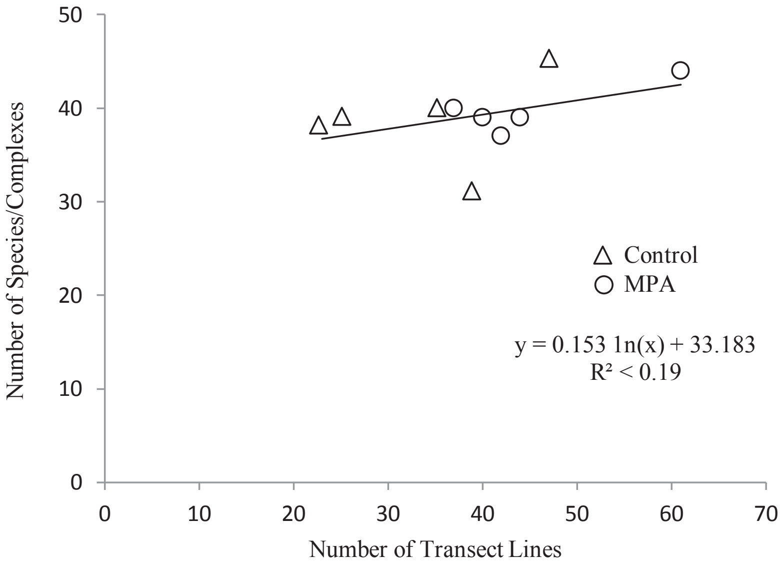

Figure 3.—The number of invertebrate species or complexes observed over the number of transect lines surveyed by remotely operated vehicle at marine protected area (MPA) and control sites offshore of the northern Channel Islands, California, 2007–2009.

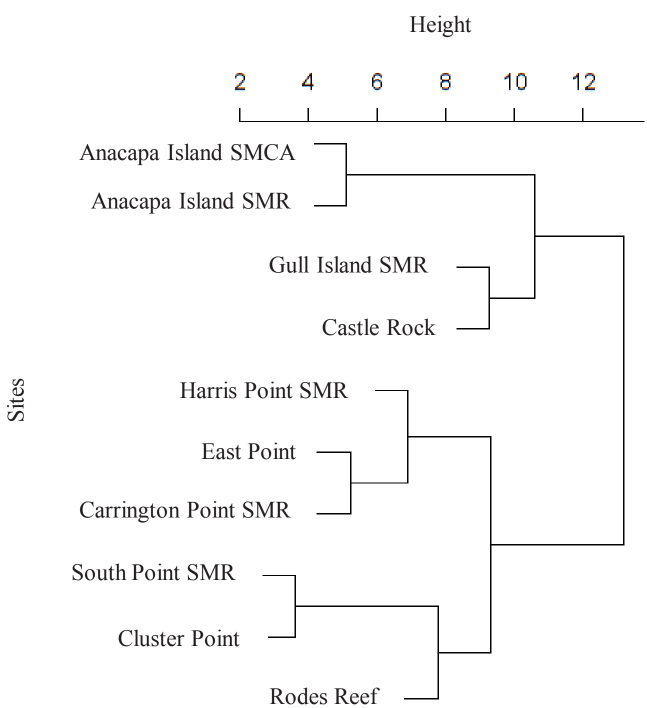

Figure 4.— Dendogram of cluster analysis results using percent occurrence by invertebrate species and complexes, 2007–2009 combined, at marine protected area (MPA) and control sites offshore of the northern Channel Islands, California. Height represents similarities or differences between the MPA and control sites. Cluster analysis was run using R method diana with metric = Manhattan; agglomerative coefficient <0.59.

Data by sites combined and depth.—We examined the effect of depth on the number of species and complexes observed with MPA and control sites combined and all years combined. The data were not separated by MPA and control due to the differences in the range of depths (Table 2). The mean depth for all sites was 39 m, with a minimum depth of 19.1 m and a maximum depth of 67.0 m (Table 2). The R^2 for the regression was <0.01 and the slope was -0.014, (P >0.32, df =392; Figure 5).

