2016 to
2017

ICAR-CIFT

ANNUAL REPORT

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Kochi

ISO 9001-2008; certified; ISO 17025-2005 accredited

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2016 - 2017

ICAR-Central Institute of Fisheries Technology
(Indian Council of Agricultural Research)
CIFT Junction, Matsyapuri P.O, Kochi - 682 029
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निदेशक के डेस्क से

डॉ. रविशंकर सी.एन.

भा कृ अनु प-केन्द्रीय मात्स्यिकी प्रौद्योगिकी संस्थान 29 अप्रैल, 1957 को केन्द्रीय मात्स्यिकी प्रौद्योगिकियां अनुसंधान स्टेशन के रूप में स्थापित किया गया था और बाद में अप्रैल 1961 में के मा प्रौ सं के रूप में नामित किया गया। यह संस्थान मात्स्यिकी के प्रग्रहण एवं पश्च प्रग्रहण प्रौद्योगिकियों में अनुसंधान के लिए एक राष्ट्रीय केंद्र के रूप अद्वितीय स्थान रखता है। हीरक जयंती समारोह के इस वर्ष में, हम इस छोटे से संग्रह में वर्ष 2016-17 की उपलब्धियाँ आपके समक्ष प्रस्तुत करते हुए प्रसन्नता व्यक्त करते हैं।

वर्ष के दौरान मत्स्यन प्रौद्योगिकी प्रभाग के शोध में प्रशंसनीय परिणाम उत्पन्न हुए, सबसे महत्वपूर्ण एक 19.75 मीटर ऊर्जा कुशल हरा मत्स्यन यान सागर हरिता कमीशन प्राप्त करना था। महाराष्ट्र में सिंधुदुर्ग तट में डायमण्ड और वर्ग मेश कॉडेडों के उपयोग का तुलनात्मक विश्लेषण गियर की श्रेष्ठता साबित कर दी। इसी तरह नैनो लोहे-ऑक्साइड, टाइटेनियम ऑक्साइड, सीरियम ऑक्साइड मिश्र धातुओं के विभिन्न संयोजनों में उपयोग करते हुए यान निर्माण इस्पात की सतह के संशोधन पर अध्ययन और साथ ही जलकृषि कैगनेट के लिए इस्तेमाल गियर भी इसके अच्छे जंग प्रतिरोधी गुणों को दिखाया। वैज्ञानिकों अधिक निचल मत्स्य के शिकार के लिए एक चार समान पेनल, 30 मी अर्ध वेलापवर्ती ट्रॉल और विशेष रूप से लक्षित एन्चोवियों के लिए 28 मी. चार सीम अभिकल्प कर सकते हैं। यह अवलोकित किया गया कि बहु-सीम ट्रॉल विशाखापट्टनम तट पर संचालित दो सीम ट्रॉल (23 कि. ग्रा./घं) की तुलना में 40 कि.ग्रा./घं की सीपीयूई के साथ काफ़ी अधिक शिकार पकड़ा।

पश्च प्रग्रहण प्रौद्योगिकियों के अध्ययन के परिणाम स्वरूप ब्राउन समुद्री शैवाल (*सरगासम विगती*)-संयोजित निष्कासित स्नैक तैयार करने के लिए प्रसंस्करण की स्थिति को अनुकूलित किया गया। सामान्य स्थितियों में तीन महीनों की निधानी आयु के साथ मत्स्य-आधारित पोषण बार और ओमेगा-3 वसा अम्ल के साथ कार्यात्मक मत्स्य सॉस भी विकसित किए गए। जल-घुलनशील काइटोसैन का लक्षण वर्णन और पायलट पैमाने पर उत्पादन एक अन्य उपलब्धि थी। इस अध्ययन के दौरान छोटे ट्यूना (*यूथाय्नुस एफ्फिनिस*) आंत से निकाले कच्चे आंत प्रोटिएजों का उपयोग एक प्रभावी रक्त डेस्टेनर का एक नवीन विचार के रूप में उभरा। बम्बई डॉक प्रोटीन आइसोइलेक्ट्रिक सोल्यूबिलाइज़ेशन द्वारा कीमें से तैयार किया गया। पोषक तत्वों, शारीरिक और कार्यात्मक गुणों का निर्धारण किया गया और अच्छे जेल गुणों के साथ उत्पादों को पुनर्गठित किया गया। पश्च प्रग्रहण के अन्य महत्वपूर्ण उपलब्धियां में, विभिन्न डिब्बो में जातीय उत्पादों को खाने के लिए तैयार की जाने वाली थर्मल प्रक्रिया की स्थिति, छोटे आकार के झींगों को शुष्कन के लिए ओसमो-डीहाइड्रेशन प्रोटोकॉल का विकास शामिल है। यह भी देखा गया कि कार्बोक्सी मिथाइल सेल्युलोज और हाइड्रॉक्सीयल प्रोफाइल मिथाइल सेलूलोज़

के साथ बटर फॉर्मूलेशन गहरे तले हुए मत्स्य फिंगारों में तेल के उद्ग्रहण को कम किया। इसके अलावा, पेंगासीस मत्स्य सॉसेज *जी. इडुलिस और एस. विगती* से आहार फाइबर के 3% तक के साथ पुष्ट संरचना और संवेदी मूल्यांकन के आधार पर बेहतर उपभोक्ता स्वीकार्यता को दिए और गहरे-तले मत्स्य कटलेट में स्क्विला प्रोटीन हायड्रोलायसेट के समावेश से तेल अवशोषण और लिपिड ऑक्सीकरण में विशेष कमी आई।

गुणता अश्वासन एवं प्रबंध प्रभाग चेतावनी दिया कि चुने हुए स्थानों में झींग फार्मों के पानी में निर्धारित मात्रा से अधिक δ-BHC और एंड्रिन जैसी ऑरगानोक्लोरीन कीटनाशकों की संख्या अधिक हैं। उन्होंने 21 सीएफआर 114 यूएसएफडीए विनियमन और पांच प्रकार की वाणिज्यिक मत्स्य अचार के लिए शीत रखने की अवधि के अनुसार विकसित की गई मत्स्य अचार की शीत-वहन की प्रक्रिया को भी अनुकूलित किया। इसके अलावा, मत्स्य उत्पादों के संरक्षण के लिए तरल धुएं के साथ उपचार करने वाली बहु रोध प्रक्रिया, संशोधित वायुमंडलीय संवेष्टन उस के बाद प्रशीतन का विकास किया गया। *स्यूडोमोनास* और *ब्रोकोथ्रिक्स थारमोस्फेकटा*, गैलिक अम्ल प्रलेपित काइटोसैन के पूर्ण निषेध के आधार पर, मत्स्य उत्पादों की निधानी आयु के विस्तार में एक संभावित यौगिक होना पाया गया। काईटोसैन, छेने प्रोटीन वियुक्त, हरी चाय निकालने और बे पत्ती के आवश्यक तेल का उपयोग करके कई पायस, ठंडा ट्यूना टुकडों के संग्रहण आयु को बढ़ाना पाया गया। ताजे मत्स्यों में सोडियम बेंजोएट की मात्रा के ठहराव के लिए एक विशिष्ट और संवेदनशील एचपीएलसी-आधारित मानक परिचालन प्रक्रिया विकसित की गई। इसके अलावा, यूरोपीय संघ के निर्यात के लिए 33 प्रकार की फ़िनफ़िश और शेलफिश प्रजातियों के संवेदी ग्रेडिंग के लिए सचित्र दिशा निर्देश विकसित किए गए।

सूक्ष्मजीव विज्ञानीय अध्ययनों से पता चला है कि *साल्मोनेला* 95 समुद्री खाद्य में और कोच्चि भर के बाजारों से एकत्र नमूनों के 41.1% में प्रचलित था। एक और दिलचस्प अवलोकन यह है कि अध्ययन के सभी एमआरएसए पृथक किए गए प्रतिजैविक दवाओं के तीन या अधिक वर्गों के लिए बहु-औषध प्रतिरोध का प्रदर्शन किए और एमआरएसए के 81.5% वियुक्तियां एटेरोटोक्सीजेनीक थे। एमआरएसए, टी 15669-एसटी, का एक नया क्लोन, समुद्री खाद्य, बर्फ़ और पानी से अलग किया गया। एरिक पीसीआर द्वारा समुद्री मत्स्य से अलग किए *वी. पाराहेमोलीटीकस* में व्यापक आनुवंशिक विविधता (55% से 100% समानता) अवलोकित की गई। प्लास्टिक विकृत जीवाणु पर प्रारंभिक अध्ययन से पता चला है कि प्लास्टिक डंपिंग साइटों से जीवाणु पीवीसी का वज़न 43% तक कम करने में सक्षम थे। शुष्कित मत्स्य में कवक नियंत्रण के लिए *पी. एल्जी* के कच्चे एंजाइम तैयारी में जैव नियंत्रण एजेंट के रूप में प्रभावी होना पाया गया। सूक्ष्मजीव विज्ञान, किण्वन और जैव प्रौद्योगिकी प्रभाग का अनुसंधान दल मल्टीप्लेक्स पोलीमरेज़ चेन रिएक्शन (पीसीआर) परख द्वारा समुद्री खाद्य में ईएसबीएल का उत्पादन करने वाले एंटरोबैक्टीरिया जीन एन्कोड के प्रतिरोध को भी मानकीकृत कर सकता है और समुद्री खाद्य में उनके रोग प्रतिरोध पैटर्न का आकलन किया जा सकता है।

जैव रसायन और पोषण प्रभाग का विशेषज्ञ दल यह पाया कि पाली असंतृप्त वसा अम्ल (पीयूएफए) पूरक में समृद्ध मत्स्य का तेल एमआरएनए और लिपिड चयापचय के एंजाइमों के प्रोटीन निचोड़ को प्रभावित करता। आरएनए निचोड़ अध्ययन, पश्चिमी ब्लोटिंग और प्रोटिओमिक दृष्टिकोण के उपयोग से पीयूएफए-समृद्ध सार्डिन तेल में लिपिड कम करने वाली शामिल यंत्रवली के प्रभाव को स्पष्ट किया गया। माल्टोडेक्सट्रिन और छेने प्रोटीन के साथ स्क्वॉलेन के माइक्रोएकैप्स्यूलेशन चार महीने की अधिक की 96% और ऑक्सीडेटिव स्थिरता की एक एनकॅप्सुलेशन दक्षता दे दी। माल्टोडेक्सट्रिन-एनकॉप्सुलेटेड स्क्वॉलेन एंटीअल्सरोजेनिक के प्रभाव का प्रदर्शन किया। स्क्वॉलेन के एनकॉप्सुलेशन के लिए काईटोसैन-छेने प्रोटीन-एनकॉप्सुलेटेड स्क्वॉलेन गोंद अरबी के रूप में अच्छी तरह साबित हुआ। काईटोसैन-छेने प्रोटीन मिश्रण के साथ स्क्वॉलेन सूक्ष्म एनकॉप्सुलेट से पुष्ट केक ऑक्सीडेटिव स्थिरता और संरचनात्मक गुणवत्ता वाले थे। स्प्रे ड्राइंग द्वारा बेटलेन और पूफा बहु पायसीकरण और मेक्रोएन्कैप्सूलेशन से एक सह-वितरण प्रणाली

भी विकसित की गयी। मानव आबादी में पोषण की कमी के महत्व को ध्यान में रखते हुए, फूकोक्सन्थीन सुपरक्रिटिकल तरल पदार्थ निष्कर्षण और भूरे रंग के समुद्री शैवाल *सरगासम* प्रजाति से लिपिड की तैयारी का प्रयास किया गया। दो समुद्री शैवाल आधारित उत्पादों *अर्थात*, समुद्री शैवाल शामिल रस न्यट्राडिंक और समुद्री शैवाल-समृद्ध मत्स्य सूप पाउडर विकसित किए गए। एक अन्य महत्वपूर्ण उपलब्धि, कैल्शियम और लोहा पुष्ट मत्स्य सूप पाउडर का विकास है और पश्चिम जयंतिया पहाड़ी जिला, मेघालय में किशोर लड़कियों के बीच परीक्षण किया गया। इस हस्तक्षेप के परिणाम स्वरूप इस विषय में शामिल 96% में हीमोग्लोबिन के स्तर में वृद्धि हुई है।

आभियांत्रिकी प्रभाग विभिन्न मत्स्यों (बांगडा, सार्डिन, नंदन और सोलफ़िश) के लिए भा कृ अनु प-के मा प्रौ सं सौर शुष्ककों का एक क्षमता मूल्यांकन अध्ययन किया। बायोमास वॉटर हीटर बैकअप के साथ एक बहुउद्देशीय (मत्स्य शुष्कन, जल ताप और बिजली उत्पादन) सौर तापीय रूपांतरण प्रणाली तैयार की गई और निर्माण कार्य प्रगति पर है। मत्स्य की आंख, मांस, त्वचा और गिल के एक हफ्ते की भंडारण अवधि के अनुसार, और इसी तरह टीएमए, मत्स्य के टीवीएन मूल्यों को भी मापन करके मत्स्य ताजगी सेंसर के विकास के लिए प्रारंभिक परीक्षण आयोजित किए गए। 10 किलो की क्षमता वाला एक नया पोर्टेबल घरेलू विद्युत शुष्कक की अभिकल्पना और संरचना की गई। शुरुआती परीक्षण पूरा हो गया है और इस शुष्कक का उपयोग घरेलू या अल्प पूंजी निवेश के साथ मत्स्य और मत्स्यन उत्पादों के सूक्ष्म स्तर शुष्कन के लिए किया जा सकता है। इसके अलावा, इस अभिकल्प में सौर ऊर्जा द्वारा पूरक ताप के लिए प्रावधान शामिल किया गया।

एर्नाकुलम में तीन चयनित मत्स्य बाजारों में विस्तृत सर्वेक्षण से पता चला कि इन बाजारों में आने वाले मत्स्य स्थानीय बंदरगाहों और अवतरण केंद्रों के अलावा केरल के बाहर (तमिल नाडु, आंध्र प्रदेश, ओडिशा और गुजरात) से थे। बाजार श्रृंखला की लंबाई 10 किमी से लेकर 60 किमी तक की विविधता में थी। मछुवा उत्तरदाताओं की बॉडी मास इंडेक्स (बीएमआई) की स्थिति की तुलना डब्ल्यूएचओ वर्गीकरण के परिणामों से पता चला है कि अधिकांश वयस्क स्वस्थ वज़न समूह (64.71%) में थे। यह भी पता चला है कि स्वस्थ वज़न और मोटापे के बीच के अंतराल महिलाओं की तुलना में पुरुषों में बहुत ही कम है। मत्स्य सहकारी समितियों के प्रमुख प्रभाव सूचक जो कि विभिन्न गतिविधियों पर मछुआरों द्वारा कथित थे, केरल और तमिल नाडु के साथ तुलना की गई थी। मछुआरों सहकारी समितियों द्वारा किए गए केरल की गतिविधियों में 85.79% संस्थानों (79.70%), उत्पादन (76.70%), लाभ (73.26%), प्रबंधन (62.48%) और आजीविका (52.91%) पर प्रभाव पड़ा। तमिल नाडु में, यह आंकड़ा केरल की तुलना में कम है, जो कि प्रबंधन के लिए 53.82% से लेकर आजीविका पर 35.87% कम है। समुद्री खाद्य प्रसंस्करण इकाइयों की अंतर-अस्थायी ऊर्जा खपत 2009-2017 की अवधि के दौरान एक अस्थिरता का रुझान दिखाया। औसत अनुमानित मासिक ऊर्जा खपत और लागत क्रमशः 127987.30 किलोवाट इकाइयों और रु 7,93,86 9.20 थे। समुद्री खाद्य प्रसंस्करण संयंत्रों की अल्पावधि ऊर्जा पूर्वानुमान एआरआईएमए (0,0,0) के प्रयोग से लगाया गया जिस में 0.073 का एक महत्वपूर्ण अनुमानित मूल्य और मानक विचलन दिखाया गया है।

नए उत्साह और नए ओज के साथ, हम देश में एक नीली क्रांति लाने में महत्तम योगदान के लिए हमारे प्रयासों को जारी रखते हैं।

कोच्चि
30 जून, 2017

(रविशंकर, सी.एन.)

From the Director's desk

Dr. Ravishankar C.N.

ICAR–Central Institute of Fisheries Technology was established as Central Fisheries Technological Research Station on 29th April, 1957 and later named as CIFT in April 1961. The Institute holds the unique position as a national centre for research in harvest and post harvest technologies of fisheries. Celebrating the Diamond Jubilee year, we are happy to present before you in this small compendium, the achievements of the year 2016-17.

The research in the Fishing Technology Division during the year yielded commendable results, the most important being the commissioning of 'Sagar Harita', a 19.75 m energy efficient green fishing vessel. Comparative analysis of the use of diamond and square mesh codends along Sindhudurg coast in Maharashtra proved the superiority of the gear. Similarly studies on surface modification of boat building steel using nano iron-oxide, titanium oxide, cerium oxide mixtures in different combinations showed its good corrosion resistance property as also in gear used for aquaculture cagenet. The scientists could design a four equal panel, 30 m semi pelagic trawl for capture of off bottom fish and 28 m four seam for specifically targeting anchovies. It was observed that multi-seam trawl caught significantly higher catches with a CPUE of 40 kg/h compared to the two seam trawl (23 kg/h) operated along Visakhapatnam coast.

Post harvest technological studies resulted in optimizing processing conditions for preparing brown seaweed (*Sargassum wightii*)-incorporated extruded snack. Fish-based nutrition bar with shelf life of three months in normal conditions and functional fish sausages with enhanced omega-3 fatty acid were also developed. Characterization and pilot scale production of water-soluble chitosan was another achievement. A novel idea of using crude visceral proteases extracted from little tuna (*Euthynnus affinis*) viscera as an effective blood destainer also emerged during the studies. Bombay duck protein isolate was prepared from mince by isoelectric solubilization. Nutritional, physical and functional properties of isolate were determined and restructured products with good gel properties were prepared. Other important achievements in the post harvest side includes, optimized thermal

process conditions for ready to eat ethnic products in different containers, development of osmo-dehydration protocol for drying small sized shrimp. It was also seen that Batter formulations with carboxy methyl cellulose and hydroxy propyl methyl cellulose significantly reduced the oil uptake in deep fried fish fingers. Further, Pangasius fish sausage fortified with up to 3% of dietary fibre from *G. edulis* and *S. wightii* gave better consumer acceptability based on textual and sensory evaluation and incorporation of squilla protein hydrolysate significantly reduced the oil absorption and lipid oxidation in deep-fried fish cutlets.

The Quality Assurance and Management Division cautions that organochlorine pesticides like δ-BHC and endrin are at higher than prescribed levels in water of shrimp farms in selected locations. They also validated cold-fill process of fish pickles developed as per 21 CFR 114 USFDA regulation and cold holding period for five variety of commercial fish pickles were optimized. Further, a multiple barrier process involving treatment with liquid smoke, modified atmosphere packaging followed by chilling was developed for preservation of fishery products. Based on complete inhibition of *Pseudomonas* and *Brochothrix thermosphacta*, gallic acid-grafted chitosan was found to be a potential additive in shelf life extension of fishery products. A multiple emulsion, using chitosan, whey protein isolate, green tea extract and Bay leaf essential oil was found to enhance the storage life of chilled tuna chunks. For quantification of sodium benzoate in fresh fish, a specific and sensitive HPLC-based standard operating procedure was developed. Further, pictorial guidelines for sensory grading of 33 varieties of finfish and shellfish species for export to EU was developed.

Microbiological studies revealed that *Salmonella* was prevalent in 41.1% of the 95 seafood samples collected from markets in and around Kochi. Another interesting observation is that all MRSA isolates studied exhibited multi-drug resistance for three or more classes of antibiotics and 81.5% of the isolates of MRSA were enterotoxigenic. A new clone of MRSA, t15669-ST, was isolated from seafood, ice and water. Extensive genetic heterogeneity (55% to 100% similarity) was observed in *V. parahaemolyticus* isolated from marine fish by ERIC PCR. Preliminary studies on plastic degrading bacteria have shown that bacteria from plastic dumping sites were able to reduce the weight of PVC by 43%. Crude enzyme preparations of *P. elgii* was found to be effective as biocontrol agent for the control of fungal infestation in dried fish. The research team of the Microbiology, Fermentation and Biotechnology Division could also standardize the genes encoding the resistance for ESBL producing Enterobacteriaceae in seafood by Multiplex Polymerase Chain Reaction (PCR) assay and their antimicrobial resistance pattern in seafood could be assessed.

The expert team from Biochemistry and Nutrition Division could find out that fish oil rich in poly unsaturated fatty acid (PUFA) supplementation affect the mRNA and protein expression of enzymes of lipid metabolism. Mechanisms involved in the lipid lowering effect of PUFA-rich sardine oil were elucidated using RNA expression studies, western blotting and proteomic approaches. Microencapsulation of squalene with maltodextrin and whey protein isolate gave an encapsulation efficiency of 96% and oxidative stability of more than four months. Anti-ulcerogenic effect of maltodextrin-encapsulated squalene was demonstrated. Chitosan-whey protein-encapsulated squalene was proved to be as good as gum Arabic for encapsulation of squalene. Cakes fortified with squalene microencapsulated with chitosan-whey protein complex had superior oxidative stability and textural quality. A co-delivery system of betalain and PUFA by multiple emulsification

and microencapsulation by spray drying was also developed. Considering the importance of seaweed in the present scenario of nutritional deficiency in human population, supercritical fluid extraction of fucoxanthin and lipid from brown seaweed *Sargassum* sp. was attempted. Two seaweed-based products *viz*., Seaweed incorporated Juice-NutriDrink, and Seaweed-enriched fish soup powder were developed. Another important achievement was the development of calcium and iron-fortified fish soup powder and testing among adolescent girls in West Jaintia Hills District, Meghalaya. The intervention resulted in a rise in haemoglobin levels in 96% of the subjects involved.

The Engineering Division conducted a performance evaluation study of ICAR-CIFT solar dryers for various fishes (mackerel, sardine, nandan and solefish). A multi-purpose (fish drying, water heating and electricity generation) solar thermal conversion system with biomass water heater backup was designed and fabrication work is in progress. Preliminary trials were conducted for the development of fish freshness sensor by measuring colour of fish eye, flesh, skin and gill over one week storage period, and corresponding TMA, TVN values of fish flesh were also measured. A new portable household electrical dryer of 10 kg capacity was designed and fabricated. Initial testing has been completed and the dryer can be used for household or micro scale drying of fish and fishery products with lower capital investment. Also, provision for supplemental heating by solar power was incorporated in the design.

Detailed survey in three selected fish markets in Ernakulam revealed that the fish arrivals to these markets were from outside Kerala (Tamil Nadu, Andhra Pradesh, Odisha and Gujarat) besides local harbours and landing centres. The length of market chain is diverse ranging from 10 km to 60 km. The body mass index (BMI) status of the fisher respondents was compared using the WHO classification. The results showed that majority of adults were in the healthy weight group (64.71%). This also revealed that the gaps between healthy weight and obese were very narrow in males than in females. The major impact indicators of Fishermen Co-operative Societies as perceived by the fishermen on various activities were compared for Kerala and Tamil Nadu. In Kerala activities undertaken by Fishermen Co-operative Societies had impacted on access to institutions (85.79%), production (76.70%), profit (73.26%), management (62.48%) and livelihood (52.91%). In Tamil Nadu, the figures were lesser in comparison to Kerala ranging from 53.82% for management to a low of 35.87% on livelihoods. The inter-temporal energy consumption of seafood processing units showed a fluctuating trend over the period of 2009–2017. The average estimated monthly energy consumption and the cost was 127987.30 Kwh units and ₹ 7,93,869.20 respectively. Short term energy forecasting of seafood processing plants was estimated using ARIMA (0,0,0) which showed a significant estimated value and standard deviation of 0.073.

With new enthusiasm and new vigour, we continue our efforts for maximum contribution in bringing out a 'Blue Revolution' in the country.

Kochi
30 June, 2017

(Ravishankar, C.N.)

