

Temporal Behaviour of Marine Landing in Karnataka. ii-Seasonal Patterns*

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Seasonal patterns of 21 fisheries in Karnataka (after isolation from time-series components) are presented. Depending on the pattern of seasonal fluctuation in landings, 19 fisheries have been grouped into five patterns, A, B, C, D and E. Ribbon fishes and 'other clupeids' did not exhibit any significant seasonal pattern. Pattern A with highest landings in the 4th quarter (October to December), followed by the 1, 2 and 3 quarters, is the most common in 10 species/groups (comprising 78% of the total landings). Harmonic analysis has been carried out using the seasonal indices.

Few natural resources are available uniformly throughout the year. This is equally true of a fishery. The seemingly erratic behaviour of marine fish landings, do fall into specific patterns year after year. Seasonality in marine fish landings in India has been noticed by several workers (Chakraborty *et al.*, 1973, Kumaran, 1978a). In view of the limited studies employing time-series analysis in decomposing quarterly or monthly catch over the years, this study on seasonal patterns was taken up.

Materials and Methods

Source of material is the same as that reported by Gadagkar & Sundararaj (1985). The four components T_t , C_t , S_t and I_t were estimated by the method of Croxton *et al.* (1967) and supplemented by,

(i) estimation of stabilised seasonal indices by interactive procedures. This procedure involved sequential estimation of TC components by weighted moving average of five quarters with weights (1/8, 2/8, 2/8, 2/8, 1/8 respectively). These estimates were employed to construct seasonal indices and this cycle was repeated by re-estimating TC values, that is, deseasonalising the data

by dividing each observation by the seasonal index, and so on. These interactive cycles were repeated until two successive seasonal indices differed by not more than 0.5 (arbitrarily chosen).

(ii) After SI components were estimated by dividing each observation by the corresponding TC estimate in each cycle of interaction, Friedman's two-way analysis of variance (Siegel, 1956) was employed to the year-by-quarter table of SI's to look for significant differences between seasons and non-significant difference between years-significant differences between quarters merely establishing seasonality and non-significant differences between years, besides pointing to the persistence of a constant seasonal pattern from year to year, also suggesting the use of the arithmetic mean over years as an adequate measure of seasonal score.

The final figures obtained were then taken as the seasonal indices for the species/group. In order to ascribe a mathematical format to these indices as well as to join them by a smooth curve, harmonic analysis was carried out using the procedure of Douglas (1964). Bajpai *et al.* (1977) opine that it is not necessary to carry out harmonic analysis beyond the $\left(\frac{r}{2}\right)$ th harmonic, 'r' being

the number of intervals. In this study the analysis has therefore been restricted only

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upto the first harmonic. It was found to be an adequate fit (visually) in most cases.

Results and Discussion

The analysis revealed demonstrable seasonal influences in all the 21 species/groups. To know the seasonal behaviour the fishes were grouped into five categories, depending on the pattern of seasonal fluctuations in landings. For convenience of presentation, these patterns have been named, A, B, C, D and E. Table 1 presents the 'average' seasonal indices-averaged over the species/groups belonging to each pattern.

Table 1. *Seasonal indices averaged over the species/groups belonging to each pattern*

Pattern	Quarter				Total
	1	2	3	4	
A	90	23	36	251	400
B	48	28	207	117	400
C	70	94	32	204	400
D	162	72	92	74	400
E	175	89	52	84	400

Table 1 gives a basis-average seasonal index for comparison between the various seasonal patterns. Another basis for comparison is the seasonal 'effect' or 'influence', that is, the percentage fluctuation contributed by each quarter to the total amount of fluctuation, ignoring the direction. In the absence of any seasonal influence, the base value is 100 for the seasonal factor in the time-series model $Y = TCSI$ (multiplicative model), the deviation of each seasonal index from 100 may be a measure of seasonal effect. Ignoring the direction of such fluctuations, only their magnitudes and their reduction to percentages are reported in Table 2.

Table 3 presents the final iterative stabilized seasonal indices (Part 1) and percentage seasonal 'influence' (Part 2) for 19 species/groups, after grouping them into the observed seasonal patterns A, B, C, D and E. Ribbon fishes and 'other clupeids' did not exhibit any significant seasonal pattern.

