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An Appraisal of Growth and Instability of Marine Fish Production in Karnataka, India

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Abstract

This study attempts to understand the growth and instability of marine fish production using secondary fisheries related data of Karnataka for the period 1980-2010. Craft-wise decadal growth rate of marine fish production was measured using Compound Growth Rate (CGR) and instability was studied by using Coppock Instability Index (CII) and Coefficient of Variation (CV). The results showed high instability in the number of purse seiners and gillnetters and longliners during 1980-90 (D1) and trawlers and rampanies during 1990-00 (D2). The growth rate of purse seine boats and other mechanised boats was more during 1980-90 (D1) and for trawler and rampanies during 1990-00 (D2). The maximum instability and growth rate for the purse seiners' harvest was seen during 1990-00 (D2) and 1980-90 (D1) respectively. Similarly for trawlers, peak harvests occurred during 2000-10 (D3) and for other mechanized boats and rampanies it occurred during 1980-90 (D1). The instability in terms of CPUE for purse seiners was the highest during 1990-00 (D2), whereas the overall growth rate in terms of CPUE showed negative trend. Likewise, peak instability and growth rate in terms of CPUE for trawlers and other mechanised boats was observed during 2000-10 (D3) and 1980-90 (D1) respectively. The overall growth rate in terms of CPUE for rampanies was negative, since their overall number increased during the entire study period.

Keywords: Catch per unit effort, Coppock Instability Index, coefficient of variation, compound growth rate

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Introduction

The fisheries sector has emerged as an important commercial activity during 1980's from its subsistence, supplementary status. Economic importance of fisheries sector to the country can be identified from the fact that it is a source of animal protein for human consumption, income, employment and foreign exchange earnings (Bhatta et al., 2000). The average total fish production in the Karnataka State during the last 5 years was about 3 lakh MT with the contribution of marine sector being 60% and inland sector 40%. The State produces 2.18 lakh MT of marine fish and is ranked 6th position in country with total fishers population of 1.71 lakh. The State contributed about 4.8% of India's total marine fish production. Coastal Karnataka has 191 marine fishing villages spread over three districts, each fishing village covering an average of 1.6 km coastal line (GOI, 2008). Karnataka was the first State in the country to introduce purse seines during 1975-76. The number of purse seiners increased from 2 in 1975-76 to 305 in 2008-2009. This resulted in steep rise of annual average catch from 85,000 MT (prior to 1976) to 160,000 MT (after 1976) (Jayaraj, 1983).

The decline in the prawn and mackerel catch by 111 MT during 1997-98 in Mangalore and Malpe region caused a significant loss of ₹ 19.4 crores. A study rightly pointed the decrease in the marine fish production by 12.8% in the State and 31.4% in the Dakshina Kannada district. It was also stated that the decline in production was the result of short-term fluctuation and there was no symptom of long-term decline in the marine fish production. There were mounting signs of biological and socio-economic un-sustainability that threatened the coastal fisheries (Muthiah et al., 2000). The introduction of trawlers has adversely affected other shore seines and fish landings. Hence, to study the impact of mechanized and motorized crafts on the fish landings with the objective of analyzing the growth and instability of marine fisheries production for the period 1980-2010 in Karnataka State.

Materials and Methods

The present study's secondary data on marine fish production was collected from the Department of Fisheries, Government of Karnataka. The marine fish production data were divided into three periods such as Decade 1 (1980-1989), Decade 2 (1990-1999), Decade 3 (2000-2009) and overall period. Decadal growth rate and instability of marine fish production in Karnataka was measured for different category of fishing crafts such as purse seiners, trawlers, rampanies and other mechanized boats. The growth rate was studied by estimating Compound Growth Rate (CGR), and instability by using Coppock Instability Index (CII) and Coefficient of Variation (CV). The CII, CV and CGR were calculated across the different fishing crafts for the parameters such as number of boats, quantity of marine fish production, and Catch Per Unit Effort (CPUE) for three decades D1, D2 and D3 individually and for the overall period (1980-2010).

