Bull. Southern California Acad. Sci.
115(1), 2016, pp. 1–14
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The Return of the King of the Kelp Forest: Distribution, Abundance, and Biomass of Giant Sea Bass (*Stereolepis gigas*) off Santa Catalina Island, California, 2014-2015

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Abstract.—It is rare to find evidence of top predators recovering after being negatively affected by overfishing. However, recent findings suggest a nascent return of the critically endangered giant sea bass (*Stereolepis gigas*) to southern California. To provide the first population assessment of giant sea bass, surveys were conducted during the 2014/2015 summers off Santa Catalina Island, CA. Eight sites were surveyed on both the windward and leeward side of Santa Catalina Island every two weeks from June through August. Of the eight sites, three aggregations were identified at Goat Harbor, The V's, and Little Harbor, CA. These three aggregation sites, the largest containing 24 individuals, contained a mean stock biomass of 19.6 kg/1000 m^2 over both summers. Over the course of both summers the giant sea bass population was primarily made up of 1.2 - 1.3 m TL individuals with several small and newly mature fish observed in aggregations. Comparison to historical data for the island suggests giant sea bass are recovering, but have not reached pre-exploitation levels.

The giant sea bass (*Stereolepis gigas*) is the largest teleost to inhabit nearshore rocky reefs and kelp forests in the northeastern Pacific (Hawk and Allen 2014). Though previously taxonomically classified as a sea bass (Serranidae), the giant sea bass is actually a wreckfish, in the family Polyprionidae (Shane et al. 1996). Unlike most wreckfishes, they are a relatively shallow water species, inhabiting depths from 3 - 40 m. Their historical range is from Humboldt Bay, CA to Baja Mexico (Point Abreojos) and into the northern Gulf of California. However, they are primarily found south of Point Conception. Although, the giant sea bass is the largest member of the southern California rocky reef and kelp forest fish community, very little is known about its basic biology and life history (Allen and Andrews 2012). These fish have been documented to grow over 250 kg (Domeier 2001) and live up to 76 years old (Hawk and Allen 2014). However, there are reports of giant sea bass living as old as 90 - 100 years and over 270 kg (Fitch and Lavenberg 1971), and even possibly reaching sizes of 360 kg as noted by author Charles F. Holder at the turn of the twentieth century (Holder 1910). These early reports of giant sea bass size and age remain unverified.

Along with being a long-lived and slow growing species, with the exception of growing rapidly within the first year of life (Hawk and Allen 2014), they are also relatively late to mature. It is believed that giant sea bass mature between 11 - 13 years of age (Fitch and Lavenberg 1971). However, there have been no studies explicitly confirming age at sexual maturity. To maintain their large body mass, giant sea bass feed on a wide variety of demersal and conspicuous rocky reef fishes as well as cephalopods and crustaceans. They have been documented to feed on rays, guitarfish, skates, flatfish, small sharks, barred sand bass, kelp bass, blacksmith,

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ocean whitefish, sargo, sheephead, octopus, spiny lobster, cephalopods and squid (Domeier 2001, Love 2011). They are likely capable of feeding on nearly any species inhabiting nearshore rocky reefs and kelp forests off southern California, as they are the apex, tertiary megacarnivore of this system (Cross and Allen 1993, Horn and Graham 2006).

Like many slow growing, late maturing, large bodied marine predators worldwide (Pauly et al. 1998, Jackson et al. 2001, Dayton et al. 2002, Myers and Worm 2003), the giant sea bass population has historically been depleted due to overfishing and has been rare off southern California (Domeier 2001, Pondella and Allen 2008). During most of the twentieth century, they were highly sought after throughout the Southern California Bight and Mexico by both commercial and recreational fishermen. During the early twentieth century, the commercial fishery which began using hand lines had switched to gill nets providing peak landings during the early 1930's at over 114 mt before the crash of the commercial fishery off southern California in 1935 to under 10 mt (Crooke 1992). The commercial fishery of giant sea bass taken from Mexican waters had greater landings and durability than those off southern California. Peaking in the early 1930's at over 362 mt with a steady decrease throughout the 1960's (Crooke 1992). The recreational fishery for giant sea bass off southern California peaked in 1963, and in Mexico in 1973. That these peaks in recreational landings were after the crash of the commercial fishery is due to the later development of the recreational fishery, and not the population size itself (Domeier 2001). By the mid 1970's, several boats would target presumed spawning aggregations sites throughout the month of July off southern California and Mexico, consistently landing high numbers (Crooke 1992) and in one case up to 255 fish in three days (Domeier 2001). Likewise, during the 1960's and 70's the practice of spearfishing grew in popularity. The gregarious and bold disposition of giant sea bass did not help this apex predator against the increasing numbers of spearfishers, as they were easy targets and landed at high frequencies (Fitch and Lavenberg 1971, Crooke 1992).

This combination of various fishing pressures led to their near disappearance during the 1970's (Pondella and Allen 2008), and by 1981 both southern California and Mexico landings dropped below 5 mt (Crooke 1992, Domeier 2001). In 1981, a law was passed prohibiting the take of any giant sea bass off California, with the exception of two fish per vessel trip for commercial fishermen using gill or trammel nets, and the moratorium was put into effect in 1982. This law was later amended in 1988, allowing one incidental fish per commercial fishing trip off California waters. However, though this amendment limited the number able to be sold in California by commercial fishermen, it still allowed fishing via gill and trammel nets over nearshore rocky reefs and kelp forest habitat (Pondella and Allen 2008). These nearshore habitats that were targeted are those used by giant sea bass, especially during aggregation months from May - October, and the incidental bycatch of giant sea bass was discarded at sea (Crooke 1992, Domeier 2001), or rumored to be shared among commercial fisherman. Due to concerns over the viability of the giant sea bass population off southern California, this species was red listed in 1996 by the International Union for Conservation of Nature (IUCN) as a critically endangered species (Cornish 2004).

