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Fisheries Centre, University of British Columbia, Canada

Edited by

Dalal Al-Abdulrazzak and Daniel Pauly

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Content

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Director's Foreword

It is with great pleasure that I write this foreword to the Fisheries Centre Research Report titled *From Dhows to Trawlers: a Recent History of Fisheries in the Gulf Countries, 1950 to 2010*, edited by Dalal Al-Abdulrazzak and Daniel Pauly, on the recent history of fishing in the Gulf between the Arabian Peninsula and Iran. These fisheries have grown in importance in recent decades, not only because people cannot eat oil, but also because income from oil is used to propel the demand for fish in the region.

In fact, the time has come for the countries around the Gulf to come together and do something about their largely unregulated or ill-regulated fisheries, or they will lose what has now become an important element of their food security.

The 'catch reconstructions' presented in this report should be useful to the seven countries of the Gulf, because they attempt to document all their fisheries, and not solely those that are covered by the national monitoring systems presently in place.

I conclude by congratulating the editors of this report and the authors of the contributions included therein for producing an innovative document for the fisheries of the Gulf.

U. R. Sumaila,

Director,

Fisheries Centre, UBC.

Preface

Writing the preface to this report should be very easy – once we are past the name of the place that it is about.

The place in question is the gulf between the Arabian Peninsula and Iran, long known to English speakers as the 'Persian Gulf', recently renamed 'Arabian Gulf' (even though there is already a more imposing 'Arabian Sea'), and which those who want to avoid trouble – including ourselves – name the 'Gulf', even though will get complaints from both sides in any case…

Be as it may, the Gulf is important, not only because so much of the oil consumed in the world transits through the Strait of Hormuz, its outlet, but also because it is on its shore that much of the history of the Arab and Iranian people unfolded, and where their future will continue to unfold. The waters of the Gulf were not only used for trade – although this was always a very important component of the Gulf's culture – but also as an important source of seafood.

The latter role of the Gulf has become more and more important in recent decades, as the populations and income in the Gulf countries grew. Indeed, a situation has been reached now where the fisheries resources are overexploited in most of the Gulf's countries, and catches have ceased to increase.

So far, reviews of the Gulf's fisheries have been based on analyses of the 'catch' data, which the Gulf countries – all members of the Food and Agriculture Organization of the United Nations (FAO) – submit annually to FAO. However, it is now well established that official data of this sort throughout the world, tend to misreport actual catches (i.e., all the fish and invertebrates killed by fishing), and the Gulf countries are no exception.

To compensate for this, the chapters included in this report presents, for each country in the Gulf time series of 'reconstructed catch', i.e., of the catches of all their fisheries (industrial, artisanal, recreational, subsistence, etc.) and the discards (fish caught, but discarded at sea). This will allow the impact of the fisheries of the Gulf and its ecosystems to be assessed and realistic management measures to be implemented, which they all need.

Finally, we wish to take the opportunity to thank Dr. Dirk Zeller and Ms. Kyrstn Zylich for their crucial advice on several reconstructions, and Mr. Frédéric Le Manach for his assistance with the finalization of this report.

Dalal Al–Abdulrazzak and Daniel Pauly

May 2013

Missing sectors from Bahrain's reported fisheries catches: 1950-2010[1]

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Abstract

This study applies previously established catch reconstruction approaches to re-estimate total marine catches for Bahrain from 1950 to 2010. Utilizing all available quantitative and qualitative data from both peer-reviewed and grey literature, combined with conservative assumptions and interpolations, the catches for all Bahraini marine fisheries are estimated. When accounting for catches from discards, illegal fishing, recreational catches, and other missing small-scale sectors, these estimates suggest that data supplied to the FAO by Bahrain potentially underestimate catches by a factor of 5 since 1950. Incomplete and under-reported data can lead to mismanaged fish stocks which is particularly problematic in the case of Bahrain, which is small, and thus shares many stocks with other Gulf countries.

Introduction

Bahrain is the smallest of the Persian Gulf states and the only island country in the region (Figure 1). Archipelagic in nature, Bahrain consists of about 40 low lying islands, with the 55 km long and 18 km wide Bahrain Island being the largest; consequently, Bahrain has a rich maritime history that includes fishing (CBD 2012) and pearling, as evidenced by its 'Pearling Trail', a UNESCO Word Heritage Site. Due to the wide range of seasonal variation in hydrological parameters in the Persian Gulf (Longhurst 2007), as well as the small area of Bahrain's Exclusive Economic Zone (EEZ), a significant number of fish species utilize Bahrain's waters on a seasonal basis. Consequently, Bahrain shares many of its fish fauna with other Gulf countries (Randall *et al.* 1978; Carpenter *et al.* 1997; also see FishBase [www.fishbase.org]).

Despite the historical presence of large-scale shrimp fishing, fisheries were of minor economic importance (prior to the discovery of oil in the 1960s) and now are valued mostly for their cultural contribution. Possibly because of the minuscule contribution of fisheries to the economy (0.4% of GDP), their management receives little attention, and regulations are not strongly enforced, and thus largely ineffective.

The main fishing gears used are shrimp trawls, gillnets, large wire traps (Arabic: *gargoor*) and hook-and-line. All commercial fishing is conducted as single-day trips. In the inshore areas, tidal weirs (Arabic: *hadrah*) are also used. Most of the catch is consumed locally, although some shrimp and crab are exported to neighbouring countries such as Saudi Arabia. A small number of seafood processing companies purchase surplus shrimp not destined for export. Bahrain's landings do not meet the fish demand of its over 1.3 million inhabitants, and therefore must be supplemented by imports.

Habitat destruction from coastal development, compounded with ill-enforced fisheries regulations, has led to a number of challenges for fisheries. Land reclamation is particularly problematic because fishermen are forced to fish further out and into Qatar's EEZ, leading to illegal catches and violent standoffs (Mahdi 2010). Other challenges include the deployment of banned gears such as driftnets

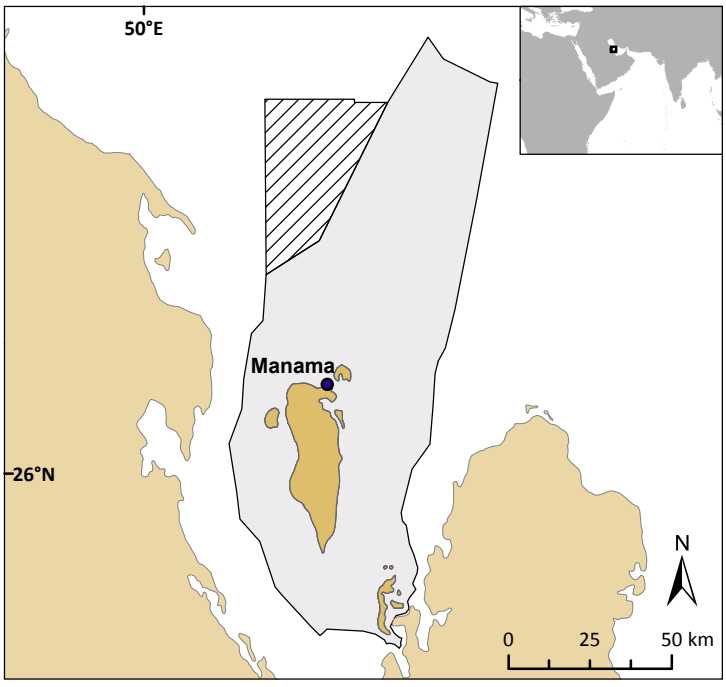

Figure 1. Map of Bahrain; showing the extent of its EEZ in grey; including the joint-regulation zone with Saudi Arabia (stripped area).

[1] Cite as: Al-Abdulrazzak D (2013) Missing sectors from Bahrain's reported fisheries catches: 1950-2010. pp. 1-6. *In*: Al-Abdulrazzak D and Pauly D (eds.) From dhows to trawlers: a recent history of fisheries in the Gulf countries, 1950 to 2010. Fisheries Centre Research Reports 21(2). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

and the operation of unauthorized foreign vessels in Bahrain's EEZ. Bahrain also has a rapidly growing recreational fisheries sector (Uwate *et al.* 1994), which may be taking large quantities of commercially important species, but is unregulated and therefore unreported.

Species composition of landings has changed over time, masking the decline of traditionally exploited species such as orange-spotted grouper (*Epinephelus coioides*) and penaeid shrimps, which have been offset by increased catches of blue swimming crab (*Portunus pelagicus*), a species that was previously discarded, but is now being retained to meet demand from a growing immigrant community. Catches of more desirable species and shrimp have declined dramatically.

Methods

This contribution follows the conceptual framework of the catch reconstruction as outlined by previous studies (Zeller *et al.* 2006; Zeller *et al.* 2007; Jacquet *et al.* 2010; Le Manach *et al.* 2012).

Using Google Earth, Al-Abdulrazzak and Pauly (2013), estimate 880 ± 57 *hadrah* were operating in Bahrain in 2005, generating an annual catch of 17,125 ± 5,147 t. These estimates are 8.7 times larger than what is reported to FAO for Bahrain in 2005. Since the number of *hadrah* is not known to have substantially fluctuated in the last five decades, the total reported catch from 2005 (1,960 t) was subtracted from all years, and the estimated catch (17,125 t) was added instead. From 1950-1964, reported landings were less than 1,960 t and therefore applying this method resulted in slightly lower overall catches (i.e., less than 17,125 t). Although it is known that *hadrah* catches have not fluctuated much in the last five decades, less information is known regarding the 1950s. Therefore, we kept the methodology the same for the entire time period, as it is not unreasonable to assume that catches may have been slightly lower in those early years. Species composition was estimated from data supplied by the Ministry of Fisheries in Bahrain (A.H. Al-Radhi, pers. comm., Directorate of Fisheries Resources).

To estimate discards by the shrimp trawlers, the shrimp to fish ratio of 1:15 reported by Abdulqader (2002) was applied to obtain the total by-catch. Abdulqader (2002) and Kelleher *et al.* (2005) estimate that Bahrain's discard rate was 24% in the 2000s. It was assumed that more discarding occurred at the start of the fishery, thus a conservative discard rate of 80% was applied from 1950-1979, followed by 50% from 1980-1999, and 24% from 2000-2010. A 3-year moving average was applied for smoothing and species composition ratios were applied from the Abdulqader (2002) study.

A number of sources reporting on the border disputes between Qatar and Bahrain highlight illegal fishing by Bahraini fishermen in Qatar's EEZ (e.g., Lessware and Mahdi 2010; Mahdi 2010; Khatri 2012). Here it is assumed that illegal fishing took place since the start of the border dispute in 1980, and that illegal fishing amounts to only 2% of commercial catch in the period from 1980 to 2010. Species composition were applied based on landed catch ratios.

Driftnets were banned in 1998 after complaints from trap fishermen that trawlers were operating in shallow water and cutting their floats (De Young 2006). Despite the ban, illegal driftnets for narrow-barred Spanish mackerel continue to be used (Uwate and Shams 1996, 1997; Abdulqader 2010) and pose a significant problem. It is conservatively assumed that since the 1998 ban, illegal catches by driftnets constitute 1% of total reported catch.

Uwate *et al.* (1994) conducted a survey of recreational fishermen and estimated that recreational catch amounts to 4% of commercial catch. It was assumed that this percentage was the same since the start of reporting and therefore was applied from 1950-2010. Because no data were available on species composition, species composition ratios from Kuwait were applied to the reconstructed recreational catch.

As in other Gulf countries, fishers are migrant labourers from Southeast Asia and Bahrain who make very little incomes, and therefore have a high incentive to fish for subsistence. From 1960-2010 foreign fishers made up 0.0046% of the population. It was assumed that fishers take 5 kg·week^{-1} for subsistence purposes, extrapolated from the start of the oil boom in 1960 until 2010. Because these take home catches are composed of less desirable species, subsistence catches were assigned species composition based on discarded species.

Results and discussion

For the period of FAO reporting, 1950-2010, estimated fisheries catches were almost 5 times what is reported by the FAO on behalf of Bahrain. Reconstructed catches for Bahrain totalled 1,877,300 t over the 1950-2010 period compared to 379,238 t reported by FAO.

Catch data as reported by FAO on behalf of Bahrain suggest a steady increase in catches from 800 t in 1950 to a peak of 16,359 t in 2009, before a slight decrease in 2010. In contrast, reconstructed time series data suggest a fluctuating increase in catches throughout, with a sharp peak of 50,600 t in 1996. Catches declined until 2001 and then increased up to 2010.

The catch of recreational fisheries is likely underestimated, for two reasons. First, the study of Uwate *et al.* (1994), which formed the basis of the estimates presented here, is likely outdated at present. Bahrain's population has strongly increased in recent years leading us to predict that participation has also greatly increased. Second, the study, which was conducted by people working for Bahrain's Fisheries Directorate, was only carried out in selected ports, not all ports that service recreational fisheries. Other sources (e.g., Uwate and Shams 1996; De Young 2006) highlight the significance of recreational catches in Bahrain, but without providing tonnage. However, the study estimates catches to be only 4% of all commercial catches. Ultimately, this value was chosen in order to remain conservative.

Discards, as reconstructed here, were substantial, and on average accounted for 28% of total estimated catches each year (Figure 2a; Appendix Table A1). Bahrain's by-catch to trawled shrimp ratio of 15:1 is nearly 3 times the global average and highlights the need for concern regarding the ecological and economic impacts of this wasteful practice (Alverson and Hughes 1996; Kelleher *et al.* 2005).

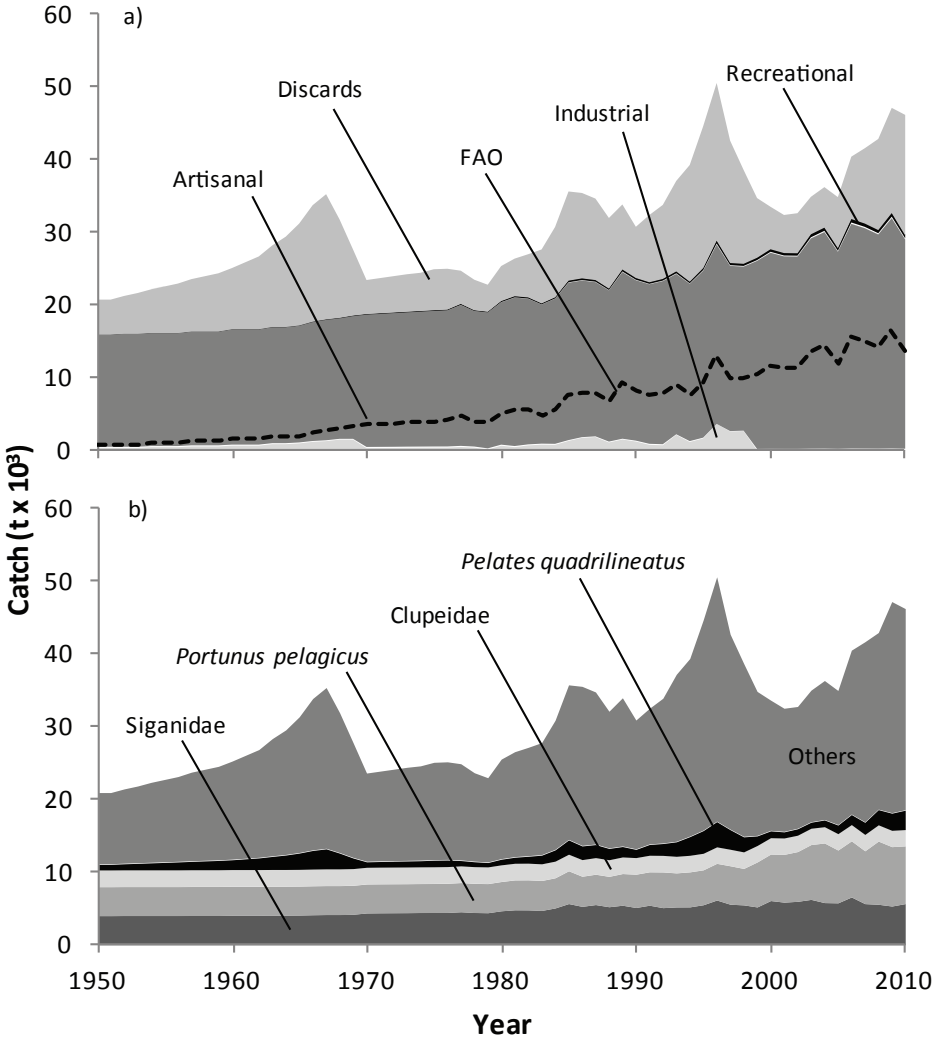

Figure 2. Total reconstructed catch for Bahrain by a) sector (with comparison to FAO data), and b) major taxa, 1950-2010. Note that subsitence catches were included on the sector graph (a) but are not visible (too small).

The four main taxa caught by Bahrain are Siganidae (15.7%), *Portunus pelagicus* (15.5%), Clupeidae (7.4%), and *Pelates quadrilineatus* (4.7%) (Figure 2b; Appendix Table A2). Juveniles of commercially important species make up the majority of by-catch and *hadrah* catches, which may lead to growth overfishing.

This reconstruction supports growing concern over the status of Bahrain's fisheries. Although catches appear to be increasing, it is more likely that the declines are masked by previously discarded species being retained. Masked declines, coupled with shared stocks, unsustainable fishing practices through illegal driftnets and high discard rates all point to stocks that are overfished. In addition, Bahrain's population has essentially doubled in the last decade, from 638,000 in 2000 to 1.3 million in 2010, placing enormous pressure on the country's natural resources.

In addition, this reconstruction indicates poor data coverage for Bahrain's officially reported catch series. The reconstruction undertaken here accounts for missing sectors, including discards, illegal and recreational catches, and offers a more complete accounting for *hadrah* catches. Thus, the reconstructed time series better reflects the catches extracted from Bahrain's marine ecosystems. Although there is some uncertainty surrounding the estimates, assumptions in this report are conservative throughout and illustrate more likely historical trends and patterns.

Acknowledgements

Thank you to A.H. AlRadhi, from Bahrain's Directorate of Fisheries Resources, who graciously shared *hadrah* catch data. This is a contribution of the *Sea Around Us* Project, a scientific collaboration between the University of British Columbia and The Pew Charitable Trusts.

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Appendix Table A1. FAO landings vs. total reconstructed catch (t) for Bahrain, 1950-2010, as well as catch by sector.

Year	FAO landings	Total reconstructed catch	Industrial	Artisanal	Subsistence	Recreational	Discards
1950	800	20,800	400	15,600	0	32	4,800
1951	800	20,800	400	15,600	0	32	4,800
1952	900	21,300	400	15,700	0	36	5,200
1953	900	21,700	400	15,700	0	36	5,600
1954	1,000	22,200	500	15,700	0	40	6,000
1955	1,000	22,600	500	15,700	0	40	6,400
1956	1,000	23,000	500	15,700	0	40	6,800
1957	1,200	23,600	600	15,800	0	48	7,200
1958	1,200	24,000	600	15,800	0	48	7,600
1959	1,200	24,400	600	15,800	0	48	8,000
1960	1,500	25,100	700	16,000	2	60	8,400
1961	1,500	25,900	700	16,000	2	60	9,200
1962	1,500	26,700	700	16,000	2	60	10,000
1963	1,800	28,200	900	16,100	2	72	11,200
1964	1,800	29,400	900	16,100	2	72	12,400
1965	2,000	31,200	1,000	16,200	2	80	14,000
1966	2,500	33,800	1,200	16,500	2	100	16,000
1967	2,800	35,300	1,300	16,700	2	112	17,200
1968	3,000	31,800	1,500	16,700	2	120	13,500
1969	3,300	27,700	1,500	17,000	2	132	9,100
1970	3,500	23,500	380	18,300	3	140	4,700
1971	3,600	23,800	390	18,400	3	144	4,800
1972	3,700	24,000	400	18,500	3	148	5,000
1973	3,800	24,300	420	18,500	3	152	5,200
1974	3,900	24,500	430	18,600	3	156	5,300
1975	4,000	25,000	440	18,700	3	160	5,600
1976	4,084	25,000	440	18,800	3	163	5,600
1977	4,837	24,800	530	19,500	4	193	4,600
1978	4,000	23,500	440	18,700	4	160	4,200
1979	3,801	22,800	180	18,800	4	152	3,700
1980	5,115	25,400	690	19,700	4	205	4,800
1981	5,747	26,400	500	20,500	4	230	5,200
1982	5,594	27,000	730	20,100	5	224	5,900
1983	4,812	27,700	830	19,200	5	192	7,400
1984	5,599	30,800	810	20,100	5	224	9,700
1985	7,763	35,700	1,330	21,800	5	311	12,300
1986	8,057	35,400	1,730	21,700	5	322	11,700
1987	7,842	34,700	1,840	21,300	5	314	11,200
1988	6,736	32,000	1,120	20,900	6	269	9,700
1989	9,207	33,900	1,520	23,000	6	368	8,900
1990	8,105	30,800	1,250	22,200	6	324	7,000
1991	7,553	32,400	810	22,100	6	302	9,200
1992	7,983	33,800	760	22,600	6	319	10,200
1993	8,958	37,100	2,130	22,200	6	358	12,400
1994	7,628	39,300	1,190	21,800	7	305	16,000
1995	9,389	44,600	1,660	23,100	7	376	19,500
1996	12,940	50,600	3,570	24,800	7	518	21,700
1997	10,050	42,600	2,570	22,800	7	402	16,800
1998	9,849	38,600	2,630	22,700	7	394	12,900
1999	10,620	34,700	110	26,000	8	425	8,200
2000	11,718	33,500	120	27,100	8	469	5,800
2001	11,230	32,400	110	26,600	8	449	5,200
2002	11,204	32,700	110	26,600	9	448	5,500
2003	13,638	34,900	140	29,100	9	546	5,200
2004	14,489	36,200	140	29,900	10	580	5,600
2005	11,854	34,900	120	27,300	11	474	7,000
2006	15,595	40,400	160	31,100	11	624	8,600
2007	15,015	41,600	150	30,500	12	601	10,400
2008	14,175	42,900	140	29,600	13	567	12,500
2009	16,359	47,100	160	31,900	14	654	14,500
2010	13,491	46,200	130	28,900	15	540	16,600

Appendix Table A2. Total reconstructed catch (t) for Bahrain by major taxa, 1950-2010.

Year	Siganidae	*Portunus pelagicus*	Clupeidae	*Pelates quadrilineatus*	Others[a]
1950	4,000	3,940	2,270	768	9,800
1951	4,000	3,940	2,270	768	9,800
1952	4,010	3,940	2,270	832	10,200
1953	4,010	3,940	2,270	896	10,600
1954	4,010	3,940	2,270	960	11,000
1955	4,010	3,940	2,270	1,024	11,400
1956	4,010	3,940	2,270	1,088	11,700
1957	4,020	3,940	2,270	1,152	12,200
1958	4,020	3,940	2,270	1,216	12,600
1959	4,020	3,940	2,270	1,280	12,900
1960	4,050	3,940	2,270	1,344	13,500
1961	4,050	3,940	2,270	1,472	14,200
1962	4,050	3,940	2,270	1,600	14,900
1963	4,060	3,940	2,270	1,792	16,200
1964	4,060	3,940	2,270	1,984	17,200
1965	4,080	3,940	2,270	2,240	18,700
1966	4,120	3,940	2,270	2,560	20,900
1967	4,140	3,940	2,270	2,752	22,200
1968	4,140	3,940	2,270	2,164	19,300
1969	4,190	3,940	2,270	1,453	15,800
1970	4,360	3,940	2,270	749	12,200
1971	4,380	3,940	2,270	775	12,400
1972	4,390	3,940	2,270	800	12,600
1973	4,400	3,940	2,270	826	12,800
1974	4,420	3,940	2,270	841	13,000
1975	4,430	3,940	2,270	903	13,400
1976	4,440	3,970	2,270	900	13,500
1977	4,530	3,970	2,270	732	13,300
1978	4,430	3,970	2,270	673	12,200
1979	4,390	3,970	2,270	596	11,600
1980	4,660	3,980	2,270	772	13,700
1981	4,790	4,070	2,270	828	14,500
1982	4,790	4,090	2,270	950	14,900
1983	4,710	4,070	2,270	1,188	15,400
1984	5,050	4,100	2,270	1,547	17,800
1985	5,640	4,460	2,270	1,961	21,300
1986	5,270	4,100	2,270	1,878	21,900
1987	5,510	4,130	2,270	1,791	21,000
1988	5,210	4,130	2,270	1,553	18,800
1989	5,420	4,310	2,270	1,431	20,400
1990	5,110	4,530	2,270	1,127	17,800
1991	5,420	4,540	2,270	1,479	18,700
1992	5,090	4,860	2,270	1,628	20,000
1993	5,180	4,630	2,270	1,991	23,000
1994	5,190	4,760	2,270	2,566	24,500
1995	5,490	4,750	2,270	3,120	29,000
1996	6,130	4,990	2,270	3,468	33,700
1997	5,550	5,230	2,270	2,690	26,900
1998	5,470	4,960	2,270	2,066	23,800
1999	5,180	6,120	2,270	1,315	19,900
2000	6,060	6,320	2,270	935	18,000
2001	5,840	6,500	2,270	839	17,000
2002	5,950	6,770	2,270	882	16,800
2003	6,220	7,460	2,270	826	18,100
2004	5,780	8,110	2,270	924	19,200
2005	5,740	7,190	2,270	1,182	18,500
2006	6,540	7,640	2,270	1,378	22,600
2007	5,640	7,190	2,270	1,664	24,800
2008	5,550	8,600	2,270	2,087	24,400
2009	5,310	8,080	2,270	2,357	29,100
2010	5,640	7,850	2,270	2,665	27,700

[a] Others category includes 62 additional taxonomic groups.

Fisheries catch reconstruction for Iran, 1950-2010[1]

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Abstract

Total marine fisheries catches were estimated for the Iranian Exclusive Economic Zone (EEZ) waters from 1950 to 2010. All fisheries sectors, i.e., industrial (large-scale, commercial), artisanal (small-scale, commercial), subsistence and recreational, as well as foreign catches were reconstructed to recalculate total catches. Overall, total catches in Iran's EEZ waters from 1950-2010 were approximately 18.2 million tonnes, of which 14.9 million tonnes were taken by Iranian fishers. It is evident that the data reported by FAO on behalf of Iran (around 5.7 million tonnes in EEZ waters only) represent mainly the large-scale fisheries in this region. Thus, management of artisanal and recreational fisheries is hampered by lack of key data, as is the prevention of illegal fishing.

Introduction

The Persian Gulf, which separates Iran in the Northeast from the neighbouring countries of Iraq, Saudi Arabia, Bahrain, Kuwait, Qatar and the United Arab Emirates in the southwest, extends from the Shatt al'Arab delta in the west to the Strait of Hormuz in the east (Walters and Sjoberg 1988; Esmaeili 2006; Figure 1). The average depth of this shallow water body is approximately 50 m, and its maximum depth is about 90 m near the Strait of Hormuz (Walters and Sjoberg 1988). The biodiversity in the Gulf is greatly influenced by the high salinity and seasonal temperature fluctuations. In winter, the water temperature can go as low as 3°C; conversely, during the summer, the temperature can rise to 50°C (Anon. 2013d).

The main shipping lanes of the world's largest oil fields pass through the Gulf's exit, the Strait of Hormuz, and thus, its ecology has been impacted by the pollution caused by multiple oil spills, to which, unfortunately, the effects of mining, a land reclamation project, and largely unregulated fishing must be added (Anon. 2013e).

In addition to oil production, fishing plays an important role in many of the economies or societies of the countries surrounding the Gulf region, including in Iran. Khozestan (western coast of Iran), Boushehr (central coast) and Hormozgan (eastern coast) are the three most important Iranian coastal provinces in terms of their contribution to the fishing industry (Esmaeili 2006). Reports show that over 54% of the fish caught in 2003 in Iranian coastal waters of the Gulf originated from the largest province, Hormozgan (Esmaeili 2006). Over 700 species of fish occur in the Persian Gulf (see FishBase; www.fishbase.org), and over 80% are either directly or indirectly associated with coral reefs (Anon. 2013a). Although their catch is declining, mackerels and shrimp are still among the most important target species (Peighambari and Daliri 2012). It seems that overfishing as a consequence of lack of proper management, together with environmental degradation, can explain the observed decline of fish stocks in the Gulf region (Anon. 2013c). Here, we provide re-estimated total marine catches by Iran in the EEZ waters from 1950-2010, using a catch reconstruction approach (Zeller *et al.* 2007), with the hope of providing a more accurate and comprehensive baseline for the management of the Gulf fisheries of Iran.

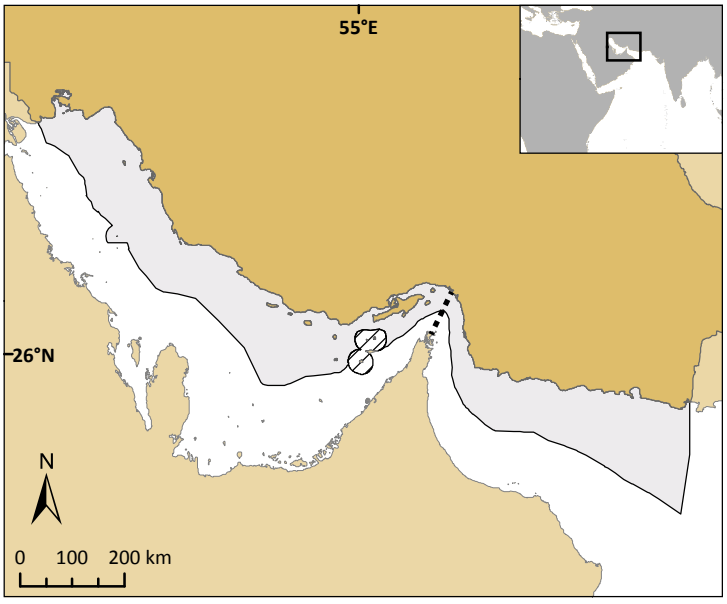

Figure 1. Map of Iran showing the extent of its EEZ (in grey), including the contested zone with the United Arab Emirates (stripped area). The 'Gulf' ends at the Strait of Hormuz (dotted line).

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Methods

Fisheries catch data were obtained from the FAO FishStat database, independent studies and government related fisheries websites. As Iran has a substantial and very active tuna fleet operating in the Indian Ocean, we assumed that nine large pelagic species are mainly being caught primarily outside Iranian waters, i.e., albacore tuna (*Thunnus alalunga*), bigeye tuna (*T. obesus*), black marlin (*Istiompax indica*), Indo-Pacific sailfish (*Istiophorus platypterus*), kawakawa (*Euthynnus affinis*), longtail tuna (*T. tonggol*), skipjack tuna (*Katsuwonus pelamis*), swordfish (*Xiphias gladius*) and yellowfin tuna (*T. albacares*). Thus, in order to separate catches from within the EEZ from offshore catches in the Indian Ocean, we filtered out reported landings of these nine species from the FAO dataset and used these adjusted data as the reported landings baseline.

We identified four sectors of Iranian fisheries, i.e., industrial (large-scale, commercial), artisanal (small-scale, commercial), subsistence (small-scale, non-commercial), and recreational. In addition, we identified discarding and illegal catches as items to be estimated. Data 'anchor points' (*sensu* Zeller *et al.* 2007) for each of these components were derived and linear interpolations were used between anchor points to provide a complete time series of total catches for 1950-2010.

