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MFiS

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Kappaphycus alvarezii, a fast growing seaweed suitable for mariculture (Photo credit: Johnson, B.)

Marine Fisheries Information Service Technical and Extension Series envisages dissemination of information on marine fishery resources based on research results to the planners, industry and fish farmers, and transfer of technology from laboratory to the field.

Marine Fisheries Information Service
Technical & Extension Series

From the Editorial Board

Warm greetings to all our esteemed readers

The oceans rich in resources covering both the biological (plants, fishes) and physical (oil, gas, minerals) realms are of strategic importance to all coastal nations. Public appreciation of the wealth of its marine resources and sustainably tapping it delivers manifold benefits to the country and its people. Seaweeds have a long cultural history of utilisation as food in several Asian countries. They are also an important source of bio-fertilizers, industrial products like agar, alginates and carrageenan as well as bio-active molecules used in pharmaceuticals and nutraceuticals. As a prime aquaculture species global production in 2016 crossed 30 million metric tonnes (wet weight) dominated by countries such as China, Korea and Japan as estimated by the Food and Agriculture Organisation. In India, agar yielding red seaweeds and algin yielding brown algae are collected seasonally from natural seaweed beds. Recently, cultivation of the red seaweed *Kappaphycus alvarezii* has become popular among the fishing community in Ramanathapuram, Thoothukudi, Pudukottai, Kanyakumari and Thanjavur districts in Tamil Nadu and also in districts of Amreli, Gir-Somnath and Porbandar in Gujarat. Projections of a global commercial seaweed market worth US$ 261 billion by 2025 with Asia-Pacific region as the key player have emerged. Undoubtedly, development of seaweed based industries in India will positively impact livelihoods of small-scale fishermen by making seaweed farming lucrative and creating a value-chain. With this background, the present issue of MFIS highlights the various nutraceuticals developed from seaweeds by ICAR-CMFRI. The articles on economic valuation of marine fish landings and other developments in the marine fisheries sector will be helpful in understanding the intricacies and potential of the fisheries sector in India.

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Contents

Nutraceutical products from seaweeds - wonder herbs of the oceans

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Abstract

Seaweeds encompassing several species are common in the coastal areas of Indian subcontinent, and can be termed as the wonder herbs of the ocean due to their potential pharmaceutical properties. Marine-based resources are drawing the attention of nutraceutical industries due to their protective function against various chronic diseases and the growing demand for new compounds of 'marine natural' origin. Considering this, ICAR-Central Marine Fisheries Research Institute developed research program to systematically search identified seaweed species for the development of promising bioactive molecules. The nutraceutical products Cadalmin™ Green Algal extract and Cadalmin™ Antidiabetic extract as green alternatives to synthetic drugs to combat rheumatic arthritic pains and type-2 diabetes, respectively were developed. Following this, Cadalmin™ Antihypercholesterolemic extract and Cadalmin™ Antihypothyroidism extract to combat dyslipidemia and hypothyroid disorder, respectively were also developed. The lead molecules with action against angiotensin converting enzyme-I, from seaweeds were also isolated, and added to a nutraceutical product Cadalmin™ Antihypertensive extract that is being out-licensed.

***Keywords**: Seaweeds, secondary bioactive metabolites, nutraceutical products, Cadalmin™*

Introduction

The oceans cover about 70% of the planet's surface with a high biodiversity. Yet, very few marine species have been explored or used for pharmaceutical purposes. The bioactive metabolites of marine origin have attracted the attention of medical practitioners and scientists for the past few decades because several of these chemicals exhibit pronounced pharmacological activities. Seaweeds are classified as Rhodophyta (red algae), Phaeophyta (brown algae) or Chlorophyta (green algae) depending on their nutrient, pigments, and chemical composition and formed part of the traditional diet of coastal communities particularly in Japan, China and Korea. The discovery of metabolites with biological activity from seaweeds has increased substantially in the last three decades. These substances exhibit an appreciable number of distinct biological activities, such as anti-tumoral, anti-viral, anti-fungal, insecticidal, cytotoxic, phytotoxic, and anti-proliferative actions. Most of the bioactive substances isolated from seaweeds are chemically classified as brominated, aromatics, nitrogen-heterocyclic, nitrosulphuric-heterocyclic, sterols, dibutanoids, proteins, peptides, sulphated polysaccharides, terpenes, acetogenins, alkaloids and polyphenolics. Seaweeds are also the only sources for industrially important phycocolloids like agar, carrageenan and alginate which have applications as stabilizer, viscosifier, gelling and emulsifying agents.

Why seaweeds are prolific producer of pharmacologically active metabolites

Seaweeds were reported to possess structurally diverse compounds of various bioactivities endowed with antihypertensive, anti-inflammatory, and anticarcinogenic activities. These species which grows in saline habitats

Fig.1. Cultured seaweed harvest at Mandapam, Tamil Nadu

Fig.2. Seaweed harvest from Indian seas

evolved a number of specialized biochemical mechanisms to withstand salt-triggered oxidative stress conditions, which is governed by multiple biochemical mechanisms facilitating cell homeostasis and ability for retention of water. However, the absence of oxidative damage in the structural components, deterrence of predation, and the ability to reproduce successfully suggest that their cells are the storehouse of bioactive metabolites with potential pharmacological properties. Therefore, these marine floras are considered as valuable sources of bioactive compounds with potential pharmacological significance.

Nutraceuticals from seaweeds

The rich diversity of seaweeds represents an untapped reservoir of bioactive compounds with valuable pharmaceutical and biomedical use. The pioneering research work at ICAR-Central Marine Fisheries Research Institute (CMFRI) involved chemical profiling of major species of seaweeds for lead pharmacophores coupled with evaluation of target biological activities against different disease models, for example, 3-hydroxy-3-methylglutaryl coenzyme A reductase, type-2 diabetes modulators (dipeptidyl peptidase-4, protein tyrosine phosphatase 1B), angiotensin converting enzyme, inflammatory cyclooxygenase-2 and 5-lipoxygenase. Optimized physical/chromatographic procedures were developed to isolate and purify the molecules with target bioactivities.

A database of seaweeds with high-value bioactive molecules responsible to combat various life-threatening and lifestyle diseases could be developed. This research could also develop protocols to prepare nutraceutical products enriched with lead pharmacophores with different properties against various drug targets for use against hypothyroidism, dyslipidemia, hypertension, type-2 diabetes, and inflammatory disorders (Fig.3). The natural anti-inflammatory supplements enriched with lead molecules as nutraceutical Cadalmin™ Green Algal extract (Cadalmin™ GAe) from seaweeds as effective green alternative to the synthetic drugs available in the market to combat rheumatic arthritic pains was subsequently out-licensed to the biopharmaceutical company for commercial production and marketing in India and abroad. The research efforts to isolate the lead molecules with action against type-2 diabetes led to the development of a nutraceutical product Cadalmin™ Antidiabetic extract (Cadalmin™ ADe). Cadalmin™ Antihypercholesterolemic extract (Cadalmin™ ACe) and Cadalmin™ Antihypothyroidism extract (Cadalmin™ ATe) developed to combat dyslipidemia and hypothyroid disorders, respectively, were also out-licensed to a pharmaceutical company.

What are nutraceuticals and how they are different from drugs?

The term "nutraceutical" was coined by Dr. Stephen DeFelice, founder and chairman of the Foundation for Innovation in Medicine who defined it as "any substance that is a food or a part of a food and provides medical or health benefits, including the prevention and treatment of disease". Nutraceutical has been defined as "concentrated, isolated, or purified" pharmacologically bioactive molecules. Nutraceuticals are clearly not drugs, and unlike synthetic drugs, the potential pharmacologically active substances are derived from natural sources, and are concentrated by using green extraction/purification techniques. The purification process eliminates the unnecessary components in the product, and increases the quantities of the intended pharmacophore(s), which are specifically active against a particular disease. This apparently leads to greater pharmacological activities of the nutraceutical products, while maintaining the mean lethal dose (LD_{50}) greater than the threshold limits indicate the safety of the products. The LD_{50} of the nutraceutical products developed by ICAR-CMFRI were found to be greater than 4000 mg/kg body weight of the mammalian subjects tested that indicated the safety of the products. Since early 2000s, the world has viewed the extensive growth of the billion dollar nutraceutical industry and nutraceuticals are the preferred product portfolio of the leading pharmaceutical companies in India and abroad. The greatest challenge remains to formulate the regulatory guidelines to enable the physicians to prescribe this group of specialized medicines, and this will encourage research and development of this group of products.

Nutraceutical products developed by ICAR-CMFRI

The nutraceutical products Cadalmin™ Green Algal extract (Cadalmin™ GAe) and Antidiabetic extract (Cadalmin™ ADe) as green alternatives to synthetic drugs to combat rheumatic arthritic pains and type-2 diabetes respectively, were developed from seaweeds by ICAR-CMFRI. Cadalmin™ Antihypercholesterolemic extract (Cadalmin™ ACe) and Cadalmin™ Antihypothyroidism extract (Cadalmin™ ATe) developed to combat dyslipidemia and hypothyroid disorder, respectively were also commercialised. Semi-synthetic C-4/C-6 methylene-polycarboxylate cross-linked hybrid drug delivery system and a topical antibacterial formulation developed from seaweeds were found to be comparable with commercially available products. The lead molecules from seaweeds, with action against angiotensin converting enzyme-I, were isolated and added to a nutraceutical product Cadalmin™ Antihypertensive extract (Cadalmin™ AHe). Seaweed-derived natural template inspired synthetic derivatives as potential pharmacophores with potential antibacterial activities against methicillin-resistant *Staphylococcus aureus* and anti-angiotensin-I inhibitory activities were also designed and developed. Several cosmeceutical products from seaweeds are also in pipeline or being commercialized.