Table 2. *Quarter-wise seasonal 'influence' under each seasonal pattern*

Pattern	Quarter	1	2	3	4	Total
A	Absolute	10	17	64	151	302
	Percentage	3	26	21	50	100
B	Absolute	52	72	107	17	248
	Percentage	21	29	43	7	100
C	Absolute	30	6	68	104	208
	Percentage	14	3	33	50	100
D	Absolute	62	28	8	26	124
	Percentage	50	23	6	21	100
E	Absolute	75	11	48	16	150
	Percentage	50	7	32	11	100

Harmonic analysis was carried out using the seasonal indices for each fishery and for the average indices under each pattern. The results are presented in Fig. 1 and the mathematical format that $f(t)$, the seasonal function assumes in each case, is given in Table 4.

1. Pattern A: This is the most common pattern with as many as ten species/groups demonstrative in (Table 3). The fisheries that follow this seasonal pattern together make up almost 78% of the total landings. It naturally follows that 'total' also follows pattern A—highest landings in the 4th quarter (October to December), followed by the 1, 3, 2 quarters. The 4th quarter contributes to as much as 50% of the total seasonal fluctuation (Table 2). The curve (Fig. 1) being symmetrical about the base line, however, does not convey this information.

October to December is the best fishing season for the whole country has been pointed out by Kumaran (1978a), Chakraborty *et al.* (1973) and others. These studies have shown that the neighbouring states of Kerala and Maharashtra show a similar seasonal pattern with the 4th quarter registering the highest landings followed by the 3, 1 and 2 in Kerala; and 2, 1 and 3 quarters in Maharashtra. One possible explanation for these quarter-wise fluctuations in these three neighbouring states is to the early start of

Table 3. *Stabilized seasonal indices and percentage seasonal 'influence' for 19 species/groups classified into 5 patterns*

Pattern	Species/group	Part I Seasonal index				Part II Seasonal influence			
		1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
A	(a) Perches	101.30	50.56	88.59	159.55	1	41	9	49
	(b) Elasmobranchs	117.46	51.39	66.52	164.63	11	30	20	39
	(c) <i>Caranx</i> spp.	130.66	36.57	42.31	190.46	13	26	24	37
	(d) <i>Hemirhamphus</i> spp. and <i>Belone</i> spp.	116.38	39.32	17.24	227.06	6	21	29	44
	(e) <i>Chirocentrus</i> spp.	75.26	10.58	57.35	256.81	8	28	14	50
	(f) Pomfrets	91.08	16.56	18.52	273.85	3	24	23	50
	(g) <i>Anchoviella</i> spp.	59.05	10.83	37.64	292.48	11	23	16	50
	(h) Oil sardine	106.04	2.43	3.89	287.64	2	25	25	48
	(i) Seer fish	67.81	5.34	22.34	304.52	8	23	19	50
	(j) Mackerel	40.18	3.38	4.10	352.33	12	19	19	50
B	(a) <i>Leiognathus</i> spp.	81.92	50.95	136.34	130.79	13	37	27	23
	(b) Sciaenids	69.11	35.42	186.92	108.55	16	34	46	4
	(c) <i>Thrissocles</i> spp.	41.74	17.42	203.18	137.66	21	29	37	13
	(d) Soles	26.00	16.77	197.54	159.69	24	26	31	19
	(e) <i>Lactarius</i>	21.45	18.36	311.49	48.69	19	19	50	12
C	(a) Cat fishes	85.55	124.08	19.82	70.54	8	13	42	37
	(b) Lesser sardines	53.70	63.03	44.98	238.28	17	13	20	50
D	Penaeid prawns	161.57	72.39	92.33	73.71	50	23	6	21
E	Other								
	Crustaceans	174.79	88.75	52.19	84.27	50	7	32	11
	Total	97.41	26.00	29.68	246.91	1	25	24	50

the south-west monsoon in the south (Kerala) which reaches the coast of Maharashtra a little later. This partly explains the low catch in the 2nd quarter in the states of Kerala and Karnataka, and the low catches in the 3rd quarter in Maharashtra. Sankaranarayanan & Qasim (1969) investigating the influence of hydrographical factors on the fisheries of the Cochin area have pointed out that the fishing season starts from September–October when both fish and prawn begin to appear in large numbers in coastal waters, gradually intensifying to reach a peak when stable conditions prevail in the sea.