To estimate likely Iranian catches within the Persian Gulf as opposed to outside (i.e., along the coast of the Iranian provinces of Sistan and Balochestan), a complete reconstruction of the six components was produced for both portions of the Iranian Exclusive Economic Zone (EEZ): within and outside the Persian Gulf (see Figure 1). The reconstruction of marine catches in the Sistan and Baluchestan provinces was facilitated through data provided by the Sistan and Baluchestan province portals (Anon. 2012c).

Artisanal catches

The official data on Iranian artisanal fishing effort distinguish two components: 'fibreglass' and 'wooden' vessels. In 1991, there were 3,176 fibreglass fishing vessels (Everett 2000). Due to the non-availability of fibreglass vessels in the 1950s and 1960s, we assumed that this represented small wooden crafts during the earlier decades and that there were 60% fewer such fishing vessels in 1950 compared to 1991. (Table 1). Furthermore, we assumed that total capacity (i.e., vessel numbers) would have been 50% higher in 1977, before the Islamic revolution, than in 1950. We also assumed that vessel capacity was halved during the 1980-1988 Iran-Iraq war. For 2001-2010, we were able to obtain capacity information from the official Iranian Fisheries website (Anon. 2012b). We performed a series of linear interpolations to complete the capacity time series from 1950 to 2001.

The number of wooden fishing vessels (here interpreted as larger crafts) was reported for 1991 and from 2001 to 2010 by Esmaeili (2006). We assumed the number of wooden vessels in 1950 was 20% lower than in 1991. In 1977 before the Islamic revolution, we assumed capacity was 20% higher than the capacity in 1950. Wooden vessel capacity was also assumed to be halved during the 1980-1988 Iran-Iraq war. We interpolated linearly between 1950 and 2001.

Table 1. Artisanal fishing vessels (small craft/ fibreglass and larger wooden) and catch per unit of effort (CPUE) data and derived anchor points. Values between anchor points were interpolated.

Year	small craft/ fibreglass (No. of vessels)	Larger wooden (No. of vessels)	CPUE ($t \cdot vessel^{-1} \cdot year^{-1}$)
1950	1,270 [a]	2,053 [a]	50
1977	1,906 [a]	2,464 [a]	41
1991	3,176 [b]	2,567 [d]	36 [d]
2001	2,817 [c]	7,086 [d]	27
2002	2,954 [c]	6,933 [d]	24
2003	2,945 [c]	7,356 [d]	20 [d]
2004	3,047 [c]	7,559 [d]	20
2005	3,210 [c]	7,496 [d]	20
2006	3,250 [c]	7,563 [d]	19
2007	3,257 [c]	7,663 [d]	19
2008	2,999 [c]	7,847 [d]	19
2009	3,033 [c]	7,970 [d]	19
2010	3,066 [c]	7,932 [d]	18

[a] 1950: 60% lower than 1991; 1977: 50% higher than 1950.
[b] Everett (2000).
[c] Iranian Fisheries website (Anon. 2012b).
[d] Esmaeili (2006).

Esmaeili (2006) lists catch per unit of effort (CPUE) for 1991 and 2003 as 36 $t \cdot vessel^{-1} \cdot year^{-1}$ and 20 $t \cdot vessel^{-1} \cdot year^{-1}$, respectively, with a peak of 50 $t \cdot vessel^{-1} \cdot year^{-1}$ in 1997. Given the high variability of these CPUE estimates, we interpolated them from 1999 to 2003 to smooth the data. We assumed that CPUE in 1950 was equivalent to the peak reported CPUE in 1997 (i.e., 50 $t \cdot vessel^{-1} \cdot year^{-1}$). Given the known overexploitation of marine resources in coastal waters of Iran (Esmaeili 2006), we reduced CPUE for 2010 by 10% compared to the 2003 value (Table 1). Intervening years were interpolated linearly.

Combining the derived capacity time series with the estimated CPUE time series allowed us to estimate a likely catch time series for the artisanal fleet from 1950-2010 in the Iranian EEZ. Then, we multiplied the total estimated artisanal catch by the percentage of catches from the provinces of Sistan and Baluchestan. To obtain these percentages, we divided the reported catch of these provinces (Anon. 2012c) by the reported total landings by Iran to FAO (from FAO Fishstat). This amounted to 42,650 $t \cdot year^{-1}$ for a total of 236,717 $t \cdot year^{-1}$ reported by FAO (excluding large migratory species) for 1996 (18%) and 104,665 $t \cdot year^{-1}$ compared to a total of 291,305 $t \cdot year^{-1}$ reported by FAO (35%) for 2003. We assumed that the 18% ratio was constant between 1950 and 1996 and that the 35% ratio was constant between 2003 and 2010, then interpolated linearly between 18 and 35% for the years 1997 to 2002. The resulting percentage time series was then used to allocate the total estimated Iranian artisanal catch within and outside the Gulf.

Using Google Earth, Al-Abdulrazzak and Pauly (2013) estimate 726 ± 28 weirs were operating in the Persian Gulf waters of Iran in 2005, generating an annual catch of 12,240 ± 4,223 t. Since Iran does not report their weir catches and because

the number is not known to have substantially fluctuated in the last five decades, we assume the catch is constant and apply 12,240 t·year^{-1} from 1950 to 2010. Species composition was estimated from Al-Abdulrazzak and Pauly (2013).

Subsistence catches

We extracted an estimate of the human population of Iran from the historical population demography website Populstat (www.populstat.info/), and used linear interpolations between census years to determine a complete population time series for 1950 to 2010. We then assumed that only the coastal population of Iran consumes domestically caught marine fish, and assumed that this would be the population within 10 km of the coast (CIESIN 2007). The fraction of coastal population for years prior to the years covered by the data source (pre-1990s, CIESIN 2007) was assumed to be a constant fraction of the total Iranian population. However, during the Iran-Iraq war (1980-1988), we assumed the coastal population used for estimating consumption was one fourth to reflect the severe military restrictions and high migrations towards northern areas (Figure 2).

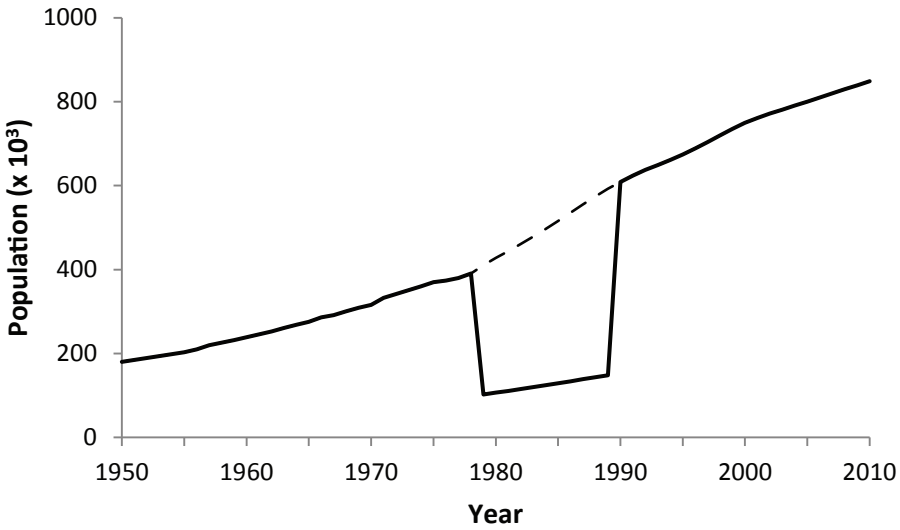

Figure 2. Human population data used for the subsistence calculation, 1950-2010 (solid line). An adjustment was made to the coastal population time series (dotted line) during the Iran-Iraq war years (1980-1988) to reflect severe restrictions imposed during that time.

Estimates of the coastal population were then combined a derived consumption rate time series. The average fish consumption of the population of Bandar Abbas, a coastal city of Iran was estimated at 3.4 meals·person^{-1}·month^{-1}, i.e., 41 meals·person^{-1}·year^{-1} (Adeli *et al.* 2011). We assumed each person consumed 500 g of fish per meal (i.e., 20.5 kg·person^{-1}·year^{-1}). After adjusting as best as possible for the international seafood trade, i.e., exports and import (Everett 2000; Anon. 2007), we derived the difference between the trade adjusted consumption and the landings as reported by FAO on behalf of Iran. This difference was deemed to represent unreported catches. This estimated difference, divided by the total population of Iran (Figure 2), was assumed to represent an estimate of per capita subsistence catch of 17 kg·person^{-1}·year^{-1}. We assumed this rate applies to the year 2010, but assumed a rate nearly 50% higher (i.e., 25.5 kg·person^{-1}·year^{-1}) for 1950, and interpolated the rate between these two years. We then multiplied this assumed subsistence catch rate by the adjusted southern coastal population, i.e., living within 10 km of the coast (Figure 2), to derive an estimated total subsistence catch in southern Iran.

Recreational catches

We assumed recreational fishing existed throughout the rule of the Shah, from 1950 to 1979, and after the Iran-Iraq war from 1989 to 2010. We assumed that any personal fishing that occurred during the war years was subsistence fishing and thus we estimated that there was zero recreational fishing during the war years (1980-1988); also, recreational fishing is popular primarily in the Persian Gulf, and hence, we assumed that no recreational fishing occurred in Sistan and Baluchestan. For 2010, it was estimated that around 0.12% of the population in Oman participated in recreational fishing (Cisneros-Montemayor and Sumaila 2010). We assumed this same rate applied to the coastal Iranian population in 2010. We then assumed half of this rate for the pre-war time period (1950-1979), i.e., 0.06%. Participation was set to zero for the years 1980-1988, and then we interpolated from zero in 1988 to 0.12% in 2010. To estimate recreational catches, we assumed that recreational fishers catch 5 kg·trip^{-1} and fish for one day per week (i.e., 52 days·year^{-1}). Therefore, we multiplied the number of fishers by the number of the fishing days (52 days) and the assumed catch rate (5 kg·trip^{-1}) to obtain an approximate time series of recreational catches.

Industrial (large-scale, commercial) catches

Data for the large-scale fisheries in the EEZ waters of Iran were largely based on information provided by the FAO and a variety of literature resources, as well as the Iranian official fisheries website. Given the absence of historic information on fishing effort by large-scale vessels, we considered the first anchor point for 1950 to be zero vessels. In 1957, there were three large vessels contributing to the fisheries in the Persian Gulf, while by 1961 there were 12

(Keddie 1971). By 1968, 50 large vessels operated in Iranian waters (Keddie 1971). We assumed effort was 20% higher before the Islamic revolution and the Iran-Iraq war. Furthermore, we assumed that the effort was halved by 1980 due to the start of Iran-Iraq war. For 1991, Everett (2000) reports 120 vessels. Anon. (2012b) provided data for years 2001-2010. We performed a series of interpolations to fill in the gaps throughout the time period (Table 2).

To estimate the CPUE for the large-scale fishing, we used information from Esmaeili (2006) for 2003 (i.e., 202.9 t·vessel^{-1}·year^{-1}, Table 2) and assumed that the CPUE would be 10% higher in 1950 and 2% higher in 1991. We also assumed that the CPUE in 2010 was 10% lower than in 2003 given the general over-exploitation of stocks (Esmaeili 2006). Lastly, we multiplied the interpolated effort time series with the interpolated CPUE time series to estimated large-scale catches in the waters of Iran for 1950-2010. To separate out the industrial catches taken in Sistan and Baluchestan from those of the Gulf, we applied the same method as for artisanal catches (see above) and information provided by Anon. (2012c).

Table 2. Industrial fishing vessels and catch per unit of effort (CPUE) data and derived anchor points. Values between anchor points were interpolated.

Year	No. of trawlers	CPUE (t·vessel^{-1}·year^{-1})
1950	0	227.7
1957	3 [a]	224.2 [e]
1961	12 [a]	222.7
1968	50 [a]	218.7
1980	25 [b]	212.6
1991	120 [c]	207.0 [f]
2001	74 [d]	203.6
2002	73 [d]	203.3
2003	75 [d]	202.9 [g]
2004	76 [d]	200.0
2005	77 [d]	197.1
2006	78 [d]	194.2
2007	47 [d]	191.3
2008	45 [d]	188.4
2009	44 [d]	185.5
2010	47 [d]	182.6 [h]

[a] Keddie (1971).
[b] Assumed 50% of 1968 capacity due to war.
[c] Everett (2000).
[d] Anon. (2012b).
[e] Assumed 10% higher than in 2003.
[f] Assumed 2% higher than in 2003.
[g] Esmaeili (2006).
[h] Assumed 10% lower than in 2003.

Foreign fishing

Reports on illegal fishing in Iranian waters are rare. The only source with some information regarding this issue was available via a website on illegal fishing (Anon. 2012a). The information obtained from this website was based on news reports of foreign fishing from 2006 to 2008. It appears that the bulk of foreign fishing in the Persian Gulf was conducted by Asian fleets (from China, South Korea and India), as well as some by vessels from neighbouring countries (Saudi Arabia, Bahrain and UAE), and from Pakistan in a few instances (Anon. 2012). Asian vessels were reported to catch around 100 tonnes per week during an average of 6 month operations in the Gulf in 2007 and 2008, while the number of Chinese vessels was given as 12 (Anon, 2012). Similarly, four Indian vessels flagged to Saudi Arabia were operating in Iranian waters in 2007 and 2008, catching around 50 t·week^{-1} over a 12 month period. Around 336 other vessels, including vessels from South Korea, Saudi Arabia, Bahrain, and the UAE were trawling for shrimp in Iranian waters, and caught 100 t·vessel^{-1}·year^{-1} in 2007 and 2008. We multiplied this CPUE by the total number of boats (n = 336) to estimate the foreign catch for 2007 and 2008, and distributed this evenly among South Korea, Saudi Arabia, UAE and Bahrain flags. We assumed foreign catches decreased by 20% in 2010 because of more efficient Iranian monitoring, and because of the international sanctions imposed on Iran, resulting in higher maritime scrutiny and security. We also assumed foreign catches were twice as high before the end of the war, given lower monitoring levels. Therefore we interpolated from zero in 1974 at the declaration of the Iranian EEZ, and performed a series of linear interpolations to fill in the gaps. Note that China did not start fishing in Iran waters until 1986.

Table 3. Species composition for unreported artisanal and industrial catches, reported "marine fishes nei", and illegal catches, modified from Paighambari and Daliri (2012).

Taxon name	Common name	% of catch
Penaeus semisulcatus	Green tiger prawn	11.1
Portunus pelagicus	Blue swimming crab	7.8
Pomadasys stridens	Striped piggy	5.2
Scyphozoa	Jellyfish	4.8
Arius gagora	Gagora catfish	4.1
Photopectoralis bindus	Orangefin ponyfish	3.5
Leiognathus equulus	Common ponyfish	3.5
Leiognathus lineolatus	Ornate ponyfish	3.5
Ilisha megaloptera	Bigeye ilisha	2.8
Ilisha melastoma	Indian ilisha	2.2
Psettodes erumei	Indian halibut	1.9
Platycephalus indicus	Bartail flathead	1.8
Metapenaeus affinis	Jinga shrimp	1.8
Saurida tumbil	Greater lizardfish	1.8
Otolithes ruber	Tigertooth croaker	1.7
Chiloscyllium arabicum	Arabian carpetshark	1.7
Chiloscyllium punctatum	Brownbanded bambooshark	1.7
Nemipterus japonicus	Japanese threadfin bream	1.7
Trichiurus lepturus	Largehead hairtail	1.5
Parapenaeopsis stylifera	Kiddi shrimp	1.5
Scomberomorus guttatus	Indo-Pacific king mackerel	1.5
Scomberomorus commerson	Narrow-barred Spanish mackerel	1.3
Dasyatis bennetti	Bennett's stingray	1.2
Himantura uarnak	Honeycomb stingray	1.2
Himantura walga	Dwarf whipray	1.2
Pastinachus sephen	Cowtail stingray	1.2
Aetobatus narinari	Spotted eagle ray	1.2
Aetomylaeus maculatus	Mottled eagle ray	1.2
Aetomylaeus nichofii	Banded eagle ray	1.2
Grammoplites suppositus	Spotfin flathead	1.1
Others [a]	—	22.1

[a] 92 species accounting for less than 1% of the catch make up this category.

Discarding

Here, we assumed the majority of discarding is associated with large trawlers (i.e., large-scale fishing). We used the ratio of 4.17 kg discards per kg of landed targeted species (i.e., shrimp and demersal fishes) for large trawlers as per Alverson *et al.* (1996). We did not estimate discarding by the artisanal fleet, which may also exist for certain gear types. Thus, our estimate of discarding is likely a conservative under-estimate.

Taxonomic breakdown

Data concerning the species composition of catches in Iranian waters are very limited. Paighambari and Daliri (2012) provide a percentage breakdown of species

captured in the Persian Gulf. Their catch composition (minus 12 taxa not caught within Iranian waters) was applied to the unreported artisanal (excluding the weir catches), unreported industrial, and illegal fisheries of Iran (Table 3). The reported data contained large amounts of catch in the category "marine fishes nei" and therefore the same species breakdown used for the unreported catch (minus the three shrimp species) was used to disaggregate that category. Recreational and subsistence catches were disaggregated using anecdotal data from pictures posted on web-logs of Iranians engaged in recreational fishing (www.fishingir.blogfa.com). The eight most commonly observed taxa by recreational activities are *Sphyraena* spp., *Seriphus* spp., *Chanos chanos*, *Hyporthodus* spp., *Caranx* spp., Sparidae, *Elops* spp. and *Myliobatis* spp., and we allocated recreational and subsistence catches in equal proportions to these taxa.

Results

Artisanal catches

Artisanal catches increased gradually from 1950-1977, with an average catch of around 186,600 t·year^{-1}, of which just under 156,000 t·year^{-1} were taken inside the Persian Gulf (Figure 3). During the Islamic revolution and subsequent Iran-Iraq war, the estimated artisanal catches dropped to a low of 117,900 t·year^{-1} in 1985. Catches slowly increased after the war and reached a peak of almost 426,700 t·year^{-1} in 1997, before declining sharply to around 220,000-230,000 t·year^{-1} by the end of the time period (Figure 3).

Subsistence catches

The estimated subsistence catch increased steadily from 4,600 t·year^{-1} in 1950 to around 9,000 t·year^{-1} by 1979 (Figure 4). Subsistence catches decreased to less than 3,000 t·year^{-1} during the civil war, and then increased steadily from around 3,000 t·year^{-1} in 1988 to over 14,000 t·year^{-1} by 2010 (Figure 4). Subsistence fishing appears more dominant in Persian Gulf waters, accounting for nearly 80% of total subsistence catches (Figure 4).

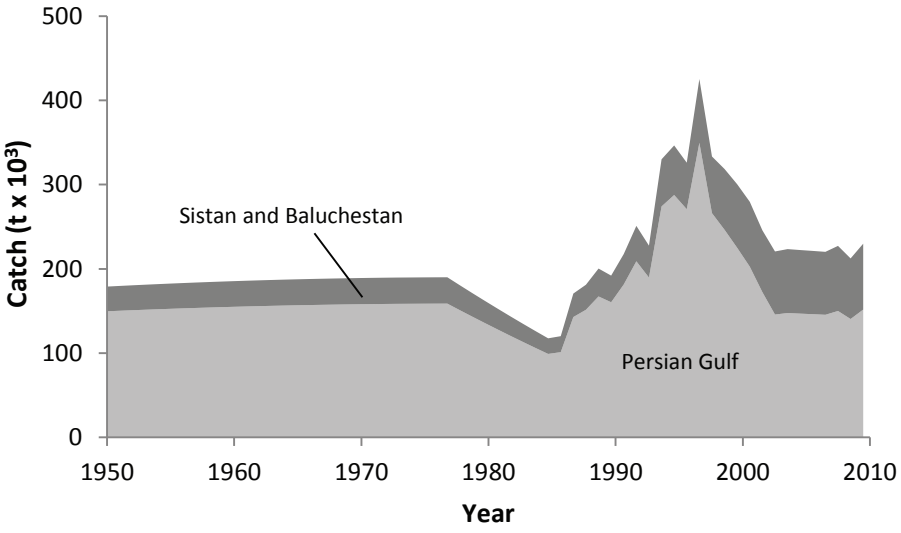

Figure 3. Iran's artisanal catches in the Persian Gulf and Sistan and Baluchestan, 1950-2010.

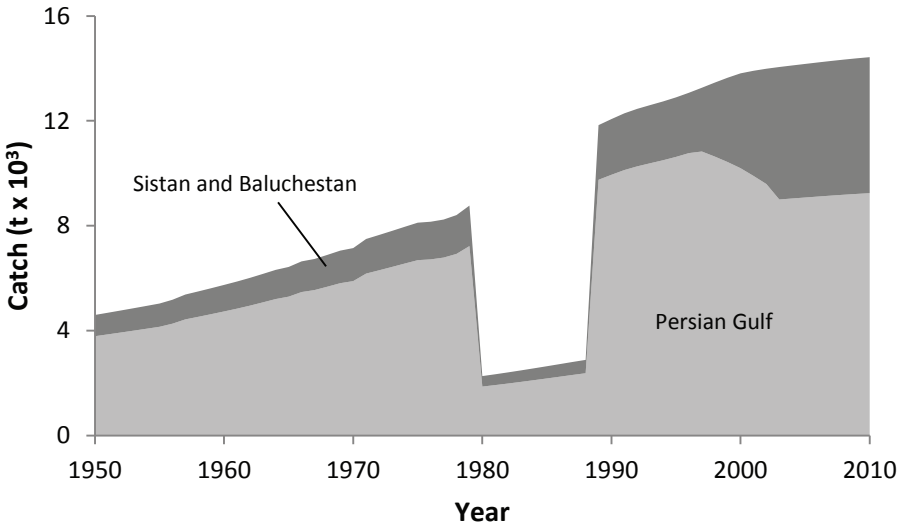

Figure 4. Iran's estimated subsistence catches in the Persian Gulf and Sistan and Baluchestan, 1950-2010.

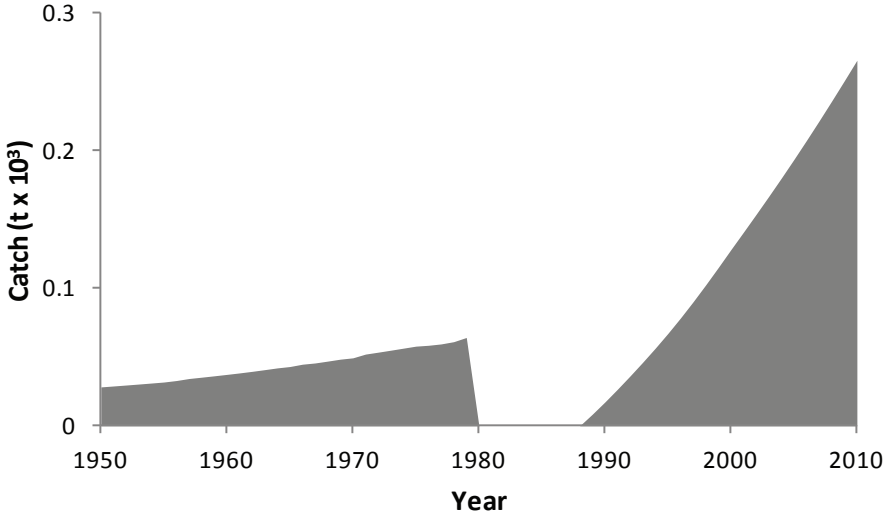

Figure 5. Recreational fishery catches in Iran, 1950-2010.

Recreational catches

Recreational catches (for the Persian Gulf waters only) were estimated at around 28 t·year^{-1} in 1950, increasing gradually to 64 t·year^{-1} by 1979. After the war years catches steadily increased from 8 t·year^{-1} to reach a peak of 265 t·year^{-1} in 2010 (Figure 5).

Industrial catches

Large-scale, industrial catches were considered to be zero in 1950. Initially, landings increased slowly to just under 500 t·year^{-1} by the mid-1950s, before increasing rapidly to around 13,000 t·year^{-1} by the late 1970s (Figure 6). During the war years, industrial catches declined to a low of around 6,000 t·year^{-1} before increasingly rapidly post-war to a peak of almost 25,000 t·year^{-1} by 1991. Thereafter, industrial catches declined to around 8,600 t·year^{-1} by 2010. Catches in Persian Gulf waters dominated total industrial catches, accounting for around 79% of total industrial catches by Iran (Figure 6).

Foreign fishing

Our estimates of foreign catches in Iranian waters are approximate, and suggest an increase from around 11,000 t·year^{-1} in the mid-1970s, to a peak of over 140,000 t·year^{-1} in the late 1980s (Figure 7). More recently, foreign catches appear to have declined to around 60,000 t·year^{-1}. Foreign catches appear to have been dominated by China and, to a lesser extent by India (Figure 7).

Discards

Discards appeared to be low throughout the 1950s, but increased with the expansion of industrial fishing (i.e., trawlers) to reach a pre-war high of just under 19,000 t·year^{-1} (Figure 8). Discards increased again after the war, reaching an all-time peak of over 36,000 t·year^{-1} in 1991, before declining to around 12,000 t·year^{-1} by the end of the time period (Figure 8).

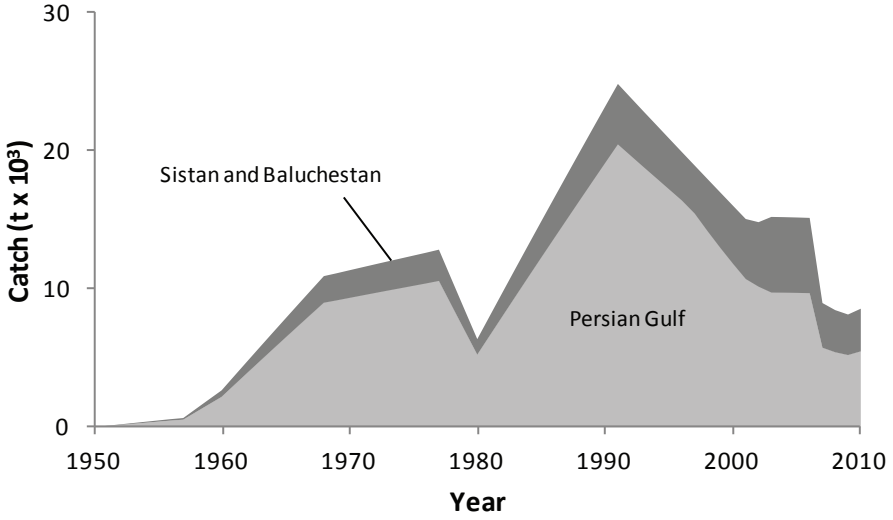

Figure 6. Iranian landings by the industrial sector, 1950-2010. (Discards not included on this graph).

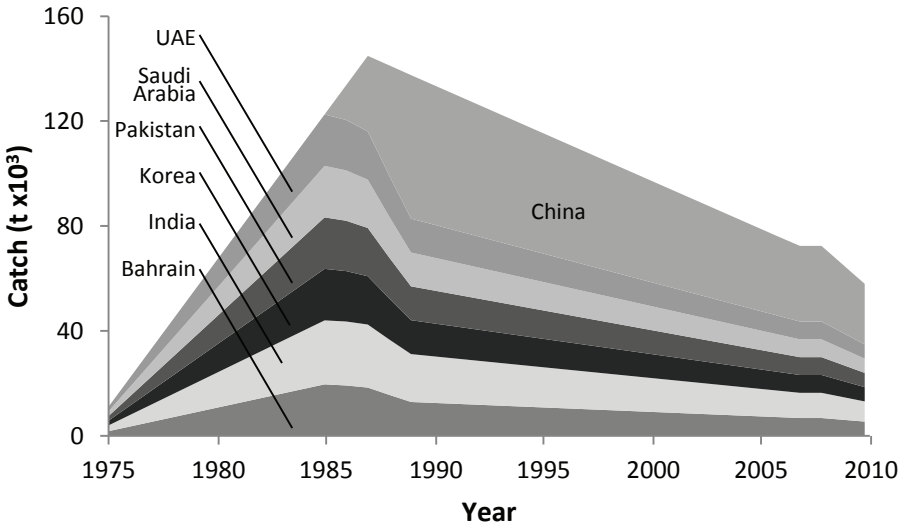

Figure 7. Foreign catches estimated as being taken from the waters of Iran, by the major foreign fishing countries. Note that the time-scale starts in 1975 as opposed to 1950.

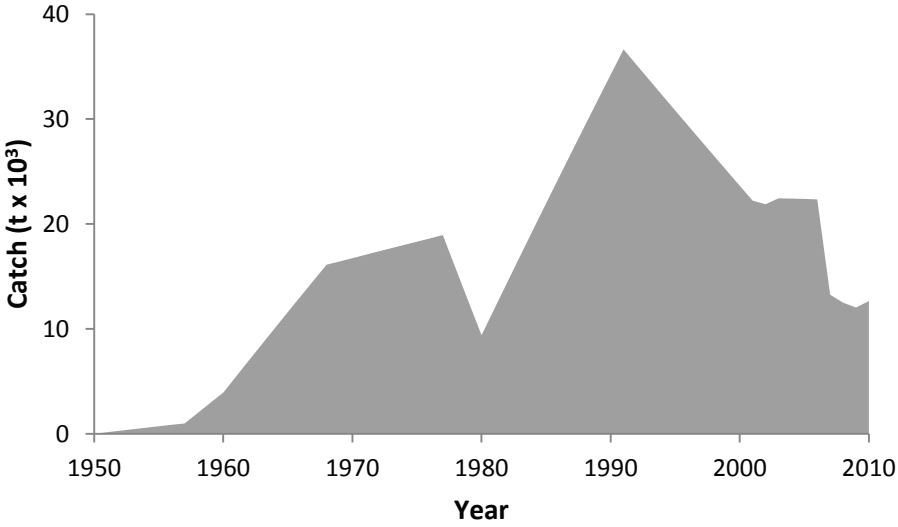

Figure 8. Estimated discards by the Iranian fisheries within their EEZ, 1950-2010.

Total reconstructed catch

Our reconstruction of the total marine fisheries catches for Iran was estimated at almost 14.9 million tonnes for 1950-2010, i.e., 2.6 times the 5.7 million tonnes reported by FAO on behalf of Iran (adjusted to account for catches taken by Iran outside its own waters, Figure 9a). Catches were heavily dominated by the artisanal sector, which accounted for nearly 12.7 million tonnes over the full time period. Overall, the majority of catches were taken within the Persian Gulf waters of Iran (i.e., 11.9 million tonnes), while only 3 million tonnes appear to have been caught in EEZ waters outside the Persian Gulf.

Reconstructed catches were derived for 145 taxa, compared to the 50 taxa reported by FAO on behalf of Iran. Catches were dominated by shrimps (family Penaeidae) with 1.3 million tonnes caught over the 1950-2010 time period (8.8% of the total catch; Figure 9b). Shrimps' contribution to the total catch has been decreasing over the time period, averaging 13% of the total catch from 1950-1970, and then declining to under 3% in 2010. Other important families include Leiognathidae (7.4%), Portunidae (6.8%), Clupeidae (5.5%), Haemulidae (5.0%), Carangidae (4.4%) and Scombridae (3.8%). Leiognathidae, Portunidae and Haemulidae have also decreased in their contribution to the total catch over the time period. Conversely, Clupeidae, Carangidae and Scombridae have all had in increase in their contribution to the total catch over the time period.

