Growth, productivity and instability of fish production in India: A special reference to marine sector by East and West Coast

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Abstract

India is a one of the countries who are blessed with large scale potential for economic development through fisheries. Traditionally fishing has always been an important occupation both in terms of livelihood and in meeting the food security necessities of millions of people. At present the contribution of this sector is 0.79 percent to the total GDP and providing employment opportunities over 14.4 million directly or indirectly in around 3500 coastal villages and port towns. Fishermen venture into the sea risking their lives every day and predominantly this sector belong to the economically weaker section of the society; living in social isolation in remote villages and largely ignored till the dawn of independence and even after. However, this sector stands out as one of the mainstays of the self-employed economy after agriculture and handloom sectors in India. In this connection, the study analyzed the growth rates and pattern of the fish production and productivity and the shares of different components by East Coast and West Coast in marine sector. It reveals that shifting into both mechanized boats and motorized crafts will increase fish production with the same area and number of active fishermen.

Keywords: Fish Production; Fishermen; Growth; Instability; Marine Sector

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1. Introduction

India is endowed with a wide diversity of water resources, which sustain a large fisheries sector in the country. India has a coastline of 8,118 km with an Exclusive Economic Zone (EEZ) stretching over 2.02 million km, and a continental shelf covering 0.53 million km (World Bank, 2010). India also has inland water sources covering over 190,000 km and open water bodies with a water-spread area of about 740,000 hectares. Brackish water area that could be used for aquaculture is 1.24 million hectares, of which only 165,000 hectares have been developed. Total fish production from India's fisheries sector in 2008-10 triennial average was an estimated 7.94 million tons (Table 1). The Indian fisheries sector consists of several sub-sectors based on fish production. The marine sub-sector contributed about 39.1 percent of total fish production, or 3.11 million tones. The balance, termed inland fisheries, was accounted for 60.9 percent by freshwater aquaculture, inland capture, and coastal aquaculture. India contributes nearly five percent towards global fish production. The country ranks third in the world in total fish production and second in inland aquaculture (Ramachandra et al., 2003). Traditionally fishing has always been a significant important occupation as a source of animal protein for human consumption, food and livelihood security, poverty reduction, wealth creation, foreign exchange earnings and rural development (Gbola and Yvette, 2010). At present the contribution of this sector is 0.79 percent to Gross Domestic Product (GDP) and 4.4 percent to agriculture GDP (Figure 1).

Historically, fishery sector stands out as one of the mainstays of the self-employed economy after Agriculture and Handloom & Textiles. Fishermen venture into the sea risking their lives every day. According to 17th Livestock Census of 2003 (Government of India), this sector also generates over 14.5 million jobs of which 4.6 million are men (32 percent), 4 million are women (28 percent) and 5.8 million are children (40 percent) directly or indirectly in about 3,500 coastal villages and port towns. Traditionally they are the sentinels guarding the seacoast day and night. Such an important sector for the livelihoods of the millions and nation's security is predominantly belonging to the economically weaker section of the society living in social isolation in remote villages.

Table 1. Trends in Triennial Average Fish Production in India (in 000' tons)

Sub-Category	1978-80	1986-88	1996-98	2008-10
Marine	1512.33 (64.0)	1729.33 (57.3)	2871.00 (53.7)	3110.67 (39.1)
Inland	850.33 (36.0)	1288.33 (42.7)	2473.67 (46.3)	4837.67 (60.9)
Total	2362.67 (100.0)	3017.67 (100.0)	5344.67 (100.0)	7948.33 (100.0)