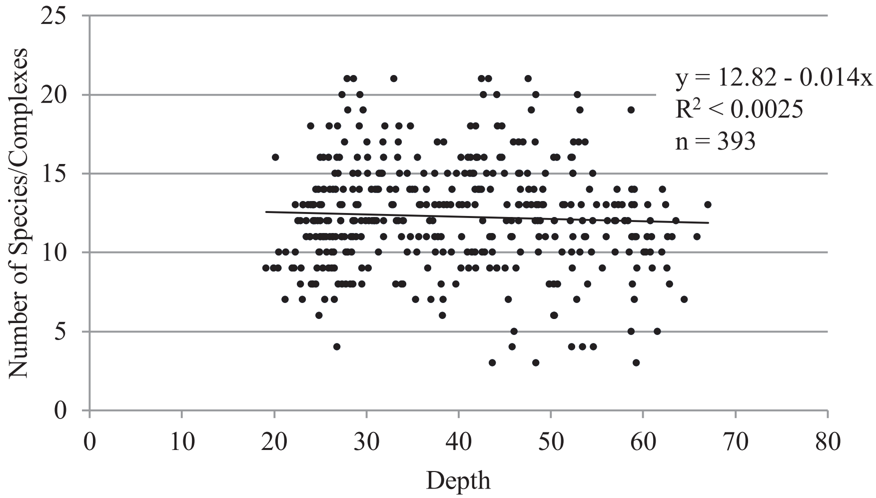

Figure 5.—The number of invertebrate species and complexes observed by depth at sites offshore of the northern Channel Islands, California, 2007–2009.

We also examined depth effects on number of species or complexes per line using ANOVA to separate depth effects from site and year effects. Sites were not differentiated by control and MPA. Only Harris Point SMR indicated a strong depth and year effect. Harris Point SMR showed depth, year, depth:year and depth:site:year effects with P <0.05. However, when all sites were included there was little depth or year effect with P >0.5. The adjusted R^2 was 0.5258, df =353.

Data by biogeographic province.—From all survey lines that were processed, we were able to use 204 lines in the Oregonian Province, 108 in the Transition Zone, and 81 in the Californian Province (Table 1). Data were grouped by MPA, control, and sites combined within biogeographic province (Table 5).

Both *Adelogorgia phyllosclera* and *Eugorgia rubens* were found in all three provinces; however, *E. rubens* had a higher PO (91) in the Californian Province, and a lower PO in the Transition Zone and Oregonian Province (41 and 19, respectively) while *A. phyllosclera* had PO values of 30, 17, and 2, respectively in the Californian Province, Transition Zone, and Oregonian Province when reviewing combined MPA and control sites. *Muricea* spp. was absent from the Oregonian Province, and was found in the Transition Zone, and Californian Province with a greater PO (1.9 and 42.0, respectively) in combined MPA and control sites (Table 5).

Astropecten spp. was found in all three biogeographic regions, with greater PO values moving from the Oregonian Province into the Transition Zone to the Californian

Table 5.—Percent occurrence by invertebrate species and complex and biogeographic province for years combined at locations surveyed offshore of the northern Channel Islands, California, 2007–2009.

