

Census of Active Commercial Fishermen in Puerto Rico: 2008

DANIEL MATOS-CARABALLO and JUAN J. AGAR

Introduction

Tropical fisheries have long provided sustenance, income, and employment to many coastal communities in the Commonwealth of Puerto Rico (Griffith and Valdés-Pizzini, 2002; Griffith et al., 2007; Agar et al., 2008). However, the declining health of many fish stocks and the ensuing impacts on coastal communities prompted the overhaul of the existing management regime (Matos-Caraballo et al., 2005; Matos-Caraballo et al., 2008; Matos-Caraballo, 2009). Many reef fish species, particularly snapper

(Lutjanidae) and grouper (Serranidae) stocks, are vulnerable to overexploitation because of their slow growth, late sexual maturity, sedentary behavior, and predictable aggregated spawning events (Sadovy and Eklund, 1999).

On 11 March 2004, Puerto Rican Regulation No. 6768 brought about sweeping changes in the way local fisheries were managed, including mandatory licensing and landings reporting requirements, which had been voluntary since 1931, and stringent conservation measures (DRNA, 2004; Matos-Caraballo, 2009). Among the controversial management measures were the establishment of commercial license tiers tied to income reporting requirements, additional closed seasons for red hind, *Epinephelus guttatus*, and mutton snapper, *L. analis*; and new minimum size restrictions for commercially valuable species such as silk snapper, *L. vivanus*; yellowtail snapper, *Ocyurus chrysurus*; blackfin snapper, *L. buccanella*; and queen conch, *Strombus gigas*. Additionally, the new rules mandated the

purchase of permits for harvesting queen conch, spiny lobster, *Panulirus argus*; land crab, *Cardisoma guanhumi*; sirajo gobies, *Sicydium plumiere*; and miscellaneous by-catch species, and closed the Nassau grouper, *E. striatus*, and goliath grouper, *E. itajara*, fisheries, which had been closed in Federal waters since the early 1990's (Matos-Caraballo, 1997; Matos-Caraballo, 2009). The regulation also prohibited, after a three-year waiting period, the use of beach seines to protect juvenile fish. Notwithstanding these changes, Commonwealth fisheries remained under a regulated open-access regime.

In spite of the Commonwealth's best intentions to rebuild and conserve local stocks, these regulations generated considerable hostility towards local fishery managers. Hundreds of fishermen ceased reporting their landings statistics and refused to participate in the biostatistical sampling program.¹ Ceasing to

¹ The biostatistical sampling program is responsible for collecting size frequency data and age at length data from commercial landings.

Daniel Matos-Caraballo is with the Fisheries Research Laboratory, Department of Natural and Environmental Resources, P.O. Box 3665, Mayagüez, Puerto Rico 00681 (email: matos_daniel@hotmail.com), and Juan J. Agar is with the Social Science Research Group, Southeast Fisheries Science Center, National Marine Fisheries Service, NOAA, Miami, FL 33149 (email: Juan.Agar@noaa.gov). The views and opinions provided or implied in this manuscript are those of the authors and do not necessarily reflect the positions or policies of the National Marine Fisheries Service, NOAA, or the Department of Natural and Environmental Resources.

ABSTRACT—The implementation of Puerto Rican Regulation No. 6768, which overhauled the existing fishery management framework, generated considerable hostility towards local managers. Among the controversial management measures adopted in 2004 were the assignment of fishing licenses based on fishing income, the establishment of closed seasons, and new minimum size restrictions for commercially valuable species. Though tensions have subsided, considerable opposition to these regulations remains. This paper provides a characterization of the current population of active small-scale fishermen, discusses their perceptions about the biological and socio-economic condition of

the fishery, and describes their attitudes towards the new management framework.

This study revealed that the number of active fishermen decreased from 1,731 in 1988 to 868 in 2008. Although a declining resource base was one of the main drivers behind these waning participation statistics, rising fuel costs and burdensome regulations exacerbated the rate of attrition. The majority of the fishermen were middle-aged men (50 years) with moderate levels of formal education and high levels of fishing dependence which limited their employment opportunities outside the fishery. Most of the vessels were small (20 ft) and outfitted with a single outboard engine (80 hp). Hook and line and SCUBA were dominant

gears because of their versatility and cost effectiveness. Fishermen suggested that their opposition to the regulations would continue unless they were afforded greater regulatory flexibility and provided with a larger role in the decision-making process. Fishermen were adamant about the need to reconsider the income reporting requirements to secure a fishing license because of the potential for losing public assistance benefits. They also objected to increasing the minimum size of many deepwater snapper (Lutjanidae) and grouper (Serranidae) species because it forced them to discard dead fish, a practice they consider wasteful since these species do not survive the ascent to the surface once hooked.

report or misreporting of landings is a common method of resistance used to repudiate management actions that are perceived to be heavy handed or unfair (Scott, 1987; Garcia-Quijano, 2009). Though resentment began to subside in 2006, the resolution of the conflict remains problematic. This paper provides a characterization of the current population of active small-scale fishermen, discusses their perceptions about the biological and socio-economic condition of the fishery, and describes their attitudes towards the new management framework. When possible, the results of this work are compared with earlier socio-economic assessments to examine long-term trends and patterns.

Methods

This study replicated the methodology used in earlier censuses of active commercial fishermen dating back to 1988.² Briefly, the methodology consisted of personnel from Puerto Rico's Department of Natural and Environmental Resources (DNER) Commercial Fisheries Statistics Program (CFSP) organizing meetings in every fishing center to discuss the need for the census and to survey the commercial fishermen in attendance. Fishermen who did not attend these meetings were identified with the assistance of the presidents of the fishing centers and other fishermen present at the meetings. Port agents attempted to reach these elusive fishermen at the dock and/or at their homes. If a commercial fisherman declined to participate in the survey (or was not found), CFSP personnel tried to obtain this fisherman's information from other fishermen who knew the non-respondent (or missing fisherman). About 5% of the population of purported active commercial fishermen either declined

² Two additional censuses of active commercial fishermen were conducted in the early 1990's. The first census estimated that there were 1,332 active fishermen in 1990 and the second one estimated that there were 1,155 active fishermen in 1992. The senior author, who participated in both of these data collections, does not believe that the above totals captured the entire population of active fishermen given the limited resources available for the sampling effort. Thus, we omitted them from our discussion.

Table 1.—Demographic characteristics by coastal region.

Characteristic	North coast	East coast	South coast	West coast	Puerto Rico	<i>n</i>
Number of fishermen	162	155	233	318	868	868
Number of captains	129	124	168	217	638	868
Number of helpers	33	31	62	101	230	868
Age (average in years)	53.0	50.8	51.3	47.3	50.1	863
Age distribution (%)						
≤30 years	7.5	7.8	13.0	16.1	12.2	863
31–40	10.6	19.5	11.7	18.0	15.2	863
41–50	22.4	20.1	22.1	24.3	22.6	863
51–60	24.2	24.0	17.8	18.9	20.5	863
61–70	29.2	22.7	26.0	14.5	21.8	863
≥71	5.6	5.2	6.9	7.3	6.5	863
Fishing experience (average in years)	29.6	30.1	29.2	26.9	28.6	852
Educational attainment (%)						
Less than high school	43.4	42.1	43.9	52.2	46.6	853
High school	39.6	44.7	43.0	36.1	40.1	853
Some college or professional training	10.1	6.6	7.0	6.6	7.3	853
College or more	6.9	6.6	6.1	5.1	5.9	853
Percentage of fishermen who reside in a different municipality than where they land their catch (%)	12.7	9.4	7.3	5.7	8.1	855

to participate in the census or could not be reached by CFSP staff.

