The Fish Assemblages Inside and Outside of a Temperate Marine Reserve in Southern California

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Abstract.—The purpose of this investigation was to evaluate the effect of a small marine reserve (established 1988) on a temperate rocky reef fish assemblage at Santa Catalina Island, California. Fish surveys on SCUBA were conducted at two reserve and two non-reserve sites from October 2002 to January 2004. Sites were similar in fish density, species richness and biomass of the entire fish assemblage. However, the adult densities of two important fishery species, California sheephead (*Semicossyphus pulcher*; 7.6 ± 0.5 and 5.5 ± 0.4/100 m^2 inside versus outside) and kelp bass (*Paralabrax clathratus*; 3.6 ± 0.4 and 2.9 ± 0.4 inside versus outside), were significantly higher within the reserve. The reserve appears to be effective in increasing density and biomass of two impacted species that were readily observed and surveyed on SCUBA.

Introduction

Fully protected marine reserves are a powerful tool for conservation and management prompted by declining fish stocks (Botsford 1997; Halpern and Warner 2002). Marine reserves have various functions, one of which is to prevent fishing and the removal of any living or nonliving marine resource (Lubchenco et al. 2003). Benefits of marine reserves for fish and invertebrate populations have been demonstrated previously in many studies, largely in tropical regions (Bell 1983; Alcala 1988; Bennett and Attwood 1991; Buxton and Smale 1989; Russ and Alcala 1989; McClanahan and Shafir 1990; Polunin and Roberts 1993; Grigg 1994; Jennings et al. 1994; McClanahan 1994; Watson and Ormand 1994; McClanahan and Kaunda-Arara 1996; Stoner and Ray 1996). The interest in no-take refuges has emerged, in part, because of the collapse of many fisheries worldwide and the failure of traditional fisheries management techniques to protect them. Marine reserves may influence ecosystems in many ways (Russ 2002). Theoretically, inside a marine reserve, 1) fishing mortality is reduced significantly, 2) densities of target species increase, 3) mean size/age and biomass of target species may increase significantly and 4) higher production of propagules of target species occur per unit area. Areas outside of the marine reserve may benefit both from the density-dependent spillover of adults into fished areas and in the net export of eggs/larvae from the marine reserve (Russ and Alcala 1996). The latter can lead to an enhanced supply of recruits to fished areas (Russ 2002). Despite the fact that marine reserve research has focused on tropical habitats (e.g., Craik

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1981; Russ 1985; Russ and Alcala 1996), marine reserves are becoming increasingly popular as management tools in California in response to declining fish stocks (Paddack and Estes 2000, Craig et al. 2004, Parnell et al. 2005, Parnell in press. However, relatively few studies have described the effects of marine reserves in California. This may be due, in part, to the fact that these reserves are few in number (Paddack and Estes 2000) and generally small in size (Lowe 2003; Parnell et al. 2005). Despite this lack of knowledge, there has been considerable interest in expanding marine reserves throughout California in an effort to enhance stocks of impacted species (Paddack and Estes 2000). The Marine Life Protection Act of 1999 mandates the establishment of a marine reserve network in California to promote the sustainability of marine resources and is currently being developed by the Department of California Fish and Game. Therefore, it is both ecologically and economically critical that we understand the role of marine reserves in structuring fish assemblages in southern California so that effective marine reserves can be developed to maximize fish production and minimize restricted habitat. In this study we examined some of these hypotheses in a temperate, island ecosystem in southern California.

It is perhaps most important to evaluate the effect of marine reserves on species that are most intensively targeted. In southern California, the kelp bass (*Paralabrax clathratus*) and the California sheephead (*Semicossyphus pulcher*) are prominent members of the southern California rocky reef fish assemblage and support substantial fisheries. Fishing pressure on kelp bass has increased over the last 50 years and has resulted in a decrease in landings in California (Rodgers-Bennett 1991, Allen & Hovey 2001). California sheephead are a protogynous hermaphrodite that have been historically targeted by recreational fishermen, both hook and line and using spear. However, since 1988 this species has also been targeted by the live-fin fishery and has accounted for nearly 90 % of all target species landed by this fishery since its inception in southern California (Palmer-Zwahlen et al. 1993). Kelp bass and California sheephead may serve as good indicators of the potential of marine reserves to enhance or restore fish stocks in California. Parnell et al. (2005) reported a significant increase in the proportion of large California sheephead males between the San Diego-La Jolla Ecological Reserve and comparable nearby habitats outside the protected area. Paddack and Estes (2000) studied three reserves in central California and found increased fish abundance and increased size of the heavily exploited rockfishes (Scorpaenidae) within two of the three reserves.

