BULLETIN OF MARINE SCIENCE, 86(3): 499–514, 2010

COMPARING LANDINGS OF UNITED STATES RECREATIONAL FISHERY SECTORS

Will F. Figueira and Felicia C. Coleman

ABSTRACT

Recent research reveals that recreational fisheries are responsible for a significant share of the total marine finfish catch worldwide, especially for overfished stocks. In some cases, recreational fisheries are the primary pressure on fished stocks. Considerable interest rests in knowing which sector—the for-hire (i.e., charter boats and headboats), the private boat, or shore-based fisheries—catches the most. The general impression in the United States is that the for-hire sector takes the majority of the recreational landings because of its greater professionalism and therefore more efficient fishing practices. Restriction of these fisheries, rather than private-boat or shore-based sectors, has therefore been suggested to be the most effective means of limiting recreational catch. Published data suggest otherwise, however, despite concerns about the unevenness of data quality. Using a 24-yr time series of landings data on marine fish from the United States marine recreational fishery database, we demonstrate that the majority of recreational landings are taken by the private/rental-boat sector (65%), probably as a result of the sheer number of participants, whereas the for-hire sector takes 22% and the shore sector only 13%. The ability to assess the impacts of the private/rental-boat fisheries is limited chiefly by access to fishers for sampling, so better data are critically needed, in the form of survey access to recreational-fishing participants through licensing.

Although debate continues about the role of climate change in stock declines (Cook and Heath, 2005), overfishing is clearly a major threat facing coastal (Jackson et al., 2001) and pelagic (Myers and Worm, 2003) ecosystems worldwide (Crowder et al., 2008). Landings from the world's capture fisheries have been steadily declining since the late 1980s, especially when systematic overreporting by China is accounted for (Watson and Pauly, 2001). The total take in 2005 was 76.7 million metric tons (mt) (excluding Chinese landings), 91% of which came from the marine environment (FAO, 2006). Even though historical evidence suggests that fisheries are unsustainable enterprises (Jackson et al., 2001; Pauly et al., 2002)—indeed in 2005, 77% of the world's fishery stocks of known status were either fully exploited (52%), overexploited (17%), depleted (7%), or recovering from depletion (1%) (FAO, 2006)—their social and economic importance complicates the reduction of fleet capacity, effort, and take required to rebuild them.

Perhaps the most fundamental challenge to the management and conservation of fished stocks is simply identifying the sources of mortality. Historically, commercial fishers have taken most of the blame for worldwide stock depletions (Cooke and Cowx, 2006, and references therein), but increasingly, the role of recreational fisheries is being recognized (Post et al., 2002; Lewin et al., 2006). For many stocks, the majority or even all of the landings are recreational (McPhee et al., 2002; Coleman et al., 2004). For federally managed marine fish stocks listed as overfished or experiencing overfishing in the United States, Coleman et al. (2004) demonstrated that, in 2002, 23% of the total nationwide landings were taken by the recreational fishery, but this proportion was much higher in some regions such as the Gulf of Mexico, where it was 65%.

These statistics have not gone unnoticed, and indeed catch and effort data from recreational fisheries are regularly included in stock assessments in the United States and figure prominently in management decisions for stocks such as red snapper and gag grouper (see Table 1 for scientific names) in the Gulf of Mexico (NMFS, 2005; SEFSC, 2007a,b). Data on catch and fishing behavior of recreational fishers are also used to inform the design of marine reserves (Schroeder and Love, 2002; Lynch, 2006).

For the purposes of data collection, managers typically recognize three recreational sectors, (1) the shore-based sector, in which participants (often artisanal fishers) fish from shore, beach, bank, and man-made structures like bridges and seawalls; (2) the private/rental-boat sector, in which participants use either their own or rented boats to fish; and (3) the for-hire sector, composed of charter boats and headboats (also called "party" boats). Charter boats and headboats are vessels on which fishing space and assistance are provided for a fee. Whereas charter boats typically carry small preformed groups (3–6 customers), headboat groups are typically much larger (10–30+) and formed through an open registration process. The grouping of headboat and charter-boat categories into the "for-hire" sector distinguishes them from the other, nonguided, types of recreational fishing (shore and private/rental boats). These categories represent not just the different platforms from which people fish but the level of expertise and motivation for fishing, especially in the for-hire sector, because the individuals who participate do so under the paid guidance of very experienced fishers. This type of recreational fishing can be very efficient because it is largely profit driven; past performance determines customer return.

In the United States, data on these sectors are collected by a network of interrelated survey programs in both state and federal waters. The Marine Recreational Fisheries Survey (MRFSS) collects data on shore-based and private/rental-boat fishing for all coastal states except Alaska and Texas (which administer their own surveys). It also collects data on charter-boat fishing on the East Coast and in the Gulf of Mexico. Charter-boat fishing data on the West Coast are collected by several oceanboat survey programs. Headboat fishing data for the East Coast and Gulf of Mexico are collected by the headboat logbook survey program (for more information see http://www.st.nmfs.noaa.gov/st1/recreational/queries/caveat.html).

As management's need for higher temporal and spatial resolution of recreational fishing data increases, the complexity and general structure of this network of programs has come under more intense scrutiny. Indeed, a National Research Council (NRC) panel reviewing recreational fisheries assessment in the United States expressed a general concern over the potential for bias and unresolved error in the catch and effort estimates derived from many of these programs (NRC, 2006). Estimates for the shore-based and private/rental-boat sector caused particular concern because of the number of participants, many of whom are not captured in effort sampling (conducted by phone) because they live outside of the survey area (coastal counties) and because of the infeasibility of sampling even a small proportion of the multitude of access points used by these groups. In comparison, the for-hire sector is much more rigorously sampled by means of logbooks, phone lists of registered operators, and dockside surveys at known home ports.

Despite the NRC's concern, particularly about the shore-based and private/rental-boat sectors, nothing is known about the direction or magnitude of bias in the data. In addition, although efforts to revise and improve the assessment program are cur-

Table 1. Species mentioned in the text and tables.