Source: Handbook of Fisheries Statistics, 2011
Note: Figure in parenthesis indicates share of the sub-sector during the period
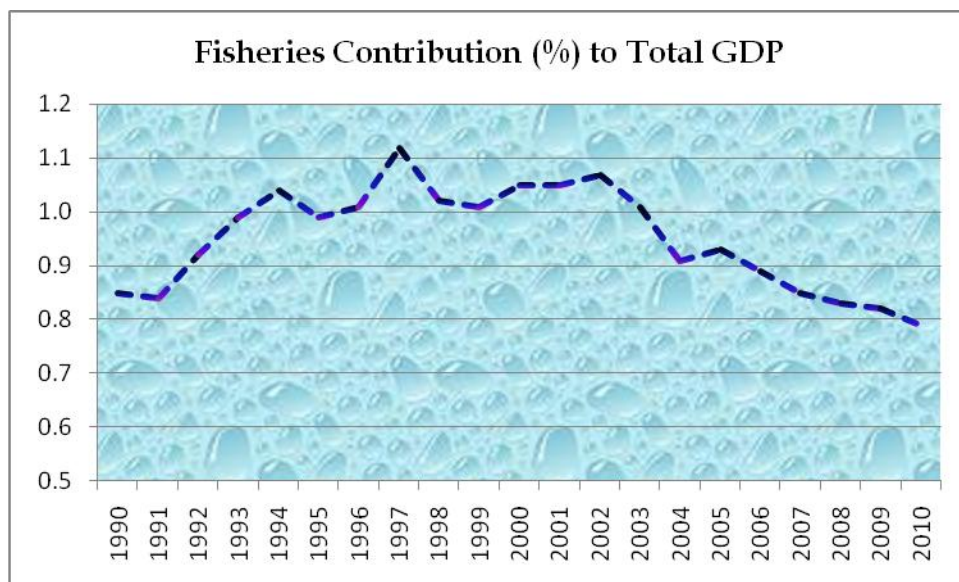
Figure 1. Fisheries Contribution to the Grass Domestic Product (GDP) of India

1.1. Research issues

a) The deceleration in growth in fish production in the recent period in India

b) Poor performance in marine sector as compared to inland fish production

c) Production is higher in East Coast despite it holds lower Continental Shelf as compared to West Coast

d) Deceleration in growth is accompanied by increase in instability in the earlier period increase in growth was accompanied by declining instability in the recent period

e) Technology contributes for higher productivity in fish production and also labour is the most important factor

1.2. Need for the study

The status of marine fisheries in India is in a crucial phase now. The production has progressively increased by nearly 6 times during the last 50 years (Devraj and Vivekanandan, 1999). The triennium averages show that the marine fish production is increased from 1.5 million tons during 1978-80 to 3.1 million tons during 2008-10. However, the share of marine sector is persistently decreasing from 64 percent to mere 39 percent in the total fish production during the same period. Whereas, the Inland sector fish production share is bridging the gap in total fish production through significant improvement over the period of time (Figure 2).
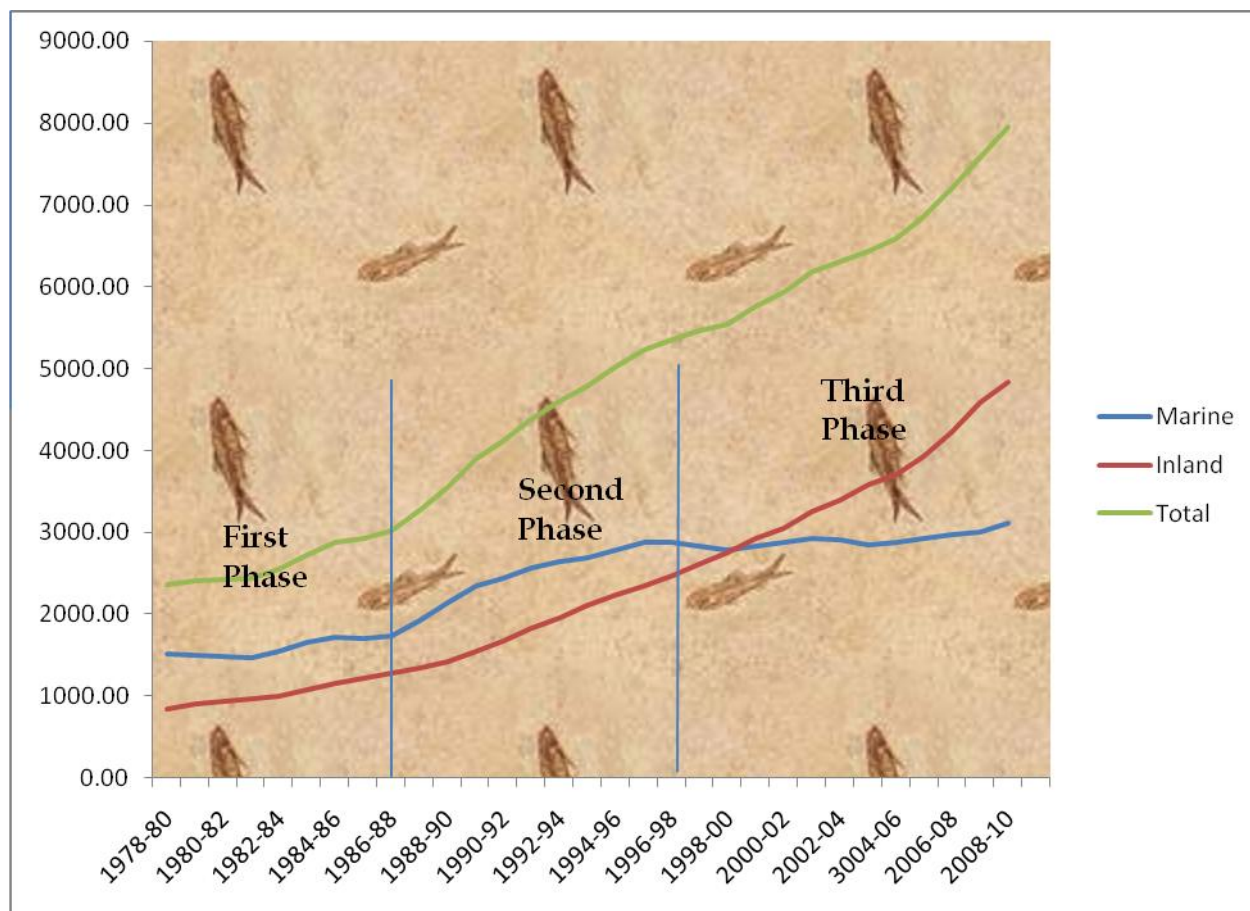
Figure 2. Triennial Average of Fish Production in India (in 000' tons)

