



*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

*No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.*

## **Crisis of Sustainability or Perils of Ill-managed Open Access Fisheries? Analysis of Long-term Catch Trends in Marine Fisheries of Maharashtra and India**

**M. Suresha Adiga<sup>a\*</sup>, P.S. Ananthan<sup>a</sup>, H.V. Divya Kumari<sup>b</sup> and V. Ramasubramanian<sup>a</sup>**

<sup>a</sup>Central Institute of Fisheries Education, Versova, Andheri (W), Mumbai-400 061, Maharashtra

<sup>b</sup>Department of Aquaculture, College of Fisheries, Mangalore-575 002, Karnataka

### **Abstract**

The dynamics in the landings of marine fisheries resources in Maharashtra over the past five decades (1961-2010) have been examined after classifying them into 24 different resource groups. The decade-wise compound growth rates (CGR) of different resource groups and coefficient of variation have been calculated. The present status of 25 resource groups has been examined separately based on a simple criterion. The study has revealed that marine fishery in Maharashtra state is facing crisis since late-1990s. Most of the fish stocks that were classified as abundant and less abundant at the country level, have come under declining category in the case of Maharashtra. It indicates that state-wise scenario is different from the national scenario and state-wise understanding of marine fishery resources is very important for formulating regulatory and management measures.

**Key words:** Compound growth rate, decadal fish landings, fisheries, stock status, Maharashtra, India

**JEL Classification:** Q22

### **Introduction**

The marine fish landings in India have fallen by 4 per cent to 3.78 million tonnes (MT) in 2013 from the all-time high of 3.94 (Mt) in 2012 (CMFRI, 2014). Between 1996 and 2009, the marine fish landings have been fluctuating or became almost stagnant. The review of studies on macro level growth trends and stock assessments has revealed that most of the fisheries resources are under stress or over-exploited to maximum sustainable yield (MSY) level; some are fully exploited and only a few remain under-exploited (Srinath, 2003; Srinath and Balan, 2003; Dehadrai and Yadava, 2004; Pillai, 2006). The demersal fisheries, that constitute about 45 per cent of total landings, were over-fished mainly by the mechanized sector (Vivekanandan and Jayasankar, 2008). The economic

loss of juvenile fishing in India was estimated at ₹ 85,558 crore (US\$190 million) which is an indication of the extent of over-exploitation (Najmudeen and Sathiadhas, 2008) and perhaps the impending crisis in the fisheries sector. Vivekanandan *et al.* (2009) have reviewed the status of sustainability of 98 species by constructing a Sustainability Index (SI). On a scale of 1-6, most fishes (68%) had SI values ranging between 3 and 4, indicating a medium level of sustainability. It was found that 12 species had SI values below 3, which may be considered as the vulnerable species.

Based on the rate of exploitation, James (2010) has cautioned that several single species fisheries in India may tilt the marine fish production in any year. The dynamics of marine fish landings in India during the past 60 years were analyzed by Sathianandan *et al.* (2011), who are largely optimistic about the fish landing scenario at the macro level. Of the 26 resource groups

\* Author for correspondence

Email: suresha1947@gmail.com

studied following the method suggested by Mohamed *et al.* (2010), it was found that 18 resource groups fell under the 'abundant' class 5 groups fell under 'less-abundant' class, and 1 group each was under 'declining', 'depleted' and 'collapsed' classes, with important resource groups being either under 'abundant' or 'less-abundant' class. However, the assessment of commercially important marine fish landing trends at the state or provincial level is crucial, at least for two reasons: one, fishing in territorial waters is governed by the respective state governments, and two, availability of different fishery resources and their rate of exploitation are different across states. No detailed long-term catch trend analysis seems to have been carried out in the state of Maharashtra, though changes on a yearly basis are captured in annual reports of CMFRI (CMFRI, 2012). Understanding the pattern and crucial milestones in fish landings over a period of time is *sine quo non* would provide insights into the level of resource exploitation with reference to the potential as well as help prepare appropriate management measures.

In this paper, the dynamics of marine fish landings in Maharashtra have been analyzed over the past five decades. The status of stocks and its sustainability depend on biological, ecological and environmental factors. Various methodologies are available to study the stock status and sustainability of fisheries, which are very complex and need intensive data. Time series landings data on major resource groups provide a broad understanding on the status of stock.

## Materials and Methodology

The data on marine fish production in Maharashtra for the past fifty years (1961-2010) were collected from the publications of Central Marine Fisheries Research Institute, Cochin. The marine species were classified into 24 groups. For Maharashtra, compound growth rates (CGR) were estimated decade-wise for both overall catch and total landings of each species group during 1961 to 2010. The CGR was also estimated for the total and decade-wise landings of India from 1961 to 2010 mainly to compare with the state growth trend. The coefficient of variation (CV) was worked out for each decade and the decadal mean catch was identified to see the trends over the period 1961-2010. The decade-wise percentage contribution of each group to the total state landings during the respective decades

was estimated to see the trend in contribution of major group to state production over a period of time. The decade-wise trend in marine fish landings and major developments in fishery in the state were then summarized.

