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Historical dynamic of the traditional fish landings and fishing efforts along the Omani Coast

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Abstract
The Omani traditional fishery is an open access fishery like any other open access fisheries around the world. The current study reviews and analyses the landings and fishing effort of the traditional fisheries at the group level of, small and large pelagics and demersals between the years 1995 and 2018. The traditional fishing efforts (number of boats and fishermen) have been increasing steadily during the years. The number of fishermen increased annually between 1097 and 1126 and the number of fishing boats increased between 521 and 550. The total catch increased steadily as well reached its maximum in 2018 with a total catch of 5,22,533 tons, which recorded a 60% increment from 2017. The small-pelagic landings increased almost three-fold in 2018 as compared to 2017 landings. This study estimated the maximum sustainable yield and its affiliated effort and the findings are discussed thoroughly.

Keywords: Oman, traditional fisheries, fish landings, fishing effort, MSY

Introduction

With respect to administrative purposes, Oman is divided into 11 governorates (*Muhafazat*), eight of these are located along the coastal line (Fig. 1). These are from North to south, Musandam, North and south Al Batinah, Muscat, North and South Sharqiyah, Al Wusta, and Dhofar. These governorates are further divided into different provinces (*Wilayat)*. In 2019, the estimated population of Oman is 4.97 million [World Population Prospects (2019 Revision)]. During the past decade the population of Oman increased rapidly, as a result the number of traditional fishermen and fishing efforts also increased significantly.

Fishing along the Oman coast has been carried out for a long time with a coast line of 3165 km, which is open to the Arabian sea, Gulf of Oman, and the Arabian Gulf. Oman's coastal traditional fisheries contribute significantly to the total fish production within the country (MAFW, 2018–1988). In 2018, traditional fishery contributed to 99% of the total landings (MAF, 2018) [12].

It is well known that marine and traditional fisheries provide important sources of income, food, and job opportunities. In developing countries, the traditional fisheries are considered to be even more important as an easy source of income as it contributes to 25% of the world landings (Mathew, 2001) [10]. Hence, understanding the dynamics of these coastal traditional fisheries is considered as a priority for fishery scientists and managers for development and sustainability purposes.

All the Omani traditional fishermen, must obtain a fishing license irrespective of being full time or part time; however, the type and amount of fish to catch or gear to be used and the frequency of fishing are not identified. Like many other part-time fishermen around the world, these fishermen are also mostly driven to the fishery based on the market demand and the availability of free-time (Trevor *et al*., 2006) [15]. In addition, most of these part-time fishermen use passive gears for fishing and operate mostly during the weekends or while at annual leaves from their regular jobs and engage themselves for fishing near the coast line. However, these part-time fishermen could be opportunistic fishermen, that is whenever, the market demands for fish they will join the fishery. This behaviour of fishermen makes it very difficult to estimate the real annual fishing effort and this eventually causes depletion of fish stocks due to open access and the problem of the common property (Dwi *et al*., 2018; Trond and Jon 2008; Hartwick 1982; Hardin 1968) [2, 16, 7. 5].

The rapid increase in the traditional fishing fleet (both fishing boats and fishermen) and consequently the sharp increase in the total fish landings over the past decades led to the current analysis of fish landings and fishing effort study. The objectives of the present study are therefore: (a) To review the finfish landings and efforts (number of boats and number of fishermen) for the last 24 years (1995–2018); (b) To review and analyze the exploitation status of the Omani finfish fisheries by estimating the maximum sustainable yield (MSY) and the catch per unit of effort (CPUE).

Fig 1: Map of Oman showing different governorates

Materials and Methods

For the current review and analysis, landings (nominal catches) and fishing effort (number of fishermen and total number of fishing boats) data for the traditional fishery along the coast of Oman were extracted from the Ministry of Agriculture and Fisheries Wealth statistics Year Book for the years 1995–2018 (MAF 1995–2018) [12]. The data were obtained only for finfishes since they make the most of the fish landings. These data are reported by the ministry into fish group levels rather than fish species. These data are divided into groups (large pelagics, small pelagics, and demersals) by the Ministry Year Books. The type of fishes included under each of these groups are listed in Table 1 by species. All other fish types including sharks, rays, crustaceans, and mollusks were excluded from the study.

The ministry compiles the fishery statistics data from different fishing villages and landing sites along the Omani coastal regions (Table 2) and makes it available to the interested parties. The fishery statistics are disseminated yearly through the Ministry's Annual Year Book.

