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RESEARCH ARTICLE

The worth of giants: The consumptive and non-consumptive use value of the giant sea bass (*Stereolepis gigas*)

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Abstract

1. Although the economic value of wildlife historically has been attributed to its consumptive use, the global growth of ecotourism has expanded wildlife valuation to include non-consumptive uses. In California, the critically endangered giant sea bass (*Stereolepis gigas*) is paradoxically both a flagship species in the recreational dive industry and regularly sold in California's commercial fisheries when incidentally caught. The differences in the economic value of *S. gigas* to these two key stakeholders – commercial fishers and recreational scuba divers – were explored.
2. The average annual landing value of *S. gigas* was US$12 600, this value was determined using California commercial fishery landing receipt data. In contrast the estimated average value of *S. gigas* to recreational divers was US$2.3 million per year. The non-consumptive use value was calculated by approximating the annual number of recreational charter boat divers and determining divers' willingness-to-pay for a *S. gigas* sighting.
3. Stated landings volumes of *S. gigas* appear to represent a minimum annual extraction of 2% to 19% of the *S. gigas* population. Using self-reported fishery catch location data, *S. gigas* bycatch hotspots were identified and used to inform suggestions for strategic spatial and temporal closures.
4. Overall, these results highlight the value of giant sea bass beyond fisheries and underscore the importance of incorporating non-consumptive values when developing harvest policies and marine management plans.

KEYWORDS

contingent valuation, species management, wildlife economic value, wildlife-viewing

1 | INTRODUCTION

Historically, the primary recognized value of wildlife, from elephants to seahorses, has been the value that can be obtained through their harvest and direct use. Economic forces, such as overexploitation and coastal and land development, are the primary drivers of declining wildlife populations and species extinctions (Barnosky et al., 2011; Jackson et al., 2001; Rosser & Mainka, 2002). However, some species may have substantial economic value that extends beyond traditional use for consumption. Explicitly accounting for these alternative values can, in certain cases, provide a more complete view of a species' worth and lead to more informed species management.

The economic value of an ecosystem or a species can be categorized as either use or non-use values. Non-use value is the intrinsic value of a species' or ecosystem's existence regardless of our interaction with it (Pascual et al., 2010). Use values can be split into at least two categories: consumptive use values, where the goods produced by an ecosystem, or the extraction of a species, can be consumed (e.g. fisheries) and non-consumptive use values, where the species or ecosystem is valued for our desire to interact with it (e.g. whale watching) (Pascual et al., 2010). The consumptive use value of wildlife, particularly marine species, is readily apparent. Globally, wild fish capture in 2014 was 93.40 million tonnes (FAO, 2016) and in the United States alone, the value of the 4.30 million tonnes of wild fish landed that year amounted to US$5.45 billion (National Marine Fisheries Service, 2015). Thus, interest in preserving this valuable resource exerts considerable influence on national and international policy. However, there is increasing awareness of the non-consumptive use values of wildlife to the public and the importance of using these values to better inform management of certain species (Lew, 2015).

Along the coast of California and Baja California, giant sea bass (*Stereolepis gigas*) hold a unique ecological position in the local kelp forest system as the largest teleost carnivore, weighing up to 253 kg (Eschmeyer & Herald, 1983). This slow-growing fish was once a valuable species in California markets. Its commercial fishery began in the late 1800s and peaked in 1932 at over 100 tonnes (Domeier, 2001). Increases in fishing pressure led to depletion in *S. gigas* numbers and the crash of the fishery in the 1970s (Domeier, 2001). The fishery collapse led to a suspension of the *S. gigas* fishery in 1981. However, regulations still allowed the take of two incidentally caught fish per trip in the commercial set gillnet and trammel net fisheries, which principally target white sea bass (*Atractoscion nobilis*) and California halibut (*Paralichthys californicus*) (Domeier, 2001; National Marine Fisheries Service, 2013). In 1988, given the continuing population decline of *S. gigas*, this regulation was amended to allow the take of only one incidentally caught fish per trip (California Fish and Game Code Section 8380, 2016).

Evaluations of the population status of *S. gigas* in 1996 led to it being classified as critically endangered by the IUCN Red List (Cornish, 2004). *Stereolepis gigas* has never, however, been listed as a threatened or endangered species by the State of California (CADFW, 2017). Recent work suggests that southern California *S. gigas* populations may be recovering, likely due to the banning of inshore gillnets in 1994; however, their numbers remain far below pre-exploitation levels (House, Clark, & Allen, 2016; Pondella & Allen, 2008).