		Biogeographic Province		
Phylum	Species and complexes	Oregonian	Transition	Californian
Porifera				
	Acarnus erithacus	34.3	25.0	4.9
	Craniella arb	49.5	8.3	7.4
	Geodia mesotriaena	52.9	28.7	17.3
	Halichondria panacea	3.9	1.9	0.0
	Neopetrosia zumi	0.5	0.9	0.0
	Polymastia spp.	60.3	17.6	18.5
	Red sponge	2.9	0.0	0.0
	Rhabdocalyptus spp.	1.0	9.3	3.7
	Spheciospongia confoederata	2.9	0.9	0.0
	Staurocalyptus spp.	0.0	0.0	3.7
	Tethya aurantia	79.4	34.3	27.2
	White sponge	6.9	17.6	9.9
	White sponge branching	2.5	8.3	1.2
	Xestospongia spp.	8.8	0.0	2.5
Cnidaria				
	Adelogorgia phyllosclera	2.0	16.7	25.9
	Aglaophenia struthionides	1.0	0.9	0.0
	Balanophyllia elegans	0.5	2.8	0.0
	Coenocyathus bowersi	0.5	26.9	0.0
	Corynactis californica	64.2	38.0	18.5
	Epizoanthus scotinus	0.5	0.0	0.0
	Eugorgia rubens	19.1	40.7	91.4
	Gorgonacea	2.0	0.9	3.7
	Halipteris californica	23.0	75.9	24.7
	Muricea spp.	0.0	1.9	42.0
	Pachycerianthus fimbriatus	4.4	11.1	9.9
	Parazoanthus lucificum	0.0	0.0	29.6
	Plexauridae	68.1	95.4	86.4
	Ptilosarcus gurneyi	9.8	12.0	0.0
	Stylaster californicus	4.4	0.9	0.0
	Stylatula elongata	28.4	61.1	13.6
	Urticina columbiana	70.1	61.1	33.3
	Urticina lofotensis	6.9	5.6	0.0
	Urticina mcpeaki	0.0	0.9	0.0
	Urticina piscivora	2.0	2.8	0.0
	Urticina spp.	0.5	0.9	1.2
Bryozoa				
	Diaperoforma californica	24.0	16.7	2.5
	Heteropora pacifica	52.9	29.6	0.0
	Hippoporina insculpta	30.4	7.4	1.2

Table 5.—Continued.

Mollusca			
Dorididae	9.8	5.6	0.0
Doryteuthis opalescens (eggs)	1.5	0.0	0.0
Leopecten diegensis	0.0	2.8	0.0
Megathura crenulata	0.0	1.9	23.5
Octopus spp.	0.5	0.0	0.0
Arthropoda			
Cancer productus	0.5	0.0	0.0
Cancridae	0.5	2.8	0.0
Loxorhynchus crispatus	0.5	0.0	0.0
Loxorhynchus grandis	2.9	0.9	2.5
Panulirus interruptus	0.0	0.0	1.2
Echinodermata			
Astrometis sertulifera	2.0	0.0	0.0
Astropecten spp.	4.4	7.4	12.3
Ceramaster patagonicus	1.5	0.9	0.0
Dermasterias imbricate	20.6	14.8	4.9
Henricia spp.	43.1	43.5	24.7
Luidia foliolata	18.1	48.1	4.9
Lytechinus pictus	0.0	0.0	2.5
Mediaster aequalis	81.9	73.1	50.6
Ophioderma panamensis	1.0	0.0	1.2
Ophiopsila californica	0.5	0.0	0.0
Ophiothrix spiculata	3.4	8.3	100.0
Ophiurida	19.6	7.4	1.2
Orthasterias koehleri	17.2	9.3	8.6
Parastichopus spp.	81.9	83.3	100.0
Patiria miniata	93.6	89.8	98.8
Pisaster spp.	59.3	52.8	56.8
Poraniopsis inflata	5.4	1.9	0.0
Pycnopodia helianthoides	80.9	75.0	1.2
Strongylocentrotus franciscanus	7.4	34.3	28.4
Strongylocentrotus purpuratus	0.5	0.0	0.0
Chordata			
Ascidia paratropa	0.5	0.0	0.0
Botrylloides spp.	0.0	1.9	0.0
Cystodytes lobatus	3.4	0.0	0.0
Polyclinum planum	18.1	6.5	0.0
Styela montereyensis	2.5	13.9	0.0
Number of Species/complexes	64	56	42
Number of Transect Lines[a]	204	108	81

[a]Does not include transect lines excluded from analysis.

Province when reviewing MPA and control sites combined (4.4, 7.4, and 12.3, respectively) (Table 5). Notably, *Pycnopodia helianthoides* had a PO of 1.2 with MPA and control combined within the Californian Province, with an increase of PO in the Oregonian and Transition Zone (80.9 and 75.0, respectively).

Data by island.—One MPA and control site-pair was located offshore of San Miguel Island (Figure 1, Table 1). Thirty-four individual species were identified along with 14 complexes (Table 6). *Astropecten* spp. and *Ophiothrix spiculata* were found with a PO of 3.3 and 11.7, respectively (Table 6).