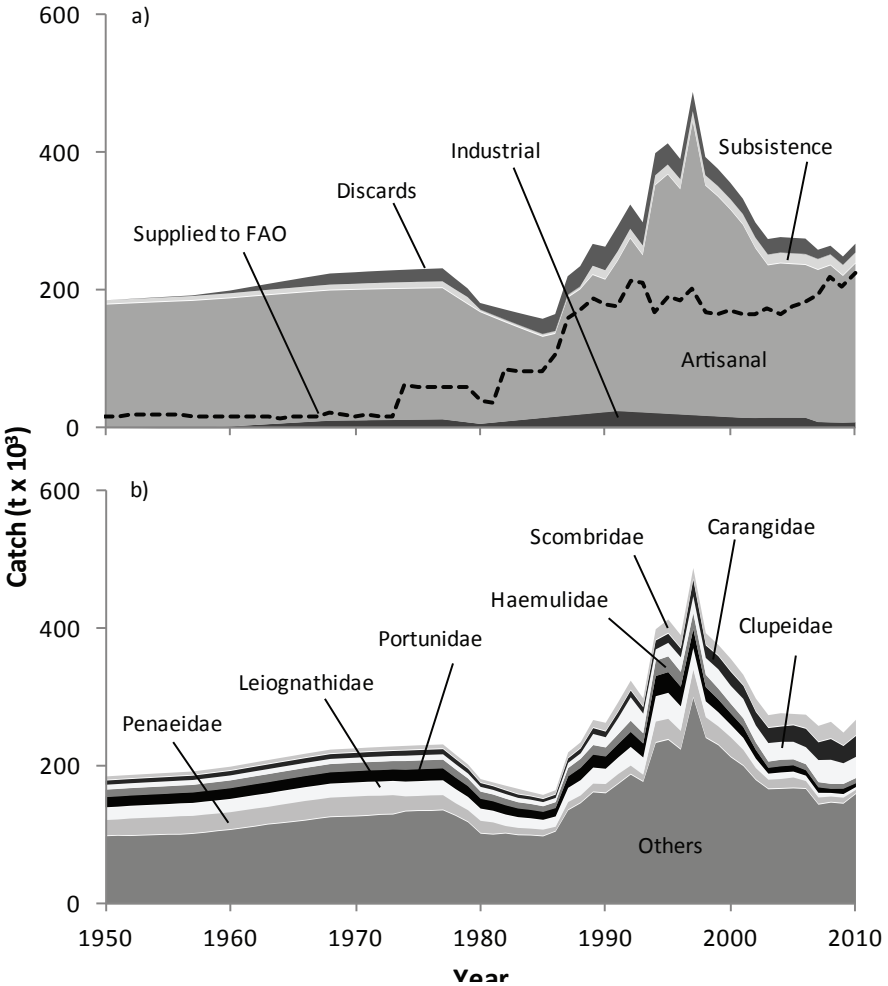

Figure 9. Total reconstructed catches for Iran for 1950-2010 by a) fishing sector plus discards (with comparison to FAO data, adjusted for large pelagic catches taken in offshore Indian Ocean waters); and b) by major taxonomic groups. Note that the recreational sector catches were included but are not visible on the sector graph (a) and that reconstructed catches consist of 145 individual taxonomic groups, here pooled into the 7 largest families plus 'others'.

Discussion

We reconstructed the best estimates of total marine fisheries catches taken by Iran in their own EEZ waters over the 1950-2010 time period. These estimates account for under-reported commercial catches and discards, as well as unreported recreational and subsistence catches. Overall, Iranian fishers caught almost 14.9 million tonnes, which is 2.6 times the 5.7 million tonnes FAO reports on behalf of Iran. While the major differences between reconstructed and reported catches occurred in the early time period, even in the most recent years, around 20% of likely total catches appear to be unreported. Both domestic consumption and export of seafood play a role in Iran's food security, therefore, a more comprehensive historic baseline of past total catches is important for our understanding of fisheries development and trends in Iran.

Unfortunately, our data suggest that marine fisheries in Iran have been poorly documented and assessed over time. It is likely that any data that have been supplied to the FAO are, for the most part, values of large-scale industrial fisheries together with some components of market sales.

Unsustainable fishing practices and pressures and ecological changes in the Persian Gulf have led to a reduction of catch rates over time. The abundance of target species such as shrimp, mackerels and major fish species has declined over the years. Unfortunately, despite this observed reduction in the abundance of various species in the Persian Gulf, fisheries continue to operate at unsustainable rates. This is also exemplified by the pearl fisheries occurring in the Persian Gulf (Anon. 2013b, 2013f).

The oil and gas industry is the major export earner for Iran. Over the last few decades, this emphasis on the oil and gas industry has eroded the traditional dominance of the fishing sector in coastal regions. With approximately 25,000 tankers passing through the Strait of Hormuz annually, the Persian Gulf plays a strategic role in the Middle East. With the ever increasing development of the oil industry in the region, oil pollution from offshore installations, oil tankers, tanker terminals and petrochemical plants has become a major threat to the ecology of the Persian Gulf, but its effect on the fisheries cannot be assessed.

Our data and study suggest the need for a transparent and more comprehensive data collection and reporting system, accounting for large-scale, small-scale, subsistence, recreational and foreign fishing be developed and implemented. This would help toward the establishment of a management plan for the fisheries of Iran, which should also include assessing and mitigating the impact of oil pollution on these fisheries.

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Appendix Table A1. FAO landings vs. total reconstructed catch (t) for Iran, 1950-2010, as well as catch by sector.

Year	FAO	Total reconstructed catch	Industrial	Artisanal	Subsistence	Recreational	Discards
1950	16,000	184,000	0	179,000	4,600	28	0
1951	16,000	185,000	110	180,000	4,690	29	160
1952	18,000	186,000	210	181,000	4,770	30	310
1953	18,000	187,000	300	182,000	4,860	30	450
1954	18,000	188,000	400	182,000	4,950	31	590
1955	18,000	189,000	500	183,000	5,040	32	730
1956	18,000	190,000	590	184,000	5,180	33	870
1957	17,000	191,000	670	184,000	5,380	34	990
1958	17,000	194,000	1,340	185,000	5,500	35	1,980
1959	16,000	196,000	2,010	185,000	5,620	36	2,960
1960	16,000	198,000	2,670	186,000	5,750	37	3,940
1961	16,000	202,000	3,720	186,000	5,880	38	5,490
1962	16,000	205,000	4,770	187,000	6,020	39	7,030
1963	15,000	208,000	5,810	187,000	6,170	41	8,570
1964	14,200	211,000	6,850	188,000	6,320	42	10,090
1965	15,900	214,000	7,880	188,000	6,430	43	11,610
1966	16,700	217,000	8,900	188,000	6,640	45	13,120
1967	17,100	220,000	9,920	189,000	6,740	46	14,630
1968	20,700	223,000	10,940	189,000	6,890	47	16,130
1969	18,300	224,000	11,150	189,000	7,060	48	16,430
1970	17,300	225,000	11,360	190,000	7,150	49	16,750
1971	17,800	226,000	11,580	190,000	7,500	52	17,070
1972	15,700	227,000	11,790	190,000	7,650	53	17,380
1973	15,800	228,000	12,000	190,000	7,810	55	17,700
1974	60,665	229,000	12,210	190,000	7,960	56	18,010
1975	60,270	229,000	12,420	190,000	8,120	58	18,320
1976	59,475	230,000	12,630	191,000	8,160	58	18,630
1977	58,836	231,000	12,850	191,000	8,240	59	18,950
1978	59,330	216,000	10,690	181,000	8,410	61	15,760
1979	58,729	202,000	8,530	172,000	8,770	64	12,580
1980	38,375	180,000	6,380	162,000	2,270	0	9,410
1981	37,326	176,000	8,100	153,000	2,340	0	11,940
1982	83,724	171,000	9,810	144,000	2,410	0	14,460
1983	81,765	166,000	11,510	135,000	2,490	0	16,970
1984	82,648	162,000	13,210	126,000	2,570	0	19,480
1985	82,804	157,000	14,890	118,000	2,650	0	21,970
1986	108,188	164,000	16,570	120,000	2,730	0	24,440
1987	158,940	219,000	18,240	171,000	2,810	0	26,910
1988	169,443	234,000	19,900	182,000	2,890	0	29,360
1989	188,688	266,000	21,560	201,000	11,840	8	31,800
1990	180,299	262,000	23,200	193,000	12,070	17	34,230
1991	175,238	292,000	24,840	218,000	12,290	27	36,640
1992	214,463	323,000	23,850	252,000	12,460	36	35,180
1993	211,588	297,000	22,860	228,000	12,600	46	33,720
1994	169,097	398,000	21,880	331,000	12,740	56	32,270
1995	189,284	412,000	20,900	348,000	12,900	67	30,820
1996	183,672	389,000	19,920	327,000	13,070	78	29,380
1997	202,556	487,000	18,950	427,000	13,260	90	27,940
1998	168,410	392,000	17,970	334,000	13,460	102	26,500
1999	163,525	375,000	17,000	319,000	13,650	115	25,070
2000	169,226	355,000	16,030	301,000	13,810	128	23,650
2001	165,634	332,000	15,070	280,000	13,910	140	22,230
2002	164,472	297,000	14,840	246,000	13,990	153	21,890
2003	173,725	273,000	15,220	221,000	14,050	166	22,450
2004	165,695	276,000	15,210	224,000	14,110	179	22,430
2005	176,360	275,000	15,180	223,000	14,170	193	22,390
2006	182,741	274,000	15,150	222,000	14,230	207	22,350
2007	193,739	258,000	8,990	221,000	14,280	221	13,270
2008	219,881	264,000	8,480	228,000	14,340	235	12,510
2009	205,441	248,000	8,160	213,000	14,380	250	12,040
2010	224,740	266,000	8,580	231,000	14,430	265	12,660

Appendix Table A2. Total reconstructed catch (t) for Iran by major taxa, 1950-2010.

Year	Penaeidae	Leiognathidae	Portunidae	Haemulidae	Clupeidae	Carangidae	Scombridae	Others[a]
1950	23,900	17,400	15,700	10,800	6,530	6,020	4,720	98,900
1951	24,100	17,500	15,800	10,900	6,560	6,060	4,740	99,600
1952	25,900	17,400	15,700	10,800	6,520	6,030	4,710	99,200
1953	26,000	17,500	15,800	10,900	6,550	6,070	4,730	99,900
1954	26,100	17,600	15,800	10,900	6,570	6,110	4,760	100,500
1955	26,200	17,700	15,900	11,000	6,590	6,140	4,780	101,100
1956	27,300	17,600	15,900	10,900	6,580	6,150	4,760	101,100
1957	26,600	17,800	16,000	11,000	6,630	6,230	4,810	102,300
1958	26,800	17,900	16,100	11,100	6,660	6,280	4,850	104,000
1959	26,100	18,100	16,300	11,300	6,730	6,370	4,910	106,300
1960	26,200	18,300	16,400	11,300	6,760	6,420	4,940	108,000
1961	26,500	18,400	16,500	11,400	6,810	6,490	4,990	110,400
1962	26,700	18,600	16,600	11,500	6,850	6,560	5,030	112,900
1963	26,000	18,800	16,800	11,700	6,930	6,650	5,100	115,800
1964	27,400	18,900	16,800	11,700	6,930	6,680	5,100	117,600
1965	28,200	18,900	16,900	11,800	6,950	6,710	5,120	119,500
1966	29,000	19,000	16,900	11,800	6,970	6,760	5,140	121,600
1967	28,700	19,200	17,100	11,900	7,030	6,840	5,200	124,200
1968	28,900	19,300	17,200	12,000	7,070	6,900	5,230	126,500
1969	29,100	19,400	17,200	12,000	7,080	6,930	5,240	127,100
1970	29,600	19,400	17,200	12,000	7,080	6,940	5,240	127,500
1971	29,500	19,400	17,200	12,100	7,090	7,010	5,260	128,400
1972	28,200	19,600	17,400	12,200	7,150	7,090	5,310	129,900
1973	28,700	19,600	17,400	12,200	7,150	7,110	5,310	130,400
1974	22,500	20,400	18,000	12,700	7,370	7,370	5,520	134,700
1975	22,300	20,500	18,000	12,700	7,390	7,410	5,540	135,500
1976	23,100	20,400	18,000	12,700	7,370	7,400	5,520	135,500
1977	22,500	20,500	18,000	12,700	7,400	7,440	5,550	136,400
1978	18,700	19,600	17,300	12,100	7,130	7,160	5,290	128,600
1979	18,000	18,200	16,300	11,300	6,750	6,790	4,930	119,200
1980	19,100	16,700	15,200	10,400	6,320	5,500	4,520	102,600
1981	18,200	15,900	14,600	9,900	6,100	5,260	4,310	101,300
1982	11,400	15,600	14,400	9,700	6,010	5,170	5,720	102,800
1983	11,100	14,500	13,600	9,000	5,710	4,840	7,040	100,300
1984	10,500	13,900	13,100	8,700	5,540	4,670	5,320	100,000
1985	10,300	13,200	12,600	8,200	5,320	4,440	4,790	98,700
1986	7,500	13,900	13,100	8,600	5,520	4,670	5,240	105,600
1987	12,400	19,600	17,400	12,200	7,140	6,460	7,460	136,500
1988	11,800	21,200	18,600	13,200	7,590	6,970	7,750	146,800
1989	13,100	22,400	19,400	13,900	15,920	8,460	10,390	162,500
1990	14,000	21,200	18,500	13,100	14,580	8,110	11,430	161,200
1991	15,100	23,200	20,000	14,400	23,150	8,770	12,950	174,500
1992	13,600	26,200	22,300	16,300	34,010	9,730	12,930	188,300
1993	10,900	24,100	20,800	15,000	28,430	9,110	11,470	177,600
1994	31,600	35,900	29,600	22,300	16,760	12,800	14,870	234,200
1995	31,100	36,900	30,300	22,900	20,030	13,120	19,240	238,700
1996	27,700	34,900	28,800	21,600	21,460	12,520	18,090	224,400
1997	41,100	30,800	27,700	23,000	25,280	23,930	15,380	299,800
1998	30,700	22,200	20,900	18,000	24,790	18,040	16,480	241,400
1999	27,900	19,700	18,900	15,800	28,260	19,000	14,880	230,900
2000	29,600	17,300	16,900	14,100	26,180	20,200	17,460	213,300
2001	24,000	16,400	16,100	12,800	28,230	19,070	14,440	200,700
2002	18,000	12,800	13,200	10,900	24,570	19,540	18,140	180,300
2003	14,400	7,700	9,200	9,100	26,620	21,770	17,390	167,000
2004	14,800	8,500	9,700	9,400	25,760	22,140	18,050	167,600
2005	16,300	7,600	9,800	8,700	25,190	23,870	15,150	168,300
2006	12,100	6,800	8,600	8,800	24,390	26,670	19,180	167,400
2007	10,900	5,800	8,800	7,600	31,630	25,710	22,570	144,700
2008	9,300	4,200	6,800	7,300	34,510	30,100	23,680	147,700
2009	9,300	4,200	8,600	7,000	29,540	24,950	18,210	146,100
2010	6,500	3,000	6,300	7,600	30,300	30,390	22,160	160,200

[a] "Other" contains 68 additional additional families and 3 higher taxonomic groupings.

Reconstructing Iraq's fisheries: 1950-2010[1]

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Abstract

Iraq's fraction of the Persian Gulf waters, surrounding the mouth of the Shatt al-Arab, is tiny, and so are its marine fisheries, which, moreover, have been impacted by a succession of wars over the past few decades. Its fisheries remain underdeveloped and understudied, and hence little documented. Here, Iraqi marine fisheries catches are reconstructed from 1950 to 2010, based on admittedly fragmentary evidence. Overall, the catches reconstructed here are 1.8 times those reported to FAO on behalf of Iraq, and are dominated by unreported catches of hilsa shad (*Tenualosa ilisha*). This study illustrates the need to establish management infrastructure for fisheries monitoring and regulation enforcement, especially in light of the many stocks that are shared with other Persian Gulf countries.

Introduction

Iraq has the smallest fishing grounds of the Persian Gulf countries, essentially near the mouth of the Shatt al-Arab River, which is formed by the confluence of the Euphrates and Tigris river about 200 km upstream. Thus Iraq's marine fisheries are of minor importance compared to its freshwater fisheries. The marine fisheries are all artisanal in nature, with gillnetting for hilsa shad (*Tenualosa ilisha*), pomfret (*Pampus* spp.), and mullet (*Liza* spp.) being dominant fishing activities, complemented by some traditional dhows operating small trawl nets. Fish supply is relatively low throughout the region and does not meet local demand (Jawad 2006). There are apparently no marine recreational fisheries.

Iraq has one of the richest water resources in the Middle East due to the presence of the Tigris and Euphrates rivers, the smaller Shatt al-Arab and Shatt al-Basrah rivers, and the Mesopotamian marshes. The marshlands serve as nursery grounds for a number of migratory fish such as the hilsa shad, and also provide important nutrients to the fisheries of the northern Gulf through the Shatt al-Arab River (Jawad 2006).

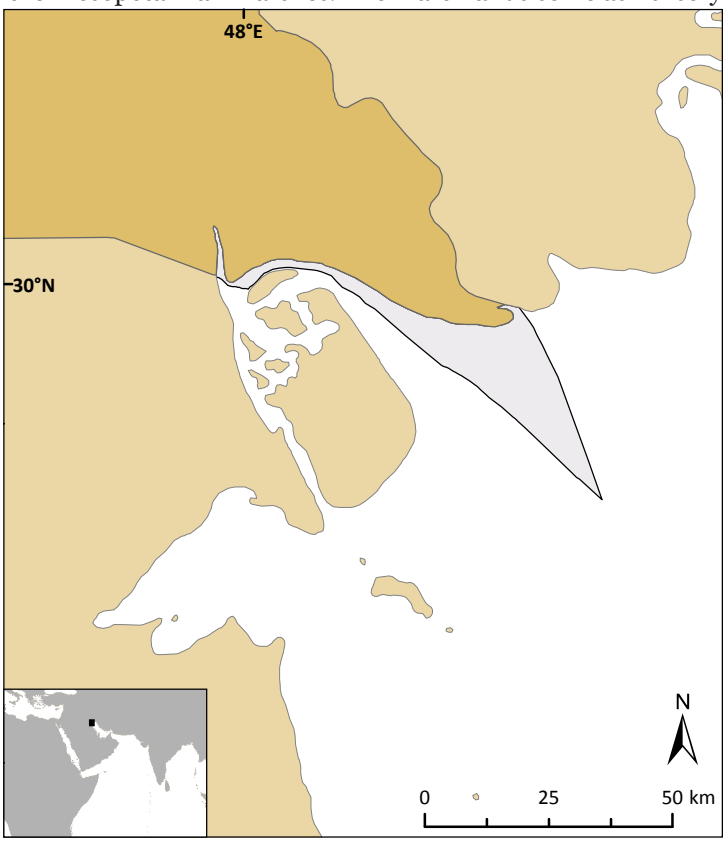

Figure 1. Map of Iraq, showing the extent of its small EEZ (in grey).

Between the 1950s and 1990s, large areas of the Mesopotamian marshes were drained, at different times and for different reasons (Al-Yamani *et al.* 2007). Although the initial draining of the central marshes was intended for land reclamation for agricultural purposes, it later became a political attempt to force Marsh Arabs (Ma'dan people) out of the area through water diversion tactics. The marshes, which have been reduced in extent by over 90%, have long been considered as a refuge for people persecuted by Saddam Hussein's government. Not surprisingly, thousands of fish and waterfowl died as the waters receded (North 1994). In addition, damming naturally flowing rivers reduces freshwater discharge into the sea, leading to reduced nutrient concentration in coastal waters, which consequently diminishes plankton productivity, and in turn, fish landings (Al-Yamani *et al.* 2007). It is speculated that the damming could also increase the salinity of the northwestern Gulf, raising concerns about jellyfish outbreaks and changes in plankton (and hence fish) community density and distribution (Al-Yamani *et al.* 2007).

A number of major wars have greatly shaped the country's fisheries. The Iran-Iraq war, which lasted from 1980-1988, presumably led to decreased

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marine fisheries catch, though the lack of detailed records precludes firm inferences (Ali 2001). In addition, the first Gulf War in 1991 led to UN imposed sanctions which implied that areas in the Northern Persian Gulf traditionally exploited by Iraqi fishers could no longer be accessed. Thus, patrols by non-Iraqi forces meant that the Shatt al-Arab waterway and areas around Bubiyan Island and Warba Island (Kuwait) were closed to all forms of fishing. This, combined with other factors (general insecurity and perhaps oil pollution, see below), meant that Iraq's reported catches dropped to near zero in 1991 and 1992.

Several studies were carried out on the impact of the 1991 Gulf War oil spill on fisheries stocks (e.g., Linden *et al.* 2004; Al-Sabbagh and Dashti 2009). Impacts of oil spills tend to be highly variable, affecting food webs, life history cycles, and entire marine ecosystems (Al-Sabbagh and Dashti 2009). In this case, it has been suggested that declines in fish stocks were a result of planktonic larval or egg mortality, not adult mortality because many of the fish species live in depths below the oil slick, and because the warm waters sped up the breakdown of oil (Linden *et al.* 2004).

As the northern Gulf became safer to navigate in 1994-1995, fisheries catches started to recover. However, the funds allocated towards fisheries management and monitoring suffered as a result of the UN sanctions, leading fisheries to be essentially unregulated. The damming of the upper Tigris and Euphrates rivers and the draining of the marshes in the Shatt al-Arab delta also negatively affected marine resources, particularly in the case of the hilsa shad, *Tenuolosa ilisha* (Al-Dubakel 2011).

Following the combats that led to the change of government in 2003, Iraqi fishers began to expand their fishing southward, returning to Bubiyan and Warba Islands, as well as fishing illegally in other parts of Kuwait's Exclusive Economic Zone (EEZ).

While the ichthyofauna of Iraq has been reasonably well documented (www.fishbase.org), there are currently no management plans in place for any of Iraq's fisheries. Detailed catch statistics have not been collected since the early 1990s and no stock assessments have been performed. Thus, the numbers presented here will remain tentative until this situation is addressed.

Corrupt governance and lack of infrastructure have complicated data gathering on Iraqi fisheries. For example, under the former Ba'athist government, the State Organization of Fisheries controlled the administration of freshwater and marine fisheries, including the administration of fishing licenses. As such, they discriminated against non-Ba'ath people, especially Marsh Arabs (Jawad 2006), refusing to issue licenses. In addition, Uday Hussein, the eldest son of Saddam Hussein controlled the most productive areas of the marshlands and demanded payments from fishers in exchange for access (Jawad 2006). Later, the State Organization of Fisheries was dissolved and replaced by a marine fisheries cooperative that only served the Basrah province.

Methods

Iraq reports to FAO only a miscellaneous category called 'marine fishes nei' up until 2003. From 2004 on, catches are also reported for 'hilsa shad, 'mullets' (Family Mugilidae) and '*Penaeus* shrimps'. To improve the taxonomic resolution, taxonomic information from the 2004-2010 time period, as well as information on the species caught in the waters of neighbouring Kuwait, was used to disaggregate the data from 1950-2003. The 'marine fishes nei' category was initially assigned to 76% Mugilidae, 2% Penaeidae, 22% miscellaneous marine fish, which was adapted from relative proportions in the reported data. The miscellaneous marine fish portion was then broken down further; ten percent remained miscellanous marine fish, while the other 90% was assigned to the four most common families found in Kuwait waters (croakers, 40%; groupers, 35%; grunts, 15%; and snappers 10%) (see Kuwait; Al-Abdulrazzak, this volume). These methods were also utilized (with slight adjustments) for the 2004-2010 time period as there was still large amounts of 'marine fishes nei' reported. Note that 'hilsa shad' was not part of the disaggregation breakdown as there was additional information utilized to reconstruct these catches.

Al-Dubakel (2011) reports shad catches from 1990-2007, as well as average percentages of shad catches compared to total catch from 1965-1975 (56.9%), 1990-1992 (38.9%), and 2003-2007 (5.1%). Because Al-Dubakel's total catch estimates are much higher than FAO's over the same time period, and because they were not reported as part of the freshwater catches, we assumed that the shad is not already reported in the miscellaneous marine fishes category and therefore adopted Al-Dubakel's (2011) estimates as unreported 'hilsa shad' catch.

Iraq's coastline is very short (Figure 1) and only 0.001% of the population of Iraq lives within 10 km of the coast. We assume a conservative subsistence catch rate of 500 g/person/week (i.e., the equivalent of two servings per week) and apply this to the derived coastal population from 1950-2010. We used the 2004-2010 FAO data (excluding shrimp) as a guideline to derive a subsistence breakdown (approximately 44% *Tenualosa ilisha*, 32% miscenalleous marine fish, and 24% Mugilidae).

A number of accounts exist of significant illegal fishing by Iraqi trawlers and gillnetters in Kuwait's and Iran's EEZs (e.g., De Young 2006; Al-Saadoun 2012; Saleh 2012). We estimated illegal fishing in Kuwait's EEZ to be 10% of reported catches for the years 2003-2010, and disaggregated it into shrimp (Penaeidae, 5%), pomfret (*Pampus*

argenteus, 2%), shad (*Tenualosa ilisha*, 2%), and mullet (Mugilidae, 1%). For illegal fishing in Iran, we estimate catches to be 3% of reported and apply the same species composition ratios used for catches in Kuwait.

Finally, we apply a bycatch ratio (15:1) to reported, estimated and illegal Iraqi shrimp catches, of which 98% of the fish is discarded and only 2% is retained (as miscellaneous marine fishes), derived from the nearby Kuwait shrimp fishery (Ye *et al.* 2000). We also applied the same species composition from Kuwait to the discards.

Results and discussion

Data supplied to FAO offer poor taxonomic resolution and omit illegal catches and shrimp discards. After incorporating these components in our reconstruction, our catch estimates over the 1950-2010 time period are 1.8 times what is reported to FAO (Figure 2a; Appendix Table A1). We predict that our reconstructed catches are likely to be an underestimate, as without more information on fishing practices in Iraq, our assumptions were conservative.

Since shrimp stocks are shared with Iran and Kuwait, the unregulated and illegal trawling may impact landings in these countries. Iraqi vessels are landing significant quantities of shrimp, particularly species that have not been previously landed in Iraq in these large quantities (Al-Dubakel 2011). Catches from Iran and Kuwait waters (2003-2010) were estimated to be 3% and 10%, respectively, of the total reonstructed catch from 1950-2010.

Discards are likely present from more than just the shrimp fishery, but scant information exists, and is therefore difficult to quantify. In Iraq, the majority of fishermen are Shiite Muslims who therefore do not consume fish without scales visible to the naked eye. Therefore, bycatch species such as *Muraenesox cinereus, Arius thalassinus,* and *Trichiurus lepturus* are discarded back to sea (Jawad 2006). Discards made up 26% of the total estimated catch.

The main species of Iraq's marine fisheries were Mugilidae (39%), *Tenualosa ilisha* (17%), *Arius thalassinus* (8%), Sciaenidae (5%), and *Epinephelus* spp. (5%) (Figure 2b; Appendix Table A2).

Jawad (2006) suggests that regulating access may be more effective than implementing catch or effort controls. Due to the remoteness of certain areas in the marshlands, and because most fishers make their own gear, size and gear control are difficult to implement. Concerns have also been raised concerning oil pollution and runoff from industrial and household wastes (Al-Dubakel 2011). Oil spills are commonly seen along the Shatt Al-Arab, particularly from the *Abu Flous* port (Al-Dubakel 2011).

A number of major challenges hinder Iraq's ability to manage its fisheries. First, infrastructure for fisheries management and monitoring needs to be rebuilt. Enforcement of existing and new fisheries legislature cannot be implemented otherwise. Second, marine habitat degradation, particularly the draining of the marshes, must be addressed. Finally, and perhaps most importantly, Iraq should be incorporated into regional fisheries management plans since many stocks are shared with other Gulf countries.

The management of Iraq's marine fisheries has deteriorated

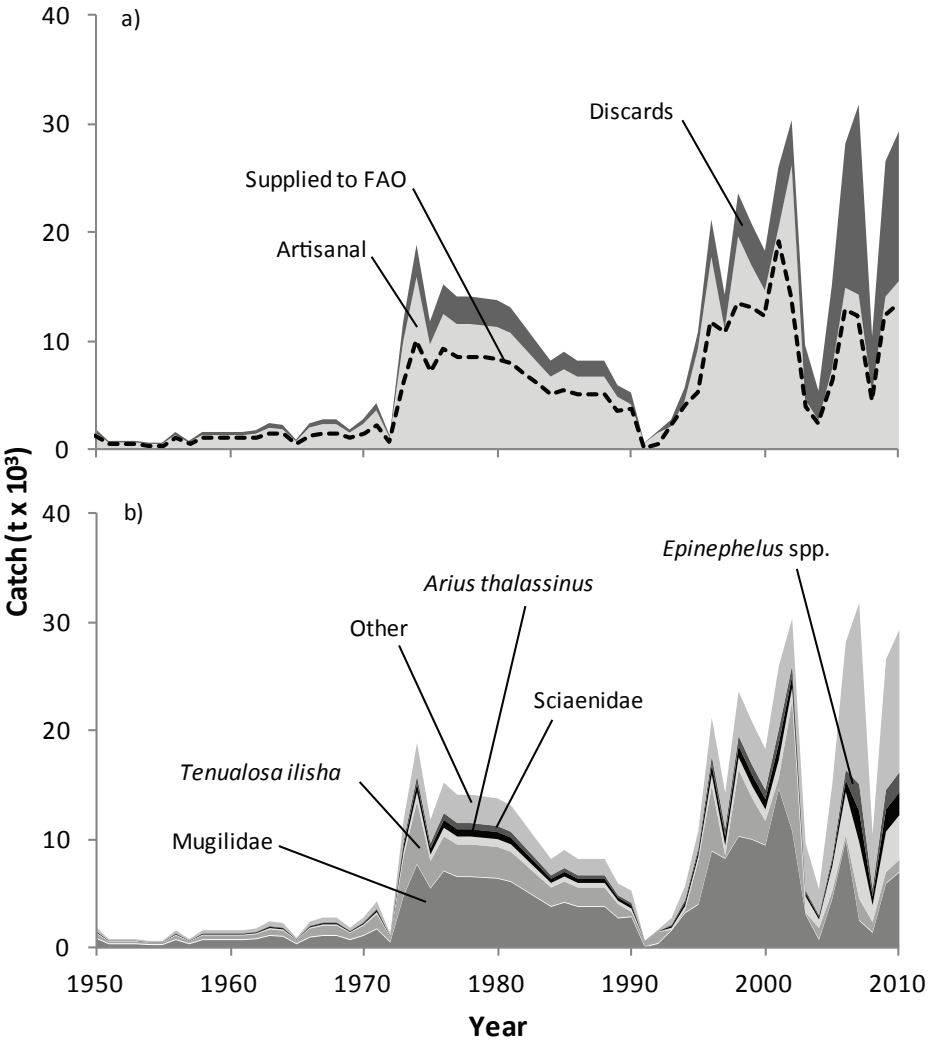

Figure 2. Total reconstructed catch for Iraq, 1950-2010, by a) sector (with comparison to FAO), and b) major taxa. Note that subsistence catches were included in the sector graph (a) but are not visible (too small).

significantly since 2003, while increased fishing effort (and a corresponding increase in landings) has occurred during the same time. This does not bode well for the long-term sustainability of the country's fisheries. It is clear that unregulated fishing of shared fish and shrimp stocks of the northern Gulf must be brought under control.