During the phases of early 1980s to late 1990s marine fish is continuously increasing, this phenomenal increase is largely due to motorization of traditional fishing craft, introduction of ring seines and increase in the number and efficiency of craft and gears in the 1980s and substantial growth in the number and efficiency of trawlers and motorized craft and change in the export trade from resource based to food engineering based industry in the 1990s (Devaraj and Vivekanandan). It is clear from the above (Figure 2) that the total fish production is rapidly increasing over the period of time from 2.36 million tons to 7.94 million tons in India. The sub-sectors of marine and inland fish production are increasing gradually till 1997. Subsequently, the marine sector is seeming to be in saturation phase might be caused to over exploitation of natural resources or increase in the active fishermen population. However, the inland sector overall production has increased at a higher rate than that of marine sector. Broadly Indian Coastal area can be classified into two categories for instance East Coast[1] and West Coast[2]. Therefore, this study purposely

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[1] East Coast Includes four States and two Union Territories of Andhra Pradesh, Odisha, West Bengal, Tamil Nadu, Andaman & Nicobar and Pondicherry

[2] West Coast includes five States and two Union Territories (UTs) of Gujarat, Karnataka, Goa, Kerala, Maharashtra, Daman & Diu and Lakshadweep

investigates at what extent east coast and west coast contribute in the saturation phase of marine fish production in India.

Against this background this study is undertaken, with the following specific objectives:

- To examine the trends in marine fish production in India for different periods
- To explore the attributes for poor performance of marine sector by East and West Coast in recent period
- To study the relation between the growth and instability in marine fish production for different periods
- To analyze the marine fish productivity by active fishermen and continental shelf (sq. km) for two coastal areas

2. Data and methodology

The study is based on secondary data for the last 33 years, i.e. from 1978-79 to 2010-11 for India. The fish production data is largely drawn from Handbook on Fisheries Statistics – 2011 (Government of India) for fish production and Marine Fisheries Census – 2005 for active fishermen population. This data has been classified into three categories based on growth performance of marine fish production for instance initial phase, growth phase and saturation phase in India for instance period I (1978 – 87); period II (1988 to 1997); and period III (1998 to 2010). To investigate the saturation phase of IIIrd period the data from all coastal states and UTs have been taken to analyze by east coast and west coast from 1998 onwards.

