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Original Research Article

Assessment of Inland Fisheries Population Dynamics in Goa

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ABSTRACT:
Development of a sound data base in inland fisheries has been receiving attention in the recent past. To build, up a reliable data base, it is essential that data collection and estimation methodology is evolved based on scientific lines and the same is put to practice for assessing the nature and quantity of inland fishery resources. Population dynamics deals with mechanisms of population regulation in an area and their management practices to analyse the biomass dynamics of populations. Population dynamics narrates how the population increase or decrease over the time, as it is regulated by natality, mortality, immigration, and emigration. It is helpful in understanding changing population patterns and causative issues such as habitat loss, predation and optimal harvesting rates. An attempt was made to investigate the population dynamics of economically important inland fish species of Goa. Primary Data was collected from the Directorate of fisheries, Government of Goa web site for the present assessment, to get the abundance of resources. In the Present study, data composed of 20 inland captured fisheries species of which the prawns, clams, mullets and crabs are among the highest catch and milk fish 0.212, anchovy 0.158, megalops 0.096 , lutianes 0.0827, black water clams 0.0730 have shown excellent growth potential during the study period.

Keywords: Emigration, Fisheries, Goa, Immigration, Mullets, Prawns.

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INTRODUCTION

Fisheries biologists contribute to fisheries science in two ways – firstly, by studying the basic biology and distribution of resource species, and secondly, by studying the population dynamics of species (King, 1995). Population dynamics is concerned with the biological and environmental processes influencing short and long-term changes in the size and composition of populations. It deals with the way populations growth rate are affected by birth rate and death rate, immigration and emigration, ageing populations and population decline. Population dynamics has been the dominant

branch of mathematical biology, although more recently the scope of mathematical biology has greatly expanded. (Dutta, *et al*., 2017).

In India, the fisheries sector is contributing considerably to the economy of the nation. It is an important source of valuable foreign exchange and employment, providing livelihood for many economically backward fishers of the country. Millions of fishers in the country depend on inland capture fisheries and aquaculture. Indian fisheries are very crucial in terms of quality and quantity of the global fisheries. India is the second largest producer of inland fish in the world and fourth in fish production. (Ayyappan and Diwan, 2006)

India has a total water surface area of 3, 14,400sq.km. The inland fishery resources of the country comprises of 14 major rivers, 44 medium rivers, innumerable small rivers and canals of 1,95,210 km, reservoirs of 3 153 366 ha, tanks and ponds of 24.14 lakh ha, estuaries and floodplain lakes of 7.98 lakh ha, brackish water lakes of 12.40 lakh ha etc. and receives an average annual rainfall of 1,100 mm. The marine water bodies are mainly capture fisheries resources, whereas the inland water bodies are used for culture and capture fisheries. Inland capture fisheries of India have an important place; it contributes to about 30% of the total fish production. There is a great potential for the growth of economic capture fishery due to the large network of inland water bodies in the country. (Subhendu Datta, 2011).

Fishing is carried on by almost every village around the creeks of the Zuari, Mandovi, Sal and Arambol rivers and along the lakes, ponds in Goa. The state contributes about 2% to the national output. Inland fisheries, are classified into capture and culture fisheries and aquaculture which does not take place in marine waters, thus includes fishing in both lotic and lentic, in freshwater, brackish water, estuarine, natural and aquaculture. (Mohanta and Subramanian, 2001). Capture fisheries is mainly exploitive of natural fish populations and the culture fisheries is man managed aquaculture practices.

Though agricultural statistics collection has a long history in India, the significance of fisheries statistics realised very recently. At present, very meagre, data on inland fishery resources and their exploitation is available, resulting in great difficulties of planning and managing. (Shan *et al.,* 2013). In fisheries management, stock refers to a harvested or managed unit of a fish composed of multiple species. River herring is an example of a multispecies stock. Anchovies and blue back herring are labelled as river herring for management purposes due to their similar physical appearances and being harvested together. A mixed stock fishery consists of fish that are of different species, sizes, and ages, geographic or genetic origins. It is always a challenge to manage mixed stock fishery due to the involvement of different types of target groups having different commercial fishing methods.

