Final Report: Mortality and Population Abundance of Three Species of Paralabrax off San Diego, California, R/OPCCFRW-3
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Executive Summary

Part I

In collaboration with Scripps Institute of Oceanography (SIO) and the recreational fishing community, the San Diego Oceans Foundation (SDOF) helped implement a study to gain a better understanding of the population status of two bass species. Kelp Bass (*P. clathratus*) and Barred Sand Bass (*P. nebulifer*), have shown signs of long-term decline. The cooperative and transparent design of our research program was the single most important contributing factor to its overall success, and SDOF played an important role with respect to vessel chartering and program outreach. The most important avenue was direct participation in the project via field sampling aboard Commercial Passenger Fishing Vessels (CPFVs) chartered by SDOF. We conducted 51 ¾-day charters in two years from San Diego to Long Beach, which created opportunities for over one thousand anglers to get hands-on experience with field research, and to communicate with project researchers. These trips were highly successful in achieving our goal of tagging and releasing both Kelp Bass and Barred Sand Bass. During these standardized sampling trips, we achieved high catch rates for both Kelp Bass and Spotted Sand Bass, both during and outside their respective spawning seasons, but low catch rates of Barred Sand Bass due to recent declines in spawning aggregation behavior in their traditional spawning grounds. SDOF also played an important role in program outreach and communicating with broader audiences, regularly distributing program updates to the extensive list of SDOF supporters. The collaborative nature of this project was highly successful, and our broad array of outreach efforts was a highly efficient and effective way to educate the public about the program. The overall success of this project was largely due to the extensive collaborative relationships we developed between the fishing, scientific, and fisheries management communities, and we encourage this approach for future studies.

Introduction

Marine recreational fishing plays a vital role in the ecological, social, and economic constitution of California. In 2006, California recreational anglers generated the highest sales in the nation (by state) at an estimated $3 billion on retail goods and services (Gentner & Steinback 2008). In 2013, California recreational anglers contributed $2.8 billion to the state economy, and spent over 5.3 million angler-days fishing in marine waters (CADFW 2014 Annual Forum Report). Given both the value and impact of recreational fisheries in the state, there is a critical need for detailed and quantitative information specific to fish populations. However, even species with extensive fisheries histories that are relatively well studied have nonetheless exhibited signs of long-term decline, and still lack up-to-date stock status information. One such group of species is in the genus *Paralabrax*, which consists of Kelp Bass (*P.clathratus*), Barred Sand Bass (*P. nebulifer*), and Spotted Sand Bass (*P. maculatofasciatus*). These species have

fisheries data that date back to the 1930s, with population analyses dating back several decades (e.g., Clark 1933, Collyer 1949, Collyer and Young 1953, Young 1963), yet signs of population declines have been shown for two of the three species (Sweetnam 2009, Jarvis et al. 2010, Erisman et al. 2011, Jarvis et al. 2014). These two species, Kelp Bass and Barred Sand Bass, consistently rank among the top recreational fisheries by landings. Pooled CPFV logbook data for all targeted fishes in California from 1936-2008 indicate that Kelp Bass ranked 1st in number of fish kept for a single species (excluding "unidentified rockfishes"), with approximately 20.6 million fish landed during the 67-year period. Barred Sand Bass ranked 4th overall (excluding Pacific mackerel and "unidentified rockfishes") with 12.7 million landed. However, both species were often pooled into a "rock bass" category (ranked 5th overall) prior to the mid-1970s, which accounts for an additional 11.9 million fish (Jarvis et al. 2014). Thus, Kelp Bass and Barred Sand Bass likely represent the top two species (excluding Pacific mackerel and "unidentified rockfishes") landed on CPFVs throughout the recorded history of recreational fishing in California. However, signs of their long-term declines have become evident (Erisman et al. 2011), which has been due to a combination of fishing and oceanographic factors (Jarvis et al. 2014).