Compound Growth Rate was estimated based on method used by Fauzi & Anna (2012). The growth rate of marine fish production during the period 't' was estimated using following formula.

$$\log y_{it} = \log \alpha + t \log \beta + \varepsilon$$

Where,

$\log y_{it}$ = Marine fish production at time t, α is the constant, β is coefficient containing the growth rate and ε is an error term.

$$CGR = \exp(\beta) - 1$$

Where,

β = expresses the rate of change and when multiplied by 100 gives the percentage growth rate

The CII technique was used by Coppock (1962) to measure instability and the technique was further used by Shah (2007) and Fauzi & Anna (2012) to study the instability in fisheries production of developing countries and Indian frozen scampi export (Jeyanthi & Nikita, 2012). This technique was also applied in agriculture research (Pathak & Mohankrishanan, 1988). This method requires a less extensive data set and is suitable for evaluating the fisheries policies in developing countries.

The formula to calculate the CII is given below:

$$CII = [\text{Anti log}\sqrt{\log V} - 1] \times 100$$

$$\log V = \frac{[\log\left(\frac{X_{t+1})}{X_t}\right) - m]^2}{N - 1}$$

Where,

X_t= Fish production in the year 't', N = Number of years, m= Arithmetic mean of the difference between the logs of X_{t+1}, X etc. and log V = logarithmic variance of the series.

CV was used to measure variability and standard measure of instability of marine fish production. CV was computed for decade-wise marine fish production in Karnataka (Bhujel, 2008).

Coefficient of Variation = Standard deviation / Mean * 100

Results and Discussion

Fish production per fishing unit in the State was 16.70 MT which is well above the national average of 12 MT (GOK, 2009). The decadal growth of state's average marine fish production per km of coastline was almost double that of national average production since 1950s and the rate of increase was steep during 70s and 80s, mainly due to highly efficient exploitation of the pelagic resources by the purse seine fleet. During 1970-80 and 1980-90s, rate of growth of production increased at decreasing rate although overall decadal growth was 40%. However from 1990-00 to 2000-09, the total marine fish production declined from 1 84 419 to 1 59 833 MT (Table 2). In the national level, there was no decline in total marine fish production but stagnation and marginal decline in production was observed in the state which is an indicator of overfishing and unsustainability.

The share of non-mechanised/traditional sector declined from 59% in 1976-77 to 6% in 2008-09. The average catch rate per non-mechanised unit has declined from 1.03 MT in 1984-85 to 0.35 MT in 2008-09. The catch rate of mechanised units has declined from 80 MT in 1979-80 to 12 MT in 2008-09. The year wise perusal of marine fish production of Karnataka shows a declining trend with year to

Table 1. Marine Fisheries Resources in Karnataka

Particulars	Coastal line (km)	EEZ (million km^2)	Continental shelf (million km^2)	Number of landing centers	Number of fishing villages
Dakshina Kannada	42	N.A	N.A	3	21
Udupi	98	N.A	N.A	10	64
Uttara Kannada	160	N.A	10-11000	13	106
Karnataka	300	87000	27000	26	191
India	8811 (3.40)	2.02 (4.30)	0.53 (5)	2251 (1.15)	3202 (5.97)

Source: GOK (2009) and GOI (2008) N.A= Not available

*Figures within the parentheses represent the State's percent share in India's marine fisheries resources.

Table 2. Marine fish production in Karnataka and India

(in Mt)

Decades	Karnataka		India	
	Average annual production	Average production km^{-1} of coastline	Average annual production	Average production km^{-1} of coastline
1980-1989	151401.4	504.67	1697300 (8.92)	213.8
1990-1999	184419.3	614.73	2252300 (8.19)	299.6
2000-2009	159833.0	532.78	2924000 (5.47)	360.19

Source: GOK (2009) and CMFRI (2011)

Note: Figures within the parentheses represent the State's percent share in India's average annual production

year fluctuations (Table 3). The marine fish production potential of the State is estimated at 4.25 lakh MT, of which about 50% falls within the inshore region of 50 m depth and remaining within the off shore/deep zone (Jayaraj, 1983). Compared to the estimated potential of the State of 4.25 lakh T, the actual catch is around 1.5 lakh T, which is only 35% of the potential (CMFRI, 2005). On the other hand, there were already signs of unsustainability as indicated by stagnating total fish catch, declining size of fish and declining catch per unit of fishing effort (Nandakumar & Nayak, 2010). Thus, the resource potential and actual landings of Karnataka depict a disturbing picture.