कार्यकारी सारांश

- 'सागर हरिता' एक 19.75 मी ऊर्जा कार्यक्षम हरा मत्स्यन जहाज कमीशन प्राप्त किया।
- 1x0.6x0.6 मी के आयाम के साथ एक संशोधित ट्रॉप की शिकार कार्यक्षमता को केकड़ा और पलस्पॉट (*एट्रोप्लास सुरटेन्सीस*) के लिए क्रमानुसार 1.05 कि ग्रा और 1.02 कि ग्रा के रूप में निर्धारित किया गया।
- विशाखपट्टणम तट में परिचालित दो सीवन ट्रॉल (23.0 कि ग्रा/घं) की तुलना में एक सी पी यू ई के साथ बहुसीवन ट्रॉल 40.0 कि ग्रा/घं के विशेष रूप से उच्च शिकार को प्राप्त किया।
- रेनबोउ सार्डिन और लेसर सार्डिन दोनों मिलकर 80%, यह प्रमुख जातियां विशाखपट्टणम तट में परिचालित 30 मी दूर निचल ट्रॉल लगाए 60 मि मी मेश पेनलों से पलायन करते।
- 40 मि मी डायमण्ड मेश कोडएन्ड में *जहनीस ड्यूसुमीरी* का L_{50} मूल्य 7.51 से मी था और चयन रेंज 3.4 से मी था।
- 22 और 25 मि मी अंतरण स्क्विल्ला अपवर्जन ग्रिड में *परापेनीओप्सीस स्टेलीफेरा* का L_{50} मूल्य क्रमानुसार 95 और 105 मि मी था। 22, 25 और 30 मि मी अंतरण के लिए *मेटापीनस मोनोसीरस* का L_{50} मूल्य क्रमानुसार 113, 128 और 129 मि मी था।
- सिंधूदुर्ग तट में डायमण्ड और वर्ग मेश कोडएन्ड के प्रयोग के तुलनात्मक विश्लेषण से पता चला कि 15 में से 12 वाणिज्यिक महत्व की प्रजातियों की औसत लम्बाई 7.85% बढ़ी। वर्ग मेश कोडएन्ड से पलायन का दर 0.76 कि ग्रा प्रति घंटे था, प्राप्त कुल शिकार 3.9% (2142.4 कि ग्रा) है।
- भिन्न संयोजन में नैनो लोहेऑक्साइड, टाइटेनियम ऑक्साइड, सीरियम ऑक्साइड मिश्रण की प्रयुक्त से यान निर्माण इस्पात का सतह संशोधन किया गया। परिणाम सूचित किए कि $Fe_2O_3 : CeO_2 : TiO_2$ संयोजन 0.005: 0.001: 0.005% एक अच्छे जंग रोध गुणों को रखते।
- भिन्न सांद्रणों में नैनों जिंक ऑक्साइड, टाइटेनियम ऑक्साइड, सीरियम ऑक्साइड के साथ यान निर्माण इस्पात में संशोधित किया गया और परिणाम सूचित किए कि 0.01:0.01:0.005% $Fe_2O_3 : CeO_2$:TiO_2 के उत्तम जंगरोध अनुपात को रखते।
- 1) पॉलीएनीलीन और नैनो कॉपर ऑक्साइड, 2) पालीएनीलीन नैनो कॉपर आक्सेड, और 3) पॉलीएनीलीन, जिंक ऑक्साइड, टाइटेनियम ऑक्साइड, कॉपर ऑक्साइड मिश्रण की प्रयुक्ति से एच डी पी ई जलकृषि पिंजराजाल सतह को संशोधित किया गया। नदीमुख में 90 दिनों के अनाश्रण के बाद भी सभी तीन उपचार उत्तम जैव विकृत प्रतिरोध को प्रदर्शित किए।
- मानसून के दौरान तटीय जल में सी डी ओ एम स्रोत नदीमुख से था और मानसून के बाद, सी डी ओ एम का मुख्य स्रोत तटीय मूल का अपघटित जैव पदार्थ था।
- एक चार समान पैनल, 30 मी अर्धवेलापवर्ती टॉल निचल तल मत्स्यन के शिकार के लिए और विशेष रूप से लक्षित एन्कोवीस के लिए 28 मी चार सीवन को अभिकल्पित किया गया।
- 35 मी से 47 मी के बीच एमएमएमएलडी रेंज के क्षेत्रों में यल्लोफीन ट्यूना के उच्च शिकार को रिकार्ड किया गया। लम्बी डोरी शिकार का हुकन दर अध्ययन संकेत करता कि भारतीय पूर्व तट में दिसंबर से फरवरी के बीच यल्लोफीन ट्यूना का उत्तम मत्स्यन मौसम है।
- कारबोक्सी मीथल सेलुलोस और हाइड्रोक्सील प्रेपील मीथल सेलूलोस के साथ बटर सूत्रीकरण गहरे तले मत्स्य फिंगर में तेल की मात्रा को विशेष रूप से कम करता।

- भूरा समुद्रीशैवाल (*सरगासम विगती*)-संयोजित निष्कासित स्नैक की तैयारी के लिए संसाधन अवस्था को अनुकूलित किया गया।
- सामान्य स्थिति में तीन महिनों की निधानी आयु के साथ मत्स्य आधारित पोषण बार।
- वृद्धि किए ओमेगा-3 वसा अम्ल मात्रा के साथ कार्यात्मक मत्स्यन सॉसेज को विकसित किया गया।
- भिन्न डिब्बों में खाने के लिए तैयार एथनीक उत्पादों के लिए तापीय प्रक्रिया की स्थिति को अनुकूलित किया गया।
- जल-घोलनीय काईटोसैन का पायलट स्तर उत्पादन को अनुकूलित किया गया और उसके गुणों को चित्रीकरण किया गया।
- छोटे आकार के झींगों के शुष्कन के लिए ओस्मो-डीहाइड्रेशन प्रोटोकल को विकसित किया गया।
- *जी. इडूलीस* और *एस. विगती* से 3% तक आहारी फायबर के साथ पेंगासीस मत्स्य सॉसेज को पुष्ट किया गया। यह संरचनात्मक एवं संवेदी मूल्यांकन के आधार पर उत्तम उपभोक्ता स्वीकार्यता को दिया।
- स्क्विल्ला प्रोटीन हाइड्रोलेसट के संयोजन से गहरे तले कटलेटों में विशेष रूप से तेल अवचूषण और लीपिड ऑक्सीकरण कम होता।
- छोटे ट्यूना (*इयूथीनस एफीनस*) आंत्रों से निष्कार्षित कच्चे आंत्र प्रोटीएसेस रक्त डेस्टेनरे के रूप में प्रभावी पाया गया। मत्स्य एवं मुर्गी रक्त वितितियों को 20 मिनट के भीतर और बकरा एवं भेडों के रक्त वितितियों को क्रमानुसार 10 और 15 मिनट के समय में निकला गया।
- एसोइलेक्ट्रीक घोलीनीकरण द्वारा कीमें से बम्बई डॉक प्रोटीन वियुक्तियों को तैयार किया गया। वियुक्तियों के पोषण्विक, भौतिक एवं कार्यात्मक गुणों का निर्धारण किया गया और अच्छे जेल गुणों के साथ पुनःसंरचित उत्पादों को तैयार किया गया।
- प्राथमिक उत्पादन केन्द्रों में, 5.89% के नमूने स्वीकार्य सीमा से ज्यादा जीवाणु भर को रखते।
- झींगा फर्मों के जल में निर्धारित स्तर से ज्यादा δ-BHC और इन्ड्रीन जैसे इंद्रियग्राही क्लोरिन पीड़कनाशियों को खोजा गया।
- 21 सी एफ आर 114 यू एस एफ डी ए विनियमन के अनुसार मत्स्य अचार का कोल्ड-फिल प्रक्रिया का मान्यकरण और वाणिज्यिक मत्स्य अचार के पांच जातियों के लिए शीत वहन अवधि को अनुकूलित किया गया।
- मत्स्यन उत्पादों के परिरक्षण के लिए द्रव्य धूम्र, संशोधित वायुमंडलीय संवेष्टन और उसके बाद शीतन के साथ एक बहु रोध प्रक्रिया सम्मेलित उपचार को विकसित किया गया।
- *स्यूडोमोनस* एवं *ब्रोकोटीक्स थारमोस्पक्टा* के संपूर्ण निषेध आधारित गैलीक, अम्ल-प्रलोपित काईटोसैन मत्स्यन उत्पादों की निधानी आयु में संभावित यौगिक के रूप में पाया गया।
- काईटोसैन, वियुक्ति, हरी चाय निचोड़ और बाय पत्ता अनिवार्य तेल प्रयुक्त एक बहु मिश्रण प्रशीतित ट्यूना टुकड़ों की संग्रहण जीवन वृद्धि करना पाया गया।
- उच्च दाब (200 एमपीए और 400 एमपीए, 5 मिनट का वहन समय) का अनुप्रयोग बिना शुद्ध किए सीपी (*विलोरीटा साइप्रीनोडेस*) अखोजनीय स्तर में *ई.कोली* संदूषण को प्रभावी रूप से उन्मूलन कर सकता।
- सूर्य शुष्कित सफ़ेद सार्डिन में *स्टेफीलोकोक्स* द्वारा एन्ट्रोटोक्सीन उत्पादन पर अनुकरण जब *एस. औरस* स्तर 10^8 cfu/g, जल प्रति-क्रिया 0.968 और नमी मात्रा 54.79% पहुँचने तक 6 घंटों के शुष्कन के बाद एन्टेरोटोक्सीन उत्पादन के आरंभ को सूचित किया।
- सूर्य शुष्कन के दौरान स्टेफीलोकोकल एन्टेरोटोक्सीन की संरचना को 1% स्तर तक प्रोपीओनीक अम्ल में एक पूर्व ड्रिप से रोक सकते है।
- 0.15% नमक युक्त 1.65% एस टी पी पी उपचार से झींगों में, 1:3 के उपचार घोलनीय अनुपात का ऊतक और 7 घंटों की सोकने की अवधि अधिकतम मान्य फास्फेट उद्ग्रहण करता।
- स्वच्छ मत्स्य में सोडियम बेंजोएट की मात्रात्मकता के लिए एक विशेष एवं संवेदी एच पी एल सी-आधारित मानक परिचालन प्रक्रिया को विकसित किया गया।

- भारत के दक्षिण पश्चिम तट में अवतरित *लूटजनास बोहर* में सीगुएटोक्सीन के उत्पन्न को अवलोकित किया गया।
- ई यू के निर्यात के लिए फिनफिश एवं कवच मत्स्य प्रजातियों के 33 जातियों के संवेदी श्रेणीकरण के लिए सचित्र मार्ग निर्देश विकसित किए गए।
- कोचि और आस पास से इकट्ठे किए गए 95 समुद्री आहार नमूनों में 41.1% में *सालमोनेल्ला* विद्यमान था।
- केरल के पालघाट में हैजा से प्रभावित इलाकों के कुओं से *विब्रियो कोलरा* 01 ओगावा स्ट्रेन्स को पृथक्क किए गए।
- सभी एम आर एस ए आइसोलेटों में बहु दवा प्रतिरोध दर्शाया जो दो या तीन प्रतिजीवाणुओं के लिए है और एम आर एस ए की पृथक्क एंटेरोटोक्सिजेनिक थे।
- समुद्री आहार, हिम और पानी से एम आर एस ए का नया क्लोन t1 5669- ST को हॉल किया गया।
- स्क्रीन किए गए 55 स्ट्रेनों में दवा असिनोमौसेटस पृथक्क में एम आर एस ए के विरुद्ध गैरजीवाणवीय प्रक्रिया नज़र आया और इन्हें *स्ट्रेप्टोमेसेस* जाति और *लैसिनिबासिलस* जाति के नाम से पहचाना गया।
- एटिक पी सी आर द्वारा समुद्री मत्स्य से पृथक किए *वी. पाराहीमोलिटिकस* में विस्तृत जेनेटिक हेटोरोजेनिटी पाया गया (55% से 100% साम्य)।
- थैईम तेल में अमैलेज, कासिनेस जेलाटिनेस पाया गया और *वी. पाराहीमोलिटिकस* और वी कोलेरा पृथक्क भिन्न सांद्रों में थे।
- प्लास्टिक फेंके जानेवाले जगहों पर जीवाणु ने पी वी सी का वजन 43% तक कम कर पाया।
- *ए. हाइड्रोफिला* के 15 स्ट्रेनों का LD_{50} मूल्य और *ए. जेंडई* को नौ स्ट्रेन और खेतों से पृथक्क किए गए। *ए. वरनोनी* में बीमारी का आउट बेक क्रमशः रोहू फिंगरलिंग 10^2-10^3, 10^7 और 10^4-10^5 के रेंज में था।
- *पी. एलजै* का अपरिष्कृत किण्वक सूखे मत्स्य में रोगाणु संक्रमण के नियंत्रण के लिए जीव नियंत्रण एजेंट प्रभावकारी पाया गया।
- समुद्री आहार में ESBL उत्पाद करनेवालों के लिए मल्टीप्लेक्स चेन प्रतिक्रिया स्तरीय किए गए और उनके जीवाणवीय नमूनों को निर्धारण किया गया।
- मत्स्य तेल जो पूफा सम्पलीमेंटेशन से भरपूर है वे mRNA करते हैं अैर प्रोटीन किण्वकों को प्रभावित करते हैं। पूफा से भरपूर सारडीन तेल के लिपिड निम्नीकरण प्रक्रिया को RNA एक्प्रेशन अध्ययन, पश्चिम ब्लोटिंग एवं प्रोटियोमिक पहल द्वारा स्पष्ट किया गया।
- थिमामिन - पैरिडोक्सिन - बानिलिक अम्ल - ग्राफट किया गया कैटोसन दबाव आधारित चूहों में तनाव अल्पीकरण प्रभाव दर्शाया।
- स्क्वालीन को माल्टोडेक्सट्रिन के सूक्ष्म एनकेपसूलेशन और प्रोटीन पृथक्क 96% एनकेपसूलेशन क्षमता दर्शाया। इसका आक्सीकारक स्थिरता चार महीने से ज्यादा रहा है। माल्टोडेक्सट्रिन -एनकेपसूलेटेड स्कवालीन का गैर अलसेरोजेनिक प्रभाव प्रदर्शित किया गया।
- कैटोसन-वै-प्रोटीन एनकेपसूलेटेड स्क्वालीन गम अरबिक जैसा ही था। यह स्क्वालीन के एनकेपसूलेशन के लिए अच्छा है। स्कवालीन माइक्रोएनकेपसूलेटेड से फोरटिफै किए गए केक की उच्च आक्सीकारक स्थिरता और बनावट गुण पाया गया।
- बहु इमल्सीफिकेशन द्वारा जेलाटिन और पूफा का सह डेलिवरी पद्धित विकसित किया गया। स्प्रे शुष्कन द्वारा माइक्रोएनकेपसूलेशन विकसित किया गया।
- ब्राउन सीवीड *सारगासम* जाति से फूकोजांतिन और लिपिड का सूपर क्रिटिकल फलूयिड निचोड़ कोशिश की गई। दो समुद्री आहार आधारित उत्पाद जैसे सीवीड आधारित पौष्टिक पेय, और समुद्री शैवाल आधारित मत्स्य सूप विकसित किया गया।
- विकसित किए गए कैलशियम और लोहे फोरटिफाइड मत्स्य सूप चूर्ण को मेघालय के पश्चिम पहाड़ी जिलों में युक्तियों में जांच किया गया। इससे उनके हीमोग्लोबिन स्तर में 96% वृद्धि हुई।

- *लिटोपीनस वन्नोमी* का हेपाटोपेनक्रियास का नमी, प्रोटीन और चर्बी मात्रा 32%, 23.75% और 41.88% था। ओलिक (31%) और लिनोलिक (25%) प्रबल फैटी अम्ल रहा। जबकि लैसिन (20%) और गलूटामिक अम्ल (16%) प्रमुख अमिनो अम्ल है।
- *उलवा लैक्टूका* का एसेटोन निचोड का सोख स्पेक्ट्रा 425 nm और 660 nm रहा।
- डी एच ए फोरटिफाइड पौष्टिक पूरक एक साल के कवच आयु के बाद भी स्वीकार्य अवस्था में था ।
- भिन्न मत्स्य आहारों से पाले गए पिज़ारें में खेती किए गए ग्रूपर का पौष्टिक प्रोफाइलिंग से यह पता चला कि *डीकापटेरेस रूसेली* मांस गुण को बढाने के लिए बेहतर चारा था।
- भा कृ अनु प-के मा प्रौ सं सौर शुष्ककों को भिन्न मत्स्यों के लिए (मेकरेल, सारडीन, नंदन और सोल मत्स्य) निष्पादन मूल्यांकन किया गया।
- एक बहु उद्देशीय (मत्स्य शुष्कन, पानी तापन और विद्युत उत्पादन) सौर तापीय परिवर्तन पद्धित को बयोमास पानी हीटर बैक अप के साथ अभिकल्पित किया गया और इसका संविरचन पर काम हो रहा है।
- भा कृ अनु प-के मा प्रौ सं का मौजूदा सौर - एल पी जी हैब्रिड ड्रायर को पुनः अभिल्पित किया गया। मत्स्य ऑख का रंग, चमड़ा, और गिल को एक संग्रह के संचयन अवधि में माप करके मत्स्य फ्रेशनर सेनसर के विकास के लिए प्राथमिक ट्रायल्स किया गया। मत्स्य के चमड़ो की टी एम ए, टी वी एन मूल्यों को भी मापा गया।
- 10 कि ग्राम का घरेलू विद्युत ड्रयर को अभिकल्पित और संविरचित किया गया। शुरूआती जांच पूरा हुआ है। इसे मत्स्य और मात्स्यिकी उत्पादों के माइक्रो सेल के लिए उपयोग किया जाता है। इस अभिकलपना में सौर ऊर्जा द्वारा विद्युत उत्पाद करने की सुविधा दी गई है।
- एरणाकुलम में ट्राल मात्स्यिकी के आर्थिक इनपुट सूचक यह दर्शाया कि मत्स्य ट्रिप का औसत प्रचालनात्मक दाम एवं डीजल के दाम को मिलाकर होता है। डीजल - ₹ 42,117.50, इंजन तेल - ₹ 525, हिम - ₹ 7000, रेशन - ₹ 5000 और मरमत एवं रख रखाव रु. 1000। मालिक के आमदनी का 40% कर्मीदल बांट लेते हैं ट्राल मत्स्यन से ट्रिप आधारित आमदनी ₹ 17,750 से 70,800 में बढा।
- एरणाकुलम के चुने गए तीन मत्स्य बाजारों के मत्स्य आपूर्ति से यह पता चला जा कि इन बाजारों में मत्स्य केरल के बाहर से आता था, स्थानीय बंदरगाह और अवतरण केंद्रों के अलावा बाजार चेन की लंबाई 10 कि मी से 60 कि मी की है।
- मत्स्य प्रतिवादियों के बी एम आई को डब्ल्यू एच ओ वर्गीकरण के अनुसार तुलना किया गया। परिणाम यह दर्शाया कि ज्यादातर वयस्क स्वास्थ्यपरक और मोटापावालों में पुरुष, महिलाओं की अपेक्षा ज्यादा मोटे थे।
- कोजिकोड के पुढियापा में मछुवारों का मत्स्यन क्षमता उपयोगिता का अवबोधन से यह पता चला कि सबसे महत्वपूर्ण आयाम बढता मत्स्यन दबाव और दाम है। वे संपदा अवनति और संरक्षण पर चिंतित है। कोल्लम में यही अध्ययन किया गया जिससे यह पता चला कि उनके प्रबंधन में सामूहिक भागीधारी का अवबोधन पर सबसे तरजीह दिया गया। औसत रैंकिंग स्कोर 4.83 सामूहिक समुद्र हक 4.67 और भिन्न मत्स्यन पणधारियों के बीच झगडों का एम आर एस 4.60 रहा।
- केरल और तमिल नाडु के मछुवारों के भिन्न कार्यकलापों पर मछुवारे सहकारिता समितियों द्वारा बताए गए प्रमुख प्रभाव सूचकों की तुलना की गई। केरल में मछुवारे सहकारिता समितियों द्वारा किए जा रहे क्रिया कलापों में संस्थानों (85.79%), उत्पादन (76.70%) लाभ (73.26%) प्रबंधन (62.48%) और आजीविका (52.91%) था। तमिल नाडु में केरल की अपेक्षा आंकडे कम थे। प्रबंधन में 53.82% और आजीविका के लिए 35.87% प्रभाव को उच्च, मध्यम और निम्न में वर्गीकृत किया गया।
- समुद्री आहार संसाधन एककों का अंतर तात्कालिक ऊर्जा खपत 2009-17 में लडखडाता प्रवृत्ति नज़र आया। औसत अनुमति मासिक ऊर्जा खपत और उसका दाम 127987.30 यूनिट और ₹ 7,93,869.20 क्रमशः था। समुद्री आहार संसाधन संयत्रों का अल्पकाल ऊर्जा भविष्यवाणी को ARIMA द्वारा आंका गया। यह महत्वपूर्ण अनुमानित मूल्य और 0.073 की स्तरीय विचलन दर्शाया।
- भा कृ अनु प-के मा प्रौ सं (768 प्रौद्योगिकियॉं) के सारे एस डी टी आउटपुटों का पूरा दस्तावेजीकरण किया गया। जिसमें नए

सुधरित प्रौद्योगिक उत्पाद और संसाधित परामर्श और नीति इनपुट शामिल है। प्रौद्योगिकियों का प्रौद्योगिकी हस्तांतरण स्थिति आकलन किया गया और 43 को प्रभाव हस्तांतरण के लिए चुना गया।

- पिछले 20 सालों का प्रौद्योगिकी हस्तांतरण के तरीकों पर अध्ययन किया गया और इन्हें वर्गों में बांटा गया। प्रौद्योगिकियों को क्षेत्र में वांछित प्रभाव, प्रसार का तरीका, वांछित लाभार्थी और प्रौद्योगिकी के स्वभाव पर पूरी जानकारी इकट्ठा की गई।
- प्रौद्योगिकी, आर्थिक और सामाजिक, तीन प्रकार के सूचकों को एस एंड टी के आउटपुटों के प्रभाव को निर्धारण करने के लिए अंतिम रूप दिया गया। यह वैज्ञानिकों और प्राप्त माध्यमिक सूचना के आधार पर किया गया।
- एस एंड टी के आउटपुटों को भिन्न वर्गों के लिए निर्धारित साधन अलग से तैयार किए गए।

Executive Summary

- 'Sagar Harita', a 19.75 m energy efficient green fishing vessel designed by ICAR-CIFT was commissioned.
- The catch efficiency of a modified trap with dimensions of 1×0.6×0.6 m was determined as 1.05 kg and 1.02 kg respectively for crabs and Pearlspot (*Etroplus suratensis*).
- Multi-seam trawl caught significantly higher catches with a CPUE of 40 kg/h compared to the two seam trawl (23 kg/h) operated along Visakhapatnam coast.
- Rainbow sardines and lesser sardines together constituting 80%, were the major species that escaped from the 60 mm square mesh panels attached to 30 m off-bottom trawl operated along Visakhapatnam coast.
- The L_{50} value for *Johnius dussumieri* in 40 mm diamond mesh codend was 7.51 cm and the selection range was 3.4 cm (6.70 cm – 8.45 cm).
- The L_{50} values for *Parapenaeopsis stylifera* were 95 and 105 mm respectively in the 22 and 25 mm spacing squilla exclusion grids. The L_{50} values for *Metapenaeus monoceros* were 113, 128 and 129 mm, respectively for 22, 25 and 30 mm spacing.
- Comparative analysis of the use of diamond and square mesh codends along Sindhudurg coast showed that the mean length of 12 out of the 15 commercially important species increased by 7.85%. The rate of escapement from the square mesh codends was 0.76 kg per hour, which is 3.9% of the total catch retained (2142.4 kg).
- Surface modification of boat building steel was done using nano iron oxide, titanium oxide, cerium oxide mixtures in different combinations. The results showed that the combination of 0.005:0.01:0.005% of Fe_2O_3:CeO_2:TiO_2 has good corrosion resistance property.
- The boat building steel surface was modified with nano zinc oxide, titanium oxide, cerium oxide in varied concentrations and the results showed that the ratio of 0.01:0.01:0.005% Fe_2O_3:CeO_2:TiO_2 has excellent corrosion resistance.
- HDPE aquaculture cagenet surface was modified using: 1) Polyaniline and nano copper oxide, 2) Polyaniline nano copper oxide, titanium dioxide, and 3) Polyaniline, zinc oxide, titanium oxide, copper oxide mixtures. All the three treatments exhibited excellent biofouling resistance even after 90 days of exposure in the estuary.
- CDOM source in the coastal waters during monsoon was from the estuary and during post-monsoon, the main source of CDOM was the decomposed organic matter of coastal origin.
- Designed a four equal panel, 30 m semi pelagic trawl for capture of off bottom fish and 28 m four seam for specifically targeting anchovies.
- High catches of yellowfin tuna were recorded in the areas where Monthly mean Mixed Layer Depth (MMMLD) ranged between 35 m to 47 m. Hooking rate studies of long line catches suggests that the best fishing season for yellowfin tuna is between December to February in east coast of India.
- Batter formulations with carboxy methyl cellulose and hydroxy propyl methyl cellulose significantly reduced the

oil uptake in deep fried fish fingers.