2.1. Growth rates

In order to examine the growth of fish production in each period, semi-log trend exponential growth rates have been estimated by using the following formula;

$$\ln Y_t = b_0 + b_1 t + e_t \tag{2.1}$$

where,

Y_t = fish production in year Marine or Inland or Total

b_0 = intercept

b_1 = slope of coefficient or exponential growth

e_t = error term

t = time period

2.2. Instability index

Instability index for growth rates is calculated for annual growth rate of fish production as the usual measure of instability in growth rates across the periods. For instance, (as per Mohammad P.W. 2007 estimation for Growth and Instability in Fish in Pakistan) the period wise instability index was estimated separately for marine and inland in different periods of fish annual growth rates in India. The followed estimation of instability index is given by;

$$II = \sqrt{\frac{1/n \ \Sigma(g_i - \bar{g})^2}{G_e}} \qquad (2.2)$$

where,

g_i is the annual growth rate

G_e is the exponential growth rate for the entire period

2.3. Production function

In order to understand the contribution of various factors for marine fish production, Cobb-Douglas production functions have been estimated. Land, labour and capital are identified as the major factors influencing fish production. Land is taken as Continental Shelf Area in Sq. Km which indicates the area available for catching marine fish. Lobour is defined as the number of active fishermen working in the area, people participating on part-time basis and people engaged in marketing of fish are not included in this number. Capital is defined in terms of Crafts and Boats. Three types of technologies are available for fish production; motorized crafts, mechanized boats and traditional crafts. When the capital is taken in absolute numbers all the coefficients have turned out to be insignificant because of multicolliniarity problem. Hence, capital is defined as percentage of motorized crafts and percentage of mechanized boats.

The functions are estimated for State-wise data on various fish production in the triennium of 2008-09 to 2010-11. The functional form is taken as;

$$ln \ MFP_i = \alpha + \beta_1 \ ln \ CS_i + \beta_2 \ ln \ AF_i + \beta_3 \ ln \ MC_i + \beta_4 \ ln \ MB_i + u_i \qquad (2.3)$$

where,

MFP_i = Marine Fish Production in year i

CS_i = Continental Shelf in year i

AF_i = Active Fishermen in year i

MC_i = Motorized Crafts in year i

MB_i = Mechanized Boats in year i

u_i = Random error

2.4. Productivity

Productivity per fishermen and productivity per Sq Km of Continental Shelf is calculated by:

Total Fish Production/Active Fishermen and Sq Km of Continental Shelf area   (2.4)

3. Results and discussions

Fish production in India grows at an annual rate of 4.2 percent per annum during the entire period covering 1978-79 to 2010-11. The growth rate is statistically significant at 1 percent level of significance. As this growth rate is higher than the population growth rate of about 2 percent per capita availability of fish had gone up by about 2 percent per annum.

The entire period of 33 years can be divided into three sub-periods, the first two covering each 10 years and the last for 13 years. The growth rate deferred in the three sub-periods with low growth in the initial period, high growth in the second period and again low growth in the third period.

The growth rate in the middle period is very high at 5.6 percent per annum as compared to about 3.5 percent in the other two periods. Thus, there is acceleration and then deceleration in the growth rates of fish production in India. Hence, these three periods can be designated as initial – low growth period; high growth – middle period; and deceleration period – third period.

The performance in the middle period is so high that the growth rate has gone up to 5.6 percent per annum. The growth rate in the third period has come down to the growth rate of initial period.

The growth performance is contributed by both marine and inland fish productions. However, the growth of marine fish production is always lower than that of inland fish production. Considering the entire period, the growth rate of marine fish production is only one half of the growth rate of inland fish production – 2.7 percent in marine as against 5.9 percent in inland fish production.

The variation in the growth rates in the three periods is mainly contributed by marine fish production. In the initial period marine fish production grows at 1.8 percent and it rose to 4.5 percent in the high growth period. The sector suffered steep deceleration in the third period with a growth rate of only 1 percent per annum. On the other hand, inland fish production showed more stable growth of more than 5 percent per annum in each period and slightly higher growth rate of 7.1 percent in the high growth period.

In order to provide continuous availability of fish for consumption, the production should not suffer from high instability. In order to examine the problem of instability in fish production growth is calculated using the annual growth rate of fish production.

The coefficient of variation (CV) of annual growth rates is taken as the index of instability. The results as shown in Table 2 indicates that instability is very high in the first period and low in the second period, the

third period of deceleration as also witnessed increase in the instability. Thus, the deceleration in the growth rate between second and third periods is accompanied by increase in the instability. However, the initial period is the worst period with low growth of about 3 percent and very high instability of about 136 percent.