Charismatic fauna are incidentally caught in many fisheries, and are either retained owing to some commercial value (e.g. elasmobranchs) or discarded (e.g. seabirds, dolphins) (Croll et al., 2016; Lewison et al., 2014; Lewison, Crowder, Read, & Freeman, 2004). In California, incidentally caught *S. gigas* are legally sold at the landing port and are regularly found in local fish markets, giving this source of bycatch monetary value to fishers. In addition to their value in fisheries, *S. gigas* are also a highly regarded underwater attraction to California's sizeable recreational scuba diving industry (Diving Equipment and Marketing Association (DEMA), 2014). Their bold and curious nature often results in close encounters with divers. These encounters, in conjunction with the their large size, makes them a charismatic and desirable underwater sighting (Figure 1).

FIGURE 1 Giant sea bass (*Stereolepis gigas*) and scuba diver in southern California kelp forest. Photo: J. McClain

Comparisons of the consumptive and non-consumptive values of a subset of other marine megafauna (e.g. reef sharks and manta rays) have provided useful information to species management approaches that maximize value to local communities and stakeholders (Anderson, Adam, Kitchen-Wheeler, & Stevens, 2011; Clua, Buray, Legendre, Mourier, & Planes, 2011; Vianna, Meekan, Pannell, Marsh, & Meeuwig, 2010). Such values have not yet been estimated or compared for *S. gigas*.

Contingent valuation methods provide one mechanism for assigning dollar values to values that do not typically involve market purchases or cash flow by asking respondents for a willingness-to-pay for a specific good (Mitchell & Carson, 1989). Values derived from contingent valuations provide a hypothetical dollar value for a good, not a present or future profit. However, these valuations can provide important information regarding stakeholder preference for the conservation or maintenance of a good or resource (Sanchirico, Lew, Haynie, Kling, & Layton, 2013).

Reducing incidental catch of charismatic species, many of which are valued for recreational viewing (e.g. sharks and cetaceans), is a pressing issue in conservation and fisheries management (Lewison et al., 2004, 2014). Identifying incidental catch hotspots using catch data can inform management strategies for reducing non-target species mortality and preserving recreationally valued species (Cambiè, Sánchez-Carnero, Mingozzi, Muiño, & Freire, 2013; Grantham, Petersen, & Possingham, 2008; Lewison, Soykan, & Franklin, 2009).

Using landing receipt data and contingent valuation surveys, this study provides the first comparison of the consumptive value and estimated non-consumptive use value of the critically endangered *S. gigas* to two important stakeholders, commercial fishers and recreational scuba divers. The results indicate that *S. gigas* are highly valued as a non-consumptive resource, demonstrate the importance of incorporating multiple values when evaluating outcomes of marine management strategies and policy, and provide suggestions for potential management of this important species by using catch location data derived from the landing receipts.

2 | METHODS

2.1 | Value to fishers

California Department of Fish and Wildlife (CADFW) landing receipt data from all commercial fishing trips between 2006 and 2015 were used to determine contemporary average price per whole fish, average size (kg) of fish caught, annual gross value of *S. gigas* to the entire California commercial fleet, and the number of *S. gigas* landed per year. Given that the CADFW regulation during this period only permits fishers to land one incidentally caught *S. gigas* per fishing trip, each landing receipt in the data was assumed to refer to a single landed fish. CADFW landing receipts were also used to determine the average annual value of the target fishery (*A. nobilis* and *P. californicus*) between 2006 and 2015.

Although *S. gigas* are occasionally hooked by recreational fishers, in California recreational take of this species is prohibited. For this reason, an estimate of the consumptive value of *S. gigas* to recreational fishers was not included in the study.

2.2 | Value to divers

2.2.1 | California divers

An estimate of the annual number of charter boat diver days (divers diving from charter dive boats, as opposed to shore diving) who dive south of Point Conception, a core area within the geographic range of *S. gigas* (Domeier, 2001), was generated to calculate the annual non-consumptive value of *S. gigas* to the California scuba diving community. Although California also has a significant private vessel and shore-diving scuba diver demographic, only the value to charter boat divers was considered as this can be most meaningfully and accurately assayed.