Table 1.: Valuable finfishes used in the analysis and normally reported in the Ministry's annual statistics Under Groups levels (small pelagics, large pelagics, and demersals)

Small pelagics	Large Pelagics	Demerslas
Moolgarda seheli	Auxis thazard	Arius thalassinus
Mugilidae	Scomber japonicus	Lutjanus malabaricus
Mugil cephalus	Thunnus albacares	Lutjanus rivulatus
Liza subviridis	Scomberoides commersonnianus	Lutjanus madras
Chirocentrus dorab	Scomberoides tala	Lutjanus coeruleolineatus
Small pelagic	Katsuwonus pelamis	Lutjanus bengalensis
Hemiramphus spp	Chanos chanos	Lutjanus ehrenbergii
Hemiramphus far	Pomatomus saltatrix	Trichiurus lepturus
Parastromateus niger	Sarda orientalis	Lethrinus lentjan
Megalaspis cordyla	Thunnus tonggol	Lethrinus harak
Decapterus kurroides	Seriolina nigrofasciata	Lethrinus nebulosus
Selaroides leptolepis	Caranx lugubris	Lethrinus microdon
Selar crumenophthalmus	Seriola dumerili	Lethrinus mahsena
Atule mate	Alectis indica	Atractoscion aequidens
Alepes djedaba	Carangoides armatus	Umbrina ronchus
Carangoides equula	Caranx heberi	Argyrosomus heinii
Rastrelliger kanagurta	Carangoides bajad	Pseudotolithus senegalensis
Herklotsichthys quadrimaculatus	Carangoides fulvoguttatus	Protonibea diacanthus
Sardinella gibbosa	Carangoides chrysophrys	Otolithes ruber
Sardinella albella	Caranx melampygus	Siganus siganus
Sardinella longiceps	Carangoides malabaricus	Siganus sutor
Nematalosa nasus	Trachinotus africanus	Siganus canaliculatus
	Trachinotus botla	Siganus javus
	Trachinotus blochii	Pristipomoides multidens
	Elagatis bipinnulata	Pristipomoides typus
	Caranx ignobilis	Pristipomoides filamentosus
	Caranx sexfasciatus	Parupeneus heptacanthus
	Gnathanodon speciosus	Mulloidichthys vanicolensis
	Carangoides gymnostethus	Parupeneus barberinus
	Euthynnus affinis	Parupeneus macronema
	Sphyraena barracuda	Parupeneus cyclostomus
	Sphyraena jello	Upeneus sulphureus
	Sphyraena forsteri	Mulloidichthys flavolineatus
	Sphyraena obtusata	Nemipterus bipunctatus
	Scomberomorus commerson	Nemipterus japonicus
	Acanthocybium solandri	Psettodes erumei
	Istiophorus platypterus	Plotosus spp
	Xiphias gladius	Ephippidae
	Istiompax indica	Cynoglossus bilineatus
		Acanthopagrus bifasciatus
		Cheimerius nufar
		Rhabdosargus sarba
		Acanthopagrus latus
		Argyrops filamentosus
		Argyrops spinifer
		Pagellus affinis
		Plectorhinchus pictus
		Plectorhinchus schotaf
		Plectorhinchus flavomaculatus
		Plectorhinchus playfairi
		Pomadasys commersonnii
		Pomadasys argenteus
		Epinephelus tauvina
		Epinephelus radiatus
		Epinephelus stoliczkae
		Epinephelus epistictus
		Epinephelus diacanthus
		Epinephelus areolatus
		Epinephelus chlorostigma
		Epinephelus tukula

Table 2: Major fish landing sites used by the Ministry of Agriculture and Fisheries wealth for fish statistics data collection, distributed by Regions or governorates and wilayat (W) (states)

Musandam Region		Al-Batinah Region		Muscat Region		Al-Sharqiah Region		Al-Wusta Region		Dhofar Region	
Wilayat Bukha		**W. Shinas**		**W. Seeb**		**W. Jalaan Bani Bu Hassan**		**W. Mahoot**		**W. Salalah**	
algari	bukha port	shinas port	alaludaet	alseeb souq		garoon		film	alnakda	dahariz	maghsil
W.Khasab		albuladh	asrar omar	**W. Muscat**		**W. Jalaan Bani Bu Ali**		ras ruwais	khlouf	raysut	alhaffah
khasab port	nadhi	um alena	sur alabri	sidab		alashkarah	aldaffah	serab	sedrah	**W. Rakhyut**	
hana		sur almazari	hamra	**W. Mutrah**		algefin	bander jadeed	**W. Al-duqum**		rakhyut beach	
W. Dabba		alfarfath		mutrah souq		alhdah	alkhabah	ras duqum	ajwairah	**W. Dhalkut**	
dabba port		**W. Liwa**		**W. Qurayat**		khuwaimah	ruwais	daythab	ras madrakah	dhalkut beach	
		hamool		qurayat beach	dagmar	asilah	suwaih	shuair	nafun	**W. Mirbat**	
		W. Sohar		bama		ras ruwais		haitam		mirbat jetty	
		sohar souq	alafefa			**W. Sur**		**W. algazer**		**W. Taqah**	
		W. Saham				sur beach	fins	soqrah	lakbi port	taqah beach	
		saham souq				ras alhad	tiwi	mader		**W. Sadah**	
		W. Al-khabura				kalhat				hasek	had been
		khbura souq	abbasa			**W. Masirah**				sadah beach	
		W. Al-Suwaiq				ras asia	gshar shaiq			**W. Shaleem**	
		suwaiq souq				haqail	alhaar			sharbithat	shuwaimiyah
		W. Al-Musana'a				masirah port	alaejah			halanyat	
		musanaa souq	widam								
		W. Barka									
		barka souq	alsawadi								