Table 2. Growth and Instability of Fish Production in India

Period	Exponential Growth Rates			Instability Index* (%)		
	Marine	Inland	Total	Marine	Inland	Total
Period I (1978-1987)	1.8	5.1	3.1	307.8	103.7	135.8
Period II (1988-1997)	4.5	7.1	5.6	169.1	46.3	77.7
Period III (1998-2010)	1.0	5.5	3.5	481.0	62.0	81.7
Overall (1978-2010)	2.7	5.9	4.2	233.0	65.8	93.3

Note: 1. All the Growth Rates are significant at less than 1 percent level of significance
* Instability Index is the Coefficient of Variation (CV) of year to year growth rates production (%)

The results of State and UTs-wise exponential growth rates of marine fish production by East and West Coasts are presented below Table 3. Marine fish production growth rate per annum in India is positive and significant at 1 percent level of significance while in the East Coast and West Coast it is significant at 5 percent and 10 percent level of significance respectively.

The marine fish production growth rate in all the States and UTs of East Coast and West Coast are positive (except in Pondicherry in East Coast and in the state of Keral in West Coast). Though, it is statistically significant only in the states of Andhra Pradesh and Odisha at 1 percent level of significance in East Coast and in Karnataka at 5 percent level of significance in the West Coast.

The coefficient of variation (CV) of annual growth rate shows that the instability is very high in West Coast mainly contributed by the states and UTs of Gujarat, Lakshadweep, Daman & Diu, Goa and Kerala. In the East Coast the instability is comparatively high to India's instability index and in this coast line it is largely contributed by Andaman & Nicobar Islands, West Bengal and Tamil Nadu. Thus, the deceleration in the growth rate between in the East Coast and West Coast is accompanied by increase in the instability.

Table 3. Instability in marine fish growth rate by East and West Coast States (1999-2010)

State	Exponential Growth Rate	Instability Index@ (%)
AP	4.40 (5.32)*	242.67
Odisha	1.20 (3.44)*	312.23
Tamil Nadu	0.80 (1.07)	1309.78
West Bengal	0.30 (0.81)	2091.41

A&N Island	1.30 (0.54)	3618.47
Pondicherry	-1.60 (-0.91)	-1740.77
East Coast	**1.50 (2.86)****	**488.48**
Gujarat	0.20 (0.38)	4845.00
Karnataka	3.90 (2.29)**	558.94
Goa	1.40 (0.51)	3789.08
Kerala	-0.30 (-1.43)	-1326.30
Maharashtra	0.70 (1.68)	875.27
Daman & Diu	0.90 (0.43)	3733.49
Lakshadweep	0.40 (0.27)	5053.80
West Coast	**0.60 (2.21)*****	**723.96**
India	**0.90 (3.32)***	**447.74**

*Note: *, **, *** significant at 1, 5 and 10 percent level of significance respectively*

@ Instability Index is the Coefficient of Variation (CV) of year to year growth rates production (%)

3.1. Share of east coast and west coast by marine fish production and resources

It is examined that more than 57 percent of the length of coast line, 61.6 percent of active fishermen belongs to east coast but in the share of fish production in marine sector is mere 32.5 percent. As far as Continental Shelf is concerned, east coast consist lower share and west coast consist more than 71 percent. Thus, it is clear that the more share of continental shelf is leads to more quantum of fish production.

Table 4. Distributions of Resources by East and West Coast

Resources	East Coast	West Coast	Total
Active Fishermen	547895 (61.6)	341633 (38.4)	889528 (100.0)
Length of Coast Line (in Km)	4645 (57.2)	3473 (42.8)	8118 (100.0)
Continental Shelf (in Sq Km)	153 (28.9)	377 (71.1)	530 (100.0)

Note: Figures in parenthesis are percentages in total

The share of advanced technological crafts and boats are examined in below Table 5. Andhra Pradesh and Andaman & Nicobar Islands consist below half percent of modern technological crafts and boats and remaining states like Tamil Nadu and Pondicherry consist more than 70 percent of crafts and boats; West Bengal consists more than 82 percent mechanized boats. However, in the east coast the advanced technological equipments are more than 65 percent (including 38 percent motorized crafts and 27.6 percent mechanized boats).

In the west coast the share of mechanized boats is very high i.e. 48 percent followed by motorized crafts 36.9 percent. It means west coast has more number of technological fishing equipments.