Common name	Scientific name
Albacore	*Thunnus alalunga* (Bonnaterre, 1788)
Atlantic cod	*Gadus morhua* Linnaeus, 1758
Atlantic croaker	*Micropogonias undulatus* (Linnaeus, 1766)
Barred sandbass	*Paralabrax nebulifer* (Girard, 1854)
Bigeye tuna	*Thunnus obesus* (Lowe, 1839)
Black drum	*Pogonias cromis* (Linnaeus, 1766)
Black rockfish	*Sebastes melanops* Girard, 1856
Black sea bass	*Centropristis striata* (Linnaeus, 1758)
Blue marlin	*Makaira nigricans* Lacépède, 1802
Bluefin tuna	*Thunnus thynnus* (Linnaeus, 1758)
Bluefish	*Pomatomus saltatrix* (Linnaeus, 1766)
Bocaccio	*Sebastes paucispinis* Ayres, 1854
Bull shark	*Carcharhinus leucas* (Müller and Henle, 1839)
California halibut	*Paralichthys californicus* (Ayres, 1859)
Canary rockfish	*Sebastes pinniger* (Gill, 1864)
Chinook salmon	*Oncorhynchus tshawytscha* (Walbaum, 1792)
Coho salmon	*Oncorhynchus kisutch* (Walbaum, 1792)
Cow rockfish	*Sebastes levis* (Eigenmann and Eigenmann, 1889)
Darkblotched rockfish	*Sebastes crameri* (Jordan, 1897)
Dolphin	*Coryphaena hippurus* Linnaeus, 1758
Dusky shark	*Carcharhinus obscurus* (Lesueur, 1818)
Gag grouper	*Mycteroperca microlepis* (Goode and Bean, 1879)
Goosefish	*Lophius americanus* Valenciennes, 1837
Greater amberjack	*Seriola dumerili* Risso 1810
Haddock	*Melanogrammus aeglefinus* (Linnaeus, 1758)
King mackerel	*Scomberomorus cavalla* (Cuvier, 1829)
Lingcod	*Ophiodon elongatus* Girard, 1854
Mullet	*Mugil* spp.
Nurse shark	*Ginglymostoma cirratum* (Bonnaterre, 1788)
Pacific barracuda	*Sphyraena argentea* Girard, 1854
Pacific ocean perch	*Sebastes alutus* (Gilbert, 1890)
Red drum	*Sciaenops ocellatus* (Linnaeus, 1766)
Red grouper	*Epinephelus morio* (Valenciennes, 1828)
Red snapper	*Lutjanus campechanus* Poey (1860)
Sailfish	*Istiophorus platypterus* (Shaw, 1792)
Sandbar shark	*Carcharhinus plumbeus* (Nardo, 1827)
Scalloped hammerhead	*Sphyrna lewini* (Griffin and Smith, 1834)
Scup	*Stenotomus chrysops* (Linnaeus, 1766)
Sheepshead	*Archosargus probatocephalus* Walbaum, 1792
Shortspine thornyhead	*Sebastolobus alascanus* Bean, 1890
Spanish mackerel	*Scomberomorus maculatus* (Mitchill, 1815)
Spinner shark	*Carcharhinus brevipinna* (Müller and Henle, 1839)
Spot	*Leiostomus xanthurus* Lacépède, 1802
Spotted seatrout	*Cynoscion nebulosus* (Cuvier in Cuvier and Valenciennes, 1830)
Striped bass	*Morone saxatilis* (Walbaum, 1792)
Summer flounder	*Paralichthys dentatus* (Linnaeus 1766)
Tautog	*Tautoga onitis* (Linnaeus 1758)
Tiger shark	*Galeocerdo cuvier* (Péron and Lesueur, 1822)
Vermilion snapper	*Rhomboplites aurorubens* (Cuvier in Cuvier and Valenciennes, 1829)
White hake	*Urophycis tenuis* (Mitchill, 1814)
Winter flounder	*Pseudopleuronectes americanus* (Walbaum, 1792)
Yelloweye rockfish	*Sebastes ruberrimus* (Cramer, 1895)
Yellowfin tuna	*Thunnus albacares* (Bonnaterre, 1788)
Yellowtail amberjack	*Seriola lalandi* Cuvier and A Valenciennes, 1833

rently underway, the historical data will continue to be used because they are the best available upon which to base assessments of stock status. As a result, understanding just how large a proportion of the actual landings are attributable to each of these different sectors is extremely important. Within the recreational fishery, the for-hire sector has often been assumed to take the highest proportion because of its inherently commercial nature, and the result is an attitude that management of recreational fisheries should be focused most strongly on the fore-hire sector. Understanding whether this approach is justifiable requires careful evaluation of the actual levels of harvest within the various recreational sectors. Such an analysis can also help to reveal the potential impact of the suspected bias in data. For example, if in fact the majority of landings do come from the for-hire sector, then some amount of bias or error in the data for the shore-based and private/rental-boat sectors would be much less important than were the situation reversed.

In the study reported here, we used a comprehensive metaanalysis of 24 yrs of all state and federal marine recreational finfish landings data from the contiguous continental United States to assess the relative landings of the different recreational fishing sectors.

Methods

The analyses presented here represent an update (through 2004) of the comprehensive marine fish landings database described by Coleman et al. (2004), excluding commercial landings and focusing on the recreational landings by sector and by region of the United States. We consider "landings" (what the National Marine Fisheries Service, NMFS, calls "harvest") to be all fish known to have been killed, and we include two components of what surveys categorize as catch: (1) fish caught and brought back whole and (2) fish caught and filleted or released dead at sea. The third category of catch, fish caught and released alive, was not included because we could not account for subsequent release mortality. Our rationale for excluding live discards is due to the uncertainty in the discard data. In red snapper, for instance, there are no data on live discards from headboats and only limited information from Texas (Cass-Calay, 2004). The numbers reported here may therefore underestimate true mortality.

Although substantial data on recreational fishing in the United States are available through web-based searches (including those on the NMFS website), the data available are not comprehensive. Missing are the headboat data from the East Coast and Gulf of Mexico, all data from Texas, and all charter-boat data from the West Coast. To construct the database for our study, we went directly to primary sources of data. Data on East Coast and Gulf of Mexico shore-based and private/rental-boat fishing were obtained from MRFSS personnel. Shore-based, private/rental-boat, and charter-boat data for the West Coast were also obtained from the MRFSS as compiled by the Pacific States Marine Fisheries Commission. All MRFSS data were poststratified (by means of SAS programs developed by NMFS personnel) for assignment of landings to four management regions of the United States: The Northeast (NE), Maine to Virginia; the South Atlantic (SA), North Carolina to the east coast of Florida; the Gulf of Mexico (GOM), the west coast of Florida to Texas; and the Pacific (PAC), California to Washington. All Texas data were collected from the Texas Department of Parks and Wildlife, and headboat data for the East Coast and Gulf of Mexico came from the NMFS headboat survey program (initiated in 1986). NMFS headboat data are reported by the vessel's home port, facilitating regional assignments. Gaps in the data exist in the Pacific for 1990–1992 (when no surveys were conducted) and for 2003 and 2004 (data were unavailable at the time of our study because of reorganization of the reporting structure and reassembly of those data). For additional information on the development of this landings database, see Coleman et al. (2004).