The MSY, the affiliated fishing effort at the maximum sustainable yield (Fmsy), and the CPUE were calculated by using the Schaefer model, where

$MSY = a_{2/4} * b$, $Fmsy = -a/2 * b$, and $CPUE = a + bf$

where "a" is the intercept and "b" is the slope, and "f" is the fishing effort (number of boats).

Results

The fish landings in Oman increased from 1,95,006 t in 2017 and reached 5,22,533 t in 2018, almost an increase of 60%. The traditional fishery which is dominated by 5- to 9-meter-powered fiber-glass boats contributed for 99.1% to the total landings. For the last decade, starting from 2007, the number of fiber-glass boats were reported to be 13,862, while the total number of traditional fishermen were 34,757. Hence, an increase of 10,850 boats in the traditional fishing fleet versus 14,958 fishermen. In 2018, the number of traditional fishing boats were reported to be 23,726, which is an increase of 150%. On the other hand, the number of licensed fishermen reached 49,715, an increase of 110%.

The total fish landings in Oman increased rapidly since 2011–2018. Through the years 1995–2010, landings increased by 1,50,068 t, while the landings increased sharply by (37%) 2,05,905 t only within 2 years, that is 2017 and 2018 (Fig. 2). The lowest recorded landings were in 1998, that is 1,06,105 t, while the highest were observed in 2018, that is 5,53,445 t. During the period 1995–2018, the finfishes collectively contributed to 97% of the total Oman traditional landings. Average small-pelagics landings contributed the highest among the finfish landings (42%). On the other hand, average large-pelagics and demersal landings contributed almost the same, 28 and 27%, respectively (Fig. 3).

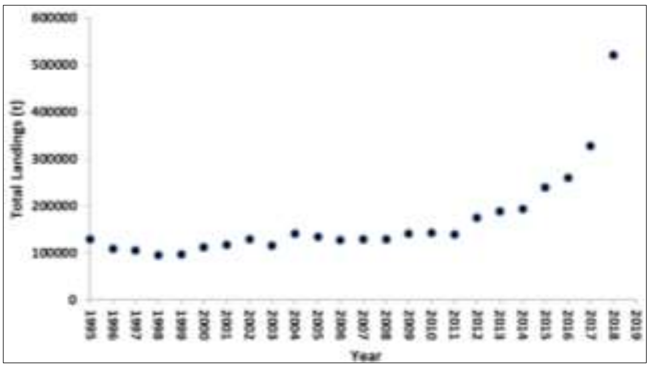

Fig 2: Total fish landings in Oman during 1995–2018

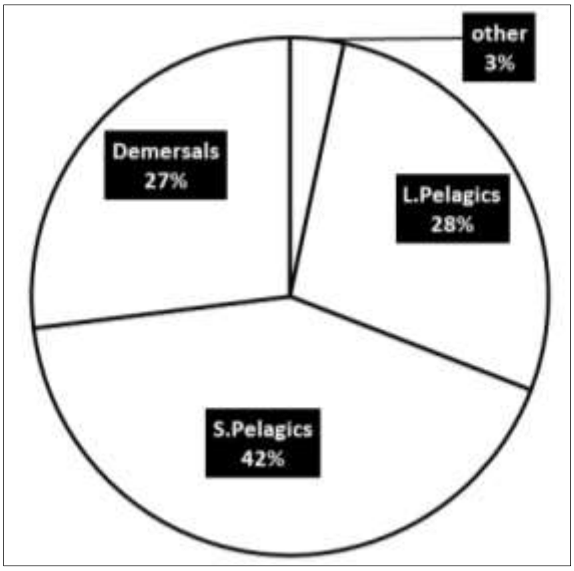

Fig 3: Average percentage contribution of each finfish category (group) to the total average of total fish landings in Oman for the period 1995–2018