The questionnaire inquired about household demographics; fishing practices; catch disposition; marketing channels; capital investment in fishing vessels, gears and equipment; perceptions about the health of the fishery; and the main socio-economic issues impacting their livelihoods (Fig. 1). The fieldwork took place between January and October, 2008. The confidentiality of the data is protected by article 9 of Puerto Rico's Fisheries Law No. 278 (DRNA, 2004) and Section 402(b) of the Magnuson-Stevens Fishery Conservation and Management Act (NMFS, 2007).

Results and Discussion

In all, CFSP personnel conducted 868 in-person, voluntary interviews with commercially active fishermen around 92 fishing centers in 39 coastal communities (Fig. 2).³ To offer detail and contextualize the findings of this work, we present regional and Commonwealth level statistics. The Commonwealth was partitioned into four coastal regions: north, east, south, and west (Fig. 2). The

³ The northern coastal municipalities of Manatí, Toa Baja, and Quebradillas reported no commercial fishing activity. According to key informants, fishermen dislike operating from Manatí and Toa Baja because of the strong ocean surges and from Quebradilla because of its high cliffs. Fishermen, who reside in Quebradilla, reportedly land their catch in the coastal municipalities of Isabella and Arecibo instead.

northern region extends from the municipalities of Isabella to Luquillo. The eastern region runs from the municipalities of Fajardo to Maunabo, including the islands of Vieques and Culebra, and the southern region stretches from the municipalities of Patillas to Lajas. The western region spans the municipalities of Cabo Rojo to Aguadilla. This section presents summary statistics for selected demographic characteristics; fishing dependence; fishing and marketing practices; capital investment on vessels, gear, and equipment; and opinions about the biological and socio-economic health of the fishery.

Demographic Profile

Most respondents were middle-aged men who lived in the same coastal municipalities where they landed their catches. Fishermen's ages ranged from 16 to 89 years, with an average of 50 years (Table 1). The northern region had older fishermen relative to the western region (53 vs. 47 years). About 12% of the respondents were 30 years or younger (Table 1), which is marginally lower than the 16% observed in the 1996 census of commercial fishermen.⁴ Recruitment rates for fishermen less than 31 years of age were almost two times higher in the south and west regions than

⁴ In a different study, Gutierrez-Sanchez (1982) estimated that 14.8% of the commercial fishermen were less than 30 years old (*n*=291).



Estado Libre Asociado de Puerto Rico
Departamento de Recursos Naturales y Ambientales

CENSO PESQUERO 2007-2008

Número de entrevista _____ Fecha _____

Entrevistador: _____

1. Nombre del pescador: _____
2. Apodo: _____
3. Lugar de desembarco (Centro): _____
4. Pertenece a alguna organización de pesca: Si ___ No ___ Cual _____
5. Dirección postal (Opcional): _____
6. Teléfono: (____) - ____ - _____
7. Barrio y Municipio de residencia: _____
8. Edad: _____
9. Años de experiencia como pescador: _____
10. Número de familiares que dependen económicamente de Usted _____ (inclúyase)
11. Nivel de educación mas alto alcanzado:
 Escuela elemental (K-Sexto) Escuela intermedia (Séptimo-Noveno)
 Escuela superior (Décimo-Doce) Cursos técnicos (post-secundarios)
 Algo de Universidad Grado de Universidad
 Algo de Escuela Graduada Estudios Graduados/Profesional
12. Posee licencia: Si _____ No _____ Número (opcional) _____
Si, tiene licencia Tiempo Completo Parcial Principiante
13. Tipo de pescador: Capitán Proel
 Tiempo completo
 Tiempo parcial (ocupación principal): _____
14. Cuantas horas por semana dedicas a:
a) Pescar _____ horas/semana
b) Mantenimiento y reparación de su barco y motores _____ horas/semana
c) Mantenimiento y reparación de artes _____ horas/semana
d) Venta de pescado _____ horas/semana
15. Tipo de pesca:
 Peces de arrecife Pargos de agua profunda Carrucho Octopus
 Peces ornamentales Pesca pelágica Juey
 Ceti Langosta Carnada

Figure 1.—Commercial fisherman census form.

16. Localización área de pesca (caladeros):
 Orilla Talud o beril Plataforma insular Aguas oceánicas (Pelágico)

17. Porcentaje de la pesca expedido por los siguientes canales (que sume al 100%):
Asociación _____ % Pescadería o Comprador _____ % Ambulante _____ %
Restaurante _____ % Pescadería propia _____ %

18. Manejo de la pesca:
 Desbucha Desbucha c/hielo Vivero Entero en hielo Entero s/hielo

19. Información sobre la embarcación:

Variables	Barco # 1 (Principal)	Barco # 2	Barco # 3
Dueño único (SI/NO)			
Año de construcción			
Eslora (pies)			
Manga (pies)			
Construcción del casco	" Madera " Fiberglass " Madera y fiber " Aluminio " Acero " Otro : _____	" Madera " Fiberglass " Madera y fiber " Aluminio " Acero " Otro : _____	" Madera " Fiberglass " Madera y fiber " Aluminio " Acero " Otro : _____
Motor	" Fuera de borda ____ " Interior ____ " Fuera de Borda / Interior ____	" Fuera de borda ____ " Interior ____ " Fuera de Borda / Interior ____	" Fuera de borda ____ " Interior ____ " Fuera de Borda / Interior ____
Propulsión (HP)	Motor # 1 ____ HP Motor # 2 ____ HP Motor # 3 ____ HP	Motor # 1 ____ HP Motor # 2 ____ HP Motor # 3 ____ HP	Motor # 1 ____ HP Motor # 2 ____ HP Motor # 3 ____ HP
Equipo eléctrico (número)	" GPS ____ " Depth finder ____ " Fish finder ____ " Radio-telefóno ____ " EPIRB ____ " Celular ____	" GPS ____ " Depth finder ____ " Fish finder ____ " Radio-telefóno ____ " EPIRB ____ " Celular ____	" GPS ____ " Depth finder ____ " Fish finder ____ " Radio-telefóno ____ " EPIRB ____ " Celular ____
Equipo de pesca (número)	" Fisga ____ " Tanques ____ " Bichero ____ " Canasto ____ " Slurp gun ____	" Fisga ____ " Tanques ____ " Bichero ____ " Canasto ____ " Slurp gun ____	" Fisga ____ " Tanques ____ " Bichero ____ " Canasto ____ " Slurp gun ____
Equipo de pesca (número)	" Winch ____ " Malacate Elect ____ " Malacate Hidr ____	" Winch ____ " Malacate Elect ____ " Malacate Hidr ____	" Winch ____ " Malacate Elect ____ " Malacate Hidr ____

Figure 1 (continued).—Commercial fisherman census form.

20. Información sobre artes de pesca:

Artes	Cantidades
Cordeles	
Cordel de mano	
Silga	
Caña (Spinning, trolling)	
Palangre horizontal	
Palangre de tiburón	
Palangres Verticales	
Fuete o Potala	
Fuete de Galonear	
Redes	
Trasmallo o filete	
Mallorquín (Peces, langostas)	
Atarraya (Carnada, camarones)	
Redes para peces ornamentales	
Submarina	
Skin	
SCUBA	
Trampas	
Nasa	
Cajones	

21. ¿Cuántos tripulantes participan en la pesca? _____

22. Opinión del Estado de los Recursos Pesqueros:

- Mejor Igual Peor que otros año

Razones:

- Contaminación
 Sobrepesca
 Destrucción de hábitat
 Otras _____

23. Porcentaje del ingreso del hogar (no personal) proviene de la pesca: _____ %

24. ¿Cuáles son los tres mayores problemas socio-económicos que afectan su pesca?

1. _____
2. _____
3. _____

*(Si dice reglamento especifique que regulación en particular, NR: no responde; NS: no sabe)

Figure 1 (continued).—Commercial fisherman census form.