It is rare to find evidence of a long-lived, slow growing, and late maturing species recovering after being strongly affected by overfishing (Hutchings 2000). However, after the gill net fishery was banned within three nautical miles of the mainland and one nautical mile of the islands with Proposition 132 in 1994, the population began to recover (Pondella and Allen 2008). After being seldom seen in southern California from the 1970s - 1990s (Domeier 2001), and not being observed in quarterly surveys by the Vantuna Research Group of Occidental College off the Palos Verdes coast between 1974 - 2001, giant sea bass began to be observed in 2002, and have been seen to the present day (Pondella and Allen 2008). Likewise, incidental commercial catch and CPUE from the Ocean Resource Enhancement Hatchery Program (OREHP) scientific gill net surveys showed a significant positive increase from 1995 - 2004, an increase that was not correlated to fluctuations in environmental factors (Pondella and Allen 2008). These findings allude to a nascent return of giant sea bass within the Southern California Bight.

Giant sea bass frequented yearly site-specific aggregations for presumed spawning purposes in the past, as fishermen targeted and depleted these areas during the 1970's (Crooke 1992). Due to the elimination of previous spawning aggregations and the majority of the southern California giant sea bass population, modern day locations of aggregation sites are largely unknown. For conspicuous aggregation sites to reappear it is likely that population numbers would have to reach a certain abundance (Domeier 2001). However, anecdotal reports by the recreational dive community today suggests that historical spawning aggregations are returning primarily off La Jolla, Santa Catalina Island, and Anacapa Island, California. Surveying spawning aggregation sites allows for a unique opportunity to access a larger percentage of the reproductive population that would otherwise be spread over a greater geographic distribution (Johannes et al. 1999, Whaylen et al. 2004, Heppell et al. 2012). Furthermore, with information on a spawning aggregation biomass, through a length-weight relationship for the species and an estimate of total abundance, the spawning stock biomass of a species can be estimated (Jennings et al. 1996).

Our study applies underwater visual censuses (UVC) using length calibrated lasers for more precise size estimation (Gingras et al. 1998, Colin et al. 2003, Heppell et al. 2012) to provide the first population assessment of the endangered tertiary carnivore, the giant sea bass, of the rocky reefs and kelp forests off southern California at Santa Catalina Island, CA. The objectives of this study were to 1) identify and document spawning aggregation sites and peak aggregation periods throughout the summers of 2014 and 2015; and 2) establish baseline mean densities, stock biomass, and length/biomass distribution frequencies to compare with historical fish surveys.

Materials and Methods

Study Sites

Eight sites were surveyed off Santa Catalina Island, CA during the summer of 2014 (6/9/14 to 8/13/14) and 2015 (6/11/15 to 8/11/15) (Fig. 1a). In an attempt to get both a windward and leeward representative sample for the island, the eight sites were located at Johnson's Rock (33°28′37.08″ N lat. 118°35′22.57″ W. long.), Little Geiger (33°27′27.62″ N lat. 118°30′ 51.03″ W. long.), Empire Landing (33°25′59.96″ N lat. 118°26′52.44″ W. long.), between Twin Rocks and Goat Harbor (33°25′04.49″ N lat. 118°23′38.24″ W. long.), Italian Gardens (33°24′39.92″ N lat. 118°22′32.50″ W. long.), Casino Point (33°20′58.68″ N lat. 118°19′ 30.56″ W. long.), The V's (33°18′45.94″ N lat. 118°22′11.38″ W. long.), and Little Harbor (33°23′08.10″ N lat. 118°28′48.94″ W. long.). Sites averaged a distance of 7 km apart. Each of the eight sites contained habitat presumed suitable for giant sea bass aggregations based on characteristics of the Long Point State Marine Reserve (SMR) put into effect to protect the best known site for giant sea bass in southern California (CA MLPA South Coast Project 2009). Each site consisting of deep (>18 m) rocky reefs, and reef edges, where *Macrocystis* kelp forests were present. Of the eight sites, four are thought to be possible giant sea bass aggregation sites based on historical records and reports from the recreational diving community (The V's, Casino Point, Italian Gardens, and Goat Harbor). The Vs site was not surveyed in 2015 due to high surge and low visibility throughout the season.