Table 4 presents the growth and instability index of marine landings of purse seiners. The landings were divided into four phases: Decade 1, 2, 3 and overall period. As can be noted from the table, number of purse seiners and landings by this vessel showed the highest instability index during the 1980-89 and 1900-1999 respectively. This conforms to the observations of McElroy (1991a, 1991b) that higher influx of this vessel during the early 1980s caused a massive increase in growth in production. This can be elucidated from the compound growth rate (CGR) for number of boat-PS for Decade 1 (3.81%) where the growth rate was highest. Comparatively, CGR during Decade 3 was the least (-3.11%) in case of NB-PS with overall CGR being negative (-0.04%). The highest instability in production for PS was found during Decade 2 (CII-D2=85.67) whereas, CV was highest during Decade 1 (30.28). While the overall CGR for PS in terms of production has shown negative growth rate (-3.56%), the overall CII and CV of production from PS were observed to be considerably high *viz.,* 36.67 & 41.56 respectively. Highest growth rate for PS in terms of production was seen during Decade 1 (2.47%) resulting in overfishing and the same has been reflected in the study conducted by Fauzi & Anna (2012). Peak CII for PS in terms of CPUE was seen during Decade

Table 3. Sector-wise marine fish production in Karnataka

Year	Total marine fish production (Mt)	Marine fish production (metric ton per fishing unit year^{-1})	
		Share of mechanised sector	Share of non-mechanised sector
1976-77	62785	17.70 (40.53)*	-NA
1979-80	191026	80.14 (81.68)	-NA
1984-85	168046	51.11 (92.73)	1.03 (7.27)
1989-90	186132	45.96 (92.11)	1.26 (7.89)
1994-95	172500	31.87 (89.49)	1.52 (10.51)
1999-00	165653	24.91 (95.00)	0.43 (5.00)
2004-05	171227	20.88 (96.44)	0.32 (3.56)
2005-06	176897	19.63 (96.10)	0.33 (3.90)
2006-07	168881	44.44 (97.15)	0.23 (2.85)
2007-08	123956	12.34 (92.98)	0.41 (7.02)
2008-09	123978.6	12.43 (93.58)	0.35 (6.42)
Average	166612.55	32.85 (87.98)	0.53 (12.02)

Source: GOK (2005) and GOK (2009) Note: N.A= Not available

*Figures within the parentheses are percent share of mechanized and non mechanized boats

Table 4. Scores of Coppock Instability Index (CII) and CGR for Purse Seiners (PS)

Factors	CII-D1	CII-D2	CII-D3	CII-Overall	CGR-D1	CGR-D2	CGR-D3	CGR-Overall
NB-PS	63.84 (12.82)	5.29 (5.44)	45.65 (10.11)	20.12 (9.62)	3.81	-0.48	-3.11	-0.04
Prod-PS	48.24 (30.28)	85.67 (26.37)	47.73 (26.02)	36.67 (41.56)	2.47	-5.96	-1.31	-3.56
CPUE-PS	34.71 (33.80)	85.27 (26.88)	71.93 (28.72)	43.65 (43.4)	-1.29	-5.51	1.86	-3.57

Note: NB-PS = Number of Boats-Purse seine, Prod-PS = Production-Purse seine, CPUE-PS =Catch per unit effort-Purse seine

*Figures within the parentheses are coefficient of variation.

2 (85.27) and similarly, CV hit the highest during Decade 1 (33.80). Likewise, maximum CGR for PS in terms of CPUE was found during Decade 3 (1.86%) which was preceded by the least growth rate during Decade 2 (-5.51%). The Overall CGR for PS in terms of CPUE has shown negative growth rate (-3.57%).