CadalminTM ADe: The bioactive ingredients in Cadalmin™ ADe competitively inhibit dipeptidyl peptidase-4 and tyrosine phosphatase 1B thereby hindering the occurrence of type-2 diabetes. Type-2 diabetes and obesity are characterized by resistance to hormones insulin, possibly due to attenuated or diminished signaling from the receptors. A large body of data have identified protein tyrosine phosphatase 1B (PTP1B) as a major negative regulator of insulin signaling. Pharmacological agents capable of inhibiting the negative regulator(s) of the signaling pathways like PTP 1B are expected to potentiate the action of insulin and therefore be beneficial for the treatment of type 2 diabetes. Antidiabetic extract inhibits PTP1B, thereby hindering the occurrence of type-2 diabetes. Another mode of action of Antidiabetic extract is inhibition of dipeptidyl peptidase-4 (DPP-4), which is an antigenic enzyme expressed on the surface of most cell types and is associated with immune regulation and signal transduction. DPP-4 inactivates the incertins GLP-1 and GIP by removing amino acids from these peptide hormones. GLP-1 and GIP are essentially required for insulin secretion from the βcells of pancreas. *In vitro* antidiabetic experiments showed that the active principles effectively inhibited DPP-IV, tyrosine phosphatase, and βglucosidase. The results demonstrated the potential of the formulation to effectively inhibit the mediators, which are responsible to induce type-2 diabetes through various metabolic pathways. The product developed from seaweed was compared with that of standard drugs after administering the animals with streptozotocin (a diabetes inducer). The diabetic control had glucose level recorded at greater than 380 mg/dL, whereas the blood glucose levels maintained at about 74 mg/dL (at 65 mg/kg body weight), when the animals were administered with the active ingredients. The HbA1c levels maintained at about 4.6% (the normal range being 4.3-6.3%) after administering the animals with the nutraceutical product. The active principles of Cadalmin™ Antidiabetic extract from seaweeds thus effectively inhibit various mediators, which are responsible for inducing type-2 diabetes through various metabolic pathways. The bioactive ingredients in the nutraceutical product interfere with the release of simple sugars from the gut, which in turn reduces postprandial (after eating) hyperglycemia (high blood sugar levels). It has no side effects (LD_{50} > 5000 mg/kg body weight) as proved from the preclinical and acute/long term chronic toxicity studies on experimental subjects. The active ingredients in the product packed in plant-based capsules to meet the dietary needs of vegetarians has a promising consumer appeal, and market potential especially for the large vegetarian population in India and abroad.

CadalminTM GAe: The product is effective for combating arthritic pain and inflammatory diseases in human beings. The active principles in Cadalmin™ GAe competitively inhibit pro-inflammatory mediators, resulting in

Fig. 3. Nutraceuticals developed by ICAR-Central Marine Fisheries Research Institute for use against rheumatoid arthritis, type-2 diabetes,obesity/dyslipidemia,hypothyroidism and hypertension (Left to right)

decreased production of inflammatory prostaglandins and leukotrienes, and its activity was found to be superior to some of the synthetic non steroidal anti-inflammatory drugs available in the market. A lower cycloxygenase-1/5-lipoxygenase and cycloxygenase$_{1/2}$ (<1.0), simultaneous inhibition of cycloxygenase-2 and 5-lipoxygenase enzymes and significant *in vivo* activity indicate higher selectivity and lower side-effect profiles of Cadalmin™ GAe as compared to the synthetic non-steroidal anti-inflammatory drugs. Time dependent *in vivo* animal model studies on experimental subjects revealed the superior inhibition of inflammatory response to the tune of 73-76% by Cadalmin™ GAe. Long term animal model experiments proved the efficiency and safety of this nutraceutical. Cadalmin™ GAe suppresses the edema produced by histamine, and exhibits its anti-inflammatory action by means of either inhibiting the synthesis, release or action of anti-inflammatory mediators. The mean lethal dose (LD_{50}) of Cadalmin™ GAe was found to be greater than 4000 mg/kg body weight of the mammalian subjects that indicate the safety of the product. As part of the preclinical assay of the product, feeding of Cadalmin™ GAe even at a dose upto 2500 mg/kg body weight did not induce significant change in body weights, hematological indices, histopathological, and serum biochemical parameters between the control and treated groups. This product has been commercialized with a biopharmaceutical company and ICAR-CMFRI is in search of more commercial partners for wider dissemination of the product in the marketplace.

CadalminTM ACe: Bioactive pharmacophore leads from seaweeds were used to develop the nutraceutical product, and were found to inhibit hydroxymethyl glutaryl coenzyme A reductase, various target receptors and other rate limiting enzymes, which are responsible to cause obesity and dyslipidemia. The total cholesterol (~ 90 mg/dl), triglyceride (TG 88.14 mg/dl), high density cholesterol (HDL 39.18 mg/dl), low density cholesterol (LDL 28.09 mg/dl) and very low density cholesterol (VLDL 22.36 mg/dl) were found to be within the acceptable limits after oral administration of the product in the mammalian subjects, with respect to positive control (total cholesterol 185.5 mg/dl, TG 193.28 mg/dl, HDL 33.65 mg/dl, LDL 110.9 mg/dl and VLDL 38.86 mg/dl). *In-vivo* evaluation of the product prevents high fat-induced (HFD) hyperlipidemia, characterized by significantly lower level of serum LDL (28.09 mg/dL), lipid peroxidation status (1.93 nmoles/mg protein) and, substantially lower atherogenic index (0.11 mg/g tissue), constitutes a promising anti-lipidemic efficacy of the formulation. hydroxymethyl glutaryl reductase enzyme inhibitory activity of the formulation was found to be greater than 90% at a concentration of 5 mg/mL. This product showed potential to inhibit hydroxymethyl glutaryl reductase (IC_{50} 0.15 mg/mL), an established statin target, and reduce obesity and hypercholesterolemic disorders as determined by the *in vivo* mammalian model. Other liver and lipid parameters, which clinically signify dyslipidemia and obesity, were also found to be within the clinically acceptable limits. Time dependent shelf life studies conducted to identify the oxidative changes for the product in an accelerated shelf-life study revealed that the content of the bioactive pharmacophores of the product on shelf for a period equivalent to 24 months exists. The product was out-licensed in 2017.

CadalminTM AHe: The active principles of Cadalmin™ AHe from seaweeds effectively inhibit various mediators, which cause hypertension through various metabolic pathways. It blocks angiotensin converting enzyme that converts angiotensin I to angiotensin II. The bioactive ingredients in the nutraceutical product effectively modulate the serum level of oxidative stress marker nitric oxide, lipid peroxidase and the potent vasoconstrictor angiotensin-II which increases blood pressure, and promotes inflammation and remodeling of the cardiovascular system, which leads to thrombosis or ventricular hypertrophy. Animal model anti-hypertension experiments showed that the active principles effectively decreased the angiotensin-II levels in the cadmium chloride ($CdCl_2$) induced hypertension in rats. Serum nitric oxide, lipid peroxidase and angiotensin-II levels were also significantly decreased in hypertension affected group treated by Cadalmin™ AHe. In $CdCl_2$ plus Cadalmin™ AHe group serum NO level has been significantly regulated upto 8.5 μg/dL at 100 mg/kg body weight and 9.00 μg/dL at 200 mg/kg body weight compared to the diseased group (13.06 μg/dL at 100 and 200 mg/kg body weight) and positive control group (9.17 μg/dL at 100 and 200 mg/kg body weight). The serum angiotensin-II level in $CdCl_2$ + Cadalmin™ AHe group were comparatively lesser 0.205 pg/mL at 200 mg/kg body weight than the diseased group (0.432 pg/mL at 200 mg/kg body weight) and positive control (0.211 pg/mL at 200 mg/kg body weight). Preclinical trials showed no toxicity related significant changes in renal or hepatic function, hematological indices and serum biochemical parameters in the experimental subjects. The results also demonstrated a lack of test substance-related general organ or systemic toxicity and hypertensive disorders following oral administration at a dose as high as 2000 mg/kg/d. No side effects (LD_{50} > 4000 mg/kg BW) as proved from the acute/

long term chronic toxicity studies on experimental subjects were recorded. This product is available in encapsulated form and is intended to be used as oral application. Large scale extraction of the active principles from the raw material was optimized in a factory unit.

CadalminTM ATe: This nutraceutical with anti-hypo thyroidism principles extracted from seaweed, with an ecofriendly "green" technology has been commercialized by a leading Indian MNC in wellness during the year 2018. The bioactive leads concentrated in Cadalmin™ ATe were found to stimulate thyroid releasing hormone and increase the activity of selenodeiodinase to produce metabolically active thyroid hormones tetraiodothyronine (T_4) and 3, 5, 3′-triiodothyronine (T_3). The current mode of treatment for hypothyroidism is levothyroxine-replacement therapy. However, there are certain limitations associated with this as it requires lifelong treatment, and is associated with poor compliance in some patients. Hence effective and alternative therapeutic strategies to treat hypothyroidism have been sought. The TSH in thyroid gland is responsible for the synthesis, storage and release of metabolic hormones thyroxine (T_4) passive hormone containing four iodine and triiodothyroxine (T_3) active hormone. The predominant hormone produced by the thyroid gland is T_4, with approximately 70-90 mcg of T_4 and 15-30 mcg of T_3 produced daily. The production of the T_3 hormone by the thyroid gland is insufficient to meet the daily requirements of the organs in the body. Therefore, approximately 80% of the body's required T_3 comes from peripheral conversion of T_4 to T_3. Although both T_4 and T_3 are active, T_3 is more active as thyroid receptors within the cell nucleus have a 10-fold greater affinity for $T_{3.}$ *In vivo* anti-thypothyroidism experiments showed that the active principles effectively increased thyroid stimulating hormone to produce thyroid hormones (T_3 and T_4) into various experimental groups with healthy control and hypothyroidism induced by administering methimazole (MTZ) @100-150 mg/kg body weight (@ one-time dose for 15 days). Serum T_3, T_4 and TSH levels were significantly decreased in hypothyroid group. MTZ is a reversible goitrogen and induces hypothyroidism by inhibiting crucial enzyme deiodinase required for thyroid hormone synthesis. Inhibition of deiodinase impairs the iodination of tyrosyl residues and coupling of iodotyrosyl residues to form iodothyronine. Hypothyroid rats treated with Cadalmin™ ATe exhibited an improved thyroid profile. In MTZ+active ingredient groups with and without bioactive ingredients from seaweed, serum T_3, T_4 and TSH levels were significantly elevated respectively compared to diseased group. The results demonstrated the potential of Cadalmin™ ATe to effectively stimulate the production of thyroid hormones. Cadalmin™ ATe developed from seaweed was compared with that of standard drugs after administering the animals with methimazole (MTZ) (a hypothyroidism inducer). Serum triiodothyronine (T_3) level for the active ingredient with Cadalmin™ ATe treated group (1.4 ng/dL at 150 mg/kg body weight) was greater than the active ingredient alone treated group (0.7 ng/dL at 150 mg/kg body weight) and positive control group (∼1 ng/dL). Notably thyroxine (T_4) level for the active ingredient with Cadalmin™ ATe treated group (9 μg/dL at 150 mg/kg body weight) was greater than the active ingredient alone treated group (5 μg/dL at 150 mg/kg body weight) and positive control group (6 μg/dL). One of the bioactive components combines with the tyrosine (aromatic amino acid) to synthesize thyroid hormones to create a more stable, steady supply of iodine for the thyroid. The deiodinase-activativing bioactive component in Cadalmin™ ATe was found to play significant role in the control of thyroid hormone metabolism and hence useful to treat hypothyroidism.