The fish stock enhancement potential of coastal reserves in California is promising. However, it is critical to enhance our understanding of this tool in the offshore California islands. The southern California islands consist largely of rocky shorelines while only 10–15% of the southern California mainland shoreline contains rocky substrate, effectively doubling the amount of hard bottom shoreline in California (Stephens et al. 2006). The southern California islands are likely less affected by anthropogenic influences including pollution and coastal runoff, although many are utilized intensively for recreational marine activities. These islands have also been the focus of a proposed reserve network to enhance fish stocks. The purpose of the present investigation was to evaluate the effect of a temperate marine reserve on the structure of fish assemblages on a southern Cal-
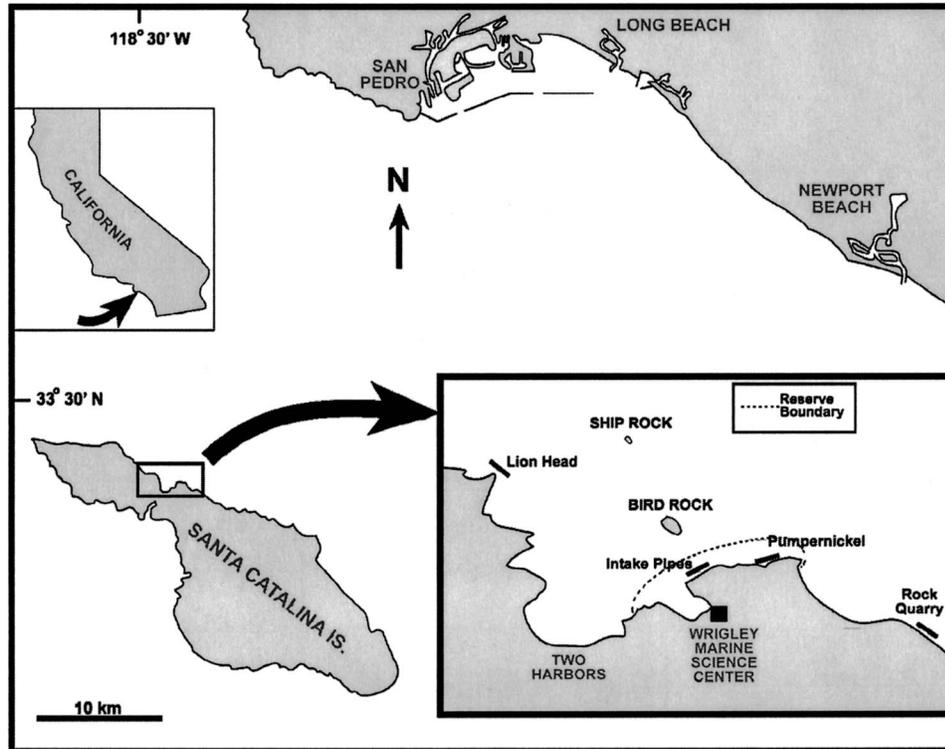
Fig. 1.   Location of the study sites at Santa Catalina Island, California.

ifornia island near the isthmus at Santa Catalina Island, California, using SCUBA surveys.

Methods

Four sites located near Big Fisherman's cove on the leeward side of Santa Catalina Island, California were studied from October 2002 to January 2004 (Figure 1). The Catalina Marine Science Center State Marine Reserve was established in 1988 and encompasses approximately 0.06 nm², and 1.08 nm of shoreline. This no-take reserve was established primarily for research and is under control of the adjacent Wrigley Institute for Environmental Studies, University of Southern California. The marine reserve is well marked and enforced, while recreational fishers and divers heavily utilize areas adjacent to the reserve. Two sites were located within the boundaries of this marine reserve: Pumpernickel Cove (33°32.89′ N, 118°28.78′ W) and Intake Pipes (33°26.82′ N, 118°29.11′ W), and two sites were located outside just outside the reserve: Lion Head (33°22.18′ N, 118°30.03′ W) and Rock Quarry (33°26.55′ N, 118°28.33′ W). Preliminary dives were conducted along the leeward side of Santa Catalina Island to qualitatively determine suitable reference habitats that were similar to the reserve sites in terms of size, habitat and vertical relief. Sites consisted of high relief (> 1m) boulder and rock cobble habitat that supported giant kelp (*Macrocystis pyrifera*) between five and 20 meters.

Conspicuous fishes were surveyed quarterly at the study sites from October 2002 to January 2004 (Figure 1). Fishes were surveyed using visual transects on SCUBA at six m and 12 m isobaths. All transects were conducted between 1000 and 1400 hrs. On each sampling date, divers swam 2 m wide $\times$ 50 m long transects along shore counting all conspicuous fishes within the 100 m^2 area and assigning each fish to one of five age classes (adult, sub-adult, juvenile, young of year or recruit). Counts made by two divers were averaged for each transect. All fishes that passed divers from behind were omitted to avoid duplicate counts of an individual fish or fishes that might be attracted to divers (Terry and Stephens 1976; Stephens and Zerba 1981; Stephens et al. 1984; Froeschke et al. 2005).

Biomass of fishes were estimated by age classes defined by total length estimates. The midpoint of each size class was used to estimate biomass for each species, in each age class, using established length-weight regressions following the methods of Froeschke et al. (2005). For species that did not have well-established length-weight relationships, the average mass of the individuals from each age class was estimated from collections taken during nearshore gill-net monitoring off southern California (Ponedella and Allen 2000; L.G. Allen and D.J. Pondella unpublished data). Biomass of the scythe butterflyfish (*Chaetodon falcifer*) and kelp perch (*Brachyistius frenatus*) were estimated using length-weight regressions from closely related and similarly shaped species for which the relationship was known (*Chaetodon auriga* for scythe butterflyfish and *Cymatogaster aggregata* for kelp perch). Cryptic species that were observed on transects were estimated by taking the mean weight of that species collected at the non-reserve sites during this study.