Santa Rosa Island had the most sites consisting of two MPA sites and three control sites (Figure 1, Table 1). Forty-seven invertebrates were identified to species, along with 14 complexes (Table 6). *Megathura crenulata* was identified offshore of Santa Rosa Island with a PO of 1.0. *Astropecten* spp. and *O. spiculata* were observed with a PO of 5.8 and 4.7, respectively.

Santa Cruz Island hosted one MPA site (Figure 1, Table 1). Twenty-nine species were observed, along with 14 complexes (Table 6). *Halipteris californica* and *Muricea* spp. were present at Santa Cruz Island with a PO of 100 and 3.3, respectively. *Astropecten* spp. was observed with a PO of 6.6.

One MPA and control site pair (consisting of an SMR and SMCA) was located offshore of Anacapa Island (Figure 1, Table 1). Twenty-eight invertebrates were identified to species, as well as 14 complexes (Table 6). *Muricea* spp. was identified offshore of Anacapa Island with a PO of 42.0. *M. crenulata* increased offshore of Anacapa Island with a PO of 23.5. *Astropecten* spp. and *O. spiculata* were found with PO values of 12.3 and 100, respectively. At the Anacapa Island sites the PO of all bryozoans dropped substantially and chordates were absent.

Discussion

Marine invertebrate identification from ROV video can be challenging. Often small differences in structure or characters must be closely examined to identify invertebrates to species level. Such fine details sometimes are not available from the videos due to low light conditions, camera resolution, algae cover, sand-impacted reefs, or limited underwater visibility resulting from turbidity or occasional mysid swarms. When these observational difficulties were prolonged, the line was removed from analysis to avoid unintended bias.

The loss of ambient light with water depth required the use of lights on the ROV. The use of artificial lights can cause some invertebrates to change their behavior and perhaps be less visible; however, the lights were necessary to perform the survey and accurately identify species.

Differences observed between sample years were confounded by changes to the camera system used to identify invertebrates in this study. Loss of the downward camera was a factor in 2008 and 2009. Perhaps the most critical factor, however, was the increased resolution in 2009 when the Sidus replaced the DOE camera. Calibration of the two different camera systems were not conducted offshore of the northern Channel Islands. In future analysis of the ROV data, researchers should consider evaluating the datasets from different camera systems separately when examining time-trends in abundance. Alternatively, concurrent use of new and old camera systems on the same ROV would allow for quantitative calibration across time series, critical to evaluating any MPA effects over time.

Table 6.—Percent occurrence by invertebrate species and complex, and island for years combined at locations surveyed offshore of the northern Channel Islands, California, 2007–2009.

Phylum	Species and complex	Island: San Miguel	Santa Rosa	Santa Cruz	Anacapa
Porifera					
	Acarnus erithacus	11.7	46.1	3.3	4.9
	Craniella arb	46.7	42.9	0.0	7.4
	Geodia mesotriaena	61.7	39.3	44.3	17.3
	Halichondria panacea	0.0	5.2	0.0	0.0
	Neopetrosia zumi	1.7	0.0	1.6	0.0
	Polymastia spp.	53.3	55.5	6.6	18.5
	Red sponge	5.0	1.6	0.0	0.0
	Rhabdocalyptus spp.	3.3	0.0	16.4	3.7
	Spheciospongia confoederata	3.3	2.6	0.0	0.0
	Staurocalyptus spp.	0.0	0.0	0.0	3.7
	Tethya aurantia	60.0	85.3	0.0	27.2
	White sponge	18.3	2.1	29.5	9.9
	White sponge branching	8.3	0.0	14.8	1.2
	Xestospongia spp.	26.7	1.0	0.0	2.5
Cnidaria					
	Adelogorgia phyllosclera	0.0	2.1	29.5	25.9
	Aglaophenia struthionides	0.0	1.6	0.0	0.0
	Balanophyllia elegans	1.7	1.6	0.0	0.0
	Coenocyathus bowersi	0.0	1.6	44.3	0.0
	Corynactis californica	56.7	70.2	6.6	18.5
	Epizoanthus scotinus	0.0	0.5	0.0	0.0
	Eugorgia rubens	16.7	16.2	68.9	91.4
	Gorgonacea	5.0	0.5	1.6	3.7
	Halipteris californica	10.0	32.5	100.0	24.7
	Muricea spp.	0.0	0.0	3.3	42.0
	Pachycerianthus fimbriatus	0.0	8.4	8.2	9.9
	Parazoanthus lucificum	0.0	0.0	0.0	29.6
	Plexauridae	68.3	74.3	96.7	86.4
	Ptilosarcus gurneyi	15.0	10.5	6.6	0.0
	Stylaster californicus	3.3	4.2	0.0	0.0
	Stylatula elongata	28.3	29.8	82.0	13.6
	Urticina columbiana	60.0	79.6	34.4	33.3
	Urticina lofotensis	3.3	9.4	0.0	0.0
	Urticina mcpeaki	0.0	0.5	0.0	0.0
	Urticina piscivora	3.3	1.0	4.9	0.0
	Urticina spp.	0.0	1.0	0.0	1.2
Bryozoa					
	Diaperoforma californica	26.7	26.2	1.6	2.5
	Heteropora pacifica	26.7	59.7	16.4	0.0
	Hippoporina insculpta	23.3	29.3	0.0	1.2