Landings estimates for each recreational fishing sector were compiled from the database for each stock in each region. We converted number of fish landed to biomass using estimates of fish weights from creel surveys specific to the site, time, species, and fishing sector. In cases where such data were unavailable, estimates from neighboring geographic regions, fishing sectors, or years were used as described by Coleman et al. (2004). Using these data, we first analyzed the overall landing trends in the United States. Although such broad overviews across stocks provide certain insights, species will clearly experience different impacts from different sectors. We therefore subsequently examined only those stocks listed as either overfished (OF, biomass below threshold level) or experiencing overfishing (EOF, fishing mortality greater than threshold level) in the latest update on the status of the stocks (NMFS, 2009, second quarter). Coleman et al. (2004) demonstrated that 25% of the landings of these stocks take place in the recreational fishery nationwide (as high as 65% in the Gulf of Mexico). Because these stocks represent those currently at the greatest risk from overfishing, determining which sectors are responsible for their landings is especially important. We include landings summaries for the 10 most commonly caught species in each sector, for both all fish stocks and only the OF or EOF stocks. On the basis of these summaries, we provide time series of stocks for which different sectors tend to dominate the landings as examples of general trends in the types of stocks fished most heavily by each sector.

Results

The long-term average (1981–2004) annual recreational landings were highest in the NE and GOM and lower in the SA and PAC (Table 2). The annual average was slightly lower in recent years than over the long term, and decreases were greatest in the NE (Table 2, Fig. 1), but overall the NE still accounts for the largest numbers of recreational landings. In the four most recent years, the private/rental-boat sector dominated in all regions. Where separated, charter-boat landings were five to six times higher than headboat landings. These trends have been relatively constant over the period we studied, although some increase was evident in the GOM for-hire sec-

Table 2. Average regional and total long-term (1981–2004) and recent (2000–2004) annual recreational landings (in metric tons, mt) for all fishing sectors combined and percentage of the total of recent (2000–2004) landings contributed by each recreational fishing sector. Shore, shore-based fishery; Private, private/rental-boat fishery; Headboat fishery; and Charter boat fishery)

	Average annual harvest (1000 mt)		Harvest by fishing sector (percentage of total) (2000–2004)			
Region	1981–2004	2000–2004	Shore	Private	Headboat	Charter
All stocks						
Northeast	52.67	42.96	8.7	72.7	18.6[a]	
South Atlantic	25.25	28.96	17.9	59.8	19.6	2.7
Gulf of Mexico	38.80	40.86	14.8	63.6	18.4	3.2
Pacific[b]	18.25	17.94	6.7	54.5	38.8	
All	131.16	123.54	12.7	65.1	22.2	
Stocks that are overfished or are experiencing overfishing						
Northeast	9.17	5.57	1.8	70.1	28.1	
South Atlantic	2.98	2.24	5.4	58.7	22.0	14.0
Gulf of Mexico	9.82	12.93	5.5	63.6	26.0	5.0
Pacific[b]	1.61	0.99	1.9	48.9	49.2	
All	27.19	27.64	5.0	68.8	26.2	

[a] Headboat and charter sectors are not separated in the Northeast or Pacific.
[b] Results based on 2000–2002 data only (2003–2004 not available)

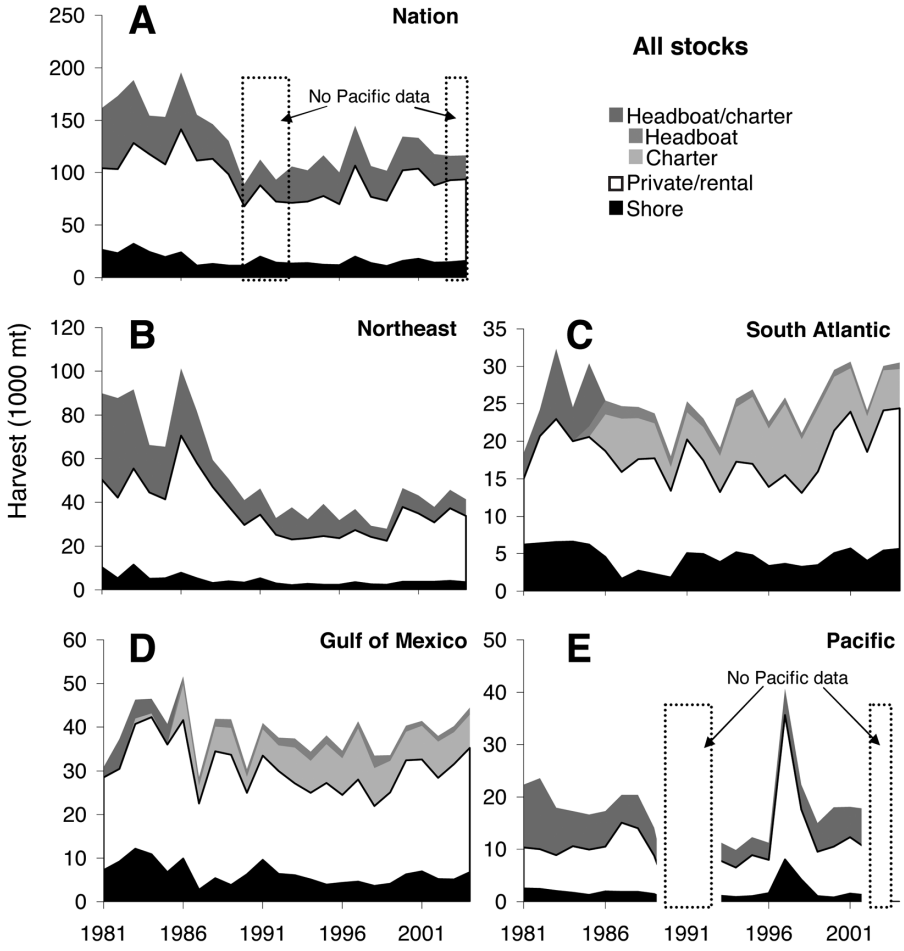

Figure 1. Time series of marine recreational fisheries landings in metric tons (mt) × 1000, separated by recreational fishery sectors. Total landings from the (A) contiguous United States, (B) Northeast, (C) South Atlantic, (D) Gulf of Mexico, and (E) Pacific. On the Pacific coast, no complete sets of recreational data were collected for the years 1990–1992 from any of the federal or state organizations that maintain these databases. Pacific data for 2003–2004 were unavailable at the time of this study. The 1997 spike in Pacific landings is due to very high reported landings of coho salmon in Puget Sound, WA.

tor since the early 1990s and in the NE private/rental-boat harvest during the 1980s (Fig. 1).

We found a similar trend in the OF and EOF stocks; private/rental-boat landings were the highest, followed by for-hire and then shore-based boats (Table 2). The increasing contribution by the for-hire sector in the GOM is also evident for these stocks (Fig. 2).