A list of all known California dive vessel operators who operate south of Point Conception was compiled using vessel registry lists and key local informant surveys (n = 40) and each boat's maximum stated dive passenger capacity was noted using publicly available vessel listings. All 40 dive vessel operators were contacted, but only a subset (n = 17) were responsive to a survey aimed at obtaining information on their average number of trips per year (t) and average passenger capacity (c) on said trips. Total number of diver days (d) per year for each vessel was calculated as

$$d = t\ (c \times s) \tag{1}$$

where s refers to maximum stated dive passenger capacity for each vessel, and summed these values to provide total number of diver days per year for all surveyed vessels (D_s) (see Table 1 for summary of variables).

Estimates of number of diver days per year for all vessel operators that were not surveyed ('non-surveyed vessels') were generated using values acquired from surveyed vessels. Because the subset of the surveyed vessels was not randomly selected, but rather a result of vessel operator responsiveness, post-stratification sample weighting was used to adjust for missing data from non-surveyed vessels. Post-stratification sample weighting is commonly used to account for non-responses and missing data and reduces potential bias by incomplete representative sampling of a population (Brick & Kalton, 1996; Little & Rubin, 1989) and has previously been used in data regarding surveyed vessels (Lew, Himes-Cornell, & Lee, 2015). Two weighting factors were used in the weighting adjustment: home port location and vessel passenger capacity (see Supplementary material, Appendix A, Table A.1 for details). Once weighted, surveyed vessels were then binned into three groups based on their stated maximum passenger capacities (≤ 6 divers, 7–29 divers, 30–40 divers). Basic economies of scale dictate that per-passenger operational cost should decrease as passenger capacity increases, thus average operating capacity likely differs between groups. Weighted average number of trips per year and average capacity per trip were then averaged across vessels for each of the vessel groups to obtain t_a (weighted average number of trips per year) and c_a (weighted average capacity per trip) for each of the three vessel groups (Table A.2). Using the following formulae:

$$d_a = t_a\ (c_a \times s) \tag{2}$$

$$D_e = d_a \times n \tag{3}$$

where s is maximum stated capacity for each vessel and n is the number of vessels in each vessel group, d_a (average number of diver days per vessel per year) and D_e (estimated number of diver days in a year) were calculated for each vessel group. The sum of the D_s and the D_e values for the three vessel groups provides D_t, the total estimated number of charter boat diver days in southern California per year (Table 1). A supplementary conservative estimate of total diver days per year, D_c, was also generated using the lowest responses for average capacity and average trips per year (Table A.3). A non-weighted estimate was also generated for comparison (Table A.3).

2.2.2 | Non-consumptive use value survey

The target demographic for the non-consumptive value survey was scuba divers who dive off the California coast. After conducting a preliminary survey of 28 scuba divers during observational ride-alongs on dive trips and southern California regional scuba club meetings in 2014, divers were surveyed from August to December 2015. Mailed surveys and face-to-face interviews are the more commonly used surveying techniques; however, recent studies have not found a significant difference in data quality and estimates from contingent valuation surveys between these and on-line surveys (Fleming & Bowden, 2009; Lindhjem & Navrud, 2011; Marta-Pedroso, Freitas, & Domingos, 2007). Thus, an on-line valuation survey was designed in order to maximize reach to scuba divers. The on-line survey was distributed to southern California scuba diving club e-mail lists and posted on regional scuba diving on-line magazine websites.

Respondents were asked to provide general information regarding their scuba diving habits and experience in and outside of California, as

TABLE 1 Variables and definitions for diver day calculations

Variable	Definition
c	Average capacity per trip for each surveyed vessel. Value is expressed as a percentage of maximum stated capacity.
c_a	Average capacity per trip averaged across all vessels for each vessel group. Value is expressed as a percentage of maximum stated capacity.
d	Dive days per year for each surveyed vessel.
d_a	Average diver days per year averaged across all vessels for each vessel group.
n	Number of vessels in each vessel group.
t	Average number of trips per year for each surveyed vessel.
t_a	Average number of trips per year averaged across all vessels for each vessel group.
s	Maximum stated passenger capacity. Value is expressed as a whole number.
D_s	Estimated total number of diver days per year for all surveyed vessels.
D_e	Conservative estimate of total number of diver days per year for all surveyed vessels.

well as their typical diving-related expenses including gear rental, travel distance, and dive boat pricing. In addition, respondents were asked to answer questions pertaining specifically to *S. gigas* including their knowledge of the fish, how they rank the importance of seeing *S. gigas* on a dive (scale of 1 to 5) (see Appendix C, Supplementary material for explanation of rating scale), and past experiences with *S. gigas* on dives. Finally, respondents were asked a series of valuation questions regarding *S. gigas* (see Appendix C for full survey).