Transcribed data were entered and checked twice prior to statistical analysis. All statistical analyses were performed using *Systat* 9.0 (Systat Software Inc., Richmond CA, USA). Variation in the density and biomass of fishes among locations and sampling dates (season) was investigated using two-way analysis of variance (ANOVA) with replication. As is common with most ecological data, transect data were non-normal and had unequal variances. Data were $\log_{10} (x+1)$ transformed, which restored normality and homoscedasticity to these data prior to statistical analyses being performed.

Results

A total of twenty-eight species were observed on the 130 transects conducted during this study (Table 1). Species richness was similar between reserve and non-reserve sites (n = 23). Density, frequency of occurrence, and relative abundance were calculated for sites inside and outside of the reserve (Table 2). While densities of species varied among sites, blacksmith (*Chromis punctipinnis*) was the most abundant species at every site. Blacksmith accounted for 60% of all individuals inside the reserve and 67% outside the reserve and were present during all sampling periods (Frequency of Occurrence > 90%; Table 2). Total fish density did not differ significantly between the two sites in the reserve or the two sites out of the reserve, thus data were pooled at reserve and non-reserve sites to test for reserve effects on fish abundance and biomass. Mean density of conspicuous fishes was 163.7 $\pm$ 17.0 (number/100 m^2 $\pm$ 1 S.E.) in the reserve and 204.0 $\pm$ 19.3 outside the reserve (Figure 2a). Overall, fish density did not differ significantly between reserve and non-reserve sites (ANOVA, $F_{1,128}$ = 1.97; P = 0.16).

Table 1.   The scientific and common names of fishes surveyed at Santa Catalina Island. Fishes were organized by orders and families.

Taxa	Common name
Lamniformes	
Carcharhinidae - requiem sharks	
Galeorhinus galeus (Jordan and Gilbert, 1883)	tope
Rajiformes	
Dasyatidae - stingrays	
Urobatis halleri (Cooper, 1863)	round stingray
Anguilliformes	
Muraenidae - morays	
Gymnothorax mordax (Ayres, 1859)	California moray
Scorpaeniformes	
Scorpaenidae - scorpionfishes	
Scorpaena guttata (Girard, 1854)	California scorpionfish
Sebastes atrovirens (Jordan and Gilbert, 1880)	kelp rockfish
Sebastes serranoides (Eigenmann and Eigenmann, 1890)	olive rockfish
Sebastes serriceps (Jordan and Gilbert, 1880)	treefish
Hexagrammidae - greenlings	
Oxylebius pictus (Girard, 1854)	painted greenling
Perciformes	
Serranidae - sea basses	
Paralabrax clathratus (Girard, 1854)	kelp bass
Malacanthidae - tilefishes	
Caulolatilus princeps (Jenyns, 1840)	ocean whitefish
Haemulidae - grunts	
Anisotremus davidsonii (Steindachner, 1876)	sargo
Sciaenidae - croakers	
Cheilotrema saturnum (Girard, 1858)	black croaker
Kyphosidae - sea chubs	
Girella nigricans (Ayres, 1860)	opaleye
Medialuna californiensis (Steindachner, 1876)	halfmoon
Chaetodontidae - butterflyfishes	
Chaetodon falcifer (Hubbs and Rechnitzer, 1958)	scythe butterflyfish
Embiotocidae - surfperches	
Brachyistius frenatus (Gill, 1862)	kelp perch
Embiotoca jacksoni (Agassiz, 1853)	black perch
Rhacochilus toxotes (Agassiz, 1854)	rubberlip seaperch
Rhacochilus vacca (Girard, 1855)	pile perch
Pomacentridae - damselfishes	
Chromis puntipinnis (Cooper, 1863)	blacksmith
Hypsopops rubicundus (Girard, 1854)	garibaldi
Labridae - wrasses	
Halichoeres semicinctus (Ayres, 1859)	rock wrasse
Oxyjulis californica (Gunther, 1861)	senorita
Semicossyphus pulcher (Ayres, 1854)	California sheephead
Clinidae - clinids	
Alloclinus holderi (Lauderback, 1907)	island kelpfish
Heterostichus rostratus (Girard, 1854)	giant kelpfish
Gobiidae - gobies	
Lythrypnus dalli (Gilbert, 1890)	bluebanded goby
Rhinogobiops nicholsii (Bean, 1882)	blackeye goby
Pleuronectiformes	
Pleuronectidae - righteye flounders	
Pleuronichthys coenosus (Girard, 1854)	C-O sole

Table 2. The mean density per 100 m² ± standard error (S.E.), frequency of occurrence (F.O.) and relative abundance for fishes inside and outside of the Catalina Marine Science Center State Marine Reserve at Santa Catalina Island, California from 2002-2004.