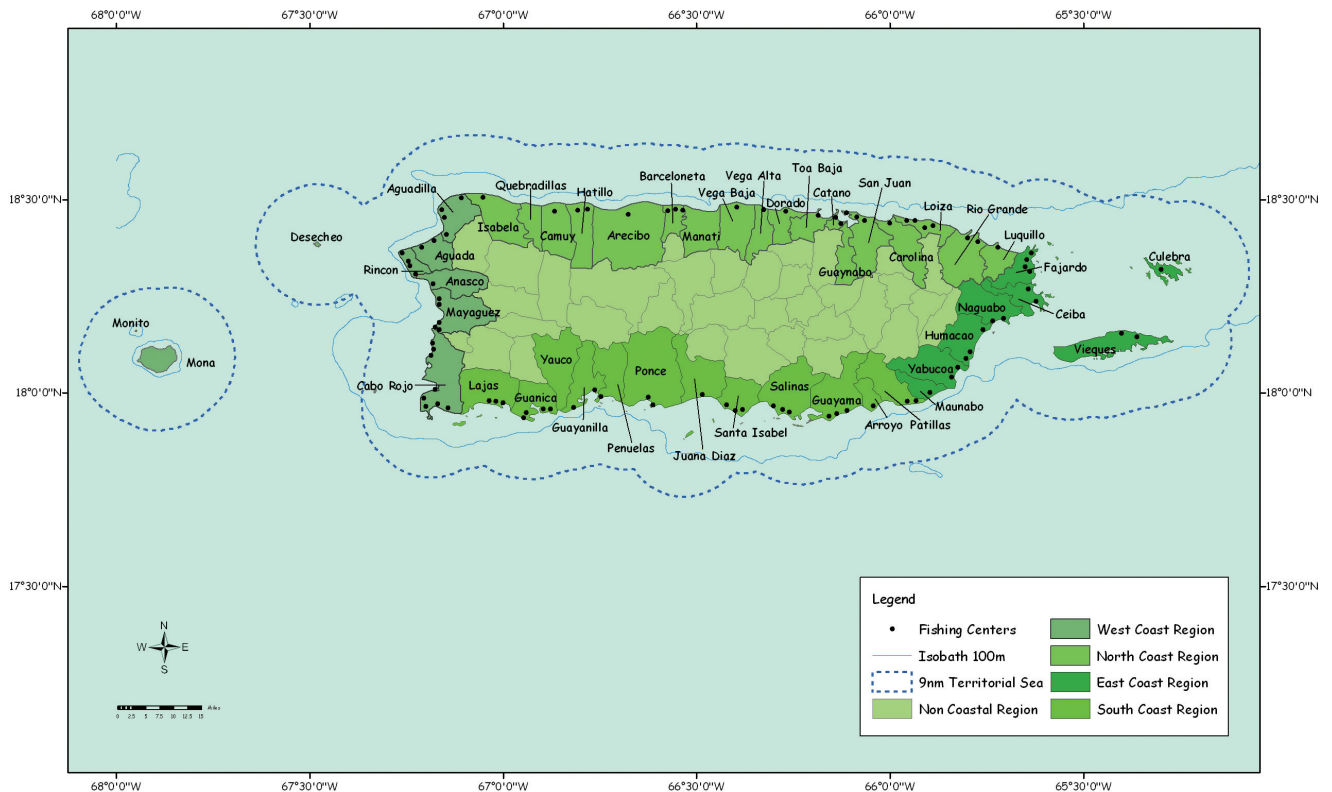


Figure 2.—Distribution of fishing centers in the Commonwealth of Puerto Rico.

in the north and east regions. Recruitment in the west coast was mainly comprised of full-time fishermen whereas recruitment in the south coast largely consisted of part-time fishermen. The presence of greater numbers of full-time fishermen in the west coast is due to the higher productivity of the local fishing grounds, the long fishing tradition of the region, and the limited employment opportunities outside the fishing industry. Part-time fishermen who live along the south coast also work for nearby petrochemical and pharmaceutical firms and produce farms harvesting tomatoes and mangos. The plurality of the respondents resided on the west (37%) coast and the remainder lived in the south (27%), north (19%), and east (18%) coasts. Only 8% of those surveyed lived in a different municipality from where they landed their catches. Seventy-four percent of the interviewees were captains and the remaining 26% were crew.

Most Puerto Rican fishermen had considerable fishing experience and

moderate levels of formal education. Fishing experience ranged from 1 to 75 years, with an average of 29 years. Regionally, fishing experience was fairly uniform ranging from 27 years in the west coast to 30 years in the east coast (Table 1). Approximately 47% of the respondents did not complete high school. Forty percent of the surveyed fishermen reported that their highest educational attainment was high school and another 6% reported having a college degree (Table 1). In contrast, U.S. census data for 2000 shows that about 40% of the Puerto Rican adults (25 years or older) did not complete high school. Another 22% reported that their highest educational accomplishment was a high school diploma, and another 18% reported having a college degree (Ladd and Rivera-Batiz, 2006). These statistics illustrate that, on average, commercial fishermen have lower educational attainment levels than those of typical Puerto Rican adults, which limit their employability outside the fisheries sector. In

comparing the educational attainment of Puerto Rican fishermen relative to other U.S. Caribbean fishermen, we find that Puerto Rican fishermen, on average, have more years of formal education. For example, Kojis (2004) reports that about 59% of fishermen in the U.S. Virgin Island did not complete high school, another 30% had only attained a high-school diploma, and another 5% had obtained a college degree.

Most respondents had small household sizes. The number of dependents (including the fisherman) ranged between 1 and 10, with an average of 3.1 (Table 2). Comparable figures were reported by Griffith et al. (2007) who found that the average household had 3.2 members (including the fisherman). Although there are no comparable statistics for the entire population of commercial fishermen in the U.S. Virgin Islands, Agar et al. (2008) found that the average number of dependents for trap fishermen ranged from 2.8 in St. Thomas and St. John to 3.4 in St. Croix.

Fishing Dependence

The majority of respondents were full-time fishermen (Table 2). Almost 75% of the respondents self-reported that they operated on a full-time basis, which is 39% higher than the levels reported in the 2002 census of commercial fishermen (Matos-Caraballo et al., 2005). The pointed percentage increase likely reflects the decline in construction jobs as the Puerto Rican construction boom abated. Table 3 shows that number of construction employment opportunities decreased by 15.6% between 2007 and 2008 (Junta de Planificación de Puerto Rico⁵). The elevated proportion of full-time fishermen may also be an unintended consequence of Regulation No. 6768, which requires the submission of tax records to obtain a commercial fishing license.⁶ Presently, Puerto Rico's Department of Agriculture grants full-time fishermen a 90% tax exemption on their fishing income. Part-time fishermen do not receive a tax exemption; thus, they are taxed

⁵ Junta de Planificación de Puerto Rico. 2010. Estadísticas Económicas. Online at <http://www.jp.gobierno.pr/>.

Table 2.—Fishing dependence indicators by coastal region.

Indicator	North coast	East coast	South coast	West coast	Puerto Rico	<i>n</i>
Self-reported full-time fishermen (%)	64.8	78.1	76.0	77.7	74.9	868
Household income derived from fishing (%)	54.9	78.3	76.9	82.6	75.2	826
Household income derived from fishing (%)						
0–24.9	15.6	4.5	4.4	2.9	5.9	826
25–49.9	23.4	15.7	4.8	5.1	10.2	826
50–74.9	31.2	12.7	28.6	19.9	23.2	826
75–100	29.9	67.2	62.1	72	60.6	826
Number of dependents (average, including self)	3.0	3.5	2.9	3.1	3.1	837
Percentage of fishermen belonging to a fishing association (%)	85.2	53.5	66.1	48.1	60.8	868
Number of licensed fishermen	92	114	134	217	557	868
Full-time licenses	53	80	96	165	394	868
Part-time licenses	10	14	13	9	46	868
Beginner licenses	29	20	25	43	117	868

at a higher marginal rate than their full-time counterparts. Moreover, the high fuel prices experienced in 2008 may have disproportionately impacted

⁶ Full-time fishermen are required to show their state income tax returns to document that 50% or more of their income is derived from fishing whereas part-time fishermen need to show that fishing contributes between 20 and 49% of their income. The regulation also provides for a third type of license, the so-called 'beginner' ('principiante' in Spanish) or apprentice license, which does not have any income reporting requirements but only lasts for a year and cannot be renewed. Full-time and part-time licenses can be renewed every four years.

marginal, part-time operations (Table 3). When part-time fishermen were asked about their other occupations, 81% declined to share this information, 5% said that they worked on construction and 3% stated that they received retirement benefits (i.e. pensions and social security payments). About 60% of the fishermen belonged to a fishing association (Table 2).