The Fresh Water Fish Seed/ Hatcheries in Goa are located at Kerim, Anjuna and produces 10 million fry and 3 lakh of advanced fingerlings. Additional seed were procured from hatcheries outside the State to ensure supply of good quality seed in Goa. About14 lakh fish fingerlings were supplied to Goan fresh water fish farmers.

Covering Salaulim reservoir in South Goa and Anjunem Dam reservoir in North Goa state has around 3300 hectares of water spread area of fresh water bodies. In addition to this, in several irrigation bandharas in Mayemlake and smaller perennial and seasonal water sheets. In this regard, fresh water aquaculture offers a good potential to increase fresh water fish production as well as to generate self-employment for the inland rural youth. Short-term trainings are being organized at regular intervals to motivate the farmers to take up the freshwater fish culture. (Sarkar *et.al.*, 2013) The Department through the fresh water fish seed hatchery supplies quality fish fingerlings to the farmers. About 200 hectares is under extensive fresh water farming in the state for exploration of potential cage culture in reservoirs and abandoned mining pits. Catla, Rohu and Mrigalie fast growing fingerlings of Indian Major Carps were stocked in Amthane, Anjuna, Panchwadi and Salaulim, under the National Fisheries Development Board (NFDB) Scheme.

Future yields and stock biomass levels can be predicted by means of mathematical models to adopt suitable management measures pertaining to optimization of fishing effort and increase or decreasing of fishing fleets, sustained without depletion. Therefore these models form a direct link between the resource management, and fish stock assessment. (Thorson *et al.,* 2015)

Goa is the one of the important fishing grounds of India. Its average annual catch was 80000 to 120000 tons. In the present study, twenty economically important inland fish population data is computed to obtain the growth rate patterns of the fisheries and to analyse the changing trends in the inland fishery of Goa.

METHODS

Goa holds a huge scope in the fisheries development. Goa is situated at 15.2993° N, 74.1240° E has a large area of 3701 Km2, coast line of 105km, continental shelf of about 10 million/ha and actively fished area of about 20000 sq. km.

Five years raw data and the other information were collected from the fisheries survey of Goa's website www.fisheries.goa.govt.in. Individual fish data was converted into a bar graph year wise so that it can be easy to differentiate the highest and lowest annual catch during the period under consideration. First the single data was converted into grouped data and calculated the difference between the values of the two years. Then computed the growth rate of the grouped data of individual fish.

$$\text{Growth rate} = \frac{\text{Starting Value} - \text{End Value}}{\text{End Value}}$$

RESULTS

Growth rate patterns of important fish from Goa inland waters were calculated in the present investigation. This data analysis was from the year 2015 to 2019 in which the highest catch of prawns was in 2017 it was 946 whereas the least catch was in the year 2019 which was 455. Highest catch of Lady Fish was in the year 2017, it was 180 whereas the least catch was in the year 2019 which is 60. Mullet's highest catch was in the year 2017 it was 726 whereas the least was in 2015 which was 429. The highest catch was in the year 2017 for *Gerres.sps* and it was 123 and the least catch was in the year 2019 which was 41. *Lutianus* recorded the highest catch in the year 2018 it was 185 where the least was in the year 2019 which was 80.The difference between the highest catch and the lowest catch was very high.

The highest catch of cat fish was in the year 2017 it was 603. Where the lowest catch of cat fish was in the year 2016 and it was 416.Highest catch of anchovy fish was in the year 2017, it was 106. And the lowest catch was in the year 2019, it was 25. Highest catch of Pearl spot was in the year 2017 it was 421 and the lowest catch was in the year 2016 it was 249.The highest catch of Betki was in the year 2018 it was 188 and the least catch of betki was in the year 2015 it was 63. In 2015 Milk fish catch was 28 and in 2019 there was only 03 tons of fish.

The highest catch of megalops was in the year 2016, it was 40 tons. 2019 has the lowest catch of 10. The highest catch of *Scatophagus* which was 89, in the year 2015 and the lowest catch of *Scatophagus* was in2019 which was 36.In the year 2017 *Ambasis* has the highest catch which was 395 and 2015 has the least catch of the soles fish which was 154.Year 2017 has the highest catch of crab and it was 557 tons and the least catch of crabs was in the year 2019 which was 364 tons. The highest catch of Black water clamps was in the year 2016 it is 264 and the least was in the year 2017 which is 45.