During the years 1995–2018, in the year 2018 the highest landings for the large and small pelagics were recorded, 3,38,905 t and 1,01,783 t, respectively. While the highest for the demersals were recorded in 2017, reaching 81,845 t. The highest annual increment for the large pelagics was recorded in 2015 an with increase of 18,755 mt from 2014 (38%). The highest drop in the large-pelagic landings was in 1996, when the landings dropped by 9548 mt, that is, a drop of 18% from 1995. On the other hand, the highest annual increment in the small-pelagic landings was 1,80,845 mt in 2018, increasing (114%) from 2017. The highest drop for the small pelagics was recorded in 2002, dropping up to 16,463 mt (25%) from 2001. The demersals experienced the lowest drop in landings in the year 2001. The landings dropped by 7355 mt, that is, by 22% from 2000 (Table 3).

Large-pelagic fish landings showed a fluctuation with a low landing period from 1998 to 2003. The landings slowly started to pick up again during the years 2004–2007. The landings dropped again in 2007–2010 before they started to sharply increase in 2011–2018. In 2001, the lowest landings were recorded, 25,525 t, while in 2018, the highest landings were recorded, 1,01,713 t. The CPUE for the large pelagics showed no pattern and fluctuated between 1.90 t/boat/y to

4.44 t/boat/y with an average of 2.92 t/boat/y. However, the highest CPUE observed was in 1995 when it was estimated at 4.44 t/boat/y (Fig. 4).

Small-pelagic fish landings were almost stable from 1995 to 2011 before they sharply started to increase from 2011 to 2018. In 2018, the small-pelagic landings reached the highest ever recording 3,38,904 t and increased by 1,42,022 t (almost three times, 366%) as compared to 2017 landings. The CPUE for the small pelagics ranged between 2.17 and 14.28 t/boat/y with an average of 4.15 t/boat/y (Fig. 5).

Apart from 1995 to 2001, the total demersal-fish landings increased gradually from 2002 to 2018. Unlike the landings for both large and small pelagics, the year 2018 recorded a minor drop in the landings of demersal fishes as compared to 2017. In 2001, the lowest landings were recorded, 25,939 t, as compared to the highest in 2017, 86,293 t. The CPUE fluctuated between 1.93 and 3.71 t/boat/y with an average of 2.87 t/boat/y (Fig. 6).

Table 3: Annual total landings and their annual increments and catch per unit of effort based on fishing licenses and boats and their annual increments for the years 1995–2018

Annual Total Large pelagic fishe landings, total Small pelagic fish Landings and total demersal fish landings																
	Large Pelagics				Small Pelagics				Demersals				fishing licenses		Fishing Boats	
Year	Landings	Annual Increment	Mt/license	Mt/Boat	Landings	Mt/license	Mt/Boat	Annual Increment	Demersals	Mt/license	Mt/F.Boat	Annual increment	numbers	Annual Increment	numbers	Annual Increment
1995	52069		2	4	41496	2	4		35253	1	3		24489		11732	
1996	42521	-9548	2	4	33551	1	3	-7945	33450	1	3	-1803	25575	1086	11732	0
1997	41027	-1494	2	3	25451	1	2	-8100	38634	1	3	5184	26096	521	11746	14
1998	32828	-8199	1	3	30684	1	2	5233	32713	1	3	-5921	26944	848	12284	538
1999	30905	-1923	1	2	31365	1	2	681	34186	1	3	1473	27516	572	12585	301
2000	27543	-3362	1	2	51538	2	4	20173	33294	1	3	-892	28575	1059	13248	663
2001	25525	-2018	1	2	66607	2	5	15068	25939	1	2	-7355	29333	758	13464	216
2002	31845	6319	1	2	50144	2	4	-16463	47150	2	3	21210	30421	1088	13652	188
2003	34116	2272	1	2	41868	1	3	-8276	40534	1	3	-6615	31587	1166	13831	179
2004	49096	14979	2	4	49158	2	4	7289	42598	1	3	2064	32434	847	13943	112
2005	45221	-3875	1	3	48729	1	4	-428	40698	1	3	-1900	32744	310	13560	-383
2006	41213	-4008	1	3	48904	1	4	175	37406	1	3	-3293	33751	1007	13706	146
2007	43283	2069	1	3	48871	1	4	-33	37895	1	3	489	34757	1007	13862	157
2008	38979	-4304	1	3	51823	1	4	2952	39151	1	3	1256	37520	2763	14796	934
2009	36697	-2282	1	3	54221	2	4	2398	50523	2	4	11373	32140	-5380	14330	-466
2010	37856	1159	1	2	55805	2	3	1584	49774	1	3	-750	36320	4180	18031	3701
2011	41992	4136	1	2	51223	1	3	-4582	47171	1	3	-2603	40161	3841	18027	-4
2012	55131	13139	1	3	70698	2	4	19474	49710	1	3	2539	42553	2392	19245	1218
2013	54371	-761	1	3	79466	2	4	8768	54476	1	3	4765	44521	1968	20630	1385
2014	49465	-4906	1	2	89459	2	4	9993	54525	1	3	49	45635	1114	21616	986
2015	68220	18755	1	3	110613	2	5	21155	61141	1	3	6616	46837	1202	22237	621
2016	76898	8679	2	3	119237	2	5	8624	63492	1	3	2352	47899	1062	22720	483
2017	83174	6275	2	4	158060	3	7	38823	86293	2	4	22801	49299	1400	23232	512
2018	101783	18609	2	4	338905	7	14	180845	81845	2	3	-4448	49715	416	23726	494
Average	**47573**	**2161**	**1**	**3**	**72828**	**2**	**4**	**12931**	**46577**	**1**	**3**	**2026**	**35701**	**1097**	**16164**	**521**
min	**25525**	**-9548**	**1**	**2**	**25451**	**1**	**2**	**-16463**	**25939**	**1**	**2**	**-7355**	**24489**	**-5380**	**11732**	**-466**
max	**101783**	**18755**	**2**	**4**	**338905**	**7**	**14**	**180845**	**86293**	**2**	**4**	**22801**	**49715**	**4180**	**23726**	**3701**