The contingent valuation method (CVM), a commonly used method developed for determining the public's stated willingness to pay for non-consumptive public goods (Mitchell & Carson, 1989) and a reliable method for estimating the value of a non-consumptive resource (Carson, Flores, & Meade, 2001), was used to estimate the economic value of *S. gigas* to recreational divers. The payment card (PC) approach to elicit willingness-to-pay (WTP) from respondents (Mitchell & Carson, 1981) was adopted in this study's survey design. With this method, the question is presented in multiple-choice format and respondents are asked to select a WTP value from a set of available predetermined value options. Various valuation methodologies are available for estimating WTP (Mitchell & Carson, 1981), though the effect of questionnaire format may be insignificant when valuing endangered species (Loomis & White, 1996; Richardson & Loomis, 2009). However, the PC elicitation method has been widely used to elicit WTP with regard to wildlife conservation and preservation of natural attractions (Farr, Stoeckl, & Alam Beg, 2014; Jakobsson & Dragun, 2001; Ressurreição et al., 2012; Reynisdottir, Song, & Agrusa, 2008). This method minimizes starting point bias and reduces non-responses (Mitchell & Carson, 1989), and any biases with regard to 'anchoring effects', where a numerical prompt alters a respondent's stated value, can be circumvented by not truncating values available in the payment card (Rowe, Schulze, & Breffle, 1996). In the survey, respondents were asked how much they would be willing to pay, in addition to what they typically pay for a dive charter, for (1) a *potential* sighting of a giant sea bass, and for (2) a *guaranteed* sighting of a giant sea bass. Although it is impossible to guarantee a natural wildlife encounter, a *guaranteed* sighting was used in the WTP elicitation to investigate the value of a *S. gigas* sighting, not of a hypothetical *S. gigas*-viewing industry. Any surveys that were submitted, but were not entirely completed or had skipped questions regarding WTP, were excluded from the analysis.

2.2.3 | WTP statistical analysis

Given high variance in responses, an α-trimmed mean (α =0.05) of the WTP responses for a *S. gigas* sighting, was used. Trimmed means provide a more robust estimate of mean WTP (FAO Economic and Social Development Department, 2000; Mitchell & Carson, 1989). Both conservative and average annual non-consumptive use values of *S. gigas* were calculated by superimposing the WTP distribution from survey responses to D_t, the estimated number of boat divers in a year, and D_c, the conservative estimated number of boat divers in a year. In order to identify the potential for familiarity with *S. gigas* in altering the results, WTP was calculated and non-consumptive use values aggregated for divers who not only dived in California, but also listed California as their primary dive location (Appendix A).

A censored regression (tobit) model was used to determine predictors of diver WTP for a *guaranteed* sighting (*censReg* function, package censReg, R) using the dependent variables of diver experience, behaviour, and knowledge (Table A.4). Censored regressions are preferred when using payment card WTP data as the commonly used ordinary least squares (OLS) regressions for determining WTP can often result in biased estimates (Cameron & Huppert, 1989). All analyses were computed in R (R Core Team, 2015).

2.3 | Spatial and temporal *S. gigas* catch hotspots

The location and month for when *S. gigas* catch-per-unit-effort (CPUE) was highest along the California coast between 2006 and 2015 was determined using the landing receipt data from commercial set gill and trammel net fisheries. CPUE was calculated using catch as biomass of *S. gigas* landed per month and effort calculated as number of gill and trammel net fishing trips in that month. Self-reported catch location information from landing receipts was used to map out average *S. gigas* CPUE per year during this period, and catch date data were used to determine how average *S. gigas* CPUE varied across the months. The values were mapped onto the 547 reporting blocks (approx. 256 km^2) that overlapped with the main portion of *S. gigas* range using QGIS (QGIS Development Team, 2017). For the 15 reporting blocks and month in which average *S. gigas* CPUE was highest, the monetary value of landings from species harvested in the target fishery (i.e. *A. nobilis* and *P. californicus*) was calculated from CADFW landing receipt data and compared the month's value with the overall annual value of the target fishery. For additional details on spatial and temporal hotspot determination using number of individuals caught, total *S. gigas* biomass landed, and bycatch proportion see Appendix B, Supplementary material.