The highest catch of false clamps was in the year 2015 it is 614 and the least was in the year 2017 which was 89. The maximum oysters catch was in the year 2019 it was 210 and the least was in the year 2015 which was 62. Highest catch of mussel was in the year 2018, it was 158 whereas the least catch was in the year 2015 which was 29. lepo has the least catch among all other fishes. The maximum lepo catch was in the year 2015 it was 11 and the least was in the year 2017 which was 01. Miscellaneous fish diversity maximum in 2019, which was 891The minimum catch, was in the year 2017 it was 601 (Table 1). The

growth rate of Prawns was 0.0022. Lady fish was0.0293, of Mullet was 0.0004, of ***Gerres sps.*** was 0.029 and *Lutianus* was 0.0827.(Table 2).The Growth rate values of Cat Fish was zero, *Anchovy* was 0.1588, Pearl Spot was 0.0004, Bhetki was 0.4968 and Milk fish was 0.2127 (Table 3). Growth rate values of megalops was 0.0961, *Scatophagus* was 0.0207, *Ambassis* was 0.0029, crabs was 0.039 and Black water clams was0.0730 (Table 4).Growth rate values of false clams was 0.0075, oysters was 0.0066, mussels was 0.0061, Lepo (sole or flounder) -0.738(for four years) and miscellaneous fish was 0.0003 (Table 5).

Table 1: Fish Production of Goa inland waters from 2015-2019.

S.No.	FISH	2015	2016	2017	2018	2019
1	Prawns	822	770	946	804	455
2	Lady Fish	95	98	180	123	60
3	Mullets	429	447	726	632	508
4	*Gerres sps*	78	103	123	81	41
5	*Lutianus*	88	123	142	185	80
6	Cat Fish	423	416	603	570	423
7	*Anchovy*	34	40	106	63	25
8	Pearl spot	291	249	421	379	330
9	Bhetki	63	93	113	188	65
10	Milk fish	28	20	14	17	03
11	Megalops	35	40	31	33	10
12	*Scatophagus*	89	81	59	58	36
13	*Ambassis*	154	229	395	313	279
14	Crabs	368	379	557	529	364
15	Black water clams	151	264	45	58	99
16	false clams	614	322	82	89	189
17	Oysters	62	74	79	111	210
18	Mussels	29	37	107	158	96
19	Lepo (sole or flounder)	11	07	01	03	-
20	Miscellaneous	784	611	601	626	891
	Total	4648	4403	5332	5020	4169

Table 2: Growth rates values Prawns Lady fish, Mullets, *Gerres. sps* and *Lutianus*

Years	Growth rate									
	Prawns		**Lady fish**		**Mullets**		***Gerres. sps***		***Lutianus***	
	(f)	**(fx)**	**(f)**	**(fx)**	**(f)**	**(fx)**	**(f)**	**(fx)**	**(f)**	**(fx)**
2016	52	0.067	-3	-0.030	-18	-0.040	-25	-0.242	-35	-0.284
2017	-176	-0.186	-82	-0.455	-279	-0.384	-20	-0.162	-19	-0.133
2018	142	0.176	57	0.463	94	0.148	42	0.518	-43	-0.232
2019	349	0.767	63	1.05	124	0.244	40	0.975	105	1.312
Total	367	0.825	35	1.027	-79	-0.031	37	1.088	08	0.661
Mean $\bar{x}$ =∑(fx) ÷ ∑(f)		0.0022		0.0293		0.0004		0,0294		0.0827