The average total large-pelagic landings for the years 1995–2018 was 47,573 t with an overall annual increment of 2161 mt per year. On the other hand, the average small-pelagic landing was 72,828 t with an overall increment of 12,931 t per year. The average demersals landings was 46,577 t with an overall increment of 2026 t per year (Table 3).

\Annually, the fishing licenses increased by 1097, while the number of boats increased by 521 boats per year. Both the number of fishermen and the number of boats experienced a decrease in 2009. The number of fishermen decreased by 14% while the number of boats decreased by 3% only (Table 3). The regression showed a steady increase in the fishing effort, with an annual increase in the number of boats and fishing licenses by 550 and 1126, respectively (Fig. 7).

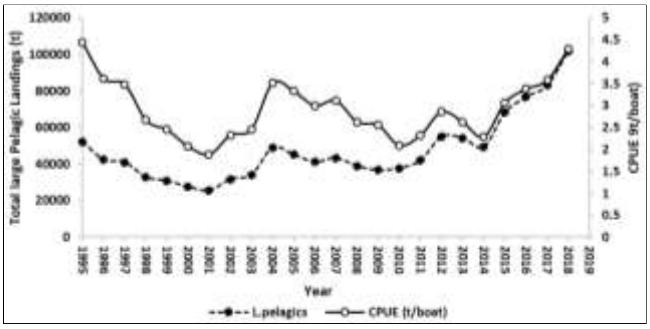

Fig 4: Total large-pelagic fish landings and catch per unit of efforts for the years 1995–2018

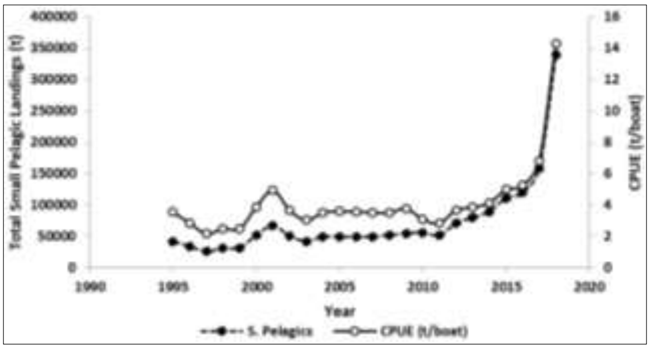

Fig 5: Total small-pelagic fish landings and catch per unit of effort for the years 1995–2018

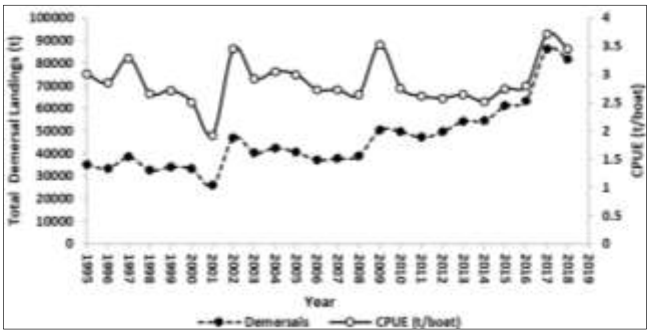

Fig 6: Total demersal-fish landings and catch per unit of effort for the years 1995–2018