Conclusion

Seaweed derived bioactive components with potential health benefits are an emerging area of research. Seaweeds have a long tradition as a food source in Asian countries, being part of the Western diet only to a limited extent. In 2014, production of seaweeds through mariculture (44% of all aquaculture) was estimated at about 27 million tons wet weight, registering annual growth rate of 8% and valued at 7 billion US$ (FAO 2016). The Regional Centre ICAR-CMFRI at Mandapam, Tamil Nadu ventured to develop indigenous cultivation technology for seaweeds since 1970s. Considering the present status of under-utilization of seaweeds, exploring bioactive compounds and development of any biologically useful products can bring dual benefits-one, as health products and secondly, commercial farming in coastal habitats, resulting in C-sequestration and C-budgeting in a scenario where global climate change poses a serious threat. Development of value-added products from these underutilized species will promote their farming in coastal habitats, which has not been seriously explored earlier due to the lack of knowledge about their commercial importance. Devoted research program to develop various health products from seaweeds will also pave the way to effectively harness the potential of this natural wealth of Indian coastal waters.

Valuation of marine fish landings in India

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Abstract

Marine fish landings in India registered 5.6% increase to reach 3.83 million tonnes (mt) during 2017. The valuation of fish landings done for 2015-2017 period indicated that the movement of fish from one state to other has resulted in higher price realization. The prices of low value fish species have not been stable for several reasons and the prices varied depending on species, seasons and abundance of other fish and fishery products. During glut seasons, many species earned a lower price and thus fell into the low value category.

Keywords: *Marine fish, valuation, markets*

The marine fisheries sector of India supports 4 million fishermen population spread across nine maritime states and two union territories for their livelihood by providing employment to nearly 9.9 lakh fishermen and contribute export earnings to the tune of 45,000 crores rupees. Sustained marine fish production from the sea can be ensured only if harvest is made judiciously with management and control. The Socio-Economic Evaluation and Technology Transfer Division (SEETTD) of the ICAR-CMFRI through its operational research projects is engaged in the collection of the price realization of marine finfish and shell fish resources in the selected landing centers and retail centers across the coastal states. The price data of the commercially traded fish species is collected on a weekly/ fortnightly basis through a structured schedule called MAP (Market Price). Based on the collected data average prices were worked out taking into consideration the parameters of seasonality and species wise size ranges. The present study portrays the trend on the valuation of marine fish landings during the period 2015-2017.

Valuation of fish landings

During 2017 the estimated value of marine fish landings at landing centre level was ₹ 52,431 crores, (8.37% increase over 2016), in 2016 it was ₹ 48381 crores (20.7% increase over 2015) and in 2015 ₹ 40100 crores (26.3% increase over 2014). Besides all the externalities there is a huge increase in the marine fish landings from 2015 to 2017. At the retail level, the estimated value during 2017 was ₹ 78408 crores (6.98% increase over 2016), ₹ 73289 (12.4% increases over 2015) in 2016 and ₹ 65180 crores (24.5% increase over 2014) (Table 1).

Table 1: Percentage changes in the valuation of fish landings 2015-17

Parameters	2017	2016	2015
Landing Centre Valuation(LCV)	52431	48381	40100
(Crores)	(8.37)	(20.7)	(26.3)
Retail Centre Valuation(RCV)	78408	73289	65180
(Crores)	(6.98)	(12.5)	(24.5)

#figures in parenthesis indicates the increase in percentage of LCV and RCV from the previous year.

Valuation of fish landings across states

The valuation of the marine fish landings at the landing centre (LCV) and retail centre (RCV) across the coastal states is furnished in Table 2.The state wise analysis of the valuation indicated that Gujarat registered the highest valuation of marine fish at the LCV (18.94%) and RCV (18.79%) during 2017 and the second position during 2015 and 2016. Kerala held the second position in LCV (18.50%) during 2017. Karnataka retained the third position in LCV and RCV throughout the 2015-17 period.

Species wise valuation of Indian marine fisheries

The marine fisheries show seasonal variations to a great extent and the valuation of landings of the major species are given in Table 3. Oil sardine's contribution to share in landings have increased from 7.8 to 8.87% during 2015-2017. Due to reduced volumes of the threadfin breams landings in 2015-17, their share in value came to a low of 4.78 to 4.13%.

Table 2: Valuation of fish landings across states ('000 crores)

State	Landing Centre valuation			Retail Centre valuation		
	2017	2016	2015	2017	2016	2015
Kerala	9699 (18.50)	9149 (18.91)	9570 (23.86)	13501 (17.22)	12398 (16.92)	14640 (22.46)
Karnataka	6639 (12.66)	6247 (12.91)	4620 (11.52)	10196 (13.00)	9108 (12.43)	6404 (9.83)
Goa	1245 (2.37)	997 (2.06)	1060 (2.64)	1796 (2.29)	1451 (1.98)	1964 (3.01)
Maharashtra	6397 (12.20)	5369 (11.09)	4630 (11.54)	9488 (12.10)	8313 (11.34)	5596 (8.59)
Gujarat	9931 (18.94)	8427 (17.41)	7030 (17.53)	14729 (18.79)	13130 (17.92)	9851 (15.11)
Tamil Nadu	6807 (12.98)	6492 (13.41)	5630 (14.03)	11088 (14.14)	10728 (14.64)	7959 (12.21)
Puducherry	432 (0.82)	605 (1.25)	190 (0.47)	618 (0.79)	868 (1.18)	266 (0.41)
Andhra Pradesh	2679 (5.11)	2516 (5.20)	3050 (7.60)	4043 (5.16)	3916 (5.34)	3908 (6.00)
Odisha	1729 (3.30)	1645 (3.40)	2480 (6.18)	2901 (3.70)	2836 (3.87)	3350 (5.14)
West Bengal	5783 (11.03)	5501 (11.37	1220 (3.40)	8490 (10.83)	8190 (11.17)	1187 (1.82)
Daman & Diu	1089 (2.08)	1433 (2.96)	620 (1.54)	1557 (1.99)	2351 (3.21)	1070 (1.64)
Total	52431	48381	40100	78408	73289	65180

#figures in parenthesis indicates the percentage share to total landings

Table 3. Species wise share in Landings (in %)

Species	2017		2016		2015	
	Landings	Share in value	Landings	Share in value	Landings	Share in value
Oil sardine	338,029	8.87	195163	7.6	256016	7.8
Indian mackerel	295,246	7.75	249241	7.04	237801	6.98
Ribbon fishes	240,502	6.31	217100	5.22	177259	5.21
Other sardines	236,668	6.21	195163	8.19	256016	7.52
Penaeid prawns	211,749	5.56	200116	5.80	199195	5.85
Non-Penaeid prawns	202,216	5.31	169558	4.75	149101	8.74
Threadfin breams	157,170	4.13	9728	4.74	11030	4.78

Average Landing Centre and Retail Centre Price realization

The unit price realized at the first point sales and last sales indicate that prices have increased progressively from 2010-2017(Fig.1).The landing centre price (LCP) shows a steady increase from ₹67.67 crores to ₹136.08 crores (50.27% increase over 2010) and the retail centre price (RCP) have increased from 110.44 crores to 206.2 crores (46.64% increase over 2010) respectively.

Marketing efficiency across states

Marketing efficiency is measured as the Fishermen Share of the Consumer's Rupee (FSCR) across the major species. The marketing efficiency of the different coastal states during the year 2015-2017 are indicated in Table 4. It shows that Kerala registered the highest marketing efficiency in (73.79% and 71.84% respectively) and Odisha the lowest (59.59% in 2017 and 58.00% respectively). Whereas in 2015, West Bengal registered the highest marketing efficiency of 78.21% and Goa holds the lowest marketing efficiency of 49.3%. The increase in the landings is one of the major reason for the increased efficiency and *vice versa*.

Marketing efficiency of species

The high value fishes showed the maximum percentage share of fishermen in the consumer's rupee than the low value fishes. In general the high value species like penaeid prawns (79%), seer fishes (76.65%), squids (73%) and hilsa shad (73%) registered higher marketing efficiencies compared to non-penaeid prawns, threadfin

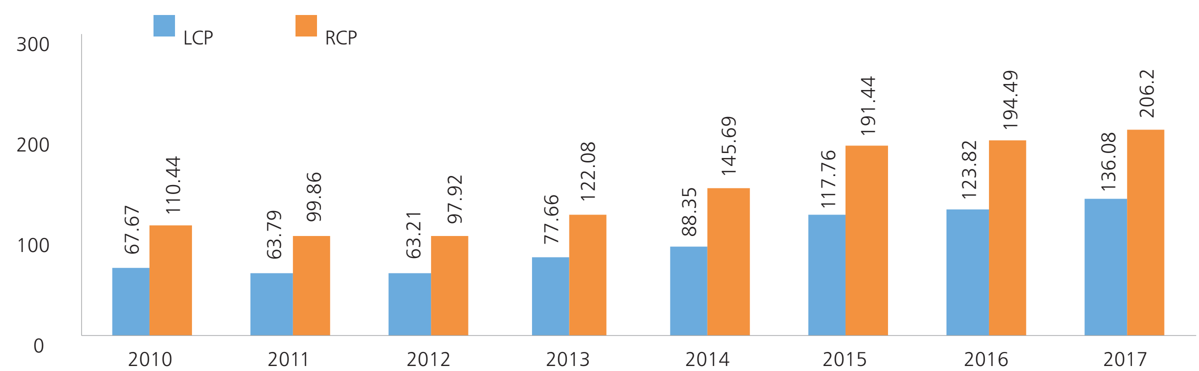

Fig 1: The unit price realized at the point of first sales (LCP) and last sales (RCP)

Table 4: Average Market efficiency - All India

States	2017	2016	2015
Kerala	71.51	73.79	65.39
Karnataka	65.17	68.59	60.01
West Bengal	65.64	67.17	78.21
Orissa	56.69	58.00	61.69
Andhra Pradesh	62.39	64.25	63.12
Puducherry	66.16	69.70	50.00
Goa	66.18	68.71	49.30
Maharashtra	62.03	64.59	61.76
Gujarat	62.71	64.18	60.06
Daman Diu	58.69	60.95	58.14
Tamil Nadu	58.07	60.51	58.38