Table 3: The growth rate of Cat Fish, Anchovy, Pearl spot, Betki and Milk fish

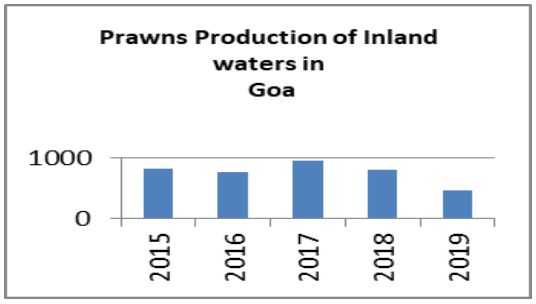
Years	**Growth rate**									
	Cat Fish		***Anchovy***		**Pearl spot**		**Betki**		**Milk fish**	
	(f)	**(fx)**	**(f)**	**(fx)**	**(f)**	**(fx)**	**(f)**	**(fx)**	**(f)**	**(fx)**
2016	7	0.016	-6	-0.150	42	0.168	-30	-0.322	8	0.400
2017	-187	-0.310	-66	-0.622	-172	-0.408	-20	-0.176	06	0.428
2018	33	0.057	43	0.682	42	0.110	-75	-0.398	-3	-0.176
2019	147	0.347	38	1.52	49	0.148	123	1.892	14	4.666
Total	0	0.112	9	1.429	-39	0.019	-2	0.993	25	5.318
Mean $\bar{x}$ =∑(fx) ÷ ∑(f)		0		0.1588		-0.0004		-0.4968		0.2127

Table 4: Growth rates values of megalops, *scatophagus*, *Ambassis*, crabs, Black water clamps

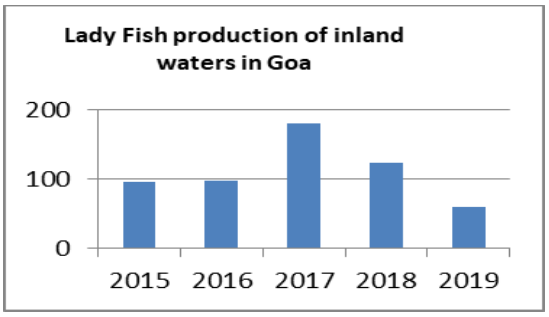
Years	**Growth rate**									
	Megalops		***Scatophagus***		***Ambassis***		**crabs**		**Black water clamps**	
	(f)	**(fx)**	**(f)**	**(fx)**	**(f)**	**(fx)**	**(f)**	**(fx)**	**(f)**	**(fx)**
2016	-5	-0.125	8	0.098	-75	-0.327	-11	-0.029	-113	-0.428
2017	9	0.290	22	0.372	-166	-0.420	-178	-0.319	219	4.866
2018	-2	-0.060	1	0.017	82	0.261	28	0.052	-13	-0.224
2019	23	2.3	22	0.611	34	0.121	165	0.453	-41	-0.414
Total	25	2.404	53	1.099	-125	-0.363	4	0.157	52	3.800
Mean $\bar{x}$ =∑(fx) ÷ ∑(f)		0.0961		0.0207		0.0029		0.0394		0.0730

Table 5: Growth rates values of false clams, oysters, mussels, lepo (sole or flounder) and Miscellaneous fish.

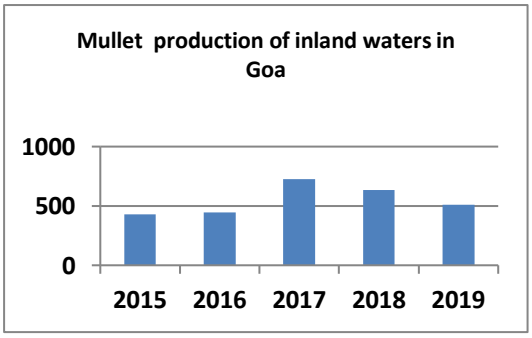
Years	**Growth rate**									
	false clams		**oysters**		**mussels**		**(Lepo) sole**		**Miscellaneous fish.**	
	(f)	**(fx)**	**(f)**	**(fx)**	**(f)**	**(fx)**	**(f)**	**(fx)**	**(f)**	**(fx)**
2016	292	0.906	-12	-0.162	-8	-0.216	4	0.571	173	0.283
2017	240	2.926	-5	-0.063	-70	-0.654	6	6.00	10	0.016
2018	-7	-0.078	-32	-0.288	-51	-0.322	-2	-0.666	-25	-0.039
2019	-100	-0.529	-99	-0.471	62	0.645	-	-	-265	-0.297
Total	425	3.225	-148	-0.985	-67	-0.547	8	-5.905	-107	-0.037
Mean $\bar{x}$ =∑(fx) ÷ ∑(f)		0.0075		0.0066		0.0081		-0.738		0.0003