Species	Reserve				Non-Reserve			
	Mean	S.E.	F.O.	%	Mean	S.E.	F.O.	%
Alloclinus holderi	0.06 ± 0.03		0.06	0.04				
Brachyistius frenatus	5.94 ± 1.06		0.80	3.63	4.59 ± 0.69		0.70	2.25
Caulolatilus princeps	0.03 ± 0.02		0.03	0.02				
Chaetodon falcifer					0.13 ± 0.07		0.08	0.06
Cheilotrema saturnum					0.03 ± 0.03		0.02	0.02
Chromis punctipinnis	99.80 ± 13.95		0.94	60.96	136.41 ± 19.51		0.93	66.88
Embiotoca jacksoni	0.42 ± 0.11		0.25	0.26	2.00 ± 0.45		0.52	0.98
Galeorhinus galeus	0.09 ± 0.06		0.03	0.05				
Girella nigricans	1.10 ± 0.16		0.52	0.67	2.21 ± 0.39		0.59	1.09
Gymnothorax mordax	0.01 ± 0.01		0.01	0.01	0.02 ± 0.02		0.02	0.01
Halichoeres semicintus	4.58 ± 0.44		0.93	2.80	2.51 ± 0.28		0.79	1.23
Heterostichus rostratus	0.12 ± 0.04		0.12	0.07	0.05 ± 0.03		0.05	0.02
Hypsopops rubicundus	4.51 ± 0.33		0.91	2.75	6.07 ± 0.34		1.00	2.97
Lythyrypnus dalli	13.51 ± 1.85		0.86	8.25	18.18 ± 2.31		0.97	8.91
Medialuna californiensis	1.41 ± 0.94		0.28	0.86	0.92 ± 0.25		0.34	0.45
Oxyjulis californica	12.22 ± 3.28		0.78	7.46	7.56 ± 2.85		0.61	3.71
Oxylebius pictus					0.03 ± 0.02		0.03	0.02
Paralabrax clathratus	9.74 ± 0.60		1.00	5.95	10.13 ± 0.70		0.98	4.97
Pleuronichthys coenosus	0.01 ± 0.01		0.01	0.01				
Rhacochilus toxotes	0.06 ± 0.03		0.06	0.04	0.03 ± 0.03		0.02	0.02
Rhacochilus vacca	0.01 ± 0.01		0.01	0.01				
Rhinogobiops nicholsii	2.38 ± 0.32		0.77	1.45	6.92 ± 1.10		0.97	3.39
Scorpaena guttata	0.01 ± 0.01		0.01	0.01	0.02 ± 0.02		0.02	0.01
Sebastes atrovirens	0.04 0.03		0.03	0.03	0.16 ± 0.06		0.13	0.08
Sebastes serranoides					0.02 ± 0.02		0.02	0.01
Sebastes serriceps	0.10 ± 0.04		0.09	0.06	0.49 ± 0.11		0.34	0.24
Semicossyphus pulcher	7.57 ± 0.47		0.99	4.62	5.46 ± 0.39		0.97	2.68
Urobatis halleri					0.02 ± 0.02		0.02	0.01