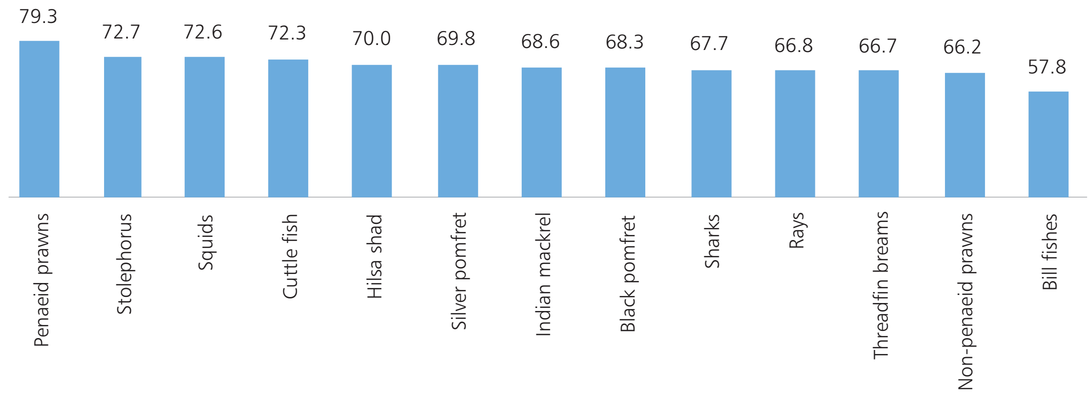

Fig 2. Highly marketing efficient species

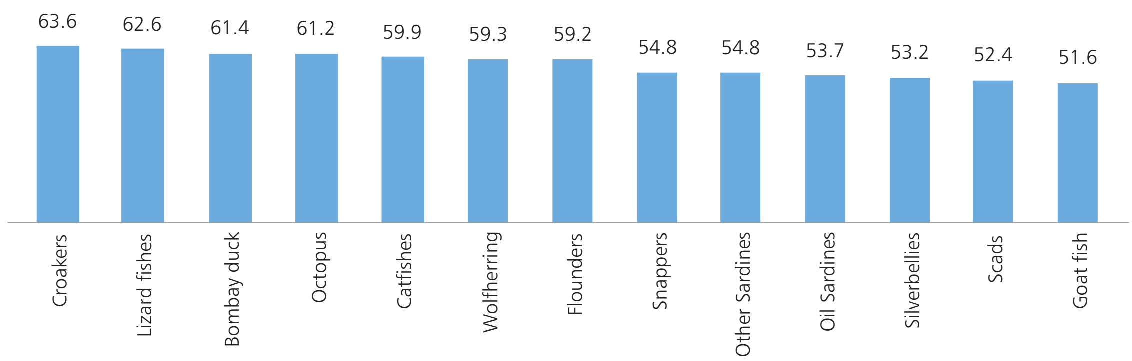

Fig 3. Low marketing efficient species

breams, lizard fishes, snappers, scads and oil sardine. The large number of intermediaries and the high marketing margins lead to the decline in marketing efficiency of the low value fishes (Figs. 2 and 3).

Conclusion

The estimated value of marine fish landings during 2017 have shown 8.4% and 20.7% increase over 2016 and 2015 respectively. The prices of low value fish species have not been stable for several reasons and the prices varied depending on species, seasons and abundance of other fish and fishery products. During glut seasons, many species earned a lower price and thus fell into the low value category. The prices of many of the low value food fishes are likely to go up owing to the ever-widening gap between demand and supply. It is not the quantity of fishes landed but the value of the fishes landed that is important as it could offer breathing space to the fishermen if they fail to catch adequate quantity.

References

Shyam Salim and P.K. Safeena, 2017. CMFRI Special Publication No.127 pp. 23-26.

CMFRI-Annual Report 2017, pp. 193 - 200

CMFRI-Annual Report 2016, pp. 206 - 210

CMFRI- Annual Report 2015, pp. 202 - 210

Cephalopod fishery off Thoothukudi coast, Tamil Nadu

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Abstract

In Thoothukudi district of Tamil Nadu, cephalopod resources are principally exploited by single day trawlers followed by hook and line. During 2012-18, nearly 54% of cephalopods landed were caught by mechanised trawl net; 32% by outboard crafts operating hook and line, 8% by gill net and rest by other gears. From 2012-18, the cephalopod landing showed a fluctuating trend and major cephalopod species landed by trawl net were *Sepia pharaonis, S. prabahari*, *Sepioteuthis lessoniana, Uroteuthis (P) singhalensis* and *U. (P) duvaucelii.* In hook and line, *S. pharaonis* was the dominant species followed by *S. lessoniana* and *Octopus cyanea.*

Keywords: *Cephalopod resources, trawl, Thoothukudi*

Introduction

Cephalopods are the second major seafood export item from India and its demand in export trade is consistent. Nearly 40% of the global cephalopod catches are taken by squid jigging followed by trawling (25%) and the rest by other gears. In India, cephalopods are mainly exploited by single day and multi-day mechanised trawlers. In 2017, estimated all India cephalopod landings were 0.220 million t in which Gujarat (24.6%) followed by Tamil Nadu (23.6%), Kerala (22.7%) and by other maritime states contributed. In Tamil Nadu, Thoothukudi is a major centre for cephalopod landings with estimated average annual landings of 3462 tonnes during the 2012-18 period. The fishery trends are captured in the short note given below.

Craft and gears

In Thoothukudi district cephalopod resources are principally exploited by single day trawlers followed by hook and line and gill nets. Of the 27 fish landing centres of Thoothukudi district, only at Thoothukudi fishing harbour and Vembar fish landing centre, mechanised single day trawlers are operated for cephalopod fishery. In rest of the centres, the fishery is carried out by motorised and traditional boats.

At Thoothukudi Fisheries Harbour nearly 150 to 200 trawlers are operated daily for cephalopod fishing. Wooden and steel trawlers in three sizes, small (35-40 feet), medium (40-50 feet) and large (up to 80 feet) based at Thoothukudi fishing harbour are operated. In Vembar around 20 numbers of small sized trawlers are engaged in fishing During the peak cephalopod fishing season from June to September, around 50 small and medium size wooden trawlers off Thoothukudi Fisheries Harbour and 20 boats from Vembar are regularly engaged in cephalopod fishing. Subsequently, the number of boats engaged chiefly for cephalopod fishery is limited, but sizeable quantities of cephalopods are landed along with other fishery resources. The fishing activity takes place between 0500 and 1700 hours each day of fishing.

Hook and line are operated from motorised boats in some fishing villages of Thoothukudi district namely, Kalavasal, Mottaikopuram, Veerapandiapattinam, Amalinagar, Kombuthurai, Vemabar, Periyasamypuram, Punnakayal and Vembar. It takes place throughout the year and is locally called as "*Kanavai Thoondil*". Fishers are generally using small size squids mainly needle squid, *Uroteuthis (Photololigo) singhalensis* as a bait. Other squids such as *Uroteuthis (Photololigo) duvaucelii* and *Sepioteuthis lessoniana* are used when needle squid is not available. For hook and line fishing, fishermen usually set out from shore in *Vallam* or FRP boats. Fishing activity is carried out at the distance between 12 and 20 km from shore and at the depth of 13 to 25 m. Cephalopod fishery by hook and line is done directly from *vallam* where the crew size is restricted between 6 and 9 persons. The fishing is also carried out in small groups of 12-18 persons is carrying a thermocol raft and moving to the fishing grounds in the FRP boat. After reaching the fishing ground, the crew members individually fish from their thermocol rafts. The fishing duration may vary according to the prevailing season. For cephalopod fishery, the fishers are using fish aggregating devices (FADs) to catch the cephalopod. In Thoothukudi region fishermen are mainly using twigs of plants such as *Tephrosea purpurea* (*Kozhinji* in Tamil) and *Prosopis juliflora* (*odai maram/ velikathan* in Tamil) as FADs due to its profusion in the shore region. The fishing is carried out for about 5-7 hours. After accomplish the fishing activity, fishers may reach the landing centre between 12:00 and 13:00 hrs during peak fishing season; but during lean season they will return back between 15:00 and 16:00 hrs. The peak fishing season of hook and line fishery for cephalopods is during the months of August and September.

Catch and species composition

During 2012-18, nearly 54% of cephalopods were landed by mechanised trawl net; 32% by outboard crafts operating hook and line, 8% by gill net and 6% is contributed by other gears. From 2012-18, the cephalopod landing showed a fluctuating trend with peak production during 2018. The average annual landing of cephalopod was 3462 t during this period. In 2012, the estimated landings were 3244 t which dwindled to nearly half (1903 t) in 2013. During 2014 and 2015, landings recovered (4160 t and 4327 t respectively) after which again it plummeted to 2452 t in 2016. In 2017 there was a gradual increase in the landings (3742 t) and in 2018 it reached to 4403 tonnes (Fig.1). The Catch per Unit Effort (CPUE) of cephalopod for trawl net and hook and line was 5.9 kg/hour and 15 kg/unit respectively. The major cephalopod species landed by trawl net were *Sepia pharaonis*, *S. prabahari, Sepioteuthis lessoniana, Uroteuthis (P) singhalensis* and *U.(P) duvaucelii* (Fig.2). Other species like *Amphioctopus membranaceus, A. neglectus* and *Octopus cyanea* were also represented in the landings in stray numbers. In hook and line, *S. pharaonis* was the dominant species followed by *S. lessoniana* and *O. cyanea* (Fig.3). Price range of the various cephalopod species vary based on the landing quantity and season. When there is a glut in landings, the prices dip considerably and prices are high during lean season as indicated in Table 1.

Table 1. Size range (Dorsal Mantle Length in mm) of cephalopods in the fishery and their price range.