The goal of our project was to work cooperatively with the recreational fishing community, the California Dept. of Fish and Wildlife, and non-profit organizations to conduct a quantitative analysis of CPUE, length frequency, and post-release mortality for all three bass species in the San Diego county coastal area, both inside and outside local marine protected areas (MPAs). The San Diego Oceans Foundation's goal was to outreach to the community and inform them of the importance of reporting tagged fish, which included informational meetings, and incentives to local fishermen. There are primarily two MPA types located in our study area. These include State Marine Reserves (SMRs), which prohibit all extractive activities, and State Marine Conservation Areas (SMCAs), which are primarily no-take, but include some allowances for recreational take only. This information will shed light on functionality of both old and new MPAs, responses of each species to recently increased minimum size limits, and the often overlooked impacts of catch-and-release fishing.

Methods

Study Area

Sampling trips were conducted from Long Beach, California south to the US-Mexico border, although the primary research sites consisted of north San Diego County, La Jolla, Mission Bay, Point Loma, San Diego Bay, and Imperial Beach off the San Diego County coast (Fig. 1). The north San Diego County area was divided into two sites, which consisted of the Swami's State Marine Conservation Area (SMCA) established in 2012, and the adjacent Encinitas area that has always been open to fishing. The La Jolla area was divided into three sites, which consisted of 1) the Matlahuayl State Marine Reserve (SMR), which was expanded and renamed in 2012 from the former La Jolla Ecological Reserve implemented in 1971, 2) La Jolla (has always been open to fishing), and 3) the South La Jolla SMR, which was recently established in 2012. Sites were chosen based on suitable habitat and known popular fishing locations for each of the three species. Adult Kelp Bass generally are targeted along open coast rocky reef and kelp bed habitat, Barred Sand Bass are targeted in bay and coastal sand flats near rocky reefs, and Spotted Sand Bass are fished in primarily soft bottom bay habitats. As such, primary Kelp Bass sites included La Jolla and Point Loma kelp beds, Barred Sand Bass sites

included Imperial Beach and north San Diego County, and Spotted Sand Bass sites were located in Mission Bay and San Diego Bay.

Field Methods

Two approaches were used to implement tagging efforts for the three bass species. The first consisted of ¾-day charters aboard Commercial Passenger Fishing Vessels (CPFVs) in collaboration with the San Diego Oceans Foundation, a local 501(c)3 non-profit organization. By chartering local sportfishing vessels, the San Diego Oceans Foundation made it possible for volunteers to work along scientists to tag bass. These CPFV charters focused on sampling coastal sites only (not sites inside bays), and the primary target species for these trips were both Kelp Bass and Barred Sand Bass. The second sampling approach was with private vessels in the two bay sites, Mission Bay and San Diego Bay. These trips focused primarily on tagging the third species of *Paralabrax*, Spotted Sand Bass.

The CPFV tagging charters were separated into sampling periods based on season during the two-year study (Table 1). Seasons consisted of fall 2012 (Sep-Nov), summer 2013 (Jun-Aug), fall 2013 (Sep-Nov), and summer 2014 (Jun-Aug). Each individual charter focused specifically on one site and one target species. This yielded site-specific CPUE for both the target species as well as all bycatch that was associated with each target species. Volunteer recreational anglers were invited aboard each of these charters to assist with the fishing, and SIO researchers were aboard for catch data collection. All fish caught were measured, recorded, and released immediately after capture. The information collected for each individual fish caught consisted of the species, standard length (mm), latitude-longitude, time, depth, and physical condition of the fish.

Catch-and-release mortality was measured using two methods. First, mortality events were observed visually from the boat, yielding an initial mortality estimate. However, initial post-release mortality rates are likely to be underestimates of overall catch-and-release mortality given that they represent only immediate mortality events that were observable from the boat. Thus, the second method consisted of fish being held in moored net pens located in San Diego Bay for a 10-day assessment period, yielding a short-term post-release mortality estimate. Fish from a local annual fishing tournament in both 2013 and 2014 were released into these net pens, and then all fish were released after the temporary holding period. All mortality events during the holding period were recorded.