- Processing conditions for preparing brown seaweed (*Sargassum wightii*)-incorporated extruded snack was optimized.
- Fish-based nutrition bar with shelf life of three months in normal conditions was developed.
- Functional fish sausages with enhanced omega-3 fatty acid content were developed.
- Optimized thermal process conditions for ready to eat ethnic products in different containers.
- Pilot scale production of water-soluble chitosan was optimized and its properties were characterized.
- Developed osmo-dehydration protocol for drying small sized shrimp.
- Pangasius fish sausage fortified with up to 3% of dietary fibre from *Gracilaria edulis* and *S. wightii* gave better consumer acceptability.
- Incorporation of squilla protein hydrolysate significantly reduced the oil absorption and lipid oxidation in deep-fried fish cutlets.
- Crude visceral proteases extracted from little tuna (*Euthynnus affinis*) viscera was found to be effective as blood destainer.
- Bombay duck protein isolate was prepared from mince by isoelectric solubilization. Nutritional, physical and functional properties of isolate were determined and restructured products with good gel properties were prepared.
- Organochlorine pesticides like δ-BHC and endrin were detected at higher than prescribed levels in water of shrimp farms.
- Validation of cold-fill process of fish pickles was developed as per 21 CFR 114 USFDA regulation and cold holding period for five variety of commercial fish pickles were optimized.
- A multiple barrier process involving treatment with liquid smoke, modified atmosphere packaging followed by chilling was developed for preservation of fishery products.
- Based on complete inhibition of *Pseudomonas* and *Brochothrix thermosphacta*, gallic acid-grafted chitosan was found to be a potential additive in shelf life extension of fishery products.
- A multiple emulsion, using chitosan, whey protein isolate, green tea extract and Bay leaf essential oil was found to enhance the storage life of chilled tuna chunks.
- Application of high pressure (200 MPa and 400 MPa; holding time of 5 min.) could effectively eliminate the contaminating *E. coli* population in non-depurated clam (*Villorita cyprinoides*) to non-detectable levels.
- Simulation studies on enterotoxin production by *Staphylococcus* in sun-dried white sardine indicated initiation of enterotoxin production after 6 h of drying, when *S. aureus* level reached 10^8 cfu/g, water activity 0.968 and moisture content 54.79%.
- A prior dip in propionic acid at 1% level prevents formation of Staphylococcal enterotoxin during sun-drying.
- Maximum allowable phosphate uptake takes place in shrimp with 1.65% STPP treatment containing 0.15% salt, tissue to treatment solution ratio of 1:3 and soaking period of 7 h.
- A specific and sensitive HPLC-based standard operating procedure was developed for quantification of sodium benzoate in fresh fish.

- Incidence of Ciguatoxin was observed in *Lutjanus bohar* landed along south west coast of India.
- Pictorial guidelines for sensory grading of 33 varieties of finfish and shellfish species for export to EU was developed.
- *Salmonella* was prevalent in 41.1% of the 95 seafood samples collected from markets in and around Kochi.
- *V. cholerae* O1 Ogawa strains were isolated from well water of areas affected with cholera outbreak in Palakkad, Kerala.
- All MRSA isolates exhibited multi-drug resistance for three or more classes of antibiotics and 81.5% of the isolates of MRSA were enterotoxigenic.
- A new clone of MRSA, t15669-ST, was isolated from seafood, ice and water.
- Two Actinomycetes isolates out of 55 strains screened were found to have antibacterial activity against MRSA and identified as *Streptomyces* spp. and *Lysinibacillus* spp.
- Extensive genetic heterogeneity (55% to 100% similarity) was observed in *V. parahaemolyticus* isolated from marine fish by ERIC PCR.
- Thyme oil was found to inhibit amylase, caseinase, gelatinase and DNAse activity of *V. parahaemolyticus* and *V. cholerae* isolates at different concentrations.
- Bacteria from plastic dumping sites were able to reduce the weight of PVC by 43%.
- The LD_{50} value of 15 strains of *A. hydrophila* and nine strains each of *A. jandaei* and *A. veronii* isolated from farms with disease outbreak ranged between 10^2-10^3, 10^7 and 10^4-10^5, respectively in rohu fingerlings.
- Crude enzyme preparations of *P. elgii* was found to be effective as biocontrol agent for the control of fungal infestation in dried fish.
- Multiplex Polymerase Chain Reaction (PCR) assay was standardized for the genes encoding the resistance for ESBL producing Enterobacteriaceae in seafood and their antimicrobial resistance pattern in seafood was assessed.
- Fish oil rich in poly unsaturated fatty acid (PUFA) supplementation affect the mRNA and protein expression of enzymes of lipid metabolism. Mechanisms involved in the lipid lowering effect of PUFA-rich sardine oil were elucidated using RNA expression studies, western blotting and proteomic approaches.
- Thiamine-pyridoxine-vanillic acid-grafted chitosan showed stress mitigatory effect in stress-induced rats.
- Microencapsulation of squalene with maltodextrin and whey protein isolate gave an encapsulation efficiency of 96% and oxidative stability of more than four months. Anti-ulcerogenic effect of maltodextrin-encapsulated squalene was demonstrated.
- Chitosan–whey protein-encapsulated squalene was proved to be as good as gum Arabic for encapsulation of squalene. Cakes fortified with squalene microencapsulated with chitosan-whey protein complex had superior oxidative stability and textural quality.
- Developed a co-delivery system of betalain and PUFA by multiple emulsification and microencapsulation by spray drying.
- Supercritical fluid extraction of fucoxanthin and lipid from brown seaweed *Sargassum* sp. was attempted. Two seaweed-based products *viz*., Seaweed incorporated Juice-NutriDrink, and Seaweed-enriched fish soup powder were developed.
- Calcium and iron-fortified fish soup powder developed was tested among adolescent girls in West Jaintia Hills

District, Meghalaya. The intervention resulted in a rise in hemoglobin levels in 96% of the subjects involved.

- The moisture, protein and fat content of hepatopancreas of *Litopenaeus vannamei* were 32.00%, 23.75% and 41.88%, respectively. Oleic (31%) and linoleic (25%) were the predominant fatty acids while lysine (20%) and glutamic acid (16%) were the main amino acids.
- Absorption spectra of acetone extract of *Ulva lactuca* revealed two peaks at 425 nm and 660 nm corresponding to chlorophyll *a* and showed antibacterial activity towards *E. coli* and *V. cholerae*.
- DHA-fortified nutritional supplement was found in acceptable condition even after one year shelf life storage.
- Nutritional profiling of cage-farmed grouper fed with different feed fishes indicated *Decapterus russelli* as the best feed for enhancing meat quality.
- Performance evaluation study of ICAR-CIFT solar dryers was conducted for various fishes (mackerel, sardine, nandan and solefish).
- A multi-purpose (fish drying, water heating and electricity generation) solar thermal conversion system with biomass water heater backup was designed and fabrication work is in progress.
- Redesigning of the existing ICAR-CIFT solar-LPG hybrid dryer has been completed.
- Preliminary trials were conducted for the development of fish freshness sensor by measuring colour of fish eye, flesh, skin and gill over one week storage period, and corresponding TMA, TVN values of fish flesh were also measured.
- A new portable household electrical dryer of 10 kg capacity was designed and fabricated. Initial testing has been completed and the dryer can be used for household or micro scale drying of fish and fishery products with lower capital investment. Also, provision for supplemental heating by solar power was incorporated in the design.
- Economic input indicators of trawl fishery in Ernakulam showed that average operational cost during a fishing trip is: Operational costs including cost of diesel - ₹ 42,117.50, Engine oil - ₹ 525, Ice - ₹ 7000, Ration - ₹ 5000 and Repair and maintenance - ₹ 1000. The crew's share amounted to 40% of the owners' revenue. The trip-wise income from trawl fishing ranged from ₹ 17,750 to ₹ 70,800.
- Fish supply chain for three selected fish markets in Ernakulam revealed that the fish arrivals to these markets were from outside Kerala (Tamil Nadu, Andhra Pradesh, Odisha and Gujarat) besides local harbours and landing centres. The length of market chain is diverse ranging from 10 km to 60 km.
- The body mass index (BMI) status of the fisher respondents was compared using the WHO classification. The results showed that majority of adults were in the healthy weight group (64.71%). Among the respondents studied, 56% males and 73% females were falling in the healthy weight category. This also revealed that the gaps between healthy weight and obese were very narrow in males than in females.
- Fishermen perception on fishing capacity utilization at Puthiyappa, Kozhikode revealed that most important dimension is 'Increasing fishing pressure and cost'. It is followed by their concern about resource depletion and need for conservation. The same study at Kollam showed that the perception towards community participation in management was the most preferred among the five factors regulating the community resources, with a mean ranking score (MRS) of 4.83 followed by community sea rights (MRS-4.67) and *inter-intra* conflicts between different fish stakeholders with MRS of 4.60.
- The major impact indicators of Fishermen Co-operative Societies as perceived by the fishermen on various activities were compared for Kerala and Tamil Nadu. In Kerala activities undertaken by Fishermen Co-operative Societies had impacted on access to institutions (85.79%), production (76.70%), profit (73.26%), management (62.48%) and livelihood (52.91%). In Tamil Nadu, the figures were lesser in comparison to Kerala ranging from

53.82% for management to a low of 35.87% on livelihoods. The impacts were classified as high, moderate and low for various parameters.

- The inter-temporal energy consumption of seafood processing units showed a fluctuating trend over the period of 2009–2017. The average estimated monthly energy consumption and the cost was 127987.30 Kwh units and ₹ 7,93,869.20, respectively. Short term energy forecasting of seafood processing plants was estimated using ARIMA (0,0,0) which showed a significant estimated value and standard deviation of 0.073.
- Completed documentation of all the S&T outputs of ICAR-CIFT (768 technologies), including all new/improved technology products and processes consultancies and policy inputs. Assessed the technology transfer status of technologies and 43 were selected for impact assessment.
- Studied the modes of technology transfer of each of the S&T outputs for the past 20 years and categories were made. Completed profiling of technologies, based on their expected impact in field, mode of dissemination, intended beneficiary and nature of technology.
- Indicators of three types, technological, economic and social are finalized for assessing the impact of S&T outputs separately based on information gathered from concerned scientists and secondary information for developing impact assessment tool.
- Assessment tools are prepared separately for different categories of S&T outputs.

ICAR-Central Institute of Fisheries Technology

The ICAR-Central Institute of Fisheries Technology (named at the time of inception as Central Fisheries Technology Research Station) was set-up following the recommendation of a high power committee constituted by the Ministry of Food and Agriculture, Government of India. It started functioning at Kochi on 29th April, 1957 under the Department of Agriculture of the then Ministry of Food and Agriculture with a small nucleus of staff for research work in fishing craft and gear. Other Divisions soon followed. The administrative control of the Institute was brought under the Indian Council of Agricultural Research on 1 October, 1967.

Vision

To facilitate sustainable harvesting and total utilization of fishery resources through innovations in harvest and post harvest technologies.

Overview

The Institute is the only national centre in the country where research in all disciplines relating to fishing and fish processing is undertaken. Research Centres function at Visakhapatnam (Andhra Pradesh), Veraval (Gujarat) and Mumbai (Maharashtra).

Mission

Ensure responsible harvesting of fishery resources through eco-friendly, energy efficient and economical means; ensure total utilization of the harvested fish through appropriate processing, value addition, packaging and waste utilization; ensure food safety and nutritional security to the consumer and minimize carbon and water foot print per unit volume; and to ensure equitable benefits to the stakeholders, across the value chain.

Mandate

- Basic and strategic research in fishing and processing
- Design and develop energy efficient fishing systems for responsible fishing and sustainable management
- Development of implements and machinery for fishing and fish processing
- Human resource development through training, education and extension

Budget allocation and expenditure

(For the year 2016-2017 – All values in INR in Lakhs)

Particulars	Non-Plan		Plan	
Budget Head	**Allocation**	**Expenditure**	**Allocation**	**Expenditure**
Establishment charges	2340.00	2339.73	-	-
Overtime allowances	0.50	0.36	-	-
Traveling allowances	17.00	17.00	35.00	35.00
Works	-	-	225.00	225.00
Other charges (Equipments)	12.00	12.00	89.50	89.50
Other charges (Contingency)	303.50	303.48	480.00	480.00
Furniture and fixtures	2.00	1.95	13.50	13.50
Library	2.00	2.00	4.00	4.00
Information Technology	-	-	18.00	18.00
Pension and Retirement Benefits	190.00	189.93	-	-
Loans and Advances	15.00	5.69	-	-
NEH Programme	-	-	20.00	20.00
Tribal Sub Plan	-	-	1.50	1.50
Total	**2882.00**	**2872.14**	**886.50**	**886.50**

Staff position as on 31 March, 2017

Category	Sanctioned	Filled
RMP/Director	1	1
Scientific	95	81
Technical	127	94
Administrative	81	55
Supporting	63	38
Auxiliary	5	3
Total	**372**	**272**

ICAR-CIFT

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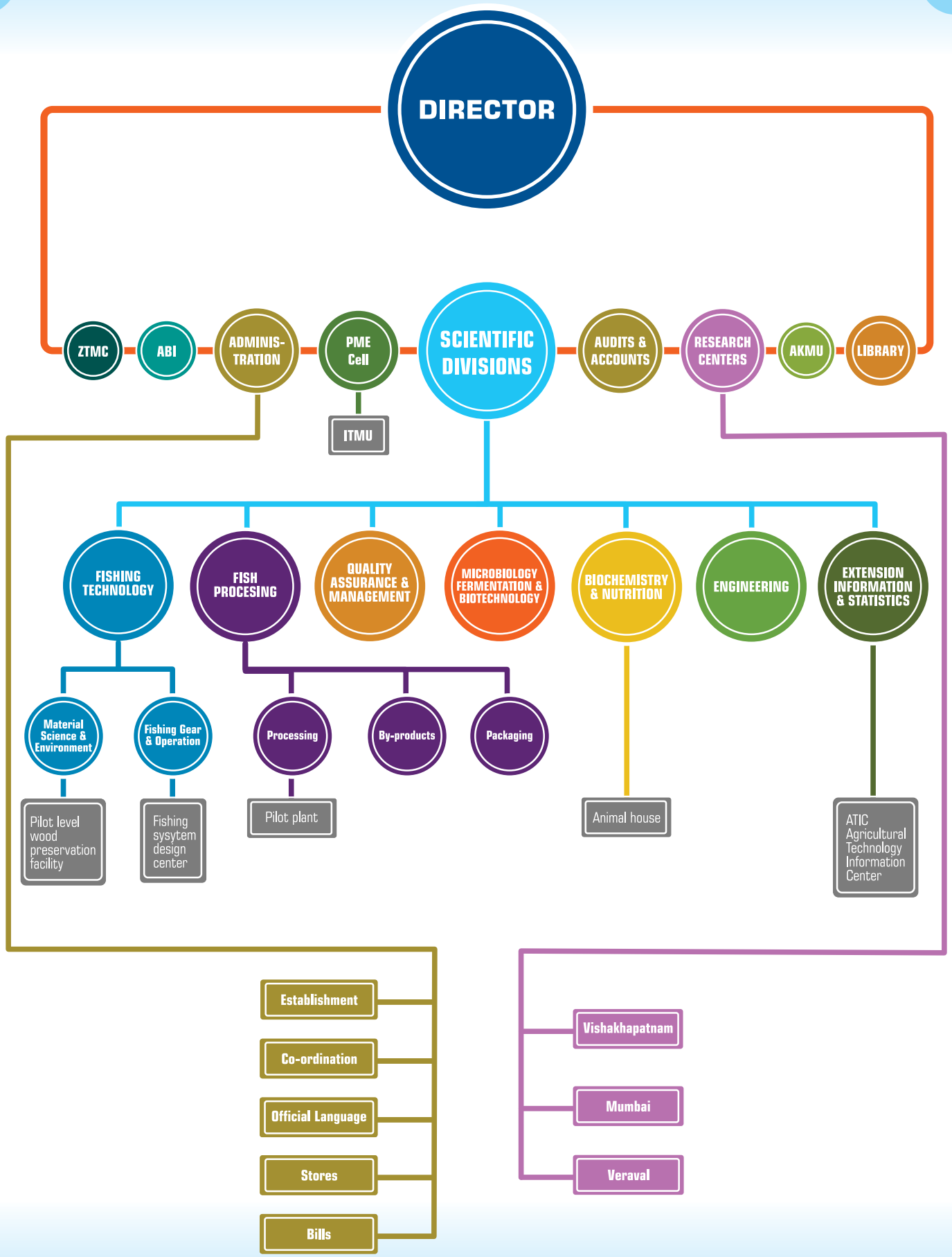
DIRECTOR
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ABI
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FISH PROCESING
QUALITY ASSURANCE & MANAGEMENT
MICROBIOLOGY FERMENTATION & BIOTECHNOLOGY
BIOCHEMISTRY & NUTRITION
ENGINEERING
EXTENSION INFORMATION & STATISTICS
Material Science & Environment
Fishing Gear & Operation
Processing
By-products
Packaging
Pilot level wood preservation facility
Fishing sysytem design center
Pilot plant
Animal house
ATIC Agricultural Technology Information Center
Establishment
Co-ordination
Official Language
Stores
Bills
Vishakhapatnam
Mumbai
Veraval

RESEARCH ACHIEVEMENTS

FISHING TECHNOLOGY

Research projects handled

Institute projects

- Service life enhancement of fishing materials through application of nano particles and its impact on environment
- Design development and standardization deep sea fishing vessel and gear systems for commercial operation
- Investigations on fish behavior and responsible fishing systems

Externally funded projects

- Green fishing systems for tropical seas
- Studies on the ecological linkages between plankton production and *Acetes* sp. abundance along Veraval coast, Gujarat
- Demonstration and field testing of bycatch reduction and juvenile excluder devices along Sindhudurg District, Maharashtra
- Assessment of food loss from selected gillnet and trammel net fisheries of India
- Retrieval of phytoplankton biomass and associated optical constituents based on long term bio-optical studies

Most significant achievements

- 'Sagar Harita', a 19.75 m energy efficient green fishing vessel designed by ICAR-CIFT was commissioned.
- The catch efficiency of a modified trap with dimensions of 1×0.6×0.6 m was determined as 1.05 kg and 1.02 kg, respectively for crabs and Pearlspot (*Etroplus suratensis*).
- Multi-seam trawl caught significantly higher catches with a CPUE of 40 kg/h compared to the two seam trawl (23 kg/h) operated along Visakhapatnam coast.
- Rainbow sardines and lesser sardines together constituting 80% were the major species that escaped from the 60 mm square mesh panels attached to 30 m off-bottom trawl operated along Visakhapatnam coast.
- The L_{50} value for *Johnius dussumieri* in 40 mm diamond mesh codend was 7.51 cm and the selection range was 3.4 cm (6.70 cm - 8.45 cm).
- The L_{50} values for *Parapenaeopsis stylifera* were 95 and 105 mm, respectively in the 22 and 25 mm spacing squilla exclusion grids. The L_{50} values for *Metapenaeus monoceros* were 113, 128 and 129 mm, respectively for 22, 25 and 30 mm spacing.
- Comparative analysis of the use of diamond and square mesh codends along Sindhudurg coast showed that the mean length of 12 out of the 15 commercially important species increased by 7.85%. The rate of escapement from the square mesh codends was 0.76 kg per hour, which is 3.9% of the total catch retained (2142.4 kg).
- Surface modification of boat building steel was done using nano iron oxide, titanium oxide, cerium oxide mixtures in different combinations. The results showed that the combination of 0.005:0.01:0.005% of Fe_2O_3:CeO_2:TiO_2 has good corrosion resistance property.
- The boat building steel surface was modified with nano zinc oxide, titanium oxide, cerium oxide in varied concentrations and the results showed that the ratio of 0.01:0.01:0.005% Fe_2O_3:CeO_2:TiO_2 has excellent corrosion resistance.
- HDPE aquaculture cagenet surface was modified using: 1) Polyaniline and nano copper oxide, 2) Polyaniline nano copper oxide, titanium dioxide, and 3) Polyaniline, zinc oxide, titanium oxide, copper oxide mixtures. All the

three treatments exhibited excellent biofouling resistance even after 90 days of exposure in the estuary.

- CDOM source in the coastal waters during monsoon was from the estuary and during post-monsoon, the main source of CDOM was the decomposed organic matter of coastal origin.
- Designed a four equal panel 30 m semi pelagic trawl for capture of off bottom fish and 28 m four seam for specifically targeting anchovies.
- High catches of yellowfin tuna were recorded in the areas where Monthly Mean Mixed Layer Depth (MMMLD) ranged between 35 m to 47 m. Hooking rate studies of long line catches suggests that the best fishing season for yellowfin tuna is between December to February in east coast of India.

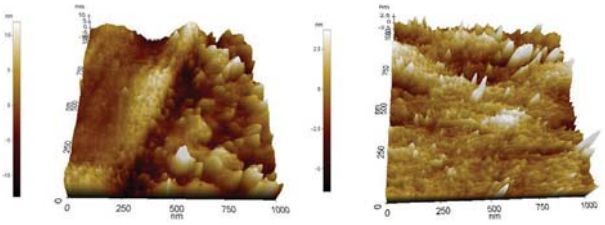
Chief findings

Institute projects

Service life enhancement of fishing materials through application of nano particles and its impact on environment

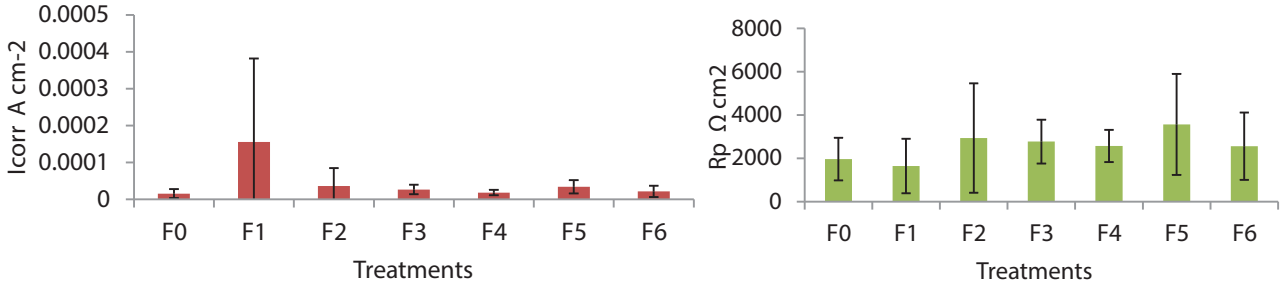
Corrosion resistant nano iron, titanium and cerium oxide coating over boat building steel

Boat building steel coated with nano iron oxide, titanium oxide and cerium oxide exhibited excellent potential for resistance against corrosion. The corrosion potential E_{corr}, corrosion current density I_{corr}, and polarization resistance R_p ranged from -0.753 ± 0.065 to -0.613 ± 0.030 V, 1.83×10^{-5} ± 7.5×10^{-6} to 4.55×10^{-5} ± 3.55×10^{-5} Acm^{-2} and 1417 ± 980 to 3570 ± 2334 Ω cm^2, respectively. The optimum ratio with maximum efficiency was 0.005:0.01:0.005 of Fe_2O_3, CeO_2 and TiO_2. R_p in the high frequency (HF) and low frequency (LF) regions ranged from 10.19 ± 2.30 to 93.08 ± 44.94 Ω cm^2 and 1.13 ± 0.09 to 377.05 ± 152.41 Ω cm^2, respectively. The CPE in the HF and LF regions ranged from 1.06×10^{-8} ± 5.26×10^{-11} to 4.30×10^{-8} ± 1.00×10^{-8} F and 1.98×10^{-4} ± 7.32×10^{-5} to 7.1×10^{-3} ± 7.4×10^{-4} F, respectively.