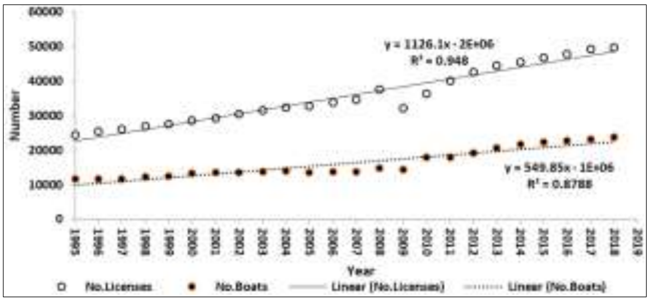

Fig 7: Number of fish license and fishing boats during the years 1995–2018

Catch per unit of effort

Catch per unit of effort for the large pelagics for the years 1995–2018 resulted in a positive correlation (Fig. 8).

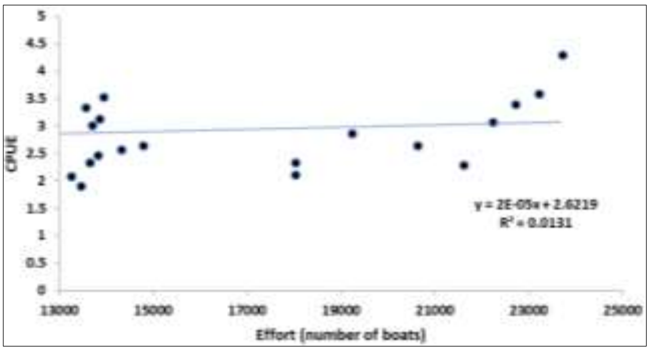

Fig 8: Total large-pelagic fishes catch per unit of effort against effort (total number of boats) for the years 1995–2018

This positive correlation does not fit the Schaefer model assumption. However, owing to the landing patterns identified with the large-pelagic landings, the landing dataset were divided accordingly into four sets, 1995–2003, 2004–2011, 1995–2010, and 2012–2018 (Fig. 9). The MSY and the F_{MSY} were calculated for each period.

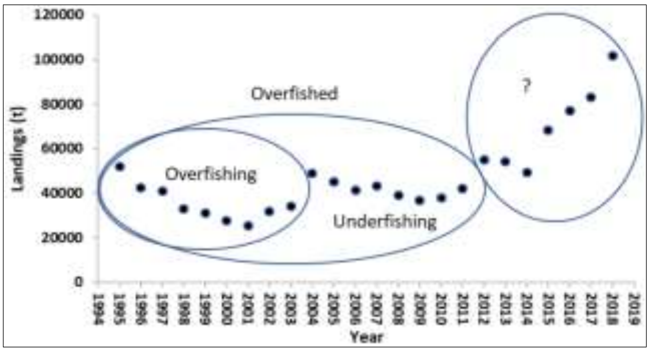

Fig 9: Total Omani large-pelagic landings in tons for the years 1995–2019 are divided into four different patterns 1995–2003 (overfished), 2004–2011 (underfished), 1995–2010 (overfished), and 2012–2018 (does not fit the Schaefer model)

During the period 1995–2003 the MSY calculated was 52,058 t for 8164 fishing boats. This indicated overfishing during the period as the average number of boats were 12,710 catching an average of 35,376 t (more effort bringing less catch than expected).

During the period 2004–2011 the MSY calculated was 47,946 t for 15,590 fishing boats. This indicated an underfishing as the average number of boats were 15,032 catching an average of 41,792 t.

During the period 1995–2010 the MSY calculated was 38,773 t for 12,905 fishing boats. This indicated overfishing, as the average number of boats were 13,531 catching an average of 38,170 t (more effort bringing less catch than expected).

Between 2012 and 2018, the correlation between CPUE against fishing efforts was positive and MSY and the affiliated fishing efforts could not be calculated.

For the demersals, CPUE against the effort for the years 1995–2018 resulted in a positive correlation (Fig. 10). This positive correlation does not fit the Schaefer model assumptions. The dataset was divided into four sets according to the patterns observed in Fig. 11, 1995–2008, 1995–2001, 2002–2008, and 2009–2016.