Acknowledgements

We acknowledge the support of the *Sea Around Us* Project, a scientific collaboration between The University of British Columbia and The Pew Charitable Trusts.

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Appendix Table A1. FAO landings vs. total reconstructed catch (t) for Iraq, 1950-2010, as well as catch by sector.

Year	FAO landings	Total reconstructed catch	Artisanal	Subsistence	Discards
1950	1,200	1,970	1,620	1	350
1951	500	820	670	1	150
1952	500	820	670	1	150
1953	500	820	670	1	150
1954	400	660	540	2	120
1955	400	660	540	2	120
1956	1,000	1,640	1,350	2	290
1957	500	820	670	2	150
1958	1,000	1,640	1,350	2	290
1959	1,000	1,640	1,350	2	290
1960	1,000	1,640	1,350	2	290
1961	1,000	1,640	1,350	2	290
1962	1,100	1,810	1,480	2	320
1963	1,500	2,460	2,020	2	440
1964	1,400	2,300	1,880	2	410
1965	500	940	790	2	150
1966	1,300	2,430	2,050	2	380
1967	1,500	2,810	2,360	2	440
1968	1,500	2,810	2,360	2	440
1969	1,000	1,870	1,580	2	290
1970	1,500	2,810	2,360	3	440
1971	2,300	4,300	3,620	3	680
1972	700	1,310	1,100	3	210
1973	6,300	11,780	9,920	3	1,850
1974	10,100	18,880	15,910	3	2,970
1975	7,200	11,810	9,690	3	2,120
1976	9,283	15,230	12,490	3	2,730
1977	8,601	14,110	11,580	3	2,530
1978	8,600	14,110	11,580	3	2,530
1979	8,500	13,940	11,440	3	2,500
1980	8,400	13,780	11,310	4	2,470
1981	8,000	13,120	10,770	4	2,350
1982	7,000	11,480	9,420	4	2,060
1983	6,000	9,840	8,080	4	1,760
1984	5,000	8,200	6,730	4	1,470
1985	5,500	9,020	7,400	4	1,620
1986	5,000	8,200	6,730	4	1,470
1987	5,000	8,200	6,730	4	1,470
1988	5,000	8,200	6,730	4	1,470
1989	3,617	5,940	4,870	4	1,060
1990	3,754	5,280	4,180	5	1,100
1991	125	670	630	5	40
1992	543	1,710	1,550	5	160
1993	2,133	2,780	2,150	5	630
1994	4,221	5,690	4,450	5	1,240
1995	5,253	10,830	9,280	5	1,540
1996	11,688	21,200	17,760	5	3,440
1997	10,783	14,270	11,100	6	3,170
1998	13,463	23,610	19,640	6	3,960
1999	13,093	20,830	16,970	6	3,850
2000	12,389	18,310	14,660	6	3,640
2001	19,200	25,970	20,320	6	5,640
2002	14,100	30,340	26,180	7	4,150
2003	4,000	9,630	4,620	7	5,000
2004	2,355	5,410	2,720	7	2,690
2005	6,359	15,160	7,350	7	7,810
2006	12,959	28,170	14,910	7	13,250
2007	12,319	31,760	14,280	7	17,470
2008	4,486	10,430	5,180	8	5,240
2009	12,246	26,570	14,090	8	12,470
2010	13,490	29,300	15,520	8	13,770

Appendix Table A2. Total reconstructed catch (t) for Iraq by major taxa, 1950-2010.

Year	Mugilidae	*Tenualosa ilisha*	*Arius thalassinus*	Sciaenidae	*Epinephelus*	Others[a]
1950	910	409	110	100	83	360
1951	380	171	40	40	35	150
1952	380	171	40	40	35	150
1953	380	171	40	40	35	150
1954	300	137	40	30	28	120
1955	300	137	40	30	28	120
1956	760	341	90	80	69	300
1957	380	171	40	40	35	150
1958	760	341	90	80	69	300
1959	760	341	90	80	69	300
1960	760	341	90	80	69	300
1961	760	341	90	80	69	300
1962	840	375	100	90	76	330
1963	1,140	511	130	120	104	460
1964	1,060	477	120	110	97	430
1965	380	285	40	40	35	150
1966	990	741	110	100	90	400
1967	1,140	855	130	120	104	460
1968	1,140	855	130	120	104	460
1969	760	570	90	80	69	300
1970	1,140	855	130	120	104	460
1971	1,750	1,310	200	180	159	700
1972	530	400	60	60	49	210
1973	4,790	3,586	560	500	437	1,910
1974	7,680	5,748	890	800	700	3,060
1975	5,470	2,449	640	570	499	2,180
1976	7,060	3,158	820	740	643	2,820
1977	6,540	2,926	760	680	596	2,610
1978	6,540	2,925	760	680	596	2,610
1979	6,460	2,892	750	670	589	2,580
1980	6,380	2,858	740	670	582	2,550
1981	6,080	2,722	710	630	554	2,430
1982	5,320	2,382	620	550	485	2,120
1983	4,560	2,042	530	480	416	1,820
1984	3,800	1,702	440	400	347	1,520
1985	4,180	1,872	490	440	381	1,670
1986	3,800	1,702	440	400	347	1,520
1987	3,800	1,702	440	400	347	1,520
1988	3,800	1,702	440	400	347	1,520
1989	2,750	1,232	320	290	251	1,100
1990	2,850	402	330	300	260	1,140
1991	100	502	10	10	9	40
1992	410	1,002	50	40	38	170
1993	1,620	2	190	170	148	650
1994	3,210	202	370	330	293	1,280
1995	3,990	4,002	460	420	364	1,590
1996	8,880	6,002	1,030	930	810	3,550
1997	8,200	252	950	850	747	3,270
1998	10,230	6,103	1,190	1,070	933	4,090
1999	9,950	3,803	1,150	1,040	907	3,970
2000	9,420	2,203	1,090	980	859	3,760
2001	14,590	1,003	1,690	1,520	1,331	5,830
2002	10,720	12,003	1,240	1,120	977	4,280
2003	3,090	107	1,500	320	277	4,330
2004	760	1,014	810	230	205	2,400
2005	4,570	627	2,340	470	409	6,750
2006	9,880	466	3,970	1,100	966	11,780
2007	2,530	1,935	5,240	2,860	2,504	16,680
2008	1,410	913	1,570	820	719	4,990
2009	5,920	1,001	3,740	2,070	1,812	12,020
2010	6,960	1,104	4,130	2,120	1,859	13,130

[a] Others category includes 8 additional taxonomic groups.

Reconstructing Kuwait's marine fishery catches: 1950-2010[1]

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Abstract

Kuwait's fisheries have grown substantially over the past 60 years. Here, Kuwait's fisheries are reconstructed to include discards, recreational, and illegal catches. The resulting estimates of just under 2 million t are 6.4 times the 312,250 t reported to FAO, and discards, which constitute the largest missing sector, are 10 times greater than the total landed finfish in the country. This study illustrates the magnitude of the data reporting problems faced by Kuwait and provides further evidence for the need for more and better-enforced fisheries regulations in the region.

Introduction

Kuwait is located in the northeast of the Arabian Peninsula, on the shore of the Persian Gulf (Figure 1). It lies between latitudes 28° and 31° N, and longitudes 46° and 49° E, and borders Saudi Arabia to the south and Iraq to the north. Kuwait is one of the world's smallest countries in terms of land mass and is characterized by flat, sandy desert. It has nine islands, eight of which remain uninhabited. The capital, Kuwait City is located on Kuwait Bay, a natural deep-water harbor.

Kuwait was a British colony from 1899-1961 and is now a constitutional emirate with the oldest directly elected parliament among the Arab Persian Gulf countries. Kuwaiti nationals are a minority of the population, making up just 1 million out of the 3.5 million people. The country's economy is almost solely based on crude oil, which makes up nearly half of GDP and 95% of export revenues (World Factbook, 2011)

Interestingly, despite their predominately small-scale nature, Kuwait's fisheries remain the second most important natural resource after oil (Carpenter 1997). In general, fisheries management in Kuwait is not well developed, although weakly enforced legislation has been in place for the industrial shrimp fishery since the early 1980s. Because fisheries are of minor economic importance (at least when compared to oil), and therefore are of low political significance. The fisheries consist of two main sectors: a limited industrial (large-scale) shrimp fishery and substantial artisanal (small-scale) finfish and shrimp fisheries.

Methods

Fisheries catches as presented by the FAO on behalf of Kuwait occur in FAO statistical area 51. Total fish catches were estimated by following the conceptual framework outlined in Zeller (2006; 2007). Data were gathered from published and grey literature, and subsequently combined with clearly defined assumptions and interpolations.

Industrial sector

The industrial, or large-scale sector, consists exclusively of a shrimp trawl fishery. This sector started in the early 1960s and expanded rapidly, and by 2006, it grew to 35 trawlers. The main shrimp species targeted are the green tiger prawn (*Penaeus semisulcatus*), jinga shrimp (*Metapenaeus affinis*) and the kidi shrimp (*Parapenaeopsis stylifera*), with seasonal reported landings ranging from 1,000 to 5,200 t (Ye *et al.* 1999a). The official shrimp fishing

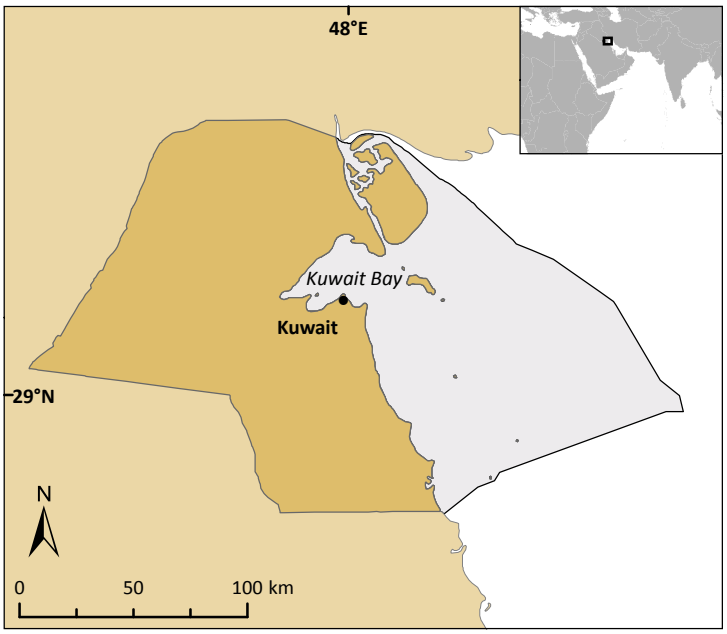

Figure 1. Map of Kuwait, showing the extent of its EEZ (grey area).

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season runs from September 1 of any given year to early/late spring of the next depending on catch rates. Trawling occurs in the coastal waters from 5 to 35 m depth, although Kuwait Bay and a three-mile coastal zone have been closed to trawling since 1983 (Ye *et al.* 1999b). Official reported shrimp landings were assigned to both the industrial and artisanal sectors. It has been reported that 45% of total shrimp landings are caught by artisanal vessels. As the industrial shrimp fishery did not begin until 1960, the proportion of shrimp catches caught be industrial vessels was interpolated from zero percent in 1959 to 55% in 1965. From 1965-2010, the proportion of 55% was kept constant.

Considerable illegal shrimp fishing occurs during the 3-6 month closed season (Mohammed *et al.* 1998; Siddiqui and Al-Mubarak 1998; Al-Sabbagh and Dashti 2009), suggesting poor to non-existent monitoring and enforcement of management rules. Here, it was conservatively estimated that out-of-season shrimp catches comprise 10% of total reported shrimp catch, starting from the earliest incident (1990) of illegal catches mentioned in the literature (Al-Sabbagh and Dashti 2009) to 2010. A set tonnage of 500 t was reported as being caught illegally in 1992. These illegal shrimp catches were also assigned to both the artisanal and industrial sectors using the same proportions as were used for the reported catches.

Bycatch (i.e., species that are unintentionally retained by fishing gear) is a major component of shrimp fisheries globally, raising concerns of ecological and economic impacts (Alverson and Hughes 1996; Kelleher *et al.* 2005). The average ratio of bycatch to shrimp is 5:1 in temperate and subtropical waters, and 10:1 in tropical waters (Slavin 1982). The subtropical Kuwaiti shrimp trawl fishery, however, has a fish-to-shrimp bycatch ratio of 15.32:1 (Ye *et al.* 2000). Of this bycatch, 98% is discarded at sea and the remaining 2% is landed, yet not reported (FAO 2006). Thus, both landed and discarded catches are unaccounted for. Species composition ratios were applied from the Ye *et al.* (2000) study. Marine catfish (Ariidae) and elasmobranchs (sharks and rays), which are not consumed in Kuwait for religious reasons, comprise the bulk of the discarded bycatch.

Bycatch was estimated as a multiple of both the reported legal shrimp catch and the unreported illegal catch, and then smoothed by applying a 3-year moving average. The estimated bycatch was subsequently disaggregated into unreported discards (98%) and unreported landed bycatch (2%). On average, the discards from the Kuwaiti shrimp fishery were 10 times higher than the tonnage of finfish reported to be landed in Kuwait annually.

Artisanal sector

The artisanal sector essentially comprises three components: a shrimp fishery, a boat-based finfish fishery and a traditional fixed intertidal stake net fishery. The artisanal shrimp fleet catches 45% of total shrimp landings using both traditional dhows and small outboard motor fibreglass vessels (FAO 2006). Since the industrial shrimp fishery did not begin until 1960, shrimp catches from 1950-1959 were labelled as 100% artisanal. Then, as described above, the artisanal proportion of the shrimp fishery was interpolated from 100% in 1959 to 45% in 1965, and kept constant to 2010. Improvements in the equipment of these fleets have resulted in dhows being able to access the same fishing grounds as the fibreglass vessels. Ye *et al.* (1999a) found nearly identical rates of bycatch and discard between artisanal and industrial shrimp fleets, and therefore the same 15.32:1 ratio was applied to the artisanal shrimp catches (including the illegal catches calculated above) to estimate unreported discards and unreported landed bycatch.

Kuwait's boat-based finfish fishery consists of two vessel types: wooden dhows and speedboats. These vessels are licensed for a single gear type, which can be hemispherical wire traps (*gargoor*), or drift or fixed gillnets of various mesh sizes. The dhow fleet consists of 120 boats, of which 94 use *gargoor* traps and 26 use gillnets (FAO 2006). The speedboat fleet consists of 748 vessels, 28 of which are licensed for *gargoor*, and 720 for gillnets (FAO 2006). The boat-based finfish fishery has seen significant declines in catches in recent years, with a record low of 2,500 tonnes in 2001. This has been attributed to overcapacity, although no efforts have been put into place to reduce capacity and effort (FAO 2006). The reported FAO data (minus the shrimp catch) were taken to be representative of the baseline catch for the boat-based artisanal fishery plus the traditional fixed intertidal stake net fishery.

Significant numbers of sharks are landed in Kuwait, yet are not listed in FAO catch data (Moore *et al.* 2012). The majority of these are caught as bycatch by small speedboats operating gillnets to target teleosts, or less commonly, dhows operating *gargoor* traps. Despite sharks being impermissible to eat by Shiite Muslims, a growing expatriate community has lead to sharks being landed whole and consumed within the country (Moore *et al.* 2012). A handful of countries in the Gulf do report their shark landings, and FAO data from Bahrain (based on its proximity and similar fishery profile) were used to estimate the potential contribution of sharks in Kuwait's catches. Bahrain reported shark catches (Carcharhinidae) for 2004-2010, and these catches were divided by the total reported finfish catch to obtain an average shark to finfish ratio of 5%. This ratio was applied to Kuwait's reported finfish time series.

Recreational sector

An active recreational fishery targets demersal species from small speedboats, but no data are available on the number of participants or species landings (FAO 2006). Cisneros-Montemayor and Sumaila (2010) estimate that

recreational fisheries involve 0.12% of Kuwait's population. Thus, this ratio was applied to the total population from 1950-2010 to get a time series of number of recreational fishers. As a conservative estimate, it was assumed that recreational fishers catch 1 kg of fish per trip and that they only fish on the weekends. Therefore, the number of fishers was multiplied by the number of fishing days (104 days) and by a catch of 1 kg to obtain a rough time series of recreational catches. The estimated catches for the years during and immediately after the first Gulf War (1990-1992) were eliminated, as it was assumed that no recreational fishing occurred. Rao and Behbahani (1999) estimate that the majority of species caught by recreational fishermen are *Epinephelus chlorostigma*, *Sparidentex hasta*, *Otolithes ruber*, and *Acanthopagrus latus*; thus the recreational catch was evenly distributed among those 4 species.

Subsistence Sector

Although vessel owners are Kuwaiti nationals, fishers are foreign workers from Southeast Asia and Iran, who have modest incomes, and therefore have a high incentive to fish for subsistence. From 1960-2010, foreign fishers made up 0.0015% of the population and it was assumed that each fisher takes 5 kg per week for subsistence purposes from the start of the oil boom in 1960 until 2010. It was further assumed that no subsistence fishing occurred during and immediately after the Gulf War, from 1990-1992. Finally, because these take home catches are composed of less desirable species, the catch composition of the discarded species were applied to the subsistence catches.

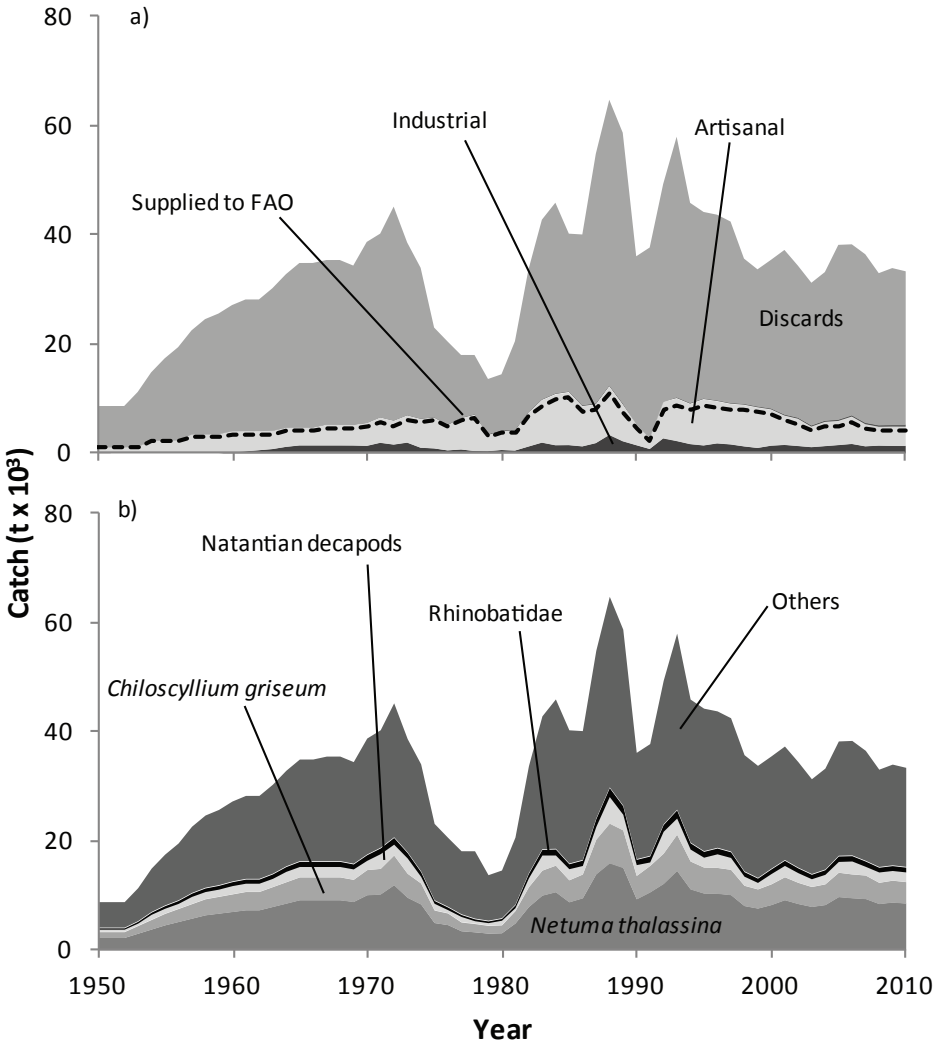

Figure 2. Total reconstructed catch for Kuwait by a) sector (with comparison to FAO data), and b) major taxa, 1950-2010.

Results and discussion

Catch data for Kuwait as reported by the FAO suggest a gradual increase in reported landings from 1,000 t in 1950 to a peak of 10,788 t in 1988, before declining to an average of around 4,700 t per year in the 2000s (Figure 2a; Appendix Table A1). In contrast, the reconstructed total marine fisheries catches suggest a rapid increase in catches at the start of the industrialized shrimp fishery in 1960, peaking at 45,000 t in 1972, with a second peak of 64,600 t occurring in 1988 (Figure 2a). A final peak is present in 1993 (57,800 t) before declining to a final tonnage of 33,200 t in 2010 (Figure 2a). Trends in catch series often reflect political events that impacted the fishery sector in a country; in this case, the decline in catches from 1972 to 1979 is most likely a result of the Iran-Iraq war. Similarly, the decline in catches in 1990 is reflective of the first Gulf War and the occupation of Kuwait by Iraqi forces.

Total reconstructed catch for Kuwait fisheries was estimated to be 1,997,000 t which is 6.4 times the amount reported by the FAO (312,250 t) on behalf of Kuwait (Figure 2a). Kuwait's fisheries were estimated to be 42.8% industrial, 56.8% artisanal, 0.01% subsistence and 0.45% recreational. Although it appears that non-commerical sectors are fairly insignificant, these estimates were made with limited information and therefore were made to be conservative. This is an area that requires further study.

The main taxa caught in Kuwait are *Netuma thalassina* (25%), *Chiloscyllium griseum* (11%), natantian decapods (5%) and Rhinobatidae (3%) (Figure 2b; Appendix Table A2). The three non-shrimp categories mostly consist of dicards. If we look only at retained catch the top taxa include natantian decapods (29%), *Pampus* spp. (7%), Serranidae (6%), Sciaenidae (6%), Mugilidae (5%) and *Tenualosa ilisha* (5%).

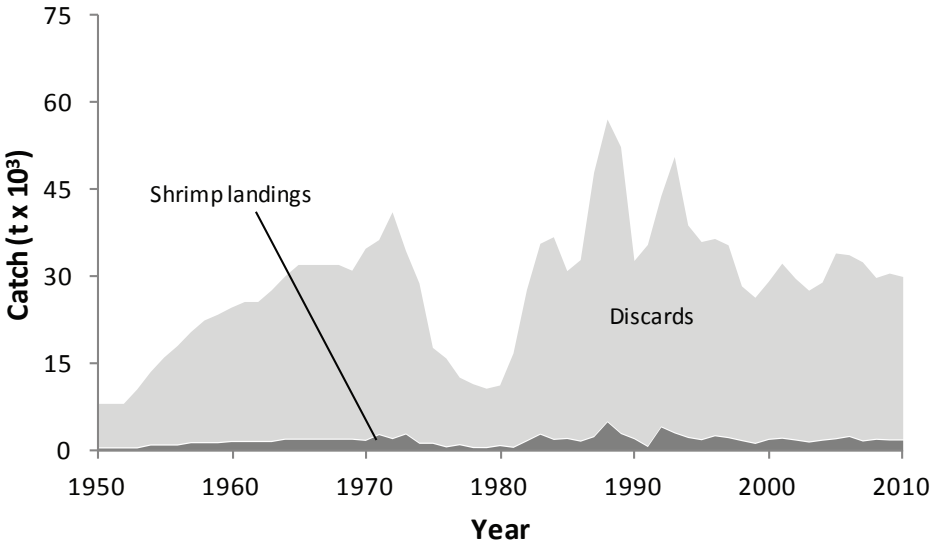

Figure 3. Estimated discards from Kuwait's shrimp fishery in comparison to shrimp landings (includes data from legal and illegal shrimp fishery).

As seen from the values above, the estimated time series also illustrates the magnitude and importance of discards (Figure 3). In terms of tonnage, discards amounted to almost 10 times the amount of reported, landed finfish. The non-reporting of discards is particularly problematic. In some countries, such as Kuwait, good estimates of discards are available. Yet in most other cases, particularly in developing countries, there is a general lack of quantitative information on discards or discard rates (Kelleher *et al.* 2005). This is partly because several different fishing gears may be used, different species may be targeted on a single fishing trip or vessel, and because fisheries change over time (Kelleher *et al.* 2005). Therefore, attributing a single discard rate to a particular fishery may lead to large errors. Globally, discards are reported to be to 8% of reported landings (Kelleher *et al.* 2005).

The catch reconstruction supports concerns over the status of fisheries in Kuwait. Sharp declines in all sectors, coupled with other indicators of overexploitation such as the reduced mean size of landed fish (Dadzie *et al.* 2005; Al-Sabbagh and Dashti 2009) and a decline of catch per effort suggest that the fisheries are suffering from overcapacity. Additionally, population pressure also occurs, as a 'youth bulge,' a common demographic characteristic in the Middle East, is certain to cause further strain on resources. Combined, unregulated fishing practices and population pressure suggest that 'Malthusian overfishing' occurs in Kuwait, a situation where declining yield coupled with socio-economic conditions drive fishers to over-exploit and destroy their resource base (Pauly 2006).

The overall reported catches for Kuwait's artisanal and industrial fisheries potentially underestimate total catches by a factor of 6.4 over the 1950-2010 time period. Such substantial differences between reported landings and reconstructed total catches illustrate the magnitude of the data reporting problems faced by Kuwait, and, by inference, other countries (e.g., Zeller *et al.* 2007; Zeller *et al.* 2011a; Zeller *et al.* 2011b). It also points at a fundamental problem of fisheries catch data being viewed purely from a commercial, market perspective, which accounts only for what is landed and utilized for commercial sale or export (Pauly and Zeller 2003; Zeller and Pauly 2004). In contrast, given the global move towards viewing and managing fisheries on an ecosystem scale (Pikitch *et al.* 2004), fisheries data collection, and hence catch accounting, needs to account for total catches, notably to be able to maintain important ecosystem processes (Pauly 1985a, b; Pauly and Matthew 1986; Pauly and Palomares 1987). This requires comprehensive accounting for all extractions of fish and invertebrates during fishing operations, including the recording (or estimation) and reporting of discarded catch, and the estimation and reporting of catches from unregulated sectors such as the recreational fishery and the traditional stake net fishery. Given the high costs of monitoring such sectors using traditional catch monitoring approaches, alternative methods such as utilizing national surveys and census opportunities have been suggested (Zeller *et al.* 2007) for the more widely dispersed and hard to monitor small-scale and recreational fisheries sectors.

Acknowledgements

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Appendix Table A1. FAO landings vs. total reconstructed catch (t) for Kuwait, 1950-2010, as well as catch by sector.

Year	FAO landings	Total reconstructed catch	Industrial	Artisanal	Subsistence	Recreational	Discards
1950	1,000	8,700	-	1,180	-	19	7,500
1951	1,000	8,700	-	1,180	-	21	7,500
1952	1,000	8,700	-	1,180	-	22	7,500
1953	1,000	11,300	-	1,230	-	23	10,000
1954	2,000	14,800	-	2,310	-	24	12,500
1955	2,000	17,400	-	2,360	-	25	15,000
1956	2,000	19,400	-	2,400	-	26	17,000
1957	3,000	22,500	-	3,470	-	26	19,000
1958	3,000	24,600	-	3,510	-	29	21,000
1959	3,000	25,600	-	3,530	-	32	22,000
1960	3,500	27,100	190	3,880	1	33	23,000
1961	3,500	28,100	380	3,700	1	37	24,000
1962	3,500	28,200	570	3,510	1	42	24,000
1963	3,500	30,200	780	3,340	1	48	26,000
1964	4,000	32,800	1,180	3,490	2	54	28,000
1965	4,000	34,800	1,440	3,280	2	60	30,000
1966	4,000	34,800	1,440	3,280	2	67	30,000
1967	4,500	35,300	1,440	3,800	2	73	30,000
1968	4,500	35,300	1,440	3,800	3	80	30,000
1969	4,500	34,300	1,430	3,790	3	87	29,000
1970	4,700	38,600	1,360	4,160	3	94	33,000
1971	5,700	40,200	1,920	4,610	3	101	33,500
1972	5,000	45,100	1,590	4,350	3	109	39,000
1973	6,101	38,600	1,950	4,960	4	116	31,500
1974	5,502	33,900	1,020	5,250	4	124	27,500
1975	5,934	23,000	900	5,600	4	132	16,400
1976	4,648	20,500	540	4,610	4	139	15,200
1977	5,913	18,000	710	5,680	5	147	11,500
1978	6,489	18,000	430	6,580	5	155	10,800
1979	3,065	13,600	420	2,980	5	163	10,100
1980	3,689	14,500	610	3,430	5	172	10,300
1981	3,714	20,500	510	3,690	6	180	16,100
1982	6,628	33,600	1,240	6,170	6	189	26,000
1983	8,722	42,700	1,950	7,740	6	198	32,800
1984	9,639	45,800	1,470	9,260	6	207	34,900
1985	10,116	40,200	1,490	9,610	7	217	28,800
1986	7,630	40,000	1,270	7,300	7	229	31,200
1987	7,699	54,700	1,860	7,040	8	242	45,600
1988	10,788	64,600	3,340	8,810	8	253	52,200
1989	7,643	58,600	2,200	6,690	8	260	49,400
1990	4,454	36,000	1,490	3,910	-	-	30,600
1991	2,034	37,600	800	2,080	-	-	34,800
1992	7,871	49,200	2,710	6,680	-	-	39,800
1993	8,466	57,800	2,230	7,770	7	228	47,600
1994	7,752	45,800	1,680	7,310	7	216	36,600
1995	8,616	44,100	1,430	8,390	6	203	34,100
1996	8,255	43,600	1,810	7,670	6	203	33,900
1997	7,827	42,400	1,620	7,380	7	210	33,200
1998	7,798	35,600	1,260	7,540	7	220	26,600
1999	7,398	33,600	980	7,350	7	232	25,100
2000	6,977	35,400	1,390	6,580	8	242	27,200
2001	5,846	37,200	1,530	5,320	8	251	30,100
2002	5,360	34,300	1,340	4,940	8	258	27,800
2003	4,059	31,200	1,120	3,740	8	265	26,100
2004	4,833	33,100	1,310	4,400	9	273	27,200
2005	4,895	38,100	1,500	4,380	9	283	31,900
2006	5,635	38,200	1,710	4,960	9	293	31,200
2007	4,373	36,400	1,280	4,020	10	305	30,800
2008	3,979	32,900	1,410	3,430	10	318	27,800
2009	4,000	33,900	1,350	3,520	10	330	28,700
2010	4,000	33,300	1,340	3,510	11	342	28,100

Appendix Table A2. Total reconstructed catch (t) for Kuwait by major taxa, 1950-2010.