Most respondents stated that they were highly dependent on fishing to support their families. On average, Puerto Rican fishermen reported that fishing income made up about 75%

Table 3.—Number of fishermen and construction jobs, commercial landings, and retail gasoline price over time.

Year	No. of active fishermen (census data)	No. of full-time active fishermen (census data)	No. of part-time active fishermen (census data)	Adjusted landings ¹ (lb)	Construction jobs (1,000's) ²	% Change in construction jobs	Retail gasoline price (nominal \$/gal., U.S. city) ³
1988	1,731	1,306	425	3,837,386	—	—	0.96
1989				4,808,093	55	—	1.06
1990				4,560,774	56	1.8	1.22
1991				5,137,710	54	-3.6	1.20
1992				3,624,480	57	5.6	1.19
1993				4,449,363	56	-1.8	1.17
1994				4,511,971	55	-1.8	1.17
1995				5,557,385	58	5.5	1.21
1996	1,758	1,262	496	5,419,597	61	5.2	1.29
1997				5,313,666	66	8.2	1.29
1998				4,776,180	74	12.1	1.12
1999				4,551,945	83	12.2	1.22
2000				6,276,077	82	-1.2	1.56
2001				5,301,956	84	2.4	1.53
2002	1,163	423	740	4,048,506	83	-1.2	1.44
2003				3,364,452	85	2.4	1.64
2004				2,626,310	89	4.7	1.92
2005				2,209,908	85	-4.5	2.34
2006				1,761,742	91	7.1	2.64
2007				1,971,432	90	-1.1	2.85
2008	868	650	218	2,006,786	76	-15.6	3.32
2009				—	59	-22.4	2.40

¹ Cummings, N., and S. Turner. 2009. Southeast Fisheries Science Center, NMFS, NOAA. Personal commun.

² See text footnote 5.

³ Department of Energy. 2010. Online at <http://www.eia.doe.gov/emeu/aer/txt/ptb0524.html>.

of their household income (Table 2).⁷ Eighty-four percent of the interviewees stated that income derived from fishing contributed in excess of 50% to their household income. Parsing fishing income by time devoted to fishing, we find that self-reported full-time fishermen obtained 84% of their household income from fishing whereas self-reported part-time fishermen drew 47% of their household income from fishing. The documented levels of fishing reliance were higher than fishing dependence statistics reported elsewhere, suggesting that the loss of employment opportunities in construction, escalating fuel costs, and regulatory tightening (e.g. licensing requirements, seasonal closures, and minimum size restrictions) may have discouraged fishing on a part-time basis. For example, Griffith et al. (2007) estimated that fishing activities contributed between 40% and 45% to the average fisherman's household income.

Fishing dependence levels were more pronounced in the west (83%), followed by the east (78%), south (77%), and north (55%). The western region exhibited the highest levels of dependence on fishing because it encompasses the most productive fishing area and has the highest number of full-time fishermen. Conversely, the northern region had the lowest levels of dependence because it has the least productive fishing grounds and has the lowest number of full-time fishermen. The northern region also has an important pharmaceutical and retail industry.

Of the 868 fishermen interviewed, 557 self-reported to have valid licenses, with 394 full-time licenses, 46 part-time licenses, and 117 apprentice (or beginner) licenses (Table 2). By contrast, the DNER license database (which became available after our data collection was completed) indicated that there were 1,129 valid licenses in February 2009

⁷ Similar levels of fishing dependence have been reported for the commercial fishing fleet in the U.S. Virgin Islands. According to Kojis (2004), fishermen from St. Thomas and St. John derived about 74% of their household income from fishing and fishermen from St. Croix derived about 60%.

Table 4.—Main fishing grounds and target species by coastal region.

Item	North coast	East coast	South coast	West coast	Puerto Rico	<i>n</i>
Average hours per week spent on fishing related activities						
Fishing	28.5	31.0	30.7	31.1	30.5	849
Maintaining and repairing vessel and engine	3.9	3.6	5.1	6.6	5.1	785
Maintaining and repairing fishing gear	3.9	3.2	6.2	6.1	5.1	777
Selling catch	3.5	3.0	4.6	3.9	4.4	829
Percentage of fishermen who fish in following areas (%)						
Shore	66.7	47.7	21.9	13.5	31.8	868
Shelf break	84.0	67.1	44.6	51.3	58.4	868
Continental shelf	90.1	83.9	92.7	70.4	82.5	868
Deep water	45.7	60.7	24.5	25.8	35.4	868
Percentage of fishermen who target the following species (%)						
Reef fish	88.3	75.5	88.0	64.8	77.3	868
Deepwater snapper	71.6	71.6	39.5	51.3	55.5	868
Pelagic species	65.4	66.5	30.0	26.4	41.8	868
Spiny lobster	27.8	64.5	57.1	47.2	49.3	868
Queen conch	13.0	34.8	45.1	34.6	33.4	868
Baitfish	53.1	32.9	30.9	17.9	30.7	868
Octopus	1.9	0	19.3	1.3	6.0	868
Sirajo goby	8.0	0	0.9	0	1.7	868
Land crab	9.3	10.3	6.0	2.2	6.0	868
Ornamental fish	0.6	1.9	0.9	2.5	1.6	868

(416 apprentice, 89 part-time, and 624 full-time licenses).⁸ Although there is a significant discrepancy between the DNER figures and ours, we believe that our tally provides a better estimate of the population of active (rather than licensed) fishermen since they were derived from extensive fieldwork. Our surveyors, mainly port agents, combed all fishing centers searching for active fishermen. Moreover, DNER's statistics likely capture a large share of opportunistic fishermen on the main island of Puerto Rico who occasionally harvest spiny lobster using trammel nets and king mackerel using handlines, which would explain the large number of beginner licenses. Similarly, on the island of Vieques, a large number of opportunistic fishermen reportedly fish for mutton and yellowtail snappers every year between February and April. Regardless of the reasons behind the discrepancy, this study, which adopted the same methods used in earlier censuses of active fishermen, shows that participation rates have decreased noticeably since the late 1980's (Matos-Caraballo and Torres-Rosado, 1989; Matos-

⁸ Miguel Garcia Bermudez of DNER reported these statistics to Caribbean Fishery Management Council in June 2009. Personal commun.

Caraballo, 1998; Matos-Caraballo et al., 2005).

Of the captains interviewed, about 75% indicated having a valid license (350 full-timers, 42 part-timers, and 85 apprentices). Noteworthy is that 35% of helpers had a valid license (44 full-timers, 4 part-timers and 32 apprentices) because captains encourage helpers to acquire them to maximize the daily harvest of queen conch. Commonwealth regulations allow landings of 150 queen conch per day per licensed fisherman up to 450 queen conch per day per fishing vessel. Helpers also like having a fishing license because it affords greater flexibility to go fishing alone or with other helpers.

Fishing Practices

Puerto Rican fishermen devoted, on average, 30 h per week to catching fish (Table 4). They also spent a substantial amount of time maintaining their vessels, engines, and gears. On average, fishermen reported spending about 5.1 h a week maintaining and repairing their vessel and engine and an additional 5.1 h a week maintaining and repairing their fishing gear (Table 4). These statistics suggest that Puerto Rican fishermen spent more time on trade-related activities than their counterparts in the U.S.