Outreach was an important method to encourage reporting tagged bass. The San Diego Oceans Foundation (SDOF) educated the public about tagging research at local events such as fishing tournaments and fishing shows. Since bass is one of the most commonly caught at these tournaments, it is easy to tag fish after they have already been caught. SDOF worked with the American Sportfishing Association, Fred Hall and Sportfishing Association of California to educate the organizations on fish tagging research. SDOF held quarterly award events for fishermen who report captured fish. SDOF encouraged fishermen to report any tagged calico, barred sand bass, or spotted sand bass that they caught to provide Department of Fish and Widlife with as much data as possible to make an accurate population assessment. To add incentive, SDOF held monthly raffles where a winner wins a $200 gas gift card. SDOF outreached to volunteers to sign up for free chartered tagging trips to go out with Scripps scientists.

Results

Our tagging efforts consisted of a total of 51 individual ¾-day tagging charters aboard local CPFVs (Table 1), and 151 private vessel trips conducted from Sep 30, 2012 - Sep 17, 2014. Tags were deployed at 11 sites between Long Beach, California and the U.S.-Mexico border, including two State Marine Reserve sites (Matlahuayl SMR and South La Jolla SMR) and one State Marine Conservation Area (Swami's SMCA). A total of 19,327 fish from 71 species were caught-and-released during the trips, although Pacific Jack Mackerel (*Trachurus symmetricus*), Chub Mackerel (*Scomber japonicus*), and Jacksmelt (*Atherinopsis californiensis*) were not recorded due frequently high catches that often interfered with data collection for other species. A total of 12,581 Kelp Bass, 1079 Barred Sand Bass, and 2353 Spotted Sand Bass were caught and released during this period (Table 2). The basses represent 84.2% of the total records in the catch dataset, and the remaining 15.8% bycatch consisted primarily of Pacific Barracuda (2.45%), Brown Rockfish (1.76%), Kelp Rockfish (1.51%), Bonefish (1.36%), Yellowfin Croaker (1.06%), and 60 additional species with less frequent catches (Table 3).

Discussion

Population declines of Kelp Bass and Barred Sand Bass were documented in the 1940s due to commercial overfishing, which ultimately led to a ban on commercial fishing for these species in 1953 (Young 1963). While recreational fishing is considered to have lesser impacts than fishing on commercial scales, the popularity of these bass species among the recreational fleets has resulted in over 45 million bass landed aboard CPFVs alone in California waters since 1936 (CDFW logbook data). Overfishing is thus a concern for these species, not only because of the sheer numbers landed, but also due to the social and economic importance of the species. In addition, the regulatory history for these species has been dynamic throughout the history of the fishery (Jarvis et al. 2014), and the California Department of Fish and Wildlife recently implemented new individual bag limits and size limits for the basses, as well as new MPAs for all species. An understanding of the response of the bass fisheries to these harvest control rules and spatial regulations can help to establish management actions that ultimately facilitate a productive and sustainable fishery.

As expected, Kelp Bass CPUE was highest during the summer spawning months (Jun-Aug), although even the relatively lower catch rates incurred during the fall sampling season (Sep-Nov) translated to several hundred fish caught per trip in many cases. However, there were no site-specific differences in Kelp Bass CPUE, which was largely driven by a few days of exceptionally high catch rates outside MPA boundaries in La Jolla. In general, CPUE is impacted by numerous factors that can result in high variability in estimates. In our case, catch rates were potentially influenced by angler skill level, bait availability (e.g., anchovy, sardine, squid), and physical conditions, all of which translated into more variable CPUE. Catch-per-unit-effort may not be a particularly sensitive metric for the assessment of abundance differences among sites (Beverton and Holt 1957, Hilborn & Walters 1992), and as such may not be sufficient to detect modest differences in abundance. We also measured no significant spatial differences in CPUE for the basses relative to MPA boundaries. The South La Jolla SMR is likely still too young to show a significant MPA effect; however, the Matlahuayl SMR has been protected for over four decades, yet no MPA effect was detected relative to CPUE. Parnell et al. 2005 found limited signs of an effect within this same MPA, and highlighted the limited value of small MPAs. Hastings et al. 2014 also found similar fish communities inside and outside this MPA. The extent

of the Matlahuayl SMR was expanded in 2012, and this increase in size may yield increased fish abundance in the future.