It can be noted from Table 3 and Fig. 1 that the fluctuation due to season is least pronounced in the case of perches and is

maximum for mackerel. The slight shift between the peak and trough between the component fisheries is also noteworthy.

Mackerel: Table 3 and Fig. 1 reveal that while the 4th quarter contributes highly to the annual catch and the 1st quarter moderately, the contribution of the 2nd and 3rd quarters is negligible. The mackerel fishery depends on the inshore migration of the fish (Sekharan, 1958; Banerji, 1964). The pelagic fisheries of mackerel and oil sardine during their migration from south to north, start earlier in the season in the south and last longer than in the north, where they commence late and end early (Anon, 1977). This is evidenced by the high catches during the 3rd quarter from Kerala when compared to Karnataka. The

Table 4. Harmonic analysis for seasonal indices

Sl. No.	Pattern/Fishery	Functional form of $f(t)^*$
	Pattern A	$100 + 27.34 \cos(t) - 114.12 \sin(t)$
(a)	Perches	$100 + 6.36 \cos(t) - 54.50 \sin(t)$
(b)	Elasmobranchs	$100 + 25.47 \cos(t) - 56.62 \sin(t)$
(c)	<i>Caranx</i> spp.	$100 + 44.18 \cos(t) - 76.95 \sin(t)$
(d)	<i>Hemirhamphus</i> spp. and <i>Belone</i> spp.	$100 + 49.57 \cos(t) - 94.17 \sin(t)$
(e)	<i>Chirocentrus</i> spp.	$100 + 8.96 \cos(t) - 123.12 \sin(t)$
(f)	Pomfrets	$100 + 36.28 \cos(t) - 128.65 \sin(t)$
(g)	<i>Anchoviella</i> spp.	$100 + 10.71 \cos(t) - 140.83 \sin(t)$
(h)	Oil sardine	$100 + 51.08 \cos(t) - 142.61 \sin(t)$
(i)	Seer fish	$100 + 22.74 \cos(t) - 149.59 \sin(t)$
(j)	Mackerel	$100 + 18.04 \cos(t) - 174.48 \sin(t)$
	Pattern B	$100 - 79.53 \cos(t) - 44.65 \sin(t)$
(a)	<i>Leiognathus</i> spp.	$100 - 27.21 \cos(t) - 39.92 \sin(t)$
(b)	Sciaenids	$100 - 58.91 \cos(t) - 36.57 \sin(t)$
(c)	<i>Thrissocles</i> spp.	$100 - 80.72 \cos(t) - 60.12 \sin(t)$
(d)	Soles	$100 - 85.77 \cos(t) - 71.46 \sin(t)$
(e)	<i>Lactarius</i>	$100 - 145.02 \cos(t) - 15.17 \sin(t)$
	Pattern C	$100 + 18.61 \cos(t) ; 55.43 \sin(t)$
(a)	Cat fishes	$100 + 32.87 \cos(t) - 23.23 \sin(t)$
(b)	Lesser sardines	$100 + 4.36 \cos(t) - 87.63 \sin(t)$
	Pattern D (Penaeid prawns)	$100 + 34.62 \cos(t) - 0.66 \sin(t)$
	Pattern E (Other crustaceans)	$100 + 61.30 \cos(t) + 2.24 \sin(t)$
	Total	$100 + 33.87 \cos(t) - 110.46 \sin(t)$

*General functional form of $f(t)$

$$f(t) = A_0 + A_n \cos n(t) + B_n \sin n(t) \text{ where}$$

t = angular transformation of time interval, i.e. $0 \leq t \leq 2\pi$ with an increase of 30° per interval since 12 (monthly) intervals have been considered while plotting.