Virgin Islands. Kojis (2004) reported that fishermen in the U.S. Virgin Islands spent an average of 22.3 h per week fishing, 3.2 h per week fixing their vessel, and 4.1 h per week fixing their gear.

When we inquired about the time spent on these trade-related activities by time devoted to fishing, we found that self-reported full-timers, on average, spent 33.3 h per week fishing, 5.5 h per week maintaining their fishing boats, and 5.5 h per week maintaining their fishing equipment and gears. On the other hand, self-reported part-timers reported that, on average, they spent 21.5 h per week fishing, 4.1 h per week maintaining their fishing boats, and 3.1 h per week maintaining their fishing equipment and gear.

Fishing Grounds and Target Species

Puerto Rican fishermen continue to favor the continental shelf and shelf break as their prime fishing grounds (Table 4). About 82% of respondents reported fishing on the continental shelf which is about the same as the 83% who reported fishing on the continental shelf in 2002 (Matos-Caraballo et al., 2005).⁹ In 1996, 70% of the fishermen stated that they fished on the continental shelf (Matos-Caraballo, 1998). Fifty-eight percent of the fishermen stated that they fished on the shelf break, which is up from 19% in 2002 and 43% in 1996 (Matos-Caraballo, 1998; Matos-Caraballo et al., 2005). In contrast, the proportion of fishermen who reported fishing in deep waters dropped from 46% in 1996 and 48% in 2002 to 35% in 2008, because of higher fuel costs and tighter fishing regulations such as minimum size limits and closed seasons. Higher fuel costs also may have contributed to a greater percentage of fishermen operating from the coast, which rose from 17% in 2002 to 32% in 2008 (Matos-Caraballo et al., 2005). In 1996, 31% of the fishermen

⁹ One of the reviewers correctly pointed out that since the descriptions of fishing grounds and targeting behavior contain the views of captain and crew there may be some 'double counting' of the results. While we recognize this limitation, we did not make any changes since we are comparing these results with the results of earlier censuses, which also suffer from the same shortcomings identified by the reviewer.

Table 5.—Type and number of fishing gears by coastal region.

Gear	North coast	East coast	South coast	West coast	Puerto Rico	<i>n</i>
Handline	1,040	1,260	1,746	1,715	5,761	868
Troll line	368	464	300	313	1,445	868
Rod and reel: spinning	54	96	74	67	291	868
Rod and reel: trolling	344	101	287	187	919	868
Horizontal longline	36	21	38	60	155	868
Shark longline	13	45	8	12	78	868
Anchored bottom line	480	276	224	193	1,173	868
Drifting bottom line	158	3	27	234	422	868
SCUBA	15	58	54	90	217	868
Skin	27	60	37	18	142	868
Fish traps	241	1,587	1,661	1,075	4,574	868
Lobster traps	99	880	1,761	1,102	3,842	868
Deepwater snapper traps	79	419	86	597	1,181	868
Gillnet	104	104	216	146	570	868
Fish trammel net	10	26	46	93	175	868
Lobster trammel net	0	0	49	103	152	868
Bait cast net	202	210	229	169	810	868
Shrimp cast net	2	0	3	0	5	868
Ornamental net	0	0	4	12	16	868

reported fishing from the coast (Matos-Caraballo, 1998).

We also inquired about fishermen's targeting behavior (Table 4). A high proportion of respondents stated that they targeted reef fish (77%), spiny lobster (49%), queen conch (33%), and baitfish (31%). Unexpectedly, census figures showed that the percentage of fishermen targeting deepwater snappers increased from 37% in 2002 to 55% in 2008 despite fewer fishermen reporting having operated in deep waters. It is likely that they are taking advantage of the higher prices received for deepwater snappers, which command an average price of \$3.50/lb whereas first class reef fish species (e.g. yellowtail and lane snappers) fetch about \$2.25/lb. The proportion of fishermen seeking pelagic species also increased from 36% to 42% during the same time period. Few respondents stated that they targeted octopi (6%), land crabs (6%), sirajo gobies (2%), and ornamentals (2%).¹⁰

Next, we consider how the choice of gears and targeting behavior varies by

¹⁰ Sirajo gobies are an anadromous species whose adults spawn in freshwater, but their young spend time at sea or in brackish waters. A unique trait of these species is that when the adults return upstream to spawn they climb rocks (or any barriers impeding their upstream movements) with their modified pelvic fins. Fishermen also refer to gobies as cetí or 'chupapiedras' (suckstones). Benedetti (1996) offers an interesting account of this fishery, and describes how fishermen catch this species on river mouths between June and January on a waning moon.

region. In discussing these choices, the island's unique biogeography must be taken into consideration.

North Coast

The north region is the least productive region of the island largely because of its narrow continental shelf and exposed coast (Jarvis, 1932; Whiteleader, 1971; Suarez-Caabro, 1979). The 100-fathom curve occurs between 1 and 2 miles off the coast, which limits the amount of fishable area. In 2008, this coast produced about 7% of the total reported landings for Puerto Rico.¹¹ The limited shelf forces the fishermen to operate in a variety of locations, including the continental shelf (90%), shelf break (84%), shore (67%), and, to a lesser extent, in deep waters (46%; Table 4). The exposed coast offers little protection against heavy swells and rough seas from the Atlantic Ocean, which encourages the use of hook and line and, to a lesser extent, net gears, and discourages the use of traps and SCUBA. This region holds about 41% of the anchored bottom lines present on the island, 37% of the drifting bottom lines, 37% of rods and reels for trolling, and 23% of the horizontal longlines (Table 5). Less than 5% of the total number of

¹¹ Transmission from Daniel Matos-Caraballo, Fisheries Research Laboratory, Department of Natural and Environmental Resources, Mayagüez, Puerto Rico, to Josh Bennett, Southeast Fisheries Science Center, National Marine Fisheries Service, Miami, Florida on 5/1/2009.

fish, spiny lobster, and deepwater snapper traps are found in this area. Fewer than 7% of the SCUBA divers operate in the area.

Fishermen along the north coast target a variety of species (Table 4). About 88% of the fishermen target reef fishes such as yellowtail snapper; triggerfish, *Balistidae* spp.; and parrotfish, *Sparisima viride* and *S. chrysoterum*; 72% target deepwater snappers such as silk and queen, *Etelis oculatus*, snappers; 65% target pelagic species such as dolphinfish, *Coryphaena hippurus*; king mackerel, *Scomberomorus cavalla*; and little tunny, *Euthynnus alletteratus*; and 53% target baitfish such as herring, *Opisthonema oglinum*; mullets, *Mugilidae* spp.; and mojarras, *Gerreidae* spp. About 28% of the fishermen reported catching spiny lobster and another 13% landing queen conch. A small number of fishermen reported catching land crabs (9%) and sirajo gobies (8%) in the lower reaches of streams and lagoons and along mangrove edges.

East Coast

The east coast has an extensive shallow shelf with average depths of about 30 fathoms, and a number of reefs, banks, islets, and cays (Jarvis, 1932). In 2008, this area was responsible for about 11% of the domestic seafood production.¹¹ About 84% of the fishermen stated that they fished on the continental shelf, followed by the shelf break (67%), deepwater (61%), and shore (48%; Table 4). The shallow, ample shelf permits them to target multiple species with various gears, including lines, traps, and SCUBA (Table 5). About 75% of the fishermen stated that they target reef fish species such as yellowtail; lane and mutton snappers; hogfish, *Lachnolaimus maximus*; porgies, *Sparidae* spp.; white grunt, *Haemulon plumieri*; and parrotfish; 72% target deepwater silk and queen snappers, 66% target pelagic species such as mackerels, 64% target spiny lobster, 35% target queen conch, and 33% target baitfish (Table 4). Ten percent of the fishermen mentioned that they harvested land crabs.