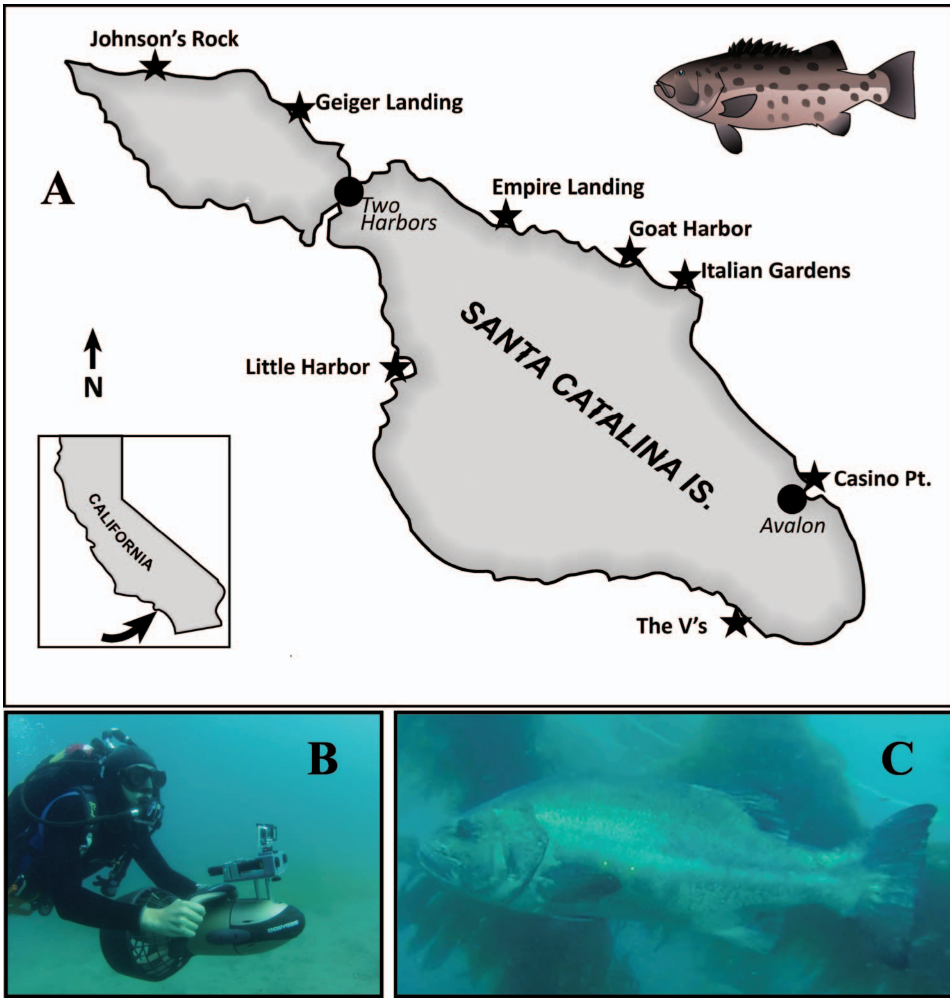


Fig. 1. Sampling sites and methods: A) Location of the eight sites surveyed off Santa Catalina Island, CA in the summers of 2014 and 2015; B) Image of a dive propulsion vehicle (DPV) with mounted length calibrated lasers and GoPro Hero 3 Black Edition video camera used for giant sea bass surveys; and C) Image of a giant sea bass showing broadside length calibrated laser markings at 10.2 cm.

Survey Methods

Surveys at each site were conducted every two weeks for two months in 2014 and 2015 for a total of 64 survey days. Each visual survey was conducted from 10:00 to 14:00 and consisted of five, three-minute, 100 m x 10 m SCUBA transects (1,000 m^2) using Sea Doo Vs Supercharged Plus Sea Scooter diver propulsion vehicles (DPVs). DPVs were outfitted with two parallel waterproof length-calibrated lasers, set at 10.2 cm apart, and a mounted GoPro Hero3 Black Edition video camera (Fig. 1b). Before surveys began, divers trained using the DPVs in combination with timed fin kicks to cover 100 m in three minutes. The five timed transects per site were spaced at least 50 m apart with each transect randomly stratified in depth from 28 - 6 m to extensively survey the reef at each site. Along each transect, giant sea bass occurring in front of divers and within the transect area were counted, and their size estimated to the nearest 25 cm. Surveys for giant sea bass covered a large area during a short amount of fixed time to aid in reducing biases that may arise during non-instantaneous UVC of large mobile fishes (Ward-Paige et al. 2010, McCauley et al. 2012). In addition, transects were video recorded to help identify separate individuals between sampling periods by size, differences in morphology, physical markings, and spot patterns.

Upon the conclusion of each transect, size-surveys were done by video recording individuals observed at a 90° angle to the video camera with the parallel lasers spaced 10.2 cm apart (Gingras et al. 1998, Colin et al. 2003, Heppel et al. 2012). To reduce possible size estimation error, giant sea bass recorded during size surveys were measured within 2.5 - 3 m of the individual fish. Images of fish from the size-survey videos that displayed broadside and perpendicular to the video camera with visible measurement laser markings (Fig. 1c) were digitally captured and length (cm SL and TL) were estimated using the software program ImageJ (http://imagej.nih.gov/ij/). The lengths obtained from the size surveys were used to validate size estimations taken during transects.

Lengths were converted to biomass (kg/1000 m^2) using the length-weight relationship recently published for this species: kg = (0.0000001)*(SL mm)$^{2.8173}$ (Williams et al. 2013). Age of sized individuals was back-calculated using the inverse of the published von Bertalanffy growth curve (von Bertalanffy 1938) for giant sea bass: $l_t = 2026.2(1\text{-}e^{-0.044(t\text{-}0.345)})$ (Hawk and Allen 2014). The 2014 surveys were conducted during 6/9 - 6/24, 6/28 - 7/12, 7/15 - 8/2, and 8/4 - 8/13/2014 while the seven sites in 2015 were conducted during 6/11 - 6/20, 6/22 - 7/10, 7/11 - 7/31, and 8/4 - 8/11.