A_0 , A_n and B_n are parameters of the equation

fishermen of Karnataka instead, fish these stocks when they migrate into inshore waters mainly during the 4th quarter.

Oil sardine: Table 3A (h) and Fig. 1 show that the landings of oil sardine, while conforming to Pattern A, differ from those of mackerel in that the contribution of the 4th quarter is not overwhelming; the 1st quarter experience fairly high catches too. The 2nd and 3rd quarters however, contribute negligibly here too.

The waters of north (13°NL) latitude have a higher salinity and appear to be more

favourable to mackerel than to the oil sardine (Rao *et al.*, 1973). This is evidenced by the very high catches of oil sardine in Kerala, comparatively moderate catches in Karnataka and the low catches in Maharashtra. In the oil sardine landings of Karnataka, the share of Dakshina Kannada is more than that of Uttara Kannada.

2. Pattern B: This pattern ranks second as far as representation is concerned, being represented by five species/groups (Table 3). Pattern B shows highest landings in the 3rd quarter, followed by the 4, 1 and 2 quarters. While the observed data shows about 43%

of the seasonal fluctuation in the 3rd quarter and a mere 7% in the 4th (Table 2). Fig. 1 shows the peak for pattern B some time in the end of October (beginning of the 4th quarter.) This could be explained by the differential pull exerted by the indices of the 2nd and 4th quarters on that of the 3rd. The curve also defines the trough in the end of April (1st quarter).

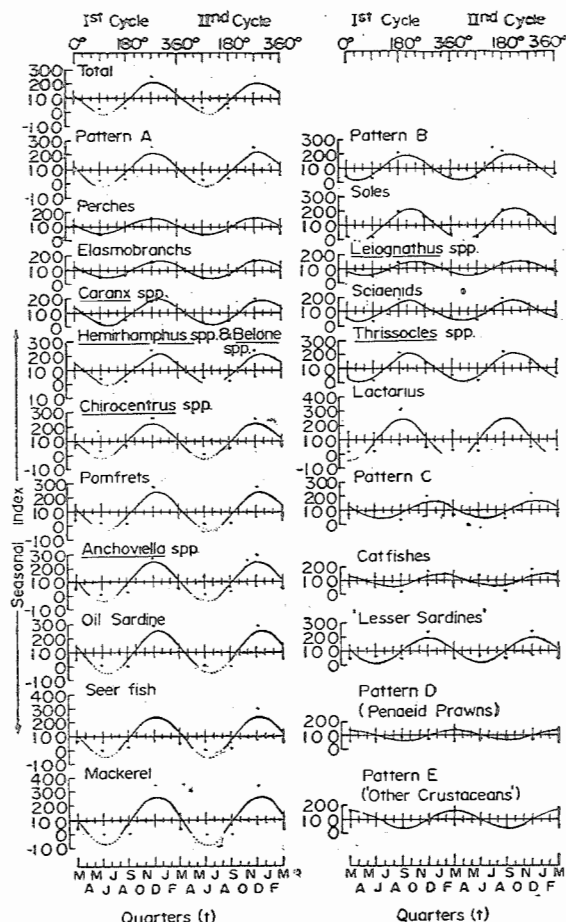


Fig. 1. Harmonic analysis of seasonal periodicities for different species (2 cycles shown).

Leiognathus spp: From Table 3 and Fig. 1, it can be seen that while the 3rd and 4th quarters land almost equally high quantities, the 1st and 2nd quarters account for comparatively lower catches. Bapat *et al.* (1968) found that trawl fishing off Karwar (Uttara Kannada) was fairly profitable during November, March and April and that the best period was January–February. Silver-bellies constitute a large percentage of the trawl catch off Karwar as well as off Mangalore. In general they constitute a round-the-year fishery.

3. Pattern C: Represented by catfishes and 'lesser sardines', this pattern is similar to A in that the 4th quarter witnesses the highest catches (Table 3). As can be seen from Table 2 the 4th quarter is responsible for 50% of the total fluctuation between the quarters, similar to A. However, C differs from A by having a secondary peak in the 2nd quarter. This difference, incidentally, is not conveyed through the figure; the curves for A and C seem to belong to the same group. This obviously is a limitation of harmonic analysis applied to quarterly data.