Untreated Nano Fe TiO_2 CeO_2 treated

Atomic Force Micrographs of untreated and nano Fe_2O_3, TiO_2 and CeO_2 treated steel

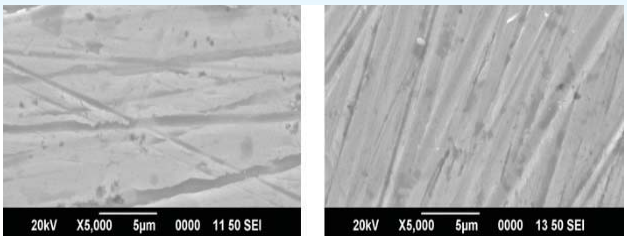


Corrosion current density and polarization resistance of nano Fe_2O_3, TiO_2 and CeO_2 treated steel

Corrosion resistant nano zinc, titanium and cerium oxide coating over boat building steel

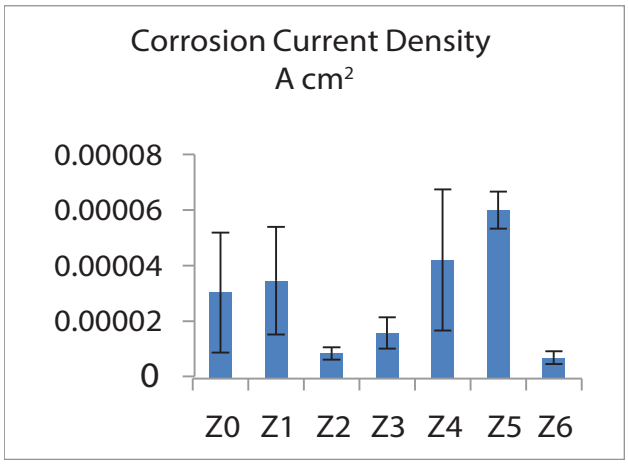
Boat building steel coated with varied concentrations of nano zinc oxide, cerium oxide and titanium oxide (ZTC) mixtures showed improved surface characteristics. Corrosion potential, corrosion current density and polarization resistance varied from -0.861± 0.068 to -0.643±0.035 V, 7.49×10^{-6} ± 2.27×10^{-6} Acm^{-2} and 1033±606 to 5038±823 Ω cm^2, respectively. Highest polarization resistance and lowest corrosion current density were exhibited by the treatment with 0.01% each of zinc oxide, cerium oxide and 0.005% titanium oxide. Higher corrosion resistance of Z6 indicated

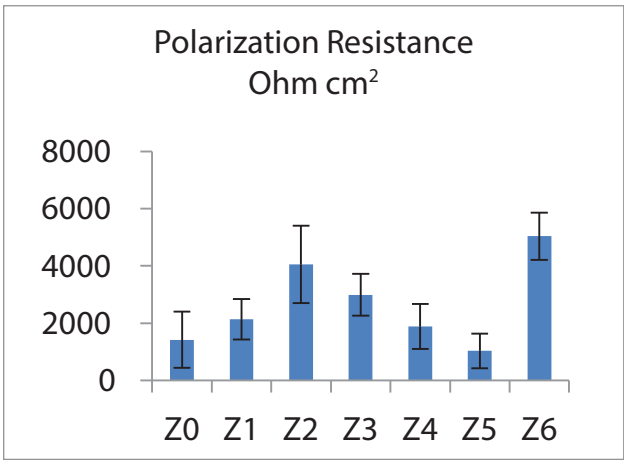
improved porosity, better coverage and uniform coating over the boat building steel. Nano zinc and cerium oxide coating over the boat steel improved R^p and I_{corr} values. Variable concentrations of the three oxides enhanced corrosion resistance than equal concentrations of ZTC.



Z0 Z6

SEM images of control and ZTC treated boat building steel

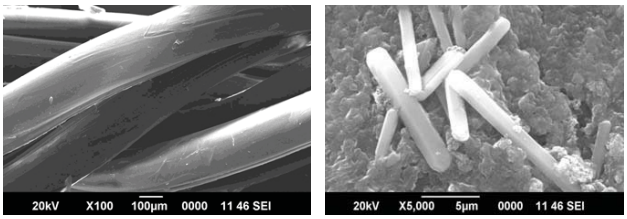




Linear polarization data of ZTC treated boat building steel

Surface modification of polyethylene nettings

A conductive coating of polyaniline (PANI) was synthesized over polyethylene webbing. The uniform coating was found to be very stable even after repeated agitations. The PANI coating is a potential substitute for loading biocides that can resist fouling in polyethylene webbing material.

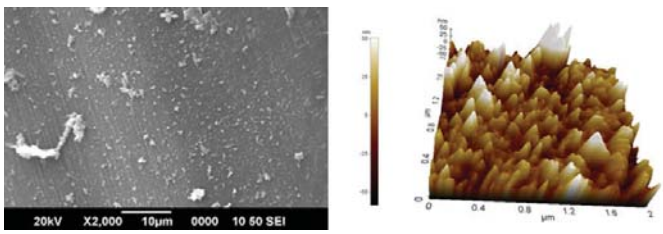


Control PANI treated

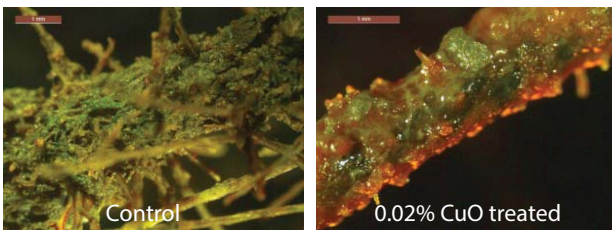
SEM images of control and PANI treated webbing

Antifouling property of nano copper oxide treated and polyaniline treated PE

A polyaniline copper oxide composite was synthesized *in situ* over polyethylene webbing used for cages which showed uniform and stable coating. The nets were exposed in the estuary and even after three months exposure, the fouling in the treated nets were significantly lower than the control.



SEM and AFM micrographs of 0.02% nano CuO-treated PE-PANI webbing

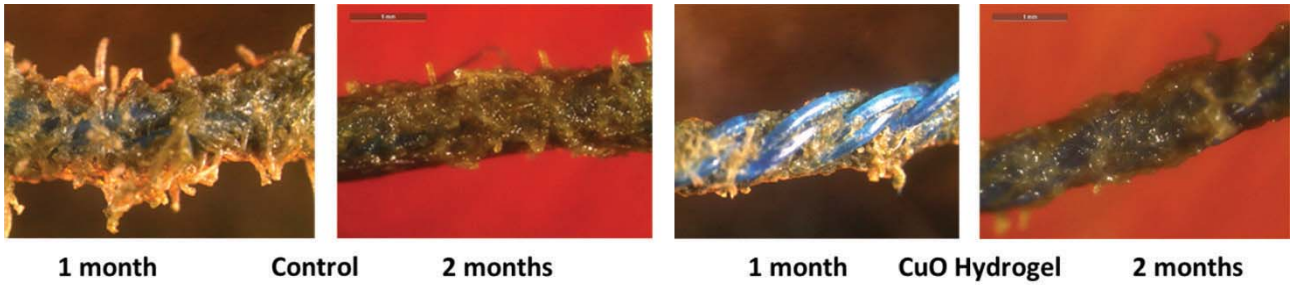


Fouling accumulation in 0.02% nano CuO loaded PE-PANI webbing after 60 days

Nano copper oxide-incorporated hydrogel coating over PE-PANI

Nano copper oxide-incorporated hydrogel was synthesized *in situ* over polyaniline surface modified polyethylene

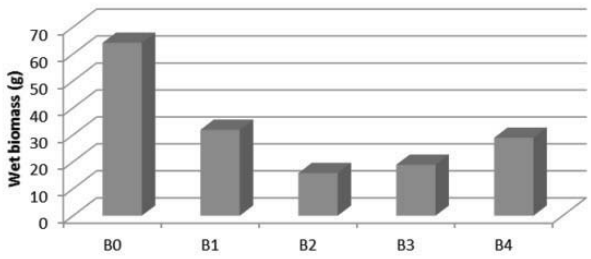
which showed good adherence of the hydrogel over PE-PANI surface as confirmed by FTIR analysis. Field evaluation showed excellent fouling resistance of treated polyethylene nettings compared to control.



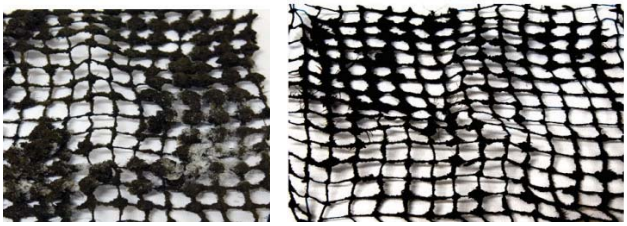
Biofouling accumulation in control and nano CuO- incorporated hydrogel treated PE-PANI webbing after two months exposure in the estuary

PE-PANI coated with nano CuO and TiO_2 for fouling resistance

Polyaniline coated polyethylene webbings were loaded with biocides of nano copper oxide and titanium oxide in varying concentrations. Ninety days evaluation of the estuary exposed samples showed lower fouling density. The fouling resistance was 55-80% less than untreated webbings.



Wet fouling biomass (g) on PE netting after 90 days of exposure in the estuary



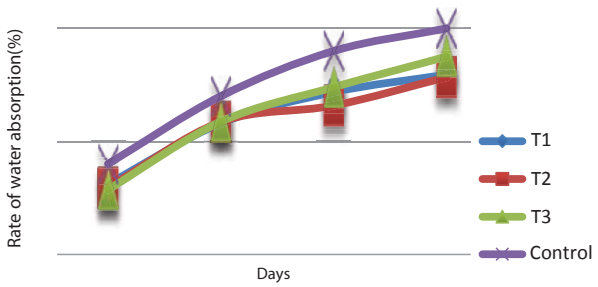
Control - Untretated

Nano CuO-TiO_2 loaded

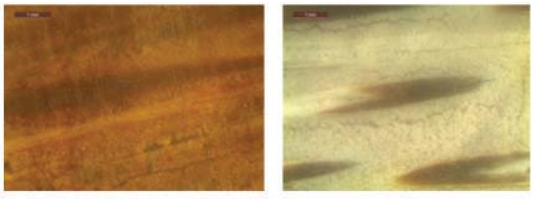
Biofouling accumulation on control and nano CuO-TiO_2 treated PE netting after 90 days exposure in the estuary

Dimensional stability of coconut wood panels treated with nano materials

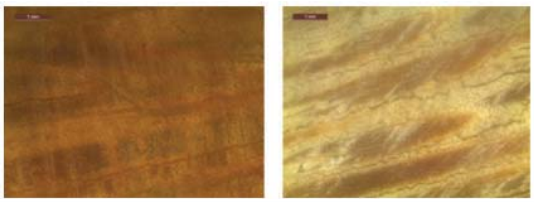
Dimensional stability of treated and untreated coconut wood was studied by water soaking method. Significant reduction in water absorption was noticed in the treated panels. The study revealed that nano CuO and TiO_2 treatment increased the Anti-Swell Efficiency (ASE) and Water Repellent Effectiveness (WRE) of coconut wood samples compared to the control untreated wood.



Rate of water absorption in nano TiO_2 treated coconut wood panels



Untreated



Nano material treated

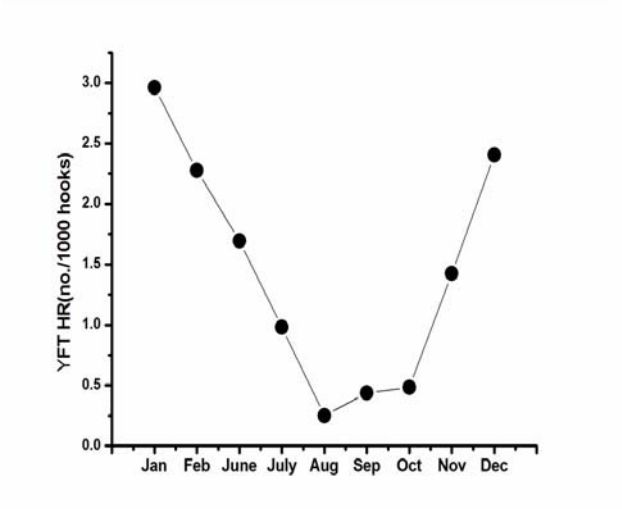
Coconut wood panels - Exposed and Unexposed

Design development and standardization of deep sea fishing vessel and gear systems for commercial operation

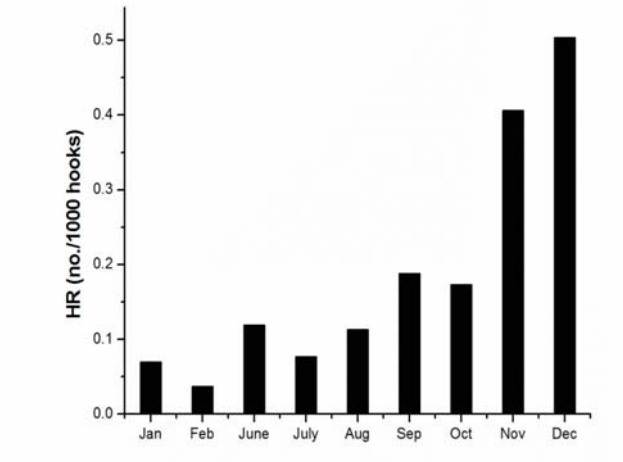
Design of 24.0 m L_{OA} long liner cum gillnetter

The preliminary design of a 24.0 m L_{OA} long liner cum gillnetter for deep sea commercial fishing operations was developed. The design includes a hydraulic long line trawler, setter and gillnet hauler and berthing facility for six crew. The hull form was analyzed using CFD software and the preliminary stability check was carried out using Maxsurf software.

A survey was conducted at Visakhapatnam among the tuna long liners to collect the preliminary details on the operational parameters, hooking rate and catch characteristics. Hooking rate of yellowfin tuna (*Thunnus albacares*) was highest (2.96/1000 hooks) in the month of January, followed by December (2.40/1000 hooks) and February (2.27/1000 hooks). High hooking rates of sailfish was maximum during September to December along the east coast.



Monthly distribution of overall long line catch



Monthly distribution of sailfish

Field trials of experimental deep sea gillnets

Field trials of new experimental gillnets of 140 mm mesh size made of 210×9×3 twine and hung at three different hanging coefficients of 0.4, 0.5 and 0.6 were conducted onboard FV Sagar Harita. CPUE were 7.06 kg/1000 sq. m of net; or 3.61 kg/h of soaking. The major species were *Scomberomorus gattatus*, *Sphyraena jello*, *Caranx* sp., *Parasromateus niger*, *Istiophorus platypterus*, *Rachycentron canadum*, *Mahi mahi*, *Rastrelliger kanagurta*, *Acanthocybium solendri*, *Megalaspis cordyla* and *Pampus chinensis*.

Comparison of catch and catching process with reference to different hanging coefficients showed that nets hung at E_1 = 0.5 contributed 58.5% of the total catch while having ratios of 0.4 and 0.6 had 28.8 and 12.7% of the catch, respectively. Wedging was the main mode of capture, followed by entangling and gilling.

Carbon foot print estimation of deep sea liners and gillnetters and GIS-based spatial data of deep sea gillnetters and long liners

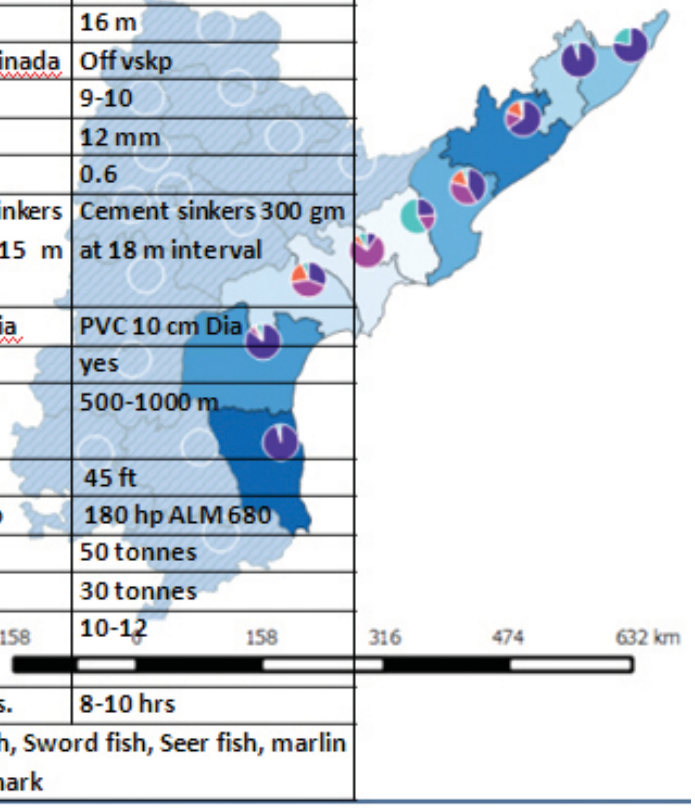
Carbon dioxide emissions of deep sea long liners and gillnetters with 15 m L_{OA} powered with Sonata 200 h.p. engine operating off Visakhapatnam was calculated. Carbon dioxide emitted for capture of one kilogram of fish in deep sea long liners and gillnets were 1.048-1.700 and 1.122-1.400 kg CO_2, respectively. A 15 m L_{OA} vessel, fitted with a 200 h.p. Sonata engine was needed for the analysis. Carbon dioxide emissions were calculated from vessels from deep sea long liners and gillnetters with 15 L_{OA} powered with Sonata 200 h.p. engine operating off Visakhapatnam**.** During

gillnetting the average fuel consumption was about (2000 L/voyage of 9-10 days) with 5000 kg of catch. During long lining the average fuel consumption was about (3000 L/voyage of 9-10 days) with 7000 kg of catch. During gillnetting, 1.04-1.70 kg CO_2 was emitted per kilogram of fish and in long lining 1.12-1.50 kg CO_2 was emitted per kilogram of fish caught.

GIS data base of deep sea gillnetters of Andhra Pradesh

Design configurations of deep sea gillnets used in Visakhapatnam and Kakinada were documented on a RDGMS platform and linked to QGIS with parameters like craft specifications, area of operation, port of registry, gear specifications, species diversity, area and abundance.

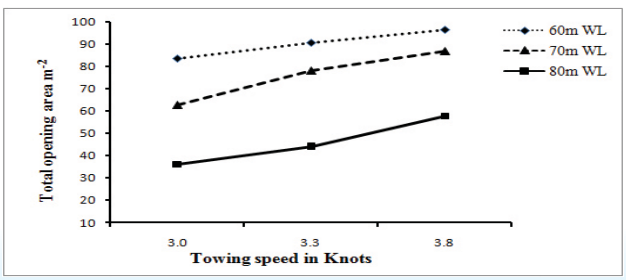
Parameters	Motorised deep sea gillnetters of Kakinada	Mechanised deep sea gillneters of Visakhapatnam
Mesh size	140 mm	160 mm
Net length	5000 m	8000 m
Depth of net	14 m	16 m
Area of operation	From off kakinada	Off vskp
Fleet no	1500	9-10
Head rope	10 mm	12 mm
Hanging ratio	0.6	0.6
Sinkers	Cement sinkers 300 gm at 15 m interval	Cement sinkers 300 gm at 18 m interval
Floats	PVC 10 cm Dia	PVC 10 cm Dia
Gillnet winch	no	yes
Depth of operation	500-1000 m	500-1000 m
Length of boat	30 – 35 ft	45 ft
Power of engine	20hp – 28 hp	180 hp ALM 680
Fish hold capacity	4 tonnes	50 tonnes
Ice	3 tonne	30 tonnes
Number of fishing days	4-5 days)	10-12
Soaking time	8 – 10 hrs hrs.	8-10 hrs
Targeted species	Tuna, Sail fish, Sword fish, Seer fish, marlin yellow fin Shark	



Thematic maps generated using data base

Investigations on fish behavior and responsible fishing systems

The gear geometry of 27 m off-bottom trawl system (OBTS) rigged with 65 kg Suberkrub otter boards were worked out. The maximum total area of opening was recorded for 60 m warp length at a towing speed of 3.8 k (96.58 m^{-2}), while the lowest was recorded when 80 m warp length was used at 3.0 knots (36.27 m^{-2}).

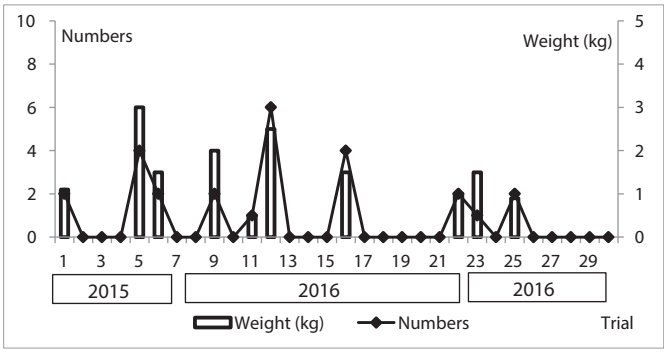


Variation in the total opening of OBTS trawl with varying speed

Experimental trials using modified collapsible traps

A modified trap with dimensions of 1×0.6×0.6 m for Pearlspot (*Etroplus suratensis*) fishery along the backwaters of Kerala was developed and field tested. Experimental trials were conducted along backwaters of Vypin Island. *Etroplus suratensis* and *Scylla serrata* formed the major catch. The catch efficiency was three crabs/operation and six fish/ operation in term of number and 1.05 kg and 1.02 kg in terms of weight, respectively for crabs and fish. The success rate for capture of fish in the modified collapsible traps was 33% (10/30 trials) when field tested along Zuari estuary and adjacent coastal regions. The average catch was 0.5 kg/trial and the major species caught were red snapper, spotted grouper and goldsilk sea bream.

Modified collapsible trap for capture of Pearlspot



Variation in the catch details observed in collapsible traps operated along Zuari estuary

Collapsible trap with dimensions of 1.5 x 0.8 m x 0.8 m with two entrance funnels made of polymer mesh were field tested at Malvan, Maharashtra. Fishes caught were *Epinephelus cholorostigma* (68%, Length 36.5-42.3 cm), *Lutjanus rivulatus* (17.5%, Length 17-22 cm) and *Charybdis feriatus* (14.5%).

Field trials of collapsible fish traps at Malvan

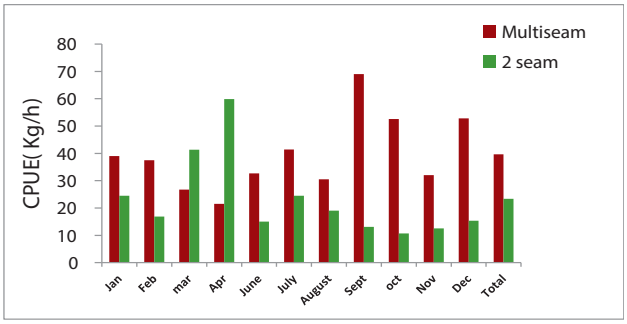
Foldable traps fabricated with three types of entrances with varying shapes were field tested at Raiwada reservoir, Visakhapatnam District of Andhra Pradesh. Circular shaped entrance made with 15 mm HDPE mesh yielded maximum

Foldable fish traps being operated at Raiwada reservoir

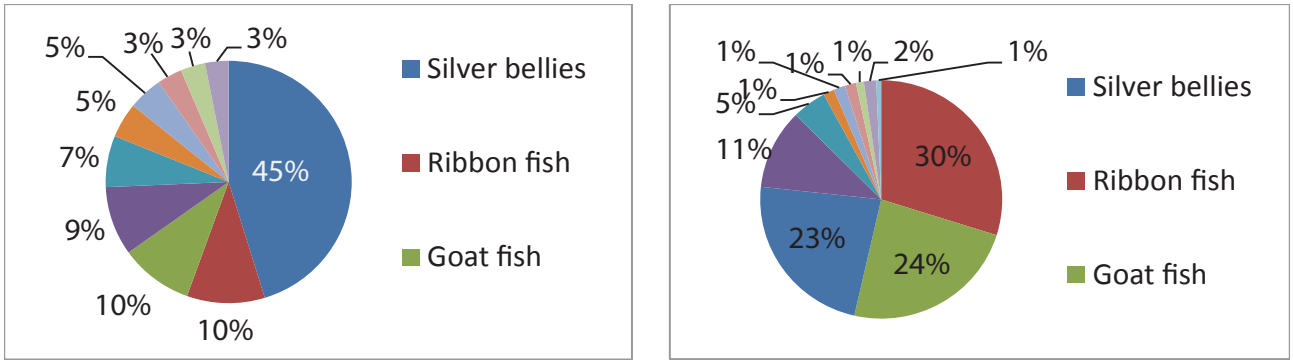
prawn catch compared to V and oval shaped entrances made with split bamboo. The catch rate per foldable trap was 0.25 kg to 0.75 kg compared to the 0.10 kg-0.25 kg catch by traditional traps. The composition of catches in the foldable trap were as follows: *Macrobrachium rosenbergii* (70%), *Channa gachua* (10%), *Mystus* sp. (10%), *Glossogobius giuris* (5%) and *Sciaena* spp. (5%).

Studies on multi-seam trawl

A multi-seam trawl was designed and catch characteristics were compared with conventional two seam commercial trawl at Visakhapatnam. The total catch landed by the multi seam trawl in 179 hours of operation was 7091 kg at an average CPUE of 40 kg/h. The two seam trawl yielded a total catch of 4181 kg/h in 179 hrs at a CPUE of 23 kg/h.