Year	*Netuma thalassina*	*Chiloscyllium griseum*	Natantian decapods	Rhinobatidae	Others[a]
1950	2,270	1,050	500	230	4,700
1951	2,270	1,050	500	230	4,700
1952	2,270	1,050	500	230	4,700
1953	3,030	1,400	500	310	6,000
1954	3,790	1,740	1,000	390	7,900
1955	4,550	2,090	1,000	470	9,300
1956	5,150	2,370	1,000	530	10,400
1957	5,760	2,650	1,400	590	12,100
1958	6,370	2,930	1,400	650	13,200
1959	6,670	3,070	1,400	690	13,800
1960	6,970	3,210	1,600	720	14,600
1961	7,280	3,350	1,600	750	15,200
1962	7,280	3,350	1,600	750	15,200
1963	7,880	3,630	1,600	810	16,300
1964	8,490	3,910	2,000	870	17,500
1965	9,090	4,190	2,000	930	18,600
1966	9,090	4,190	2,000	930	18,600
1967	9,090	4,190	2,000	930	19,100
1968	9,090	4,190	2,000	930	19,100
1969	8,790	4,050	2,000	900	18,600
1970	10,000	4,600	1,800	1,030	21,200
1971	10,160	4,670	2,800	1,040	21,500
1972	11,820	5,440	2,100	1,210	24,500
1973	9,550	4,400	2,900	980	20,700
1974	8,340	3,840	1,300	860	19,600
1975	4,970	2,290	1,300	510	14,000
1976	4,600	2,120	680	470	12,600
1977	3,480	1,600	1,060	360	11,500
1978	3,290	1,510	560	340	12,300
1979	3,050	1,400	550	310	8,300
1980	3,110	1,430	900	320	8,700
1981	4,890	2,250	600	500	12,300
1982	7,870	3,620	1,720	810	19,600
1983	9,940	4,570	2,870	1,020	24,300
1984	10,560	4,860	1,970	1,090	27,300
1985	8,730	4,020	2,130	900	24,400
1986	9,450	4,350	1,660	970	23,600
1987	13,800	6,350	2,440	1,420	30,700
1988	15,810	7,270	5,000	1,620	34,900
1989	14,970	6,890	2,990	1,540	32,200
1990	9,280	4,270	2,080	950	19,400
1991	10,520	4,840	740	1,080	20,400
1992	12,060	5,550	4,120	1,240	26,200
1993	14,420	6,640	3,090	1,480	32,200
1994	11,080	5,100	2,300	1,140	26,200
1995	10,320	4,750	1,910	1,060	26,100
1996	10,280	4,730	2,590	1,060	25,000
1997	10,040	4,620	2,270	1,030	24,400
1998	8,050	3,700	1,760	830	21,300
1999	7,590	3,500	1,280	780	20,500
2000	8,230	3,790	1,970	850	20,500
2001	9,110	4,190	2,170	940	20,800
2002	8,410	3,870	1,860	860	19,300
2003	7,900	3,630	1,510	810	17,300
2004	8,230	3,790	1,830	850	18,500
2005	9,670	4,450	2,080	990	20,900
2006	9,460	4,360	2,470	970	20,900
2007	9,330	4,290	1,690	960	20,100
2008	8,420	3,870	1,990	860	17,800
2009	8,680	4,000	1,870	890	18,400
2010	8,510	3,910	1,870	870	18,100

[a] Others category includes 22 additional taxonomic groups.

Total fishery extractions for Qatar: 1950-2010[1]

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Abstract

Qatar is an Arab state that occupies a small peninsula on the northeasterly coast of the much larger Arabian Peninsula. It shares its southern border with Saudi Arabia and is surrounded by the Persian Gulf on the other sides. Qatar's fish catches have increased sharply over the past decade due to increased fishing effort, in response to the increasing demand emanating from a rapidly growing population. Following the reconstruction approach, all available peer-reviewed and grey literature was searched for qualitative and/or quantitative data on catches that are missing from the statistics reported to FAO. Overall, data reported to the FAO from 1950-2010 underestimate catches by 38%. In the period between 1970 and 1993, discards from Qatar's bottom trawl fishery were equivalent to 30% of the reported catch. This study illustrates the urgent need to establish management infrastructure for fisheries monitoring and regulation enforcement, especially given Qatar's rate of population increase.

Introduction

Qatar is a small Arab country located on a peninsula on the western shores of the Persian Gulf, and borders Saudi Arabia in the South. The island country of Bahrain lies to the northwest of Qatar (Figure 1), whose maritime boundaries with Bahrain have only been settled as of 2001. Qatar's small size and proximity to other Arab states means that it shares marine resources with Saudi Arabia, Bahrain, and the United Arab Emirates, which further emphasizes the need for regional fisheries management cooperation.

Qatar has been ruled as an absolute monarchy of the Al-Thani family since 1825, but also was a British protectorate until it gained independence in 1971. Up until the 1940s, it was one of the poorest Gulf States, with an economy based solely on pearl diving. However, rapid industrialization following the development of the oil and gas industries has vastly increased the country's economy, and today it has the second highest GDP per capita in the world.

Qatar's waters are characterized by extreme meteorological and hydrological conditions, with water temperatures reaching over 33°C during the summer, leading to high evaporation and salinity levels. Its fisheries are almost entirely confined to the eastern side of the peninsula, which has a maximum depth of 50 m (Al-Ansi and Priede 1996). Over 150 fish species belonging to 50 families have been recorded in Qatari waters, and of these, the majority belong to the families Lethrinidae (17.2%), Serranidae (16%), Carangidae (12.6%), 'Pomadasydae'[2] (9.1%) and Scombridae (8%) (El Sayed 1992; Al-Ansi *et al.* 2002). During 1995-1996, a 'red tide' occurred which was probably the reason why 30-40 tonnes of dead fish subsequently washed up on shore (Al-Ansi *et al.* 2002).

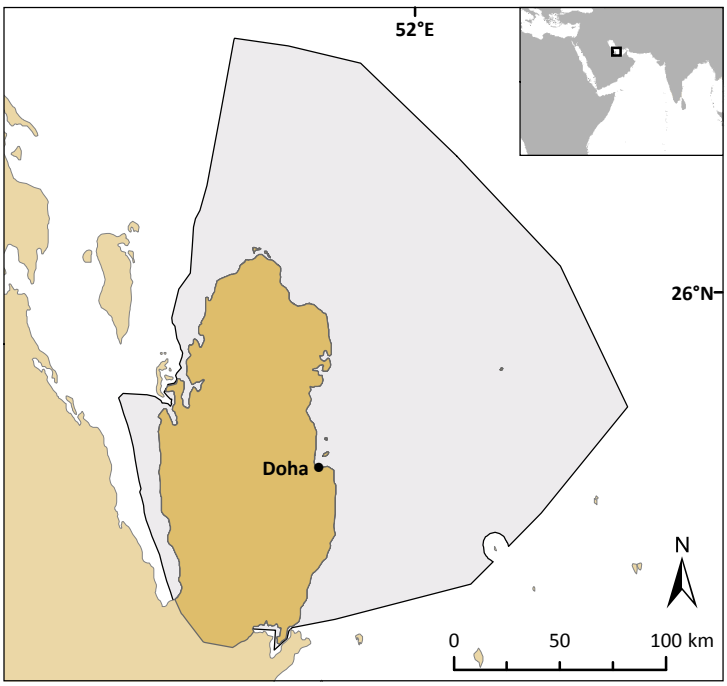

Figure 1. Map of Qatar, showing the extent of its EEZ (in grey).

Qatari fisheries are artisanal in nature and are composed of 2 distinct vessel types: traditional *dhows* and small outboard-powered fibreglass vessels both with an operational range of 60-100 km (Al-Ansi and Priede 1996). Both vessel types target pelagic and demersal species, with fish traps (*gargoor*) being the most common fishing gear, followed by

[1] Cite as: Al-Abdulrazzak D (2013) Total fishery extractions for Qatar: 1950-2010. pp. 31-37. *In*: Al-Abdulrazzak D and Pauly D (eds.) From dhows to trawlers: a recent history of fisheries in the Gulf countries, 1950 to 2010. Fisheries Centre Research Reports 21(2). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

[2] Now part of the family Haemulidae (see www.fishbase.org)

gillnets, hand and troll lines. Seasonal trolling and hand-lining for Spanish mackerel (*Scomberomorus* spp.) also takes place. The commercial shrimp fishery was closed in 1993 and periodic re-assessments of the country's shrimp stocks have not warranted its re-opening. Since the closure of the Qatari National Fishing Company (QNFC), which operated 3 bottom trawlers, a sharp increase in the number of artisanal boats occurred, in order to compensate for the decreased CPUE (El Sayed 1996).

As in neighbouring countries, the ownership of vessels is restricted to citizens, while actual fishing operations employ expatriate labour from India, Bangladesh, and Iran. Due to increased standards of living as a result of the oil boom, few Qatari's are drawn to fishing. Yet, per capita fish consumption in the country is 16.5 kg·year^{-1}, more than twice the average in the Arab world for 1995.

Fisheries management in Qatar is rudimentary at best, although in theory, vessel fishing licenses are required. No fisheries management plans exist and as a result, policy directions for fisheries management are unclear and subject to frequent change. Basic stock assessment data, rates of effort, and fishery market potentials are also lacking (El Sayed 1992). In 1998, the Fisheries Department of the Ministry of Municipal Affairs and Agriculture ceased issuing new fishing licenses, capping the fleet at 515 vessels (Morgan 2004). No restrictions were places on gear or vessel size, and as a result, new higher-capacity vessels were introduced to replace the smaller vessels in the fleet, hence the increased fishing effort in recent years. Because robust stock assessments are lacking, it is uncertain to what extent the increased fishing effort can be sustained.

Illegal fishing is a major problem for Qatar, given the small scale and economic importance of the industry. Illegal fishing (such as by driftnets) is common because enforcement agencies are unable to ensure compliance with regulations (Morgan 2004; Richer 2009). In addition, a growing and uncontrolled recreational fishing sector, estimated to deploy over 1,000 crafts, catches significant quantities of fish (Morgan 2004).

Methods

This contribution follows the conceptual framework of the catch reconstruction method as outlined by previous studies (Zeller *et al.* 2006; Zeller *et al.* 2007; Jacquet *et al.* 2010; Le Manach *et al.* 2012).

A preliminary step in this reconstruction was to attempt to improve the taxonomic resolution of the reported data. Prior to 1982, the data presented by the FAO on behalf of Qatar consist solely of "marine fishes nei" and "green tiger prawn". In 1982, 20 new taxa entered the data and the proportion (and tonnage) of "marine fishes nei" greatly decreased. Therefore, it was assumed that species which appeared in 1982 were being caught previously, and thus could be used to disaggregate the miscellaneous category. For the period 1950-1981, the species proportions from the 1982 data (excluding the green tiger prawn) were applied to the "marine fishes nei" catch to disaggregate it into more informative taxonomic groups. The disaggregated data were then used as the baseline for the reconstruction.

Al-Abdulrazzak and Pauly (2013) estimate that in 2005, 17 *hadrah* (tidal weirs) contribute to an annual catch of 286 ± 100 t annually, despite their being banned since 1994 (M.S. Al-Muhindi, Ministry of Fisheries, pers. comm.). It was assumed that *hadrah* were more abundant prior to the ban in 1994, and therefore that 286 t were caught annually from 1994-2010, and twice that amount (572 t) prior to the ban. The species composition of *hadrah* in Al-Abdulrazzak and Pauly (2013) was also used here.

To estimate recreational catch, the same method as was used in the Kuwait reconstruction, was applied, where a 0.12% participation rate was applied to total population from 1960-2010 to obtain a time series of recreational fishers, and a conservative estimate of 1 kg of fish per trip, along with 104 fishing days per year (See Kuwait, Al-Abdulrazzak, this volume). Similarly, Kuwait's reconstructed recreational catch species composition ratios were applied.

Although Qatar's bottom trawl fishery is considered "semi-industrial" by FAO (Morgan 2004), for the purposes of this report it was considered to be industrial. Ibrahim (1989) estimates that 496-635 t were discarded by Qatar's bottom trawl fishery for 1986-1987. The study also presents the percent contribution of the bottom trawl fishery to the total finfish landings (excluding sharks) and the average percent contribution (32%) was used to determine the amount of finfish reported landings from 1970 (start of the fishery) to 1993 (when it was closed) that came from the bottom trawl fishery. A discard rate of 50% (Ibrahim *et al.* 1989) was applied to the bottom trawl fishery (i.e., 50% of the total catch was discarded). The same study also provided a discard rate of 4% (of the total catch) for the rest of the artisanal fishery, and this rate was applied to all other artisanal finfish catches (reported, unreported, and discarded). Discarded species composition originates from the same Ibrahim *et al.* (1989) study.

Qatar reports requiem shark landings for 1982 and 1983 (1 and 5 t respectively), but not for other years. However, studies exist which show that sharks are frequently caught in both targeted and bycatch fisheries (Al-Ansi and Priede 1996; Moore 2012), and a graph in Sivasubramaniam and Ibrahim (1983) documents monthly shark landings in 1982 at Al Khor, eastern Qatar. Annual shark landing data of 133 t were extracted from Sivasubramaniam and Ibrahim (1983), and a per capita rate for 1983 estimated (0.00048 t). Neighbouring UAE and Saudi Arabia report steadily increasing shark landings to FAO, but both are also known to be shark fin re-exporting countries and

therefore it is difficult to interpret these trends (Moore 2012). As a conservative estimate, it was assumed the per capita shark rate was constant from 1950-1994, but then declined to 90% from 1995-1999, 80% from 2000-2005, 70% from 2006-2007, and 60% from 2008-2010. A 3-year moving average was used for smoothing.

Driftnets were banned in 1989, but continue to be used routinely with 2-3 violations occurring per day (Richer 2009). A rough estimation of illegal driftnet catch is presented here which was inspired by the work of Sumaila *et al.* (2006). First, because of the large numbers of violations occurring, it is assumed that 10% of 515 registered vessels take part in illegal driftnetting. Next, the ratio of registered vessels to total reported catch is estimated, to obtain the annual total catch per vessel from 1989-2010. For illegal fishing to be worthwhile, the expected penalty must be at least equal to the expected gain; it is here conservatively assumed that vessels deploying driftnets are catching 20% more than they would legally (i.e., deploying *gargoor* traps from their boats instead of illegal driftnets). Finally, the annual total catch per vessel fishing illegally was multiplied by the estimated number of participating vessels (56) to estimate illegal driftnet catches for from 1989-2010.

Like other countries in the Gulf, commercial fishing is undertaken by foreign labourers who have a high incentive to subsistence fish. In order to estimate this sector, it was assumed that fishers (0.0066% of the population) take home an average of 5 kg per week, and extrapolate from the start of the oil boom in 1960 to 2010. Because these catches are composed of less desirable species subsistence catches were assigned based on the family level of discarded species.

Results and discussion

For the period of FAO reporting, 1950-2010, reported catches for Qatar are annually, on average, under-reported by 62% (Figure 2a; Appendix Table A1). Total catches reported to the FAO over the same period were 258,253 t, while the methods used here estimate an additional 98,900 t were extracted but unreported.

Catch data as reported by the FAO on behalf of Qatar show a steady increase of catches, more than doubling in the last few decades (Al Jedah *et al.* 1999; Feidi 2005), with a sharp increase from 2001 until 2010. This is unsurprising given that Qatar's population grew from 770,000 in 2001 to 1.4 million in 2009 (Sale *et al.* 2011), generating an increase in demand and a corresponding increase in effort, with new, higher-capacity vessels replacing the older smaller vessels in the fleet (Morgan 2004).

The five main taxa caught by Qatar are Lethrinidae (18%), Serranidae (9%), *Scomberomorus commerson* (8%), Carangidae (6%), and Siganidae (5%) (Figure 2b; Appendix Table A2).

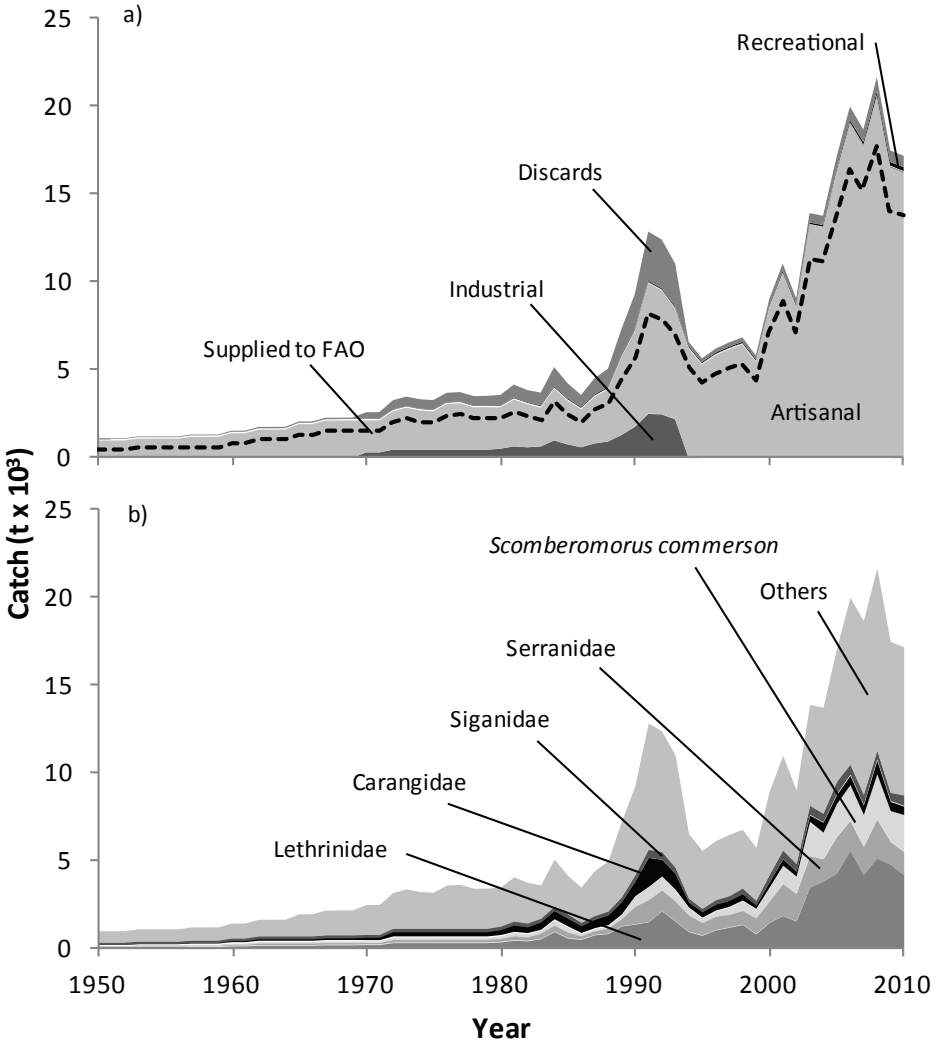

Figure 2. Total reconstructed catch for Qatar by a) sector (with comparison to FAO data), and b) major taxa, 1950-2010. Note that the subsistence sector is not visible on the sector graph (a) and recreational catches are only slightly visible at the end of the time period (black fill).

In particular, the reconstruction highlights the extent of illegal fishing in Qatar. The small scale and minor economic value of Qatar's fisheries means that directing resources at fisheries enforcement is not economically justifiable (Morgan 2004). Although Qatar has banned the use of *hadrah* since 1994, the contribution of Al-Abdulrazzak and Pauly's (2013) suggests that from 286 to 572 t (or 429 t on average) of fish are caught annually by

hadrah since 1994. In addition, it was estimated that on average, 1,082 t were caught annually by illegal driftnetting from 1989 to 2010. These estimates of illegal catches presented here are very tentative, and are likely to be replaced by higher figures when the assumptions used here are replaced by field estimates.

The reconstruction also highlights the magnitude of discarding in the region. For the years when the QNFC was operational (1970-1993), discards from the bottom-trawl fishery constituted 30% of reported catch; of this, 38% consisted of fish of length above 15 cm, i.e., suitable for human consumption (Ibrahim *et al.* 1989). An additional 18% was greater than 20 cm and of commercial value in Qatar (Ibrahim *et al.* 1989). If retained, these fish could have increased QNFC's annual income by more than 15-30% (Ibrahim *et al.* 1989).

Given the country's rapidly growing population, the corresponding increase in recreational fishing is unsurprising. However, Morgan (2004) predicts that the catch of the recreational sector (which is unmonitored) could one day exceed that of the commercial sector. Thus, management issues for this growing sector must be addressed. Unlike neighbouring countries, Qatar currently meets most of the fish demands of its 1.8 million residents, only importing 1,679 t in 2001 (Morgan 2004). However, Qatar's reliance on imports is likely to increase in light of its growing population.

In order to accommodate expanding industries and rapid population growth, major coastal development projects are underway resulting in land reclamation and dredging, with little to no studies on their short- and long-term ecological impacts on marine life (Sheppard *et al.* 2010). These development projects are certain to impact fisheries yet are not addressed, since no formal management plan exists for any fishery. In addition, although fishery input controls are used (gear restrictions, limiting number of vessels, etc.), they are ineffective because compliance is limited. Given these rapid developments, the lack of stock assessments and fishery management plans is cause to worry about the future prospects of Qatar's fish stocks.

The reconstruction approach undertaken here accounts for missing sectors, including discards, shark catches, illegal and recreational catches. Thus, the reconstructed time series may better reflect the catches extracted from Qatar's marine ecosystems from 1950-2010 than the official statistics. Although the reconstructed time series are entirely dependent on the assumptions made by this study, they are preferable to the alternative of assuming 'zero' catch for sectors with missing data components. Thus, despite considerable data uncertainties and lack of precision, conservative catch reconstruction approaches are far less misleading (particularly in with respect for fisheries policy formulation) than assuming no data means 'zero' catch.

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I thank U.R. Sumaila for stimulating conversations that inspired the methods for reconstructing illegal driftnet catches. I also thank M.S. Al-Muhindi from the Qatar Ministry of Fisheries for informing us of the *hadrah* ban. This is a contribution of the *Sea Around Us* Project, a scientific collaboration between the University of British Columbia and The Pew Charitable Trusts.

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Appendix Table A1. FAO landings vs. total reconstructed catch (t) for Qatar, 1950-2010, as well as catch by sector.

Year	FAO landings	Total reconstructed catch	Industrial	Artisanal	Subsistence	Recreational	Discards
1950	400	1,030	0	990	0	0	40
1951	400	1,030	0	990	0	0	40
1952	400	1,030	0	990	0	0	40
1953	500	1,130	0	1,090	0	0	44
1954	500	1,130	0	1,090	0	0	44
1955	500	1,130	0	1,090	0	0	44
1956	500	1,140	0	1,090	0	0	44
1957	600	1,240	0	1,190	0	0	48
1958	600	1,240	0	1,190	0	0	48
1959	600	1,240	0	1,190	0	0	48
1960	800	1,460	0	1,400	1	6	56
1961	800	1,460	0	1,400	1	6	56
1962	1,000	1,670	0	1,600	1	7	65
1963	1,000	1,680	0	1,600	1	8	65
1964	1,000	1,680	0	1,610	1	8	65
1965	1,300	1,990	0	1,910	1	9	65
1966	1,300	1,990	0	1,910	1	10	65
1967	1,500	2,200	0	2,120	1	11	69
1968	1,500	2,200	0	2,120	2	12	69
1969	1,500	2,210	0	2,120	2	12	69
1970	1,500	2,510	310	1,820	2	14	364
1971	1,500	2,520	310	1,820	2	15	364
1972	2,000	3,190	470	2,170	2	16	534
1973	2,200	3,400	470	2,380	2	18	534
1974	2,047	3,250	470	2,230	3	19	534
1975	1,989	3,200	470	2,180	3	20	534
1976	2,400	3,620	470	2,590	3	21	534
1977	2,433	3,660	470	2,630	3	23	534
1978	2,200	3,430	470	2,400	3	24	534
1979	2,200	3,440	470	2,410	3	25	534
1980	2,178	3,500	520	2,350	4	28	594
1981	2,604	4,080	660	2,650	4	31	739
1982	2,331	3,770	610	2,450	5	34	683
1983	2,114	3,630	650	2,200	5	38	733
1984	3,174	5,080	1,000	2,930	6	42	1,110
1985	2,485	4,160	770	2,480	6	46	862
1986	1,981	3,500	610	2,150	7	49	685
1987	2,679	4,440	820	2,640	7	52	919
1988	3,088	4,990	930	2,950	8	55	1,041
1989	4,376	7,230	1,300	4,400	8	57	1,462
1990	5,704	9,240	1,770	5,420	8	59	1,981
1991	8,137	12,800	2,520	7,400	8	60	2,807
1992	7,847	12,340	2,490	7,010	8	61	2,769
1993	6,996	10,980	2,210	6,240	8	61	2,458
1994	5,088	6,530	0	6,210	9	62	247
1995	4,273	5,580	0	5,300	9	63	209
1996	4,741	6,130	0	5,830	9	64	231
1997	5,033	6,480	0	6,160	9	66	244
1998	5,281	6,770	0	6,440	9	68	255
1999	4,399	5,750	0	5,450	10	71	215
2000	7,142	8,950	0	8,520	10	74	344
2001	8,866	10,970	0	10,460	10	76	424
2002	7,157	8,990	0	8,560	11	78	344
2003	11,295	13,850	0	13,220	11	82	537
2004	11,134	13,690	0	13,060	12	89	528
2005	13,935	17,020	0	16,240	14	102	658
2006	16,376	19,920	0	19,010	17	122	772
2007	15,190	18,600	0	17,720	20	147	715
2008	17,688	21,580	0	20,560	24	174	830
2009	14,064	17,410	0	16,530	27	199	662
2010	13,760	17,110	0	16,210	30	219	650

Appendix Table A2. Total reconstructed catch (t) for Qatar by major taxa, 1950-2010.

Year	Lethrinidae	Serranidae	*Scomberomorus commerson*	Carangidae	Siganidae	Others[a]
1950	78	47	37	57	151	650
1951	78	47	37	57	151	660
1952	78	47	37	57	151	660
1953	97	59	46	70	157	700
1954	97	59	46	70	157	700
1955	97	59	46	70	157	710
1956	97	59	46	70	157	710
1957	116	71	55	84	164	750
1958	116	71	55	84	164	750
1959	116	71	55	84	164	750
1960	153	95	73	110	176	850
1961	153	95	73	110	176	860
1962	191	119	91	137	189	950
1963	191	119	91	137	189	950
1964	191	119	91	137	189	950
1965	191	119	91	137	189	1,260
1966	191	119	91	137	189	1,260
1967	210	131	100	150	195	1,410
1968	210	131	100	150	195	1,420
1969	210	131	100	150	195	1,420
1970	225	119	91	192	189	1,690
1971	225	119	91	192	189	1,700
1972	336	178	137	286	220	2,030
1973	336	178	137	286	220	2,240
1974	336	178	137	286	220	2,100
1975	336	178	137	286	220	2,040
1976	336	178	137	286	220	2,460
1977	336	178	137	286	220	2,500
1978	336	178	137	286	220	2,270
1979	336	178	137	286	220	2,280
1980	376	199	153	320	231	2,220
1981	471	250	192	400	258	2,510
1982	434	230	177	369	248	2,320
1983	555	318	158	452	248	1,890
1984	957	373	304	493	282	2,670
1985	590	345	289	467	273	2,200
1986	519	204	124	427	224	2,000
1987	777	236	114	498	254	2,560
1988	846	308	143	577	262	2,850
1989	1,271	426	213	716	311	4,290
1990	1,381	1,015	562	838	383	5,060
1991	1,515	1,257	716	1,667	480	7,160
1992	2,125	1,200	766	960	451	6,840
1993	1,550	1,145	636	911	365	6,370
1994	951	950	406	298	257	3,670
1995	747	728	255	332	224	3,290
1996	1,058	768	307	353	288	3,360
1997	1,201	736	411	355	300	3,480
1998	1,356	804	552	375	348	3,340
1999	823	913	496	206	303	3,000
2000	1,482	1,215	768	293	450	4,740
2001	1,869	1,820	1,019	367	514	5,380
2002	1,552	1,567	963	279	463	4,170
2003	3,483	1,804	1,945	356	532	5,730
2004	3,809	1,293	1,511	562	495	6,030
2005	4,276	2,094	1,882	506	721	7,540
2006	5,555	1,743	2,037	526	590	9,470
2007	4,202	1,613	1,811	534	579	9,870
2008	5,134	2,259	2,563	775	508	10,350
2009	4,778	1,318	1,750	522	485	8,560
2010	4,182	1,335	2,107	479	605	8,400

[a] Others category includes 39 additional taxonomic groups.

Catch reconstruction of the fisheries of Saudi Arabia in the Gulf, 1950-2010[1]

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Abstract

The catch of Saudi Arabia in the Gulf is reconstructed from 1950–2010 by examining local records, Food and Agriculture Organization of the United Nations (FAO) data and general knowledge of the fisheries. The fishery was divided into sectors, the major ones being artisanal and industrial. In addition, subsistence, recreational and discards of the industrial trawl fishery, which are excluded from official report, were explicitly included. A previous catch reconstruction of Saudi Arabia's Red Sea fishery was used as a reference to calculate the catches of the sectors in the Gulf. The catches in each sector were further disaggregated to their taxonomic composition. The results showed that from 1950 – 2010, the total reconstructed catch (Red Sea and the Gulf) was 2.1 times what Saudi Arabia reports to FAO (2.4 times for the Gulf only). The artisanal fishery is by far the most important in the Gulf, contributing 51% of total catch and 77% when only the retained catch is considered. The industrial fishery is second in its contribution to total catch, followed by the subsistence and recreational fisheries. Most of the taxa caught are demersal fishes, reflecting the nature of the ecosystem, which is generally shallow, covered by sea grass beds, and sandy and muddy bottoms.

Introduction

The 'Gulf' (to avoid having to choose between Arabian and Persian Gulf) is a semi-enclosed and generally shallow sea with an average depth of 35 m and a maximum of 100 m in its southeastern part, near the Strait of Hormuz. It has high salinity due to high evaporation, low rainfall and limited water exchange with the adjacent Arabian Sea. Water temperature can reach up to 40°C in the summer and 20°C in winter. The shallow inshore areas are generally covered by sea grass beds, which act as nursery ground for many fish species. There is no well-developed coral reef system in the Gulf as compared to the Red Sea, but it still has a multitude of reef fishes (see Randall *et al.* 1978; Carpenter *et al.* 1997; and see www.fishbase.org). Most of the deeper sea floor is covered with coarse gravel, fine clay or mud, which makes it suitable for trawling, with shrimp being the most sought-after resource (Sheppard *et al.* 1992; Sakurai 1998). Unlike the Red Sea, where shrimp are targeted only by the industrial sector, they are targeted in the Gulf by both the artisanal and industrial sectors.