Mean biomass (kg/100 m² ± S.E.) was 15.9 ± 1.8 in the reserve and 13.0 ± 1.5 outside the reserve. Similarly, no significant difference in mean biomass of fishes between reserve and non-reserve sites was detected (ANOVA, $F_{1,128} = 0.01$; $P = 0.91$; Figure 2b). Biomass peaked in Fall 2003 following the recruitment of juveniles to the reef, although this trend was not as dramatic as the peak in density. Overall, blacksmith strongly influenced seasonal patterns of abundance and biomass. Blacksmith accounted for almost 40% of the total biomass outside the reserve and 23% inside the reserve, ranking first and second respectively. However, this species is a relatively small planktivore that is not targeted in any current fishery. Because the comparative abundance of these fish obscured the trends that were observed in larger, less abundant fishery species, blacksmith were removed from the analysis of biomass. This substantially altered biomass patterns, as total biomass density was higher inside the marine reserve when blacksmith were excluded from the analysis (ANOVA, $F_{1,128} = 7.1$; $P = 0.01$). Biomass peaked in Winter 2003 inside the reserve, however this was primarily attributed to the presence of several adult (> 1.8 m) tope (*Galeorhinus galeus*) aggregating inside the reserve during the Winter 2003 sampling period. Similarly, biomass peaked in the
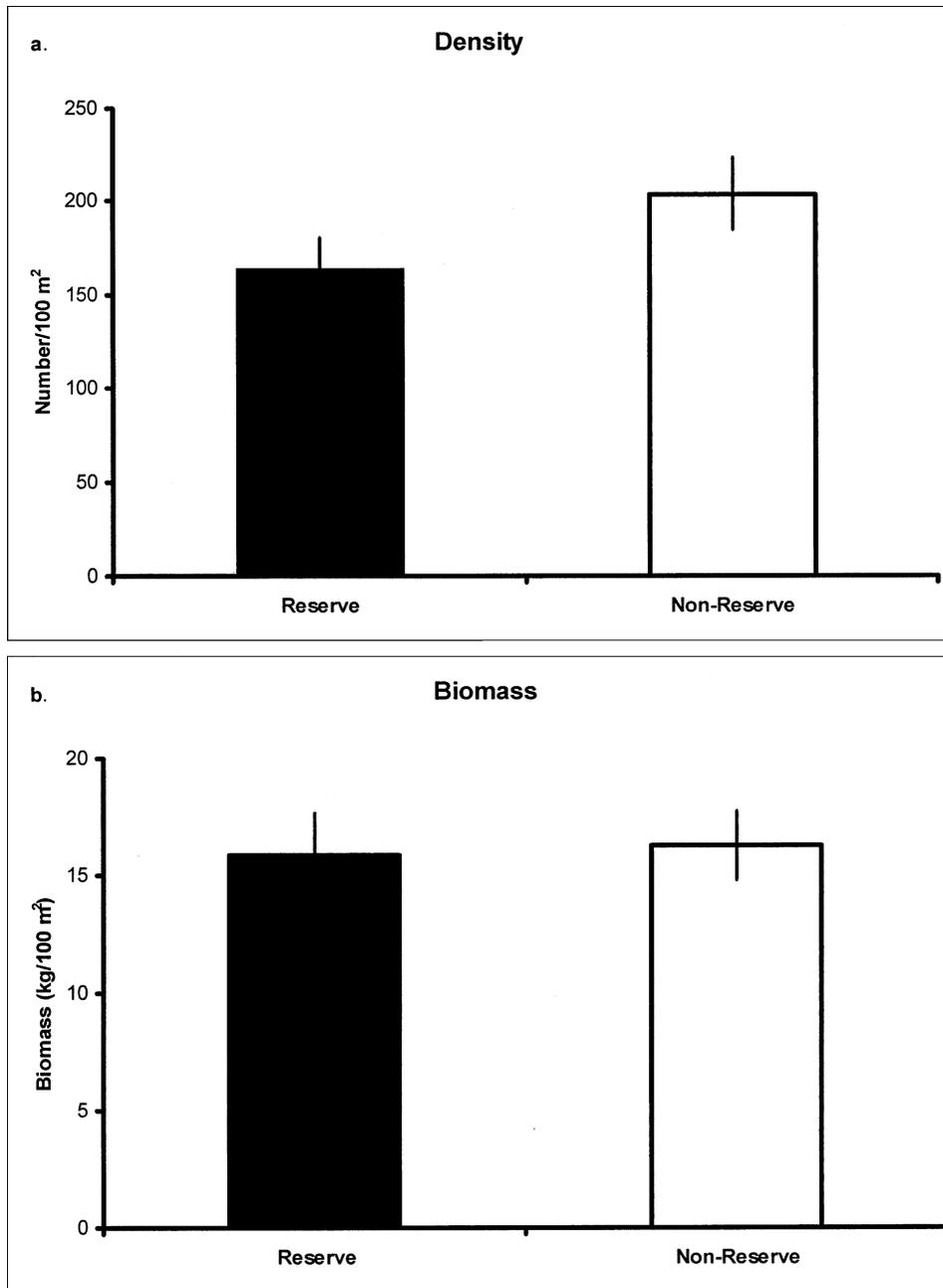
Fig. 2.   a). Mean density of conspicuous fishes inside and outside of a marine reserve at Santa Catalina Island, California. There was no significant difference in mean density between reserve and non reserve stations (ANOVA, $F_{1,128}$ = 1.97; P = 0.16). Reserve 163.7 $\pm$ 17.0 (n = 69), non-reserve 204.0 $\pm$ 19.3 (n = 61). b) Mean biomass of conspicuous fishes inside and outside of a marine reserve at Santa Catalina Island, California. There was no significant difference in mean biomass between reserve and non reserve stations (ANOVA, $F_{1,128}$ = 0.01; P = 0.91). Mean biomass was 15.9 $\pm$ 1.8 (n = 69) in the reserve and 13 $\pm$1.5 outside reserve (61).
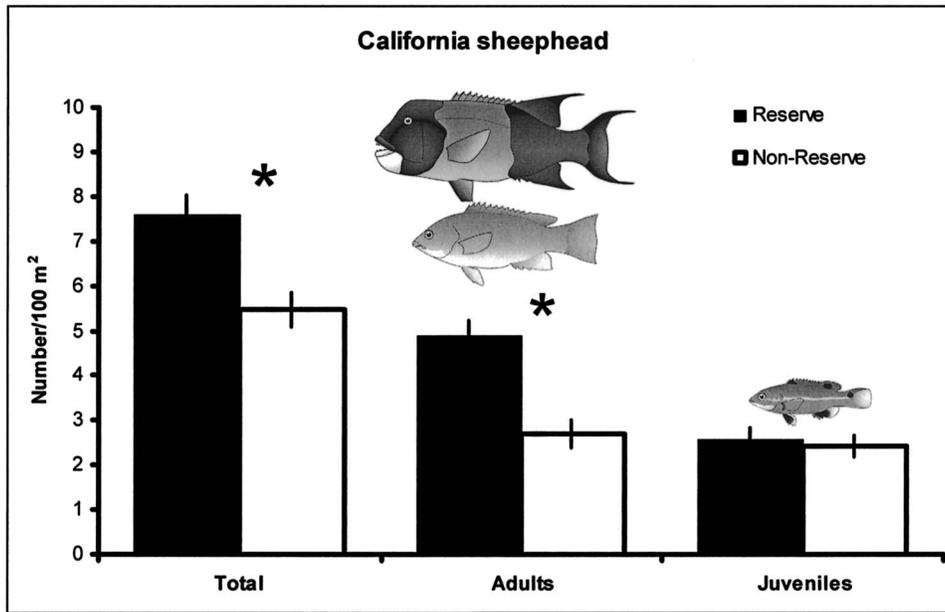
Fig. 3. Mean density of California sheephead inside and outside of a marine reserve at Santa Catalina Island, California. Total density was significantly higher within the marine reserve (Total ANOVA, $F_{1,128}$ = 9.8; P = 0.002; Adults ANOVA, $F_{1,128}$ = 17.2; P < 0.001). Density of juveniles was not significantly different between locations (Adults ANOVA, $F_{1,128}$ = 0.3; P = 0.86).