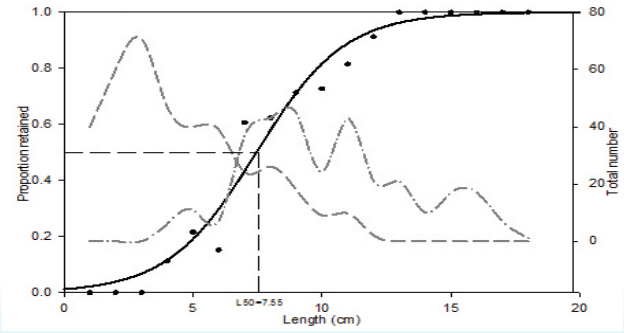
Monthly variation in the CPUE of the multi-seam and 2-seam trawls



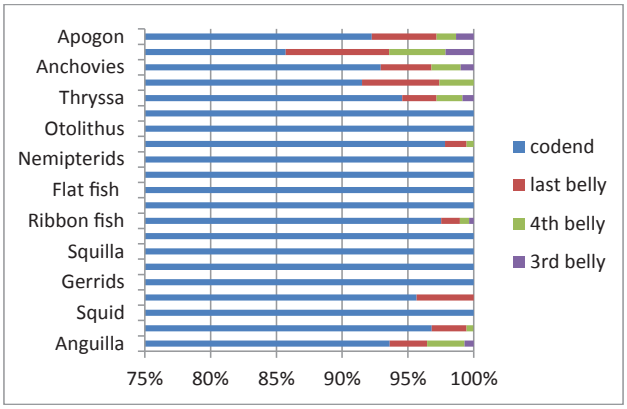
Catch composition in 2-seam trawl and multi-seam trawl

Selectivity studies

Whole trawl selectivity data of a 30 m off-bottom trawl, fitted with 60 mm square mesh test panels in the upper panel of each belly (three nos.) and covered with 15 mm nylon pockets were analyzed. The fish that escaped from the first test panels were rainbow sardines and lesser sardines (80%), silver bellies (15%) and ribbonfish (5%). Sardines (95%) and silver bellies (5%) were the species that escaped from second test panel. There was no escapement from the last panel (near to the wing of the trawl).



Selection curve of *J. dussumieri* in 40 mm diamond mesh codend



Fish escapement and retention (%) from different panels

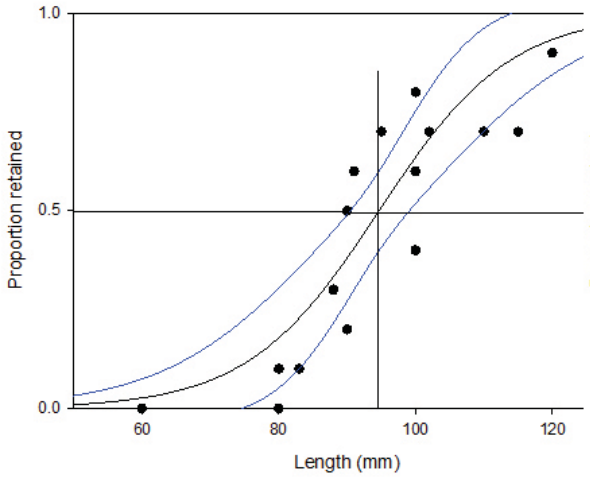
Trawl codend selection parameters for 40 mm diamond mesh codend for *Johnius dussumieri* was derived using multi-haul approach. The mean selection curve was derived after considering multiple hauls (eight hauls) in which the species was encountered. The L_{50} value was computed as 7.51 cm and the selection range for the codend for this species was 3.4 cm (6.70 cm - 8.45 cm).

The L_{25}, L_{50} and L_{75} values for *Stolephorus indicus* for 30 mm square mesh codend were 9.3, 11.7 and 11.8,

respectively. The α and β values were 10.6 and 0.9, respectively. Selection range and selection factor for the species were derived as 2.4 and 3.9, respectively.

Field trials (13 nos.) were carried out using 27 m bottom trawl rigged with squilla BRD grid (22 mm spacing). Catch of 90 kg was recorded with an average CPUE of 5.75 kg/h. The average CPUE in the upper and lower codends were 3.88 kg/h and 1.76 kg/h, respectively. The catch in the upper codend was dominated by *Alepes kleinii* (34.06%), *Ambassis commersoni* (15.01%), *Parastromateus niger* (7.65%), *Metapenaeus dobsoni* (4.72%), *Scomberomorus commerson* (3.99%) and *Thryssa mystax* (3.77%). *Thryssa* sp. (29.6%), *A. kleinii* (15.33%), *S. commerson* (11.05%), *A. commersoni* (9.27%) and *M. dobsoni* (8.56%) were the dominant species retained in lower codend. The catches of shrimps were 2.13 and 2.40 kg in the upper and the lower codends ,respectively.

In situ experiments were carried out to find the exclusion characteristics of shrimps from the newly designed squilla BRD. The L_{50} values for the grids with 22, 25 and 30 mm openings were worked out for *Parapenaeopsis stylifera* and *Metapenaeus monoceros*. The L_{50} values for *P. stylifera* were 95 and 105 mm, respectively in the 22 and 25 mm spacing grids. The L_{50} values for *M. monoceros* were 113, 128 and 129 mm, respectively for the 22, 25 and 30 mm spacing.



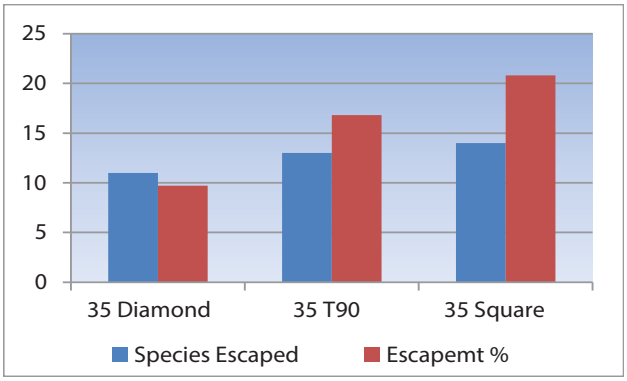
Selection curve of *P. stylifera* in 22 mm grids

Designing of 30 m four seam box trawl

Catch obtained by equal panel trawl in fishing operations on CIFTECH1 vessel was analyzed. The CPUE recorded was 38 kg/h[1]. The catch comprised of silver bellies - 17%, *Pomadasys maculates* -10%, lizard fish - 7%, *Pellona* spp. - 7%, Ribbonfish - 6%, *Upeneus* spp. - 6%, *Nemipterus* spp. - 5%, mackerel - 5%, cuttlefish - 4%, squid - 4%, *Thryssa* spp., *Strongylura crocodiles,* red snapper and Barakuda - 3% each, Sciaenids - 2% and Carangids - 2% .

Codend selectivity studies

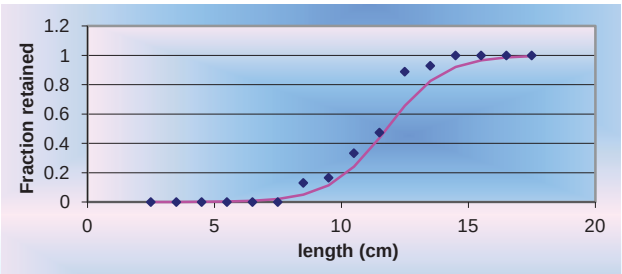
Trawl codend selectivity of 35 mm diamond, square and T-90 codends were estimated. Overall catch excluded was 9.7 and 16.8% of the total catch for 35 mm diamond mesh codend and T-90 codend operation, respectively. The escapements of juveniles are more in 35 mm square mesh codend than T-90 and diamond shaped codends.



Escapement of species from 35 m diamond, square and T90 codends

Selectivity studies

The L_{25}, L_{50} and L_{75} values for *Lactarius lactarius* in 40 mm square mesh codend was 14.9, 13.1 and 16.8, respectively. The α and β values were 8.9 and 0.5, respectively. Selection range and selection factor for *L. lactarius* were 3.68 and 3.73. The L_{25}, L_{50} and L_{75} values for *Stolephorus indicus* in 30 mm square mesh codend was 11.7, 9.3 and 11.8, respectively. The α and β values were 10.6 and 0.9, respectively. Selection range and selection factor for *S. indicus* were 2.4 and 3.9, respectively.



Selectivity curve of *Stolephorus indicus*

INGREDIENTS
Milk, Sugar, Rice Flakes

★Palada Pradhaman★

പാലട പ്രഥമൻ

കേരളീയർക്ക് ഏറ്റവും
പ്രിയപ്പെട്ടതാണല്ലോ പാലട പ്രഥമൻ.
ചേരുവകൾ കൃത്യമായി ചേർത്ത്
ഒപ്പം വിനായകയുടെ കൈപുണ്യവും
ചേർന്നതാണ് പായസത്തിൽ പ്രഥമൻ.

READY TO EAT

FISH PROCESSING

Research projects handled

Institute projects

- Development of standard processes and protocols for innovative products from aquatic resources, shelf life modeling and assessment of energy use
- Development of high value byproducts from fish and shellfish processing discards
- Innovative product development for value addition, nutrient fortification and shelf life extension of farmed and wild freshwater and marine fish
- Assessing environmental aspects of fish, fishery products and effects of chemical hazards

Externally funded project

- Development of bioplastic based sustainable nano biocomposite food packaging: 'Sustain NanoPack'

Most significant achievements

- Batter formulations with carboxy methyl cellulose and hydroxy propyl methyl cellulose significantly reduced the oil uptake in deep fried fish fingers.
- Processing conditions for preparing brown seaweed (*Sargassum wightii*)-incorporated extruded snack was optimized.
- Fish-based nutrition bar with shelf life of three months in normal conditions was developed.
- Functional fish sausages with enhanced omega-3 fatty acid content were developed.
- Optimized thermal process conditions for ready to eat ethnic products in different containers.
- Pilot scale production of water-soluble chitosan was optimized and its properties were characterized.
- Developed osmo-dehydration protocol for drying small sized shrimp.
- Pangasius fish sausage fortified with up to 3% of dietary fibre from *Gracilaria edulis* and *S. wightii* gave better consumer acceptability.
- Incorporation of squilla protein hydrolysate significantly reduced the oil absorption and lipid oxidation in deep-fried fish cutlets.
- Crude visceral proteases extracted from little tuna (*Euthynnus affinis*) viscera was found to be effective as blood destainer.
- Bombay duck protein isolate was prepared from mince by isoelectric solubilization. Nutritional, physical and functional properties of isolate were determined and restructured products with good gel properties were prepared.

Chief findings

Institute projects

Development of standard processes and protocols for innovative products from aquatic resources, shelf life modeling and assessment of energy use

Modification of ingredients in batter system and development of coated fish and shellfish products

The effectiveness of hydrocolloids as a batter ingredient on the functionality of batter coating systems was studied. Six hydrocolloids *viz*., guar gum, carboxy methyl cellulose, water soluble chitosan, methyl cellulose, hydroxy propyl

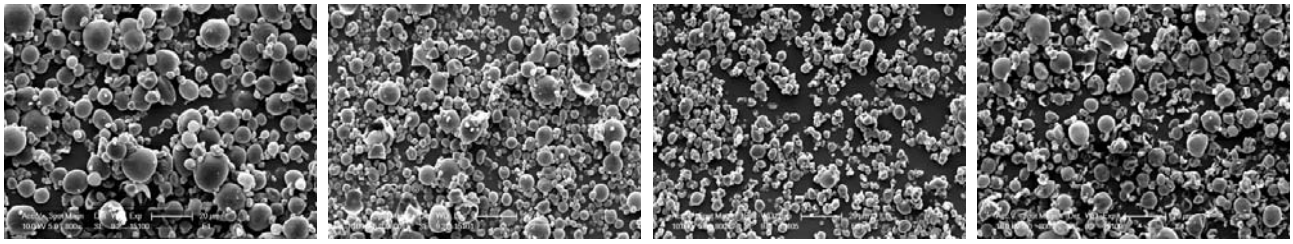
methyl cellulose and xanthan gum were used to prepare standard leavened and unleavened batter formulations. Oil uptake was minimum in xanthan gum-based leavened formulations (12%) in pre-fried samples and in coagulated samples. Batter formulations with carboxy methyl cellulose and hydroxy propyl methyl cellulose significantly reduced the oil uptake in deep fried fish fingers. Both conventional fried and microwave fried crusts increased the redness (a*) and yellowness (b*) values than pre-fried crusts. There was no significant difference in b* values between conventional fried and microwave fried crusts.

Application of fish protein hydrolysate as an ingredient in foods

Antioxidant activity of tuna fish protein hydrolysate (FPH) in food was evaluated. Tuna protein from red meat of yellow-fin tuna hydrolysed using papain under RSM optimized hydrolytic conditions (0.34% E/S, 30 min. and 60 °C) was used. Different FPH fortified mayonnaise was prepared by partial replacement of egg yolk. Based on initial accelerated storage studies and sensory evaluation, a combination (FPH fortified mayonnaise: 5% TPH and 10% egg yolk) and control (15 % egg yolk alone) was used for final storage studies at chilled condition (4 °C). Incorporation of TPH in mayonnaise increased the protein content and decreased the fat in mayonnaise. Further during storage, the oxidation reduced in TPH-fortified mayonnaise.

Evaluation of antioxidant activity of tuna protein hydrolysate

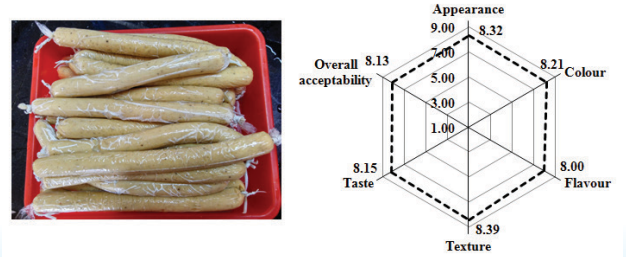
Tuna protein from red meat of yellowfin tuna hydrolysed using papain under RSM optimized hydrolytic conditions was used both as wall material and core material in different combinations for encapsulation of fish oil. Encapsulates were prepared in different combinations with 5:1 wall:core material ratio. Incorporation of tuna protein hydrolysate (TPH) in oil encapsulate as core material along with fish oil was found effective as it gives better protection from oxidation. The SEM images indicate that particle size reduced when TPH was substituted as wall material.



Wall material structuer of different combinations (A) Sodium caesinate-Gum Arabic-Maltodextrin, (B) Sodium caesinate and TPH (1:1)-Gum Arabic-Maltodextrin, (C) TPH-Gum Arabic-Maltodextrin, and (D) Sodium caesinate-Gum Arabic-Maltodextrin

Bioactive properties of digest from fish products

The effect of gastric pH on digestion characteristics of fish sausages using sequential digestion by pepsin and pancreatin was studied. Fish sausages prepared from freshly landed Pinkperch (*Nemipterus* sp.) were digested at four different pH *viz*,. 2, 3, 4 and 5 using pepsin separately and with pancreatin (pH-7.3). The overall digestion (%) (pepsin + pancreatin) was significantly higher (70%) when the initial gastric pH was 2. Pepsin effectively digested the fish sausage at pH 2 (37%) than at any other pH studied. Pancreatin digestion alone was found to be high (40%) when the initial gastric digestion was carried out at the pH of 3 and 4. SDS-PAGE profile of peptide pattern also supported that the pepsin was less effective at pH 4 and 5. *In vitro* antioxidant properties such as DPPH-free radical scavenging activity and ferric reducing power were revealed by both peptic and pancreatic digest.



Fish sausage prepared from Pinkperch and its sensory attributes

Seaweed as a nutraceutical agent in biscuits

Xylanase was utilized at various levels (100, 150 and 200 ppm) to manufacture semi-sweet biscuits supplemented with *Caulerpa racemosa* (CR) @ 5%. Colour properties of CR-supplemented biscuit did not change considerably upon xylanase treatment. Instrumental hardness showed a declining tendency with increasing enzyme level.

Caulerpa racemosa-incorporated biscuits

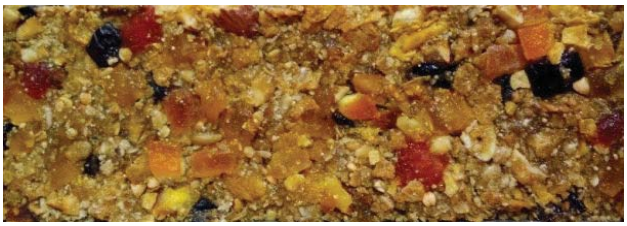
Development of extruded products fortified with seaweed

Response surface methodology based optimization of processing parameters were carried out for the preparation of brown seaweed (*Sargassum wightii*)- incorporated extruded snacks. Bulk density (g/cm^3), expansion ratio and hardness (N) were measured as a function of the three independent variables - seaweed (%), extruder barrel temperature (°C) and screw speed (rpm). Developed quadratic polynomial equations for response variables. Brown seaweed-enriched rice-corn based extruded snack prepared under optimized extrusion conditions was coated with three different falvours of 15% (w/w). The respective flavours were coated by dusting to dried extruded snacks along with sunflower oil spray at 3 levels. Among the nine different flavour-oil combinations, brown seaweed-based extruded snack coated using 15% chat masala flavour along with 10% sunflower oil was found to have maximum storage stability at ambient (27 °C, 64% RH) and accelerated (37 °C, 97% RH) storage environments.

Sargassum-enriched coated extruded snack

Development and formulation of fish-based nutritional bars and its quality evaluation

Nutritional bar was formulated with different cereal mixes, nuts and dried fruits along with dehydrated fish protein powder (fortified). The nutritional composition revealed a protein content of 7.90% in control and 15.07% in fortified bars. Sensory parameters like appearance, colour, and texture of fortified samples were found similar to control except flavor. The analysis of physico-chemical and microbial parameters concluded that the bars were microbiologically and physico-chemically stable at room temperature during storage. The bars have a shelf life of three months in normal conditions, six months in chilled and 10 months in frozen condition.



Fish-based nutritional bar

Nutritional profile of the bar	
Calories	395 kcal
Protein	15.6 g
Fat	7.8 g
Carbohydrate	65.6 g
Fibre	3.8 g

Development of dehydrated products from bivalve resources

The influence of different drying methods like solar cum electric drier (SED), vacuum drier (VCD) and fluidized bed drier (FBD) on biochemical composition, browning reaction and *in vitro* digestibility of clam (*Villorita cyprinoides*) was studied. The final moisture content of the product was 10±1%. Protein content of the dried sample was 55-60%. The biochemical characteristics like TVN, NPN, AAN, PV and TBA were found to be higher for VCD. The *in vitro* digestibility

of clam decreased on drying. Gastric digestibility was higher for FBD while the intestinal digestibility was higher for SED with VCD having the least gastric and intestinal digestibility.

Preparation of shark momos

Shark momos were prepared from *Scoliodon laticaudus* and the shelf life was evaluated in refrigerated storage. Analysis of biochemical quality parameters showed that momos had shelf life of 10-11 days in the refrigerated storage compared to 6-8 days for stuffed meat.

Shark momos

Quality and shelf life of clam paneer under refrigerated and frozen storage

Clam paneer (22% protein and 57% moisture) was developed by mixing clam meat, milk coagulum and maltodextrin. Potassium sorbate (0.1%) was added before chilled storage so as to study its preservative effect along with control sample. Cryo-preservatives (sucrose:sorbitol - 1:1 ratio, 4% of the product) and sodium tripolyphosphate (0.25%) were added to the samples for frozen storage study. During chilled storage peroxide value of the control sample increased to 2.15 within 10 days while in treated samples the value increased till 10th day of storage and then decreased with storage period. Control paneer was microbiologically acceptable till 10th day of storage and the treated samples had a shelf life of 17 days. Both samples had acceptable sensory scores till the day of microbiological rejection.

Development of functional fish sausage

Functional fish sausage with higher n-3 PUFA content was developed by incorporating Indian oil sardine meat at different levels into yellowfin tuna. Incorporation of Indian oil sardine at 1:1 and 1:2 ratio increased the energy value to 158.49 and 160.97 kcal compared to 149.11 kcal for tuna sausage. Incorporation of sardine resulted in decrease in gel strength, shear force and hardness whereas EPA and DHA content increased. n-3 PUFA content was highest in frozen sausage followed by chilled and thermal processed sausage.

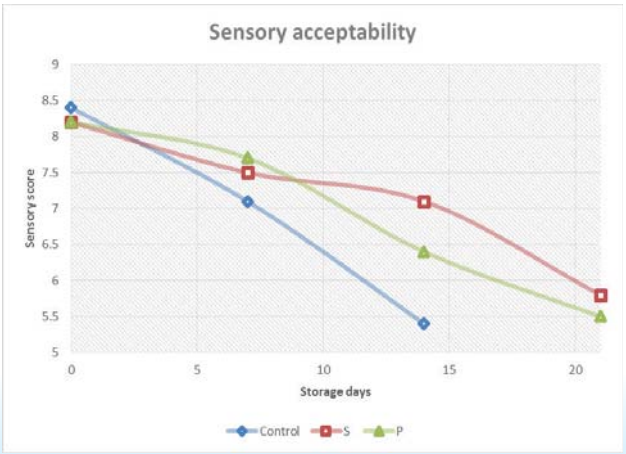
Indian oil sardine

Yellowfin tuna

Tuna - Sardine combination sausages (1:0, 1:1, 2:1 ratio)

Development of emulsion fish sausage and its characterization

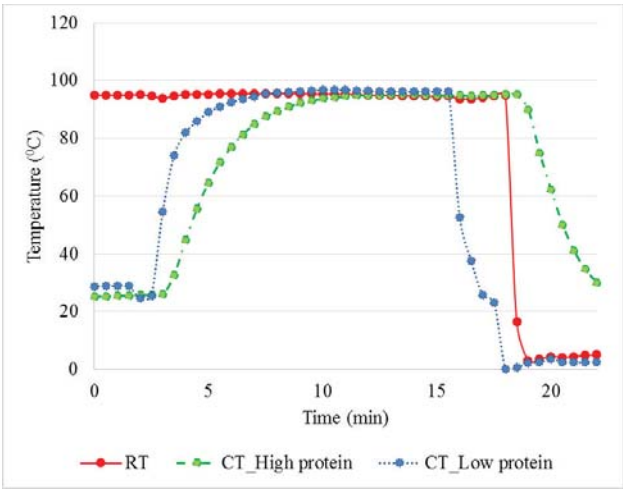
Emulsion fish sausage was prepared using Jewfish by incorporating different forms of chitosan (powder and solubilized) and its quality and shelf life was evaluated. Addition of chitosan in solubilized form (1%) improved the gel strength and colour of Jewfish sausage compared to chitosan addition in powder form. Sausages were acceptable up to 9-10, 16-17 and ~20 days for control, powdered chitosan and solubilized chitosan, respectively.



Sensory acceptability of emulsion sausage incorporated with chitosan in solubilized (S) and powder (P) form

Effect of variation in protein content and setting process on the physical properties of crab analogue product

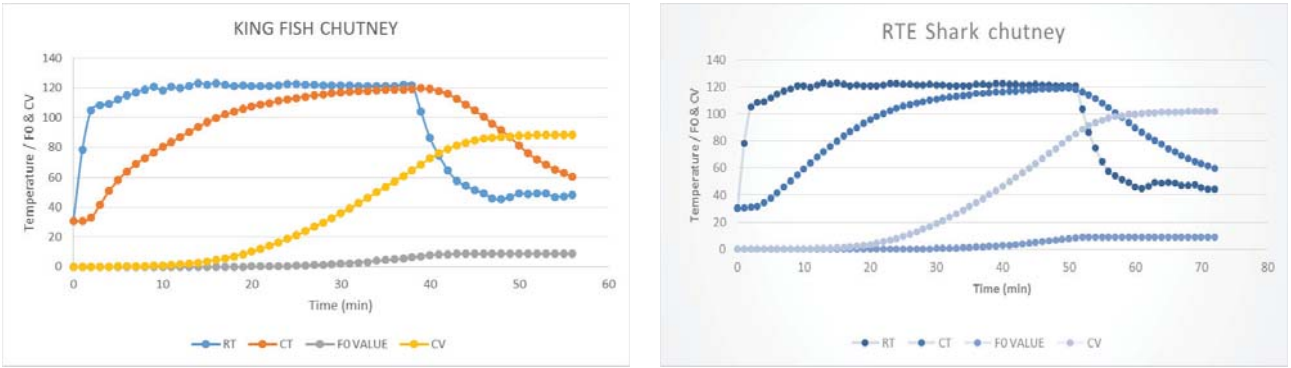
Differences in protein content on the heat penetration characteristics and physical properties of crab analogue product prepared from low value fish was evaluated. Heat penetration was faster in crab analogue product with low protein content (5%) compared to higher protein content (7%). Pasteurization value was 82.9 and 63.6 min. at 90 °C for crab analogue product with low and high protein content. Cooking loss and shrinkage was least for analogue product with high protein content whereas breaking force and hardness were more.