The present sustainability status of different resources for the state was estimated based on the criteria proposed by Mohamed *et al.* (2010) by classifying resources into five groups, viz., abundant, less-abundant, declining, depleted and collapsed. According to them, since stock abundance data were not available for all the species, it was assumed that catch is proportional to abundance and the historical maximum catch of species (e.g. for past 50 years) was taken as the baseline catch. This assumption reiterates that abundance would be close to the figure for maximum catch. For a comparison, the recent average catch of that species (recent 3 years) was compared to that of the baseline catch in percentage. Deciding a cut-off percentage, though arbitrary, is necessary to classify the stocks. The decision on the cut-off percentage was based on the range of percentages seen and a-prior knowledge of the stock catch and abundance. Based on this, the stocks were classified as the stocks as abundant (recent average catches >70% of the historical maximum); less-abundant (50-69%); declining (11-49%); depleted (6-10%) and collapsed (< 5%). In the present study, percentage contributions of these five groups to average total state catch for the past ten years (2001-2010) and for past three years (2008-2010) were identified.

## Results and Discussions

### Total Marine Fish Landings in Maharashtra

Over the past five decades, India's marine fish catch has witnessed a tremendous growth with average landings increasing from 8,32,426 tonnes during 1961-1970 to 27,38,943 tonnes during 2001-2010. During the period 1961-1970 to 1990-2000, the marine fish production in Maharashtra also showed an increasing trend. Maharashtra's contribution to India's average landings decreased from 16.63 per cent during 1961-1970 to 12.59 per cent during 2001-2010. The decadal mean catch, coefficient of variation, growth rates in India and Maharashtra marine landings are summarized in Tables 1 and 2, respectively. Over the decades, the state average landings increased significantly whereas the compound growth rate decreased. The analysis of

**Table 1. Decadal mean catch and coefficient of variation (CV) for marine fisheries in Indian and Maharashtra**

Period	Mean catch (tonnes)		CV		Percentage of Maharashtra to India
	India	Maharashtra	India	Maharashtra	
1951-1960	664527	-	19.15	-	-
1961-1970	832426	138398	15.62	16.12	16.63
1971-1980	1259624	247097	9.91	14.21	19.62
1981-1990	1692597	306175	15.84	11.04	18.09
1991-2000	2408687	349536	7.50	10.29	14.51
2001-2010	2738943	344888	11.85	17.29	12.59
1961-2010	1786455	277219	41.39	31.67	15.52

**Table 2. Decade-wise compound growth rates (CGR) of marine fish catches for India and Maharashtra, 1961-2010**

Period	CGR	
	India	Maharashtra
1951-1960	4.90	-
1961-1970	5.15	4.03
1971-1980	2.26	3.09
1981-1990	5.00	3.16
1991-2000	2.04	0.41
2001-2010	3.55	-4.69
1961-2010	3.11	2.15

growth trend in Maharashtra marine fish landings for different decades for the period 1961-2010 showed an increase in the decade of 1961-1970, as indicated by the compound growth rate of 4.03 per cent. During the decade 2001-2010, the catches declined with a negative growth trend of -4.69 per cent and the maximum percentage of variation in catch was observed in the same decade. The historical maximum annual landing in the state was recorded in the year 2002, and after that landings decreased.

### **Beginning of Mechanization in Fisheries: 1961-1970**

Prior to 1960, the majority of marine resources was landed mainly by the traditional non-mechanized fishing crafts and artisanal gears like dolnet, rampani and gill net. The fishing activities in that period were carried out in the inshore and near shore waters within 20-25 m depth. During the decade of 1961-1970, mechanization of the traditionally used bag net, gill

net and long line fishing crafts was vigorous. The annual landings in the state of Maharashtra increased from 1.16 lakh tonnes in 1961 to 1.92 lakh tonnes in 1970 with a decadal mean catch of 1.38 lakh tonnes. Around 4.03 CGR was observed during the decade and the inter-year growth rate during the decade showed a significant difference (Table 3).

The major resources contributed to the fishery during 1961-1970 were: crustaceans (31.7%), bombayduck (19.41%), clupeids (8.37%), croakers (6.64%), pomfrets (5.54%), mackerel (3.49%), ribbonfish (3.45%), catfish (3.32%), eels (3.05%) and elasmobranchs (3.02%). The majority of resources showed a positive trend in growth as indicated by the CGR mainly because of mechanization of nearly 50 per cent of traditional crafts and introduction of trawling with extension of fishing beyond 30-40 m depth during this period. The inter-year growth rate during this decade for the overall landings showed a significant difference. Four resources, viz. eel, unicorn cod, perches and goatfish, showed negative trends in the growth. The decade showed a wider variation in landings of major groups, indicating relative instability in the catch during this period.