Species	Trawl net	Hook and line	Price range (₹)
S. pharaonis	60 - 410 (236)	90 - 430 (240)	350 - 450
S. prabahari	40 - 175 (102)	-	180 - 220
S. prashadi	45 - 167 (87)	-	100 - 150
S. lessoniana	50 - 400 (177)	110 - 390 (220)	300 - 400
U.(P) duvaucelii	50 - 320 (148)	-	250 - 300
U. (P) singhalensis	32 - 315 (130)	-	150 - 250
O. cyanea	70 - 262 (160)	50 - 240 (144)	80 -150
A. membranaceus	25 - 200 (83)	-	80 - 150
A. neglectus	30 - 122 (71)	-	80 - 150

Mean dorsal mantle length is given in parenthesis

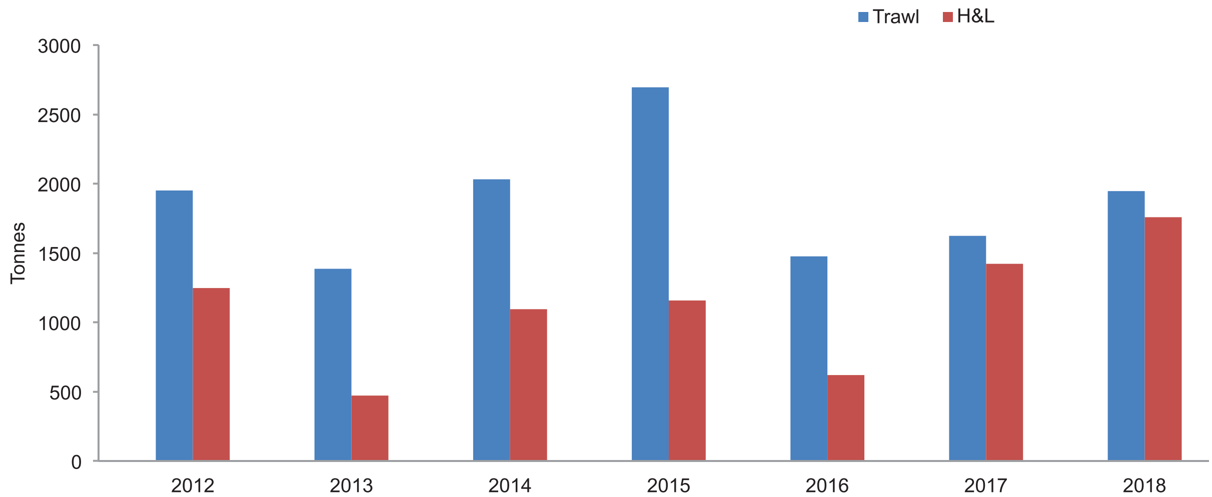

Fig.1 Annual cephalopod landings by trawlers and Hook and Line

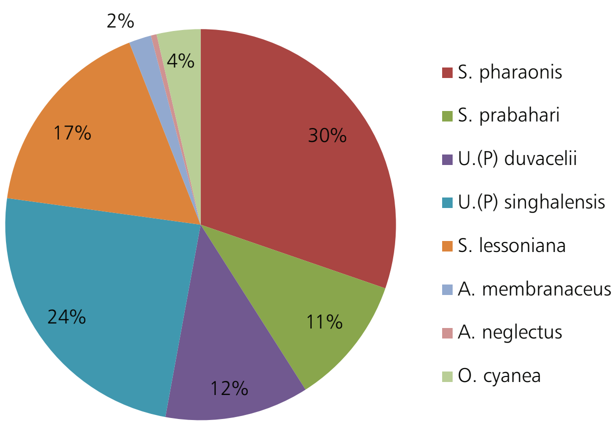

Fig.2. Cephalopod species composition in Trawl net

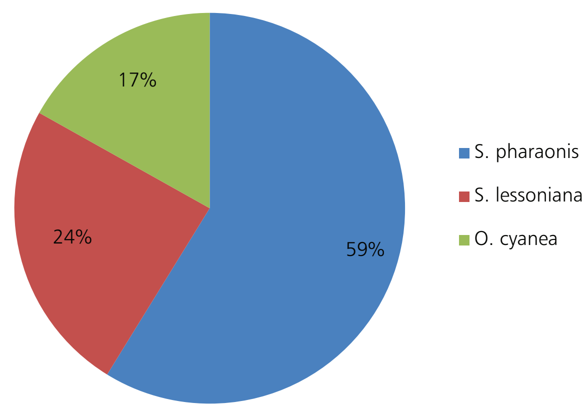

Fig.3. Cephalopod species composition in Hook and Line

Acanthopagrus berda - a potential species for mariculture in India

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Sea breams belonging to the sparidae familyare excellent food fishes and important candidate species for aquaculture. Globally, the river bream, *Acanthopagrus berda* is highly valued in commercial fisheries and aquaculture due to their excellent meat quality, market demand, easy adaptability to captivity and ability to tolerate wide variations in both salinity and temperature. *A. berda* is distributed in the estuarine and shallow coastal waters of Kerala, Tamil Nadu, Andhra Pradesh, Maharashtra and Gujarat coasts (Fig.1). Locally known as "*Karuthaeri*" along Kerala coast they are fished by artisanal fishers using cast nets and hook & line and fetch ₹ 400-500 per kg in the domestic markets. At present, India is looking for native food fishes for mariculture development and *A. berda* is considered as a priority species due to their high market demand.

To acclimatize the wild brood fish of *A. berda* to captivity and to develop protocols for inducing consistent multiple spawning, studies on its biology is a prerequisite. Only limited information of the biology of *A. berda* from Indian waters being available, biological aspects of the fish collected from the Korapuzha estuary in Kozhikode, Kerala was studied in detail.

Fishes examined were having total length ranging from 125 to 438 mm and total weight ranging from 34-1753 g. The growth pattern of *A. berda* was found to be isometric ($b = 3.06$) indicating that the fish increases in length and weight at the same rate. They were omnivores, feeding mainly on barnacles, crabs, *Modiolus* spp. and oysters. Studies on its reproductive biology indicated digynous protandrous hermaphroditism (most of the individuals function first as males and then change sex to female, but few continue to function as males and females throughout their lifespan). The males were observed dominant in smaller length classes (130-250 mm total length) whereas females (250-450 mm total length) were observed dominant in larger length classes. Their reproductive cycle consists of resting phase, lasting from February to July; pre-spawning phase, occurring from March to August and spawning phase from August to December in Korapuzha estuary. Based on the morphological and histological studies of the gonads, the ovotestes of *A. berda* were classified as given in Table 1 and shown in Fig. 2.

The simultaneous availability of both running males and females during spawning season indicated the opportunity for development of captive breeding protocols

Table 1. Histology based staging of gonads in *A.berda*

Stage	Gonad histology
Immature ovotestes	Testicular lobe containing spermatogenic cells and ovarian lobes with inactive oocytes of the chromatin nucleolar and perinucleolar stages
Inactive male	Testicular portion is characterized by spermatogonia with lesser spermatogenic activity and the ovarian portion contains the oocytes of chromatin nucleolar and perinucleolar stage with further development arrested
Active male	Tubule space and interior lumen of testicular portion dominated with spermatocytes, spermatids and spermatozoa and ovarian lobes with oocytes in chromatin nucleolar and perinucleolar stages
Active female	Ovotestes with large number of advanced vitellogenic oocytes with some previtellogenic oocytes
Inactive female	ovarian lobe with oocytes of chromatin nucleolar and perinucleolar oocytes and remnants of testis appeared with no spermatogenic activity
Transitional ovotestes	signs of degeneration in the testicular lobe, the proliferation of connective tissue and empty sperm ducts and the ovarian lobes were characterized by oocytes of chromatin nucleolar and perinucleolar stages

for *A. berda.* Broodstock collected during the spawning season were reared in captivity and fed with fresh oyster and squid meat @ 5% of their body weight. Active males were easily identified with free-flowing milt on slight abdominal pressure and active females with bulged abdomen and red colouration around the vent. They were successfully induced to spawn employing commercial inducing agent WOVA-FH and fertilized eggs were obtained at the Marine Hatchery Complex. The intra-peritoneal injection of WOVA-FH made hand stripping from *A. berda* brooders followed by artificial fertilization possible which confirms the possibility of successful captive breeding programmes for this species.

Fig.1. *Acanthopagrus berda* collected from Korapuzha estuary

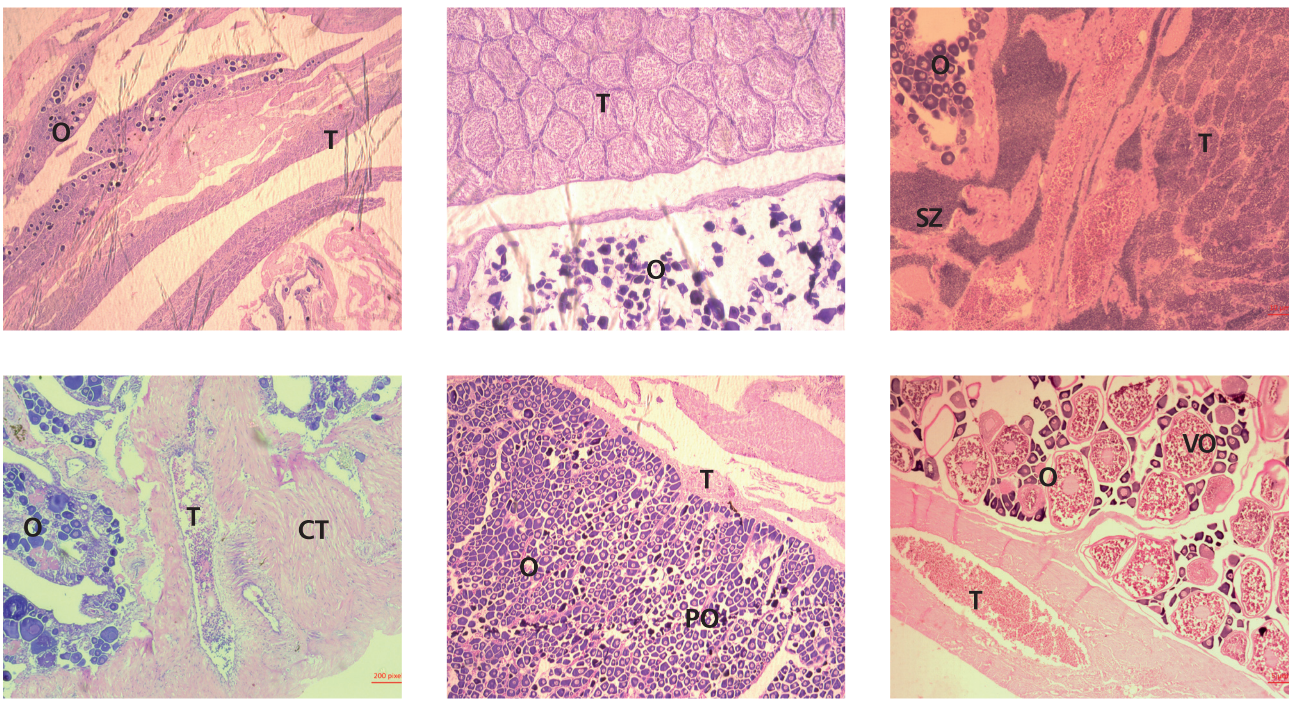

Fig.2. Classification of ovotestes of *A.berda* based on histological parameters. From left to right (a) Immature ovotestes (b) Inactive male (c) Active male (d) Transitional (e) Inactive female (f) Active female

(T-testis, O- ovary, CT- connective tissue, SZ- spermatozoa, PO-Perinucleolar oocyte, VO-Vitellogenic oocyte)

Low saline aquaponics system with Silver Pompano as a candidate species

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Introduction

Aquaponics is a sustainable food production system that integrates hydroponics and aquaculture practices in order to attain optimum utilization of nutrients by re-cycling. Aquaponics facilitates the symbiotic production of vegetables and fishes with minimum inputs, organic farming like management and higher control on production. Aquaponics system is extremely water efficient, does not require soil and does not use fertilizers or chemical pesticides. Silver pompano *Trachinotus blochii* is a preferred candidate species for mariculture due to the availability of hatchery produced seed, adaptability to commercial pellet feeds, good market demand and excellent meat quality. The species has proven good for farming in both marine as well as low saline water bodies. Adopting the principles of nutrient utilization in aquaponics and the ability of silver pompano to grow in low saline conditions, a prototype of a low saline aquaponics system integrating one month reared fingerlings of silver pompano *T. blochii*, with a common, leafy vegetable *Amaranthus* by employing a 0.25 hp submersible pump for recirculation was developed.