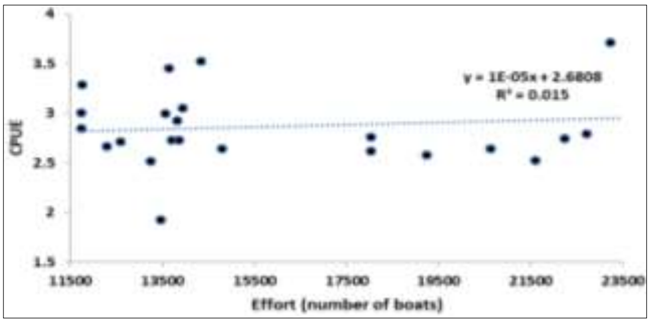

Fig 10: Total demersal fish catch per unit of effort against effort (total number of boats) for the years 1995–2018

During the period 1995–2008, the MSY calculated was 50,952 t at F_{MSY} for 27,257 fishing boats. This indicated underfishing during the period as the average number of boats were 13,153 catching an average of 37,064 t.

During the period 1995–2001, the MSY calculated was 40,210 t at F_{MSY} for 8820 fishing boats. This indicated overfishing during the period as the average number of boats were 12,398 catching an average of 33,353 t (more effort bringing less catch than expected).

During the period 2002–2008, the MSY calculated was 43,436 t at F_{MSY} for 11,170 fishing boats. This indicated overfishing during the period as the average number of boats were 13,907 catching an average of 40,776 t (more effort bringing less catch than expected).

Between 2009 and 2016 the MSY calculated was 59,323 t at F_{MSY} for 27,554 fishing boats. This indicated underfishing during the period as the average number of boats were 19,605 catching an average of 53,851 t.

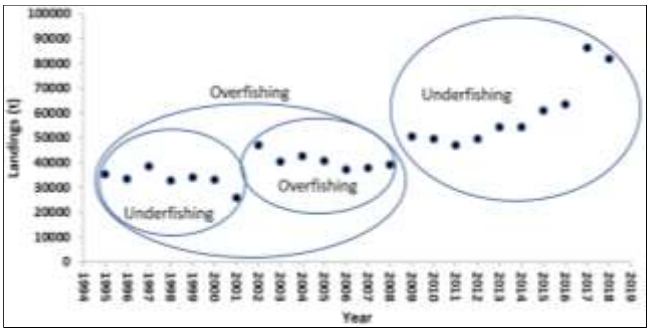

Fig 11: Total Omani demersal fish landings in tons for the years 1995–2019 are divided into four different patterns 1995–2008 (underfished), 1995–2001 (overfished), 2002–2008 (overfished), and 2009–2016 (underfished)

No landing patterns were observed for the small-pelagic fishes, and the CPUE against the effort was positive for the total small-pelagics fishery during the review period, hence the estimation of MSY and F_{MSY} was dismissed.

Discussion

The fish landings in Oman exhibited a different landing pattern depending on the fishery type (small or large pelagics and demersals). With an open access to traditional fishery, it is difficult to control or predict the annual actual fishing effort since it could be a function of different unexpected variables. Not all the 49,715 fishermen in Oman are considered to be active, a number of these fishermen (not known) are part timers and not active unless they get an opportunity. These fishermen enter the fishery when they believe there is good income. The intensity of fishing rate and the fishing gears used in addition to the fishing frequency could be increased and decreased accordingly. Furthermore, the fish type to be targeted is unpredictable. Market demand could easily result in a rush to catch and overfish any unexpected fish, whether the fish is previously defined as valuable or not. This sudden change in the fishing behaviour results normally in an increase in the fishermen income at the beginning of the fishery but owing to the higher number of fishermen who become active and enter the fishery the income decreases faster as well. Such behaviour has more negative effect on the income of the full timers. If the license given to the fishermen is treated as a "document" to grant a fishermen the right to catch without further controlling the total allowable catch, fish size, season, area, time to land, gear restriction, etc then these issued "fishing licenses" to catch do not serve the purpose of controlling fish catch. As a result, the fishery resources under such regimes can be described as "common properties under the licensing system".

The on and off fishing behaviour of the total licensed Omani traditional fishermen towards their fisheries is not different from other similar fishermen around the world. This behaviour is controlled by the dynamics of the fish market demand and supply, new fishing technology or fishing efficiency and their prices, environmental conditions, data accuracy, and fishermen behaviour among others (Maunder *et al*., 2006; Watters and Maunder 2001; Fonteneau *et al*., 2004) [8, 4, 18, 4]. The case of Oman is complicated with its long coast line and the distribution of the fishermen along it. As all the previous variables differ from one region to another along the coast, it makes it very difficult to combine catch and effort data and estimate a total MSY for a given type of fishery.