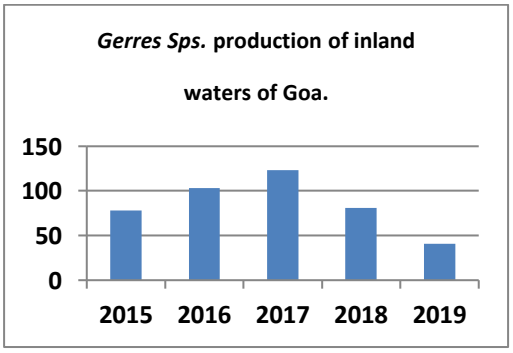
Graph 1: Prawns production of inland waters in Goa.



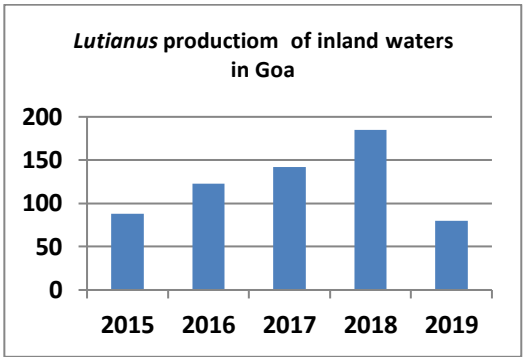
Graph 2: Lady fish production of inland waters in Goa.



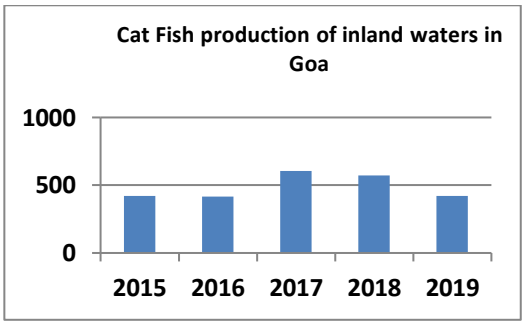
Graph 3: Mullet production of inland waters in Goa.



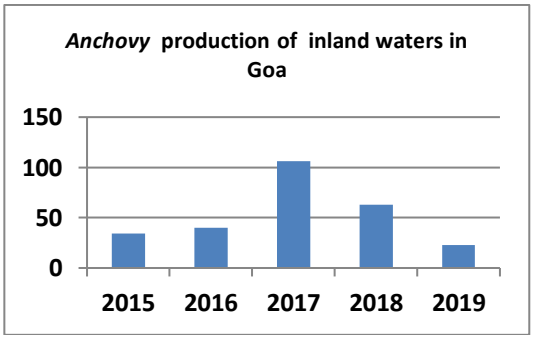
Graph 4: *Gerres Sps.* production of inland waters in Goa.



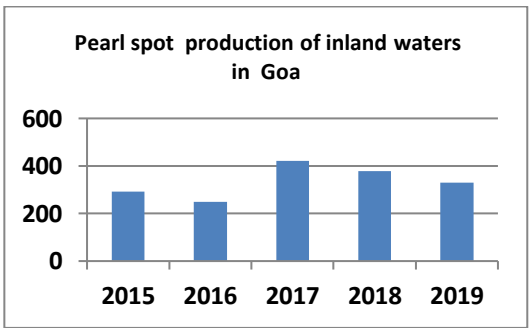
Graph 5: *Lutianus* production of inland waters in Goa.



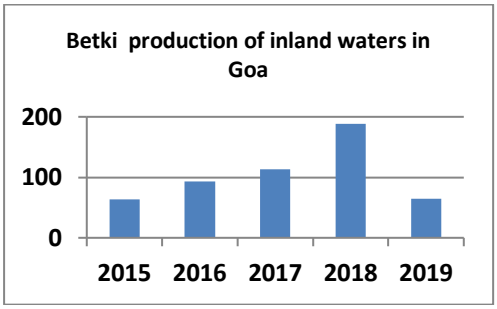
Graph 6: Catfish production of inland waters in Goa.