3 | RESULTS

3.1 | Value to fishers

Results from landing receipts indicate that an average of 97 ± 15 individuals year^{-1} (± std. error) were landed between 2006 and 2015, with a mean landing price per pound of US$2.59 ± 1.31 and mean landing price per individual fish of US$143.99 ± 14.37. Average annual landing value of *S. gigas* between 2006 and 2015 in California was US$12 606 ± 1 443. The average annual landing value of the target fishery for this decade was US$1 272 356 ± 113 130, making the landing value of *S. gigas* 0.99% of the value of the target white sea bass and halibut fishery.

3.2 | Value to divers

3.2.1 | California divers

A list of California dive boat operators known to operate south of Point Conception was compiled and operators were surveyed to obtain information on number of trips per year and average scuba diver capacity per trip for each vessel group (Table A.1). Based on the extrapolations from dive charter boat operator survey data, there are an estimated 55 280 charter boat diver days in southern California in one year (Table A.3). The more conservative estimate, which relies on using lowest number of trips per year and lowest average capacity from interview data for each vessel size group, yielded a lower bound estimate of 37 503 charter boat diver days in one year (Table A.3).

3.2.2 | Scuba diver profiles

In total, 265 divers were surveyed for this analysis. Of those contacted, 331 divers accessed the on-line survey and 279 of these divers submitted a survey; however, 14 of these 279 were excluded from the analysis due to incompleteness. Almost half of the respondents (49.8%) had been scuba diving for more than 10 years and the majority (84%) stated that one of their main reasons for diving was recreation (Table A.5). A third (33.6%) of the divers had obtained a professional level dive certification (Divemaster or Instructor) and the remainder had recreational diving licences (Table A.5).

Of the 265 divers surveyed, 245 (92%) listed California as one of their most frequented dive locations. With regard to diving frequency in California, the mean number of California dives per diver in the past year was 47.65 ± 5.49 (SE) and median of 25 for all diving (shore and boat), and 18.67 ± 2.68 (median = 7) for diving from charter dive boats. The average amount respondents typically paid for a charter boat dive trip in California was US$90.79 ± 3.69 (median = US$115).

Most (99%) of the divers had previously heard of *S. gigas* and 75% had seen one in the wild. When prompted with an open-ended question asking what they knew about *S. gigas*, 30.9% mentioned the fish was rare, endangered, or overfished; 16.2% mentioned the fish was protected from recreational fishing, and 5.7% stated that *S. gigas* population was recovering. The importance of seeing *S. gigas* on a dive was ranked as 4 and 5, on a scale of 1 to 5 where 1 is 'not important at all' and 5 is 'very very important' by most (61%) of the respondents (Figure 2).

3.2.3 | *Stereolepis gigas* WTP

Of the surveyed divers, 86.8% reported a WTP value to see *S. gigas* that was greater than US$0 per dive (Figure 3). The trimmed mean WTP for a guaranteed sighting of *S. gigas* was US$39 with a median of US$30 per dive. Overlaying the average and conservative estimated

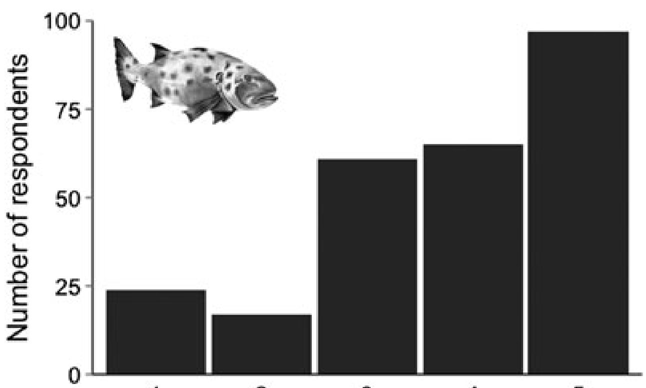

FIGURE 2 Distribution of responses from surveyed divers on the stated importance (on a scale of 1 (low) to 5 (high)) of seeing giant sea bass (*Stereolepis gigas*) while diving