Table 5 indicates the growth rate and instability of trawlers. Maximum CII and CV in the number of TL were observed during Decade 2 (CII-D2) which attributed to 62.91 and 16.51 respectively. While, the least CII was observed during Decade 3 (20.49), the least CV was found during Decade 1 (3.11). The Overall CII and CV for NB-T was 32.31 and 19.68 respectively. The CGR for NB-TL was more during Decade 2 (5.11%) and least during Decade 3 (-1.81%) whereas, the Overall CGR witnessed positive growth rate (1.95%). The instability index, CII for production (Prod-TL) hit the highest during Decade 3 (195.90) with CV of 43.49. The CGR for Prod-TL was more during Decade 3 (10.67%) and least during Decade 1 (2.50%). Higher growth in Decade 3 is related to a higher instability index in the same period and the same results were demonstrated by Shah (2007) and Wasim (2007) for some fisheries, a higher growth rate was related to higher instability, while for others, the situation was opposite. The Overall CV for Prod-TL was 44.58 with the corresponding CII of 63.05. The overall CGR for Prod-TL conforms to positive growth rate (3.55%). The CII for CPUE-TL was found highest during Decade 3 (200.64) with the CV of 43.17. The CGR for CPUE-TL was maximum during Decade 3 (12.71%) and least during Decade 2 (-1.98%). The Overall CGR for CPUE-TL displayed a positive trend (1.58%).

Table 6 shows the growth and instability rate of other mechanized boats (OMB). From the table it is obvious that the number of OMB experienced highest instability, CII and CV during Decade 1 which are 219.66 and 51.21, respectively. The least CII was seen during Decade 3 (55.51) with the least CV of 17.70. The Overall CII and CV for the number of OMB were calculated to be 133.62 and 70.15 respectively. Similarly, the CGR for number of OMB was more during Decade 1 (23.03%) and least during Decade 3 (5.14%). In general, the Overall CGR had a positive growth rate (11.54%). The positive impact of mechanization on fishing community was reported in coastal Karnataka (Seema, 2004). The CII was also calculated based on OMB production (Prod-OMB) which hit the highest during Decade 1 (343.04) with the CV of 66.83. The Overall CV and CII of Prod-OMB were analyzed to be 66.15 and 168.88 respectively. The CGR for Prod-OMB was more during the Decade 1 (39.10%) and least during the Decade 3 (3.12%). The overall CGR for Prod-OMB displayed a positive growth rate (12.32%). The instability rate in terms of CPUE-OMB was found to be highest during Decade 1 (153.49) with the CV of 38.81. The growth rate in terms of CPUE-OMB was analyzed to be elevated during Decade 1 (13.06%) and least during Decade 3 (3.12%) with the Overall CGR exhibiting a positive trend (0.69%). The central excise relief on diesel consumed by the fishing vessels, subject to some limit on annual consumption and thus helped further mechanization. Subsequently there was rapid increase in the

Table 5. Scores of CII and CGR for Trawlers (TL)

Factors	CII-D1	CII-D2	CII-D3	CII-Overall	CGR-D1	CGR-D2	CGR-D3	CGR-Overall
NB-TL	20.94 (3.11)	62.91 (16.51)	20.49 (7.08)	32.31 (19.68)	0.71	5.11	-1.81	1.95
Prod-TL	34.83 (24.17)	50.05 (15.33)	195.90 (43.49)	63.05 (44.58)	2.50	3.03	10.67	3.55
CPUE-TL	42.51 (21.86)	31.13 (13.90)	200.64 (43.17)	49.30 (34.91)	1.77	-1.98	12.71	1.58

Note: NB-TL= Number of Boats-Trawler, Prod- TL = Production-Trawler, CPUE- TL =Catch per unit effort-Trawler

*Figures within the parentheses are coefficient of variation.

Table 6. Scores of CII and CGR for Other Mechanised Boats (OMB)

Factors	CII-D1	CII-D2	CII-D3	CII-Overall	CGR-D1	CGR-D2	CGR-D3	CGR-Overall
NB-OMB	219.66 (51.21)	114.25 (34.98)	55.51 (17.70)	133.62 (70.15)	23.03	12.53	5.14	11.54
Prod- OMB	343.04 (66.83)	109.51 (35.97)	54.81 (18.60)	168.88 (66.15)	39.10	10.35	3.12	12.32
CPUE- OMB	153.49 (38.81)	20.13 (20.09)	6.48 (20.74)	66.24 (27.47)	13.06	-1.94	-1.92	0.69

Note: NB-OMB = Number of Boats-Other Mechanised Boats, Prod-OMB = Production-Other Mechanised Boats, CPUE-OMB = Catch per unit effort-Other Mechanised Boats

*Figures within the parentheses are coefficient of variation.