### **Synthetification of Gears: 1971-1980**

During 1971-1980, the annual marine landings increased from 2.15 lakh tonnes in 1971 to 2.93 lakh tonnes in 1979 with a decadal average of 2.47 lakh tonnes. The mechanization of fishing crafts continued vigorously during this period and also traditionally used cotton nets were completely replaced by the synthetic nets, which led to increased operations of dolnet by 2-3 times and increase in the landings of the majority

**Table 3. Mean fish catch, coefficient of variation (CV), compound growth rate (CGR) and per cent contribution of various major fish groups in Maharashtra state during 1961-1970**

Fish group	Mean catch (tonnes)	CV	CGR	% of total state landings
Overall	138398	15.62	4.03	-
Crustaceans	43891	18.59	4.02	31.71
Bombayduck	26858	13.04	1.52	19.41
Clupeids	11577	11.58	3.02	8.37
Croakers	9191	19.46	0.61	6.64
Pomfrets	7667	47.89	8.17	5.54
Mackerel	4832	149.35	12.64	3.49
Ribbonfish	4768	42.55	10.04	3.45
Catfish	4600	54.96	15.76	3.32
Eel	4224	68.43	-10.41	3.05
Elasmobranchs	4195	28.87	6.50	3.03
Unicorn cod	3211	41.19	-9.99	2.32
Perches	2147	57.29	-11.81	1.55
Carangids	1739	104.31	23.44	1.26
Threadfins	1297	78.68	1.84	0.94
Seerfish	1254	51.58	14.61	0.91
Goatfish	927	124.77	-1.79	0.67
Silverbellies	660	132.62	13.66	0.48
Lizardfish	289	146.52	24.10	0.21
Tunas	265	82.29	2.48	0.19
Flatfish	248	168.68	41.39	0.18
Whitefish	210	85.68	22.18	0.15
Mullets	176	73.86	14.76	0.13
HB&FB	131	92.67	26.05	0.09
Molluscs	76	122.28	15.80	0.06

of fish species groups (Table 4). The increase in total fish landings was also due to multi-day trips by the shrimp trawlers (2-3 days/trip) that ventured beyond territorial waters in the depth range of 25-40 metres. The landings of demersal resources like perches, croakers and mollusks, increased as trawlers began to target these demersal resources in addition to shrimps. Meanwhile, the mean catch of resources like mackerel, eel, unicorn cod, goatfish, silverbellies, halfbeak and fullbeak (HB and FB) and mullets decreased in this decade as compared to in the previous decade. The resources in the order of abundance were: crustaceans (36.41%), bombay duck (18.5%), clupeids (9.66%), croakers (6.73%), pomfrets (4.42%), catfish (4.19%) and ribbonfish (3.15%). Though the mean catch increased in crustaceans and catfish, the overall growth

rate showed a negative trend, as indicated by the CGRs (-0.71% and -3.91%), mainly because of higher fluctuations in landings between the years.

#### **Introduction of Purse Seiners and Multi-day Trawling: 1981-1990**

The decadal mean catch increased from 2.47 lakh tonnes in 1971-1980 to 3.06 lakh tonnes in 1981-1990 with a growth rate of 3.16 per cent and the inter-year growth rate showed a significant difference during the decade. Out of 24 groups of fisheries, 20 groups showed an increasing trend in their landings during the 1980s (Table 5). The demersal resources like croakers, pomfrets, molluscs, perches, flatfish, lizardfish and eels, showed a drastic increase in this decade compared to the previous decade. The increased landings in



**Table 4. Mean fish catch, coefficient of variation (CV), compound growth rate (CGR) and per cent contribution of various major fish groups in Maharashtra state during 1971-1980**

Fish group	Mean catch (tonnes)	CV	CGR	% of total state landings
Overall	247097	14.21	3.09	-
Crustaceans	89976	14.48	-0.71	36.41
Bombayduck	45717	31.35	10.84	18.50
Clupeids	23865	19.35	2.82	9.66
Croakers	16638	19.09	3.50	6.73
Pomfrets	10923	39.55	10.44	4.42
Catfish	10358	28.81	-3.91	4.19
Ribbonfish	9681	21.08	2.71	3.92
Elasmobranchs	7791	26.99	7.50	3.15
Eel	3044	45.11	8.83	1.23
Perches	2834	57.54	15.35	1.15
Seerfish	2415	34.29	10.50	0.98
Mackerel	2232	71.19	-22.97	0.90
Carangids	2173	24.27	1.49	0.88
Threadfins	1939	44.03	1.11	0.78
Unicorn cod	1776	112.32	-42.22	0.72
Molluscs	1472	104.17	30.42	0.60
Flatfish	1376	53.82	11.26	0.56
Lizardfish	1004	64.8	22.87	0.41
Tunas	805	82.56	22.79	0.33
Goatfish	577	55.88	-6.36	0.23
Silverbellies	517	43.76	0.95	0.21
Whitefish	484	38.99	3.23	0.20
HB & FB	72	55.51	-7.95	0.03
Mullets	65	74.39	-3.59	0.03

demersal groups were due to the multiday activity (2-4 days/trip) of trawlers becoming a standard practice in the state, while fishing was extended further to 70 m depth. The landings of mackerel recovered in this decade with a growth rate of 61.54 per cent due to the introduction of purse seines in the mid-1980s.