The MSY and the affiliated efforts (F_{MSY}) in terms of number of fishing boats resulted in the conclusion that all the finfish (at the aggregated species level) fisheries are overfished. This is when assuming that all the fishing effort is fully applied homogenously to each of the fin fisheries. An assumption that can be easily argued. This was also supported by other studies along the Oman coast using dataset from 1985–2007 (Alhabsi 2011). The overfishing conclusion, however, was supported by Valinassab *et al*. (2006) [20] who reported several important species (e.g., silver pomfret and croakers) appear to have declined since the late 1970s. Abd El Barr (2016) [11] on the other hand, recently came to the conclusion "*Some demersal fish species were found to be caught in quantities exceeding maximum sustainable yields during some fishing seasons indicating overexploitation of their stocks*". He indicated that an overfishing status of emperors, groupers, sea bream, and rabbit fish as the catches of these fishes exceeded their MSY. At the governorate level, Alhabsi (2011) indicated an overall overfishing along the coast of Batinah and Dhofar. Other publications indicated overfishing at different species levels including sardines and some large pelagics, for example (Darvishi *et al*., 2018; Al-Hosni and Siddeek 1999; Siddeek and Al-Hosni 1998) [3, 14, 1].

In an open-access fishery, reporting whether the fishery is overexploited or not depends on the accuracy of the data used, how the data were collected, and the model used to provide the conclusion. As it is seen in the current review, one could accept the conclusion that a fishery is overfished as the catches are indeed decreasing. However, when the conclusion is "overfishing" but catch is growing positively, such conclusion could be misleading. However, one could conclude, a fishery can be concluded as overfished even while rebuilding. A management interference in this case is vital, see also Bjørndal and Conrad (1987) [1].

CPUE vs effort was divided according the fish landing trends observed over the years. In some periods, the relationship was negatively correlated and in some periods the relationship was positively correlated. Positive correlations were observed in years where the landings were decreasing, while the positive correlations were observed where the landings were rapidly increasing. The positive correlation was observed prior to overfishing periods. Positive correlation between CPUE against effort could indicate a stock rebuilding or it confirms to the overfishing observed in the prior periods. Same correlations were observed in the catch per boat (CPUE) of croaker (*A. aequidens*), sweet lips (*Plectorhinchus* sp.), snappers (*Lutjanus* sp.), jobfish (*P. typus*), ribbonfish (*C. dorab* and *T. lepturus*), and catfish (*A. polystaphylodon*). The correlation increased with increasing number of fishing boats as reported by Abd El-Barr (2016) [11] using the 2005–2015 data. On the other hand, negative correlations were observed in emperors (*Lethrinus* sp.), sea breams (*A. bifasciatus* and *A. filamentosus*), groupers (*Epinephelus* sp.) and rabbit fish (*Siganus* sp.). The study by El-Barr resulted in the conclusion that the catches of emperors, groupers, sea breams, and rabbit fish exceeded their MSY. The fluctuation in the CPUE correlation was also observed and discussed in several other publications (Holland and Sutinen 1999; Prince and Hilborn 1998) [6, 13].

It is obvious from the results that reporting the correct MSY could be misleading while dealing with uncertain and inadequate data. In such cases, data could be misinterpreted and the inferences could be misleading. As a conclusion, it is difficult to infer whether the fisheries at the species level are overfished or not. This is owing to the difficulty in estimating and predicting the actual fishing effort involved or the fishing coefficient. At the fish group level (small pelagics, large pelagics, and demersals) and by using total catch versus total fishing effort "all licensed boats or fishermen" reporting whether the fisheries are overfished or not will depend again on how many fishermen or boats were really involved in the fishery. In many cases, there was no obvious relationship between the catch and the fishing effort. The fishing effort in Oman kept increasing steadily while fish landings kept on fluctuating along the years. Such no-relationship was also reported elsewhere (Waters 1991) [17]. Under unrestricted open access fisheries systems estimation of MSY and its affiliated fishing effort could be misleading.

Recommendations

Rapid increase in the fishing effort is evident along the coast of Oman over the years due to the open access system. Given the current review and the analysis of the 1985–2019 data of the traditional fisheries along the Omani coast, it is highly recommended that fishing for some valuable fisheries should be restricted. The implementation of the licensing system on these fisheries should be accompanied with catch and gear limitations, frequency of fishing, and landing time and areas. Regular stock assessment and population dynamics studies for such fisheries is crucial for sustainability. Catch per unit of effort analysis must be applied in known and defined fisheries, by species or area, rather than applying to the whole Omani traditional fishery.

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