Table 5. Mechanization and Marine Fish Production

	Traditional Crafts	Motorized Crafts	Mechanized Boats	Total Crafts and Boats
Andhra Pradesh	17837 (56.2)	10737 (33.8)	3167 (10.0)	31741 (100.0)
Odisha	4656 (43.0)	3922 (36.2)	2248 (20.8)	10826 (100.0)
Tamil Nadu	10436 (22.7)	24942 (54.1)	10692 (23.2)	46070 (100.0)
West Bengal	3066 (17.7)	0 (0.0)	14282 (82.3)	17348 (100.0)
Andaman Nicobar Island	1637 (51.3)	1491 (46.8)	61 (1.9)	3189 (100.0)
Pondicherry	662 (25.5)	1562 (60.2)	369 (14.2)	2593 (100.0)
East Coast	**38294 (34.3)**	**42654 (38.2)**	**30819 (27.6)**	**111767 (100.0)**
Gujarat	1884 (6.6)	8238 (29.0)	18278 (64.4)	28400 (100.0)
Karnataka	2862 (20.4)	7518 (53.6)	3643 (26.0)	14023 (100.0)
Goa	227 (8.5)	1297 (48.6)	1142 (42.8)	2666 (100.0)
Kerala	5884 (27.0)	11175 (51.3)	4722 (21.7)	21781 (100.0)
Maharashtra	2783 (16.0)	1563 (9.0)	13016 (75.0)	17362 (100.0)
Daman & Diu	321 (19.1)	359 (21.4)	1000 (59.5)	1680 (100.0)
Lakshadweep	727 (49.7)	606 (41.5)	129 (8.8)	1462 (100.0)
West Coast	**14688 (16.8)**	**30756 (35.2)**	**41930 (48.0)**	**87374 (100.0)**
India	**52982 (26.6)**	**73410 (36.9)**	**72749 (36.5)**	**199141 (100.0)**

Figure in the parenthesis are percentages in the total

3.2. Production functions for marine fish production

The estimated Cobb – Douglas production functions (using the formula 3) results are shown in below table.

One significant feature of the results is that the contribution of area and workers is quite stable in different specifications. Further, both mechanized boats and motorized crafts have to be included in this model as R^2 shows significantly with this specification. The elasticity of output with respect to active fishermen is about 0.5 in all the specifications. Similarly, the elasticity of output with respect to Continental

Shelf area is 0.3. Thus, there two factors determine fish production. As the share of motorized crafts and mechanized boats in total crafts increase by one percent fish production increases by 0.03 in each case. Hence, shifting to both mechanized boats and motorized crafts will increase fish production with the same area and number of active fishermen.

Table 6. Cobb – Douglas Production Functions for Marine Fish Production

Model No.	Independent Variables						
	Continental Shelf	Active Fishermen	Motorized Crafts (%)	Mechanized Boats (%)	Constant	R²	F Value
1	0.291 (4.124)	0.532 (5.532)	0.037 (3.180)	0.030 (3.921)	-5.862	0.923	39.9
2	0.311 (3.202)	0.486 (3.699)	-	0.011 (1.011)	-3.515	0.853	26.1
3	0.300 (2.722)	0.517 (3.447)	0.001 (0.058)	-	-3.381	0.812	19.7

Note: Dependent Variable is log (Marine Fish Production in tons)
t values are shown in parentheses

3.3. Productivity

Table 7. State-wise changes in Production, Share and Productivity in Marine fish

Area	Production Qty (000' tons)		Production Share		Production per fishermen in tons	
Area	1999-2001	2008-10	1999-2001	2008-10	1999-2001	2008-10
Andhra Pradesh	184.6	291.0	20.1	27.2	1.3	2.1
Odisha	120.3	132.8	13.1	12.4	1.0	1.1
Tamil Nadu	367.3	390.3	39.9	36.4	1.8	1.9
West Bengal	181.8	188.5	19.7	17.6	2.6	2.7
Andaman & Nicobar Islands	27.6	33.0	3.0	3.1	NA	NA
Pondicherry	39.1	35.6	4.2	3.3	3.8	3.4
East Coast	**920.7**	**1071.2**	**32.5**	**34.4**	**1.7**	**2.0**
Gujarat	647.4	666.5	33.9	32.7	7.8	8.0
Karnataka	176.7	269.1	9.2	13.2	4.7	7.2
Goa	65.3	85.0	3.4	4.2	26.0	33.8
Kerala	584.7	571.2	30.6	28.0	4.2	4.1
Maharashtra	405.0	419.5	21.2	20.6	5.6	5.8
Daman & Diu	18.0	15.6	0.9	0.8	3.1	2.7
Lakshadweep	13.1	12.4	0.7	0.6		
West Coast	**1910.1**	**2039.3**	**67.5**	**65.6**	**5.6**	**6.0**
India	**2830.8**	**3110.5**	**100.0**	**100.0**	**3.2**	**3.5**