Increased fishing effort, introduction of purse seines and multi-day trawling were the major factors that increased marine landings during the decade. The decadal mean landing of bombayduck, elasmobranch and whitefish increased, but the overall trend in growth was negative (-8.9%, -1.94% and -5.66% CGR, respectively), as landings started decreasing in bombayduck since 1985, while whitefish and elasmobranch showed a drastic decrease in their landings after 1988. A significant difference in the inter-

year growth rate was observed in ribbonfish, molluscs, perches, seerfish and mackerel, while bombayduck showed a significant negative trend. Similar to the previous decade, crustaceans and bombayduck continued to dominate and the other major landed resource groups were: clupeids (9.31%), croakers (6.91%), pomfrets (5.16%) and ribbonfish (5.11%).

#### **Intensification of Fishing — Longer, Deeper and Faster: 1991-2000**

During the decade 1991-2000, the mean annual catch increased to 3.49 lakh tonnes. However, interestingly, of the 24 groups, the mean landings of bombayduck, pomfrets, catfish, elasmobranchs, threadfins and goatfish decreased drastically in this decade compared to in the previous decade. Interest

**Table 5. Mean fish catch, coefficient of variation (CV), compound growth rate (CGR) and per cent contribution of various major fish groups in Maharashtra state during 1981-1990**

Fish group	Mean catch (tonnes)	CV	CGR	% of total state landings
Overall	306175	11.04	3.16	-
Crustaceans	92049	16.91	3.80	30.06
Bombayduck	46661	37.31	-8.90	15.24
Clupeids	28509	25.09	3.07	9.31
Croakers	21161	13.20	3.68	6.91
Pomfrets	15794	26.63	-2.75	5.16
Ribbonfish	15646	31.60	10.41	5.11
Catfish	12548	24.65	1.41	4.10
Elasmobranchs	10999	11.54	-1.94	3.59
Molluscs	9890	44.18	20.98	3.23
Perches	9105	52.68	18.49	2.97
Carangids	8866	69.77	29.03	2.90
Seerfish	6353	31.72	10.97	2.07
Mackerel	4994	153.37	61.54	1.63
Flatfish	4028	29.11	6.55	1.32
Eel	2610	34.50	-8.96	0.85
Lizardfish	2505	40.11	10.66	0.82
Tunas	2135	35.61	-1.04	0.70
Whitefish	1698	50.76	-5.66	0.55
Goatfish	1483	41.18	5.07	0.48
Threadfins	1370	75.52	15.60	0.45
Unicorn cod	647	112.85	31.97	0.21
Silverbellies	297	116.66	-23.25	0.10
Mulletts	115	83.97	1.68	0.04
HB&FB	105	74.07	-13.71	0.03

for Tuna fishing began during the period 1990-2003, mainly because of adoption of progressive and innovative fishing techniques, multiday gill net and hook and line fishing, conversion of idling Shrimp trawl for longlining and multi-gear operation (Pillai *et al.*, 2007). After 1995, some landings of pelagic fishes increased drastically probably because in the late-1990s, large-sized gill nets and trammel nets began to be employed in pelagic and mid-water fishes up to 50-60 m depth. During this decade, trawling was further extended to the depth of 90-100 m in offshore waters and fishing effort continued to increase as the days at sea of multi-day trawlers increased from 3-5 days/trip to 12-15 days/trip and night trawling was also introduced consequent to the construction of large size trawlers (15-20 m) with more horsepower (>300 HP)

and holding capacity. This led to the increased landings of major demersal groups like crustaceans, croakers, molluscs, and perches. Though, the state decadal mean catch increased during the 1990s, the majority of resources showed a negative trend in growth, as indicated by the CGRs (Table 6). For the first time, the bombayduck started losing its dominance (5.75%), while the crustaceans continued to hold the prime position (31.88%). The ribbonfish (9.18%) emerged as the second most important group, trailed closely by clupeids (8.25%), mackerel (7.96%), croakers (7.49%) and molluscs (6.48%) groups.

#### **Beginning of Decline: 2001-2010**

The decadal mean catch during 2001-2010 decreased to 3.44 lakh tonnes from 3.49 lakh tonnes in

**Table 6. Mean fish, coefficient of variation (CV), compound growth rate (CGR) and per cent contribution of various major fish groups in Maharashtra state during 1991-2000**

Fish group	Mean catch (tonnes)	CV	CGR	% of total state landings
Overall	349536	10.29	0.41	-
Crustaceans	111429	18.53	0.56	31.88
Ribbonfish	32078	38.33	5.76	9.18
Clupeids	28836	16.24	0.68	8.25
Mackerel	27819	33.44	12.63	7.96
Croakers	26173	10.36	1.11	7.49
Molluscs	22651	22.37	-4.29	6.48
Bombayduck	20091	51.79	-3.89	5.75
Perches	13436	16.62	-3.08	3.84
Carangids	11204	33.95	-5.48	3.21
Pomfrets	9513	31.93	-2.01	2.72
Catfish	9299	35.81	-4.09	2.66
Elasmobranchs	7885	16.61	-1.63	2.26
Seerfish	6652	31.82	1.21	1.90
Flatfish	5986	19.57	-4.49	1.71
Lizardfish	2739	63.79	-12.41	0.78
Tunas	2321	31.32	4.44	0.66
Whitefish	1466	46.32	-2.49	0.42
Eel	1316	19.10	0.34	0.38
Threadfins	771	39.55	-2.55	0.22
Unicorn cod	592	71.80	-14.02	0.17
Goatfish	379	48.07	-8.99	0.11
Silverbellies	106	65.88	1.35	0.03
Mulletts	85	106.38	14.79	0.02
HB&FB	81	54.56	9.97	0.02