The importance of individual sectors was most obvious when we restricted the analysis to those stocks with at least 10 mt of catch per year (to minimize biases caused by small but highly sector-specific fisheries) and looked simply at the sector in which the majority of the landings occurred for each stock. The private/rental-

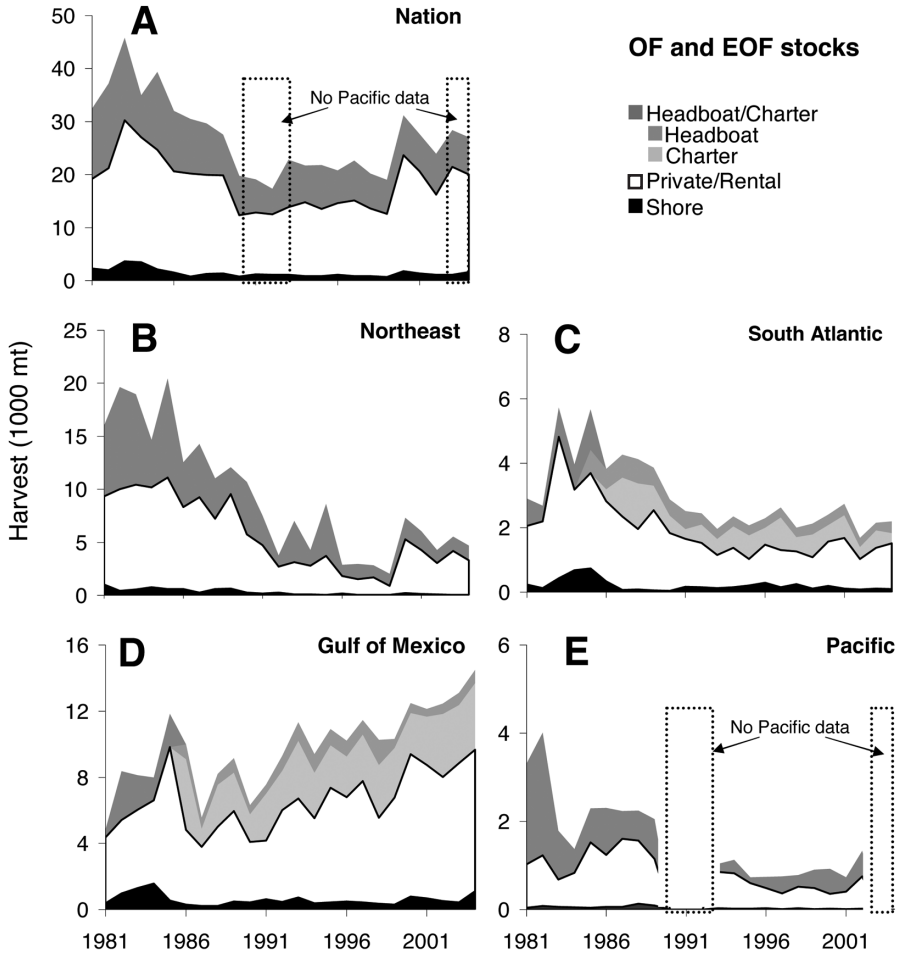

Figure 2. Time series of marine recreational fisheries landings of stocks that were overfished or experiencing overfishing (OF and EOF) in metric tons (mt) × 1000 separated by recreational fishing sector. Total landings from the (A) contiguous United States, (B) Northeast, (C) South Atlantic, (D) Gulf of Mexico, and (E) Pacific. The for-hire sector was separated into headboat and charter boat sectors in the South Atlantic and the Gulf of Mexico beginning in 1986. On the Pacific coast, no complete sets of recreational data were collected for the years 1990–1992 from any of the federal or state organizations that maintain these databases. Pacific data for 2003–2004 were unavailable at the time of this study.

boat sector again emerged as the dominant player, accounting for 40%–78% of all the stocks, whereas the division between shore-based and for-hire sectors was relatively even (Fig. 3A). The OF and EOF stocks exhibited more variation (Fig. 3B). In the NE the private/rental-boat sector was responsible for the majority of the landings for 73% of the stocks, whereas the shore-based sector took 7% and the for-hire sector took the majority in 20% of the stocks (Fig. 3B). The shore-based sector was relatively unimportant in the Pacific, whereas the for-hire sector dominated 57% of the stocks. In both the SA and the GOM, the majority of landings for 56% of the stocks were taken by the private/rental-boat sector.

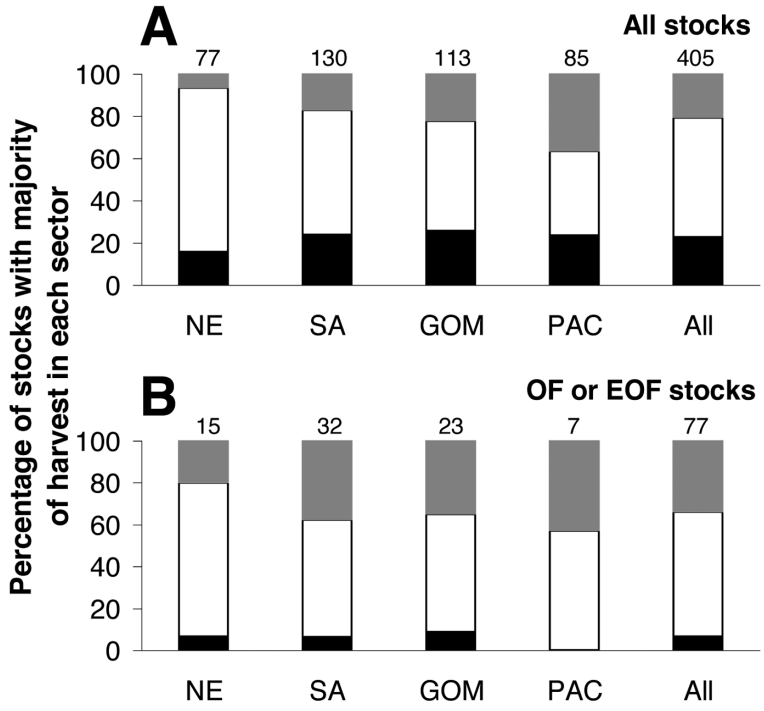

Figure 3. The percentages of (A) all stocks and (B) overfished stocks and those experiencing overfishing (OF and EOF) stocks for which a given fishing sector was the dominant (highest harvest) fishing mode for harvest of that stock. Data are based on the average annual landings for the period 2000–2004 in the Northeast (NE), South Atlantic (SA), and Gulf of Mexico (GOM) and those for 2000–2002 for the Pacific (PAC) (no Pacific data were available at the time of this study for 2003–2004). Stocks included are those with an average harvest of at least 10 metric tons (mt) per year. The total number of stocks is listed above each bar. Black, shore-based sector; white, private/rental-boat sector; grey, combined headboat and charter-boat sectors.

The most harvested species in the NE were striped bass, bluefish, summer flounder, and Atlantic croaker, which are among the top 10 recreationally landed saltwater species in the entire United States (Table 3). Striped bass and bluefish were taken largely by the private/rental-boat sector over the last 20 yrs (Fig. 4A,B). This pattern is relatively constant even though take of striped bass has increased steadily while that of bluefish has declined.