In order to provide a historical perspective on the population off Santa Catalina Island, giant sea bass recorded on subtidal surveys conducted from 1965-2013 by the Channel Islands Research Program (CIRP) were generously provided by Dr. Jack Engel (UCSB). CIRP surveys consisted of divers visually surveying the reef between 4 - 21 m in depth for all algae, macro-invertebrates, and fishes within a timed period. Organisms were identified and abundances were estimated on a relative scale from 1 (rare) to 4 (abundant). On surveys where giant sea bass occurred the number of individuals was noted.

Statistical Analyses

The abundance (#/transect) and biomass (kg/1000 m^2) estimates of giant sea bass included many zeros and did not fit the assumptions of normality required for parametric analyses. Numerical and biomass densities of giant sea bass for Site (fixed factor: 8 levels), Year (fixed factor: 2 levels), and Sampling Period (fixed factor: 4 levels) were compared using permutational analysis of variance with PERMANOVA+ for PRIMER-E ver. 6 (Anderson 2001, Anderson and Millar 2004) with individual transects used as samples. The Dwass-Steel-Chritchlow-Fligner Test for All Pairwise Comparisons was then used to test for differences between sites. For length frequency and biomass distribution analysis, lengths (mm TL) were grouped into 100 mm increments to investigate the length, biomass, and age class frequency distributions of the surveyed giant sea bass population off Santa Catalina Island for both the summer of 2014 and 2015. Length Frequencies of giant sea bass encountered in 2014 and 2015 were compared with a Non-parametric Kolmogorov-Smirnov Test using SYSTAT 13 (SYSTAT Software, Inc).

Results

Giant sea bass numerical densities (no. fish/1000 m^2) were not statistically significant among the four sampling periods (*Pseudo-F*=0.92, *P(perm)*=0.48). Despite this lack of significance, total number of individuals observed during surveys in 2014 peaked in late-July and in early July in 2015 (Figure 2) Similar to numbers, biomass (kg/1000 m^2) was not statistically different

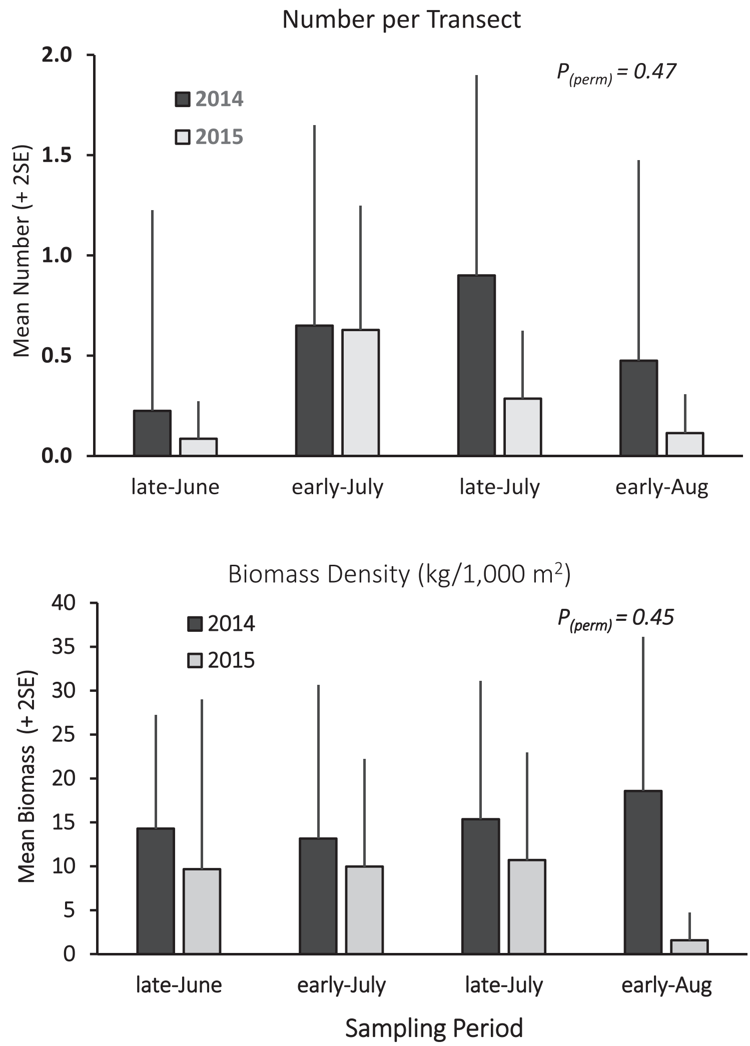
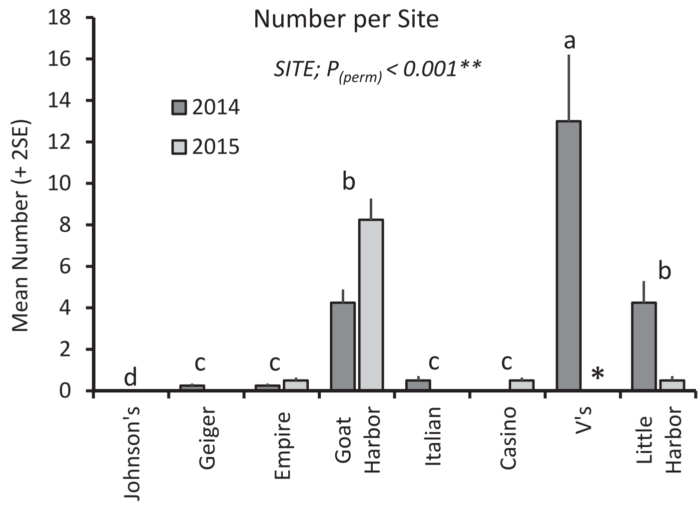


Fig. 2. Mean number of giant sea bass per two-week sampling period (top), and (bottom) mean spawning stock biomass densities (kg/1000 m^2) of giant sea bass per two-week sampling period. Error bars represent 2 standard errors. No significant differences ($P_{(perm)}$ = 0.47; 0.45) were found in temporal distribution of giant sea bass numbers or biomass in either year.

among the four sampling periods in either year (*Pseudo-F* = 0.92, *P(perm)* = 0.45). However, biomass density (Fig. 2) was consistent among the survey periods in both years with the exception of early August when biomass density peaked in 2014 and decreased in 2015.