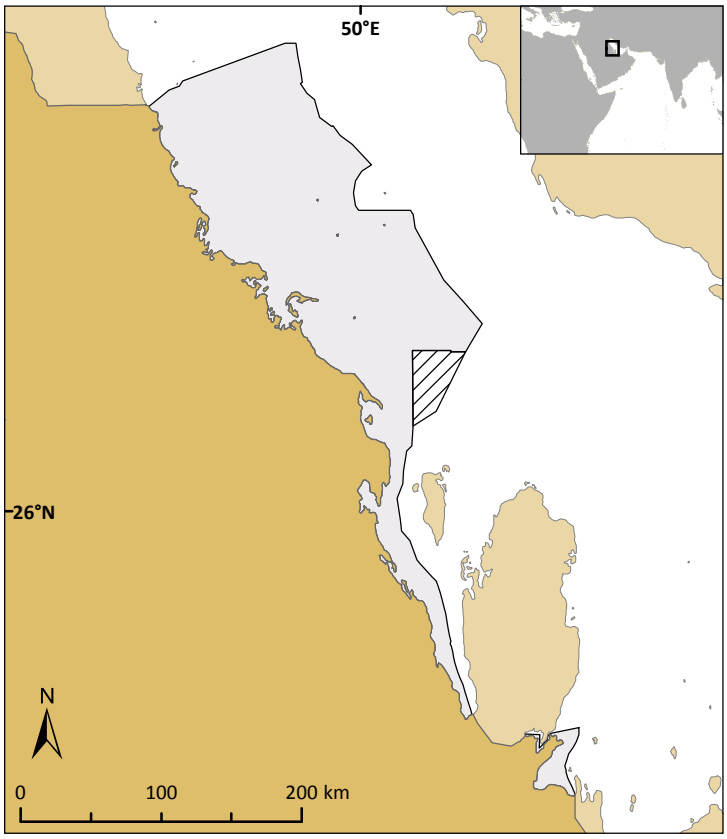

Figure 1. Map of Saudi Arabia, showing the extent of its EEZ (light grey area).

Saudi Arabia has a longer coastline in the Red Sea than in the Gulf (Figure 1). Nevertheless, as will be shown below, its fish catch has been higher in the Gulf than in the Red Sea in the last decades. Most of the Saudi fisheries in the Gulf are artisanal, at times accounting for more than 95% of the total catch. These artisanal fisheries were non-motorized until 1960. Although motorization started in early 1960s, it accelerated later, and was essentially completed in the late 1980s (Sakurai 1998). The major gears

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used by the Saudi artisanal sector in the Gulf are traps, which can generate for up to 50% of the catch. The main targets include emperors (family Lethrinidae), groupers (Serranidae), scads (Carangidae), snappers (Lutjanidae), seabreams (Sparidae) and rabbitfish (Siganidae). Other gears include gill net for pelagic species such as kingfish (*Scomberomorus* spp.) and tunas (Scombridae), and to a lesser extent handlines, longlines, trawling and trolling, with each accounting less than 5% of the total catch (DMF 2000). A single artisanal trip in the Gulf takes 5-6 days on the average, in contrast to the Red Sea, where it is usually a single day (Sakurai 1998).

Industrial fishing started along the Saudi coast of the Gulf in the early 1960s. Al-Gosaiby Fishing Company was the first industrial fishing venture that was given permit to fish and export its catch. In the 1960s and 1970s, foreign vessels from the ex-USSR and Australia were also operating in the Gulf under license from Saudi Arabia. The shrimp catch peaked in the later part of the 1970s, then declined drastically. In the mid-1990s, the Saudi government initiated a policy to reduce fishing effort and the number of industrial fishery vessels decreased, as did their contribution to the total catch (Sakurai 1998; Anon. 2011).

Recreational fishing (i.e., fishing for pleasure) has become common in Saudi Arabia since the oil-fuelled economic boom. It is usually done on the weekends (Thursday and Friday) using handlines. The fishery is not regulated except that nets of any kind may not be used. The catch can exceed 1,000 t per year, but it is not reported, although it is large enough to warrant complaints, mainly from artisanal fishers who disapprove of the lack of regulations for what they perceive as competition (Sakurai 1998).

Materials and methods

This reconstruction of the fishery catches of Saudi Arabia in the Gulf was based on local reports, the detailed catch reconstruction of Saudi Arabia's Red Sea fisheries, and on data reported to the Food and Agriculture Organization (FAO) of the United Nations (here referred to as 'FAO data'). The following steps were then carried out to perform the catch reconstruction:

1. Splitting the FAO data into Red Sea and Gulf catches;
2. Splitting the FAO data into artisanal and industrial catches;
3. Adjusting the artisanal and industrial catches in the Gulf for misreporting;
4. Estimating the taxonomic composition of the reconstructed catch, by sector;
5. Adding the catch of fisheries that were not accounted for in the official reports.

Step 1: *Splitting the FAO data into Red Sea and Gulf catches*

Saudi Arabia, as do other member countries, reports its annual total fishery catches to the FAO. For many countries with more than one coast, the total catch is split between the broad statistical areas which FAO uses to allocate catches geographically. Unfortunately, in the case of Saudi Arabia, both coasts fall in the same statistical area, the 'Western Indian Ocean', and thus we had to do the splitting ourselves. As shown in Table 1, an initial split was done based on Saudi Arabian statistical data reports available to us (for recent years), other literature (for earlier years), interpolations (for the years without any information), and backward extrapolation with adjustments (for the earliest years). Please note that this was only an inital split which gave the division of the total catch by coast. In latter steps the species breakdown information had to be taken into account which caused the proportions to change slightly and therefore this first split is not necessarily representative of the final data. However, this initial split is important for determining the misreporting ratio. The earliest available Red Sea-to-Gulf ratio was for 1979 (Barrania *et al.* 1980), followed by 1987-1998 (Sakurai 1998; DMF 2000) and 2000 (FAO 2003). For 2002, the Regional Commission for Fisheries (RECOFI 2009), which is active in the Gulf, reported the Gulf catch of Saudi Arabia, which in turn was used to calculate the percentage for the Red Sea. In more recent years, Saudi Arabia published annual fishery statistical reports, separate for each coast, which we relied on for 2004-2007 (DMF 2008). The latest year with data disaggregated between the two coasts was 2009, where statistical data were presented separately for the artisanal and industrial sectors in the Red Sea and the artisanal sector in the Gulf (Anon. 2011). The industrial catch in the Gulf was calculated using the ratio for the two sectors in 2007, where the industrial catch was 0.38% of the artisanal catch.

For years where data were not available, they were estimated using different methods. For 1950-1960 and 1975-1978, the earliest available data (for 1979) were used. Using the 1979 Red Sea-Gulf ratio for 1961-1974 resulted in unreasonably high Red Sea catches, thus a different approach was used for this period. The closest period with data that separate the Red Sea and Gulf catches was for 1987-1994. Thus, an average ratio was calculated for the total reconstructed Red Sea catch without the industrial discard to the FAO catch of Red Sea from 1987-1994 (note that discarded catches are not reported to FAO at all). The result, that FAO Red Sea data were on average 92% of the reconstructed catch, was used to calculate the FAO Red Sea catch for 1961-1974. Then, the FAO Gulf catch was obtained by subtracting the Red Sea amount from the total Saudi catch in the FAO database. The same ratio was also

used for the period 1980-1986. Although there were ratios available for 1995-1996, they resulted in the FAO Red Sea catch being slightly higher than the reconstructed catch, which is unrealistic given the pattern for the other years. Thus, the reconstructed catch without industrial discard, was assumed to be equal to the FAO Red Sea catch. For 1999, 2001, 2003, 2008 and 2010, the ratios were interpolated linearly from the neighbouring years (Table 1).

Step 2: *Splitting the FAO data into artisanal and industrial catches*

Once the data Saudi Arabia submitted to FAO were divided into the Red Sea and the Gulf, the next step was to divide the Red Sea FAO data into artisanal and industrial sectors (by total only; adjustments by taxa will be done further along). This was done using the ratio of the sectors in the reconstructed catch for the Red Sea. Here, of course, the industrial discards were not considered, as they were excluded from the official reports (Tesfamichael and Rossing 2012).

Similar to the Red Sea, the Gulf FAO data, calculated in the previous step, were divided into artisanal and industrial sectors. From 1950-1961, all catches were allocated to artisanal because industrial fishing did not start until 1962 (Sakurai 1998). Data that divided the Gulf catch into artisanal and industrial were available for some years: 1987-1998 (DMF 2000), 2000 (FAO 2003), 2004-2007 (DMF 2008) and 2009 (Anon. 2011). For 2009, only artisanal catches in the Gulf were reported, because the industrial fishery was very small in the Gulf in recent years (DMF 2008). Nevertheless, the industrial catch was calculated using the ratio for 2007. Interpolations that assumed linear change were applied for 1999, 2001-2003, 2008 and 2010. For the earlier years of the Gulf catch, 1962-1986, there were no ratios available to split the catch into the two sectors. However, shrimp catches, which are the major target of the industrial sector, were available from 1962-2007 (Sakurai 1998; DMF 2008). Thus the shrimp catch was used to calculate the industrial catch. From 1962-1978, the shrimp catch was assumed to account for 90% of the reported catch, excluding discard. This was the period when a lot of emphasis was given to shrimp trawling and many new fishing grounds explored. The shrimp catch peaked in the late 1970s and declined thereafter due to instability in the region, which resulted in reduced fishing effort (Sakurai 1998). Thus, for the period 1979-1986, the shrimp catch was assumed to account for 50% of the industrial catch. This is a realistic assumption as the shrimp catch declined abruptly in 1979 and in the closest year available, 1987, shrimp accounted for 47%. The catch of the artisanal fishery in the FAO data from 1962-1986 was calculated by deducting the industrial catch from the total catch for the Gulf calculated in step 1 (Table 2).

Table 1. Percentages used in the initial division of the catch Saudi Arabia reported to FAO into the Red Sea and the Gulf.

Year	Red Sea	Gulf	Source/Remarks
1950-60	52.7	47.2	1979 values
1961	39.0	61.0	See footnote [a]
1962	35.2	64.7	See footnote [a]
1963	33.6	66.4	See footnote [a]
1964	35.8	64.2	See footnote [a]
1965	39.4	60.6	See footnote [a]
1966	38.7	61.3	See footnote [a]
1967	38.1	61.9	See footnote [a]
1968	43.7	56.3	See footnote [a]
1969	47.2	52.8	See footnote [a]
1970	47.8	52.2	See footnote [a]
1971	46.5	53.4	See footnote [a]
1972	44.8	55.2	See footnote [a]
1973	41.4	58.6	See footnote [a]
1974	47.5	52.5	See footnote [a]
1975-78	52.7	47.3	1979 values
1979	52.7	47.3	Barrania *et al*. (1980)
1980	48.1	51.9	See footnote [a]
1981	46.0	54.0	See footnote [a]
1982	44.7	55.3	See footnote [a]
1983	40.1	59.9	See footnote [a]
1984	40.6	59.4	See footnote [a]
1985	51.4	48.6	See footnote [a]
1986	52.7	47.3	See footnote [a]
1987	66.0	33.9	Sakurai (1998), DMF (2000)
1988	67.9	32.1	Sakurai (1998), DMF (2000)
1989	68.5	31.5	Sakurai (1998), DMF (2000)
1990	72.3	27.7	Sakurai (1998), DMF (2000)
1991	74.6	25.4	Sakurai (1998), DMF (2000)
1992	68.1	31.9	Sakurai (1998), DMF (2000)
1993	69.2	30.8	Sakurai (1998), DMF (2000)
1994	62.5	37.5	Sakurai (1998), DMF (2000)
1995	53.7	46.2	Sakurai (1998), DMF (2000)
1996	50.8	49.2	Sakurai (1998), DMF (2000)
1997	53.1	46.9	Sakurai (1998), DMF (2000)
1998	48.9	51.1	Sakurai (1998), DMF (2000)
1999	47.4	52.6	Interpolated
2000	45.7	54.3	FAO (2003)
2001	43.6	56.4	Interpolated
2002	41.9	58.1	RECOFI (2009)
2003	39.4	60.6	Interpolated
2004	36.8	63.1	DMF (2008)
2005	38.6	61.4	DMF (2008)
2006	35.8	64.2	DMF (2008)
2007	40.0	60.0	DMF (2008)
2008	40.1	59.9	Interpolated
2009	40.2	59.8	Anon. (2011)
2010	40.3	59.7	Interpolated

[a] FAO Red Sea catch assumed to be 92% of reconstructed catch.

Step 3: *Adjusting the artisanal and industrial catch in the Gulf for misreporting*

Splitting the reconstructed and FAO data into artisanal and industrial catches for the Red Sea allowed us to calculate the ratio of reconstructed catch to FAO data, which reflected the amount of misreporting in the Red Sea. This resulted in the reconstructed artisanal fishery being equivalent to 1.13 times the FAO reported catch; the corresponding value for the industrial was 1.10 times. Assuming that the same ratios apply in the Gulf as well (because the fisheries operate in similar fashion, as does their governance) allowed adjusting the artisanal and industrial catch to 113 % and 110 % of the values obtained in Step 2, respectively.

Step 4: *Estimating the taxonomic composition of the reconstructed catch, by sector*

The product of Step 3 is the total reconstructed catch of Saudi Arabia's fishery in the Gulf, separately for the artisanal and industrial fisheries. However, the taxonomic composition of these catches must also be considered. Catch composition data for the artisanal fishery in the Gulf were available for 2004-2007 (DMF 2008) and the mean of these four years was used to disaggregate the catches for the other years. The catch composition of the industrial was calculated by first deducting the reconstructed shrimp catch, which was available for the whole period, from the reconstructed industrial catch. The composition of the remaining (non-shrimp) catch was calculated using the catch composition of the total Gulf catch and qualitative information on the composition of industrial catch given in DMF (2000), which states that the main catch of the industrial fishery after shrimp were emperors, scads/jacks/trevallies, barracuda and crabs, with sea catfish, rabbitfish and cuttlefish also being caught. For emperors and scads/jacks/trevallies, the percentages given were 15.5% and 7.3%, respectively. A contribution of 5% was assumed for barracuda, 3% for crabs, with 2% each for the less important taxa catfish, rabbitfish and cuttlefishes, i.e., ratios similar to those of the industrial catch of the Saudi industrial fishery in the Red Sea. These percentages were then scaled up to 100%. A total of 10% was allocated to 'miscellaneous species', which was further disaggregated based on the detailed catch composition data of Saudi Arabia's industrial fishery in the Red Sea (Tesfamichael and Rossing 2012). For the later years, 2004-2007 (when the industrial catch was very low), catch composition data were available (DMF 2008) and for 2008-2010, the average of 2004-2007 was used.

The data Saudi Arabia reported to FAO are divided into more taxa (127) than the reconstructed catch, which is strange given that we used the Saudi official national and technical reports for our catch reconstruction. The large number of taxa started in 2000 when the country introduced an extensive data recording and reporting system. Most of the taxa that were included starting in 2000 have very low catch amounts and they were aggregated as 'miscellaneous' in the national reports we used. To make full use of the additional information on catch composition in the FAO data, it was used to further disaggregate the reconstructed catch composition. First the distribution of the taxa were verified using FishBase (www.fishbase.org) to check if each taxon was to be included in both the Red Sea and the Gulf or only in one of these bodies of water. Then, for the taxa included in the FAO data, but not in the reconstruction, the ratios of the taxa in the FAO data were used to disaggregate the catch composition of the reconstructed data. For example, in the reconstructed catch, there was only one taxon item for groupers (Serranidae), but in the FAO data there were 18 taxon items for groupers, mainly species, but also including Serranidae. Overall, the "Serranidae" of the reconstructed Gulf catch was disaggregated into 17 groups using their ratios in the FAO data.

The final reporting baseline was determined by applying the Red Sea-to-Gulf proportion of each species in the total reconstructed catch to the corresponding category in the FAO data.

Table 2. Percentages used in the initial division of the catch Saudi Arabia reported to FAO for the Gulf into artisanal and industrial fisheries.

Year	Artisanal	Industrial	Source/Remarks
1950-61	100.0	0.0	Industrial fishery started in 1962
1962	99.7	0.3	See footnote [a]
1963	97.5	2.5	See footnote [a]
1964	96.1	3.9	See footnote [a]
1965	81.5	18.5	See footnote [a]
1966	77.0	23.0	See footnote [a]
1967	48.0	52.0	See footnote [a]
1968	39.1	60.9	See footnote [a]
1969	37.9	62.1	See footnote [a]
1970	40.6	59.4	See footnote [a]
1971	50.2	49.8	See footnote [a]
1972	45.9	54.0	See footnote [a]
1973	46.9	53.0	See footnote [a]
1974	59.3	40.7	See footnote [a]
1975	51.8	48.2	See footnote [a]
1976	50.5	49.5	See footnote [a]
1977	47.9	52.0	See footnote [a]
1978	72.4	27.6	See footnote [a]
1979	90.8	9.2	See footnote [b]
1980	96.8	3.2	See footnote [b]
1981	92.3	7.7	See footnote [b]
1982	74.6	25.4	See footnote [b]
1983	78.0	22.0	See footnote [b]
1984	76.5	23.5	See footnote [b]
1985	71.3	28.7	See footnote [b]
1986	71.7	28.3	See footnote [b]
1987	77.0	23.0	DMF (2000)
1988	74.7	25.3	DMF (2000)
1989	76.2	23.8	DMF (2000)
1990	75.8	24.2	DMF (2000)
1991	78.0	22.0	DMF (2000)
1992	84.1	15.8	DMF (2000)
1993	84.3	15.7	DMF (2000)
1994	88.5	11.5	DMF (2000)
1995	95.3	4.7	DMF (2000)
1996	91.1	8.9	DMF (2000)
1997	92.2	7.7	DMF (2000)
1998	93.8	6.2	DMF (2000)
1999	96.0	3.9	Interpolated
2000	98.3	1.7	FAO (2003)
2001	98.7	1.3	Interpolated
2002	99.0	1.0	Interpolated
2003	99.4	0.6	Interpolated
2004	99.8	0.2	DMF (2008)
2005	99.7	0.3	DMF (2008)
2006	99.8	0.2	DMF (2008)
2007	99.6	0.4	DMF (2008)
2008	99.6	0.4	Interpolated
2009	99.6	0.4	Anon. (2011)
2010	99.6	0.4	Interpolated

[a] Shrimp assumed to be 90% of industrial catch.
[b] Shrimp assumed to be 50% of industrial catch.

Step 5: *Adding the catch of fisheries that were not accounted for in the official reports.*

Saudi Arabia produces statistical reports of its catch and submits the data to FAO. There are fisheries, however, which are not included in any kind of reporting. Three categories of fisheries are identified in this section: subsistence, recreational and discards of the industrial trawl fishery. The subsistence catch is fish consumed by the fishing crew and fish freely given by artisanal fishers to family and friends according to tradition

in the region. This catch can be substantial, up to 50% of the catch of the artisanal fisheries based on interviews with fishers in the region (Tesfamichael *et al*. in press), and it does not appear in any fishery data recording system. The fish is either consumed or given before it can be recorded. The subsistence fishery catch was estimated based on the artisanal fishery catch. Similar to the Red Sea, subsistence catch was assumed to be 30% of artisanal catch until 1963, when motorization started to have effect on the fishery. For the later years, 20% was allocated to 1964 and 10% to 2010, and the percentage was linearly interpolated between 1965-2009. Before these percentages were applied, some taxa which are not usually given freely, were eliminated. These included taxa usually intended for export market, i.e., sharks fished for their fins and many invertebrates such as shrimp, crab and lobster. Traditionally, most of these taxa were not consumed locally and their consumption was introduced by foreign (mainly European) visitors to the region. However, nowadays, these non-traditional species are consumed by people mainly in the affluent larger urban centers and are not usually given freely to family and friends. Interestingly, the local names of most of these taxa are based on European names, rather than Arabic, as is the case for most of the fish species (Tesfamichael and Awadh 2012).

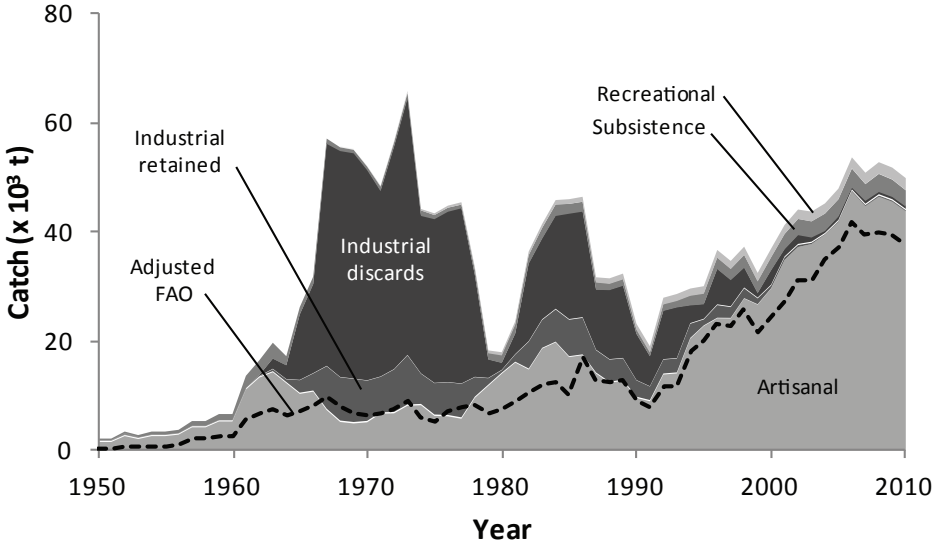

Figure 2. Total reconstructed catch for Saudi Arabia by sector, 1950-2010.

The other sector not included in official reporting is the recreational fishery, which started with the oil boom, when Saudi citizens started fishing for pleasure. Although recreational fishing occurs in Saudi Arabia's Gulf waters, the only data available were for 1996, when it was reported that there were 2,528 boats involved in the recreational fishery in the Gulf, while in the Red Sea there were 2,446 (Sakurai 1998). Thus, the recreational fishery and its composition for the Gulf were calculated using the ratio of boats for 1996 and the reconstructed recreational fishery of the Red Sea (Tesfamichael and Rossing 2012).

Finally, the discards of the industrial trawl fishery are not reported. The level of discarding in the Gulf was calculated using the total shrimp catch in the Gulf and the ratio of total discard to shrimp catch for the Red Sea, which was 5.8 (Tesfamichael and Rossing 2012). The composition of the discarded catch was also calculated based on the Red Sea data. The artisanal fishery targets a wide range of taxa, including shrimp, and almost every species caught is kept (unlike the industrial fishery); hence, discarding in the artisanal sector is negligible.

Results and discussion

From 1950 – 2010, the total reconstructed catch for the Gulf is 2.4 times what was assumed to be reported to FAO for that area (Figure 2; Appendix Table A1). The highest annual total catch was achieved in 1973, with most of the catch being industrial discards. The total catch (minus discards) exhibited a generally increasing trend, with a slight decreasing period in the 1980s. The major continuous increase of retained catch occurred after 1991, until it levelled off (after 2005). Throughout this period (1950-2010), the artisanal fishery had the lion's share of total catch (51%). The difference between reconstructed and reported catch

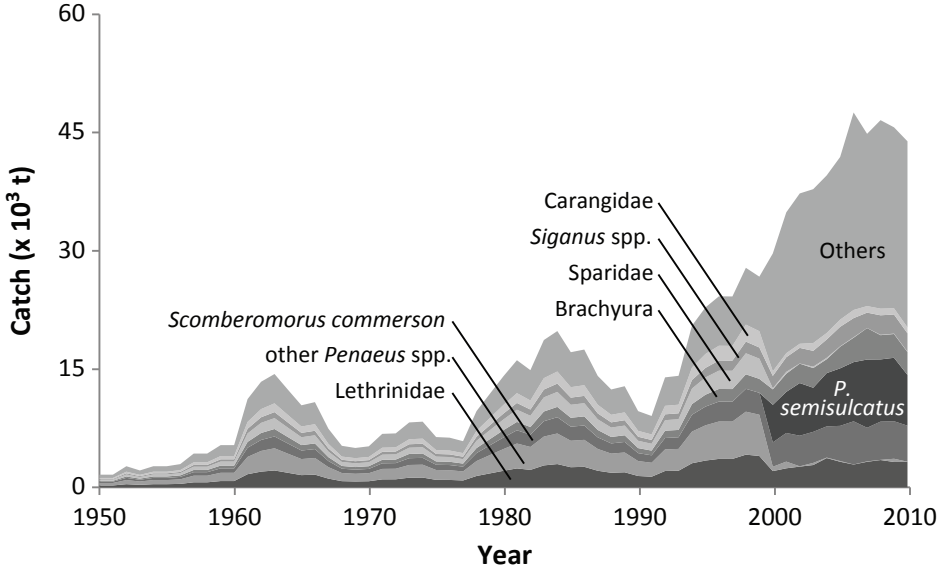

Figure 3. Composition of the dominant taxa in the Saudi artisanal fishery in the Gulf. Note that the group 'Others' is partially disaggregated in Appendix Table A2.

is higher for years with large industrial discards, i.e., in 1964-1978 and 1981-1989. During these periods the relative contribution of the industrial trawl fishery was high and its discards, which are much larger than the retained catch and not reported to FAO at all, meant that total reconstructed catch was much higher than the FAO data. Nevertheless, even for the years where the industrial catch is not high, e.g., 2000-2010, the reconstructed catch remains greater than the FAO data. Of all the sectors, the recreational fishery was the smallest contributor to the total reconstructed catch at 2.4%. The contribution of discarded catch to total catch at 33% is second to the artisanal sector. The retained industrial catch (discards excluded) at 8% is the third largest contributor to total catch, and subsistence is fourth at 5%. It is worth noting the definition used for subsistence fishery in this study is the catch amount given to family and friends for free. In other classifications, the total artisanal fishery may be categorized as subsistence, but according to the Saudi fisheries administration that is not classified as such. We also followed the classification of the country while the subsistence fishery is clearly accounted.

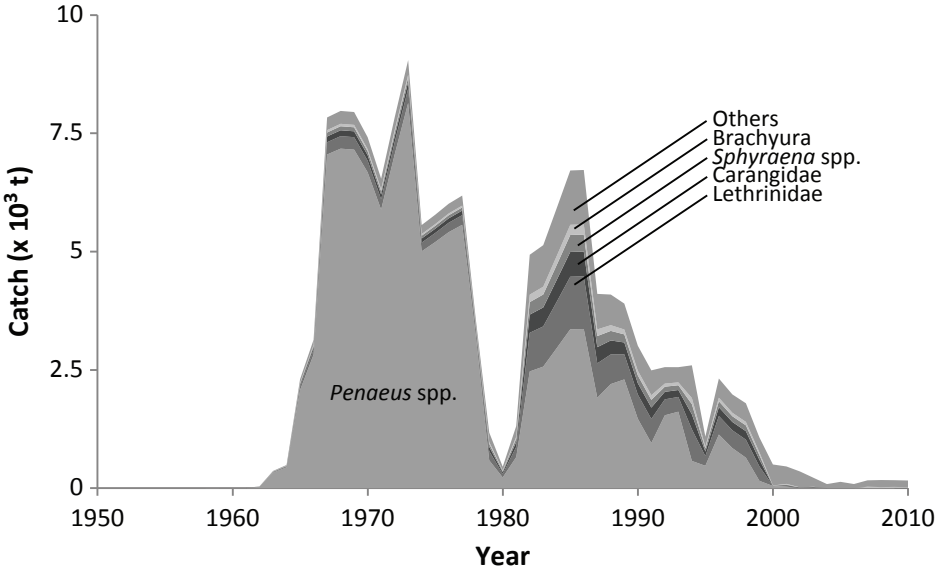

Figure 4. Dominant taxa in the retained catch of the Saudi industrial trawl fishery in the Gulf. Note 'Others' is partially disaggregated in Appendix Table A3.

The total artisanal fishery catch in the Gulf was quite low until 1960, when motorization started and the catch increased (Figure 3). The second increase happened in the 1980s when the momentum of motorization was high; by then almost all the artisanal boats were motorized (Sakurai 1998); however, the catch declined in the mid-1980s due to political instability in the Gulf area. The drastic increase in total catch started the beginning of the 1990s until it levelled off (from 2005 on). The dominant species in artisanal fishery are demersal, reflecting the shallow nature of the sea and the major gear used (traps). Trawl also contributed to the demersal catch, even though it is not the dominant gear. There is limited use of gillnet for pelagic species. As the Gulf does not support extensive coral reef ecosystems, coral reef fishes are not as important as in the Red Sea. Still, the total number of taxa in the catch of the Saudi Gulf artisanal fishery is very high (> 100), with most of them contributing very little to the total catch. Only 8 taxa are dominant, contributing more than 5% each to the total catch (Figure 3); the rest are pooled together as 'Others' to simplify the graphic presentation of the composition. A full catch composition, listing all taxa, is given in Appendix Table A2.

Since its introduction in 1962, the trawl fishery saw a rapid increase in its catch (Figure 4). The main decline towards the end of the 1970s was due to the Iraq-Iran war, as most of the foreign trawlers operating under license from Saudi Arabia left (Sakurai 1998). In 1981, Saudi Arabia started its own industrial fishery in the Gulf, which increased the catch in the mid-1980s. However, the catch quickly declined because the government introduced a policy to reduce trawl fishing effort by reducing the number of vessels allowed to operate in the Gulf (Anon. 2011). After 2005, the catch became negligible. The main target of the industrial trawl fishery is shrimp, which accounted for 71% of the total

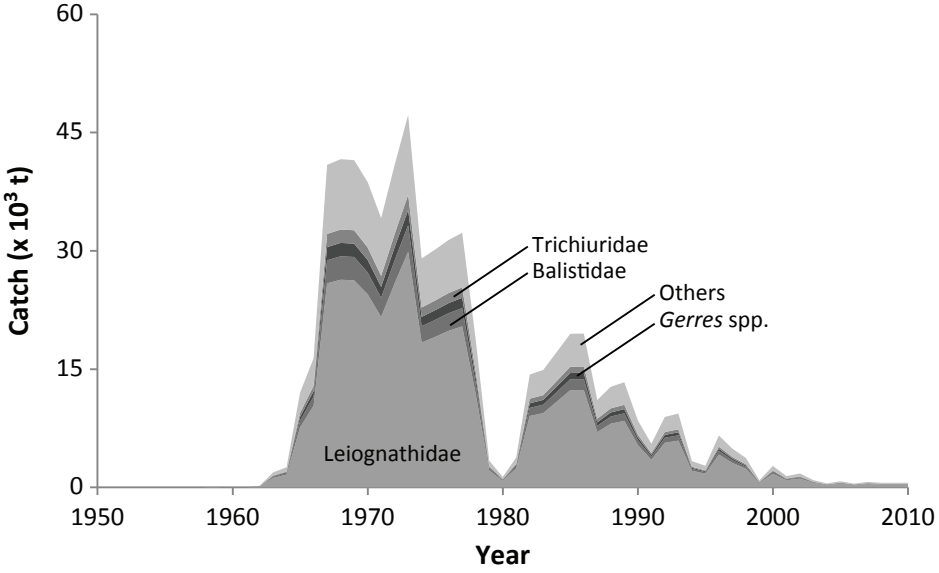

Figure 5. Composition of the discarded catch of the industrial trawl fishery of Saudi Arabia in the Gulf. Note 'Others' is disaggregated in Appendix Table A4.

retained catch (Figure 4). The discarded catch of the industrial trawl fishery is, however, more than four times what is retained (Figure 5). Besides shrimp, other taxa that have economic value are retained in the fishery. The second most retained taxa by the industrial trawl fishery are emperors (Lethrinidae), which account for only 9%. Other important retained taxa include jacks (Carangidae, 4%), barracudas (*Sphyraena*, 3%) and crabs (*Brachyura*, 2%). Other taxa are also retained, but their contribution is minor (Appendix Table A3). The discarded trawl fishery catch follows the same pattern as the retained one, because the former is calculated as a ratio of the latter. The discarded catch is dominated by ponyfish (Leiognathidae), which accounts for 63%, followed by triggerfish (Balistidae) with a contribution of 7%. The detailed list of discarded taxa is given in Appendix Table A4.