Heat penetration behavior of crab analogue product with varying protein content

Optimization of thermal process condition for ethnic fish products

Thermal processing conditions were optimized for ready to eat (RTE) ethnic food products like seerfish chutney, shark chutney and smoked mackerel. Process time was 32 min. for seerfish chutney compared to 40 min. for shark chutney. Calorie value for RTE seerfish and shark chutney was 189.4 and 247.1 k cal g^{-1}, respectively. Process time for mackerel in brine in TFS can was 5.4 and 16.2% higher compared to 2 and 4% for liquid smoke added samples, respectively. Thermal processed mackerel in brine with 4% liquid smoke resulted in least TBA and TVB-N values whereas a* and b* values increased compared to 2% and 0% liquid smoke samples. Sensorily, sample with 4% liquid smoke was appreciated more compared to other samples.



Heat penetration characteristics for RTE kingfish chutney and shark chutney

Effect of phenolic acids on the physical and oxidative status of fish oil-fortified surimi gel

Surimi gel was prepared from Pangasius fish with addition of 1% fish oil and phenolic acids - caffeic acid and p-coumaric acid (100 and 200 ppm) and their combination (100 ppm each). Control without fish oil and control without phenolic acid were also prepared and stored at 4 °C for one week. Physical and lipid oxidation status of fresh and one week stored gel was monitored. Water holding capacity was more in p-CA 200 samples, and marked effect on retaining the gel strength during storage was observed in phenolic acid added samples. Phenolic acid controlled lipid oxidation; CA 200 and p-CA 100 were found effective in delaying lipid oxidation.

Development of ethnic RTE fish product 'Ah-eemo'

Ethnic ready to eat fish product "*Ah-eemo*" was prepared from Indian mackerel and analyzed to evaluate storage stability of the product in different packaging methods such as modified atmosphere packaging (MAP), air packaging

(AP) and retort pouch packaging (RPP). Initial gas composition used for MAP was CO_2 60% and O_2 40%, respectively. MAP samples were stored at two separate temperature of 0-4 °C and 2-8 °C. AP samples were stored in chilled room while RPP samples were stored at room temperature.

Colour and texture values of MAP and AP comprised similar pattern (L* value ranging 33.46-49.50) while RPP exhibited a different pattern (L* value ranging 37.50-57.59) indicating more lightness of the product. pH values decreased with storage time for all the samples. TBA values of RPP throughout the storage period was recorded as <0.60 mg malonaldehyde/kg which are significantly different from AP and MAP which ranged from 0.50-7.652 mg malonaldehyde/kg meat. TMA and TVBN values were both within the acceptable limits for all the samples.

Marinated Ah-eemo

Ah-eemo in retort pouch

Retort cooked Ah-eemo

Development of RTE surimi curry

Incorporation of 9% corn starch and 0.1% guar gum along with 1.5% NaCl in gel preparation could improve thermal degradation of texture of surimi gel in curry form processed at two different temperatures (110 °C and 121.1 °C) as compared to control gel made with 1.5% NaCl. There was a slight change in the colour of the cubes during the thermal processing at different temperature. The L* (lightness) value for 110 °C and 121 °C were 50.24 and 58.49, respectively. Protein degradation was visible at both the process temperatures.

Surimi curry and protein pattern of surimi curry processed at different temperatures

Effect of high pressure on the functional aspects of fish protein gels

Pinkperch mince was treated at 200 MPa, 400 MPa and 600 MPa pressure for 10 min. and compared against cooked and uncooked control gels. Samples were then analyzed for their physico-chemical and functional properties. High pressure upto 200 MPa had no significant effect, but >400 MPa, pressure affects overall quality of Pinkperch gel. Gel strength increased in higher pressures, which was however lost on further cooking, whereas 200 Mpa treated gels showed similar gel strength as that of conventional heat-induced gels after cooking. When pressure as <400 Mpa was applied on Pinkperch gel, no significant loss in functionality of protein was observed, but >400 Mpa, pressure had similar effect as cooking. Changes in protein conformation were minimum at 200 MPa.

The effect of high pressure processing on protein isolates extracted from shrimp head waste was carried out. The work dealt with changes in quality, functional and microbial properties during storage of protein isolates treated

by high pressure processing. Two levels of pressure (200 and 400 MPa) with holding time (10 min. and temperature at 30 °C) were tested. Quality parameters such as pH, TVB-N, TBARS, TMA, colour and sensory analysis, functional parameters like protein solubility profile, emulsifying capacity, foaming properties, microbial parameters such as APC, Coliforms, Enterobacteriacea etc. were analyzed. High pressure processing was effective in reducing the microbial counts compared to control sample. High pressure treatment at 400 MPa effectively extended the shelf life of protein isolates up to 35 days at refrigerated storage against the control sample which had a shelf life of 21 days.

Development and shelf life evaluation of different thermal processed products: The protocols for the preparation of four types of thermal processed products *viz*. jack fruit seed and dried prawn curry, Mackerel curry with raw mango, Mahi mahi curry, kappa and sardine were standardized and the shelf life evaluation was carried out. The heat penetration characteristics of the products are assessed. A minimum shelf life of one year was observed for all the products.

Thermal processed products developed

Accelerated shelf life evaluation of thermal processed fish products

Accelerated shelf-life of RTE *Chanos chanos* in TFS can was evaluated using Q_{10} method. For this sample was stored at RT, 37, 45 and 55 °C and quality was monitred. The studies indicated a shelf life of 3.7 years.

Effect of chitosan-based coating on the microbial quality of shrimp during refrigerated storage

Fresh shrimp (*Penaeus indicus*) was collected from the fish landing centre and were coated in different solutions containing the combinations of chitosan-1% and salt-1.5% (T1), chitosan-1% and citric acid-1.5% (T2) and without coated (C) and then stored at refrigerated condition. The results indicated that coating treatments extended the shelf life of shrimp compared to uncoated shrimp. Uncoated samples (C) extended the shelf life up to 5 days, whereas T1 and T2 has a shelf life of 9 and 7 days. For uncoated samples the mesophilic count and psychrotrophic count increased from 4.86 log cfu/g to 6.56 log cfu/g and 3.39 to 8.02 log cfu/g and Enterobacteriacea counts increased from 2.9 to 4.88 log cfu/g on the 5th day. H_2S forming bacteria and Pseudomonas counts reached 5.04 and 3.05 logcfu/g on the 5th day. In T1 and T2 samples stored in refrigeration the mesophilic and psychrotrophic count reached to 7.02 and 7.07 log cfu/g on 9th and 7th day. It can be inferred from this study that the coating treatments retarded the microbial spoilage compared to uncoated shrimps.

Effect of sodium alginate coating on the quality and shelf life of dried mackerel

The effect of alginate-based edible coating containing chitosan on shelf life extension of dried mackerel was evaluated. Fresh mackerel (*Rastrelliger kanagurta*), were procured from the fish landing centre. After gutting and washing, the samples were coated with 1% alginate (Lot 1), 2% alginate (Lot 2), 2% chitosan (Lot 3), 1% alginate+chitosan (Lot 4), 1% glacial acetic acid (Lot 5) and distilled water (Lot 6) as control and then well drained. After that, it was dried in solar drier at 60 °C for 18 hrs and packed in polythene packs and stored at controlled condition. Initial APC of control was 6.8 log cfu/g whereas mackerel treated with acetic acid, 1% and 2% alginate, 2% chitosan and 1% alginate+chitosan was 6.20, 5.96, 6.45, 5.94 and 5.98 log cfu/g, respectively. Initial histamine forming bacterial count of Lot 1 to Lot 6 was 3.67, 3.56, 3.20, 3.20, 3.10 and 4.12 log cfu/g, respectively. Yeast and mould count showed highest value for control

samples of 3.46 log cfu/g and lowest for Lot 4 .

Standardization of protocol for transportation of live fish with emphasis on post-mortem quality and shelf life

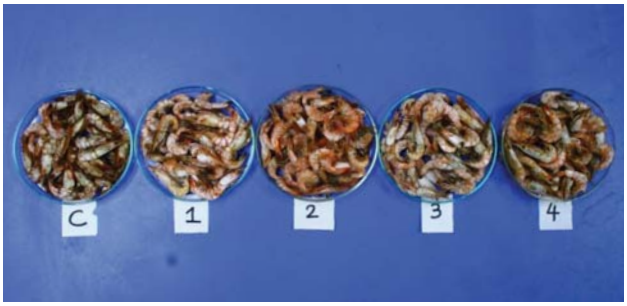
Designed a compartmentalized a prototype model of thermocol box (32x22 cm) for live fish transportation. Three independent trials were conducted with live tilapia (*Oreochromis mossambicus*) having average weight of 200 g (180-220 g) and length of 20 cm (18-23 cm). Each experiment was conducted with four fishes, which were carefully introduced in to the inter-connected compartments with a compartment size of 6.5 cm each and filled with a total volume of 5L of water. The thermocol box was further inserted into polyethylene laminated pouches and filled with oxygen. The designed system ensured reduced physical and metabolic activities during the holding period. However, the pH and DO_2 of water was reduced to less than 5.5 and 4 ppm, respectively and 50% mortality was observed after holding for 24 h at room temperature. In the second experiment 100% survival rate was observed, when the fishes were kept in HDPE box at controlled temperature (20 °C). The pH was stable and DO_2 was falling below 4 during 24 h of storage. The metabolic activities of the transported fish can be maintained at a minimum level by reducing the ambient temperature by more than 10 °C. In the present study, the ambient temperature was reduced to 18 °C and the metabolic activities of live tilapia was monitored indirectly by measuring the dissolved oxygen level and the pH of water. The water parameters indicated that the oxygen consumption rate decreased to one third when the water temperature was reduced from 28 °C to 18 °C. However, pH remained stable throughout the holding period, which indicates minimum generation of metabolic products during the holding period.

Evaluation of phenolic acids on the textural and oxidative stability of n-3 PUFA- fortified surimi gel

Effects of caffeic acid and coumaric acid on the physical attributes and oxidative stability of surimi gel fortified with fish oil were evaluated. Treatment groups were: A) surimi gel with 100 ppm caffeic acid, B) surimi gel with 200 ppm caffeic acid, C) surimi gel with 100 ppm coumaric acid, D) surimi gel with 200 ppm coumaric acid, and E) surimi gel with a combination of 100 ppm caffeic acid and 100 ppm coumaric acid. Moisture content of surimi gel without fish oil was higher (78.56%) than the fish oil-fortified samples (72.49-74.36%) whereas WHC was lowest in control without fish oil compared to other samples. Before and after storage, highest WHC was shown by sample containing phenolic acid (13.87%). Among the treatments, samples containing 100 ppm coumaric acid had the lowest TBARS value followed by 100 ppm caffeic acid. Highest gel strength was found with gel having combination of 100 ppm caffeic acid and 100 ppm coumaric acid (1.69 kgf.cm). Fish oil addition markedly reduced hardness from 213.15 N (negative control) to 177.72 N (control). Phenolic acid addition further improved the hardness values; higher values were observed for caffeic acid added samples (192.33 N). In brief, addition of caffeic acid at 100 ppm was found more effective for enhanced physical and oxidative stability in fish oil fortified surimi gel.

Osmo-dehydration protocol for small sized shrimp

A protocol has been standardized for osmo-dehydrating shrimp prior to drying for reducing the drying period. Small sized shrimp (*Penaeus longicepes*) were dipped in hypertonic solution of brine and maltodextrin for 1-4 h followed by drying in mechanical dryer at 50-55 °C. The pre-treatment reduced drying period from 12 h for control to 4 h for pre-treated shrimp. Moisture content varied from 11-14%. Osmo-dehydration for 2 h was found sufficient for reducing the moisture content of raw material from 82 to 72%.



Osmo-dehydrated and dried shrimp: C-control, Sample 1 to 4-shrimp given treatment for 1 to 4 h in osmo solution

Preparation of fish protein isolate from Pinkperch mince

Pinkperch mince was used to prepare fish protein isolate by isoelectric solubilization/ precipitation method. Yield of protein isolate obtained from fish meat was 85.40%. Restructured products were prepared by adding ingredients and product prepared with fish mince was kept as control. Products were kept under chilled storage (2 °C) for the study. Initial hardness of the sample was 17.19N and it showed an increasing trend during storage. There was no significant change in colour value (L*, a*, b*) of the product during storage. Biochemical and microbiological analysis revealed a shelf stability of 15 days for protein isolate and 12 days for control.

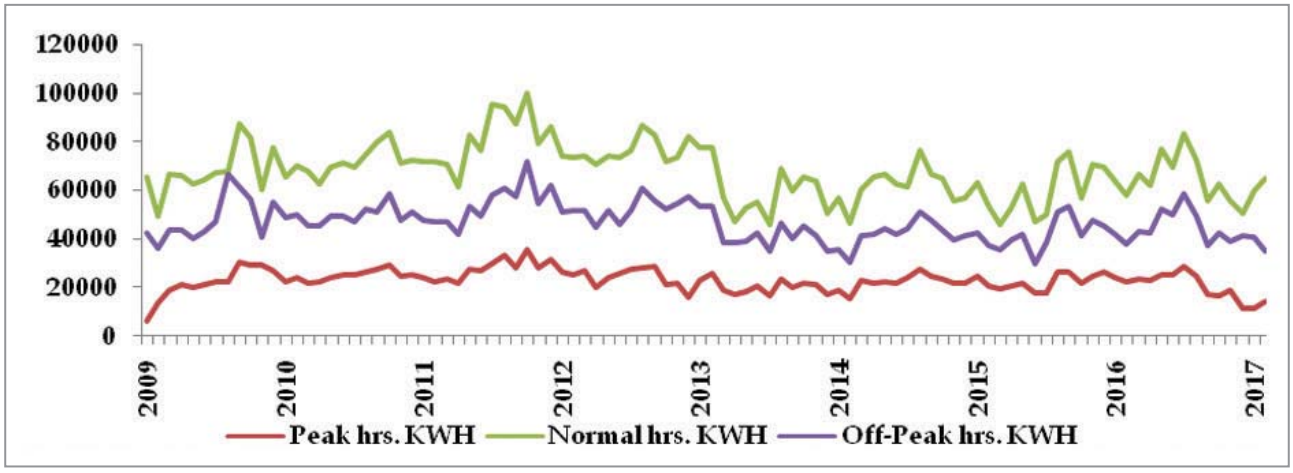
Bombay duck mince

Protein isolate

Restructured product

Assessment of energy use pattern in the seafood processing plants

Energy use pattern of two processing plants of Veraval (one EU Unit and one non-EU Unit) were studied. The average emission of CO_2 eq/unit of fish process in non-EU plant was 0.34 whereas for EU plant was 0.87. The reason behind higher emission in EU plant is attributed to less production and comparatively high energy utilization. Nine years monthly data on energy consumption were collected. The energy consumption in the seafood processing unit showed inter-temporal fluctuations between normal, peak and off hours and over the time period. Short term energy forecasting of the seafood processing unit was worked out. Time series data analysis of energy consumption of seafood processing units at Kochi in terms of monthly electricity consumption for the period 2009–2017 showed that the intra-plant, inter temporal energy consumption was more during the normal hours followed by off-peak and peak hours as categorized by the Electricity Board.



Intra-plant, inter temporal energy consumption at processing plant of Kochi

Inter-temporal energy consumption of seafood processing units showed a fluctuating trend over the period of 2009–2017. The daily energy consumption during normal hours was more due to the normal rates of electricity. The average estimated monthly energy consumption and the cost were 127987.30 Kwh units and Rs. 793869.20, respectively. Consumption-cost ratio of electricity was 1:7. Short term energy forecasting of the seafood processing plants was estimated using ARIMA (0,0,0) which showed a significant estimated value with standard deviation of 0.073.

Development of high value byproducts from fish and shellfish processing discards

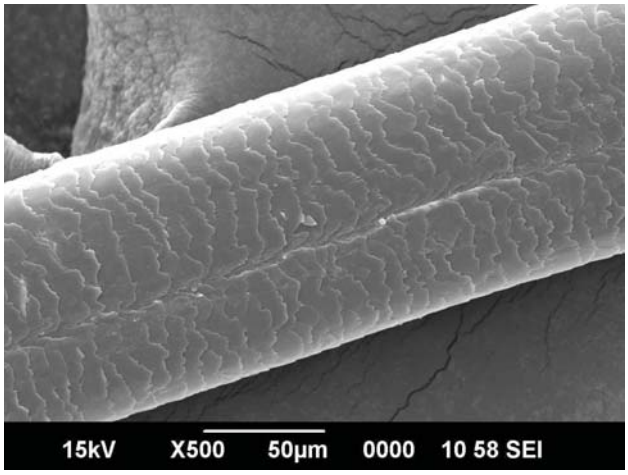
Pilot scale production and process refinement for water soluble chitosan

Pilot scale preparation of water-soluble chitosan with chitosan (90% DA) as starting raw material, yielded 18.840 kg of water soluble chitosan from the initial raw material of 7 kg. Double steam water-jacketed SS reaction vessel was used with a process temperature of 60 °C. By the new protocol, off-white coloured crystalline powder with less than 2% salt content and 95% solubility was obtained.

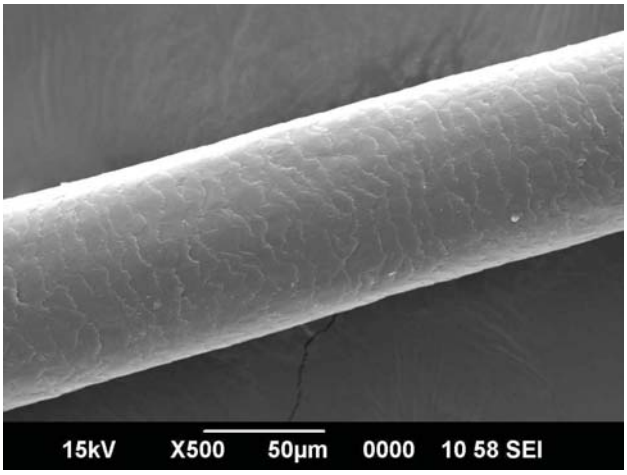
Preparation of water soluble chitosan

Water soluble chitosan-based photoprotective hydrogel

Water soluble chitosan-based hydrogel for photo-protective application was developed. The efficacy of the gel was confirmed by application on human hair, which caused minimum damage on exposure to UV rays, as revealed from SEM and optical microscopic images. The FTIR pattern also confirmed minimum structural damage to the gel treated hair compared to the control hair. The photo-protective effect of the gel was further enhanced by adding bleached melanin and *Aloe vera* sap. The hydrogel containing only CMCH yielded an SPF value of 19.67 against that of 81.68 for CMCH-Melanin gel and 103.29 for CMCH-Melanin-*Aloe vera* gel. The viscosity profile of the gel indicated the existence of a yield stress region followed by shear thinning behavior, which is ideal for hair gel preparation to prevent dripping from the hair on application.



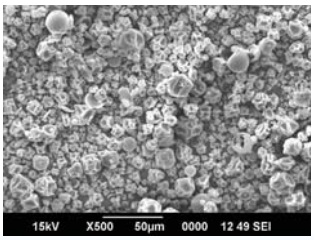
Control gel (after UV exposure)

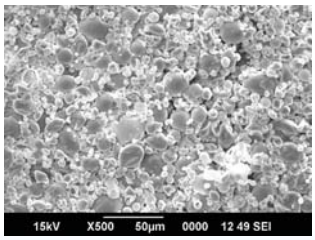


Gel treated hair (after UV exposure)

Comparison of microencapsulation efficiency of water soluble chitosan against native chitosan

The suitability of using water soluble chitosan (WCH) as wall material for encapsulating proteinaceous extractives was studied and the results were compared against that of native chitosan (CH). Maltodextrin was added as wall filler in both the formulations. In the case of CH emulsions, certain extent of coagulation was evident, though the particles could be sprayed through an atomizer. On the other hand, stable emulsion without





n-chitosan encapsulates CM-chitosan encapsulates

SEM micrographs of chitosan encapsulates

any visible aggregation was observed in WCH emulsion. The spray-dried powder indicated the presence of spherical smooth encapsulates in WCH, whereas most of them were shrunken or with visible voids in CH powder.

Extraction and characterization of bone oil from tuna head and frame

Oil was extracted from tuna head and frame bone at 60 °C under vacuum by three different protocols, *viz*. hot water extraction, enzymatic extraction, and solvent extraction method and the yield of oil from wet bone was found to be 47.71%, 62.22%, and 58.07%, respectively. The fatty acid profile of bone oil was only marginally affected by the extraction protocols attempted in the study, with comparatively lower degree of unsaturation for enzyme assisted extraction protocol. The fatty acid composition indicated the predominance of DHA (25-30%), EPA content (6.20-6.82%), arachidonic (3.02-4.65%), oleic (17.53-18.26%), stearic (7.6-8.0%), palmitoleic (5.10-5.34%) and palmitic acid (20.99-22.76%). The oxidation indices of all the three extraction protocols were within the limit. The lowest rate of oxidation was observed in heat rendering method.

Film forming properties of native chitosan and water soluble chitosan

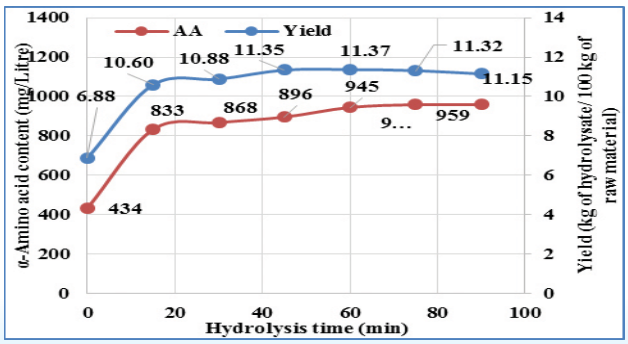
Comparative evaluation of film with 2% chitosan and water soluble chitosan was carried out. Higher tensile strength of 619 kg/cm^2 for native chitosan and a much lower value of 37 kg/cm^2 for water soluble chitosan was observed. The elongation at break value of water soluble chitosan film was 10-fold higher (51%) than that of native chitosan (5.5%), whereas vapor barrier properties of WCH film was found to be inferior, with higher water vapour transmission rate for WCH film (2.65 g/m^2/day) compared to that of CH film (1.88 g/m^2/day).

Quality evaluation of fermented fish products

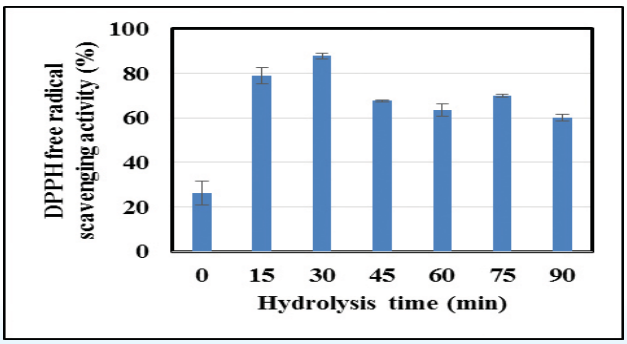
Fermented fish products were procured from different north-eastern states of India. The products under study were from Tripura (Punti shidal, Phasa shidal, Lona ilish), Arunachal Pradesh (Ngyii papi), Mizoram (Nghaum, Nghathu), Manipur (Ngari, Hentak), Assam (Salted Punti shidal), Nagaland (Phasa shidal) and Meghalaya (Tungtap). The products were analyzed for proximate composition, pH, titratable acidity, protein and lipids degraded products, microbial loads and antioxidant activity. Maximum antioxidant activity was exhibited by Punti shidal of Tripura (80.15% DPPH radical scavenging) and least activity was recorded for Hentak of Manipur (43.175% DPPH radical scavenging). Maximum TVBN (mg%) recorded was 378.62 in Phasa shidal of Nagaland. TBA (mg malonaldehyde/kg meat) was found in the range of 0.80±0.28 to 3.39±0.22 in these products. Maximum microbial load was found in Hentak of Manipur (7.43±0.88 logcfu/g) and minimum in Lona ilish of Tripura (4.33±0.17 logcfu/g). This could be due to high salt content of Lona ilish (14.81%).

Optimization of protein hydrolysate production

Optimized the conditions for the production of protein hydrolysate from waste of Pangasius using response surface methodology (Box-Behnken design). Fifteen runs were carried out to optimize the temperature, pH, and time with reference to yield and free radical scavenging activity. Pilot scale production line for fish protein hydrolysate was conducted with 20 kg.



Pilot scale production of fish head waste protein hydrolysate



Free radical scavenging activity vs Hydrolyis time

Release of peptides and changes in yield of fish head waste protein hydrolysate during pilot scale experiment

At the optimum conditions (Temperature – 65 °C, E/S-2.6% (on dry solid basis) and time 90 min.), the predicted numerical values for yield and free radical scavenging activity were in the range of 7.74–12.28% and 38.86-69.87%, respectively. The actual values obtained for yield and free radical scavenging activity from three independent experiments were 9.99-10.52% and 59.85-61.73%, respectively.