Fig.1 Low saline aquaponics system

Fig. 2. (a) Amaranthus (b) stocking size of fingerlings of Silver Pompano (c) Fingerling after one month culture in aquaponics system.

Aquaponics system

The model aquaponics system consists of a 500 litre square FRP tank, a 20 litre plastic basin mounted on a 1.5 m height wooden stand. The FRP tank was filled with 400 litres of 5 ppt saline water. Thirty fingerlings of silver pompano were stocked in the tank. The fishes were fed with an artificial diet (Nutrila, Growel India Pvt. Ltd; 45% crude protein 1.2 mm size) @ 10% of body weight. The basin was filled with fine sand at the bottom and coarse gravel at top. 30 number of Amaranthus plants were planted in the basin. Recirculation of water was carried out using a small submersible pump (with 2 m head, flow rate 2800 litre per hour, 50 hp). The flow rate of the aquaponics system was maintained as 10 litre per minute.

Water quality parameters observed in the aquaponics system such as temperature (28-29^{O}C), pH (7-7.5), Dissolved oxygen (5-6 ppm) were optimum for the growth of the fishes. Salinity was maintained little lower (6.7 ppt) than the recommended optimum level (15-25 ppt) for silver pompano culture systems, in order to reduce the negative impact of salinity on plant growth. Other parameters included NH_4^+ (0.04-0.075 ppm), NH_4-N (0.03-0.06 ppm), No_2 (0.05-0.07 ppm), No_2-N (0.01-0.021 ppm) and PO_4^- (1.2-1.5 ppm).

Details of the production obtained from the integrated aquaponics system after 30 days indicated growth rate of pompano was higher than their reported growth in conventional tanks. Even though FCR was slightly higher than the recommended (1:1.8) level, 100% survival was observed in the system. An additional production of a leafy vegetable could also be obtained through the system although the plant growth was slightly slower compared to normal farming. Damage due to pests was minimum. Since the present system is a prototype there is ample scope for the enhancement of production using bigger systems.

Brief Communications

Purse seine fishing in Maharashtra

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Purse seines are one of the important gears operated along the west coast of India for harvesting shoaling pelagic fishes, mostly oil sardine and mackerel. Purse seine fishing method invented to harvest the large shoal of pelagic fish in Maine, United State of America during 1830's later is was spread to Norway, Sweden, Japan etc. In India purse seine was introduced on experimental basis in 1954 under Indo-Norwegian project off Quilon, Kerala and other attempt was made in Goa in 1957 when the territory was still ruled by Portuguese. The commercial purse seining taken up by the fishers in Karnataka during the mid 1970s was later adopted by the fishers in Kerala and Goa. In Maharashtra, fishers from the southern region (Ratnagiri and Sindhdurg) adopted purse seine fishing in late eighties and Mirkarwada emerged as a major base of operation for these purse seiners. In northern Maharashtra, fishers were mostly engaged in set bagnet (*Dol* nets) and trawl fishing until the late 1990s when a few trawl fishers shifted to purse seine fishing expecting better economic prospects. Initially, purse seines operated in Maharashtra mostly targeted mostly the pelagic fishes like oil sardine, Indian mackerel, large carangids. Later, with modifications and technological changes several fishes including catfishes and croakers were harvested (Pravin and Meenakumari, 2016; Shibu *et al.,* 2017). Purse seiners currently operating in northern Maharashtra are also targeting very high value, large sized croakers such as *Protonibea diacanthus* (*Ghol*) and *Otolithoides biauritus* (*Koth*).

Before the introduction purse seines, mostly small-scale exploitation of oil sardine and mackerel was done by artisanal fishers in coastal area using shore seines (*rampani*) and gillnets as well as small trawlers. The number of purse seiners increased and boom in purse seine fishery lead to migration of labourers to southern Maharashtra, mostly from Andhra Pradesh initially and later from Bihar, Uttar Pradesh and West Bengal. Due to the promising economic returns purse seining technology was soon adopted in northern Maharashtra (Mumbai) and new purse seiners were introduced or trawl fishing boats were converted to purse seines. The increase in purse seine fishing in nearshore waters lead to conflicts between trawl, *Dol* net and gill net fishers. This led to the notification on 13th October, 1999 under the state's Marine Fisheries Regulation Act (MFRA) whereby, the use of purse-seine gear by any mechanized fishing vessels within territorial waters of 12 nautical miles (nmi) of Greater Mumbai, Thane, Raigad, Ratnagiri and Sindhudurg districts were prohibited.

Following the success of larger mechanized purse seining vessels, small scale fishers also made modifications in their wooden country crafts and purchased suitable small sized purse seine nets. The number of FRP mini purse seines (9-13 m OAL) are increasing, especially in southern Maharashtra. These vessels currently using two 9.9 hp engines and a supporting engine of 5-6 hp for faster hauling and pursing the bottom of net, have a crew of 7-12. The net length varies from 300-600 m and 30-45 m height.

During 2010 there were 435 purses seiners operating along the Maharashtra coast (Marine Fisheries Census, 2010) and their overall length (OAL) ranges from 14-18 m, engine power 110-240 hp, length of net 700-1500 m, depth of net 70-100 m and mesh size 24-46 mm. The average marine pelagic fish landing in Maharashtra before introduction purse seine (1960-1990) was 76,000 tons while after introduction purse seine (1991 to 2016) it increased by about 66% to 115,000 tons (Fig.3). The combined average landing of Indian mackerel and oil sardine in Maharashtra grew from 9% to 23% after introduction of purse seine. Some of the important technology adoption by purse seine fishing in recent years is hydraulic power block for hauling the purse seine and Automatic Identification System (AIS) useful for navigation and tracking fishing boats.

Fig. 1. A mechanized purse seine unit moving to fishing ground

Fig. 2. A motorized FRP mini purse seine unit at sea

The increasing number of purse seines have coincided with the trend of low catches in small scale sectors and since there is overlapping area of operation among these sectors, it has lead to conflicts at sea. The committee appointed by Government of Maharashtra to study the status of purse seine fishing and its impact on the traditional fishing and ecology along the Maharashtra coast submitted its report in May 2012. Based on these recommendations Government of Maharashtra issued an order on 5th February 2016 to regulate purse seine fishing in Maharashtra to resolve conflicts among the traditional small scale fishers and purse seine fishers.

The committee has demarcated the different zones for purse seine fishing in Maharashtra while reserving the rights of traditional fishers also (Fig. 4). These zones are:

Zone (I)- Zai to Murud: Area from shore to 12 nautical miles (nmi) shall be reserved for traditional fishing. The purse seine, ring seine including mini purse seine fishing shall be prohibited in this Zone.

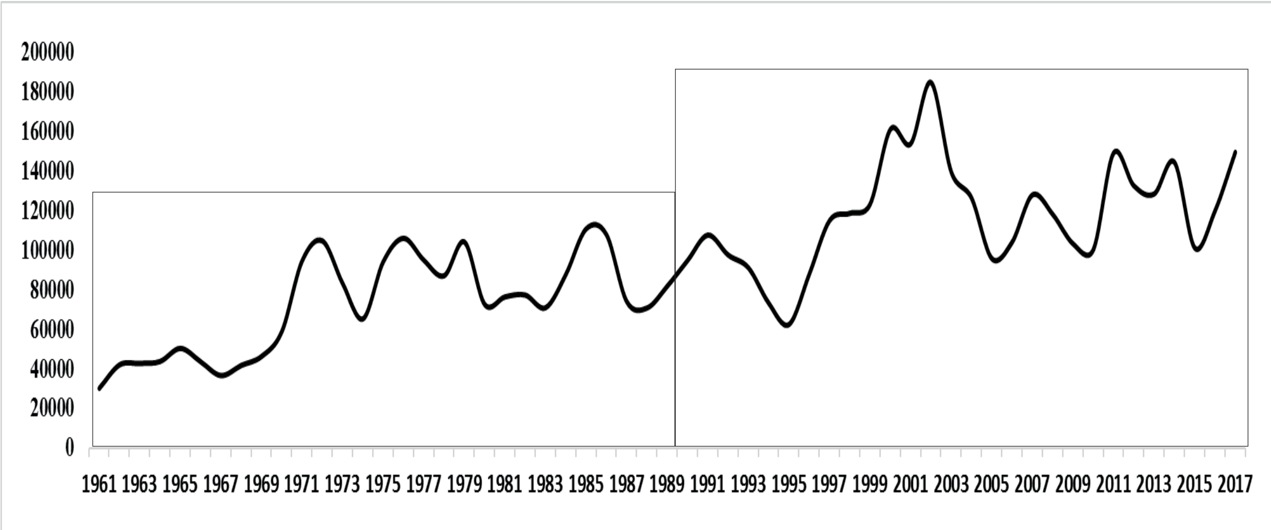

Fig.3. Trend of pelagic fish landings prior to and post-introduction of purse seines in Maharashtra

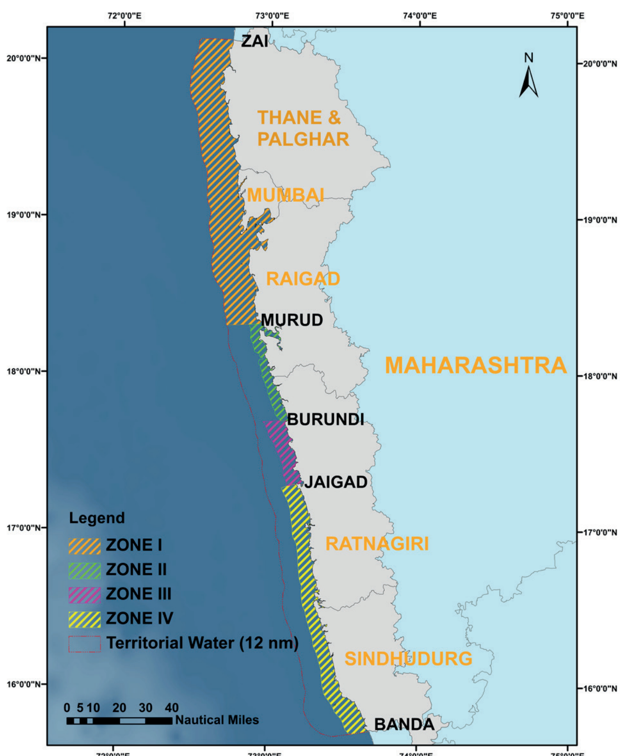

Fig.4. Zonation of the fishing grounds for operation of seines along Maharashtra coast

Zone (II) Murud to Burundi: Area up to 10 m (5 fathom) depth from shore shall be reserved for traditional fishing. The Purse seine, ring seine and mini purse seine fishing shall be permitted beyond the 10 m (5 fathom) depth.