Catch rates for Barred Sand Bass were far lower than expected, despite focusing our sampling efforts at known spawning locations during spawning season (Jun-Aug). Based on both landings records and personal communication with CPFV captains, Barred Sand Bass spawning aggregations did not form as expected at their traditional southern California sites, which normally include Imperial Beach, San Onofre, Huntington Beach flats, and Ventura flats. Such broad-scale alteration of traditional spawning behavior had never been documented since the aggregations were first discovered decades earlier. In the San Diego area, the 2013 and 2014 spawning seasons consisted of much smaller isolated groups of spawning Barred Sand Bass that were found on isolated rocky reefs off Imperial Beach, and in the Point Loma kelp forest, and these smaller "satellite" aggregations were targeted heavily by local CPFVs. Barred Sand Bass landings do tend to be lower during warmer years, and 2014 was characterized by anomalously warm sea surface temperatures (Bond et al. *in press*, Kintisch 2015), with an annual mean value that was surpassed only once in 1997 by temperatures resulting from El Niño (Scripps Institution of Oceanography Pier water temperature data). The warm waters in 2014 brought offshore species within range of ½-day CPFVs, so most of these vessels were targeting these offshore species when they would normally target Barred Sand Bass. However, 2013 was much closer to average temperatures extending back to the late 1970s, yet Barred Sand Bass spawning aggregations were virtually absent during both 2013 and 2014, and at all other traditional southern California aggregation sites during both years. Thus, it is likely that factors in addition to warm temperatures have impacted the species.

Understanding the mortality rates associated with catch-and-release angling is a necessary part of any effort to assess cumulative fisheries impacts. All three of the basses are targeted by a significant portion of the recreational fishing community for catch-and-release purposes only. California Recreational Fisheries Survey data from 2004-2013 indicate that 73% of all Kelp Bass, 55% of all Barred Sand Bass, and 95% of all Spotted Sand Bass are released by recreational anglers (CalCOFI report 2014). We found that both initial and short term mortalities associated with catch and release are surprisingly low at 1.84% and 3.1%, respectively. The CDFW currently assumes a 10% mortality rate associated with catch-and-release. While this may be high relative to the measurements in this study, it also represents a conservative approach for long-term management of the stocks. Our estimates of mortality may under-estimate the total long-term mortality associated with catch-and-release. However, given that catch-and-release mortality usually occurs within just a few days following catch-and-release (Aalbers et al. 2004, Lowe et al. 2009), it seems unlikely that extending the duration of our holding study would influence our findings. Additionally, the stress of catching and holding the fish in the net pen after an all-day fishing tournament likely imposes additional stress to the fish, with a concurrent increase in the risk of mortality. As such, we believe our estimates provide an accurate estimate of initial and short-term catch-and-release mortality.

Spatial and temporal analyses of CPUE and length frequency, as well as estimates of initial and short term post-release mortality will ultimately help to inform future stock assessments of the three bass species. This will be especially true when combined with individual growth and movement data, as well as population abundance and mortality estimates that are the subject of a separate study using the same dataset. The extensive stakeholder collaborations we developed as part of this study were vital to our research success. The

scientific community, southern California fishing community, the San Diego Oceans Foundation, and California Department of Fish and Wildlife biologists all combined their knowledge, expertise, and labor to address specific needs for local fisheries management. Hanan and Curry (2012) had similar success with the recreational fleet in Southern California, and tagged 32,366 rockfish during a 4-year period in southern California. Additionally, the success of the California Reef Check Program demonstrates that recreational enthusiasts can serve as citizen-scientists that provide useful data for subtidal MPA monitoring (e.g., Hodgson 2000). The recreational fishing community is a valuable source of information fisheries studies, and future research efforts would significantly benefit from such collaborative partnerships not only with respect to data collection, but by also gaining increased research validation through stakeholder participation. Ultimately, the success of this project was largely due to the collaborative effort between the volunteer, scientific, and fishing communities.