In the pilot scale experiment with head waste (mixed from different species), the maximum hydrolysis was achieved in 30 min., thereafter, there was a slow increase in hydrolysis process and yield till 90 min. of hydrolysis. There existed a good correlation (R2=0.9784) between alpha amino nitrogen content and yield. The free radical scavenging activity increased from 26% to 88% from 0 to 30 min. of hydrolysis time. Further increase in hydrolysis time to 90 min. reduced the radical scavenging activity to 60%.

Alkali assisted extractions of protein isolates from shrimp shell was carried out with a Box-Behnken design to study the effects of three input variables, namely pH (7, 9, 11), alkali to waste ratio (200:100, 300:100, 400:100) and extraction time (40, 80, 120 min.) on yield. The optimized conditions for the maximum yield were pH - 9.43, alkali to waste ratio of 304.11 and extraction time of 79.13 min. These conditions resulted in protein isolate yield of 15.66% on dry basis from shrimp head waste. The proximate composition of protein isolate contains 81.25±0.17% of moisture, 17.79±0.15% of protein, 0.133±0.005% of fat and 0.62±0.02% of ash.

Quality evaluation marine collagen peptide-supplemented biscuits

Storage studies of biscuits prepared with supplemented marine collagen peptide (@ 10%) and packed in metallized polyester packets was conducted for 75 days. There is no significant difference in colour and textural properties (break strength) of biscuits. Also, the water activity of biscuit samples did not differ significantly. No considerable difference was observed in TBA and FFA value for the biscuit samples during the storage. Sensory analysis on 9-point Hedonic scale revealed that collagen peptide supplemented biscuits are well acceptable even after 75 days of storage.

Chitosan for metal removal

Removal of fluoride and iron using chitosan-coated activated carbon and chitosan-coated cuttle bone carbon: Fluoride removal efficiency of activated carbon and cuttle bone carbon-coated with chitosan was assessed with varying initial concentrations of fluoride (2, 4, 8 and 10 ppm). Combination of 2.5% chitosan-coated cuttle bone carbon and 1% Al_2O_3 was found to be more effective at higher initial concentration of Fl in comparison to 2.5% chitosan-coated activated carbon and 1% Al_2O_3. 75.5% reduction in fluoride level was noted at initial concentration level of 8 and 10 ppm. A batch experiment on efficiency of Fe removal by chitosan-coated activated carbon at varying contact time of stirring (15, 30, 60 and 120 min.) and effect of initial concentration of Fe (5, 10, 15 and 20 ppm) were carried out. At an initial concentration of 10 ppm of Fe at pH 4 optimal reduction was found at a timing of 30 min. (98.31%) followed by 60 min. (97.15%). Efficiency of Fe removal was found higher (97.48 – 99.71%) at high initial concentration of Fe ranging from 10-20 ppm.

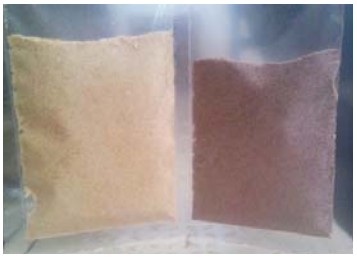
Removal of cadmium and lead using chitosan with different degree of deacetylation: Batch adsorption studies were conducted to evaluate the factors influencing the cadmium and lead absorption ability of chitosan with different degree of deacetylation (78%, 86%, 90% and 94%). Effect of contact time, adsorbent dosage and initial concentration of metal solution were evaluated during the study. At neutral pH, chitosan beads with 86% DA and 90% DA exhibited comparatively higher removal efficiency (38.8% and 37.5%, respectively) for Cd and beads with 86% DA reported 92% removal efficiency for Pb with an initial metal concentration of 5 mg/L, 60 min. contact time and 0.5% adsorbent dosage. The FTIR characterization was also done for chitosan beads of different DA. The FTIR spectra shows that the characteristic amide I is present at 1654 cm^{-1} in all the three 86, 90, 94% DA except 78% DA (1651 cm^{-1}) chitosan beads. And the C=O stretching region of the amide moiety was between 1690 -1826 cm^{-1}. The C-O stretching vibration of primary alcohol group was clearly identifiable at 78% DA and 94% DA chitosan beads at 1033 cm^{-1}. The C-H stretching was observed at 2852-2923 cm^{-1} for higher degree of deacetylation while in 78% DA it appeared at 2737 -2845 cm^{-1}. The C-H bending of CH_2 was observed in 90 and 94% DA chitosan beads at 1438-1496 cm^{-1} region, while in 86% DA it was at 1439 cm^{-1} and at 1456-1499 cm^{-1} for 78% DA chitosan beads.

Removal of iron content from water using chitosan-coated activated carbon: A study was carried out to evaluate the effectiveness of chitosan-coated activated carbon in comparison to simple activated carbon. Activated carbon was given a coating of chitosan having a degree of deacetylation 90.2. Batch studies were carried out at various combinations. Chitosan coated activated carbon was found to be highly efficient in iron removal in comparison to simple activated carbon. Chitosan coated activated carbon showed optimal iron removal efficiency at 1.50% treatment (99.23%). But in the case of simple activated carbon at 1.5% level iron removal efficiency was only 63.80%.

Optimization of extruded product incorporated with squid protein

Squid-based extruded products were made from the optimized combination using RSM. The experimental model was a combined mixture component and process factor. Independent variables (62.5% rice flour, 20% corn flour and 10% besan flour) were fixed based on the preliminary trials. Total 21 different runs were carried out and the responses like expansion ratio, sensory, breaking strength, colour etc. were analyzed. Protein content was fixed at 7.5% with tentacle and mantle ratio optimized at 5.625: 1.875. The optimized combination for extruded product was characterized for its properties. The products were coated with different flavouring mixes for getting different flavours.

The flavor extractives from squid meat was concentrated and with maltodextrin (1:4) and spray dried under following conditions: inlet temperature: 150 °C; outlet temp. 50 °C; spray flow feed rate17mL/min. The powder is having a moisture content of 4.13% and water activity of 0.387 at 25 °C. Other properties like bulk density - 0.22; tapped density-0.33; Carr's Index-33.33 and Hausner ratio - 1.5 and powder flowability were estimated. The developed flavour powder was mixed with other spice ingredients for making flavor mix. This flavor mix can be incorporated into extruded snacks, noodles, pasta etc. The encapsulated powder was characterized for physico-chemical, sensory and reconstitution properties.



Mantle and tentacle powder

Squid based extruded snack

Incorporation of seaweed polysaccharide in gelatin film

Film-forming solution was prepared with 2.5% gelatin and 2.5% Ulva extract in distilled water. Film forming solution without seaweed polysaccharide acted as control. Seaweed extract increased opacity of the film to 1.06 compared to control (0.48); improved tensile strength from to 4.25 Mpa compared to control (3.42 Mpa) and improved elongation at break (207%) than control film (160.43%). The FTIR spectra revealed the interaction among the functional groups of gelatin and seaweed.

Development of biodegradable films with improved mechanical properties

Films prepared from fish gelatin were subjected to pulsed light treatment (3 pulses/second) for one minute time at three different depths from light source – 0.76 inch, 3.26 inch and 5.76 inch. The mechanical and physical properties (tensile strength, percentage elongation at break, opacity, colour, etc.) of the gelatin film were analyzed. There were no significant difference in the tensile strength values for the gelatin films exposed to pulsed light at different exposure distances.

Incorporation of seaweed *Kappaphycus alvarezii extract* at 2.5% enhanced the tensile strength by 200% as compared to control films. Control films were highly transparent as compared to the seaweed-incorporated films.

Gelatin film and *Kappaphycus alvarezii* extract-incorporated film

Characteristics of clam shuck water powder spray dried with maltodextrin as drying aid

Shuck water from black clam (*Villorita cyprinoides*) was concentrated spray dried to obtain a free flowing powder. Prior to spray drying, maltdextrin was added at 5% (W/v) of total solid content and a stable emulsion was formed. Further, the physico-chemical and functional properties of the emulsion and the powder were analyzed. Maltdextrin acted as an anti-caking agent by decreasing the caking strength from 9 K to 12.86 kg and increasing the dispersibility and fat binding capacity. However, addition of maltdextrin resulted in slight reduction in surface active properties such as emulsion activity and foaming capacity, while yielding a stable emulsion. Further, the antioxidant properties of the powder as assessed by standard antioxidant assays indicated superior antioxidant capacity for both the powders.

Antioxidant activity of clam shuck water as influenced by different shucking temperatures

Heating at 80 °C resulted in lesser shuck water yield than at two other temperatures. DPPH radical scavenging activity was found to be highest for 80 °C (54.02) followed by steam (44.83%), 90 °C (37.4%) and 100 °C (35.4%). ABTS radical inhibition activity increased with increasing temperature of shucking (28.11% for 100 °C) while the steam shucking water had the lowest activity (12.45%). β carotene reducing activity reduced with increasing temperatures having 64.37% for 80 °C and 17.88% for 100 °C. Metal reducing activity increased with increasing temperature of shucking. Metal chelating activity was highest for 80 °C (65.44%) followed by steam (62.8%), 100°C (56.49%) and 90 °C (38.52%).

Quality assessment of squilla protein hydrolysate (SPH)-incorporated batter mix

The influence of SPH incorporation in dough and batter mix of fish cutlets was assessed. Deep-fried cutlets were analyzed for moisture, oil absorption and sensory attributes. Effect of SPH on lipid oxidation of deep-fried fish cutlet was also studied. The oil absorption of deep-fried fish cutlet reduced significantly from 14.79% to 7.54% by replacing fish meat with 2% SPH and reduced to 7.87% by replacing batter composition with 2% SPH. Water content of deep-fried cutlet increased with increasing concentration of SPH (49.62% to 57.16%) and batter composition (49.62% to 57.46%). PV of the control deep-fried cutlet was 9.79 meq O_2/kg. Addition of 0.5 to 2% SPH in fish meat has significantly reduced the primary lipid oxidation to 6.75 meq O_2/g, whereas, 0.5 to 2% SPH incorporation in to batter did not show any significant reduction in primary lipid oxidation of deep-fried fish cutlet. TBARS in fish cutlets were in the range of 0.33 to 0.48 mg MDA/kg.

Squilla protein hydrolysate (SPH) were prepared using enzymatic method and incorporated into fish cutlet with an objective to determine the influence of SPH on the oil absorption of deep-fried freshwater fish (*Catla catla*) cutlet. Cutlets prepared were deep-fried and water content, oil absorption and sensory evaluation of deep-fired fish cutlet incorporated with SPH were determined. Effect of SPH on lipid oxidation of deep-fried fish cutlet was also studied.

Addition of 0.5 to 2% SPH in fish meat has significantly reduced primary lipid oxidation to 6.75 meq O_2/Kg. Results of the sensory evaluation of deep-fried fish cutlet indicate that addition of SPH by replacing fish meat and batter composition did not show any significant influence on sensory attributes of the products. In brief, the study revealed that incorporation of SPH can significantly reduce the oil absorption and lipid oxidation in deep-fried fish product.

Utilization of sodium alginate and carrageenan for microencapsulation of fish oil and its stability

Microencapsulation of fish oil was done by using sodium alginate/carrageenan, gelatin and maltodextrin as wall materials. The core (fish oil) and wall material were used at the ratio of 1:4. Moisture and encapsulation efficiency of microencapsulates were 2.40% and 84.25%, respectively. Oxidative stability of microencapsulates were tested under accelerated (60 °C) and refrigerated temperatures (4 °C). SEM analysis showed spherical shape of the micro particles with size of 1.76 µm to 19.7 µm. Oxidative stability studies revealed that micoencapsulates containing sodium alginate were more stable than carrageenan-added sample. Moreover, TBARS values of microencapsulates crossed the limit of 2 after 4th day (2.2 mg malonoldehyde/kg) and 28th day (2.5 mg malonoldehyde/kg) under accelerated condition and refrigerated temperature, respectively for the microencapsulates-contained sodium alginate.

Freshness assessment and formation of biogenic amines during delayed refrigerated storage of Indian white prawn

Freshness assessment based on biogenic amine content of immediately refrigerated, 4 h and 8 h delayed refrigerated samples of Indian white prawn (*Fenneropenaeus indicus*) was carried out. Putrescine and cadverine content on rejection day of freshly refrigerated shrimp (7th day) was 3.13 and 2.05 ppm 4 h delayed (5th day) was 9.03 and 0.52 ppm and 8 h delayed (3rd day) 7.5 and 1.05 ppm, respectively. Immediate refrigeration extended the shelf life of prawn by 7 days in which the APC count increased from 5.15 log cfu/g to 6.95 logcfu/g.

Biochemical quality and formation of biogenic amines during refrigerated storage of Indian white prawn treated with combinations of chitosan, NaCl and citric acid

Samples of Indian white prawn dip-treated with combinations of chitosan-NaCl (T1) and chitosan-citric acid (T2) were stored at refrigerated condition, and evaluated for its quality and formation of biogenic amines. Chitosan-NaCl treated sample got rejected on 9th day of storage with a putrescine and cadaverine content of 4.96 and 1.2 ppm, respectively. While the chitosan-citric acid treated sample got rejected on 7th day of storage with a putrescine and cadaverine content of 19.35 and 0.34 ppm, respectively.

Samples of Indian white prawn coated with combinations of chitosan-NaCl (T1) and chitosan-citric acid (T2) stored at refrigerated condition were evaluated for microbial quality. Uncoated samples extended the shelf life up to 5 days whereas T1 and T2 had a shelf life of 9 and 7 days. For uncoated samples, mesophilic count and psychrotrophic count increased from 4.86 log cfu/g to 6.56 log cfu/g and 3.39 to 8.02 logcfu/g. In T1 and T2 samples, stored in refrigeration, the mesophilic and psychotropic count reached to 7.02 and 7.07 log cfu/g on 9th and 7th day. It can be inferred from the study that the coating treatments retard the microbial spoilage compared to uncoated prawns.

Quality characteristics of solar dried Indian mackerel coated with chitosan during storage

Solar dried samples of Indian mackerel treated with 1% acetic acid, 1% chitosan and 2% chitosan were studied for their quality and formation of biogenic amines. Histamine content of control sample was high compared to chitosan treated ones. Till 4th week of storage, putrescine and cadaverine content of chitosan-coated samples were less than the control.

Chitosan coating for the microbiological preservation of dried mackerel

APC of control samples reached to 5.27 log cfu/g after 30 days of storage, whereas samples treated with 1% acetic acid, 1% and 2% chitosan was 4.91, 4.33 and 2.2 log cfu/g, respectively. Total fungal count was detected after 15

days of storage for 1% chitosan and 30 days of storage for 2% chitosan, whereas for control and acetic acid treated, it reached 2.34 and 2.25 log cfu/g, respectively after 30 days of storage. Control samples were rejected on 45 days of storage and 1% and 2% chitosan coated samples were rejected on 60d and 75d.

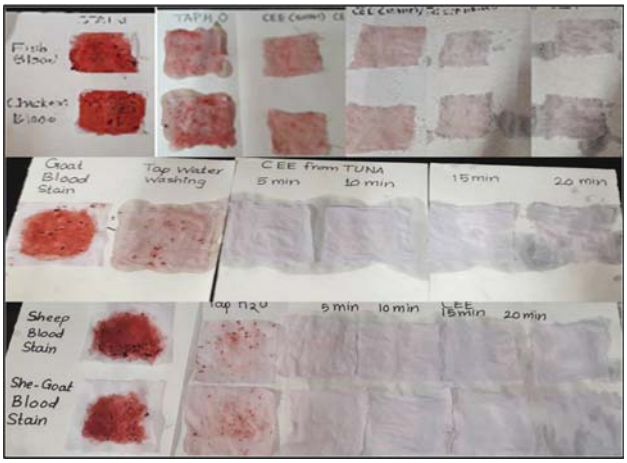
Food application of fish oil encapsulate

Microencapsulates-fortified noodles were prepared by hand extrusion. Wheat flour was used as base material and 1% salt was added for noodle preparation. Microencapsulated fish oil was added up to 0.5-5%. Based on the sensory analysis, incorporation of fish oil encapsulates upto 2% level were acceptable without affecting the taste. Results indicated that the combination of 1% salt and 2% encapsulates had higher score (3.8) for over all acceptability.

Fish oil encapsulate-fortified noodles

Application of tuna visceral protease as blood destainer

Crude visceral proteases were extracted from little tuna (*Euthynnus affinis*) viscera by homogenization with Tris-HCl buffer followed by centrifugation. The collected supernatant was further used as crude enzyme extract from tuna. It was observed that tuna crude protease extract effectively removed blood stains of fish blood and chicken blood within 20 min. and the he-goat blood stains were effectively removed within 10 min. without usage of detergent. Sheep blood stain was effectively removed within 15 min. and she-goat stain was effectively removed in 10 min. treatment time with crude enzyme extract.



Tuna visceral protease as blood destainer

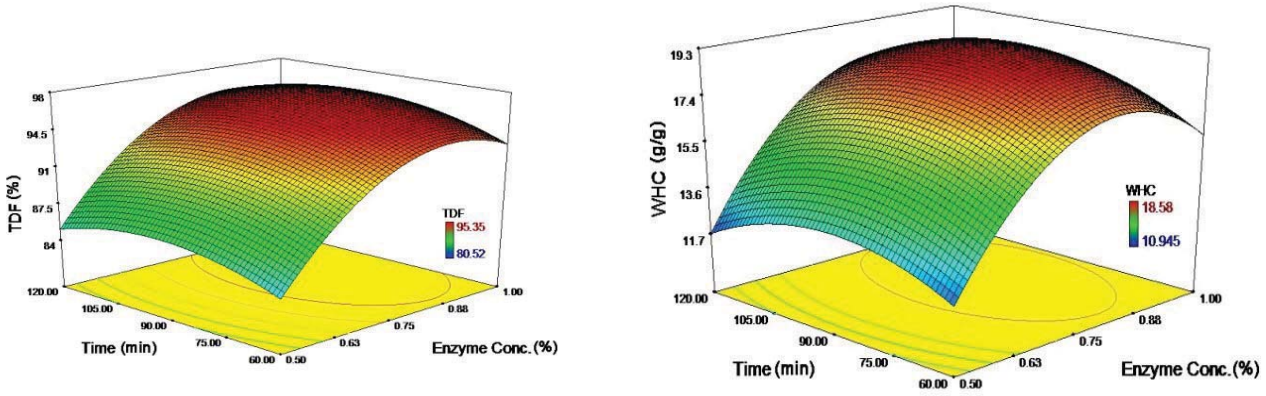
Colour and texture quality of tuna chunk marinade containing chitosan

Tuna chunk marinade was prepared with chitosan in three different treatments *viz.*, CM: Control marinade (2% acetic acid + 2% NaCl), CHM: Chitosan marinade (1% Chitosan + 2% acetic acid) and CHSM: Chitosan with salt marinade (2% acetic acid + 2% NaCl + 1% Chitosan) and their colour and textural properties were analyzed. Observations of increased paleness (whiteness) was observed in both CM and CHSM but in CM it retained raw fish colour which is clearly attributed to the presence of salt in CM and CHSM responsible for the leaching of the colour leading to paleness of the fish meat. The initial hardness of the fresh fish was 1154g. Increase in hardness was observed in both CM and CHSM *i.e.,* 1427 and 2102, respectively. But low hardness was observed in CM *i.e.,* 438. Most of the consumers prefer lower hardness for marinades which was satisfied in CM, thus indicating the suitability of chitosan in marinated products.

Innovative product development for value addition, nutrient fortification and shelf-life extension of farmed and wild freshwater and marine fish

Optimization of dietary fibre extraction process from three seaweeds

The response variables namely yield, total dietary fibre (TDF), water holding capacity (WHC), oil holding capacity (OHC) and swelling capacity (SWC) were measured on seaweeds namely *Gracilaria edulis*, *Sargassum wightii* and *Ulva lactuca* dietary fibre extracted following different combinations of extraction conditions (independent variables) obtained by Box-Behnken design. The data obtained for all the responses were analyzed by response surface methodology. The optimum extraction conditions for the dietary fibre on yield, TDF, WHC, OHC, and SWC were estimated using the model equation by solving the regression equation and analyzing the response surface contour plots. Relatively lower enzyme concentration (0.78%), hydrolysis temperature (56.58 ºC) and higher hydrolysis time (87.23 min.) were the optimum conditions needed for dietary fibre extraction for *G. edulis* compared to *S. wightii* and *U. lactuca* (0.95%, 58.65 to 60 ºC and 61.67 to 63.82 min., respectively).

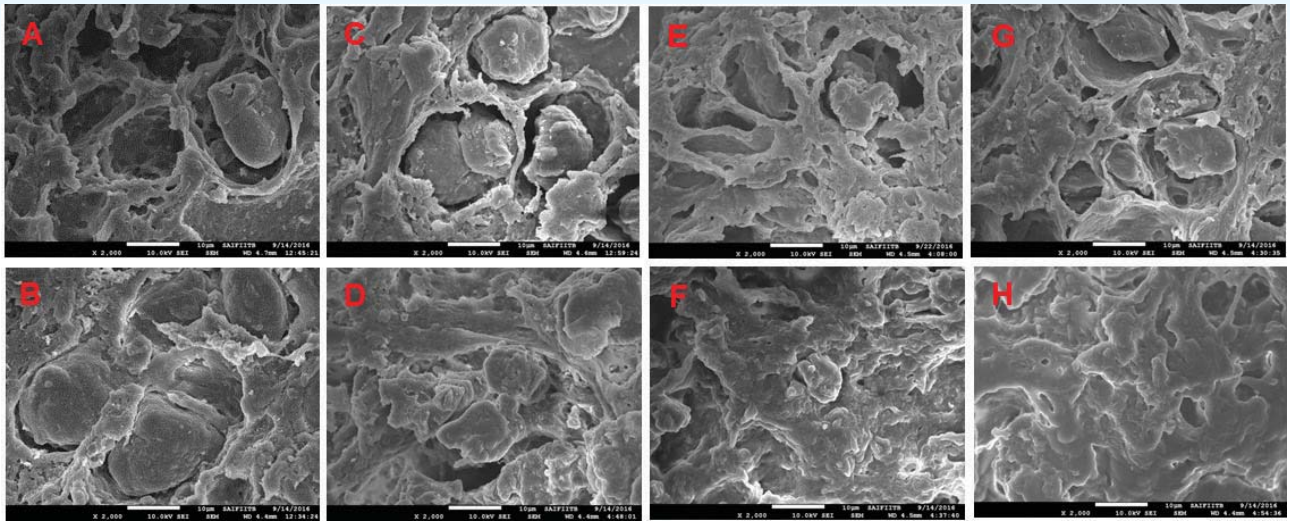


Effect of enzyme concentration and hydrolysis time on TDF and WHC of dietary fibre extracted from *G. edulis*

Development and standardization of Pangasius fish sausage fortified with dietary fibre from seaweeds

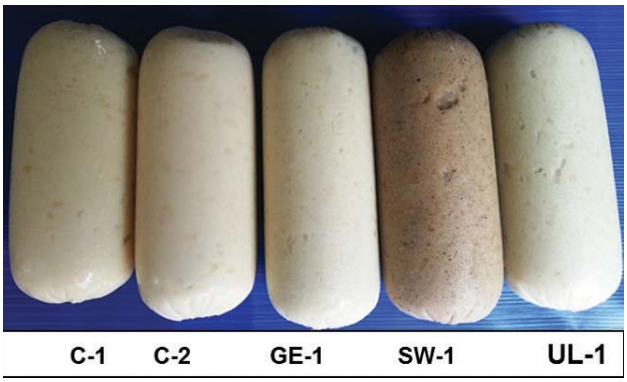
Dietary fibre fortified-fish sausage were prepared with 1-5% level of fibre from three different seaweeds namely *G. edulis*, *S. wightii* and *U. lactuca*. Results show that addition of 1% dietary fibre from *G. edulis* and *S. wightii* significantly increased the gel strength compared to control sausage. Textural and sensory analysis indicated that up to 3% of dietary fibre from *G. edulis* and *S. wightii* and 1% level of dietary fibre from *U. lactuca* can provide good textual and organoleptically acceptable fish sausage. The SEM images of sausages developed with dietary fibre showed that there is a variation in the network of dietary fibre and protein matrix in control and fibre-incorporated samples.

Control sausage and sausage containing 1-5 % level of dietary fibre from *G. edulis* (GE-1: sausage with 1% DF; GE-2: sausage with 2% DF; GE-3: sausage with 3% DF; GE-4: sausage with 4% DF and GE-5: sausage with 5% DF)



Micro structure of *G. edulis* treated sausage at X5000: A) C-1, B) C-2 (Sausage fortified with 1% carrageenan), C) GE-1, D) GE-5, E) SW-1, F) SW-5, G) UL-1 and H) UL-5

During chilled storage at 2 ºC, significantly lower level of PV, FFA, and TBARS were found in sausage containing 1% level of dietary fibre from *S. wightii* as compared to other fortified sausage and control sausage. However, TVBN content in dietary fibre-fortified sausages remained unaltered till 35 days of chilled storage study and after that, TVBN values gradually and significantly increased. Sausages fortified with dietary fibres were harder and had more chewiness than control and both the parameters increased with storage. In terms of acceptability attributes, sausages containing GE-1 and SW-1 were reasonably preferred in terms of colour, flavour, taste and overall acceptability. The results of the aerobic plate count (APC) of sausages, showed an initial reduction up to 21 days of storage followed by steady increase till the end of 63 days of storage at 2 ºC. However, the APC count was less than quality limit of 5 log cfu/g (FSSAI, 2011) or the spoilage limit of 7 log cfu/g (ICMSF, 1986) at the end of 63 days of chilled storage. The results indicate that the sausage fortified with seaweed dietary fibre are shelf stable and meet the quality requirement up to 63 days of chilled storage.