non-reserve stations in Winter 2004 when topes were observed. These animals constitute a substantial amount of biomass because of their large size even though relatively few animals were observed during the study.

Patterns of abundance and biomass were also determined for California sheephead, *Semicossyphus pulcher* (Labridae) and kelp bass, *Paralabrax clathratus* (Serranidae), two species of recreational/commercial importance. Mean density of California sheephead within the marine reserve was 7.6 ± 0.5 and 5.5 ± 0.4 outside (Figure 3). Overall, density was significantly higher within the marine reserve (ANOVA, $F_{1,128}$ = 9.8; P = 0.002). This pattern was similar when only adult California sheephead (>30 cm TL) were considered (ANOVA, $F_{1,128}$ = 17.2; P < 0.001). However, mean density of California sheephead sub-adults and juveniles were not significantly different inside and outside of the marine reserve (ANOVA, $F_{1,128}$ = 0.3; P = 0.86; Figure 3). Mean biomass of California sheephead was also significantly higher inside of the marine reserve (ANOVA, $F_{1,128}$ = 35.8; P < 0.001; Figure 5).

Total mean density of kelp bass did not differ significantly between reserve and non-reserve stations (ANOVA, $F_{1,128}$ = 0.7; P = 0.42; Figure 4). Similar to the pattern for California sheephead, density of kelp bass adults (>30 cm TL) was significantly higher inside the reserve (ANOVA, $F_{1,128}$ = 4.5; P < 0.04). However, density of juvenile kelp bass did not differ significantly between locations ($F_{1,128}$ = 0.1; P = 0.72). Biomass of all kelp bass was significantly higher inside the marine reserve (ANOVA, $F_{1,128}$ = 6.7; P = 0.01; Figure 5).

The mean densities of two resident, non-fished species that were abundant
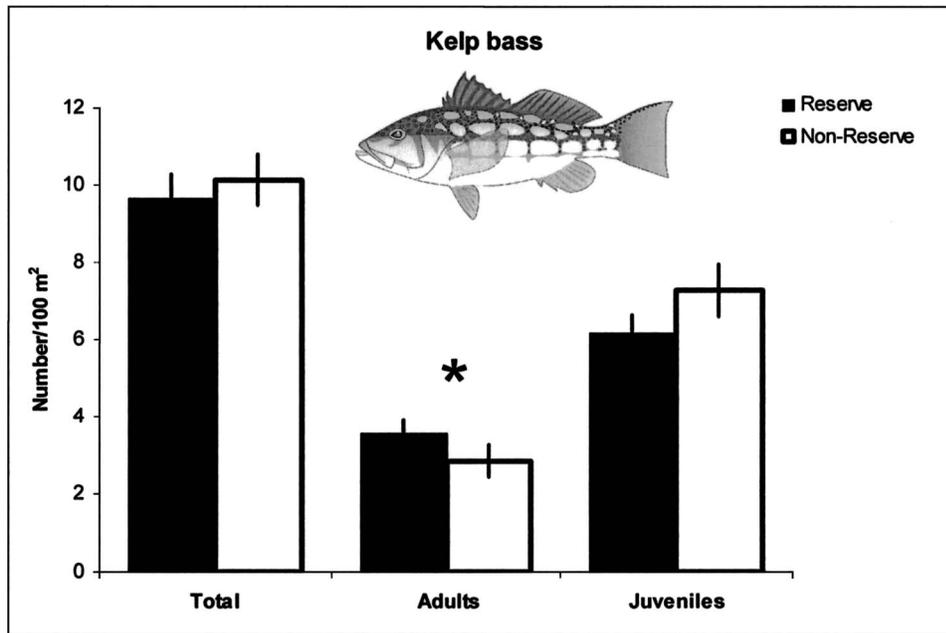
Fig. 4.   Mean density of kelp bass inside and outside of a marine reserve at Santa Catalina Island, California. Total density was not significantly higher within the marine reserve (Total ANOVA, $F_{1,128}$ = 0.7; P = 0.42; Adults ANOVA, $F_{1,128}$ = 4.5; P < 0.04). Density of juveniles was not significantly different between locations (Adults ANOVA, $F_{1,128}$ = 0.1; P = 0.72).

enough to permit statistical analysis were also compared. Mean density of garibaldi (*Hypsypops rubicundus*) was significantly higher outside the marine reserve (ANOVA, $F_{1,128}$ = 1.7; P < 0.01). Density of opaleye (*Girella nigricans*) was also greater outside of the reserve and was marginally significant (ANOVA, $F_{1,128}$ = 4.0; P = 0.05).