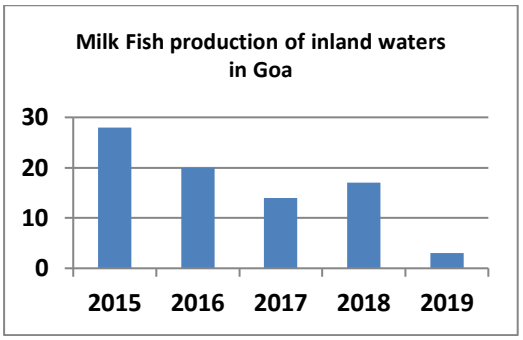
Graph 7: *Anchovy* production of inland waters in Goa



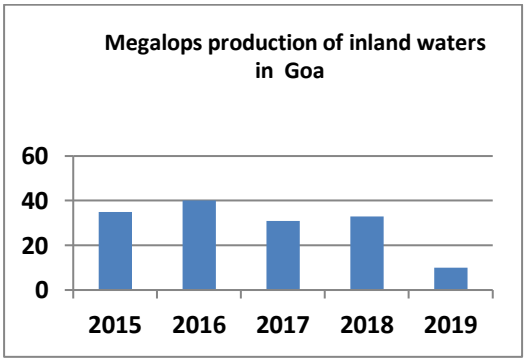
Graph 8: Pearl spot production of inland waters in Goa



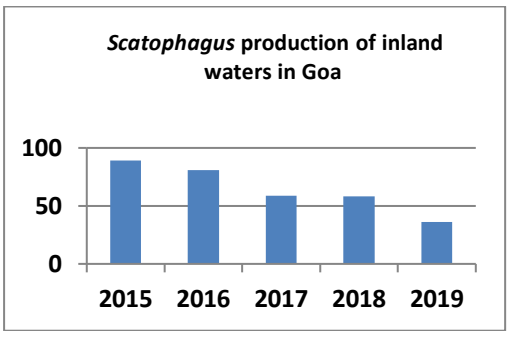
Graph 9: Betki production of inland waters in Goa



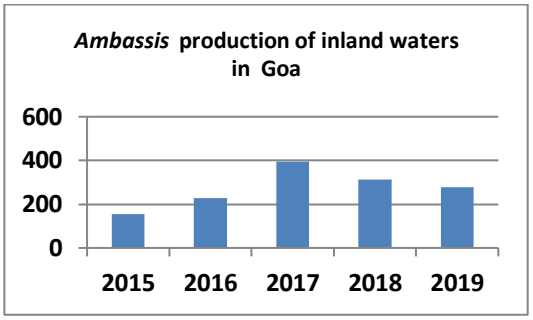
Graph 10: Milk fish production of inland waters in Goa



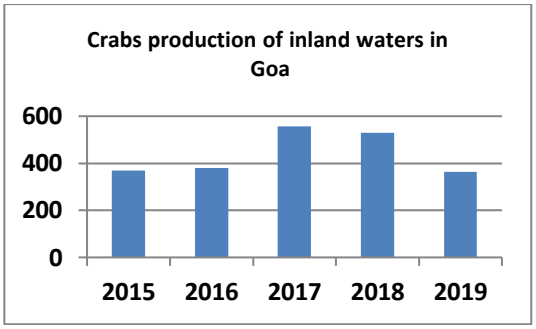
Graph 11: *Megalops* production of inland waters in Goa



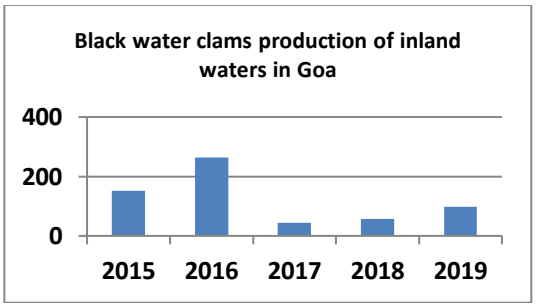
Graph 12: *Scatophagus* production of inland waters in Goa



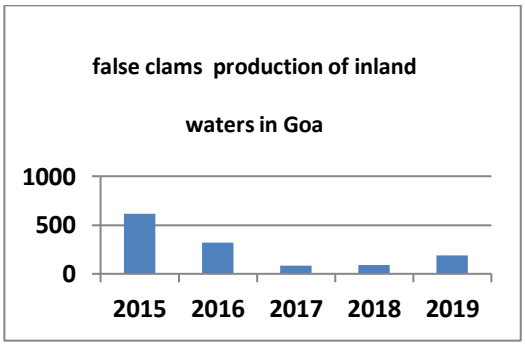
Graph 13: *Ambassis* production of inland waters in Goa