1991-2000. Consequently, the growth trend was negative with CGR of -4.69 per cent with significant inter-year variations (Table 7). The decade recorded a historical high annual landings of 4.49 lakh tonnes in 2002, after which landings from the major mechanized gears started showing a declining trend. The landings of commercially important groups like crustaceans, ribbonfish, molluscs, mackerel and pomfrets, decreased during this period affecting the total mean landings in the state negatively.

The major landings of pelagic resources showed an increasing trend in the case of clupeids, bombayduck, perches, carangids, seerfish and tunas, in which perches landings increased drastically compared to previous decade landing. However, as trawling became uneconomical, the number of purse

seiners increased dramatically to nearly 517 in 2010-11 largely by conversion of the trawlers by fitting drum winch that increased the fishing efficiency and subsequently led to increased landings of major pelagic resources. The increasing export demand coupled with good prices for crustaceans, molluscs, pomfrets on one hand and the unrestricted expansion and relentless intensification of fishing effort that began in the mid-1990s, have led to a gradual but steady decline in many resources, especially in the demersal fishes. That more and more juveniles were being caught off the Mumbai coast attested the exploitative nature of fishing as well as the desperation to fish, irrespective of age and size groups. A good number of mini purse seiners (ring seiners) were introduced in Raigad and Ratnagiri districts after 2006. Of the 24 groups, 18 groups showed



**Table 7. Mean fish catch, coefficient of variation (CV), compound growth rate (CGR) and per cent contribution of various major fish groups in Maharashtra state during 2001-2010**

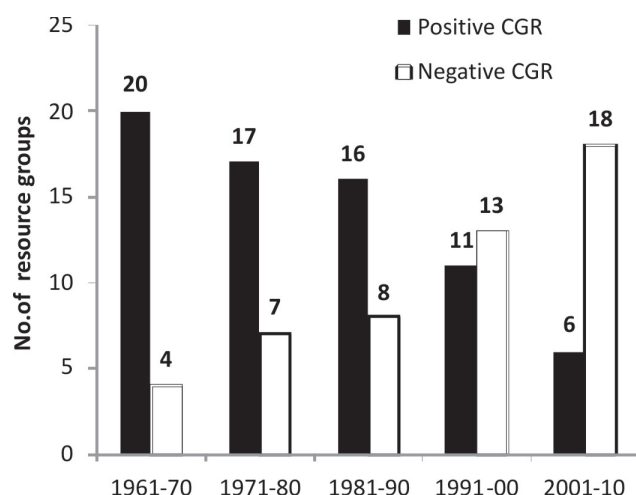
Fish group	Mean catch (tonnes)	CV	CGR	% of total state landings
Overall	344888	17.29	-4.69	-
Crustaceans	103965	20.29	-4.25	30.14
Clupeids	29894	26.76	-4.13	8.67
Ribbonfish	28756	65.00	-16.35	8.34
Croakers	27783	9.94	-1.56	8.06
Perches	26774	21.47	-5.91	7.76
Bombayduck	23855	20.28	-3.93	6.92
Molluscs	22444	26.30	-4.97	6.51
Carangids	13558	17.26	-0.18	3.93
Mackerel	11117	67.74	1.57	3.22
Catfish	10676	23.96	-3.35	3.10
Elasmobranchs	8559	31.17	-8.68	2.48
Seerfish	8162	36.26	-8.25	2.37
Pomfrets	6713	24.82	-7.71	1.95
Tunas	5335	39.20	5.26	1.55
Flatfish	3153	32.70	-7.32	0.91
Eel	2066	39.28	-9.52	0.60
Lizardfish	2035	28.79	-2.76	0.59
Threadfins	1507	36.59	-8.09	0.44
Whitefish	936	62.99	3.24	0.27
Silverbellies	724	127.69	0.13	0.21
Unicorn cod	560	31.21	-6.38	0.16
Goatfish	467	52.98	-11.99	0.14
HB&FB	241	35.84	6.09	0.07
Mulletts	80	61.83	6.55	0.02

a negative trend in the growth rate, as indicated by the CGR. The inter-year growth rate in perches, ribbon, elasmobranchs and pomfrets showed a significant difference with a negative sign.