Giant sea bass were observed at seven of the eight sites around the island (Little Geiger, Empire Landing, Goat Harbor, Italian Gardens, The V's, and Little Harbor). No giant sea bass were observed at Johnson's Rock. Numbers (Figure 3: *Pseudo-F* = 5.88; *P(perm)* $<$ 0.001) and biomass (Fig. 3: *Pseudo-F* = 5.87; *P(perm)* $<$ 0.001) differed significantly among sites over both summers of sampling. In the summer of 2014, aggregations were found at Goat Harbor, The V's, and Little Harbor. The site containing the largest number of giant sea bass was The V's, where 23 were seen on the second sampling and 24 on the third sampling in 2014. Little Harbor and Goat Harbor had the next highest numbers and spawning stock biomass.



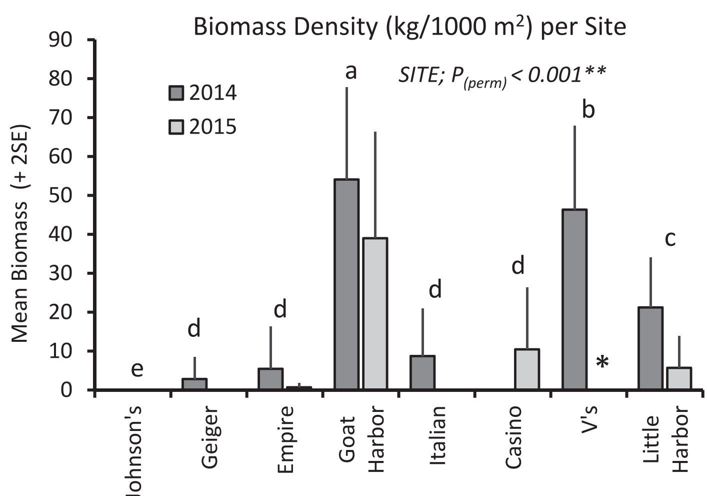


Fig. 3. Mean number of giant sea bass per transect at each sampling site (top) and (bottom) mean spawning stock biomass densities (kg/1000 m^2) of giant sea bass per site during the summers of 2014 and 2015. Sites are arranged the NE end clockwise around the island. Letters (a-e) denote sites not statistically different from one another. (* – no transects conducted in 2015 at the Vs).

An aggregation of ten fish was observed on transects at Little Harbor, while at Goat Harbor an aggregation of six was found. Mean biomass was higher at Goat Harbor (81.2 $\pm$ 29.8 kg/ 1000 m^2) than Little Harbor (34.0 $\pm$ 18.67 kg/1000m^2) due to larger individuals aggregating at Goat Harbor. In 2015, Goat Harbor was the only site to contain an aggregation. The Goat Harbor aggregation averaged 8 giant sea bass per sampling period (3, 19, 7, and 4 individuals). Biomass density at Goat Harbor ranged from 11.03 to 66.67 and averaged 39.67 kg/1000 m^2 in 2015. The remaining sites where giant sea bass were surveyed contained solitary individuals or a single pair.

Size of surveyed giant sea bass ranged from 0.9 - 2.75 m TL. According to the established age-length curve for giant sea bass (Hawk and Allen 2014), the smallest individual (0.7 m TL) was estimated to be 8 years old. The length frequencies of separate individuals that were