The region accounted for 58% of the shark longlines, 32% of troll lines, 33%

of the rod and reel (spinning), 23% of the anchored bottom lines, and 30% of the traps (both lobster and fish) present on the island (Table 5). This region also includes 42% of the skin divers and 27% of the SCUBA divers of the island.

South Coast

Although the southern platform drops off within a short distance from the coast, the coastline is not as exposed or subject to strong storms as the northern coast (Jarvis, 1932). This region yielded about 24% of the domestic catch in 2008.¹¹ SCUBA, fish traps or pots, bottom lines, and, to lesser extent, nets are responsible for most of the landings. Ninety-three percent of the fishermen stated fishing on the continental shelf compared to 45% on the shelf break, 24% in deep water, and 22% from the shoreline (Table 4). Because the shelf does not drop off abruptly and the coastline is less exposed to rough seas relative to the north coast, more fishermen target spiny lobster (57%) and queen conch (45%) (Table 4). Eighty-eight percent of fishermen mentioned that they harvested reef fish species such as yellowtail, mutton and lane snappers, porgy, parrotfish, hogfish, and grunts; 39% said they targeted deepwater snappers such as silk snapper; 30% reported that they caught pelagic species such as dolphinfish and king mackerel; and 31% said that they targeted baitfish such as ballyhoo, *Hemiramphus brasiliensis*; and herring. The south coast had the highest percentage of respondents that said that they fished for octopus (19%).

West Coast

Although the western coastline is about a third as long as the northern or southern coasts, it is Puerto Rico's most productive fishing region. In 2008, the west coast landed about 59% of the finfish and shellfish catch.¹¹ The southwest corner has a relatively shallow and extended shelf (10–15 fathom depths are found for 6 or more miles off Mayagüez) whereas in the northwest corner the ocean floor drops off sharply (Jarvis, 1932; Whiteleader, 1971; Suarez-Caabro,

1979). Off the west coast, fishermen also fish around the islands of Mona, Monito, and Desecho and deepwater banks (e.g. Bajo de Sico, Tourmaline, Abrir la Sierra, among others). Bottom lines, SCUBA, and, to a lesser extent, troll lines and fish pots are the most important gears used in this region. As in other coastal areas, fishermen fished in various areas: continental shelf (70%), shelf break (51%), deep water (26%), and the shoreline (13%) (Table 4). Sixty-five percent of the fishermen reported fishing for reef fish such as yellowtail, lane, and mutton snappers; 51% fished for deepwater snappers such as silk and queen snappers; 26% fished for pelagic species such as dolphinfish; skipjack, *E. pelamis*; blackfin, *Thunnus atlanticus*; and yellowfin, *T. albacarus*, tunas; and king mackerel; and 18% fished for baitfish such as ballyhoo (Table 4). Forty-seven percent and 35% of the fishermen reported targeting spiny lobster and queen conch, respectively. Twelve out of the 16 ornamental fishermen interviewed were found in this coastal region.

Catch Disposition and Marketing

In 2008, about 2 million pounds of finfish and shellfish were landed in Puerto Rico (Table 3). On average, Puerto Rican fishermen spent about 4.4 h per week selling their catch (Table 4). Over 55% of the respondents stated that they iced their catch. Over 33% said they sold their catch iced in whole form, and another 22% mentioned that they sold their catch iced in gutted form (Table 6).

The census showed that respondents use multiple avenues to sell their catches (Table 6). About 36% of the respondents stated that they peddled their catch themselves (locally known as “ambulantes”), up nearly 8% from 2002 levels (Matos-Caraballo et al., 2005). Peddlers use multiple marketing strategies, including delivering fish orders to the homes of their regular clients, packing their catch in iced fiberglass boxes and hauling them to strategic locations where they are put up for sale, and selling directly from

their homes (Valdés-Pizzini¹²). Fishermen favor peddling fish because of the minimum storage and freezing investments necessary to market their low volume production and the opportunity to generate additional income which otherwise would go to fish mongers and wholesalers (Valdés-Pizzini¹²).

The proportion of fishermen selling to fishing associations dropped from 47% in 2002 to 28% in 2008 because of the economic downturn (Table 6).¹³ Unlike most countries where fresh fish is preserved in ice, most Puerto Rican fishing associations sell the fish frozen, even though they market it as “fresh” fish (“pescado fresco”). “Pescado fresco” seems to denote, at least in Puerto Rico, that the fish is caught locally rather than not frozen. Fish mongers keep locally caught fish in freezers in either gutted (“limpio” as referred locally) or un-gutted (“sucio” as referred locally) form.

Margins vary by fish species and customer type. For instance, fishermen may receive \$5.00/lb for queen conch meat and then the fishing association may subsequently sell it for \$5.75/lb to restaurants or \$6.50/lb to retail customers. Lobstermen may obtain \$6.25/lb for spiny lobster and then the fishing association may sell it for \$7.00/lb to restaurants or \$7.25/lb to the public. Similarly, reef fish fishermen may receive \$3.00/lb for gutted silk snapper and then the fishing association may sell it for \$5.25/lb to restaurants or \$5.50/lb to the public. Fishing associations raise dockside prices slightly (\$0.25–\$1/lb) during Lent to satisfy increasing demand during this period.

Few fishermen reported selling directly to fish stores and restaurants. The share of fishermen selling through their retail store increased marginally from 3% in 2002 to 6% in 2008 while

Table 6.—Marketing of finfish and shellfish by coastal region.

Item	North coast	East coast	South coast	West coast	Puerto Rico	n
Percentage of fishermen who sold through these marketing channels (%)						
Fishing association (Villa pesquera)	40.7	25.8	29.6	21.1	27.9	868
Wholesaler/fish store	20.4	38.1	26.6	41.2	32.8	868
Own fish store	7.4	7.1	6.4	3.8	5.8	868
Home-based retail (ambulantes)	45.7	38.1	40.3	26.7	35.9	868
Restaurant	2.5	7.1	1.7	10.1	5.9	868
Percentage of catch sold through these marketing channels (%)						
Fishing association (Villa pesquera)	34.1	23.7	28.9	20.5	25.9	868
Wholesaler/fish store	17.9	30.5	25.3	40.4	30.4	868
Own fish store	6.2	6.8	6.4	3.7	5.5	868
Home-based retail (ambulantes)	37.9	29.5	37.6	25.2	31.7	868
Restaurant	1.5	4.4	1.0	9.2	4.7	868
Percentage of the catch disposed in the following manner (%)						
Whole	13.0	12.9	17.6	19.8	16.7	868
Whole and iced	72.2	52.9	18.9	15.1	33.5	868
Gutted	0	3.2	28.3	40.9	23.2	868
Gutted and iced	10.5	7.7	36.9	23.9	22.0	868
Live well	1.8	21.3	0.4	5.4	6.2	868

the percentage of fishermen selling to restaurants remained relatively constant at about 6% during the same time period (Table 6). During the interviews many fishermen complained that it was hard to sell to restaurants because they favor low-cost, frozen fish products from the U.S. mainland, Brazil, and Mexico. The share of fishermen selling to fish houses or wholesalers went marginally up from 30% in 2002 to 33% in 2008 (Matos-Caraballo et al., 2005).

The census also inquired about the share of landings that went through various marketing channels. On average, 32% of the catch was peddled, 30% was sold to wholesalers or fish houses, and 26% was sold to fishing associations (Table 6). Regionally, peddling was the dominant marketing strategy in the north (38%) and south (38%) coasts. The east and west coasts peddled about 30% and 25% of their production, respectively. In the west coast, most of the landings were handled by wholesalers or fish houses (40%) and fishing associations (21%).

Fishing Vessels, Gears, and Equipment

Fishing Vessels

The active commercial fleet consisted of 670 vessels (Table 7). Almost 100% of the captains owned a single (primary) fishing boat. Most of the fishing vessels were small with moderate levels

of mechanization. The average length of the primary fishing vessel was 20 ft. About 97% of the primary vessels ranged between 10 and 30 ft in length.