Discussion

This study examined the effect of a small, temperate marine reserve on Santa Catalina Island for the first time. Our results indicated important differences in density and age class distribution of two heavily targeted species in southern California.

Adult density and biomass of both kelp bass and California sheephead were significantly higher inside the marine reserve. Kelp bass larger than 30 cm TL were considered adult, they mature from 22–27 cm TL (Love et al. 1996) and the minimum legal size limit is 30 cm TL in California. Similarly, the minimum legal size for California sheephead is 30 cm TL and they mature between 19–23 cm TL at Santa Catalina Island (Warner 1975). Large adults of both species were common within the reserve while rare outside the reserve boundaries and is similar to observations reported Hobson and Chess (2001) and Erisman and Allen (2006) at Santa Catalina Island. However, the density of sub-adults and juvenile California sheephead did not differ between reserve and non-reserve sites. These findings suggest that differences in adult abundance were unlikely to be the result of poor recruitment or unsuitable habitat at non-reserve sites, and may be attri-
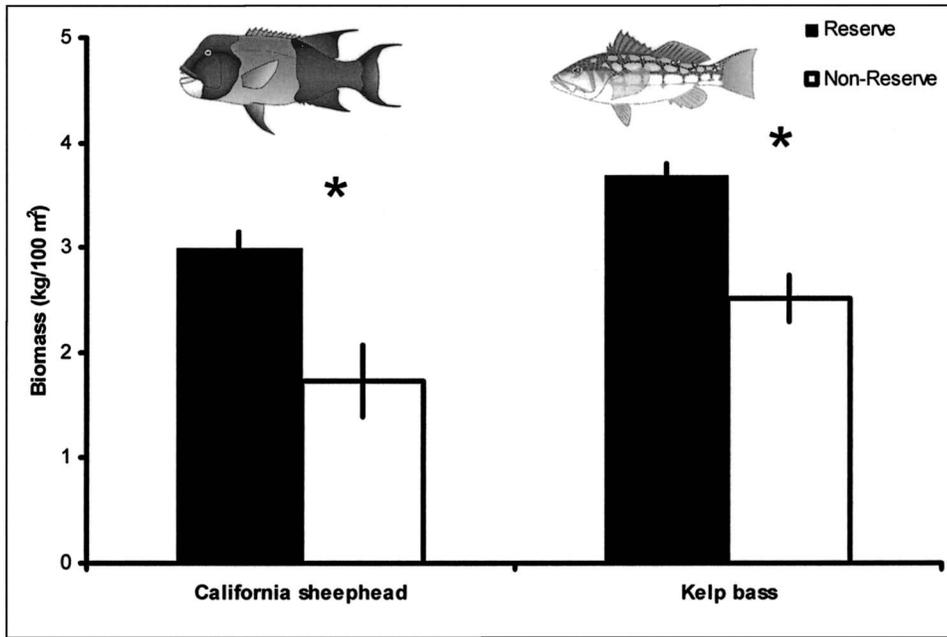
Fig. 5. Biomass of kelp bass in reserve and non-reserve stations at Santa Catalina Island. Biomass of California sheephead was significantly higher inside the marine reserve (ANOVA, $F_{1,128} = 35.8$; P < 0.001). Biomass of kelp bass adults was also significantly higher inside the marine reserve (ANOVA, $F_{1,128} = 6.7$; P $= 0.01$).

buted to the removal of adults outside of the marine reserve. While fishing pressure was not directly quantified at the non-reserve sites, both sites were targeted heavily by recreational fishers during the study period while the reserve was well enforced and no fishing or removal of animals was observed (J.T.F personal observation).

California sheephead are monandric, protogynous hermaphrodites that are targeted by anglers, spearfishermen and the recently developed live fishery to supply Asian seafood markets (Adreani et al. 2004). Since males result from sex change of larger, older females, they are naturally rare and thus, may be more vulnerable to exploitation than other species. Furthermore, excess removal of large males may lead to sperm limitation in these populations (Warner et al. 1995) or disrupt normal reproductive behaviors (Adreani et al. 2004). Also, large males exhibit high site fidelity (Topping et al., 2005), which may increase their vulnerability to fishing pressure by hook and line and spearfishers. However, these life history traits may make marine reserves particularly effective at protecting California sheephead stocks because of the territorial behavior and limited home range. Parnell (2005) reported a significant increase in the proportion of large California sheephead males between the San Diego-La Jolla Ecological Reserve and comparable nearby habitats outside the protected area even though this reserve is relatively small (~2.16 km²) and was too small to protect most other species examined (Parnell et al. 2005).