Table 6.—Continued.

Phylum	Species and complex	Island: San Miguel	Santa Rosa	Santa Cruz	Anacapa
Mollusca					
	Dorididae	13.3	8.9	1.6	0.0
	Doryteuthis opalescens (eggs)	0.0	1.6	0.0	0.0
	Leopecten diegensis	0.0	0.0	4.9	0.0
	Megathura crenulata	0.0	1.0	0.0	23.5
	Octopus spp.	0.0	0.5	0.0	0.0
Arthropoda					
	Cancer productus	0.0	0.5	0.0	0.0
	Cancridae	1.7	1.0	1.6	0.0
	Loxorhynchus crispatus	0.0	0.5	0.0	0.0
	Loxorhynchus grandis	1.7	2.6	1.6	2.5
	Panulirus interruptus	0.0	0.0	0.0	1.2
Echinodermata					
	Astrometis sertulifera	0.0	2.1	0.0	0.0
	Astropecten spp.	3.3	5.8	6.6	12.3
	Ceramaster patagonicus	5.0	0.0	1.6	0.0
	Dermasterias imbricata	3.3	25.1	13.1	4.9
	Henricia spp.	61.7	30.4	65.6	24.7
	Luidia foliolata	13.3	36.1	19.7	4.9
	Lytechinus pictus	0.0	0.0	0.0	2.5
	Mediaster aequalis	98.3	67.0	96.7	50.6
	Ophioderma panamensis	0.0	1.0	0.0	1.2
	Ophiopsila californica	0.0	0.5	0.0	0.0
	Ophiothrix spiculata	11.7	4.7	0.0	100.0
	Ophiurida	21.7	15.7	8.2	1.2
	Orthasterias koehleri	20.0	16.2	3.3	8.6
	Parastichopus spp.	76.7	80.1	95.1	100.0
	Patiria miniata	78.3	100.0	82.0	98.8
	Pisaster spp.	26.7	74.9	31.1	56.8
	Poraniopsis inflata	15.0	1.6	1.6	0.0
	Pycnopodia helianthoides	56.7	91.1	62.3	1.2
	Strongylocentrotus franciscanus	1.7	26.2	1.6	28.4
	Strongylocentrotus purpuratus	0.0	0.5	0.0	0.0
Chordata					
	Ascidia paratropa	1.7	0.0	0.0	0.0
	Botrylloides spp.	0.0	0.0	3.3	0.0
	Cystodytes lobatus	3.3	2.6	0.0	0.0
	Polyclinum planum	53.3	4.2	6.6	0.0
	Styela montereyensis	0.0	9.9	1.6	0.0
Number of Species/complexes		48	61	43	42
Number of Transect Lines[a]		60	191	61	81

[a]Does not include transect lines excluded from analysis.