Zone (III) Burundi to Jaigad: Area upto 20 m (10 fathom) depth from shore shall be reserved for the traditional fishing. The purse seine, ring seine and mini purse seine fishing shall be permitted beyond the 20 m (10 fathom) depth.

Zone IV Jaigad to Banda: Area upto 25m (12.5 fathom) depth from shore shall be reserved for traditional fishing. The purse seine, ring seine and mini purse seine fishing shall be permitted beyond the 25-meter (12.5 fathom) depth.

The State Department of Fisheries, Government of Maharashtra will also not issue new licenses for purse seine/ring seine (including mini-purse seine). The number of existing and operational purse seine, ring seine and mini-purse seine fishing licenses shall be brought down gradually to 262 and finally to 182. Purse seine, ring seine and mini-purse seine gear shall be operated by any mechanized vessel, during the period September to December only and within the specified zone.

To conserve the fish stock the use of hydraulic winch (Boom) is also prohibited for purse seine/ring seine (including mini-purse seine) fishing operations. In addition, gear specifications for purse seine/ ring seine (including mini-purse seine) that can be operated by any mechanized fishing vessel in the territorial waters of the State have been notified as given below.

The purse seine operation often creates sectoral conflicts and concerns in small scale fishers. Implementing the Maharashtra Marine Fishing Regulation Act, 1981 and Notification on Purse seine operation is tedious task unless

Table 1. Gear specifications mandated for operating seines along Maharashtra coast

Zone		Specifications of Purse Seine/Ring Seine (including mini-purse seine) Nets	
		Length (m)	Height (m)
I	Zai to Murud	Operation of purse seine, ring seine and mini purse seine nets are prohibited in this zone	
II	Murud to Burundi	125-500	10-40
III	Burundi to Jaigad	250-500	20-40
III	Jaigad to Banda	300-500	25-40

monitoring mechanisms like Vessel Monitoring System (VMS) and AIS is present in all fishing vessels, along with onboard inspections at sea. As per the Jurisdiction of MFRA, 1981 state can enforce and regulate fishing in the territorial waters (12 nmi). Beyond this zone, presently there are several ambiguities among fishermen on fishing, licensing and regulations and hence implementing the new regulations will require concerted efforts.

Brief Communications

Unusual landing of cephalopods along Ratnagiri coast off Maharashtra

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Cephalopods are a marine fishery resource of increasing importance along Maharashtra coast and mostly exploited by trawlers. In 2017 cephalopods forms 9.4% of total marine fish landing of Maharashtra. During month of mid-October

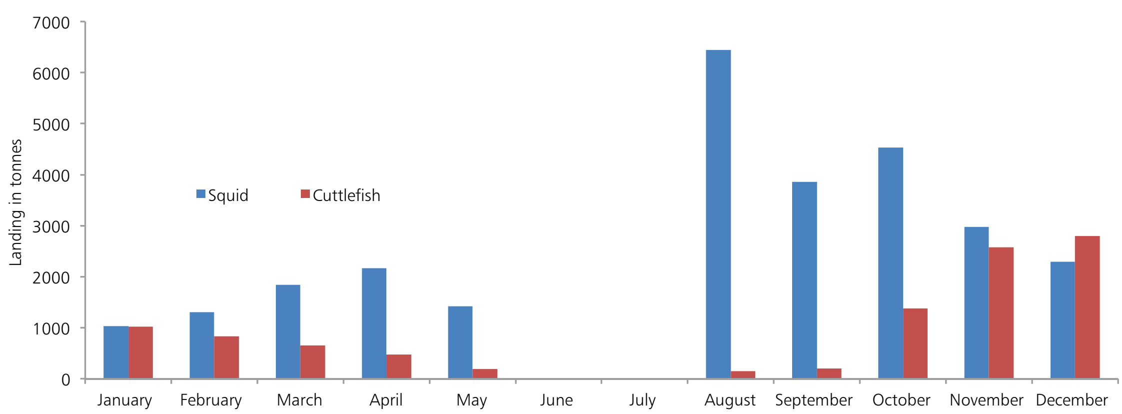

Fig. 1: Squid and cuttlefish landings of Maharashtra in 2017

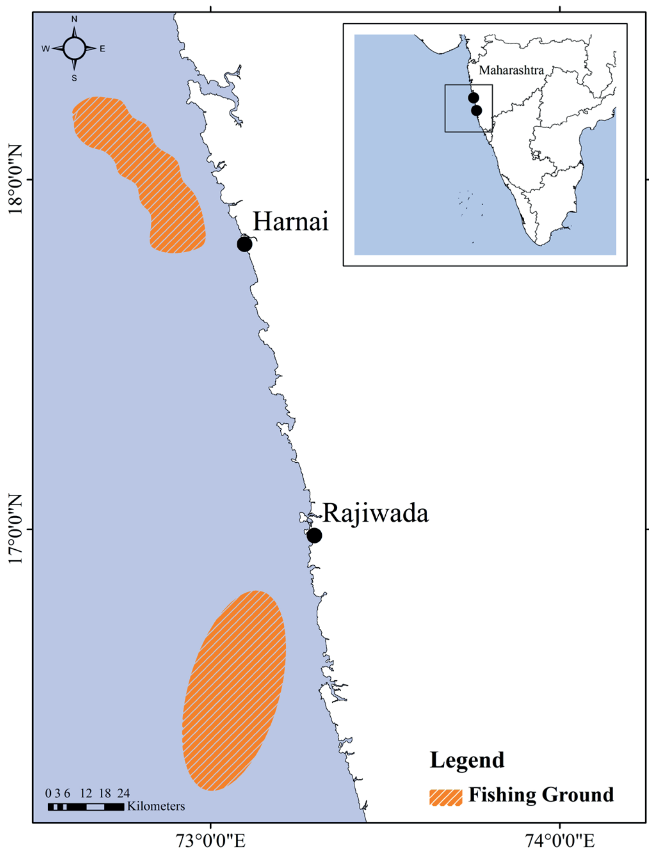

Fig.2: Fishing ground of unusual landing of cephalopod off Ratnagiri coast

to mid- November 2017 there was sudden spurt in Indian squid (*Uroteuthis (Photololigo) duvaucelii*) and Pharaoh cuttlefish (*Sepia pharaonis*) catch at Harnai and Rajiwada fish landing centre of Ratnagiri district of Maharashtra.

At Rajiwada, 20 hand jiggers were operated at 18-20 km away from Ratnagiri in South West direction in 20-22 m depth. Each hand jigger having 20 jigs suspended to 5 ropes. Their catch varies from 50-150 kg/day. But during month of mid-October to mid-November 2017 on an average each hand jigger was getting 500-700 kg catch Indian squid and Pharaoh cuttlefish per day.

At Harnai, during same period trawlers were also getting abundant catch of Indian squid and Pharaoh cuttlefish 18-19 km in North west direction. The fishing ground were demarcated on GIS platform (Fig.2).

The measurements taken at the landing centre indicated that the Dorsal Mantle Length (DML) of Indian Squid ranges from 156 to 381 mm and in Pharaoh cuttlefish ranges from 157 to 420 mm that indicate almost all were adults captured using various kinds of jigs (Figs. 3-5).

The oceanographic parameters retrieved from satellite data sea indicated that Sea Surface Temperature (SST) was in the range of 29-30°C during abundant catch of cephalopods. Mid-column (10-15m depth) temperature was 28°C. Sea surface height above geoid (SSH) increased from 20 cm to 44 cm during abundant catch period and the SSH anomalies may be influenced by ocean circulation also. Fishermen reported increased sea water currents during abundant catches and told that they never observed such high catch in last 2-3 decades. The Indian squid reportedly forms large congregations in inshore waters during the spawning season at which time they are caught by purse seiners using lights.

Fig. 3. Landings of Pharaoh cuttle fish

Fig. 4. Landings of Indian squid

Fig.5. Jigs varieties used by hand jiggers

Morphological differentiation of closely resembling ariid species, *Arius venosus* and *A. sumatranus*

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In Indian waters ariids (Siluriformes/ Ariidae) are represented by 9 genera and 25 valid species. The genus *Arius* is the most diverse with eight species reported from Indian waters which can be categorised in two broad groups. One having elongated teeth patches with globular teeth comprising of five species- *A. jella, A. maculatus, A. gagora, A. malabaricus* and *A. arius* is clubbed under maculatus complex. Other group included species like *A. subrostratus, A. sumatranus* and *A. venosus* having smaller teeth patches with villiform teeth (non-maculatus complex) (Dhanze and Jayaram. 1982). The non-maculatus complex does not contribute much to the commercial fishery barring *A. subrostratus* which forms minor fishery along southwest coast of India. *A. subrostratus* can be easily differentiated from rest of the con-generic members by smaller barbels and long snout with small mouth. The other two members

Fig 1. a) *Arius venosus*; b) *Arius sumatranus*

of non-maculatus complex are very similar in appearance and very difficult to separate out from external appearance (Kumar *et al*., 2015). Both *A. sumatranus* and *A. venosus* (Fig 1) are small to medium sized catfishes with smooth to mildly granulated head shield, narrow median longitudinal groove reaching up to the base of supra-occipital process, dorsal fin with prominent filament, body brownish grey on sides and back and lighter below and fins dusky with yellowish to brown tinge. The most contrasting difference between the two species lies in the shape of teeth patch which in triangular in *A. venosus* and transversely oval in *A. sumatranus* (Fig. 2). A minor difference in having longer maxillary barbels and shorter snout length is evident in *A. venosus*. The extent of granulation is even fainter in case of *A. venosus* (Fig. 3). Both the species are rarely landed especially along northwest coast of India and most often goes unnoticed by the field surveyors and enumerators. In this context, the current pictorial differentiation between the species will help them in easy identification and prompt reporting the species.