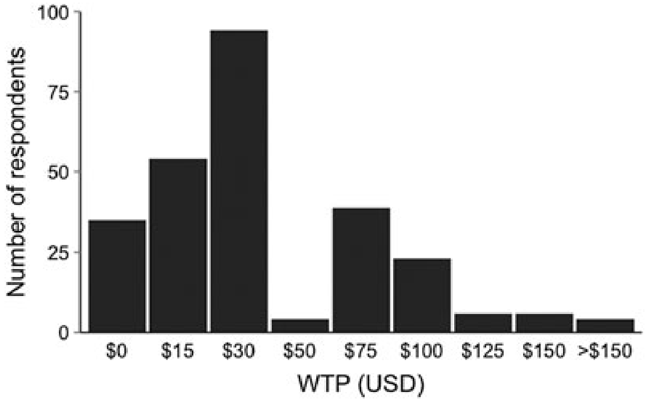

FIGURE 3 Distribution of responses from surveyed divers illustrating their willingness-to-pay (WTP) for a guaranteed sighting of a giant sea bass (*Stereolepis gigas*)

diver numbers on the WTP distribution, the non-consumptive use value of *S. gigas* equates to US$2.3 million per year. The conservative estimated value, generated using lower-range diver day numbers from survey data, is US$1.5 million per year.

The results from the censored regression suggest only three dependent variables are significant determinants of WTP (Table 2). WTP increased with the maximum amount the respondent would pay for a charter dive and the importance of seeing *S. gigas* on a dive, and decreased for respondents who reported having already seen *S. gigas* underwater (Table 2).

3.3 | Spatial and temporal *S. gigas* catch hotspots

Results from catch location data show that 14 of the 15 blocks with highest *S. gigas* CPUE are south of Point Conception (Figure 4a). Monthly catch data suggest that *S. gigas* CPUE is highest during the month of July (2.23 ± 0.49) (Figure 4b). Eight of the 14 blocks had reported no value attributed to the target fishery between 2006 and 2015 in July. Of the six blocks that did contribute to the target fishery during the month of July between 2006 and 2015, four had an average annual value of US$3 272 (summed across four blocks).

4 | DISCUSSION

This study provides the first economic valuation and comparison of the consumptive and non-consumptive use value of *S. gigas*. The results show that the estimated value of a *S. gigas* sighting to the recreational scuba diving community along the California coast is more than 150 times greater than its ex-vessel value to commercial fishers. These kinds of quantifications of the value of *S. gigas* can and should be meaningfully adopted by management practitioners considering the future of this critically endangered species.

Results from the landing receipt data indicate that the average annual value of incidentally caught *S. gigas* to commercial fishers represents less than 1% of the value of the target white sea bass and halibut fishery. Available independent CADFW reviews on selected California fisheries report the average annual ex-vessel value of the white sea bass fishery (not accounting for the value of landed halibut) to be US

TABLE 2 Results from censored regression for determinants of WTP for a guaranteed *S. gigas* sighting

Dependent variable	Estimated coefficient	Std. error	*t*-value	*P*-value
Dive years	0.193	0.214	0.903	0.366
Dives 5 years	0.009	0.011	0.816	0.415
Certification	−0.359	2.566	−0.14	0.889
Gear	−8.147	8.582	−0.949	0.343
CA diver	−18.576	9.802	−1.895	0.058
CA dives/year	−0.047	0.031	−1.541	0.123
Avg. USD/dive charter	0.01	0.048	0.212	0.832
Max USD/dive charter	0.183	0.061	2.973	0.003*
Heard of GSB	1.154	24.64	0.047	0.962
Seen GSB	−14.875	6.441	−2.309	0.021*
Considered endangered	−1.657	11.458	−0.145	0.885
Considered protected	−4.454	12.329	−0.361	0.718
Considered large	12.775	10.579	1.207	0.227
Knowledge score	2.608	9.223	0.283	0.778
GSB importance	11.885	2.012	5.907	< 0.001*

Estimated regression coefficients for the payment card responses represent marginal impacts on the dollar amount of respondents' willingness-to-pay (WTP).

*Denotes significance.