The MPA sites were not selected by a random process; they were selected based on the targeted rocky substrate in depths ≥20 m, while the control sites were chosen based on comparable habitat, depth (if practical), and exposure to their associated MPA site. The survey lines within the MPA and control sites were selected randomly. While care was taken to adhere to the site criteria using sonar maps and ROV exploratory surveys, this task proved difficult because the targeted depth and rocky substrate was found to be limited and patchy as detailed in Karpov et al. (2012). Greater than 90% of the area at our study depths was soft substrate only (K. Karpov, personal observation).

During our study, fifty-three invertebrate species were identified, and 20 to complex level (Table 4). Invertebrates identified to complex level likely also had members identified to species level; thus, some inconsistency in identification methodology should be noted. For example, the red sponge category may also include *Acarnus erithacus.* The identifications of *Neopetrosia zumi* may not be accurate and perhaps should have been included in the white sponge branching complex. *Aglaophenia struthionides,* identified from the 2007 surveys, is questionable due to the size of that species and resolution of the camera system at the time. Some occurrences of the bryozoa, genus *Diaperoforma* and *Heteropora*, may have been misidentified for each other during conditions of low lighting or low resolution. Furthermore, the northern staghorn bryozoan (*Heteropora pacifica*) can be confused with *Celleporella* spp. Most bryozoan species are small, complex animals requiring a microscope to differentiate among them. Many molluscs tend to be cryptic and the majority of molluscs identified during this study were small, compounding observational difficulties. Echinoderms also had the potential for misidentification under conditions of low visibility, including *Luidia foliolata* with *Orthasterias koehleri* and *Patiria miniata* with *Mediaster aequalis*.

The 2007–2009 ROV surveys yielded five species and two taxonomic complexes that are subject to fishing (Table 6; C. McKnight, CDFW, personal communication). These species include *Parastichopus* spp., *Strongylocentrotus franciscanus*, and *Loxorhynchus grandis*, which we found offshore of all the northern Channel Islands. Cancridae were identified offshore of San Miguel, Santa Rosa, and Santa Cruz islands. Harvested species observed offshore of Santa Rosa Island include *C. productus* and *Strongylocentrotus purpuratus*. The commercially harvested *D. opalescens* was not found during the surveys; however, their egg cases were found offshore of Santa Rosa Island. Offshore of Anacapa Island we found the only occurrence of *P. interruptus*. A few of the harvested species observed have been identified as invertebrates likely to benefit from MPAs (CDFG 2008). Focal species or complexes for MPA deep subtidal monitoring (CDFG 2004) observed in this survey included *S. franciscanus*, *S. purpuratus*, Cancridae, and *P. interruptus*. *D. opalescens*, also a focal species (CDFG 2004), was observed only in the egg stage.

The invertebrate observations included species with structure-forming potential (Tissot et al. 2006). Tissot et al. (2007) detailed the importance of benthic macroinvertebrate congregations that, along with substrate, can influence groundfish abundance and distribution.

The purpose of this study was descriptive and the statistical analysis should be considered in broad terms. Percent occurrence was used because of the number and complexity of species encountered at the ten sites. Because the statistical methods used were for exploratory data analysis, no adjustments for multiple testing were made to the probabilities. Consequently, the effects and relationships indicated by the statistical procedures should be viewed as indicators and not as proven. To allow for comparisons between sites among individual species, other methods of enumeration such as describing colonial sponges by area of coverage, would lend themselves to greater statistical precision.

When looking at site-pairs we found the result of cluster analyses was consistent for MPA and control at two of the five site-pairs (Figure 4). However, care should be taken to attribute what factors produced these clusters. Differences in habitat composition, depth, currents, and other factors likely come into play. Despite South Point SMR yielding approximately twice as much soft habitat as its control site Cluster Point, the site-pair clustered together (Figure 4, Table 3). Also, the apparent uniqueness of the Gull Island SMR and East Point site-pair from each other could result from a number of factors. For example, East Point had approximately twice as much hard habitat as Gull Island SMR (Table 3). Consequently, differences between these two sites will be confounded. These two sites were rejected by Karpov et al. (2012) in their analysis of MPA effects on finfish as least comparable site pairs due to lack of depth and habitat relief overlap; their study found less than 12% overlap in depth between the two sites.