A similar pattern emerged in the GOM with red drum, spotted seatrout, and red snapper (Table 3). These stocks were among the top 10 recreationally harvested saltwater species in the United States, and they have relatively large private/rental-boat landings. Note, however, that red snapper also had considerable for-hire landings, which reduce the overall dominance of the private/rental-boat sector in the GOM. The continuing increase in recreational landings despite an overfished condition is explained by recreational allocations that increased from 891 mt (1.96 million pounds, mp) in 1991 to 1336 mt (2.94 mp) in 1993, and then to 2032 mt (4.47 mp) in 1996, accompanied by chronic overruns until a hard quota was established in 1996. Red snapper and king mackerel in the GOM are stocks that historically had a more

Table 3. Top 10 stocks landed by marine recreational fishers in the United States in the Northeast, South Atlantic, Gulf of Mexico, and Pacific. Landings are displayed as average landings in metric tons (mt) for 2000–2004 (except for the Pacific, where the average is based on landings from 2000–2002) and as percentage by recreational fishery sector. Rank is based on national rankings of recreational landings for all species for the same period. Sector column headings as in Table 2.

			Landings by sector (percentage of total)			
Rank	Species	Annual landings (mt)	Shore	Private	Headboat	Charter
Northeast						
1	Striped bass	9,158	7.7	73.4	18.8[a]	
4	Bluefish	5,261	15.8	62.8	21.4	
5	Summer flounder	5,215	4.4	86.5	9.2	
7	Atlantic croaker	4,148	7.5	85.5	7.0	
11	Scup	2,549	8.2	73.3	18.5	
12	Atlantic cod[b]	2,548	0.0	65.8	34.2	
19	Yellowfin tuna	1,695	0.0	63.3	36.7	
20	Tautog[b]	1,689	7.1	78.4	14.4	
21	Black sea bass[b]	1,614	1.2	42.9	55.9	
26	Bluefin tuna[b]	1,282	0.0	72.9	27.1	
South Atlantic						
6	Dolphin	4,809	0.0	65.3	0.4	34.3
8	Yellowfin tuna	3,009	0.0	40.2	0.0	59.8
13	King mackerel	2,280	1.4	73.8	2.7	22.2
24	Mullet genus	1,391	29.5	70.5	0.0	0.1
34	Striped bass	887	5.5	86.2	0.0	8.3
38	Bluefish	815	59.5	36.4	0.3	3.8
39	Spanish mackerel	789	18.6	75.0	0.4	6.0
40	Spot	789	43.2	56.8	0.0	0.0
43	Sheepshead	757	16.5	83.2	0.0	0.4
48	Red drum[b]	617	16.3	81.8	0.0	1.9
Gulf of Mexico						
2	Red drum	6,377	10.1	78.2	0.0	11.7
3	Spotted seatrout	5,774	5.4	85.7	0.0	8.8
10	Red snapper[b]	2,580	0.1	41.3	13.1	45.6
14	Sheepshead	2,122	23.0	74.3	0.0	2.7
15	Gag grouper[b]	1,960	0.8	73.2	3.4	22.7
18	King mackerel	1,766	8.4	46.7	4.3	40.5
22	Dolphin	1,574	4.3	32.2	0.4	63.1
23	Black drum	1,426	19.2	71.9	0.1	8.9
25	Spanish mackerel	1,375	49.5	43.1	0.0	7.4
28	Greater amberjack[b]	1,132	3.5	34.3	5.5	56.7
Pacific						
9	Chinook salmon	2,786	1.8	70.7	27.5	
16	Coho salmon[bc]	1,820	4.4	77.3	18.2	
17	Albacore	1,808	0.0	52.3	47.7	
27	Yellowtail amberjack	1,230	0.0	52.7	47.3	
32	Barred sandbass	908	0.5	43.5	56.0	
41	Black rockfish	770	3.5	39.4	57.1	
42	California halibut	757	3.3	81.3	15.4	
45	Pacific barracuda	739	0.1	23.0	76.9	
47	Lingcod	662	2.8	56.6	40.6	
50	Yellowfin tuna[b]	590	0.0	29.1	70.9	

[a] Headboat and charter sectors are not separated in the Northeast or Pacific.
[b] Stock listed as overfished or experiencing overfishing by the Office of Sustainable Fisheries' "Status of U.S. Fisheries Report" 2009, quarter 2.
[c] Coho salmon listed for Washington coast, Queets, and Western Strait of Juan de Fuca runs only.