### Present Status of Stocks

In Maharashtra, the marine fish landings recorded a steady increase since 1961, but during the decade (2001-2010), it has shown a decreasing trend that fluctuated widely. The growth rates decreased over the decades as indicated by the CGRs and it became negative during the recent decade. The resources that have shown improvement in the percentage contribution towards total landings during the previous decade compared to during 1961-1970 period are clupeids, seerfish, tunas, carangids, whitefish,

ribbonfish, perches, croakers, lizard fish, flatfish and molluscs. Among the clupeids, golden anchovy is the major species contributing to this fishery. Prior to 1985, dolnet was the major gear for this fishery, but afterwards trawlers started encroaching dolnet zone (Khan, 2003). The decadal mean catch of seerfish in Maharashtra increased, especially from 1980s, while Indian seer fish landings also showed an increasing trend during the 1980s due to the introduction and subsequent intensification of mechanization of the craft (Devaraj *et al.*, 1999). Though, mean decadal catch of carangids showed an increasing trend from 1980s because of intensification of fishing effort, the trend in growth rate as indicated by the CGR, showed a negative sign during the past two decades. This is mainly because, the early-1990s showed higher landings



**Figure 1. Decadal changes in CGR with respect to number of resource groups, 1961-2010**

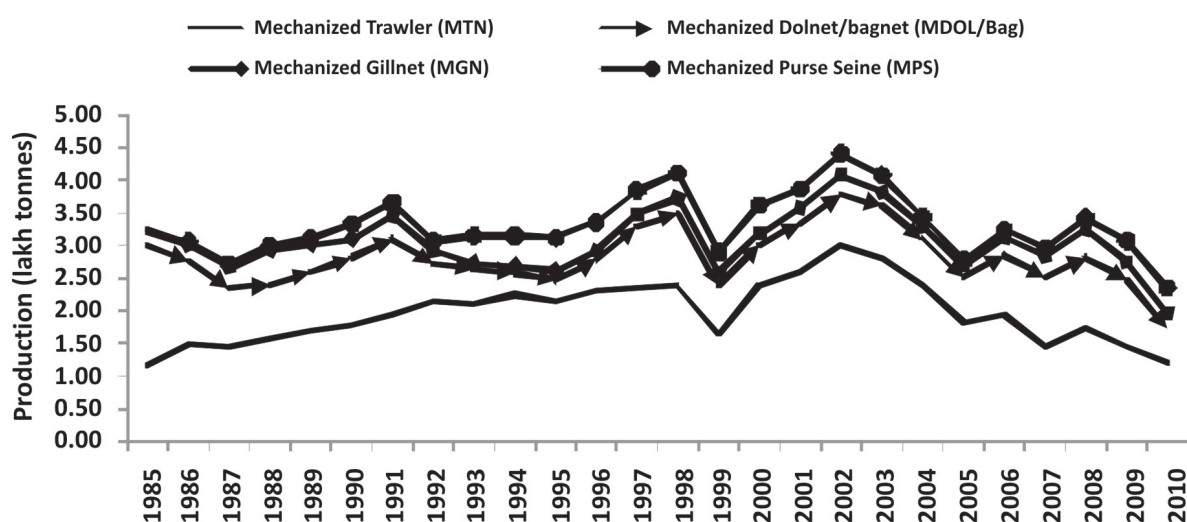
compared to late-1990s, similar to in the decade of 2001-2010.

When the average annual landings of different resources in the 2001-2010 decade were compared with those of 1961-1970, it was found that the average landings had come down in the case of unicorncod, mullets, eels, pomfrets, goatfish and bombayduck. The resources that have shown increases in average decadal landings throughout the period were clupeids, seerfish, tunas, carangids, perches and croakers. In the decade 2001-2010, the resources that have shown a decline in average landings are: mackerel, whitefish, ribbonfish, lizardfish, pomfrets, flatfish, mullets, unicorncod, crustaceans and molluscs. In the decade 2001-2010,

the resources that have shown increases in the average landings compared to the decade of 1991-2000 (other than resources showing increase in average landings over the five decades) were: bombayduck, silverbellies, half beak & full beak (HB & FB), threadfins, goatfish, catfish, elasmobranchs and eels.

The majority of resources has shown a negative trend in growth rates during the decades 1991-2000 and 2001-2010 with growth becoming negative during the later decade. While 20 groups of fishes showed a positive growth trend during 1961-1970 (as indicated by CGR), the number reduced to 6 groups by 2001-2010 (Figure 1), thereby reversing the growth trends in the five decades. Meanwhile, landings by the mechanized gears during 1985-2010 (Figure 2) indicate that landings started declining from 2002 onwards.

The 25 resource groups were classified following the method suggested by Mohamed *et al.* (2010). It was found that only two resource groups fell under the 'abundant' class, seven groups were under 'less-abundant' class and 14 groups were under 'declining' class and 1 group each was under 'depleted' and 'collapsed' classes (Table 8). This is in clear contrast to the country level scenario wherein of the 26 resource groups studied, 18 fell under the 'abundant' class, 5 groups fell under 'less-abundant' class and 1 group each was under 'declining', 'depleted' and 'collapsed' classes (Sathianandan *et al.*, 2011). A comparison between status of Indian stocks and Maharashtra stocks is presented in Table 8. For example, the status of Goatfishes along the Indian coast was classified



**Figure 2. Landings by different types of mechanized gears in Maharashtra during 1985-2010**

under 'abundant' category, but in the present study at the state level, goatfish has come under the 'collapsed' class. Similarly, many groups classified as 'abundant' and 'less-abundant' categories at the country level, fell under the 'declining' class in the case of Maharashtra. All the important resource groups of Maharashtra fisheries have been found under 'less-abundant' and 'declining' classes.