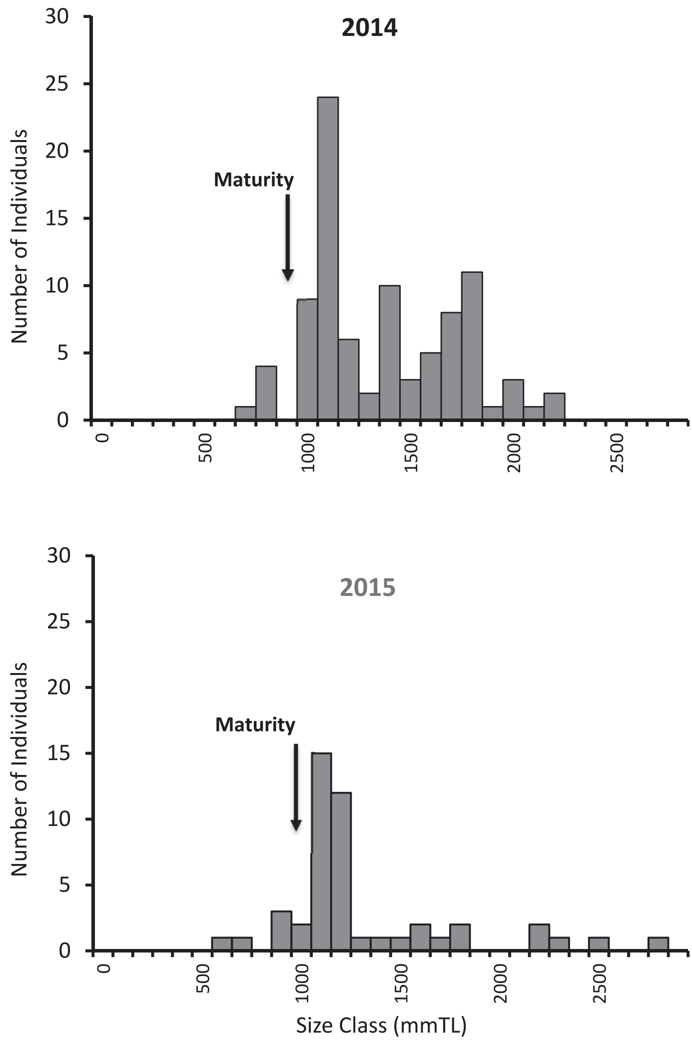


Fig. 4. Length frequencies (mm TL) of separate giant sea bass observed during survey transects in the summers of 2014 and 2015 off Santa Catalina Island. Arrows indicate presumed size at maturity based on estimate size/age estimates from Fitch and Lavenberg (1971).

not significantly different in 2014 and 2015 (K-S test; $p = 0.258$) showed the typical giant sea bass at Santa Catalina Island in 2014 and 2015 to be 1.2 - 1.3 m TL (Fig. 4). However, a large portion (25%) of the population's biomass was found in individuals between 1.9 and 2.1 m TL (Fig. 5). The largest giant sea bass observed occurred in late June in both years. The 1994 to 2003 year-classes dominated the giant sea bass population observed in the summers of 2014 and 2015 (Fig. 6). Based on ages back-calculated from measurements of total length, these eight year-classes constituted 60% of all the giant sea bass observed. Another 16% of the individuals recruited between the years 1982 and 1993 with the remainder recruiting sporadically back to 1954. Overall mean biomass of giant sea bass off Santa Catalina Island during the summer was 25.14 ± 6.57 kg/1000 m^2 in 2014 and 11.96 ± 6.28 kg/1000 m^2 in 2015, with an overall mean biomass of 19.57 ± 4.64 kg/1000 m^2 for both summers. The historical CIRP survey

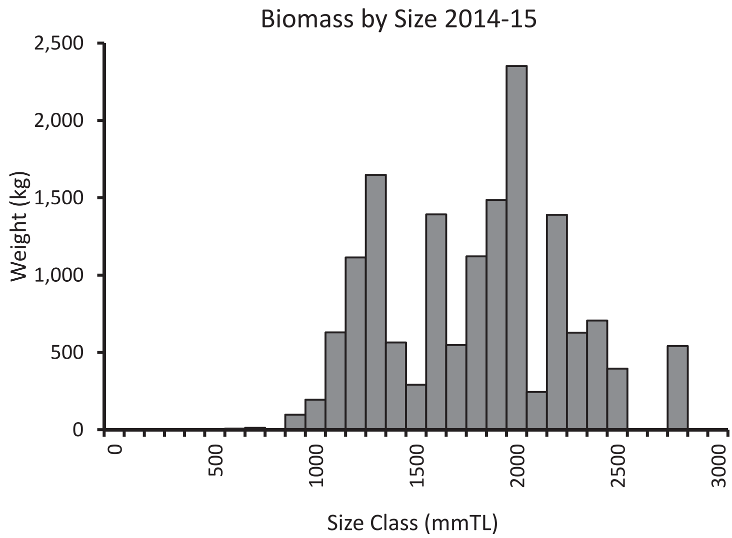


Fig. 5. Total biomass (kg) distribution per size class (mm TL) of giant sea bass observed during survey transects in the summers of 2014 and 2015.

data from 1965-2013 (Figure 7) show one giant sea bass being observed during surveys in 1966 with a 29-year absence until 1996. After 1996, giant sea bass were observed in 1997, 2000, 2001, 2002, 2003, 2006, 2007, 2010, and 2011. The highest number of giant sea bass on CIRP surveys occurred in 2001 with 11 individuals observed.

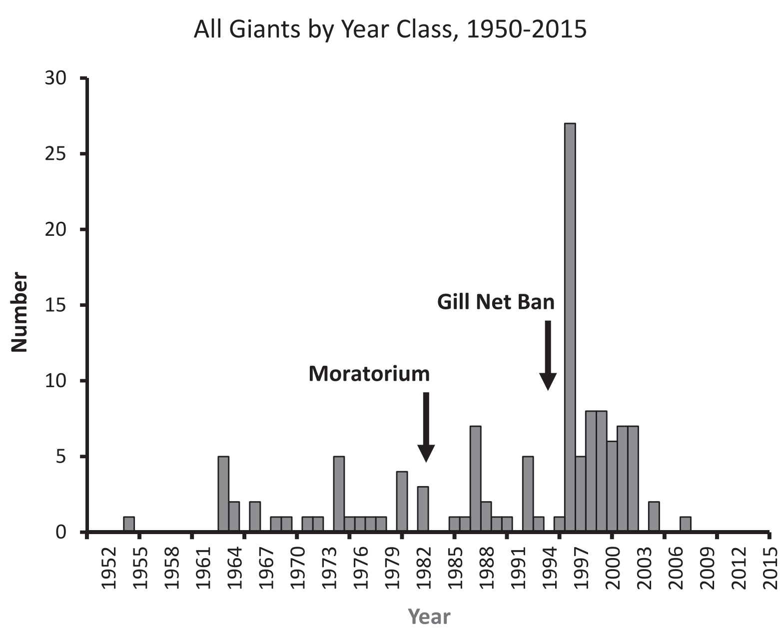


Fig. 6. Year-class strength for giant sea bass for 1950 to 2015 back-calculated from *in situ* measurements of total length converted to age after (Hawk and Allen 2014). Arrows indicate the year that the fishing moratorium was declared (1982) and the year of the Proposition 132 Gill Net Ban (1994) from coastal waters in southern California.