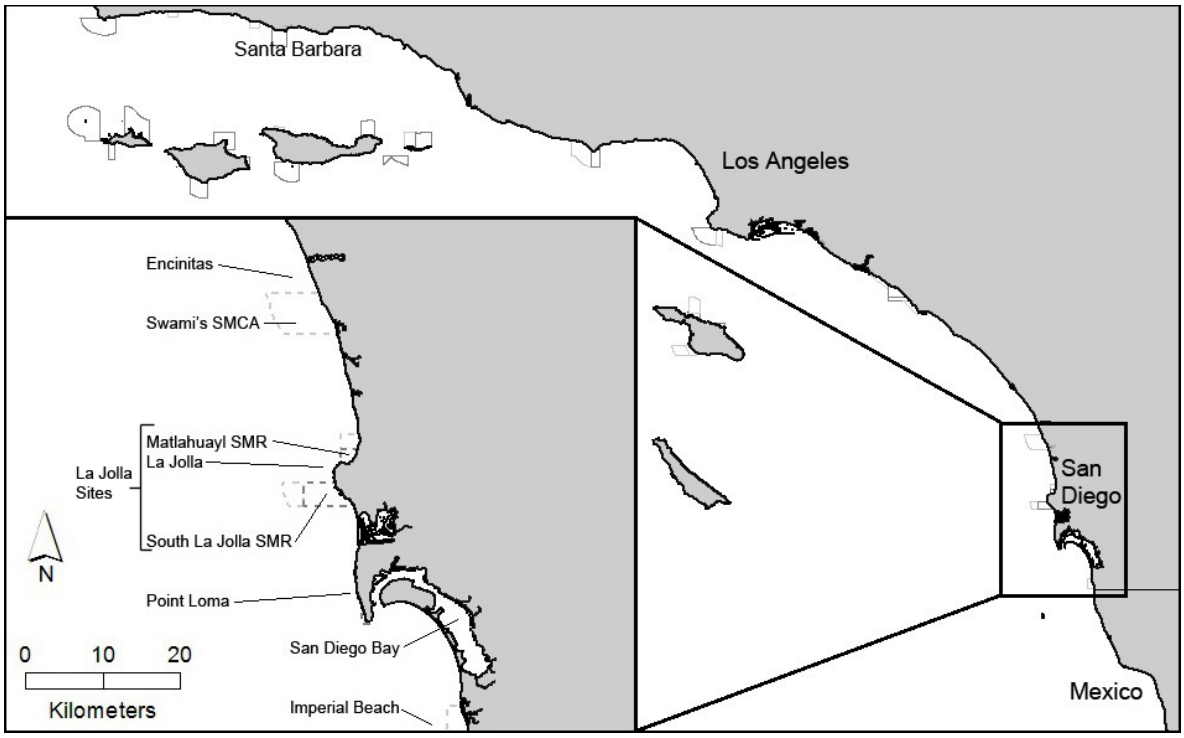

Figure 1. Map of sampling sites off San Diego, California, including MPA boundaries. Dark gray dashed lines represent State Marine Reserve (SMR) boundaries, and light gray dashed lines represent State Marine Conservation Area (SMCA) boundaries.


Image 1. San Diego Oceans Foundation volunteer holding a large calico she caught aboard the Sea Watch.

Sites	Inside / Outside	Fall 2012	Summer 2013	Fall 2013	Summer 2014
Matlahuayl SMR	inside	3	2	3	3
La Jolla	outside	3	2	3	2
South La Jolla SMR	inside	3	2	3	2
Point Loma	outside	3	2	3	2
Imperial Beach	outside		3		3
Long Beach	outside		1		
Mission Beach	outside				1
Encinitas	outside		1		
Swami's SMCA	inside		1		

Table 1. Number of CPFV sampling charters by site and sampling season. Sites are separated by location inside or outside of MPAs, which include Matlahuayl SMR (La Jolla Cove), South La Jolla SMR, and Swami's SMCA (Encinitas).

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Financial Report

The budgeted costs were reflective of actual costs.