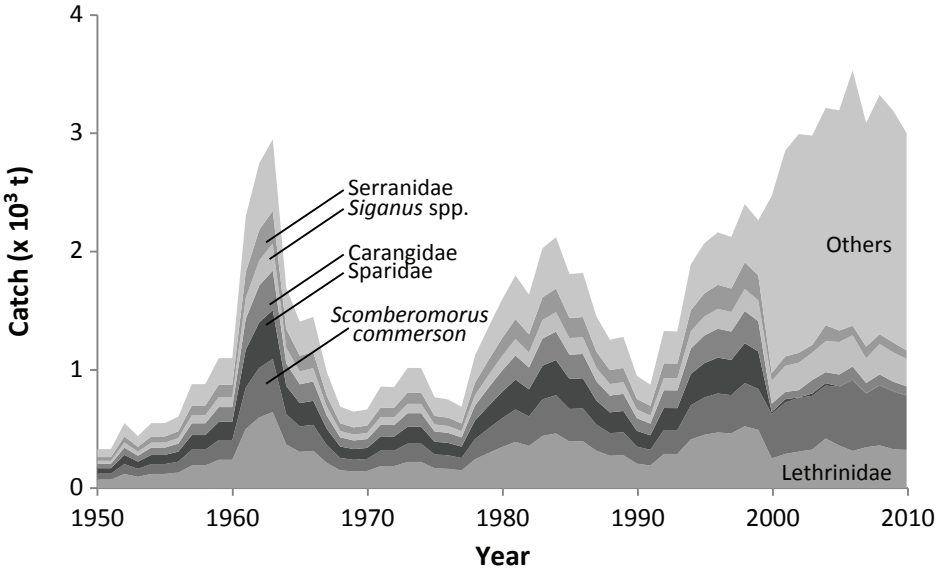

Figure 6. Catch composition of the subsistence fishery of Saudi Arabia in the Gulf. Note 'Others' is partially disaggregated in Appendix A5.

The subsistence fishery follows a pattern similar to the artisanal fishery because it was obtained as a ratio of the latter (Figure 6; Appendix Table A5). The peaks in the mid-1960s and 1980s are more accentuated in the subsistence than the artisanal fishery (Figure 3). This reflects the fact that the fishery is becoming more commercialized with time; hence a higher ratio was used to calculate the subsistence fishery in the earlier years. The taxonomic composition of the subsistence catch is similar to that of the artisanal fishery, except the taxa that are targeted for export (such as shrimp) are excluded from the subsistence fishery. Except for the periods where there were declines in total catch for all the fisheries due to instability in the region, the subsistence fishery shows small changes in its catch, as is common for such fisheries (Béné *et al.* 2007). They are a source of food for the local communities and their levels, contrary to the case of the other fisheries, do not fluctuate much in response to external factors, such as market fluctuations.

The recreational fishery of Saudi Gulf has the least contribution to the total catch (Figure 3); and is also the youngest fishery (Figure 7; Appendix Table A6). This fishery is not regulated at all, except that fishers are not allowed to use any gear besides handlining; its catch is not recorded at all.

Overall, this catch reconstruction of Saudi Arabia in the Gulf provides insights into the fisheries of the country both in terms of the length of time examined and scope. The long-term study period allowed us to examine changes over time and helped in the understanding of the major events that affected the country's fisheries. It is encouraging that Saudi Arabia has improved its fishery data recording system and data dissemination through its annual fishery statistics reports for the artisanal and industrial fisheries. These two sectors may be relatively easier to monitor than the fisheries which are not included either because of their small contribution to total catch (recreational), their diffuse nature (subsistence) or lack of economic value (industrial discards). Nevertheless, it will be very useful to establish a data collection system protocol for these unreported fisheries, even if it may not be as detailed as the

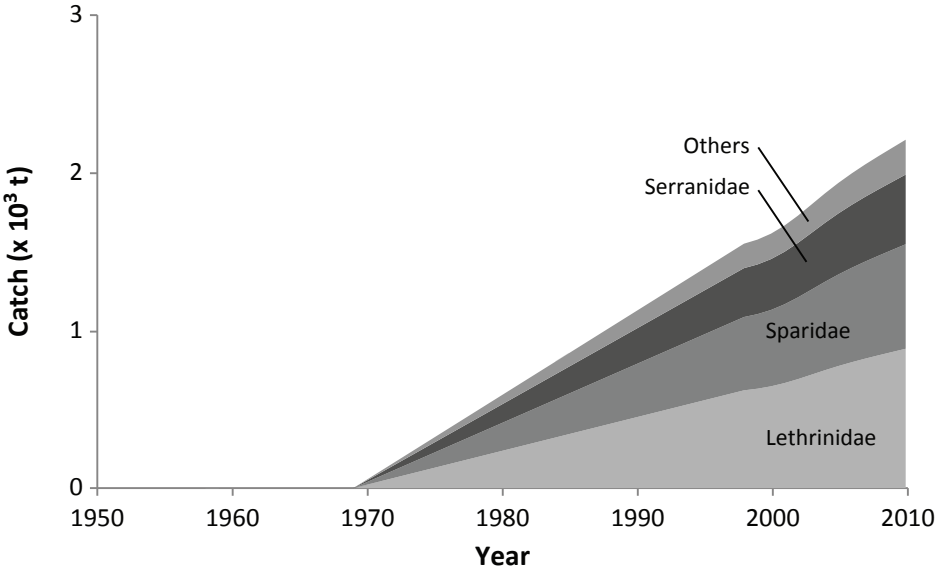

Figure 7. Catch composition of the recreational fishery of Saudi Arabia in the Gulf.

artisanal and industrial fisheries. For example, licensing for the recreational fishery can give an idea as to the size of the fishery, which, when coupled with a sampling scheme of catch rates, can help to estimate the scale of the fishery, and its impact on the ecosystem. For industrial discards, on board sampling can be done at minimum cost. Although, getting an idea as to the magnitude of the subsistence fishery can be difficult, it is possible to estimate its catch through an interview-based survey method. Once the estimates of all the sectors of the fishery are made, it will be possible to move to ecosystem-based management (Pikitch *et al.* 2004), which is needed in the Gulf, as it is elsewhere.

Acknowledgements

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Appendix Table A1. Total reconstructed catch (t) of Saudi Arabia fishery in the Gulf by sector, and catch reported by Saudi Arabia to FAO from 1950-2010.

Year	Artisanal	Industrial		Subsistence	Recreational	FAO[1]
		Retained	Discard			
1950	1,610	0	0	330	0	350
1951	1,610	0	0	330	0	350
1952	2,680	0	0	550	0	778
1953	2,140	0	0	440	0	628
1954	2,680	0	0	550	0	774
1955	2,680	0	0	550	0	770
1956	2,950	0	0	600	0	869
1957	4,280	0	0	880	0	2,032
1958	4,280	0	0	880	0	2,027
1959	5,350	0	0	1,100	0	2,511
1960	5,350	0	0	1,100	0	2,506
1961	11,190	0	0	2,300	0	5,496
1962	13,390	40	190	2,750	0	6,607
1963	14,380	360	1,890	2,950	0	7,404
1964	12,370	490	2,550	1,690	0	6,541
1965	10,410	2,300	12,020	1,410	0	7,310
1966	10,810	3,140	16,380	1,450	0	8,305
1967	7,440	7,840	40,910	980	0	9,935
1968	5,270	7,970	41,630	690	0	8,001
1969	5,000	7,950	41,510	650	0	6,919
1970	5,200	7,420	38,730	670	50	6,551
1971	6,780	6,540	34,150	860	110	6,569
1972	6,840	7,830	40,900	850	160	7,559
1973	8,230	9,050	47,240	1,020	210	9,036
1974	8,330	5,560	29,030	1,020	270	6,071
1975	6,380	5,780	30,160	770	320	5,206
1976	6,300	6,010	31,380	750	370	6,996
1977	5,850	6,180	32,280	690	430	8,074
1978	9,670	3,590	18,730	1,120	480	8,229
1979	11,890	1,180	3,410	1,360	530	6,814
1980	14,100	450	1,310	1,590	590	7,347
1981	16,120	1,310	3,800	1,800	640	8,933
1982	14,860	4,930	14,310	1,640	690	10,445
1983	18,680	5,140	14,890	2,030	750	12,214
1984	19,820	5,920	17,170	2,120	800	12,427
1985	17,140	6,710	19,470	1,810	860	10,003
1986	17,480	6,730	19,500	1,820	910	17,096
1987	14,130	4,110	11,080	1,450	960	12,709
1988	12,410	4,090	12,760	1,260	1,020	12,429
1989	12,830	3,900	13,330	1,280	1,070	12,944
1990	9,670	3,010	8,500	950	1,120	9,055
1991	9,050	2,490	5,530	870	1,180	7,902
1992	13,950	2,560	8,930	1,330	1,230	11,852
1993	14,150	2,560	9,370	1,320	1,280	11,795
1994	20,520	2,600	3,330	1,890	1,340	18,270
1995	22,820	1,090	2,730	2,070	1,390	20,171
1996	24,240	2,320	6,570	2,160	1,440	23,024
1997	24,210	1,980	4,900	2,120	1,500	22,892
1998	27,850	1,790	3,730	2,400	1,550	25,752
1999	26,730	1,070	890	2,260	1,580	21,630
2000	29,670	500	2,720	2,470	1,610	24,196
2001	34,880	460	1,430	2,850	1,670	27,404
2002	37,280	350	1,750	2,990	1,730	31,073
2003	37,820	220	910	2,980	1,800	31,086
2004	39,560	80	490	3,210	1,870	35,049
2005	41,910	130	770	3,190	1,940	37,090
2006	47,550	90	470	3,530	2,000	41,675
2007	44,840	160	680	3,090	2,050	39,552
2008	46,580	170	580	3,320	2,110	39,982
2009	45,670	170	580	3,190	2,160	39,706
2010	43,890	160	580	3,000	2,210	37,470

[1] Portion of FAO data that is assumed to be representative of the reported Gulf data, including adjustments.

Appendix Table A2. Catch (t) composition of the artisanal fishery of Saudi Arabia in the Gulf, 1950-2010.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1950	240	310	170	0	110	150	90	120	100	48	38	0	0	0	31	200
1951	240	310	170	0	110	150	90	120	100	48	38	0	0	0	31	200
1952	400	520	280	0	180	260	140	210	170	80	63	0	0	0	52	330
1953	320	420	220	0	140	210	110	170	140	64	50	0	0	0	42	260
1954	400	520	280	0	180	260	140	210	170	80	63	0	0	0	52	330
1955	400	520	280	0	180	260	140	210	170	80	63	0	0	0	52	330
1956	440	580	310	0	190	280	160	230	190	88	69	0	0	0	57	360
1957	640	840	450	0	280	410	230	330	270	128	100	0	0	0	83	520
1958	640	840	450	0	280	410	230	330	270	128	100	0	0	0	83	520
1959	800	1,050	560	0	350	510	280	410	340	159	125	0	0	0	104	650
1960	800	1,050	560	0	350	510	280	410	340	159	125	0	0	0	104	650
1961	1,670	2,190	1,170	0	740	1,070	590	870	720	333	262	0	0	0	218	1,370
1962	1,990	2,620	1,390	0	880	1,280	710	1,040	860	399	314	0	0	0	260	1,630
1963	2,140	2,810	1,500	0	950	1,380	760	1,110	920	428	337	0	0	0	280	1,750
1964	1,840	2,420	1,290	0	820	1,190	660	960	790	369	290	0	0	0	241	1,510
1965	1,550	2,040	1,080	0	690	1,000	550	810	670	310	244	0	0	0	202	1,270
1966	1,610	2,120	1,130	0	710	1,040	570	840	690	322	253	0	0	0	210	1,320
1967	1,110	1,460	770	0	490	710	400	580	480	222	174	0	0	0	145	910
1968	780	1,030	550	0	350	510	280	410	340	157	123	0	0	0	102	640
1969	740	980	520	0	330	480	270	390	320	149	117	0	0	0	97	610
1970	770	1,020	540	0	340	500	280	400	330	155	122	0	0	0	101	630
1971	1,010	1,330	710	0	450	650	360	520	440	202	159	0	0	0	132	830
1972	1,020	1,340	710	0	450	660	360	530	440	204	160	0	0	0	133	830
1973	1,230	1,610	860	0	540	790	440	640	530	245	193	0	0	0	160	1,000
1974	1,240	1,630	870	0	550	800	440	640	530	248	195	0	0	0	162	1,020
1975	950	1,250	660	0	420	610	340	490	410	190	149	0	0	0	124	780
1976	940	1,230	660	0	420	600	330	490	400	188	148	0	0	0	122	770
1977	870	1,150	610	0	390	560	310	450	380	174	137	0	0	0	114	710
1978	1,440	1,890	1,010	0	640	930	510	750	620	288	227	0	0	0	188	1,180
1979	1,770	2,330	1,240	0	790	1,140	630	920	760	354	279	0	0	0	231	1,450
1980	2,100	2,760	1,470	0	930	1,350	750	1,090	900	420	330	0	0	0	274	1,720
1981	2,400	3,160	1,680	0	1,070	1,550	860	1,250	1,030	406	378	0	0	0	314	2,040
1982	2,210	2,910	1,550	0	980	1,430	790	1,150	950	379	348	0	0	0	289	1,880
1983	2,780	3,660	1,950	0	1,230	1,790	990	1,450	1,200	452	438	0	0	0	363	2,380
1984	2,950	3,880	2,060	0	1,310	1,900	1,050	1,530	1,270	492	464	0	0	0	385	2,520
1985	2,550	3,360	1,790	0	1,130	1,640	910	1,330	1,100	431	402	0	0	0	333	2,170
1986	2,600	3,420	1,820	0	1,150	1,680	930	1,350	1,120	521	410	0	0	0	340	2,130
1987	2,100	2,770	1,470	0	930	1,360	750	1,090	910	421	331	0	0	0	275	1,720
1988	1,850	2,430	1,290	0	820	1,190	660	960	800	370	291	0	0	0	241	1,510
1989	1,910	2,510	1,340	0	850	1,230	680	990	820	382	301	0	0	0	249	1,560
1990	1,440	1,890	1,010	0	640	930	510	750	620	288	226	0	0	0	188	1,180
1991	1,350	1,770	940	0	600	870	480	700	580	270	212	0	0	0	176	1,100
1992	2,080	2,730	1,450	0	920	1,340	740	1,080	890	415	327	0	0	0	271	1,700
1993	2,110	2,770	1,470	0	930	1,360	750	1,090	910	421	331	0	0	0	275	1,730
1994	3,050	4,020	2,140	0	1,360	1,970	1,090	1,590	1,320	611	481	0	0	0	399	2,500
1995	3,400	4,470	2,380	0	1,510	2,190	1,210	1,770	1,460	680	535	0	0	0	304	2,920
1996	3,610	4,740	2,520	0	1,600	2,320	1,290	1,870	1,550	722	568	0	0	0	352	3,080
1997	3,600	4,740	2,520	0	1,600	2,320	1,290	1,870	1,550	721	567	0	0	0	304	3,120
1998	4,150	5,450	2,900	0	1,840	2,670	1,480	2,150	1,790	829	652	0	0	0	278	3,660
1999	3,980	5,230	2,780	0	1,770	2,560	1,420	2,070	1,710	796	626	0	0	0	290	3,490
2000	2,060	550	3,090	4,770	1,960	130	1,580	590	530	435	695	1,550	1,360	610	296	9,460
2001	2,410	850	3,630	5,220	2,300	240	1,850	510	660	565	817	1,800	1,550	730	364	11,370
2002	2,630	40	3,880	6,680	2,460	20	1,980	520	710	714	874	1,390	1,500	870	425	12,580
2003	2,830	270	3,940	5,590	2,500	170	2,010	990	570	885	886	1,850	1,680	990	46	12,620
2004	3,710	60	3,960	6,760	1,760	180	2,320	820	1,200	540	1,014	1,740	1,860	1,140	25	12,480
2005	3,250	90	4,460	7,300	2,740	40	2,480	910	870	735	1,084	2,180	1,800	1,110	29	12,830
2006	2,890	10	5,470	7,510	3,100	60	2,430	1,030	740	2,021	921	2,280	1,860	1,320	29	15,880
2007	3,240	50	4,260	8,660	3,990	10	1,950	830	940	838	1,025	1,940	1,930	1,400	25	13,750
2008	3,460	20	4,850	7,890	3,080	50	2,470	850	790	1,178	1,091	2,050	1,930	1,310	40	15,520
2009	3,220	410	4,760	8,050	3,020	50	2,430	780	820	1,139	1,070	1,730	2,190	1,440	33	14,540
2010	3,220	30	4,570	6,440	2,900	40	2,330	760	710	1,042	1,028	1,710	1,880	1,290	33	15,920

1: Lethrinidae; 2: *Penaeus* spp.; 3: *Scomberomorus commerson*; 4: *P. semisulcatus*; 5: Brachyura; 6: Sparidae; 7: *Siganus* spp.; 8: Carangidae; 9: Serranidae; 10: Sepiidae; 11: Elasmobranchii; 12: *Argyrops spinifer*; 13: *Lethrinus lentjan*; 14: *Rhabdosargus haffara*; 15: Scombridae; 16: Others.

Appendix Table A3. The retained catch (t) composition of the industrial fishery of Saudi Arabia in the Gulf, 1950-2010.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1950	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	33	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	327	12	6	4	2	2	2	2	0	1	1	1	1	1	0	4
1964	440	16	8	5	3	2	2	2	0	2	1	1	1	1	1	5
1965	2,072	76	36	25	15	10	10	10	0	7	4	4	3	3	3	25
1966	2,823	104	49	34	20	13	13	13	0	10	5	5	5	4	4	34
1967	7,053	260	122	84	50	33	33	33	0	25	13	12	12	11	9	85
1968	7,177	264	124	85	51	34	34	34	0	26	13	12	12	11	9	86
1969	7,156	263	124	85	51	34	34	34	0	26	13	12	12	11	9	86
1970	6,677	246	116	79	48	32	32	32	0	24	13	11	11	10	9	80
1971	5,888	217	102	70	42	28	28	28	0	21	11	10	10	9	8	71
1972	7,051	259	122	84	50	33	33	33	0	25	13	12	12	11	9	85
1973	8,144	300	141	97	58	39	39	39	0	29	15	14	14	13	11	98
1974	5,006	184	87	59	36	24	24	24	0	18	9	9	8	8	7	60
1975	5,201	191	90	62	37	25	25	25	0	19	10	9	9	8	7	63
1976	5,411	199	94	64	39	26	26	26	0	19	10	9	9	8	7	65
1977	5,566	205	96	66	40	26	26	26	0	20	10	9	9	9	7	67
1978	3,230	119	56	38	23	15	15	15	0	12	6	5	5	5	4	39
1979	588	195	92	63	38	25	25	25	0	19	10	9	9	8	7	64
1980	225	75	35	24	14	10	10	10	0	7	4	3	3	3	3	24
1981	655	217	102	70	42	24	28	28	0	21	11	10	10	9	8	75
1982	2,467	817	385	264	158	90	105	105	0	80	42	38	37	34	29	283
1983	2,568	850	401	274	165	89	110	110	0	83	43	39	38	36	30	299
1984	2,960	981	462	316	190	105	127	127	0	96	50	45	44	41	35	342
1985	3,357	1,112	524	359	215	121	143	143	0	108	57	51	50	47	40	387
1986	3,363	1,114	525	359	216	144	144	144	0	109	57	51	50	47	40	365
1987	1,910	727	343	235	141	94	94	94	0	71	37	34	33	31	26	238
1988	2,200	627	295	202	121	81	81	81	0	61	32	29	28	26	22	205
1989	2,298	531	250	171	103	69	69	69	0	52	27	25	24	22	19	174
1990	1,465	512	241	165	99	66	66	66	0	50	26	24	23	22	18	168
1991	954	508	239	164	98	66	66	66	0	50	26	23	23	21	18	166
1992	1,539	337	159	109	65	44	44	44	0	33	17	16	15	14	12	110
1993	1,615	312	147	101	60	40	40	40	0	30	16	14	14	13	11	102
1994	574	669	315	216	130	86	86	86	0	65	34	31	30	28	24	219
1995	471	205	96	66	40	26	26	26	0	20	7	9	9	9	7	70
1996	1,132	392	185	126	76	51	51	51	0	38	15	18	18	17	14	133
1997	846	376	177	121	73	48	48	48	0	37	12	17	17	16	13	130
1998	643	381	179	123	74	49	49	49	0	37	10	18	17	16	14	134
1999	153	304	143	98	59	39	39	39	0	30	9	14	14	13	11	106
2000	44	5	1	2	2	1	1	1	385	0	0	0	0	0	0	55
2001	31	33	6	6	14	5	9	9	188	0	2	3	1	0	3	149
2002	2	8	1	2	3	1	2	2	276	1	0	1	0	0	1	51
2003	6	10	3	4	4	2	3	3	118	0	0	1	0	0	1	63
2004	1	0	0	0	0	0	0	0	77	0	0	0	0	0	0	8
2005	1	0	0	0	0	0	0	0	118	0	0	0	0	0	0	13
2006	0	0	0	0	0	4	0	0	71	0	0	0	0	0	0	11
2007	1	0	0	0	28	14	0	0	105	0	0	0	0	0	0	16
2008	0	0	0	0	21	42	0	0	86	0	0	0	0	0	0	21
2009	5	0	0	0	20	39	0	0	90	0	0	0	0	0	0	13
2010	0	0	0	0	18	34	0	0	75	0	0	0	0	0	0	33

1: *Penaeus* nei; 2: Lethrinidae; 3: Carangidae; 4: *Sphyraena* spp.; 5: Brachyura; 6: Sepiidae; 7: *Siganus* spp.; 8: *Netuma thalassina*; 9: *P. semisulcatus*; 10: *Gerres* spp.; 11: Scombridae; 12: *Bothus pantherinus*; 13: Lutjanidae; 14: Sparidae; 15: Elasmobranchii; 16: Others.

Appendix Table A4. Catch (t) composition of the discard of the industrial fishery of Saudi Arabia in the Gulf, 1950-2010.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1950	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	120	14	8	8	4	4	4	4	4	2	2	2	16
1963	1,200	135	77	77	39	39	39	39	39	19	19	19	155
1964	1,610	182	104	104	52	52	52	52	52	26	26	26	208
1965	7,600	858	491	491	245	245	245	245	245	123	123	123	981
1966	10,360	1,170	668	668	334	334	334	334	334	167	167	167	1,337
1967	25,880	2,922	1,670	1,670	835	835	835	835	835	417	417	417	3,339
1968	26,330	2,973	1,699	1,699	850	850	850	850	850	425	425	425	3,398
1969	26,260	2,965	1,694	1,694	847	847	847	847	847	424	424	424	3,388
1970	24,500	2,766	1,581	1,581	790	790	790	790	790	395	395	395	3,161
1971	21,600	2,439	1,394	1,394	697	697	697	697	697	348	348	348	2,788
1972	25,870	2,921	1,669	1,669	835	835	835	835	835	417	417	417	3,339
1973	29,880	3,374	1,928	1,928	964	964	964	964	964	482	482	482	3,856
1974	18,370	2,074	1,185	1,185	592	592	592	592	592	296	296	296	2,370
1975	19,080	2,155	1,231	1,231	616	616	616	616	616	308	308	308	2,462
1976	19,850	2,242	1,281	1,281	640	640	640	640	640	320	320	320	2,562
1977	20,420	2,306	1,318	1,318	659	659	659	659	659	329	329	329	2,635
1978	11,850	1,338	765	765	382	382	382	382	382	191	191	191	1,529
1979	2,160	243	139	139	70	70	70	70	70	35	35	35	278
1980	830	93	53	53	27	27	27	27	27	13	13	13	107
1981	2,410	272	155	155	78	78	78	78	78	39	39	39	310
1982	9,050	1,022	584	584	292	292	292	292	292	146	146	146	1,168
1983	9,420	1,064	608	608	304	304	304	304	304	152	152	152	1,216
1984	10,860	1,226	701	701	350	350	350	350	350	175	175	175	1,402
1985	12,320	1,391	795	795	397	397	397	397	397	199	199	199	1,590
1986	12,340	1,393	796	796	398	398	398	398	398	199	199	199	1,592
1987	7,010	791	452	452	226	226	226	226	226	113	113	113	904
1988	8,070	911	521	521	260	260	260	260	260	130	130	130	1,041
1989	8,430	952	544	544	272	272	272	272	272	136	136	136	1,088
1990	5,380	607	347	347	173	173	173	173	173	87	87	87	694
1991	3,500	395	226	226	113	113	113	113	113	56	56	56	452
1992	5,650	638	364	364	182	182	182	182	182	91	91	91	729
1993	5,930	669	382	382	191	191	191	191	191	96	96	96	765
1994	2,110	238	136	136	68	68	68	68	68	34	34	34	272
1995	1,730	195	111	111	56	56	56	56	56	28	28	28	223
1996	4,160	469	268	268	134	134	134	134	134	67	67	67	536
1997	3,100	350	200	200	100	100	100	100	100	50	50	50	400
1998	2,360	266	152	152	76	76	76	76	76	38	38	38	304
1999	560	63	36	36	18	18	18	18	18	9	9	9	73
2000	1,720	194	111	111	55	55	55	55	55	28	28	28	222
2001	900	102	58	58	29	29	29	29	29	15	15	15	116
2002	1,110	125	72	72	36	36	36	36	36	18	18	18	143
2003	570	65	37	37	19	19	19	19	19	9	9	9	74
2004	310	35	20	20	10	10	10	10	10	5	5	5	40
2005	490	55	31	31	16	16	16	16	16	8	8	8	63
2006	300	34	19	19	10	10	10	10	10	5	5	5	39
2007	430	49	28	28	14	14	14	14	14	7	7	7	56
2008	370	41	24	24	12	12	12	12	12	6	6	6	47
2009	370	41	24	24	12	12	12	12	12	6	6	6	47
2010	370	41	24	24	12	12	12	12	12	6	6	6	47

1: Leiognathidae; 2: Balistidae; 3: *Gerres* spp.; 4: Trichiuridae; 5: Platycephalidae; 6: Tetraodontidae; 7: Soleidae; 8: Bramidae; 9: Brachyura; 10: Clupeidae; 11: Mullidae; 12: Squillidae; 13: Others;

Appendix Table A5. Catch (t) composition of the subsistence fishery of Saudi Arabia in the Gulf, 1950-2010.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1950	72	50	46	37	26	31	0	0	9	7	8	5	7	0	5	26
1951	72	50	46	37	26	31	0	0	9	7	8	5	7	0	5	26
1952	120	84	77	62	43	52	0	0	16	12	13	8	12	0	9	43
1953	96	67	62	50	34	41	0	0	12	10	10	6	10	0	7	34
1954	120	84	77	62	43	52	0	0	16	12	13	8	12	0	9	43
1955	120	84	77	62	43	52	0	0	16	12	13	8	12	0	9	43
1956	132	92	85	68	47	57	0	0	17	13	14	9	13	0	10	47
1957	191	134	123	99	68	82	0	0	25	19	21	13	19	0	15	69
1958	191	134	123	99	68	82	0	0	25	19	21	13	19	0	15	69
1959	239	167	154	124	85	103	0	0	31	24	26	16	24	0	18	86
1960	239	167	154	124	85	103	0	0	31	24	26	16	24	0	18	86
1961	500	350	322	260	178	215	0	0	65	50	54	34	50	0	38	180
1962	598	418	385	311	213	258	0	0	78	60	65	41	60	0	46	215
1963	642	449	414	334	229	277	0	0	84	64	70	44	64	0	49	231
1964	368	258	237	191	131	159	0	0	48	37	40	25	37	0	28	132
1965	306	214	197	159	109	132	0	0	40	31	33	21	31	0	23	110
1966	315	220	203	164	112	136	0	0	41	32	34	21	31	0	24	113
1967	214	150	138	111	76	92	0	0	28	21	23	15	21	0	16	77
1968	150	105	97	78	54	65	0	0	20	15	16	10	15	0	11	54
1969	141	98	91	73	50	61	0	0	18	14	15	10	14	0	11	51
1970	145	101	93	75	52	62	0	0	19	15	16	10	14	0	11	52
1971	187	131	120	97	67	80	0	0	24	19	20	13	19	0	14	67
1972	186	130	120	97	66	80	0	0	24	19	20	13	19	0	14	67
1973	221	155	142	115	79	95	0	0	29	22	24	15	22	0	17	79
1974	221	155	142	115	79	95	0	0	29	22	24	15	22	0	17	79
1975	167	117	108	87	60	72	0	0	22	17	18	11	17	0	13	60
1976	163	114	105	85	58	70	0	0	21	16	18	11	16	0	12	59
1977	150	105	96	78	53	64	0	0	20	15	16	10	15	0	11	54
1978	244	171	157	127	87	105	0	0	32	24	27	17	24	0	19	88
1979	296	207	191	154	106	128	0	0	39	30	32	20	30	0	23	106
1980	347	243	223	180	124	149	0	0	45	35	38	24	35	0	26	125
1981	391	274	252	203	140	169	0	0	51	39	43	27	39	0	30	141
1982	356	249	229	185	127	153	0	0	46	36	39	24	36	0	27	128
1983	441	309	284	229	158	190	0	0	58	44	48	30	44	0	34	159
1984	462	323	298	240	165	199	0	0	60	46	50	31	46	0	35	166
1985	394	276	254	205	141	170	0	0	51	39	43	27	39	0	30	141
1986	396	277	255	206	141	171	0	0	52	40	43	27	40	0	30	142
1987	316	221	203	164	113	136	0	0	41	32	34	21	32	0	24	113
1988	273	191	176	142	97	118	0	0	36	27	30	19	27	0	21	98
1989	278	195	179	145	99	120	0	0	36	28	30	19	28	0	21	100
1990	206	144	133	107	74	89	0	0	27	21	22	14	21	0	16	74
1991	190	133	123	99	68	82	0	0	25	19	21	13	19	0	14	68
1992	289	202	186	150	103	124	0	0	38	29	31	20	29	0	22	104
1993	288	202	186	150	103	124	0	0	38	29	31	20	29	0	22	104
1994	412	288	265	214	147	177	0	0	54	41	45	28	41	0	31	148
1995	451	315	290	234	161	194	0	0	40	45	49	31	45	0	34	180
1996	471	329	303	245	168	203	0	0	46	47	51	32	47	0	36	185
1997	462	323	298	240	165	199	0	0	39	46	50	31	46	0	35	188
1998	523	366	337	271	187	225	0	0	35	52	57	35	52	0	40	221
1999	493	345	318	256	176	212	0	0	36	49	54	33	49	0	38	206
2000	251	376	16	71	192	65	189	166	36	41	8	36	0	74	0	948
2001	289	434	28	61	222	79	216	186	43	17	21	42	0	88	17	1,109
2002	309	456	2	61	232	83	163	176	50	22	8	44	0	102	0	1,284
2003	326	454	20	114	231	65	213	193	5	44	11	44	0	115	2	1,143
2004	420	447	20	93	262	135	197	211	3	24	13	52	0	128	4	1,205
2005	360	495	5	101	275	97	241	200	3	15	21	51	0	123	5	1,204
2006	314	595	6	112	264	81	248	202	3	28	11	40	0	144	2	1,483
2007	345	454	1	89	208	100	207	206	3	19	13	48	0	149	2	1,243
2008	361	506	5	88	258	82	213	202	4	23	10	49	0	137	3	1,382
2009	329	486	5	80	248	84	177	224	3	17	13	47	0	147	2	1,328
2010	322	457	4	76	233	71	171	188	3	19	12	44	0	129	6	1,267

1: Lethrinidae; 2: *Scomberomorus commerson*; 3: Sparidae; 4: Carangidae; 5: *Siganus* spp.; 6: Serranidae; 7: *Argyrops spinifer*; 8: *Lethrinus lentjan*; 9: Scombridae; 10: *Sphyraena* spp.; 11: Lutjanidae; 12: *Netuma thalassina*; 13: *Scomberoides* spp.; 14: *Rhabdosargus haffara*; 15: Haemulidae; 16: Others.