The census tallied 637 gasoline engines and 65 diesel engines (Table 7). Most primary vessels were outfitted with single outboard engines. The average propulsion rate of the primary vessel was 80 horsepower (hp), up from 66 hp in 2002 (Matos-Caraballo et al., 2005). Regionally, propulsion rates ranged from 65 hp (48 hp in 2002) in the south region to 103 hp (79 hp in 2002) in the east region (Table 7). Most hulls were built of fiberglass (65%) and, to a lesser extent, of fiberglass and wood (22%; Table 7). Only 12% of the hulls of the primary vessels were made of wood. Thirty percent of the primary vessels were built after 2000. Most fishing vessels were manned by a captain and helper (Table 7). Diving operations tended to have a captain and two helpers because the crew need to tend the boat and dive.

Main Gears

Hook and line gear was the most common and productive gear, accounting for about 49% of the total landings in 2008.¹¹ Fishermen, particularly part-time fishermen, favored this gear because of its efficiency and cost effectiveness for catching reef fish and pelagic species. Table 5 shows that handlines comprised about 56% of the

¹² Valdés-Pizzini, undated. Canales de Mercadeo de Pescado Fresco en Puerto Rico. Unpublished manuscript.

¹³ According to Eugenio Piñero-Soler, Chairman of the Caribbean Fishery Management Council, many fishing associations have not only scaled down on the volume of their purchases but also limited the time of operation from 7 to 4 days per week (i.e. Thursdays to Sundays). Personal commun.

units in this group, followed by bottom lines (16%), troll lines (14%), rods and reels (12%), and longlines (2%). Handlines and troll lines were used to catch dolphinfish, skipjack, little and blackfin tunas, and king mackerel. Anchored bottom lines targeted queen, silk, and lane snappers; and drifting bottom lines sought yellowtail and mutton snappers; dolphinfishes; king and cero, *S. regalis*, mackerels; little, skipjack, and blackfin tunas; and sharks. Rods and reels were used to land dolphinfish, yellowtail snapper, king and cero mackerels, and

little tunny. Longlines were used to catch sharks and lane, silk, and mutton snappers. Overall, the total amount of hook-and-line gear decreased from 12,314 units in 2002 (Matos-Caraballo et al., 2005) to 10,244 units in 2008 (Table 8).

SCUBA and skin diving were the second most productive gears, together they were responsible for approximately 29% of the total landings in 2008.¹¹ Divers made up about 44% of the population of active fishermen, down from 53% in 2002 (Matos-Caraballo et al., 2005). SCUBA gear was used primar-

ily to harvest queen conch and spiny lobster and, to a lesser extent, hogfish; parrotfish; boxfish, *Ostraciidae* spp.; and queen triggerfish, *B. vetula*; whereas skin diving mainly caught queen conch and spiny lobster. SCUBA and skin divers used 322 snares, 375 spears, 775 tanks, 578 gaffs, and 275 baskets (Table 8).

Traps or pots were the third most productive gears and accounted for almost 13% of the total landings in 2008.¹¹ Table 5 shows that fish traps accounted for 48% of the trap units, followed by lobster traps (40%) and deepwater snapper traps (12%). Fish pots targeted spiny lobsters, grunts, boxfishes, queen triggerfishes, and parrotfishes, whereas lobster traps landed mainly spiny lobsters. Deepwater snapper traps caught silk, queen, vermilion, and blackfin snappers. The total number of traps dropped from 13,146 units in 2002 (Matos-Caraballo et al., 2005) to 9,597 units in 2008 (Table 8).

Nets were the fourth most productive gears. Over 9% of the island's total yield was derived from this gear in 2008.¹¹ Nets totaled 1,712 units in 2008, down from 2,798 units in 2002 (Matos-Caraballo et al., 2005). Among the nets, gillnets accounted for 33% of the units, trammel nets for 19%, and bait cast nets for 47% (Table 5). Gillnets are used to catch bar jacks, porgies, balihooos, grunts, parrotfishes, and various snappers, whereas trammel nets catch spiny lobsters, grunts, parrotfishes, and boxfishes.

The census also examined the ornamental industry, which operated with little government intervention since the 1960's. However, this changed when regulation No. 6768 mandated that ornamental fishermen had to obtain a fishing license and an ornamental permit, and had to report their landings on a monthly basis. Moreover, the new regulation limited the ornamental fishery to 20 fish species and 8 invertebrate species (Matos-Caraballo and Mercado-Porrata, 2008). Because the ornamental fishery was only recently regulated, ornamental fishermen were not interviewed in earlier censuses of active fishermen. This survey identified 16 ornamental fisher-

Table 7.—Vessel characteristics by coastal region.

Characteristic	North coast	East coast	South coast	West coast	Puerto Rico	n
No. of fishing vessels	134	124	176	236	670	868
No. of gasoline and diesel engines	132	134	181	255	702	868
Average length of primary vessel (ft)	18.8	21.0	19.2	19.9	19.7	624
Average total engine propulsion of primary vessel (hp)	78.2	103.1	64.9	80.1	80.1	642
Average crew size	1.9	2.0	1.9	1.9	1.9	847
Percentage of primary vessels whose length lies between						
<10 ft	0	1.8	0.6	0	0.5	624
10–19.9 ft	55.0	16.5	55.8	52.5	47.6	624
20–29.9 ft	45.0	75.2	43.0	44.8	49.7	624
30–39.9 ft	0	6.4	0.6	2.3	2.1	624
≥40 ft	0	0	0	5	0.2	624
Percentage of primary vessels being built between						
≤1979	24	22.6	17.9	23.1	21.8	583
1980–1989	17.8	21.3	25.3	17.5	20.2	583
1990–1999	25.6	34.7	27.2	28.6	28.3	583
≥2000	32.6	21.3	29.6	30.9	29.7	583
Percentage of primary vessels that have hulls made of						
Aluminum	1.5	0	1.2	0.4	0.8	641
Fiberglass	72.0	82.9	48.8	62.3	64.7	641
Wood	9.8	0.8	15.7	18.2	12.5	641
Fiberglass and wood	16.7	16.3	34.3	18.6	21.8	641

Table 8.—Number of fishing gear and equipment by coastal region.

Gear/equipment	North coast	East coast	South coast	West coast	Puerto Rico	n
Total lines	2,493	2,266	2,704	2,781	10,244	868
Total skin/SCUBA	42	118	91	108	359	868
Total traps	419	2,886	3,508	2,774	9,587	868
Total nets	318	340	543	511	1,712	868
Global Positioning System (GPS)	47	60	32	120	259	868
Depth finders	62	37	40	75	214	868
Fish finders	60	60	35	41	196	868
Radios	62	29	40	70	201	868
Emergency Position Indicating						
Radio Beacons (EPIRB)	0	6	5	24	35	868
Cellular phones	94	95	72	132	393	868
Electric reels	89	24	35	69	217	868
Hydraulic reels	1	8	10	17	36	868
Winches	22	41	26	37	126	868
Snares	23	101	78	120	322	868
Spears	52	85	136	102	375	868
Tanks	74	192	204	305	775	868
Gaffs	82	68	256	172	578	868
Baskets	12	70	82	111	275	868
Slurp guns	0	1	0	2	3	868

men who used slurp guns and ornamental hand nets to make a living. However, interviewees suggested that there were an additional 20 fishermen who operated illegally. Most of the respondents were skin divers who operated on rocky beaches on the northwest coast. Many of these ornamental fishermen are university or high school students who operate on a part-time basis. The ornamental fishermen interviewed reported that their operations were small in scale because they had difficulty competing with competitively priced fish from the Indo-Pacific region.