Kelp bass are the most abundant resident mesocarnivorous predators at Santa Catalina Island and are a primary target for southern California recreational fish-

eries (Quast 1968; Smith and Young 1966; Love et al. 1996). Overall, it appears that the similarity of kelp bass abundance between reserve and non-reserve sites may be deceiving. Density of kelp bass did not differ between reserve and non-reserve sites, however there were important differences in size class and biomass distributions. Biomass and adult density of kelp bass were significantly higher inside the reserve while juveniles were more abundant outside the reserve indicating an increase of large fish within the reserve. This may also be the result of differences in habitat or relief that are confounded in the experimental design of the current study. It is also possible that density dependent recruitment is occurring with kelp bass but was not detected using visual surveys, and the increased adult density within the reserve reduced successful recruitment of juveniles to this area. Density dependent recruitment has been demonstrated previoulsy on numerous, although tropical fishes (Stimson 1990; Tupper and Hunte 1994; Forrester 1995; Steele et al. 1998).

Site fidelity and fine-scale movement patterns were determined for adult kelp bass (Lowe et al. 2003) and California sheephead (Topping et al. 2005) in this marine reserve. Both species had relatively small home ranges compared to the total area of this reserve indicating that the size of this reserve (130,000 m^2). This may be particularly important for these two species. Both species require large adult populations for normal reproductive behavior. California sheephead are haremic spawners (Adreani et al. 2004) and kelp bass form large aggregations during spawning periods (Erisman and Allen 2005) which historically have been targeted heavily by anglers (Erisman and Allen 2006). Recruits of both species were observed frequently during the Fall 2003 in both reserve and non-reserve locations. This lack of difference in the abundance of sub-adults and juveniles of both species argues against recruitment related differences in adult abundance. Additionally, no reserve effect was found when examining other fishes that are not targeted by anglers.

Evidence documenting the effects of marine reserves on the stocks of temperate fishes is limited. Paddack and Estes (2000) examined three marine reserves and adjacent control areas in central California and reported a significant increase in biomass and mean size of kelp rockfish (*Sebastes atrovirens*) in two of the three reserves in the study. As with the current study, the effect was more pronounced in respect to population structure than abundance. Schroeder and Love (2002) also found significant differences in size frequency distribution and species composition of rockfishes in deep water reefs in southern California. Parnell et al. (2005) reported significant increases in density inside the San Diego-La Jolla Ecological Reserve for four species with limited home range: Calfornia sheephead, vermillion rockfish (*Sebastes miniatus*), green abalone (*Haliotis fulgens*) and red urchin (*Stronglylocentrotus franscicanus*).

Coral reefs have been examined more intensively and may provide more insight into the possible benefits of reserves to marine ecosystems. Many studies have reported significant increases in density, biomass and mean size of target species inside marine reserves (e.g. Craik 1981; Russ 1985; McCormick and Choat 1987; Polunin and Roberts 1993; Harmelin et al. 1995; Russ and Alcala 1996; Edgar and Barrett 1997; Edgar and Barrett 1999; Willis et al. 2003). Modeling studies have also suggested that marine reserves increase spawing stock biomass per recruit for fishes with high site fidelity (Polacheck 1990; DeMartini 1993). Several

studies of reserves in the Florida Keys have examined potential reproductive output of groupers (Serranidae) and reported that most species had spawning potentials less than 20% of that expected for unfished populations (Ault et al. 1997; Bohnsack 1998). However, few studies have attempted to estimate reproductive output per unit area. Paddack and Estes (2000) used density, size structure, and length-fecundity relationships of rockfishes (Scorpaenidae) to estimate reproductive output, which was nearly three times as high for two reserves that had been protected for 12 and 36 years respectively. A third reserve that had been protected for only two years did not show a significant increase in reproductive output. Despite the wealth of evidence outlining possible benefits, marine reserves remain a controversial management tool. This may be due, in part, to the relative lack of empirical versus theoretical evidence and because the majority of studies involved comparisons of single point-in time abundance of target species inside and outside reserve boundaries. Comparisons in this manner may be confounded by habitat, history and/or larval supply differences between reserve and fished locations (Roberts and Polunin 1991; Dugan and Davis 1993). Few studies, including the current investigation, have reported data at both reserve and non-reserve sites before and after implementation of reserves (BACI) that are necessary to unequivocally demonstrate the effects of reserves on marine ecosystems (Underwood 1992; Wantiez et al. 1997).

This marine reserve at Santa Catalina Island is a relatively small, but well enforced area that primarily encompasses a continuous rocky reef, kelp forest habitat. The reserve appears effective in increasing density and biomass of two impacted species that are readily observed and surveyed on SCUBA. Ultimately, these increases may result in increased reproductive output for the species that, in turn, may aid in maintenance of sustainable fisheries. It is also possible that species with similar life history characteristics to the California sheephead or kelp bass may respond similarly to reserve protection and promote sustainable fisheries to a wider range of organisms than were sampled using these methods.

Acknowledgments

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