Table 7. Scores of CII and CGR for Rampanies

Factors	CII-D1	CII-D2	CII-D3	CII-Overall	CGR-D1	CGR-D2	CGR-D3	CGR-Overall
NB-R	41.52 (7.52)	133.17 (55.47)	58.21 (70.72)	77.86 (59.63)	-8.82	19.33	1.59	8.20
Prod-R	228.38 (106.12)	151.25 (98.58)	54.30 (82.02)	45.71 (92.83)	-21.28	38.19	13.78	1.75
CPUE-R	165.73 (67.55)	43.80 (80.22)	16.12 (7.79)	57.01 (83.92)	9.01	15.80	12.00	-1.87

Note: NB-R= Number of Boats- Rampanies, Prod-R= Production-Rampanies, CPUE-R=Catch per unit effort-Rampanies
*Figures within the parentheses are coefficient of variation.

fishing capacity of both mechanised and motorized crafts which enabled even the small scale fishers to access resources away from coastal waters (Pathak & Mohankrishanan, 1988). The process was facilitated by state policies on fuel subsidies (Vivekanandan, 2002).

Table 7 demonstrates the growth and instability rate of rampanies. It is observed that the instability rate in the number of rampanies was maximum (133.17) during decade 2 with the CV hitting its peak (70.72) during decade 3. The least CII was found during decade 1 (41.52) with the least CV of 7.52. The Overall CII and CV for NB-R were calculated to be 77.86 and 59.63 respectively. The highest growth rate in the number of rampanies occurred during decade 2 (19.33%) and it plunged deeply during the decade 1 (-8.82%). In general, Overall CGR for NB-R witnessed positive growth rate (8.20%). The instability in the production of rampanies was found highest during decade 1 (228.38) with the CV of 106.12. The Overall CV in the production of rampanies was 92.83, whereas CII arrived to be 45.71. The growth rate in the production of rampanies was more during decade 2 (38.19%) and least during decade 1 (-21.28%). The overall CGR in the production of rampanies reflected positive growth rate (1.75%). The utmost instability in terms of CPUE was found during the decade 1 (228.38) with the CV of 106.12. While the maximum growth rate in terms of CPUE of rampanies was observed during decade 2 (15.80%), the least was seen during decade 1 (9.01%). The Overall CGR in terms of CPUE for rampanies showed negative growth rate (-1.87%).

The growth of marine fish production has been contributed by different types of fishing crafts operated in Karnataka for the past three decades; however the decadal contribution of each craft category varied enormously. During 1980's, the mechanization of fishing crafts had taken place and large number of purse seine boats and other mechanized boats were introduced to the then existing Karnataka fishing fleet and hence there was large instability in marine fish production during 1980-89 & 1990-1999. The instability in CPUE-PS was at its peak during decade 2 1990-1999 but the overall growth rate in terms of CPUE was negative proving inefficiency of purse seine boats. On the other hand, the CPUE of other mechanized boats was found to be promising during 1980-1989. Though the number of trawlers and rampanies were augmented in the State fishing fleet during 1990-1999, it reflected in the actual landings only during 2000-2009 with improved CPUE. The overall growth rate in terms of CPUE was negative for rampanies despite the increase in the number of rampanies during the entire study period. Thus the craft-wise contribution of marine fish landings in the State was highly unstable and growth rate of each category was not homogenous. In order to design effective strategies and policy framework for sustainable management of marine fisheries, it is indispensable to accomplish a thorough review of both past and current management of fishing practices. Results of this study could be used as a benchmark for policy makers to understand how fisheries behaved in the past three decades. Future direction can then be drawn upon to direct existing fisheries towards sustainable fisheries.

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