The difference in the status of fisheries in India and Maharashtra mainly depends on the variations in the past three-year (2008-2010) average catch and historical maximum catch (1961-2010) of a particular species. For example, in Maharashtra, of clupeids, the recent three-year average catch was 24042 tonnes and historical maximum catch was 48303 tonnes and the percentage of this (past three-year landing/historical

maximum\*100) is 49.77 per cent which falls under the declining category. But, at the all-India level (Sathianandan *et al.*, 2011), the recent three-year average catch (2008-2010) of clupeids was 877576 tonnes and the historical maximum catch was 929404 tonnes and the percentage of this (past three-year landing/historical maximum\*100) is 94.42 per cent, which falls under the abundant category. This is because at the all-India level, clupeids recent average catch is higher or nearer to the historical maximum catch and gives a higher percentage value. The majority of groups falling under the 'declining' class need caution and care to prevent further reduction. The group unicorn cod and goatfish falling under the 'depleted' and 'collapsed' classes, require immediate management interventions for recovery of these stocks.

**Table 8. Classification of different resource groups based on three-year (2008-2010) average landings**

Resource	Average landings (t) during 2008-10	Maximum annual landing (t) during 1961-2010	Year	Percentage of total landings	Stock status of Maharashtra	Stock status of India as per Sathianandan <i>et al.</i> (2011)
Croakers	26647	32315	1998	82.46	Abundant	Abundant
Tunnies	7466	10265	2008	72.73	Abundant	Abundant
Seer fish	6818	13256	2002	51.43	Less abundant	Abundant
Carangids	14297	22452	1989	63.68	Less abundant	Abundant
HB & FB	287	457	2009	62.87	Less abundant	Abundant
Perches	21381	36351	2003	58.82	Less abundant	Abundant
Catfish	10801	21086	1988	51.22	Less abundant	Abundant
Crustaceans	98192	149978	1998	65.47	Less abundant	Abundant
Molluscs	19989	31684	2003	63.09	Less abundant	Abundant
Clupeids	24042	48303	1989	49.77	Declining	Abundant
Bombayduck	19274	82136	1981	23.47	Declining	Abundant
Mackerel	15357	38355	1996	40.04	Declining	Abundant
Silverbellies	732	3195	2004	22.92	Declining	Abundant
Whitefish	1352	3146	1983	42.99	Declining	Declining
Ribbonfish	14345	66281	2002	21.64	Declining	Less abundant
Threadfins	859	4125	1976	20.82	Declining	Less abundant
Barracudas	807	1699	1967	47.52	Declining	Abundant
Lizard fish	1797	6670	1995	26.94	Declining	Abundant
Pomfrets	4963	22523	1983	22.03	Declining	Abundant
Flatfish	2498	7797	1995	32.04	Declining	Less abundant
Elasmobranch	5594	14384	2002	38.89	Declining	Less abundant
Eels	1111	10091	1961	11.01	Declining	Abundant
Mulletts	109	481	1965	22.66	Declining	Less abundant
Unicorn cod	488	5498	1965	8.88	Depleted	Collapsed
Goatfish	247	4180	1964	5.91	Collapsed	Abundant

**Table 9. Stock contribution to mean catch of Maharashtra**

Status	Percentage contribution to average catch during 2001-2010	Percentage contribution to average catch during 2008-2010
Abundant	9.60	11.22
Less abundant	53.88	56.51
Declining	34.89	30.54
Depleted	0.16	0.16
Collapsed	0.14	0.08

The contributions of these classified stocks to the state average landings were also studied to understand their relative importance. The percentage contribution of these classified stocks to average total marine landings of Maharashtra from 2008-2010 and 2001-2010 is given in Table 9. It is a worrisome sign that the less abundant (7 groups) and declining (14 groups) categories were contributing 56.51 per cent and 30.54 per cent (2008-2010), respectively towards state total landing which is the sign of crisis in waiting.

## Conclusions

Despite the average decadal mean catch of 344888 tonnes that contributed 12.59 per cent to the total marine fish of the country during the previous decade (2001-2010), the marine fishery of Maharashtra has been facing crisis since late-1990s. However, the growth rates of important resources (18 groups) have declined and shown a negative trend, as indicated by the compound growth rate during the previous decade. Increased fishing effort from shrimp trawling by multi-day fishing trips, introduction of purse seines in 1980s and increasing pollution load are responsible for declining growth rates. The historical highest annual landings were recorded in the year 2002, but thereafter the state total landings started showing a decreasing trend and reached 3.07 lakh tonnes in 2011 (CMFRI, 2012). Among the 24 groups of resources, mackerel, whitefish, ribbonfish, lizardfish, pomfrets, flatfish, mullets, unicorn cod, crustaceans and molluscs have shown a decline in their landings in recent decades.