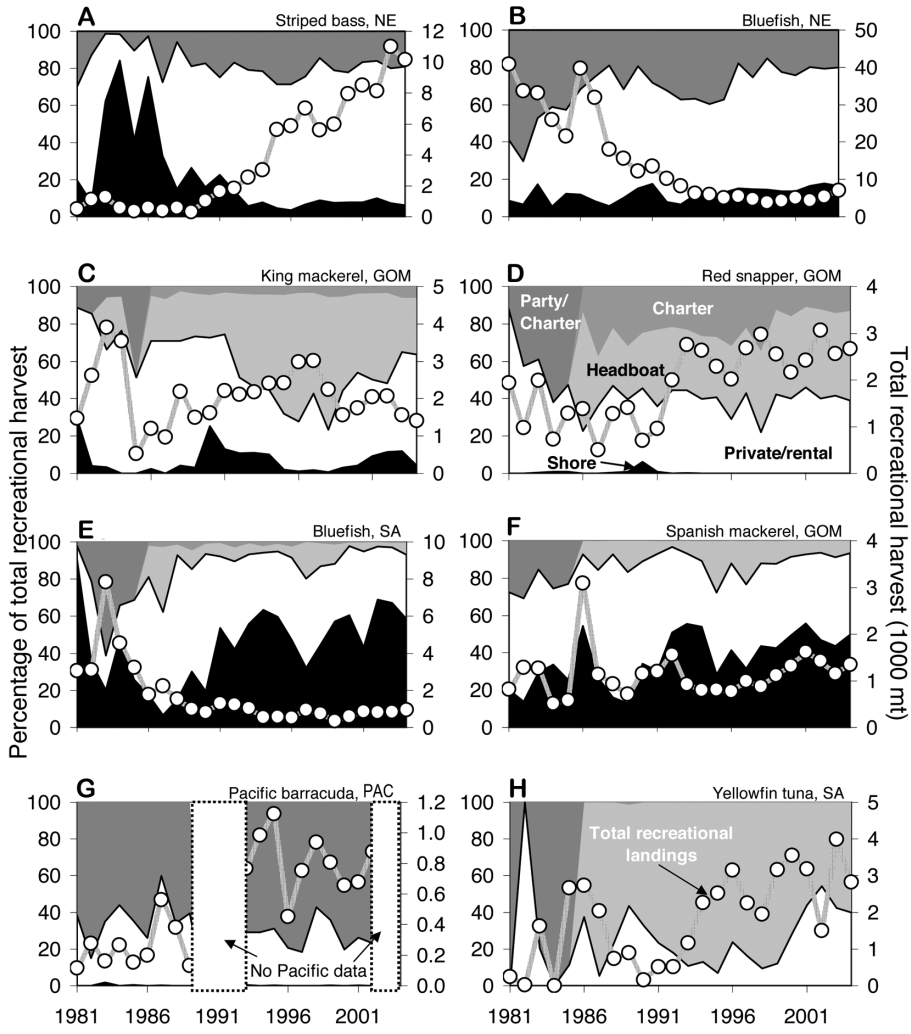

Figure 4. Time series of marine recreational fisheries landings for selected stocks indicating the percentage of recreational landings by sector (left y-axis, white and shaded areas) and total recreational landings in metric tons (mt) × 1000 (right y-axis, solid line with open circles. Panels represent examples of stocks caught commonly from private/rental boats (white), by a mixture of sectors from shore (black), and by the for-hire sector (grey; headboat and charter-boat sectors). The for-hire sector was further separated into headboat and charter-boat sectors in the South Atlantic and the Gulf of Mexico beginning in 1986. On the Pacific coast, no complete sets of recreational data were collected for the years 1990–1992 from any of the federal or state organizations that maintain these databases. Pacific data for 2003–2004 were unavailable at the time of this study.

balanced distribution of landings between the private/rental-boat and for-hire sectors (Fig. 4C,D).

The top landings in the SA came from two of the top-10 United States species, dolphin, primarily taken in the private/rental-boat sector, and yellowfin tuna, primarily taken in the for-hire sector, and a large number of less frequently landed stocks, some of which (e.g., bluefish, spot, mullet) have a substantial shore-based harvest component. Although the landings in the SA were dominated by the private/rental-

boat sector, this sector is not as large as that in the NE or GOM. Spanish mackerel from the GOM (50%) and bluefish in the SA (60%) were among the few stocks that were heavily fished by shore-based fishers, especially in the last 15–20 yrs (Fig. 4E, F).

Overall landings in the PAC were much lower than those in other regions of the country, and the for-hire sector was much more important there than in other regions, primarily because of the large landings of pelagic stocks such as albacore, yellowtail amberjack, Pacific barracuda, and yellowfin tuna by the for-hire sector. Pacific barracuda and yellowfin tuna were predominately fished by the for-hire sector over the entire time series (Fig. 4G,H).

The regional landing patterns for all stocks combined were quite similar to those for just the OF and EOF stocks in the NE, SA, and GOM (Table 3; see Appendix for complete list of top 10 OF and EOF species in each region). The same was not true for the PAC, where the majority of the OF and EOF stocks were rockfishes (especially bocaccio) or lingcod, which had much lower private/rental-boat landings than the most harvested salmonids.

Discussion

Our data make two important points: (1) that the private/rental-boat sector and shore-based together accounted for roughly three quarters of all recreational landings over the entire time series and (2) that within the for-hire sector, charter boats took about four times the landings taken by headboats.

Within these general trends were interregional differences due largely to species-specific fishing methods and fishing preferences. For example, the percentage of the landings attributable to the for-hire sector was noticeably larger in the PAC region (38% over 2000–2002) than elsewhere, largely as a result of the physical characteristics of the Pacific coast, which has a very narrow shelf that drops off rapidly into deep, relatively cold water that supports upwelling events. This configuration attracts large pelagics such as albacore, yellowtail amberjack, and Pacific barracuda, close to shore, but fishing for these deep-water species requires larger boats and more expensive equipment and tends to be the domain of charter operators rather than private/rental-boat fishers. Conversely, the SA coast north of Florida, and especially the GOM, are characterized by a much broader, shallower shelf and an abundance of estuaries that allow for greater access from shore (for fishers seeking bluefish and Spanish mackerel) and by small boats (for those seeking red drum and spotted seatrout).

The most recreationally harvested saltwater species was striped bass in the NE, the vast majority (74%) of which were taken by the private/rental-boat sector. The lack of significant for-hire landings may be a result of the strict bag limits imposed on this stock (one fish per person per day on private/rental boats and two on for-hire vessels). Because landings of striped bass are roughly twice those of the second most harvested stock in this region (bluefish), this species is a major reason for the very high levels of private/rental-boat-sector landings in the NE, but the > 90% of the stocks that are primarily taken in the private/rental-boat sector indicates this trend is truly region-wide.

These breakdowns are based on total landings and are therefore influenced by effort and participation levels within each of the fishing sectors. According to MRFSS estimates of effort available on line (http://www.st.nmfs.noaa.gov/st1/recreational/queries/index.html), on average, 33.3 million fishing trips were taken by marine rec-

reational fishers in the contiguous United States, excluding Texas (for which effort data were not available). The vast majority of these were taken from shore (47%) and in the private/rental-boat sector (45%); only 8% were taken by the for-hire sector.

The generality of trends suggested by U.S. recreational fishing data are difficult to assess because little detailed information is available on the division of catch and effort among the various recreational sectors at a global scale, but an Australian survey conducted in 2001 provides some comparisons. Although the overall recreational fishing participation rate for Australia, at 19.5% of the population, was higher than that estimated for the United States (4%), the breakdown of effort by fishing sectors was similar to that in the United States. As calculated from number of fishing events, 57% were from shore, 41.4% were from private/rental boats, and only 1.6% were from charter fishing boats (Henry and Lyle, 2003). Although catch breakdowns by sector were not available for the entire country from these survey data, the for-hire sector was estimated, for the state of New South Wales (where the division of effort was approximately the same as that nationwide), at between 3 and 6% of the total recreational landings (D. Reid, New South Wales Department of Investment and Industry, Cronulla Fisheries Science Centre, pers. comm.).

An important distinction among sectors is the level of expertise and frequency of participation of the fisherman. Some sectors—notably the for-hire sector—probably exhibit greater catch efficiency and therefore greater overall take per person, yet the data strongly suggest that patterns of overall catch are largely the result of participation rates rather than level of experience. That is, although a very small number of for-hire fishers may take more fish per individual, their catch is far outweighed by the sheer numbers of shore-based and private/rental-boat fishers participating in the fishery. This difference is analogous to those between commercial fishers (fewer of whom fish quite efficiently) and recreational fishers in general (many of whom fish relatively inefficiently). Such comparisons indicate surprisingly large landings by recreational fishers in general (Coleman et al., 2004; Cooke and Cowx, 2004) and by private/rental-boat fishers in particular (the present study).

Few data are available from other parts of the world to inform this discussion on relative take (proportion of total recreational landings) within recreational fishing sectors. In Portugal, for example, no data on saltwater fishing were collected until 2001, despite the popularity of the sport (Rangel and Erzini, 2007). In Australia, despite an estimated 19% participation rate nationwide, only one comprehensive assessment of recreational landings has been conducted, covering only a single year (Henry and Lyle, 2003). Popular vacation fishing sites in the Mediterranean such as Majorca have only recently been surveyed (Morales-Nin et al., 2005).