Both the Harris Point SMR-Castle Rock and the Carrington Point SMR-Rodes Reef site-pairs had approximately twice as much hard habitat in their control sites as their respective MPA sites (Table 3). These site-pairs did not cluster together (Figure 4). Although not a site-pair, it is interesting that the San Miguel Island Castle Rock site clustered with Santa Cruz Island Gull Island SMR site because the Castle Rock site has approximately five to six times as much hard substrate.

When reviewing cluster analysis, the Santa Rosa Island sites, four of which are within the Oregonian Province, formed their own cluster (Figure 4). The cluster also included another site within the Oregonian Province, the Harris Point SMR San Miguel Island site. Anacapa Island SMR and Anacapa Island SMCA, both with similar habitat composition and within the Californian Province, clustered together (Figure 4). The clustering of sites does suggest an island effect or, perhaps, clinal change from the Oregonian Province through the Transition Zone to the Californian Province.

Within the Oregonian Province are the site-pairs for San Miguel Island and Santa Rosa Island, areas that are commonly under the influence of cooler waters of the California Current. Assemblages of species in this zone are generally characteristic of central and northern California, Oregon, and Washington (Airame et al. 2003). In the Transition Zone, located offshore of the Santa Cruz Island and Santa Rosa Island, respectively, lie the Gull Island SMR and East Point site-pair. Within the Transition Zone, we would expect to see an overlap of both colder and warmer water species (National Centers for Coastal Ocean Science 2005). The Anacapa Island site-pair is located in the warmer Californian Province.

The majority of invertebrates observed had recorded ranges throughout the California coastline. Of the invertebrates identified to species level, literature reviews yielded only five (four cnidarians [*A. phyllosclera, E. rubens, Parazoanthus lucificum*, and *U.mcpeaki*] and one echinoderm [*Lytechinus pictus*]) with a northern range limit of Point Conception (Brusca 1980, Ricketts et al. 1985, Gotshall 2005); these invertebrates would be considered to be within the Californian Province. During the surveys *P. lucificum* and *L. pictus* were found only within the Californian Province, and *U. mcpeaki* was found only within the Transition Zone (Table 5). *A. phyllosclera* and *E. rubens* were both found in all three provinces, with greater PO in the Californian Province and lower PO in the Transition Zone and Oregonian Province (Table 5).

Considering invertebrates identified to complex level, the two gorgonians (*M. fruticosa* and *M. californica*) within *Muricea* spp. have northern ranges of Point Conception, California (Ricketts et al. 1985, Gotshall 2005). *Muricea* spp. was found in the Transition Zone with a low PO and with a greater PO in the Californian Province (Table 5).

Astropecten spp., consisting of *A. armatus* and *A. verrilli*, have a historic range from San Pedro, California to Ecuador (Ricketts et al. 1985, Gotshall 2005). *Astropecten* spp. was found in all three biogeographic regions, with greater PO moving from the Transition Zone to the Californian Province.

P. helianthoides can be found throughout California; however, it is uncommon south of Monterey Bay. *P. helianthoides* had a low PO within the Californian Province (Anacapa SMR and Anacapa SMCA) compared to the Oregonian and Transition Zone. This seems to follow a trend consistent with annual SCUBA surveys for kelp monitoring offshore of the Channel Islands (Kushner et al. 2013).

When considering species by island, some differences in occurrence are interesting. *H. californica* was found offshore of all the islands surveyed; however, PO of *H. californica* at Santa Cruz Island was 100, possibly due to Santa Cruz Island yielding a greater amount of soft substrate in which *H. californica* resides (Table 6). While *O. spiculata* was absent from the Santa Cruz Island sites and was found with relatively low PO offshore of San Miguel and Santa Rosa Islands, its PO jumped to 100 offshore of Anacapa Island (Table 6). *O. spiculata* is known to congregate in large masses and can compete with other species for food.