Appendix Table A6. Catch (t) composition of the recreational fisheries of Saudi Arabia in the Gulf, 1950-2010.

Year	Lethrinidae	Sparidae	Serranidae	Others
1950	0	0	0	0
1951	0	0	0	0
1952	0	0	0	0
1953	0	0	0	0
1954	0	0	0	0
1955	0	0	0	0
1956	0	0	0	0
1957	0	0	0	0
1958	0	0	0	0
1959	0	0	0	0
1960	0	0	0	0
1961	0	0	0	0
1962	0	0	0	0
1963	0	0	0	0
1964	0	0	0	0
1965	0	0	0	0
1966	0	0	0	0
1967	0	0	0	0
1968	0	0	0	0
1969	0	0	0	0
1970	21	16	11	5
1971	43	32	21	11
1972	64	48	32	16
1973	86	64	43	21
1974	107	80	53	27
1975	128	96	64	32
1976	150	112	75	37
1977	171	128	86	43
1978	192	144	96	48
1979	214	160	107	53
1980	235	176	118	59
1981	257	192	128	64
1982	278	208	139	69
1983	299	225	150	75
1984	321	241	160	80
1985	342	257	171	86
1986	364	273	182	91
1987	385	289	192	96
1988	406	305	203	102
1989	428	321	214	107
1990	449	337	225	112
1991	470	353	235	118
1992	492	369	246	123
1993	513	385	257	128
1994	535	401	267	134
1995	556	417	278	139
1996	577	433	289	144
1997	599	449	299	150
1998	620	465	310	155
1999	630	473	315	158
2000	645	484	323	161
2001	666	500	333	167
2002	691	518	346	173
2003	719	539	360	180
2004	748	561	374	187
2005	774	581	387	194
2006	799	599	399	200
2007	821	616	411	205
2008	843	632	421	211
2009	863	647	432	216
2010	884	663	442	221

Estimating total fish extractions in the United Arab Emirates: 1950-2010[1]

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Abstract

The United Arab Emirates (UAE) is an Arab country located along the southwestern coast of the Persian Gulf, and with a small coastline along the Gulf of Oman. Its fisheries are all small-scale in nature, with catches increasing steadily until 1999, after which they started to decline. Due to reliance on a market-sampling program for their estimation, which does not differentiate between locally caught and imported catch, the UAE is thought to systematically over-report its catches. Following the reconstruction approach, the UAE's domestic catches in the Persian Gulf were re-estimated using all available peer-reviewed and grey literature sources for quantitative and/or qualitative information on sectors missing from or misreported to statistics presented by the FAO on behalf of the UAE. Overall, the figures reported to the FAO from 1950-2010 over-estimate actual domestic catches by an average of 51% annually (47% overall) when compared to reconstructed totals, despite the reconstruction accounting for subsistence and recreational catches that are entirely missed by market-sampling. On the resource side, introduced fisheries management measures are encouraging, but not sufficient given the scale of the country's overfishing problem.

Introduction

The United Arab Emirates (UAE) has coasts on both the southern Persian Gulf and the northern Gulf of Oman (Figure 1). The country is a federation of 7 Emirates with shared administrative and political power between the federal government and the various Emirates. One of the Emirates (Fujairah) has its coastline only in the Gulf of Oman, where substantial catches may be taken (Pearson *et al.* 1998), but which are not considered here. Another Emirate (Sarjah) has a coastline both in the Persian Gulf and along the Gulf of Oman, but the latter is very small and is also not considered here. In 1962, Abu Dhabi became the first of the emirates to export oil, transforming the country's economy and infrastructure. Today, its oil reserves are ranked the 6th largest in the world (OPEC 2012).

Prior to the discovery of oil in the 1950s, pearl diving was the basis of the country's economy. The First World War, the economic depression in the late 1920s, and the development of cultured pearls in Japan led to the sector's demise.

The fisheries of UAE are all small-scale in nature, with the vast majority taking place in the Emirate of Abu Dhabi, which is reported to comprise over 60% of the country's marine area (Morgan 2004). Fishers employ two distinct fishing vessel types: fibreglass *tarads* and traditional wooden *dhows*. The *tarads* are typically 6-8m in length and equipped with 1-2 outboard engines, allowing a crew of 1-4 people to fish for 6-8 hours at a time (Grandcourt *et al.* 2002). *Dhows,* on the other hand, range from 12-22 m and are equipped with inboard diesel engines and insulated cool boxes, allowing the crew of 4-6 people to fish for 3-5 days at a time. Like other Gulf countries, vessels are owned by UAE nationals, while the majority of workers on the vessels are migrant labourers from India, Bangladesh and Iran.

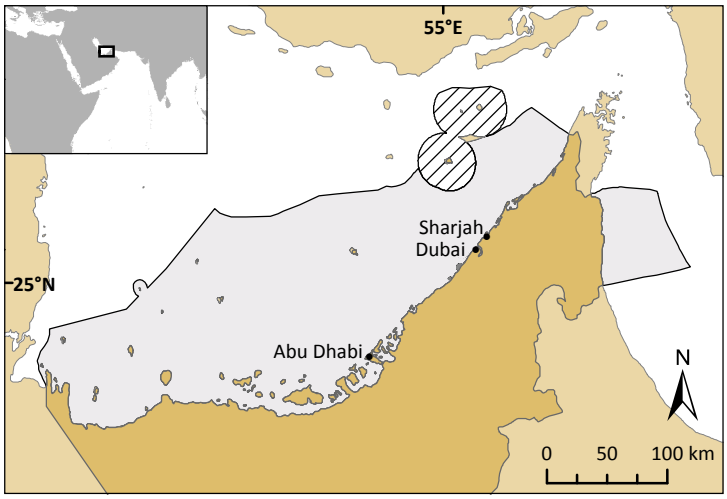

Figure 1. Map of the United Arab Emirates (UAE), showing the extent of its EEZ in grey (including the area contested with Iran; stripped area). The three capital cities of the major Emirates of Abu Dhabi, Dubai and Sharjah are also shown.

The UAE's fisheries are multi-gear and multi-species, with over 100 species occurring in the catch (Grandcourt *et al.* 2010). The majority of fish species caught belong to the families Serranidae, Lethrinidae, Lujanidae, Haemulidae, Sparidae, Carangidae and

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Mugilidae. The main fishing gear is a dome-shaped wire trap called a *gargoor*, but hand-lines, intertidal weirs (*hadrah*), trolling, gillnets, and encircling nets are also used (Grandcourt *et al.* 2002). Though fisheries are of minor importance to the UAE's economy, they are valued for the recreational opportunities they provide, for their contributions to food security, and as a part of the country's cultural heritage.

Fish are landed at one of over 30 designated landing sites along the Gulf coast, principally in Abu Dhabi, Dubai, and Sharjah. Most landing sites also have facilities for storing, auctioning, wholesale and retailing the catch. Some of the larger sites also have processing facilities for wholesale and retail markets. Imported fish (from Oman) is sold in the markets alongside locally caught fish, which does not allow for differentiation of domestic form imported seafood through market-only surveys .

Until 2004, a market survey program (which includes imports) was used to estimate catches, inevitably yielding inflated figures for truly domestic catches. Surveys performed by the Environmental Research and Wildlife Development Agency (ERDWA) compared reported and estimated catches for 2000, and found that, while estimated domestic landings were 20,000 tonnes, reported landings (as estimated from the market survey) were 110,000 tonnes (Grandcourt *et al.* 2003).

Morgan (2004) reports that both commercial and non-commercial fish stocks have declined significantly over the past 25 years (some by as much as 90%) as a result of overfishing and extensive coastal development. As a result, the number of registered fishing vessels has decreased, from 7,700 in 1998 to 5,191 in 2002 (Morgan 2004). A law requiring a UAE national to be physically present on the vessels during fishing operations has also contributed to the reduction in registered vessels (Morgan 2004).

Illegal fishing is common and likely encouraged by low enforcement of management rules. In particular, the use of driftnets for pelagic fishes such as Spanish mackerel (Morgan 2004; Barakat 2012), as well as shark fishing during the closed season (Moore 2012; Simpson 2012) are widespread.

The UAE was revealed to be the fifth largest exporter of shark fins to the Hong Kong market (Fowler *et al.* 2005; Moore 2012), despite a shark-finning ban. However, it is thought that the majority of these fins are re-exported from shark catches made in Oman (Moore *et al.* 2012). Catch statistics reported by the FAO on behalf of the UAE show steadily increasing shark catches from 1989-2008, followed by a drastic decline in 2009 (presumably due to the finning ban). This, however, is likely to be an underestimate because enforcement is weak, and sharks that are finned at sea and/or fished during the January-April closed season remain unreported.

Methods

This contribution follows catch reconstruction methods as previously outlined by other studies (e.g., Zeller *et al.* 2006; Zeller *et al.* 2007; Le Manach *et al.* 2012).

Although issues with over-reporting are acknowledged by the FAO (Morgan 2004), no efforts appear to have been made by the relevant reporting agency in the UAE to improve data reporting. Morgan (2004) estimates that catches for 2000 were over-reported by 90,000 t, while Luca Garibalidi (FAO, pers. comm.) thinks that this over-reporting figure is "too high". Therefore, in the absence of better data, reported catches were adjusted using the median of 20,000 t (Morgan's estimate of domestic catches) and 110,000 t (FAO data) as an anchor point for domestic reported catches, and all reported catches were decreased by 40%. These adjusted catches were used as the new baseline of reported landings for the analysis.

Using Google Earth, Al-Abdulrazzak & Pauly (2013) estimate 95 ± 1 *hadrah* were operating in the UAE in 2005, generating an annual catch of 1,292 ± 381 t. The UAE reports half that amount (i.e., 600 t) for the same year. Since the number of *hadrah* is not known to have substantially fluctuated in the last five decades, the reported *hadrah* catch for 2005 (600 t) was adjusted to the estimated catch (1,292 $t \cdot year^{-1}$) for all years. Species composition was estimated from data supplied by the Abu Dhabi Environmental Agency (S. Hartmann, pers. comm.).

To estimate illegal driftnet catches, an approach developed for Qatar was followed (see Qatar, Al-Abdulrazzak, this volume). To estimate annual total catch per vessel, the number of registered fishing vessels from 1998 (start of records) to 2010 was obtained from the UAE's Ministry of Environment and Water database. For the years without these records, the average number of registered vessels was used. It was assumed that 10% take part in illegal drift-netting (Table 1). As in the case of Qatar, it was estimated that vessels deploying driftnets were catching 20% more than they would legally (i.e., when deploying *gargoor* traps from their boats instead of illegal driftnets). The annual total catch per illegal fishing vessel (Table 1) was multiplied by the estimated number of participating vessels, to create a time series of illegal catch from 1989 (the start of the driftnet ban) to 2010.

The UAE has a growing recreational fishery, and although (free) recreational fishing licenses are required in Dubai and Abu Dhabi, no data on the number of participants or quantity of catches exist (Morgan 2004). Therefore, to estimate this sector, methods originally developed for Kuwait were used: it was assumed that recreational fishing began in 1960, a 0.12% participation rate was applied to the total population from 1960-2010 to obtain a time series of recreational fishers, and a conservative catch rate estimate of 1 $kg \cdot trip^{-1}$, along with 104 fishing trips per

person per year was used to calculate total recreational catch (see Kuwait, Al-Abdulrazzak, this volume). UAE's recreational fishers target Spanish mackerel, tuna, sailfish and demersal species (Bishop 2002; Morgan 2004) and this species composition was applied in equal ratios to disaggregate the recreational catch.

The telosts *Lethrinus borbonicus*, *Lethrinus microdon*, *Pomacanthus maculosus*, and *Scolopsis taeniata* are caught as incidental and generally discarded bycatch by *gargoors* targeting emperors, groupers, jacks, and sweetlips (Morgan 2004; Grandcourt *et al.* 2010). Weizhong *et al.* (2012) estimate *gargoor* discard rates to be 2.56%, and this figure was used to extrapolate total discards for the fishery. The species composition was applied in equal ratios among the above species.

Despite the UAE's high GDP, subsistence fishing occurs by the industry's foreign labourers. Foreign fishers make up 0.0046% of the country's total population, and it was assumed that fishers take home an average of 5 kg of fish per week, starting with the oil boom in 1960 until 2010. Because these take home catches are made up of less desirable species (which lack a targeted fishery), the ratios from species discarded from the *gargoor* fishery was applied.

Table 1. Parameters used for estimating illegal driftnet fishery.

Year	Number of participating vessels	Annual illegal catch per vessel (t)	Annual catch (t)
1989	564	20	11,280
1990	564	20	11,280
1991	564	20	11,280
1992	564	20	11,280
1993	564	20	11,280
1994	564	20	11,280
1995	564	20	11,280
1996	564	20	11,280
1997	564	20	11,178
1998	770	18	13,762
1999	619	23	14,106
2000	469	27	12,648
2001	459	29	13,500
2002	519	23	11,701
2003	505	23	11,411
2004	556	19	10,793
2005	557	19	10,401
2006	557	18	9,892
2007	557	17	9,388
2008	557	16	8,880
2009	605	15	9,294
2010	605	16	9,538

Results and discussion

Fisheries landings as reported by FAO show steady increases from 12,000 t·year^{-1} in 1950 to 43,001 t·year^{-1} in 1973, followed by a dramatic increase to 67,800 t·year^{-1} in 1974. Catches continue to increase steadily until their peak of 117,607 t·year^{-1} in 1999, before declining to 79,610 t·year^{-1} by 2010 (Figure 2a; Appendix Table A1). However, adjusted reported landings (i.e., domestic) increased from 7,200 t·year^{-1} in 1950 to a peak of 70,600 t·year^{-1} in 1999 before declining to 47,800 t·year^{-1} by 2010 (Figure 2a).

Total reconstructed catches are annually, on average, 34% less than landings reported by FAO on behalf of the UAE (32% overall), but are 11% higher (annual average) than the adjusted reported domestic landings (14% overall; Figure 2a). Reconstructed total catches increase gradually from 7,920 t·year^{-1} in 1950 to a peak of 86,200 t·year^{-1} in 1999, followed by a decline to 55,400 t·year^{-1} in 2008. Catches in 2010 have increased again to 59,500 t·year^{-1}.

For the 1950-2010 time period, artisanal catches accounted for 99.5% of the total reconstructed catch, while the subsistence and recreational sectors contributed 0.05% and 0.45%, respectively (Figure 2a). Estimated discards were low and accounted for 0.6% of the total catch.

The main taxa caught in the UAE are *Scomberomorus commerson* (15%) and Lethrinidae (11%), followed by *Sardinella* spp. (8%), *Stolephorus* spp. (7%), Serranidae (7%), and Carangidae (7%; Figure 2b; Appendix Table A2).

Overfishing is of particular concern for the *Scomberomorus commerson* fishery, as recruitment failure has been associated with increased fishing pressure (Grandcourt *et al.* 2005). In the neighbouring Gulf of Oman, there has been a 10-fold decrease in the yields of this species in recent years (Grandcourt *et al.* 2005).

Despite declining landings, fisheries management in the UAE remains rudimentary. At the national level, the Ministry of Agriculture and Fisheries (MAF) regulates fisheries management, but some legislative authority for policy development exists on a regional scale within component Emirates. Fisheries Regulation Committees (which comprise the MAF), fisher cooperatives, municipalities, and the Coast Guard exist in each Emirate, and address regional fisheries policy and enforcement. However, due to a lack of consensus on overarching national fisheries planning goals, differing and inconsistent decisions (or no decisions at all) are often the outcome. The coordination of the various federal and regional managing bodies into a single comprehensive and consistent national fisheries policy may prove to be the greatest challenge (Morgan 2004).

The UAE has only recently introduced fisheries management legislation and therefore, there remain significant gaps, both legislatively and managerially. Like Qatar (Qatar, Al-Abdulrazzak, this volume), UAE management practices rely on input rather than output controls. Marine protected areas, closed seasons for some migratory pelagic fish, and escape gaps in *gargoor* are the most important fisheries management measures. Until recently, the only restrictions on commercial fishing were bans on trawling and driftnets. However, in 2003, Abu Dhabi began to set limits on

the number of *gargoor* fish traps. No gear restrictions have been applied in other Emirates to date. Enforcement is also problematic as it is limited by the fisheries-specific training of the Coast Guard staff, the lack of strategic protocol, and the traditional right of appeal for misdemeanours to ministers and sheikhs. As a result, many fisheries prosecutions are never pursued and regulations are often ignored.

Stakeholder participation in fisheries policy development takes place in the form of traditional discussions, often directly with senior government figures. While these often result in compromised solutions, stakeholder participation is limited to UAE nationals only, who are the vessel owners, but are not necessarily actively engaged in fishing activities (Morgan 2004).

Compounding the fisheries crisis is the rapid development and urbanization of coastal areas in the UAE, which is expected to have pervasive and lasting effects on Gulf ecosystems. For example, in 2002, Dubai commenced construction on a series of large scale artificial island-lagoon complexes along the entire coast of the Emirate (Sale *et al.* 2011). Because of the construction's proximity to coral reefs, the sedimentation buried coral reefs (Sheppard *et al.* 2010; Sale *et al.* 2011), thus affecting fish habitat.

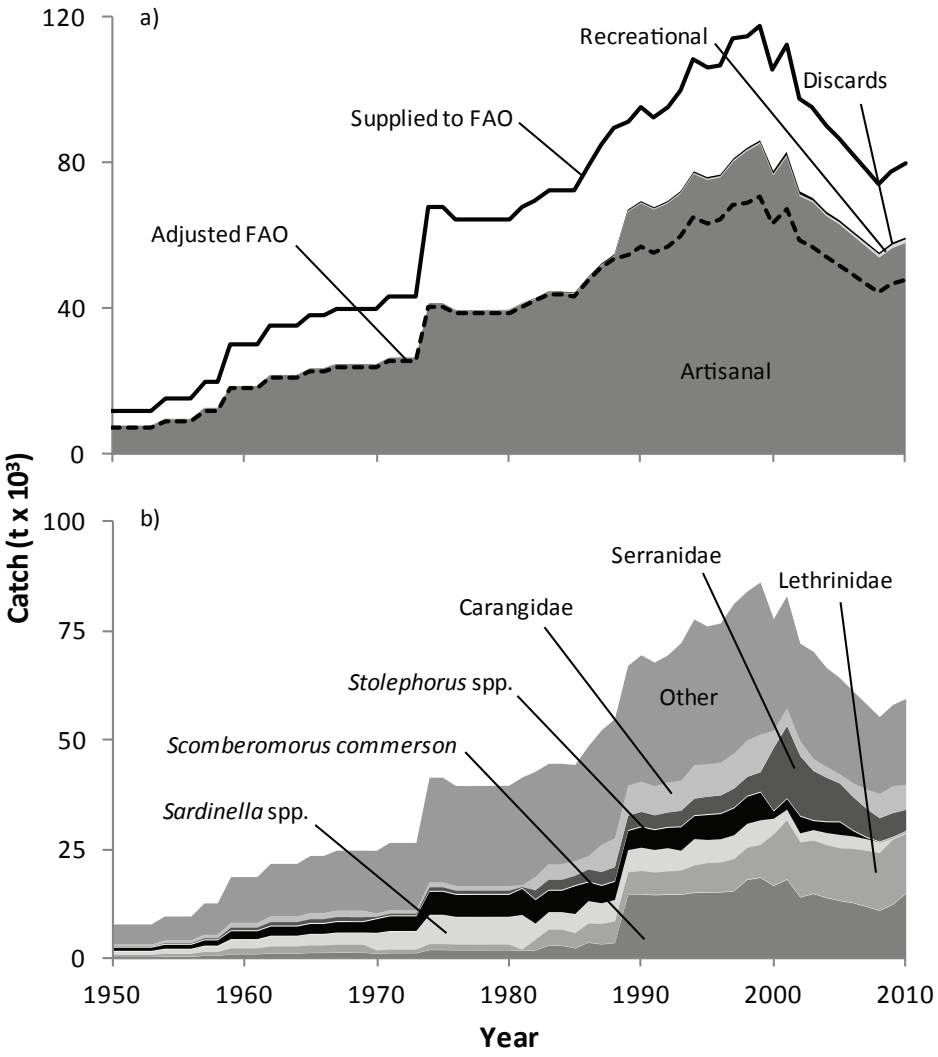

Figure 2. Total reconstructed catch for the United Arab Emirates by a) sector (with the solid line representing the landings data transmitted to FAO and the dashed line the 'adjusted FAO data'); and b) major taxa, 1950-2010. Note that subsistence catches were included in the sector graph (a) but are not visible (too small). Recreational catches are the light coloured area and discards the darker line on top.

The re-estimated catches account for missing sectors including recreational and subsistence catches, as well as discards, illegal catches, and over-reporting errors. Thus, the reconstructed time series may better reflect the catches extracted from the Persian Gulf by the UAE's fisheries from 1950-2010 than the officially reported statistics. While the reconstructed catches are entirely dependent on the assumptions made by this study and despite the considerable data uncertainties associated with the estimates, they seem preferable to the alternative of assuming 'zero' catch for sectors lacking quantitative data.

Finally, it may be noted that it would be appropriate, in subsequent analyses, to reconstruct the UAE's catches along the Gulf of Oman coast, and in the process, to revisit the assumption that these catches did not enter the fisheries statistics considered here.

Acknowledgements

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Appendix Table A1. FAO landings vs. total reconstructed catch (t) for the UAE, 1950-2010, as well as catch by sector.

Year	FAO landings[a]	Total reconstructed catch	Artisanal	Subsistence	Recreational	Discards
1950	7,200	7,900	7,900	0	0	25
1951	7,200	7,900	7,900	0	0	25
1952	7,200	7,900	7,900	0	0	25
1953	7,200	7,900	7,900	0	0	25
1954	9,000	9,700	9,700	0	0	31
1955	9,000	9,700	9,700	0	0	31
1956	9,000	9,700	9,700	0	0	31
1957	12,000	12,700	12,700	0	0	40
1958	12,000	12,700	12,700	0	0	40
1959	18,000	18,800	18,700	0	0	60
1960	18,000	18,800	18,700	1	11	60
1961	18,000	18,800	18,700	1	12	60
1962	21,000	21,800	21,700	1	14	71
1963	21,000	21,800	21,700	1	15	71
1964	21,000	21,800	21,700	2	17	71
1965	22,800	23,600	23,500	2	18	75
1966	22,800	23,600	23,500	2	20	75
1967	24,000	24,800	24,700	2	21	80
1968	24,000	24,800	24,700	2	23	80
1969	24,000	24,800	24,700	2	25	80
1970	24,001	24,800	24,700	3	29	40
1971	25,801	26,600	26,500	3	34	43
1972	25,801	26,600	26,500	4	40	43
1973	25,801	26,600	26,500	5	48	43
1974	40,680	41,500	41,400	5	57	68
1975	40,680	41,500	41,400	6	67	68
1976	38,760	39,600	39,500	7	78	65
1977	38,760	39,600	39,500	9	90	65
1978	38,760	39,600	39,500	10	103	65
1979	38,760	39,600	39,500	11	116	65
1980	38,760	39,700	39,500	12	127	65
1981	40,656	41,500	41,300	13	136	27
1982	41,853	42,900	42,500	14	144	158
1983	43,630	44,700	44,300	15	152	195
1984	43,630	44,700	44,300	15	160	195
1985	43,356	44,400	44,000	16	168	184
1986	47,593	48,700	48,300	17	178	205
1987	51,146	52,400	51,800	18	189	305
1988	53,700	54,900	54,400	19	201	320
1989	54,696	67,100	66,600	20	213	330
1990	57,077	69,500	68,900	22	226	337
1991	55,402	67,900	67,300	23	238	324
1992	57,028	69,500	68,900	24	251	334
1993	59,760	72,300	71,600	25	265	348
1994	65,160	77,700	77,000	27	279	383
1995	63,530	76,100	75,400	28	293	409
1996	64,200	76,800	76,100	30	309	413
1997	68,615	81,300	80,500	31	326	442
1998	68,843	84,100	83,300	33	344	443
1999	70,564	86,200	85,400	35	362	454
2000	63,274	77,800	76,600	36	379	783
2001	67,537	83,000	81,700	38	393	889
2002	58,544	72,200	70,900	39	406	817
2003	57,090	70,300	69,200	41	424	683
2004	54,000	66,600	65,500	44	457	649
2005	52,041	64,300	63,100	49	508	614
2006	49,500	61,300	60,100	56	582	583
2007	46,980	58,400	57,100	65	675	551
2008	44,445	55,400	54,000	74	775	521
2009	46,623	58,100	56,600	83	866	583
2010	47,766	59,500	58,000	90	937	522

[a] Adjusted FAO data that were used as a baseline.

Appendix Table A2. Total reconstructed catch (t) for UAE by major taxa, 1950-2010.

Year	*Scomberomorus commerson*	Lethrinidae	*Sardinella* spp.	*Stolephorus* spp.	Serranidae	Carangidae	Other[a]
1950	420	600	780	720	360	420	4,620
1951	420	600	780	720	360	420	4,620
1952	420	600	780	720	360	420	4,620
1953	420	600	780	720	360	420	4,620
1954	540	720	1,020	900	480	540	5,520
1955	540	720	1,020	900	480	540	5,520
1956	540	720	1,020	900	480	540	5,520
1957	720	960	1,320	1,200	600	720	7,210
1958	720	960	1,320	1,200	600	720	7,210
1959	1,080	1,440	1,980	1,800	900	1,080	10,470
1960	1,080	1,440	1,980	1,800	900	1,080	10,480
1961	1,080	1,440	1,980	1,800	900	1,080	10,480
1962	1,260	1,680	2,340	2,100	1,080	1,260	12,050
1963	1,260	1,680	2,340	2,100	1,080	1,260	12,060
1964	1,260	1,680	2,340	2,100	1,080	1,260	12,060
1965	1,380	1,800	2,520	2,280	1,140	1,380	13,080
1966	1,380	1,800	2,520	2,280	1,140	1,380	13,080
1967	1,450	1,920	2,640	2,400	1,200	1,440	13,750
1968	1,450	1,920	2,640	2,400	1,200	1,440	13,750
1969	1,450	1,920	2,640	2,400	1,200	1,440	13,750
1970	1,210	840	3,900	3,120	600	720	14,380
1971	1,330	900	4,140	3,360	660	780	15,400
1972	1,330	900	4,140	3,360	660	780	15,410
1973	1,330	900	4,140	3,360	660	780	15,420
1974	2,050	1,440	6,600	5,280	1,020	1,140	23,970
1975	2,060	1,440	6,600	5,280	1,020	1,140	23,980
1976	2,000	1,380	6,240	5,040	960	1,080	22,900
1977	2,000	1,380	6,240	5,040	960	1,080	22,910
1978	2,010	1,380	6,240	5,040	960	1,080	22,920
1979	2,010	1,380	6,240	5,040	960	1,080	22,930
1980	2,010	1,380	6,240	5,040	960	1,080	22,940
1981	1,870	380	7,800	6,000	400	380	24,690
1982	1,970	2,540	3,540	5,400	2,230	3,110	24,060
1983	3,040	3,760	3,900	4,920	2,470	3,620	22,970
1984	3,040	3,760	3,900	4,920	2,470	3,620	22,980
1985	2,440	3,550	4,270	6,410	2,330	3,420	21,990
1986	3,750	4,440	5,040	4,300	2,910	3,080	25,170
1987	3,350	4,770	4,620	3,980	3,130	6,370	26,140
1988	3,650	5,000	4,840	4,180	3,280	6,670	27,320
1989	14,790	5,100	5,080	4,380	3,360	7,000	27,420
1990	14,790	5,400	5,340	4,680	3,360	7,060	28,900
1991	14,610	5,220	5,180	4,540	3,240	6,800	28,280
1992	14,710	5,380	5,330	4,670	3,340	7,000	29,070
1993	14,720	5,560	4,540	5,380	3,600	7,020	31,440
1994	15,130	6,310	6,070	5,280	3,800	7,830	33,300
1995	15,200	6,800	5,300	5,720	4,020	7,580	31,510
1996	15,250	6,870	5,360	5,780	4,060	7,660	31,840
1997	15,530	7,350	5,520	6,180	4,340	8,150	34,230
1998	18,130	7,370	5,540	6,200	4,350	8,530	34,000
1999	18,580	7,550	5,710	6,350	4,460	8,760	34,790
2000	16,730	11,790	3,680	1,640	14,430	4,000	25,540
2001	18,190	13,570	2,520	2,420	16,610	4,120	25,620
2002	14,100	12,630	2,100	3,840	13,700	3,550	22,280
2003	14,910	12,190	2,480	2,070	11,290	2,930	24,470
2004	13,960	12,120	2,820	2,460	10,020	2,580	22,670
2005	13,290	12,070	3,110	2,890	8,710	2,260	21,990
2006	12,800	12,450	2,880	1,200	7,620	3,360	21,000
2007	11,960	12,840	2,700	300	6,480	4,560	19,510
2008	11,060	13,220	2,440	0	5,390	5,680	17,590
2009	12,430	14,880	500	0	5,490	6,290	18,550
2010	15,020	13,650	490	0	4,870	5,840	19,670

[a] Others category includes 41 additional taxonomic groups.