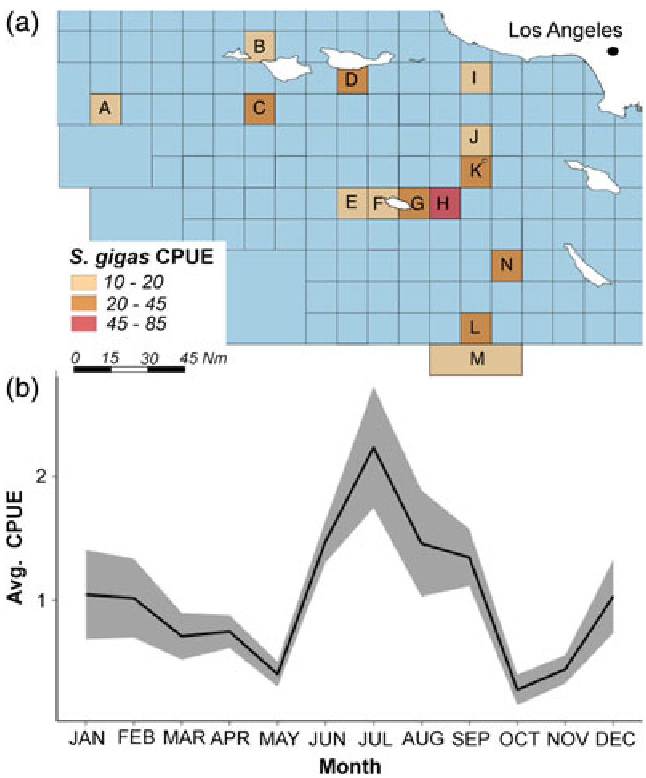

FIGURE 4 (a) 14 blocks in California with the highest average giant sea bass (*Stereolepis gigas*) catch-per-unit-effort (CPUE) for 2006–2015. (B) Average *S. gigas* monthly CPUE (2006–2015). Shaded area denotes inter-annual standard error. CPUE is calculated as sum of kg landed per month/number of commercial fishing trips per month

$1.4 million for the years 2008, 2010 and 2012 (CADFG, 2009, 2011, 2013), slightly higher than the calculated average annual value of the target fishery (US$1.2 million). In addition, the CADFW reports do not take into account the additional 7 years factored into this study's calculation and only report values for landed white sea bass, not halibut (the other target in the gillnet fishery). The incorporation of these two values would likely elevate the ex-vessel value of the target fishery. Thus, it seems likely that this study's calculation of the target fishery value to commercial fishers is an underestimate, which only underscores the marginal value that *S. gigas* landings yield relative to the target fishery.

In contrast, the estimated non-consumptive value of *S. gigas* reveals the high value of this species to the recreational scuba diver industry in California. This calculated value allows for more equitable and direct comparison between different industries and use types. However, it is important to note that the calculated annual non-consumptive value of US$2.3 million does not indicate a potential direct cash flow to the economy, but rather provides a quantitative representation of recreational divers' value of *S. gigas* and represents the potential for a marginal economic value to the diving industry. In addition, although the survey was distributed via Southern California regional lists, this did not exclude all California divers. Thus, the calculation must be considered as including all California divers, not just divers in Southern California. Given the geographical range of *S. gigas*, WTP for a *S. gigas* sighting may be different if the study had been limited to Southern California divers that may encounter them more frequently. Divers who dive from shore or from privately owned vessels, which would likely increase the total non-consumptive use value, were also not included in the calculation. Finally, as the scuba diver survey was distributed electronically through various diving-related e-mail lists, it is important to note that this convenience sample might not be representative of the entire California population. For example, it may bias against divers who maintain less of an electronic presence.

The mean WTP for *S. gigas* of US$42.81 is similar to values previously calculated for other marine megafauna. In the Great Barrier Reef, mean WTP for a guaranteed sighting of elasmobranchs ranged between US$33.82 and US$42.20, between US$42.56 and US

$44.72 for cetaceans, and between US$24.76 and US$32.64 for sea turtles (Farr et al., 2014). In a study conducted across the United States, scuba divers were willing to pay US$29.63 for an increased likelihood of a sea turtle sighting on a dive and US$35.36 for an increased likelihood of a shark sighting (White, 2008). Aggregated across the United States scuba diver population, the annual non-consumptive values of sea turtles and sharks were US$177.8 million and US$212.2 million, respectively (White, 2008). These aggregated annual values are considerably larger than the annual non-consumptive value estimated for *S. gigas* (US$2.3 million); however, this study's values are substantial considering they apply only to the California diver population.