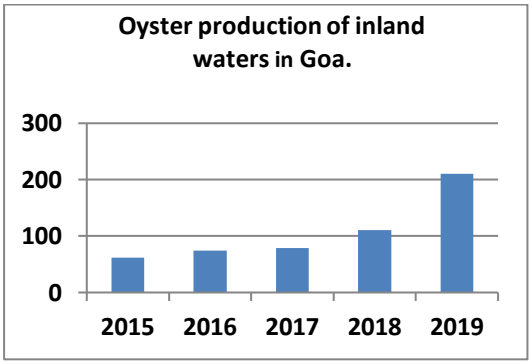
Graph 14: *Crabs* production of inland waters in Goa.



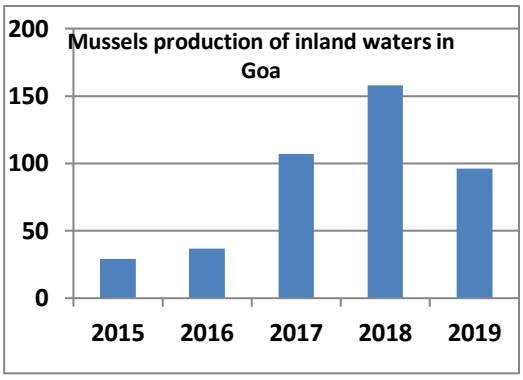
Graph 15: Black water clams production of inland Waters in Goa.



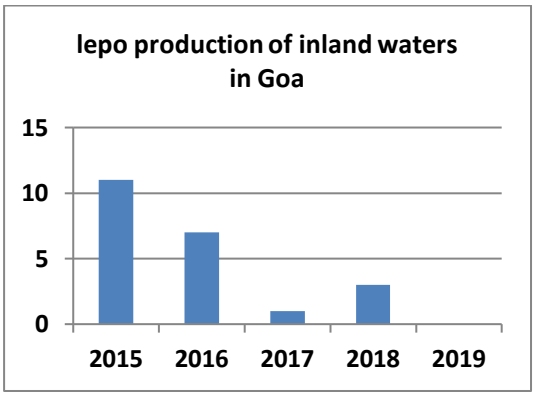
Graph 16: False clams production of inland Waters in Goa.



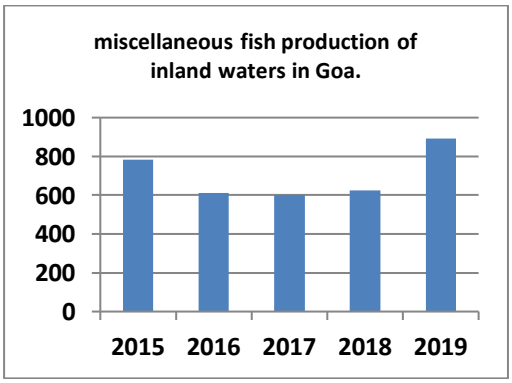
Graph 17: Oyster production of inland waters



Graph 18: Mussels production of inland waters



Graph 19: lepo production of inland waters



Graph 20: Miscellaneous fish production of inland waters

DISCUSSION

Fresh water on the planet earth is just 2.5% of the total water and of that only very small percentage is in liquid state as surface water. (Shiklomanov, 1993). However, 12.7 per cent of the global fish catch i.e. 11.9 million metric tonnes of fish in 2017, was contributed by global inland capture fisheries. Subsistence fisheries (destined for direct household consumption), commercial fisheries and recreational fisheries are included in Inland fisheries. The biggest producers of commercial inland fisheries are Asia and Africa continents contributing 67 and 35 per cent, respectively (FAO Fish. Stat. J, 2019)

Fisheries are important economically at the national and local level because of their social and economic contribution to income for rural communities. Several Goanscatch fish in inland waters, not just as professionals or for sport but also as part-time employment and to supplement their diet. One reason for this is hundreds of water bodies of different dimensions all over the state and their proximity to large water bodies with abundant fish. Fish consumption in Goa is high compared to the other states of the country, and in certain communities in Goa daily fish consumption is a must. Fishery resources are of very vital source of nutrients. It is estimated that about 17% of animal protein consumed by many low-income populations in rural areas is from fish. In other food items like other animal products, pulses and cereals, such a diverse variety of proteins, vitamins and micronutrients are not available.