Electronic Equipment

Cellular or mobile phones and global positioning systems (GPS) were the most common electronic equipment found onboard commercial fishing vessels (Table 8). About 59% of the vessels carried cellular phones and 39% had GPS. Regionally, cellular phones were ubiquitous in the east (77%) and scarcer in the south (41%) whereas GPS were more common in the west (51%) and less prevalent in the south (18%). Slightly less than one-third of the vessels had depth finders (32%), radios (30%), and fish finders (29%). Less than 5% of the fleet had emergency position indicating radio beacons (EPIRB's). Over 32% of the vessels had electric reels, and 5% had hydraulic reels. The north region had the highest percentage (66%) of vessels with electric reels (Table 8). Approximately one in five vessels had winches. Regionally, winches were relatively more prevalent in the east (33%) and less common in the south (15%).

Perceptions About the Biological and Economic Health of the Fishery

Forty-six percent of the respondents believed that the health of the stocks was worse than in previous years whereas 45% believed that the health of the stocks was about the same (Table 9). When we inquired about the main reasons for the perceived decline, equal percentages of the fishermen (28%) stated that pollution and other (miscellaneous) reasons were to blame, 12% ascribed it to habitat destruction, and 9% believed it was due to overfishing (down

Table 9.—Perceptions about the biological and socio-economic condition of the fishery by region.

Perception	North coast	East coast	South coast	West coast	Puerto Rico	n
Perception about the condition of the stocks (%)						
Better off than other years	2.6	16.9	3.5	11.0	8.4	843
Same than other years	41.7	35.9	48.7	49.2	45.4	843
Worse off than other years	55.8	47.2	47.8	39.7	46.1	843
Reasons for the declining condition of fish stocks (%)						
Overfishing	10.5	5.8	9.4	9.7	9.1	868
Pollution	48.8	31.6	29.2	16.0	28.5	868
Habitat destruction	15.4	23.2	12.0	5.7	12.3	868
"Other reasons"	24.1	21.3	30.0	31.1	27.8	868
"Other reasons" for the declining condition of fish stocks (%)						
Regulations	17.9	39.4	37.1	41.1	36.1	241
Weather and ocean conditions	46.1	24.2	35.7	26.3	31.9	241
Climate change	5.1	9.1	22.9	15.1	14.9	241
User conflicts	7.7	9.1	4.3	9.1	7.5	241
Coastal development	1.0	6.1	0	2.0	3.3	241
Main socio-economic issues (%)						
High fuel costs	79.6	43.2	56.2	60.1	59.7	868
High fishing costs (excluding fuel)	15.4	20.0	26.6	27.7	23.7	868
Regulations	28.4	22.6	37.8	42.4	35.0	868
Weather and ocean conditions	15.4	10.3	20.6	9.8	13.8	868
Coastal development	13.6	1.9	6.9	4.1	6.2	868
User conflicts	1.2	2.6	2.6	2.5	2.3	868
High cost of life	15.4	13.5	4.7	3.8	7.9	868
Low fish prices and slow markets	14.2	25.2	5.11	5.0	10.4	868

from 22% in 2002). On a regional level, fishermen identified contamination as the dominant reason for the declining stocks in the north (49%), east (32%), and south (29%). According to the fishermen interviewed, large population centers and the pharmaceutical industry are the main culprits for pollution in the north coast, large marinas and extensive coastal development are the main reasons for contamination in the east coast, and the oil refinery industry and agricultural run-off are the main sources of contamination in the south. When inquired about the "other reasons" for the declining condition of fish stocks, a plurality of the fishermen stated that they were troubled by existing regulations such as closed seasons (36%), adverse weather and ocean conditions (32%), and climate change (15%). Fishermen argued that seasonal closures which prevent them from targeting dense fish aggregations lead to fewer fish being caught, which managers mistakenly ascribed to dwindling populations rather than to the pre-emptive nature of the closure.

Commercial fishermen were also asked about the main socioeconomic issues affecting their ability to support themselves and their families (Table 9).

Overwhelmingly, fishermen cited high fuel costs (60%) as the most important socio-economic concern, followed by restrictive regulations (e.g. seasonal closures, minimum size limits, 35%), rising non-fuel related fishing expenses (e.g. bait, fishing equipment, 24%), adverse weather and ocean conditions (14%), and low fish prices and/or slow sales (10%).

When fishermen were asked about their main concerns about the new regulatory framework, most fishermen said that they were troubled by the new burdensome licensing and permitting requirements. Large numbers of fishermen, especially older fishermen, were opposed to reporting their fishing income to secure a fishing license because they feared having to pay income taxes, and more importantly, potentially losing public assistance and health care benefits. United States and Puerto Rican government transfer payments (i.e. Social Security and Nutritional Assistance Program) are important supplemental sources of household income, particularly to older commercial fishermen (Perez, 2005). Moreover, many fishermen claimed that Puerto Rico's DNER license application process was slow and that it sometimes

took in excess of six months to receive their licenses.

Another commonly voiced complaint was that the closed seasons prevented them from targeting highly profitable spawning aggregations. Federal and Commonwealth fishery management agencies favor closed seasons over permanent closures to provide for sustained participation of small-scale fishermen while affording added protection to snapper-grouper stocks (Tonioli and Agar, 2009). In addition, fishermen objected to increasing the minimum size of many deepwater snapper-grouper species because of the forgone revenues and also because it forced them to discard dead fish, which they consider wasteful since these species do not survive the ascent to the surface once hooked. Matos-Caraballo (2009) notes that for certain snapper-grouper species, such as silk snapper, about 90% of the landings are made up of sexually immature fish. Finally, fishermen shared their frustration about what they considered to be an excessive number of safety inspections at sea. Many fishermen suggested that the number of inspections could be reduced if DNER rangers provided a form indicating that safety requirements were met, which could be made available so that safety inspections would not have to take place every couple of months.

Conclusions

The study provides a detailed characterization of the population of active small-scale commercial fishermen, describes fishermen's perceptions about the biological and socio-economic condition of the fishery and discusses their attitudes towards Regulation No. 6768. This socio-economic assessment identified 868 active fishermen scattered around the island. Most of these fishermen were middle-aged men with moderate levels of formal education and high levels of fishing dependence, which limited their ability to secure employment outside the fishery. Most of the vessels were small (20 ft) and had a single outboard engine (80 hp). Hook and line and SCUBA continued to be the dominant gears because of their versatility and cost effectiveness. Higher fuel costs appear to have prompt-

ed more fishermen to operate closer to the shore. This census also showed that the number of active commercial fishermen decreased by about 50% since 1988. The estimated number of active fishermen was 1,731 in 1988; 1,758 in 1996; 1,163 in 2002; and 868 in 2008 (Matos-Caraballo and Torres-Rosado, 1989; Matos-Caraballo, 1998; Matos-Caraballo et al., 2005). The reported lower participation rates seem to be a function of a lower resource base, escalating fuel costs, and tighter regulations. Less than half of the fishermen interviewed felt that the condition of the stocks had worsened over the past few years.

Another objective of this work was to investigate the attitudes that fishermen harbored towards the new regulations. The survey revealed that there was widespread discontent concerning the licensing and permitting requirements and many of the regulations, particularly those dealing with minimum size limits and seasonal closures. Regardless whether many of the statements offered were sincere or strategic, the survey underscored that fishermen felt estranged from the decision-making process and that a more participatory process is required to move forward. This participatory process would require fishery managers to make a concerted effort to educate and disseminate information about the condition of the stocks and performance of regulations, as well as afford fishermen greater input in the decision-making process so that fishermen feel that they are sharing the benefits and costs of conservation (Pomeroy et al., 2004). Also, a greater effort must be made to overcome fishermen's reluctance to share information with decision-makers since they believe that this will lead to additional restrictions. Otherwise, it will be difficult for fishermen to rally behind the current conservation measures. Furthermore, strong compliance will require that conservation measures be perceived as meaningful and useful (Kuperan and Sutinen, 1998; Raakjaer Nielsen and Mathiesen, 2003). While it will be impossible to placate many of the fishermen's concerns, engaging them in a meaningful dialog about the need

and expectations of existing regulations will likely enhance legitimacy, acceptance, and compliance with the current conservation measures.

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