Catfishes: Most of the gear which land catfishes in the Karnataka waters are operated from September to May (Satyanarayanappa 1979). The consequent low catch during the 3rd quarter can be seen in Table 3. Sekharan (1973) has shown that off the north-east coast of India, the catfish has three peaks in a year: in March, May–June and September–October; the best period being March to June. The seasonal pattern of this fishery in the Karnataka waters does not seem very different from that of the north-east coast, except that the period of best catches seems to be the 4th quarter.

4. Pattern D: Pattern D is uniquely represented by the most important penaeid prawns. This fishery differs from the patterns listed above by having 50% of the seasonal fluctuation registered in the 1 quarter (Table 2). Fig. 1 shows that while the peak is identified correctly by the curve, the trough(s) are not. An examination of C and D (Table 1) brings forth a curious fact if the seasonal indices for each of the two patterns are ranked across the quarters, D becomes the lateral mirror image of C. In other words, the relative magnitudes of the catch across the quarters for the two patterns are exactly the opposite.

Sharma & Murty (1973) studying the prawn fishery of the west coast in relation to the hydrographical conditions of the shelf waters found that the catch was more when cold, dense and poorly oxygenated waters prevailed (during the monsoon); the findings of Banse (1959, 1968) is on the contrary, off the Mangalore coast, soon after the post-monsoon months, there is a flourishing prawn fishery may be due to

upwelling during the south-west monsoon. The monsoon period (3rd quarter) occupies the second position, probably because of reduced fishing effort. From the seasonal behaviour of penaeid prawns it can perhaps be surmised that the penaeid prawns while constituting a round-the-year fishery, prefer stable hydrographic conditions (as evidenced by the peak catches during the 1st quarter). However, they also congregate in the nearshore waters as a result of the upwelling caused during the south-west monsoon period.

5. Pattern E: 'other crustaceans' is another fishery that exclusively follows the pattern E (Table 3). Similar to D (penaeid prawns), E also registers highest catches during the 1st quarter. As much as 50% of the total seasonal fluctuation is accounted for in the 1st quarter (Table 2). Fig. 1 shows the curve fitting fairly well to the seasonal indices, both in terms of direction and magnitude. The group 'other crustaceans' mainly includes crabs, lobsters and stomatopods, and is rather poorly represented along the Karnataka coast. The peak season was February to April, which is corroborated by the high indices for the 1st and 2nd quarters in this study (Table 3). The lobster fishery in Karnataka is almost negligible.

A seasonal pattern in the catch of any fishery could occur as a result of its own behaviour, a seasonal pattern in the availability of food, periodic oscillations in the chemical and physical characteristics of the medium, or perhaps dictated by the synergetic effect of the above and other factors. Kumaran (1978b) for instance, found that the annual upwelling, especially along the west coast influences the availability of a number of commercially exploited fisheries. The role of changing temperature conditions in effecting fluctuations in the availability of fisheries has been discussed by various authors (Laevastu & Hela, 1970). Maliel (1978) in his observations on the exploratory fishing off Mangalore noted that the depth-wise distribution of certain fishes was governed by the season. The fisheries that contribute to the bulk of Karnataka's marine catch are mackerel and oil sardine, and to a lesser extent, penaeid prawns. In this study however, the role of fishing effort can be distinguished from

that of factors independent of effort, in effecting seasonal patterns in the availability of the various fisheries. Significantly different catches between the 4th and 1st quarters in 'Total' landings point to the role of biological and environmental factors. On the other hand poor 'Total' catches during the 2nd and 3rd quarters indicate dependency on effort; the fishing season along coastal Karnataka remains closed from June to August, except for the operation of a few smaller gear near the coast or in the estuaries (Satyanarayanappa, 1979). In this context it is indeed interesting to note that off the south-west coast of India, the UNDP/FAO Pelagic Fishery Project has found the highest total fish abundance around the south-west monsoon months and lowest around the turn of the year (Anon, 1976).

Such facts underscore the need for more work before observed patterns can be attributed to specific factors and predictions made reliable.

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