This work indicates the potential for an industry centred on *S. gigas* viewing with profits that might outweigh the current economic value of *S. gigas* as a commercial bycatch product. Shifts from consuming to viewing megafauna have proven to be lucrative to communities of stakeholders both in terrestrial and marine ecosystems. A single elephant has been estimated to draw in US$1.6 million to travel companies, airlines and local economies as a long-lived wildlife-viewing attraction, but only US$21 000 as a single-use consumptive resource in the ivory trade (The David Sheldrick Wildlife Trust, 2014). For the diving industry, reef sharks in Palau were found to be more than 17 times more valuable alive as a non-consumptive use resource over their lifetime than dead as a consumptive resource (Vianna et al., 2010). Globally, the estimated annual economic value of manta ray tourism is US$140 million, which exceeds the annual value of the manta ray gill raker trade of US$5 million by an order of magnitude (O'Malley, Lee-Brooks, & Medd, 2013).

As expected, WTP increased with the maximum amount a respondent would pay for a charter dive, which can be interpreted as the expected positive relationship between income or spending levels and WTP (Carson et al., 2001). As might be predicted, WTP also increased with the stated importance of seeing *S. gigas* on a dive. WTP was also found to decrease for respondents who reported having already seen *S. gigas* underwater. Previous studies show that people tend to value rarity both in economic markets (Lynn, 1991) and wildlife viewing (Booth, Gaston, Evans, & Armsworth, 2011); therefore it is not surprising to see this same effect manifest itself in this system. This may indicate that the total value of *S. gigas* could decrease over time if its population increases. Alternatively, a larger population size of *S. gigas* and increased probability of sighting *S. gigas* could recruit new eco-tourist clientele within and beyond local markets. Other lucrative wildlife encounter industries successfully recruit customers from the global market (Gallagher & Hammerschlag, 2011; O'Connor, Campbell, Knowles, & Cortez, 2009; Topelko & Dearden, 2005).

Based on the calculations in this study, the average annual number of landed incidentally caught *S. gigas* could represent somewhere between 2% and 19% of current local population estimates for this species (Chabot, Hawk, & Allen, 2015). Given uncertainties surrounding the fate of any *S. gigas* that may be lethally captured in gill and trammel nets above the allowable take of one fish per day, it may be prudent to view these as minimum estimates of population-level harvest. Although recent evidence suggests that *S. gigas* populations appear to be increasing (House et al., 2016; Pondella & Allen, 2008), it is unclear if the populations can sustain this present level of bycatch-facilitated harvest. Given the high value documented here of *S. gigas* to recreational divers, more careful investigations of the implications of this catch on *S. gigas* population dynamics is perhaps merited.

Fishing and wildlife viewing are not mutually exclusive activities, and the results from the spatial and temporal hotspot data provide potential suggestions that could serve as seasonal *S. gigas* sanctuaries that may have minimal or no financial impact on target fisheries. For example, Block 'H' (Figure 4a) generates no revenue to gill and trammel net fishers for target species in the month of July, when *S. gigas* CPUE is highest. In addition, blocks B, F, E and M have a July aggregate landing value that is worth only 0.2% of the target fishery's average annual value. Although it could be potentially unnecessary to restrict fishing in entire blocks for one month, areas such as these could provide potential opportunities to strategically identify smaller-scale reefs or patches with particularly high *S. gigas* densities (e.g. aggregation zones for spawning *S. gigas*) where closures might be tenable.

The economic value surrounding *S. gigas* extends beyond scuba divers and fishers, and there are many additional factors to consider when assessing the total economic value of a species. For example, the study did not take into account operational costs for the commercial fishing or scuba diving charter vessels nor how much the recreational diving industry depends on the viewing of *S. gigas*. It also did not incorporate other factors that certainly affect and elevate consumptive use value such as higher market chain prices. Although CADFW state-compiled landing data represents the best and only source of information on *S. gigas* catch, some variability in quality is known from this type of self-reported data (Sampson, 2011; Walsh, Ito, Kawamoto, & McCracken, 2005). Further research is needed to fully understand the potential economic value of *S. gigas* in southern California to other potential coastal stakeholders beyond the two key constituencies that were engaged (commercial fishers and recreational boat divers).

Economic valuations can be used to better inform decision-makers, managers, and policy analysts regarding additional stakeholders and their value of the species in question (Sanchirico et al., 2013). This work provides an initial estimate of the total economic use of *S. gigas* and opens the door to further work further quantifying precise values to the dive industry and the economy at large. In addition, non-consumptive use values can be included in economic-based management (EBM) strategies and future management models for endangered species like *S. gigas* and in long-term marine ecosystem planning. Such approaches would allow consideration of externalities such as benefits to recreational divers, which would help strategically maximize the value of marine resources to coastal communities.

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