Source: Handbook of Fisheries Statistics, 2011

The welfare of the fishermen depends on the fish area which will be influenced by several factors as number of active fishermen as well as the type of equipment used. In the following section the study tried to examine the per worker productivity of marine fish by east coast and west coast.

Table 7 indicates that the triennium of marine fish production by states is increasing except in the UTs. However, the share of production is decelerating in many states in recent decade. The production per active fishermen is high in west coast for instance 5.6 tons per triennium period of 1999-2001 and 6 tons per active fishermen during 2008-10.

There is significant acceleration over the decade of period per fishermen production in each and every state and there is decline trend in the state of Kerala and the UTs of Pondicherry and Daman & Diu.

The marine fish productivity by continental shelf is concerned, in the east coast it has 32.5 tons per sq. km and in west coast it is mere 18.8 tons of fish productivity. In the east coast Tamil Nadu forms highest productivity i.e. 10.2 tons of productivity followed by Andhra Pradesh 8.6 tons per sq. km of continental shelf area. In the west coast Daman & Diu has highest productivity (9.6 tons) followed by Kerala (8.4 tons) and Gujarat (3 tons) per sq. km of the continental shelf area.

Table 8. Breadth and Productivity of marine fish by Continental Shelf (Km)

	Continental Shelf (in Km)#	Productivity (in tons)*
Andhra Pradesh	33.88	8.6
Odisha	54.17	2.5
Tamil Nadu	38.10	10.2
West Bengal	107.59	1.8
Andaman Nicobar Island	18.31	1.8
Pondicherry	22.22	1.6
Total East Coast	**32.94**	**32.5**
Gujarat	115.00	5.8
Karnataka	90.00	3.0
Goa	96.15	0.9
Kerala	67.80	8.4
Maharashtra	155.56	2.7
Daman & Diu	1.63	9.6
Lakshadweep	30.30	0.4
Total West Coast	**108.55**	**18.8**
India	**65.29**	**47.6**

Note: # Calculated by dividing Continental Shelf Sq. Km by Length of Coast Line

* Indicates productivity is calculated by dividing the triennium production of 2008-09 to 2010-11 (000' tons) by continental shelf (Km)

4. Conclusion

Fisheries are an important sector in India as it provides employment to millions of people and contributes to the food security of the country. Traditionally fishing has always been a significant important occupation as a source of animal protein for human consumption, food and livelihood security, poverty reduction, wealth creation, foreign exchange earnings and rural development. At present the contribution of this sector is 0.79 percent to Gross Domestic Product (GDP) and 4.4 percent to agriculture GDP.

In this connection, the study analyzed the triennium average of production, exponential growth and instability in marine as well as inland fish production for three different periods for India; period – I as initial phase (1978-87), period – II as growth phase (1988-91) and period – III as saturation (1998-2010) in marine fish production. The study reveals that in overall period the fish production in India has grown at an annual rate of 4.2 percent per annum during entire period of 33 years i.e. 1978-79 to 2010-11. The growth rate of middle period is very high at 5.6 percent per annum as compare to about 3.5 percent in other two periods. The growth performance is contributed by both marine and inland fish productions. However, the growth of marine fish production is always lower than that of inland fish production. The variations in the growth rates in three periods are mainly contributed by marine fish production. This sector suffered steep deceleration in the third period with a growth rate of only 1 percent per annum. Therefore, the instability in the marine fish production is high because the deceleration in the growth rate between second and third periods is accompanied by increase in the instability.

One significant feature of the results is that the contribution of area and workers is quite stable in different specifications. The elasticity of output with respect to active fishermen is about 0.5 in all the specifications. Similarly, the elasticity of output with respect to continental shelf area is 0.3, therefore, there are two factors to determine fish production. It is also analyzed that the share of motorized crafts and mechanized boats in total crafts increase by one percent fish production increases by 0.03 in each case. Thus, shifting to both mechanized boats and motorized crafts will increase fish production with the same area and number of active fishermen.

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