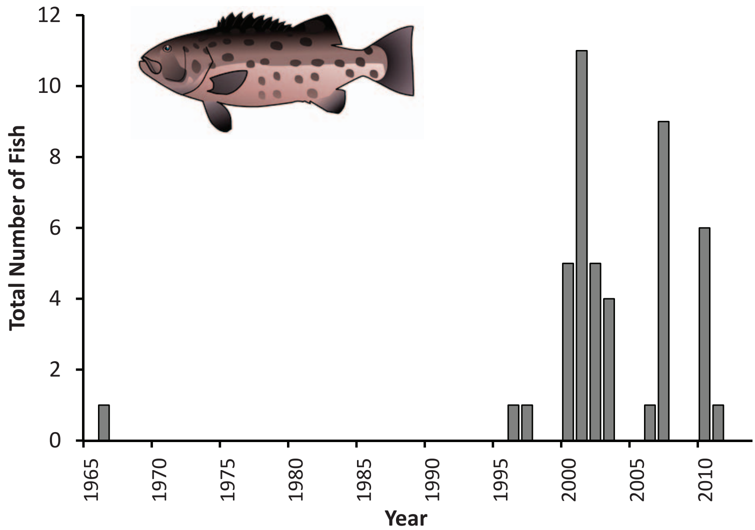


Fig. 7. Giant sea bass observed on SCUBA fish surveys conducted by the Channel Islands Research Program (CIRP) at Catalina Island from 1965-2013. Data courtesy of Dr. John Engle (UC Santa Barbara) funded by the Tatman Foundation.

We observed 44 separate individuals on transects in 2014 and 32 in 2015 based on differences in size, morphology, physical markings, and spot patterns of giant sea bass. If we assume the estimated numerical densities per m^2 are accurate over the depth range of the eight established sites, then about 87 linear km (86,905 m) of coastline around Santa Catalina Island held about 49 giant sea bass in the summer of 2014 and about half that number, about 24, in summer 2015. Similarly, biomass densities estimated that 2.1 metric tons (mt) of giant sea bass occurred around Catalina in 2014 with about 1.0 mt occurring in 2015. The number of individual giant sea bass identified by divers and the number of giants estimated from transect densities were remarkably similar in both years of the study.

Discussion

Altogether, this study provides evidence of the return of giant sea bass to the rocky reefs and kelp forests off Santa Catalina Island, and possibly the Southern California Bight, by documenting new spawning aggregation sites, considerable stock biomass, newly mature individuals recruiting to aggregations, and a large community presence at the island. Overall, abundance and biomass of giant sea bass did not differ greatly among the four sampling periods in 2014 and 2015. The large variation in numbers and biomass during the four sampling periods for both years can be largely attributed to the patchy distribution that resulted in the high number of transects where no giant sea bass were observed.

Of the eight sites, at least three were identified as giant sea bass aggregations off Santa Catalina Island, CA. These sites were located on both the leeward (Goat Harbor) and windward (The V's and Little Harbor) side of the island. Goat Harbor is the only of these three sites where aggregations were encountered in both years of this study. Goat Harbor is also the only aggregation residing in a Marine Protected Area (MPA) as of 2012. The placement of the Long Point State Marine Reserve (SMR) was to protect the best-known aggregation area for giant sea bass off southern California from Long Point to Goat Harbor (CA MLPA South Coast Project 2009), and is a popular site for recreational divers. However, though this site had a consistent aggregation during each of the four sampling periods, it did not possess the largest giant sea bass aggregation. The largest suspected spawning aggregation was found at the V's in 2014 with a total of 23 and 24 individuals occurring on transects during the second and third sampling period at 18 m depth. The individuals at the V's were typically larger, 1.2 - 2.3 m TL. Throughout the summer of 2014 human presence was minimal at this site, as the V's is located in a more remote area of the windward side of the island. However, commercial squid fishing vessels were observed in close proximity to the reef where the giant sea bass aggregation was observed (P.H.H., personal obs.). Unfortunately, the V's site was largely inaccessible to our divers in 2015. The third aggregation site was located on the reefs just outside and west of Little Harbor. The consistency of this aggregation varied. On the third and fourth sampling periods during 2014, 6 and 10 giant sea bass were observed respectively. The aggregation at Little Harbor in 2014 consisted primarily of smaller individuals (eight individuals under 1.2 m TL) compared to the other two aggregation sites at Goat Harbor and the V's. No giant sea bass were seen during surveys at Johnson's Rock in either summer. The Little Geiger and Empire Landing sites contained solitary individuals that were observed sporadically over the two years. Italian Gardens which is also inside the Long Point SMR had either solitary individuals or a single pair of giant sea bass that were likewise only observed sporadically.