The mollusc *M. crenulata* had low PO offshore of Santa Rosa Island and was not found offshore of San Miguel Island and Santa Cruz Island (Table 6). However, PO of *M. crenulata* increased offshore of Anacapa Island (Table 6). Concurrently, the PO of all bryozoans dropped substantially, and none of the chordates were detected at Anacapa Island (Table 6). While many factors can come into play, it is interesting to note that *M. crenulata* is an omnivore with a varied diet that includes bryozoans and chordates (i.e., tunicates), with a preference for red algae and tunicates (Mazariegos-Villarreal et al. 2013).

Our study is descriptive at the site level. Differences between sites and site-pairs were confounded by multiple factors including geographic distribution, depth, temperature, amount of soft substrate, differential fishing pressure, and a myriad of other potential factors including competition for space or food that could not be controlled for in our analysis. We would not expect to see any MPA effect due to the short duration of the study, nor would such an interpretation be valid, given the confounding factors including camera differences across time. Future analysis of the differences between these sites will improve methods for comparing the MPA and control sites.

Conducting a study in which all species are identified increases our knowledge of species that may not be targeted during surveys that focus on a specific group, such as surveys targeting harvested species. Because of the inclusion of all invertebrates, we established new maximum depth records for three invertebrate species in the phylum Cnidaria (Table 7) when compared to published records (Verrill 1922, Gotshall 2005, Lamb and Hanby 2005). The depths were noted at the time of observation and not obtained from average transect depths. These results are likely due to the depths covered by the ROV (42–67 m), that are not typically visited by divers using SCUBA. In addition, the California hydrocoral (*Stylaster californicus*) was found offshore of both San Miguel and Santa Rosa islands during the ROV survey (Table 6). *S. californicus* previously had not been found offshore of Santa Rosa Island at SCUBA depths (J. Engle, University of California, Santa Barbara, personal communication; Kushner et al. 2013); furthermore, literature review did not find *S. californicus* offshore of Santa Rosa Island in ROV depths. The fishery is currently closed, but this slow-growing invertebrate can be damaged by anchors or divers (Love et al. 2010), and is sensitive to sedimentation and algal overgrowth (Morris et. al 1980, Whitmire and Clarke 2007).

Table 7.—New depth records for invertebrate species and location (island) based on surveys offshore of the northern Channel Islands, California, 2007–2009.

Phylum	Species	Current Depth[a] (m)	New Depth (m)	Island
Cnidaria	*Muricea californica*	30	42.8	Anacapa
	Urticina columbiana	45–55	61.8	Santa Cruz
	Urticina lofotensis	23–25	45.3	Santa Rosa

[a]Maximum depth limits based on Verrill 1922, Gotshall 2005, Lamb and Hanby 2005.

For future ROV surveys, we recommend increasing and standardizing the camera resolution and lighting across a longer time series. The initial focus of these ROV surveys was on fish associated with hard substrate, and differences between surveys for fish and invertebrates must be a consideration in future designs. For example, utilizing a high definition still camera and strobe to photograph one-meter quadrants independently of the transects would facilitate identification of both invertebrates and fishes. Additionally, when changes in sampling gear are introduced, paired surveys using both old and new technologies should be conducted to assess the efficacy of the new technology relative to the old. Further, collection of specimens to aid in accurate identification and to determine recognizable characters for video identification would be beneficial.

Night surveys could yield increased sightings of nocturnal species, such as lobsters (Gotshall 2005, CDFW 2013). While we occasionally detected lobsters, the encounters provided little information on their abundance. Night surveys might also reveal species known to inhabit the northern Channel Islands, but that we did not detect, such as abalone or *Centrostephanus coronatus* (Gotshall 2005, Kushner et al. 2013). Future surveys would benefit from enumeration of select invertebrate species to determine changes (if any) in abundance.

Any differences between MPA and control sites will likely take several years to detect, considering the many confounding factors and dynamic processes involved. We believe, however, that this descriptive analysis of invertebrates, as well as the extended range of distribution for some species, will be useful for assessing long-term changes in species composition due to influences such as fishing or pollution and, potentially responses to climate change.

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