As a result, an overwhelming majority of landings are generated by the sectors about which we know the least, either ecologically, economically, or socially (Pitcher and Hollingworth, 2002), the shore-based and private/rental-boat fishers. If concerns about bias in the data on these sectors were justified and estimates from these sectors were two to three times too high, the for-hire sector would account for roughly 50% of the total landings. Conversely, if estimates from these sectors were similarly too small, the for-hire sector would account for closer to 10%. In either case, the shore-based and private/rental-boat sectors still account for a sizable amount of the catch.

The methods of characterizing recreational catch and managing fishers are fraught with problems, not the least of which is that no saltwater recreational license is required at all in many cases. For example, currently seven of the 21 U.S. contiguous

coastal states do not require saltwater fishing permits (all in the NE). In Australia, five of the seven coastal states and territories required some sort of saltwater fishing license, but in only two is it universal, and exemption categories and noncompliance issues are numerous (Henry and Lyle, 2003). In Portugal, no saltwater fishing licenses were required until 2007 (Rangel and Erzini, 2007). In Canada, only British Columbia requires saltwater fishing licenses for all fishers (though licenses are required for specific species, especially salmon and trout, in several other provinces). A recent review of recreational fishing around the world by Ditton (2008) reveals that only four of nine countries listed required a universal license for angling. Even in areas where licenses are required, many categories of user are exempt, including shore-based fishers, young children, and seniors, leaving large gaps in the data. The only reliable regulatory mechanism for getting a better handle on recreational fishing is a universal sampling frame established through licensing from which directed surveys can be conducted.

After the NRC review (NRC, 2006), the 2007 reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act mandated the creation of a regionally based registry program for fishers. That mandate resulted in creation by NOAA Fisheries of a National Saltwater Angler Registry in which all anglers and spearfishers fishing recreationally in federal waters must register by 1 January 2010. Although this registry does not capture the inshore fisheries, most states are moving toward a similar inshore license structure.

The problems associated with estimating effort and landings for recreational fisheries are often cited as reasons to question the reliability of the data and to avoid making management decisions. Establishing a universal sampling frame is unlikely to lead to more lenient management. To the contrary, what these data are likely to reveal, once used in directed surveys, is that recreational landings have been significantly underestimated (NRC, 2006). The results reported here serve to inform the discussion over the social and economic responsibilities of recreational fishing sectors by highlighting the large aggregate footprint of the many small contributions of private-sector participants. These results should provide additional motivation to ensure that these private-sector anglers are properly surveyed and complete estimates of recreational landings obtained.

Acknowledgments

We thank the following for providing assistance: D. Van Voorhees, L. Donniger-Few (MRFSS, Silver Spring, MD); J. MacClellan (Alaska Fish and Game); T. Kerns (Atlantic States Marine Fisheries Commission); G. Kobyinski, J. Robertson, J. Paulo Serpa (California Department of Fish and Game); S. Atran (Gulf of Mexico Fishery Management Council); D. Donaldson, R. Lukens (Gulf States Marine Fisheries Commission); C. Evans, B. Dixon, D. Vaughan (NMFS, Beaufort); J. Poffenberger (NMFS, Miami); M. Fogarty, S. Murawski (NMFS, Woods Hole); J. Palmer (NOAA and Northeast Fisheries Science Center); L. Paramore (North Carolina Division of Marine Fisheries); J. O'Leary (New England Fishery Management Council); J. Seabourne (Oregon Department of Fish and Wildlife); W. Daspit (Pacific Fisheries Information Network); W. Van Buskirk (Recreational Fisheries Information Network); K. Iverson (South Atlantic Fishery Management Council); J. Bennett, P. Phares (NOAA Southeast Fisheries Science Center); M. Fisher, V. Swan (Texas Parks and Wildlife); and D. Gombert, L. Hoines, G. Lippert, M. Stanley (Washington Department of Fish and Wildlife). We thank three anonymous reviewers and A. Thistle (Florida State University) for their very helpful comments on the manuscript. This study was supported by The Pew Charitable Trusts and the Lenfest Foundation.

Literature Cited

Cass-Calay, S. L. 2004. Revised catch rate indices for red snapper (*Lutjanus campechanus*) landed during 1981-2003 by the U. S. Gulf of Mexico Recreational Fishery. SEDAR –AW-4.

Coleman, F. C., W. F. Figueira, J. S. Ueland, and L. B. Crowder. 2004. The impact of United States recreational fisheries on marine fish populations. Science 305: 1958–1960.

Cook, R. M. and M. R. Heath. 2005. The implications of warming climate for the management of North Sea demersal fisheries. ICES J. Mar. Sci. 62: 1322–1326.

Cooke, S. J. and I. G. Cowx. 2004. The role of recreational fishing in global fish crises. BioScience 54: 857–859.

_____ and _____. 2006. Contrasting recreational and commercial fishing: searching for common issues to promote unified conservation of fisheries resources and aquatic environments. Biol. Conserv. 128: 93–108.

Crowder, L. B., E. L. Hazen, N. Avissar, R. Bjorkland, C. Latanich, and M. B. Ogburn. 2008. The impacts of fisheries on marine ecosystems and the transition to ecosystem-based management. Ann. Rev. Ecol. Evol. S39: 259–278.

Ditton, R. B. 2008. An international perspective on recreational fishing. Pages 5–55 *in* O. Aas, ed. Global challenges in recreational fisheries. Blackwell Publishing, Oxford.

FAO (Food and Agriculture Organization of the United Nations). 2006. The state of the world fisheries and aquaculture 2006. FAO Fisheries, Rome.

Henry, G. W. and J. M. Lyle. 2003. The National Recreational and Indigenous Fishing Survey. Australian Government Department of Agriculture, Fisheries and Forestry, Canberra.

Jackson, J. B. C., M. X. Kirby, W. H. Berger, K. A. Bjorndal, L. W. Botsford, B. J. Bourque, R. H. Bradbury, R. Cooke, J. Erlandson, J. A. Estes, et al. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science 293: 629–638.

Lewin, W.-C., R. Arlinghaus, and T. Mehner. 2006. Documented and potential biological impacts of recreational fishing: Insights for management and conservation. Rev. Fish. Sci. 14: 305–367.

Lynch, T. P. 2006. Incorporation of recreational fishing effort into design of marine protected areas. Conserv. Biol. 20: 1466–1476.

McPhee, D. P., D. Leadbitter, and G. A. Skilleter. 2002. Swallowing the bait: is recreational fishing in Australia ecologically sustainable? Rev. Fish. Sci. 8: 40–51.