A. SALARIES AND WAGES			Year 1 - 2012-13				Year 2 - 2013-14			Cumulative	
Staff Title/Function	# of Hours or Months CFR	Rate	CFR	Cost-Share	# of Hours or Months CFR	Rate	CFR	Cost-Share	Hours or Months	CFR	Cost-Share
1. John Valencia, Executive Dir. (Past)	1.90 mo	5000.00	9,500	0	0.00 mo	5000.00	0	0	2	9,500	0
2 Volunteers	900 hrs	19.26	0	17,334	800 hrs	19.26	0	15,408	1,700	0	32,742
3. Sam Harrod, Interim Executive Dir.					1.10 mo	5,000.00	5,500	0	1	5,500	0
TOTAL SALARIES AND WAGES			9,500	17,334			5,500	15,408		15,000	32,742
B. FRINGE BENEFITS			0	0			0	0		0	0
TOTAL SALARIES, WAGES, FRINGE BENEFITS (A+B)			9,500	17,334			5,500	15,408		15,000	32,742
C. PERMANENT EQUIPMENT				0			0	0		0	0
D. EXPENDABLE SUPPLIES (Prizes)			2,500	0						2,500	0
E. TRAVEL											
Domestic				0				0		0	0
Foreign				0				0		0	0
F. OTHER COSTS EXCLUDING TUITION REMISSION (charter bo			47,200	0			45,250	0		92,450	0
G. TUITION/REMISSION				0				0		0	0
H. SHIP TIME				0			0	0		0	0
I. TOTAL DIRECT COS *Indirect*	CFR Yr 1 Base	C-S Base	59,200	17,334	CFR Base	C-S Base	50,750	15,408		109,950	32,742
J. INDIRECT COSTS *Base*	57,200		8,880	0	52,750		7,613	0		16,493	0
K. TOTAL PROJECT CO *Rate*	15%		68,080	17,334	15%		58,363	15,408		126,443	32,742
Cost-Share Percentage											25.9%

Outreach
Outreach was an important method to encourage reporting tagged bass. The San Diego Oceans Foundation (SDOF) educated the public about tagging research at local events such as fishing tournaments and fishing shows. Since bass is one of the most commonly caught at these tournaments, it is easy to tag fish after they have already been caught. SDOF worked with the American Sportfishing Association, Fred Hall and Sportfishing Association of California to educate the organizations on fish tagging research. SDOF held quarterly award events for fishermen who report captured fish. SDOF encouraged fishermen to report any tagged calico, barred sand bass, or spotted sand bass that they caught to provide Department of Fish and Widlife with as much data as possible to make an accurate population assessment. To add incentive, SDOF held monthly raffles where a winner wins a $200 gas gift card. SDOF outreached to volunteers to sign up for free chartered tagging trips to go out with Scripps scientists. Data handling and availability via http://www.cooperativefishtagging.org/.

In the Media

- San Diego Oceans Foundation: sdof.org/programs/collaborative-fisheries/seabass-restoration/
- Cooperative Fish Tagging: www.cooperativefishtagging.org
- CA Sportfishing: http://www.californiasportfishing.org/#!Caught-a-Tagged-Bass/c24oi/E62277B5-6736-44A8-B4B8-9D90BD210651
- SD Earth Times: http://www.sdearthtimes.com/et1102/et1102s11.html
- The Clairemont Times: http://www.clairemonttimes.com/2015/02/01/61431/fish-tagging-project-off-the-coast-of-san-diego
- The Log: http://thelog.com/Article/Anglers-Can-Help-in-Coastal-Bass-Tagging-Study
- The Semmens Laboratory: http://www.semmenslab.org/myblog/research/
- La Jolla Light: http://www.lajollalight.com/news/2012/oct/31/scripps-researchers-enlist-the-curious-in-fish/
- San Diego Union Tribune: http://www.sandiegouniontribune.com/news/2013/nov/15/tagging-study-bass-/
- WesternBass.comL http://www.westernbass.com/article/sportfishers-to-help-researchers-study-marine-bass-off-san-diego

Catch Reporter App:

- Apple Devices
- Android Devices

Image 1. San Diego Oceans Foundation volunteer holding a large calico she caught aboard the Sea Watch.

Image 2. Two volunteers with calico bass.

Image 3. Lyall Belquist tagging a bass.