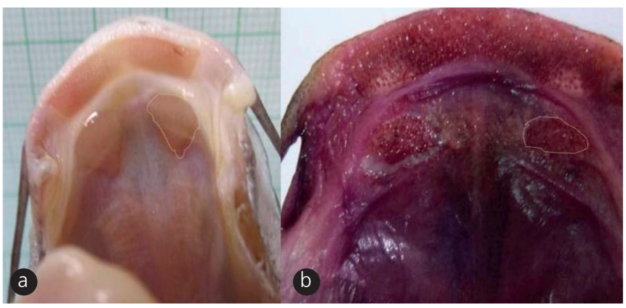

Fig. 2. Teeth patch: a) Triangular in *A. venosus;* b) Oval in *A. sumatranus*

Fig. 3. Head shield: a) *A. venosus;* b) *A. sumatranus*

References

Dhanze and Jayaram. 1982, *Proc.: Animal Sciences,* 91:79-98.

Kumar *et al*., 2015, *Indian J. Fish*. 62(4):109-115.

Brief Communications

Impact of flashfloods on the cage farms in Kerala

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Cage fish farmers across the coastal districts of Kerala suffered massive losses in the floods of August, 2018. The flooding and crop loss was also a setback to efforts of ICAR-CMFRI to popularize cage fish farming. The flood waters which completely washed many cages along with the cultured fishes meant loss was in terms of cage structure and nets, harvest ready fishes and juvenile fishes stocked for new cropping in cages. Around eight species of fish were being farmed in cages including the Asian seabass, pearl spot, red snapper, *Caranx* sp. and tilapia. All these died either due to heavy water flow of muddy waters and some escaped from the damaged nets. Many farmers thus lost their entire investments including the cage structure, nets, mooring, fish, seeds etc. The losses varied from 2 to 25 lakh rupees per person depending on the number of cages, fishes stocked and size of the fishes in the cages at the time of disaster.

A rapid damage and loss assessment was done immediately after the flood waters had receded in the affected coastal

Fig.1 Battery of cage farms damaged

districts of Kerala. The extent of damage and economic loss to cage farms was done based on data collected from fish farmers in the selected districts and data from state department of fisheries. The deluge affected the cage farmers in terms of loss or damage to cage structures and loss of fishes stocked in the cages. The economic loss to cage farms was assessed in terms of foregone value of output due to loss of fishes stocked in cages and damages in terms of input loss and infrastructure loss. The economic loss due to damage or loss of infrastructure was estimated based on partial or full destruction of cage structures at its value prior to the disaster. This also includes the repair cost of cage structure prior to its destruction. The loss of stored inputs and accessories were also included under damages. The inputs are valued at farm gate price or market rates. The economic loss

Table 1. Estimated economic loss to cage farms in the flood affected coastal districts of Kerala

Districts	Affected areas	No of affected units	Fish production loss in quantity (t)	Fish production loss in value (lakhs)	Infrastructure & Input loss (lakhs).
Alappuzha	Chengannur, Cherthala	62	14.88	66.96	15.14
Ernakulam	Kadamakkudy(Pizhala, Kothad), Gothuruthu, Ezhikkara, Kottuvally(Cheriyappilly) Chendamangalam, Moothakunnam, Aluva and Poothotta	426	191.32	661.22	90.89
Kollam	Chemmakkad, Perinad, Prakkulam	8	0.144	3.57	0.12
Kozhikode	Chelanure, Olavanna, Kadalundi, Feroke Kozhikode, Thalakulathure, Vadakara Maniyur, Koyilandy, Keezhariyur Payyoli	19	7.15	19.16	9.7
Thrissur	Methala(Anappuzha) Kaippamangalam, Mala, Kottappuram, Manalur and Naduvilkkara	70	88.25	220.07	97.21
Total		585	301.6	968.11	216.51

Source: Based on primary data collected from farmers and data from Department of Fisheries, Kerala

Fig.2 Overturned cages following the flashflood

due to production loss was estimated based on the final fish production which could have been achieved by the affected units at the time of harvest. The average yields and prices recorded in the previous farming seasons were used for estimating the economic loss for different species of fishes.

The damage estimated in and around Ernakulum and Thrissur districts showed that farmers of the cage farming areas like, Pizhala, Kadamakkudy, Kothad, Aluva, Cheriyapilly, Gothuruthu, Mala, Kaipamangalam and Moothakunnam area were affected very badly as their cages were completely damaged and fishes were lost. Around 150 fish cages had been washed away or seriously damaged in and around Kadamakkudy panchayat. Around 300 cages were submerged under the muddy waters and equal number was lost in the flood. Pizhala Island, a model village in cage fish farming, with around 200 units, experienced a massive loss when those units were washed away in the floods. Similarly Gothuruth another village where many self-help groups were involved in cage farming lost nearly 350 cages. The cages in areas like, Engandiyur, Kodungallur, Kottappuram and Sathaar Island currewere washed off along with fishes and the farmers have to start afresh. In all these places cage farming of fishes was emerging as a major farming activity of the people.

The cage farms in Alappuzha district were partially damaged with partial or complete loss of fishes. More than 95% of the cage farms in Alappuzha district were promoted through various state government schemes. The small sized cages ($8m^3$) in the district were predominantly stocked with pearl spot, which fetches a premium price of ₹500-600/kg in the domestic markets. The cages installed in the districts of Kozhikode and Kollam also suffered massive losses during the deluge. The aggregate economic loss to cage farms in the state was to the tune of ₹11.84 crores. The maximum loss occurred due to loss of fishes stocked in the cages followed by infrastructure loss. An estimated loss of ₹9.68 crores occurred due to fish loss and damage to infrastructure and inputs together contributed another ₹2.16 crores. Cage farms in Ernakulam and Thrissur districts suffered the maximum economic loss amounting to ₹10.69 crores. Lack of insurance coverage in the cage farming sector has become a major impediment in the current situation and the issue needs to be seriously addressed.

Note on a bumper catch of Threadfin sea catfish in shore seine

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For past several years catfish did not form a fishery at Karwar located in the Uttara Kannada District of Karnataka. However, during the routine observations on the fish landings at Aligadda Fish Landing Centre, Karwar, an unusual bumper catch of about 3 tons of cat fish *Arius arius* was recorded from shore seine (*Yendi bale*) in the early hours of 28th July 2018. locally known as "*Billi Shade*", the catch was so heavy that it was difficult to drag the net to the shore and the haul was partially harvested at sea itself. The net operated by around 40 fishers at a depth of less than 8 metres, was 400 m in length. The catch on that day consisted of the cat fish *Arius arius* weighing 2960 Kg (94.78%). Burrowing goby, (*Trypauchen vagina*), Smooth-backed blow fish, *Tetradon inermis*, flat fish, *Cynoglossus macrostomus*, glass perchlet, *Ambassis urotaenia*, Tail eyed goby, *Parachaeturichthys polynema*, Ribbon fish, *Trichiurus lepturus*, Silverbellies (*Leiognathus* sp.), Flat heads, *Platycephalus* sp. and sciaenids were recorded. 74 baskets of 40 kg capacity each containing catfish were auctioned locally at a rate of ₹1700 per basket. The catch was transported to the interior markets in Hubli and Bhadravati where good demand exists for catfish. A sample of the cat fish (n=42) indicated a size range of 180-280 mm each weighing from 60 to 276 g individually. The modal length was 230-244 mm with 74% in length range of 210-269 mm. Maturity indicated 73% were immature. The sex ratio (male : female) was 1:1.21 indicating dominance of females.

Unusual fish landings during monsoon season of 2018 along the Trivandrum and Kanyakumari coast

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Bumper catch of *Odonus niger* (Redtoothed triggerfish) at Thengapattanam Fisheries Harbour and Moonfish *Mene maculata* along Vizhinjam coast was one of the major observations during the monsoon 2018. An estimated 50 t of *O. niger* was landed at the Thengapattanam Fisheries Harbour. Fishing vessels of 32 feet overall length (OAL) with two outboard engines (9.9hp each) operating boat seines were used for fishing. The crew members of each vessel vary from 12-15. It was estimated that each boat landed an average of 0.7 t of *O.niger* exclusively. The mean total length of fish landed was 201 mm with an average weight

115 gm. Since it is not a common and regularly landed fish domestic price of the fish was only about ₹15-20 per kilogram. The salted and dried trigger fish had good demand in the nearby markets of Thiruvananthapuram. The gonadal examination revealed that fishes were either fully mature or spent condition. Most of the guts were empty while some were having fully digested matter.

Mene maculata, forms a major fishery along the Vizhinjam coast especially during the monsoon period. Bumper catch of about 20 tons was recorded on two observation days and comprised of mainly juveniles and sub adults of 9.2-12.1 cm length. A single box of moon fish (60-70 kg) could fetch a price of ₹150-200 only during the glut days. Boat seine were operated by boat (12.5m OAL) having two out board motor engines of 9.9 hp and 12-14 crew members. The monsoon fishery along Vizhinjam coast characterized by continuous landings of the moonfish developed as a good domestic market and the larger sized fishes could fetch a good price. A week after this landing, adult moonfishes in spent recovering stage were landed by the same boat seine units.

Kaleidoscope

An indigenous system for collection of Black soldierfly pupae and its nutritional evaluation for making fish feeds

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Black soldierfly (BSF) pupae can be utilized as an excellent means for the bioconversion of organic wastes into high value sustainable protein and lipid ingredient for aquaculture. The life cycle of this insect begins with eggs laid in clutches of approximately 500 numbers. The eggs are about 1 mm in size and hatch into larvae within 4 days to two weeks. The larva feeds on organic waste and metamorphose into a pre-pupa, normally within 2 weeks which is the most nutrient rich stage in the BSF life cycle. At this stage it can be harvested periodically and converted into a feed ingredient for aquaculture. An indigenous small-scale system for the production of BSF by utilizing waste food from the departmental canteen of ICAR-CMFRI was attempted. The eggs of BSF were observed after about 2 weeks in the food waste filled up to a quarter in the unit kept in an open area to attract the flies. Subsequently, metamorphosis from the larval and prepupal stages, pupal stage was observed in the 10th week. The BSF pupae samples were collected, dried in hot air oven and analysed for nutritional composition which revealed a composition (on % dry matter basis) of crude protein (40.42 $\pm$ 0.89), crude lipid (39.89 $\pm$ 1.74), crude fibre (8.16 $\pm$ 1.64), total ash (10.71 $\pm$ 2.04) and nitrogen free extract (NFE) of 0.82 $\pm$ 0.04. Further research on the variation in nutritional profiles based on the organic waste provided and a cost effective culture system is in progress. This is for promoting it as an effective organic bioconversion model for generation of an alternative protein ingredient for incorporation in fish feeds.

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Taylor *et al*., 1998. *Aquaculture*, 162: 219-230. (Reference with more than two authors)

Friedman and Bell. 1996. *J. shellfish Res*., 15: 535-541. (Reference with two authors)

Pauly, 1980. *FAO Fish. Tech. Pap*., 234.

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