The species which have shown increased mean catch over the decade are clupeids, croakers, perches, carangids and seerfish, even though their growth rate is negative in the recent decade. The negative growth is mainly because of having a decreasing trend in landings of these species after 2005. However, their

decadal mean catch is high compared to in the previous decades. Also, crustaceans and molluscs play an important role in maintaining the landings at a higher level over the decade even though their mean catch during the recent decade is slightly less compared to in the previous decade 1991-2000. Landing by different types of mechanized gears has shown a decreasing trend from 2002 onwards. A major cause of concern is that most of the stocks which were 'abundant' or 'less-abundant' at the national level, are actually 'declining' in Maharashtra. It indicates that the state-wise scenario is different from the national scenario and state-wise understanding of marine fishery resources is very important to formulate appropriate regulatory and management measures.

## Acknowledgments

The authors thank Dr W.S. Lakra, Director, Central Institute of Fisheries Education, Mumbai, for his encouragement and support. They also extend their gratitude to the Central Marine Fisheries Research Institute for providing data for the present study. The authors thank the anonymous referee for his critical comment on the paper.

## References

- CMFRI (Central Marine Fisheries Research Institute) (2012) *Annual Report 2011-12*. Cochin. 186 p.
- CMFRI (Central Marine Fisheries Research Institute) (2014) *Annual Report 2013-14*. Cochin. 274 p.
- Dehadarai, P.V. and Yadava, Y.S. (2004) Fisheries development. Vol.13. In: *State of the Indian Farmer—A Millennium Study*. Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India, New Delhi. 173 p.
- Devaraj, M., Mohamad Kasim, H., Muthiah, C. and Pillai, N.G.K. (1999) Assessment of the exploited Seerfish

- stocks in the Indian waters. *Journal of the Marine Biological Association of India*, **41**(1 & 2): 62-84.
- James, P.S.B.R. (2010) Taxonomic status of marine pelagic fishes of India, research priorities and conservation strategies for the sustainability of their fisheries. *Indian Journal of Animal Sciences*, **80**(4): 39-45.
- Khan, M.Z. (2003) Golden Anchovy. In: *Status of Exploited Marine Fishery Resources of India*, Eds: J. Mohan and A. A. Jayaprakash. Central Marine Fisheries Research Institute, Cochin, pp 40-44.
- Mohamed, K.S., Sathianandan, T.V., Zacharia, P.U., Asokan, P.K., Krishnakumar, P.K., Abdurahiman, K.P., Veena Shettigar, S. and Raveendra Durgekar, N. (2010) Depleted and collapsed marine fish stocks along south-west coast of India – A simple criterion to assess the status. In: *Coastal Fishery Resources of India: Conservation and Sustainable Utilization*, Eds: B. Meenakumari, M.R. Boopendranath, Leela Edwin, T.V. Sankar, Nikita Gopal and G. Ninan. Society of Fisheries Technologists, Cochin. pp. 67-76.
- Najmudeen, T.M. and Sathiadhas, R. (2008) Economic impact of juvenile fishing in a tropical multi-gear multi-species fishery. *Fisheries Research*, **92**(2): 322-332.
- Pillai, N.G.K. (2006) Pelagic fisheries of India. In: *Handbook of Fisheries and Aquaculture*. Directorate of Information & Publications of Agriculture, Indian Council of Agricultural Research, New Delhi. pp. 56-77.
- Pillai, N.G.K., Jayaprakash, A.A. and Ganga, U. (2007) Status and scope of research on pelagic fisheries of India. In: *Status and Perspectives in Marine Fisheries Research in India*, Eds: M.M. Joseph and N.G.K. Pillai. Central Marine Fisheries Research Institute, Cochin. pp. 52-114.
- Sathianandan, T.V., Jayasankar, J., Kuriakose Somy, Mini, K.G. and Mathew Wilson, T. (2011) Indian marine fishery resources: Optimistic present, challenging future. *Indian Journal of Fisheries*, **58**(4): 1-15.
- Srinath, M. (2003) An appraisal of the exploited marine fishery resources of India. In: *Status of Exploited Marine Fishery Resources of India*, Eds: M.M. Joseph and A.A. Jayaprakash. Central Marine Fisheries Research Institute, Cochin. pp. 1-18.
- Srinath, M. and Balan, K. (2003) Potential yield from Indian EEZ. In: *Status of Exploited Marine Fishery Resources of India*, Eds: M.M. Joseph and A.A. Jayaprakash. Central Marine Fisheries Research Institute, Cochin. pp. 286-290.
- Vivekanandan, E., Mohamed, K.S., Kuriakose, S., Sathianandan, T.V., Ganga, U., Pillai, S.L. and Nair, R.J. (2009) Status of marine fish stock assessment in India and development of a sustainability index. In: *The Second Workshop on the Assessment of Fishery Stock Status in the South and Southeast Asia*, held at Bangkok, Thailand, 5-9 October. pp. 1-15.
- Vivekanandan, E. and Jayasankar, J. (2008) Winter school on impact of climate change on Indian marine fisheries. In: *Winter School Lecture Notes - Part I*, held at Central Marine Fisheries Research Institute, Cochin. 18 January-7 February.

---

Received: July, 2015; Accepted: November, 2015