Morales-Nin, B., J. Moranta, C. Garcia, M. P. Tugores, A. M. Grau, F. Riera, and M. Cerda. 2005. The recreational fishery off Majorca Island (western Mediterranean): some implications for coastal resource management. ICES. J. Mar. Sci. 62: 727–739.

Myers, R. A. and B. Worm. 2003. Rapid worldwide depletion of predatory fish communities. Nature 423: 280–283.

NMFS (National Marine Fisheries Service). 2005. SEDAR 7—Gulf of Mexico red snapper stock assessment report. Available from: <http://www.sefsc.noaa.gov/sedar/>.

_____. 2009. Annual report to Congress on the status of U.S. fisheries—2008. U.S. Department of Commerce, NOAA, National Marine Fisheries Service, Silver Spring. Available from: <http://www.nmfs.noaa.gov/sfa/statusoffisheries/SOSmain.htm>.

NRC (National Research Council). 2006. Review of recreational fisheries survey methods. National Academy Press, Washington, DC.

Pauly, D., V. Christensen, S. Guenette, T. J. Pitcher, U. R. Sumaila, C. J. Walters, R. Watson, and D. Zeller. 2002. Towards sustainability in world fisheries. Nature 418: 689–695.

Pitcher, T. J. and C. E. Hollingworth. 2002. Fishing for fun: where's the catch? Pages 1–16 *in* T. J. Pitcher and C. E. Hollingworth, eds. Recreational fisheries: ecological, economical and social evaluations. Blackwell Publishing, Oxford.

Post, J. R., M. Sullivan, S. Cox, N. P. Lester, C. J. Walters, E. A. Parkinson, A. J. Paul, L. Jackson, and B. J. Shuter. 2002. Canada's recreational fisheries: the invisible collapse? Fisheries 27: 6–17.

Rangel, M. O. and K. Erzini. 2007. An assessment of catches and harvest of recreational shore angling in the north of Portugal. Fish. Manage. Ecol. 14: 343–352.

Schroeder, D. M. and M. S. Love. 2002. Recreational fishing and marine fish populations in California. CalCOFI Rep. 43: 182–190.

SEFSC (Southeast Fisheries Science Center). 2007a. Final model for Gulf of Mexico gag grouper as recommended by the SEDAR Grouper Review Panel: revised results and projections. National Marine Fisheries Service, Southeast Fisheries Science Center, Miami. Available from: http://www.sefsc.noaa.gov/sedar/download/Gag-revised-analyses-Sept-2007-1.pdf?id=DOCUMENT.

_____. 2007b. Status of Gulf of Mexico gag grouper: results and projected implications of the revision and sensitivity runs suggested by the grouper panel review. Tab B, No. 6a. National Marine Fisheries Service, Southeast Fisheries Science Center, Miami.

Watson, R. and D. Pauly. 2001. Systematic distortions in world fisheries catch trends. Nature 414: 534–536.

Date Submitted: 30 September, 2009.
Date Accepted: 29 April, 2010.
Available Online: 3 June, 2010.

Addresses: (W.F.F.) *School of Biological Sciences, Centre for Research on Ecological Impacts of Coastal Cities, Marine Ecology Laboratories (A11), University of Sydney, Sydney, NSW 2006, Australia.* (F.C.C.) *Florida State University Coastal and Marine Laboratory, 3618 Coastal Highway 98, St. Teresa, Florida 32358-2702.* Corresponding Author: (W.F.F.) *Telephone: +61 2 9351 2039, Fax: +61 2 9351 6713, E-mail: <will.figueira@bio.usyd.edu.au>.*

Appendix. Top 10 stocks landed by marine recreational fishers in the United States that are either overfished or experiencing overfishing (according to the Office of Sustainable Fisheries' "Status of U.S. Fisheries Report" for the second quarter of 2009) in the Northeast, South Atlantic, Gulf of Mexico, and Pacific. Landings are displayed as average landings in metric tons (mt) for 2000–2004 (except for the Pacific, where the average is based on landings from 2000–2002) and as percentages by recreational fishery sector. Ranks are based on national rankings of landings for all species for the same period. Sector column headings as in Table 2.

			Landings by sector (percentage of total)			
Rank	Species	Annual landings (mt)	Shore	Private	Headboat	Charter
Northeast						
5	Atlantic cod	2,548	0.0	65.8	34.2[a]	
6	Bluefin tuna	1,282	0.0	72.9	27.1	
12	Winter flounder	480	18.6	75.4	6.0	
13	Albacore	429	6.1	69.2	24.8	
17	Haddock	275	0.0	50.4	49.6	
22	Bigeye tuna	123	0.0	94.3	5.7	
37	Sandbar shark	28	3.4	93.4	3.3	
45	Dusky shark	18	21.6	74.6	3.7	
48	White hake	17	0.0	33.1	66.9	
61	Goosefish	7	0.0	70.3	29.7	
South Atlantic						
11	Red drum	617	16.3	81.8	0.0	1.9
15	Black sea bass	295	0.8	63.0	25.0	11.3
16	Gag grouper	286	6.9	68.7	7.4	17.0
18	Bigeye tuna	272	0.0	69.7	0.0	30.3
19	Vermilion snapper	261	0.2	20.9	60.5	18.5
20	Red snapper	192	2.5	62.0	14.6	20.9
23	Bluefin tuna	118	0.0	77.7	0.0	22.3
25	Red grouper	79	4.5	74.6	10.2	10.8
28	Sailfish	64	0.0	44.7	0.5	54.8
29	Bull shark	61	2.9	3.0	0.2	93.9
Gulf of Mexico						
1	Red drum	6,377	10.1	78.2	0.0	11.7
3	Red snapper	2,580	0.1	41.3	13.1	45.6
7	Greater amberjack	1,132	3.5	34.3	5.5	56.7
14	Vermilion snapper	304	0.0	25.6	36.0	38.4
24	Blue marlin	81	0.0	90.9	0.0	9.1
27	Bull shark	67	60.4	20.9	0.2	18.5
31	Spinner shark	41	31.8	52.4	0.3	15.5
34	Scalloped hammerhead	30	1.0	67.0	4.1	27.8
38	Tiger shark	25	0.0	83.3	15.5	1.3
41	Nurse shark	21	48.1	18.6	24.0	9.4
Pacific						
10	Lingcod	662	2.8	56.6	40.6	
21	Bocaccio	178	0.1	16.8	83.1	
26	Canary rockfish	70	0.2	22.3	77.5	
36	Yelloweye rockfish	29	0.0	44.7	55.3	
66	Cow rockfish	4.6	0.0	66.6	33.4	
71	Shortspine thornyhead	2.4	0.0	67.8	32.2	
74	Pacific ocean perch	0.9	0.0	22.2	77.8	
83	Darkblotched rockfish	0.002	0.0	0.0	100.0	

[a] Headboat and charter sectors are not separated in the Northeast or Pacific.