Ecosystems degradation is a natural phenomenon. Existing ecosystems are gradually getting depleted with biomass due to anthropogenic effects, production and renewal of populations effecting drastically (Barbier et al., 2011). Gradual decline in spawning-stock biomass and fishery production in many exploited inland waters have increased concerns over the multiple effects of fishing, such as habitat degradation and loss. (Pauly et al., 2002; Halpern et al., 2008).

Identifying the intrinsic and extrinsic influences on fish with heterogeneous population densities is very crucial in

characterizing population dynamics (Ray & Hastings 1996).

Inland fisheries sector is directly influenced by the Climate change, behaviour, physiology, migration pattern, distribution and reproductive capacity and mortality. The dynamics of the fishery are strongly related to seasonal rainfall patterns. Rainy season in Goa starts from late May to October in the year. According to an estimate ecosystem services of the east coast of India will decrease by 25% in 25 years, leading to a loss of US$17 billion. Hence, urgency in immediate action plans to support sustainability in fisheries. (Bimal Mohant *et. al.,* 2017) Habitat-specific animal densities can reflect structural refuge provided by a given habitat, as well as abiotic and biotic factors (e.g. salinity, temperature, prey availability, refuge from predators). The link between food availability and fish density in shallow soft bottom systems has been widely demonstrated for flatfish (Vasconcelos *et al.,* 2010), as well as its influence on inter annual variability in juvenile density and distribution (Nicolas *et al.,* 2007).

Vast literature is available on population dynamics of marine fishery covering the trends and the challenges of sustainability (Wang *et. al.*, 2010; Sanchiliana Faria and Manoj Kamat 2016; Field *et. al.,* 2020), changes of fishery ecosystem (Jin *et al.,* 2013), patterns of habitat-specific demographic variability (Rita *et. al.,* 2014), Population dynamics (Xiujuan Shan and Xianshi Jin, 2016). In the world, inland fisheries are important for poverty alleviation, food security, gender empowerment, cultural services, ecosystem function and biodiversity. However, in national and international policy discussions, they are underrepresented (Lynch et al., 2016, 2017). Knowledge gaps on inland fisheries support this lack of recognition of the sector's importance. Little attention is paid to Inland waters fishery in comparison to the marine fisheries in terms of data collection, analysis, characterization and decision making. (Bartley *et. al.,* 2015).

Survey counts are used for studies of population dynamics. Distinguishing the factual differences from observation errors is a challenge, and yet necessary for drawing appropriate conclusions. (Freckleton *et. al.*, 2006; Thorson *et. al.*, 2015). Present investigation is carried out to analyse population dynamics of the inland fisheries of Goa. Milk fish 0.212 Anchovy 0.158, megalops 0.096, lutianes 0.0827, black water clams 0.0730, crabs 0.0394, *Gerres* 0.029, lady fish 0.0293 have shown good growth potential during the study period.

There are certain limitations in the data analysis that affect the growth rates and interpretation of the results. The data is of groups or the genus belonging to the several species with common or commercial or generic names. However, present analysis helps for the evaluations of trends in landings. The concept of responsible fishing needs to be practiced by introducing limited entry, temporal as well as spatial restrictions to sustain the inland water fishery in Goa. (Devaraj, M., and E. Vivekanandan. 1999). There are several biological, economic social and political reasons for non-existence of efficient management policies and inadequate practices of implementation.

CONCLUSION

Fishing industry is very important in Goa. Lots of people are involved / dependent on this vast biological resource for their survival and it plays a vital role in the state economy. Inference from the above study reveals Goan water bodies have great diversity of fish. Milk fish, anchovy and megalops recorded the highest growth rates. Meticulous planning and responsible fishing are most essential for inland fishery in Goa.

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CONFLICT OF INTEREST

All authors declare there is no Conflict of Interest.

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