If the giant sea bass population off southern California is indeed recovering, then there is likely to be a larger proportion of smaller and younger fish within the population, which could manifest as a positive skew in length frequencies of the population (Heppell et al. 2012). In the case of a spawning aggregation, smaller size classes represent newly mature fish entering the reproductive population. Our results do not show a strong positive skew as the majority of reproductive giant sea bass off Santa Catalina Island were ~1.3 m TL and were estimated to be 18 - 19 years-old. However, smaller individuals were observed during surveys in presumed spawning aggregations off the island. These individuals were estimated to be 10 - 11 years old. Age at sexual maturity has not been adequately explored for giant sea bass, however, Fitch and Lavenberg (1971) estimated sexual maturity to begin between 11 and 13 years of age. Our findings of young giant sea bass within presumed spawning aggregations support the Fitch and Lavenberg (1971) estimates. Based on year-class strength estimates (Fig. 6), these young fish are likely new recruits to the reproductive population off Santa Catalina Island that were born after the 1994 Proposition 132 gill net ban in coastal waters. Our results also suggest that these young individuals were able to find site-specific suspected spawning aggregations that were likely once decimated by overfishing.

Although a large portion of the presumed reproductive population censused in the present study was made up of individuals 1.2 - 1.3 m in total length, this size class did not account for the largest portion of the stock biomass. The size class with the peak biomass was older (estimated to be 32 - 35 years old) and larger (1.9 - 2.0 m TL) individuals. This skew in total biomass distribution toward the larger size classes was also due to several behemoth individuals. In 2014, the largest individual on transect was measured at 2.3 m TL (1.9 m SL) with a back-calculated age of 67 years old and 177.9 kg. However, this was not the largest giant sea bass measured in 2014. An individual that was measured during underwater observations, but did not occur within a survey transect was seen at Goat Harbor and measured 2.70 m TL (380 kg). Similarly in 2015, at the same site (Goat Harbor) and sample period (late June) an individual was measured at 2.75 m (381 kg), and was observed on transect. It is possible that these two observations in 2014 and 2015 could either be of the same individual or two separate individuals. In either case, these would be the largest giant sea bass ever measured, and supports early, unverified accounts of much older and larger giant sea bass (Holder 1910). Giant sea bass in this size range are over the $L\infty$ presented in Hawk and Allen (2014). Although their age cannot be predicted accurately, it is not inconceivable that fish of this size are over 100 years of age.

Similar to Pondella and Allen (2008), fish survey data collected by the Channel Islands Research Program (CIRP) beginning in 1964 suggests a similar trend to the Palos Verdes coast in number of giant sea bass sightings off Santa Catalina Island. From the CIRP surveys only one giant sea bass was observed until the late 1990's and early 2000's to present day. However, although these data suggest a recent return of giant sea bass, historical accounts document fisherman consistently taking 70 - 100 giant sea bass from summer aggregations (Domeier 2001), suggesting that present day aggregation densities are still well under historical levels. The two aggregation sites containing the highest abundance (the V's) and younger individuals (Little Harbor) of the three spawning aggregation sites are currently in unprotected areas where fishing is allowed.

Pre-exploitation biomass for the entire southern California population of the giant sea bass has been estimated to be 1,179 mt (Ragen, 1990). For comparison, our biomass estimates of 2.1 mt and 1.0 mt of standing stock biomass off Catalina Island in 2014 and 2015 were a full three-orders of magnitude lower. If our current estimates of biomass of Catalina Island are extrapolated to the entire southern California coastline, it appears that the current standing stock of the giant sea bass population off southern California, although returning, falls far short of what the natural stocks were prior to exploitation. As others have often cited (cf., Domeier, 2001), it may well be decades before the giant sea bass population recovers to levels appropriate for renewed commercial exploitation.

Despite giant sea bass being a protected species they are often susceptible to barotrauma when caught incidentally. Schroeder and Love (2002) estimated how incidental catch and release mortality of giant sea bass could affect population sizes. Their estimates suggest that 100 giant sea bass, at a standard catch and release mortality rate of 20%, could be completely eradicated through incidental catch and release in just 16 years assuming no immigration. With the aggregation sizes found in our study, the largest being an aggregation of 24 fish, this incidental catch and release mortality rate could decimate the reproductive population off Santa Catalina Island during the summer spawning months. Seasonally established MPAs at identified giant sea bass spawning aggregation sites, similar to those set in place to protect Nassau grouper spawning aggregations in the Caribbean, could aid in reducing the incidental catch of giant sea bass near these areas. Furthermore, monitoring of aggregations after baseline estimates would allow temporal tracking of numerical densities, biomass, and population dynamics of giant sea bass off Santa Catalina Island and other sites within the Southern California Bight. Our study provides an effective way to survey these aggregations, and further surveys of the kelp forest community are needed to document what potential influences a return of a long absent top predator may have to the dynamics of this ecosystem.

Acknowledgments

We want to express our gratitude to the following people for making this research possible. Thank you to Drs. Mark Steele, Mia Adreani, and Peter Edmunds for their invaluable input, insight, and review of this research. Our upmost gratitude goes to those who helped with the challenging field work schedule including Michael Abernathy, Matt Jelloian, Juan Aguilar and the staff at the USC Wrigley Institute for Environmental Studies. Special thanks to Kelcie Chiquillo for field assistance and support. We are also grateful to Drs. Steve Dudgeon (CSUN), Jack Engle (UCSB), Milton Love (UCSB), Douglas McCauley (UCSB), Ed Parnell (SIO), and three anonymous reviewers for their advice and input to various aspects of this study.

This research was supported by funds from the CSUN Nearshore Marine Fish Research Program (NMFRP), CSUN Research and Graduate Studies, Sigma Xi GIAR, and USC Wrigley Summer Fellowships.

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