Seaweed dietary fibre-fortified fish sausages

Nutritional profiling of washed and unwashed Pangasius mince

Washing of Pangasius mince resulted in reduction of protein, and ash content, while there was an increase in the moisture content. Protein and ash reduced from 18.35±0.25 to 16.91±0.34% and 0.79±0.07 to 0.31±0.03%, respectively. Among the essential amino acids, lysine content was the highest (14%) in unwashed mince followed by leucine, isoleucine and threonine. There was an increase in the concentration of lysine from 14.00 to 23.17% in final washed mince. However, the study revealed that washing cycle did not affect the fatty acid composition of washed fish mince.

Quality assessment of DHA-fortified nutritional supplement

A nutritional supplement containing encapsulated DHA powder (2%) was prepared and vacuum packed. Fatty acid profiling of the nutritional mix indicated 2.87% linoleic acid, 0.82% EPA and 2.05% DHA in the sample. Amino acid profiling indicated the presence of aspartate, glutamate, leucine, arginine and proline in major proportions. Sensory quality and oxidative stability of the product with and without the presence of 1% ascorbic acid was evaluated over a period of 12 months storage at ambient temperature. Both the samples were in acceptable condition over the entire

storage period. Slight fishy odour was noticed in the ascorbic acid-incorporated samples at the end of 12 months storage. TBARS value of sample containing ascorbic acid was higher than those of control during the storage period. TPC of the control and AA added samples were 3.65 and 3.44 log 10 cfu/g at the end of first year.

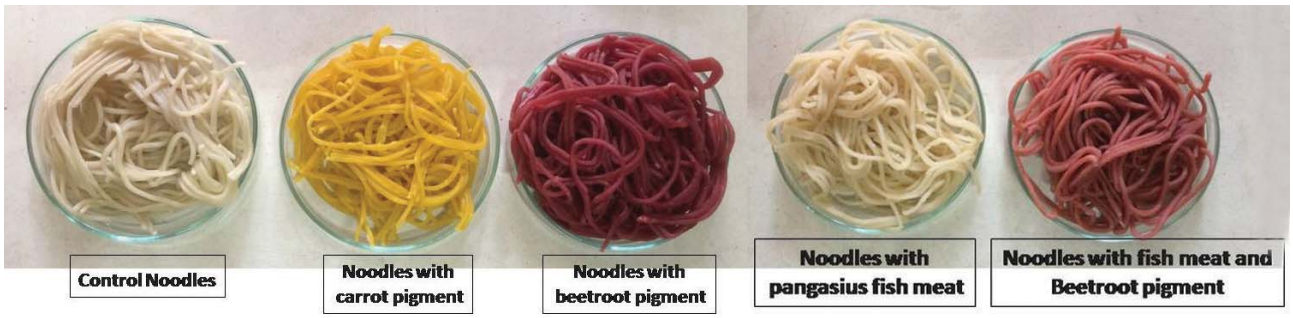
Nutritional profiling of sea cage farmed grouper

Proximate, mineral and fatty acid composition of grouper fed with different feed fishes (sardine, squid and *Decapterus* sp.) and wild caught grouper were evaluated and compared. Protein content of wild caught grouper was significantly lower (18.42%) than that of trash fish fed grouper (18-20%). Sardine-fed grouper had significantly higher fat content than other groupers. Fatty acid profiling indicated that grouper is a rich source of DHA irrespective of the diet (14.5-21.8% of total fat). Among the diets, *Decapterus* followed by sardine was found good for enriching PUFA content. Wild caught grouper had the highest EPA content (10.6%). In all the groups analyzed, muscle from the tail portion had higher fat content than those from the trunk portion. Mineral profile also indicated good quality of grouper with no variation among the treatments.

Cage farmed grouper

Characteristics of pigment-laden extract from beetroot and carrot and development of pigment fortified fish noodles

Pigment-laden liquid was extracted from beetroot and carrot and was analyzed for iron and heavy metals. Iron content in beetroot (19.53 to 23.53 ppm) was relatively higher than in carrot (1.8 to 6.6 ppm). The spectrum of the beetroot liquid showed a major peak in the visible region at 535 nm corresponding to the betacyanin which reduced by 72% up on heating (80 °C). Beetroot liquid exhibited three peaks in the infrared region at 970 nm, 1020 nm and 1100 nm. The spectrum of the carrot liquid showed two peaks in the visible region at 535 nm (major peak) and at 740 nm; two peaks in the infrared region (970 nm and 1020 nm) and one peak in the ultraviolet region (100 nm). On heating of the carrot liquid, the size of all the peaks diminished and the peak at 535 nm disappeared. Pigment-laden liquid was used to prepare coloured noodles. Five batches of noodles (noodles with carrot pigment @20-40% v/w and beetroot pigment @ 20% v/w and control noodles with and without fish mince) were prepared using a manual noodle making machine.



Composition of hepatopancreas of *L. vannamei*

It was observed that in some *L. vannamei*, the hepatopancreas appeared enlarged and bright orange in colour. In this connection, the orange coloured hepatopancreas of *L. vannamei* was studied for its composition. The hepatopancreas formed 13.85% of shrimp head weight and 0.04% of the total shrimp weight. The moisture, protein and fat content of hepatopancreas were 32.00%, 23.75% and 41.88%, respectively. The fatty acid profile showed that hepatopancreas had slightly higher proportions of MUFA (36.5%) and PUFA (33.5%) compared to SFA (31.0%). C18:1-Oleic acid was

the predominant fatty acid (31%) followed by C18:2-Linoleic (25%) and C16:0-Plamitic (24%). The amino acid profile indicated that hepatopancreas was rich in lysine (19.7%), glutamic acid (16.4%), cysteine (9.6%), aspartic acid (8.1%), arginine (7.3%) and leucine (7%).

Nutritional composition and meat characteristics *Ailia coila* fish

Ailia coila is an important indigenous fish species from Ganga river basin. In India, it is caught from West Bengal and exported to various countries including United States. It is a valuable fish species and there is scarcity of literature on the composition, quality and shelf life of the species. Fresh *Ailia coila* was analyzed for various parameters including length-weight relationship, proximate composition, biochemical quality indices, organoleptic quality, microbiological quality, texture profile analysis, colour of meat, few functional properties and SDS-PAGE profile.

The moisture, crude protein, crude fat and ash content of *Ailia coila* (average length 14.68 cm and weight 14.1g*)* were 78.83±0.07, 14.17±0.25, 3.68±0.03 and 2.34±0.05%, respectively. Total volatile base nitrogen value was 6.27 mg% indicating the freshness of fish. Biochemical quality of fish was superior as indicated by the lower values of thio-barbituric acid reacting substances (TBARS), peroxide value and free fatty acid, TVB-N, AAN etc. Protein solubility of *Ailia coila* meat in phosphate buffer was 25.46±0.51% and the extractability in extraction buffer was 89.53±0.50%, respectively. Foaming capacity of meat was recorded to be 81.21±2.78%. L, a* and b* values pertaining to the colour of *Ailia coila* meat were 70.07±0.16, 2.12±0.06 and 17.16±0.11, respectively. Sensory evaluation of fish indicated that fish taste resembled marine water fish, anchovy and overall acceptability score was good based on a 9-point hedonic scale. Chewiness, gumminess, stringiness and cohesiveness of *Ailia coila* without skin were higher than that of fish with skin.

Ailia coila

Antibiotic sensitivity of *E. coli* to carbapenems

Twenty two isolates of *E. coli* from farmed freshwater fish and marine fish were tested for their susceptibility to meropenem (0.002 µg/mL to 32 µg/mL) and ertapenem (0.002µg/mL to 32 µg/mL) using Ezy MIC strip. The MIC of *E. coli* towards meropenem ranged between 0.094 µg/mL to 3 µg/mL with a mean MIC of 0.28±0.6 µg/mL and for ertapenem the MIC ranged between 0.008 µg/mLto 0.0163 µg/mL with a mean MIC of 0.014±0.002 µg/mL 100% of the *E. coli* were sensitive to ertapenem, 95% of the *E. coli* were sensitive to meropenem and one *E. coli* isolate showed intermediate sensitivity to meropenem.

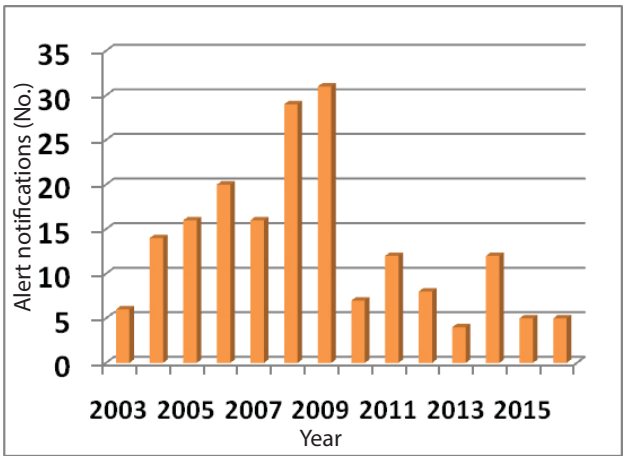
Microbial quality of fish and fishery products

Marine fish (*Rastrelliger kanagurta*, *Johnius dussumieri*, *Loligo* sp., *Portunus sangulnolentus* and *Metapenaeus dobsoni*); farmed freshwater fish (*Labeo rohita*, *Catla catla*, *Cyprinus carpio*, *Pangasionodon hypophthalmus* and *Piaractus brachypomus*), dried marine fish (*Lepturacanthus savala*, *Scomberomorus guttatus*, *Johnius dussumieri*, *Stolephorus commersonii* and *Metapenaeus* sp.) and fishery products (seerfish wafers, crab wafers, canned tuna, canned sardines and canned shrimp) procured from local markets in Visakhapatnam were tested for Aerobic Plate Count (APC), faecal Coliforms and *E. coli.* Faecal Coliforms and *E. coli* were high in marine fish (240 to <1100 MPN/g) and farmed freshwater fish (9.2 to >1100 MPN/g). In dried fish, faecal Coliforms ranged between 0 to 240 MPN/g and *E. coli* ranged between 0 and 9.2 MPN/g. In commercially available fishery products, faecal Coliforms and *E. coli* were detected in fish wafers (3.6 to 9.2 MPN/g) but could not be detected in canned fish (<3 MPN/g). 100% of marine fish, 60% of freshwater fish and 40% of dried fish had *E. coli* counts of above 20/g. *E. coli* isolated from the marine and freshwater fish samples were tested for their resistance to antibiotics. The *E. coli* isolates showed greater resistance towards nitrofurantoin (100%), meropenem (80%), levofloxacin (60%), trimethoprim (60%), ciprofloxacin (60%) and tetracycline (50%). However,

relatively low level of resistance was observed towards norfloxacin (10%) and gentamicin (10%).

Trends in the quality issues raised by the European Union in fish exported from India

Rapid Alert System for Food and Feed (RASFF) notifications pertaining to fish exported from India during 2001-2015 to European Union were analyzed. Over the last 15 years (2001-2015), a total of 362 RASFF notifications related to fishery exports from India to the EU were notified. Higher incidence of quality issues were associated with crustaceans (71%) compared to cephalopods (15%) and finfish (14%). The major quality issue responsible for RASFF notifications was veterinary medicinal products (52%), followed by heavy metals (14.4%) and the presence of pathogenic microorganisms (12.4%) indicating the need for focused action on these three quality issues. The residues of veterinary medicinal products (antibiotics) detected in fish exported from India were furazolidone (AOZ), nitrofurazone (SEM), oxytetracycline and chloramphenicol. The heavy metals, cadmium and mercury and the pathogenic bacteria *Vibrio* sp. (*V. cholerae*/*V. cholerae* non-O1/non-O139, *V. parahaemolyticus* and *V. vulnificus*) and *Salmonella* (*Salmonella paratyphi* B; *S. weltevreden*) were also reported in fish exported from India. However, there was a dominance of specific quality issues depending on the fish species. The major quality concerns associated with crustaceans was attributed to residues of veterinary medicinal products (72%) and pathogenic microorganisms (14%) whereas with cephalopods it was heavy metals (80%). However, in the case of finfish, the quality issues were diverse *viz*., bio-contaminants (33%), heavy metals (18%), pathogenic microorganisms (12%), food additive and flavourings (12%), non-pathogenic microorganisms (6%) and organoleptic aspects (6%).



Rapid Alert System for Food and Feed (RASFF) alert notifications due to presence of antibiotic residues in shrimp exported from India to the European Union

Assessing environmental aspects of fish, fishery products and effects of chemical hazards

Rheological characterization of emulsion of Pinkperch meat protein hydrolysate with and without addition of maltodextrin and gum Arabic

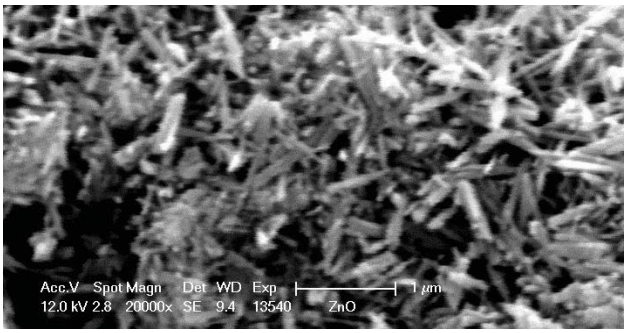
Pinkperch protein hydrolysates emulsions were prepared with and without addition of maltodextrin and gum Aabic (PPH) for rheological characterization. Herschel-Bulkley model was suitable to explain the flow behavior of PPH and PPHMG emulsions. PPH and PPHMG showed a gradual increase in both the storage modulus and loss modulus with increasing frequency. The breakdown of structure started even at low oscillatory stress in case of both the samples indicating low stability of the emulsions of PPH and PPHMG. Emulsion made with PPHMG had higher yield stress values indicating greater resistance to flow. Flow profile of PPHMG revealed shear thinning behavior due to irreversible structural breakdown.

Effect of calcium and heat setting on gelation and functional properties of surimi obtained from lesser sardine

Mince of lesser sardine (*Sardinella brachysoma*) without setting (A_1) and mince subjected to setting at 35 °C for a period of 45 min. (A_2) was utilized for the study. Decreased solubility and free–SH group content were observed in heat set gel samples of surimi indicating gel forming ability. Set samples exhibited lower foaming capacity as compared to unset samples.

Scanning Electron Microscope analysis of ZnO nanoparticles

Scanning electron microscope (SEM) analysis indicated that ZnO-NP appeared as nano wires with uniform size and shape with sharp edges. The average length and width was around 500 nm and 80 nm, respectively. The shape and size of the metal doped ZnO-NP was also similar to that of ZnO-NP. But the bulk ZnO appeared as amorphous material in the SEM analysis.



SEM of ZnO nano particle

Antimicrobial activity of chitosan and zinc oxide nanoparticles-incorporated chitosan against various bacteria

The maximum absorption of bulk ZnO was found at 380 nm and for ZnO-NP the maximum absorption was observed at 327 nm. The nanoparticles were effective in inhibiting Methicillin Resistant *Staphylococcus aureus* (MRSA), both the effectiveness of nanoparticles as well as bulk particles. Chitosan (CS) and zinc oxide nanoparticle-incorporated chitosan (ZnO-NP-CS) activity was evaluated against various gram positive, gram negative, catalase positive, catalase negative, oxidase positive and oxidase negative bacteria. The results indicated that ZnO-NP-CS was having higher antimicrobial activity against all bacteria; around 10 mm size higher zone of inhibition compared to the chitosan. Like chitosan, ZnO-NP-CS was also highly active against gram negative bacteria compared to gram positive bacteria. Higher sensitivity of oxidase positive bacteria was observed for both CS and ZnO-NP-CS.

Antimicrobial activity of chitosan (A) and ZnO-NP-CH (B) against *Vibrio cholera*

Antimicrobial activity of chitosan and zinc oxide nanoparticles-incorporated chitosan in different organic acids

Eight organic acids were used to dissolve chitosan and to assess antimicrobial activity of various bacteria using well diffusion method. It was observed that variations in the antibiogram were based on different acids responsible for chitosan solution preparation i.e., some of the bacteria were susceptible to particular organic acid. Among the eight organic acids, propionic and acetic acid were found more suitable acid for chitosan preparation for better antibacterial activity.

Effect of malic acid-chitosan coating and drying on the quality of Bombay duck

Fresh Bombay duck was cleaned, split opened and dip treated with malic acid /chitosan solution for 5 min., dried at 50 °C, packed and stored at room temperature. Biochemical and microbial analysis of dried samples were done at monthly interval for upto four months. Results showed that malic acid-chitosan treated sample had lower TVB-N (100 -161mg%) than control (183 mg%). However, there was no significant difference in PV and TBA values during storage.

Effect of kokum extract on the quality of Bombay duck

Kokum (*Garcinia indica*) extract prepared showed highest DPPH activity (88.64%) at 2% levels. Fresh Bombay duck were cleaned, split opened and dip treated with kokum extract (2%) solution for 5 min., dried at 50 °C, packed and stored at room temperature. Results showed that kokum extract treated sample had less TVB-N (6.8mg%) than control (8.90 mg%). Similarly, lower peroxide value was observed for kokum extract treated sample (3.2 meq.O_2/kg) than control (4.2 meq.O_2/kg).

Green coffee as a natural antioxidant in mackerel mince

The effect of green coffee extract as a natural antioxidant in chill stored Indian mackerel (*Rastrelliger kanagurta*) mince was studied. Total phenolic content of green coffee extract was 203.26±1.98 g/kg extract. Fresh Indian mackerel mince was added with 1.0%, 1.5% green coffee and 200 ppm BHT in different lots. Chill storage study (4 °C) of mackerel mince indicated enhanced quality for green coffee treated ones compared to control and BHT treated ones with reduced fat oxidation and protein changes.

Antibacterial activity of green coffee extract

Antibacterial activity of the green coffee extract showed that *S. aureus, B. thermosphacta* and *B. cereus* were highly susceptible to green coffee extract. *S. aureus*, *B. thermosphacta* and *B. cereus* were inhibited at a concentration of 12.5 mg, 3.125 mg and 6.25 mg, respectively.

Antimicrobial activity of green coffee at different concentration against *B. thermosphacta*

Quality improvement of cuttlefish with inclusion of additives

The effect of sodium citrate and salt on the quality of cuttlefish (*Sepia pharaonis)* was studied under refrigerated storage condition. Four sets of sample were prepared for analysis. First set was treated with salt, the second set was treated with E331 (sodium citrate), third set was treated with salt and citric acid and the fourth set was left untreated to serve as control. The samples were individually quick frozen at a seafood factory and brought to the laboratory, packed in multilayer film of EVOH pouches and held in refrigeration (5±1 °C) for further studies. Samples were periodically analyzed for the changes in sensory, biochemical and microbiological quality characteristics.

Sodium citrate improved the pH which resulted in increase in the tenderness during cooking. Sodium citrate and salt reduced the TVBN and TMA content compared to untreated sample. Sodium citrate treated with salt reduced the mesophilic count and Enterobacteriaceae. However, there is no significant difference between all the other samples. Sodium citrate with salt reduced the TVBN content and mesophilic count in cuttlefish during refrigerated storage. Sodium citrate acted as pH regulator and reduced the pH of the sample as compared to the untreated and salted samples and it had a significant positive effect on cooking yield in the cuttlefish under refrigerated storage.

Solubility of Pinkperch protein hydrolysate without and with maltodextrin and gum Arabic was evaluated at different pH. Minimum solubility of protein hydrolysate was observed at pH 5 whereas that of protein hydrolysate added with maltodextrin and gum Arabic was observed at pH 7.

Heavy metal content analysis of seaweeds of Gujarat coast

Four tropical seaweeds collected from Okha (*Ulva reticulata*, *Valoniopsis* sp., *Sargassum johnstonii* and *Padina tetrastromatica)* were analyzed for their heavy metal content. The typical cell wall polysaccharides and proteins in seaweed provide excellent binding sites for metal retention and hence seaweeds accumulate minerals and essential elements from their environment. Each country has its own legislation pertaining to maximum limit of heavy metals in algal food products. The study revealed that the heavy metal content of the seaweeds are within the acceptable level. The mercury level ranged from 0.02 to 0.05 mg/100 gm of dried samples. The study also revealed that on an average, brown algae contains higher arsenic than green algae.

As arsenic compounds enter into marine algae naturally, many marine algae have evolved a process of converting arsenic into lesser toxic form mainly into arseno-sugars by successive oxidative alkylation. This is why even though marine algae can contain high levels of arsenic, most of them is bound into organic form such as arseno-sugars, which are not acutely toxic. The overall study indicates that none of the seaweeds studied delivered the harmful level of heavy metals.

QUALITY ASSURANCE & MANAGEMENT

Research projects handled

Institute projects

- Food safety hazards of fish and fishery products: Assessment and mitigation measures
- Development of standard processes and protocols for innovative products from aquatic resources, shelf life modeling and assessment of energy use
- Development of high value byproducts from fish and shellfish processing discards
- Marine biomolecules, characterization and utilization for nutraceutical, biomedical and industrial applications

Externally funded projects

- Characterization of harmful algal blooms along Indian coast
- Development of bioplastic based sustainable nano-biocomposite food packaging - "Sustain Nanopack"
- Preparation of pictorial guidelines based on freshness ratings for the species of fishes exported to European Union
- All India network project on Fish health

Most significant achievements

- Organochlorine pesticides like δ-BHC and endrin were detected at higher than prescribed levels in water of shrimp farms.
- Validation of cold-fill process of fish pickles was developed as per 21 CFR 114 USFDA regulation and cold holding period for five variety of commercial fish pickles were optimized.
- A multiple barrier process involving treatment with liquid smoke, modified atmosphere packaging followed by chilling was developed for preservation of fishery products.
- Based on complete inhibition of *Pseudomonas* and *Brochothrix thermosphacta*, gallic acid-grafted chitosan was found to be a potential additive in shelf life extension of fishery products.
- A multiple emulsion, using chitosan, whey protein isolate, green tea extract and Bay leaf essential oil was found to enhance the storage life of chilled tuna chunks.
- Application of high pressure (200 MPa and 400 MPa; holding time of 5 min.) could effectively eliminate the contaminating *E. coli* population in non-depurated clam (*Villorita cyprinoides*) to non-detectable levels.
- Simulation studies on enterotoxin production by *Staphylococcus* in sun-dryed white sardine indicated initiation of enterotoxin production after 6 h of drying, when *S. aureus* level reached 10^8cfu/g, water activity 0.968 and moisture content 54.79%.
- A prior dip in propionic acid at 1% level prevents formation of Staphylococcal enterotoxin during sun-drying.
- Maximum allowable phosphate uptake takes place in shrimp with 1.65% STPP treatment containing 0.15% salt, tissue to treatment solution ratio of 1:3 and soaking period of 7 h.

- A specific and sensitive HPLC-based standard operating procedure was developed for quantification of sodium benzoate in fresh fish.
- Incidence of Ciguatoxin was observed in *Lutjanus bohar* landed along south west coast of India.
- Pictorial guidelines for sensory grading of 33 varieties of finfish and shellfish species for export to European Union was developed.

Chief findings

Institute projects

Food safety hazards of fish and fishery products: Assessment and mitigation measures

Determination of level of pathogens and chemical contaminants at selected nodes in the food chain

Chemical and microbiological contamination level of fresh fishes available in supermarkets/Malls of Kochi was evaluated. APC was above 6 logs in 50% of samples of *Nemipterus japonicus*. Coagulase positive Staphylococci was detected at a level of 1.3 log cfu/g. Coliforms were found to be high (3.47 log cfu/g) and *E. coli* was found in one sample. Enterobacteriaceae count was in the range of 4.50 to 2.59 log cfu/g and other pathogens were absent. The bacterial load in mackerel sold in all supermarkets (4 nos.) was in acceptable range (4.47-5.13 log cfu/g). Coliforms and Enterobacteriaceae count was observed in the range of Nil to 1.3 log cfu/g and Nil to 2.23 log cfu/g, respectively. Other pathogens were found to be absent. Biochemical quality parameters such as TVBN, TMA, pH, FFA and PV were in the range of 12.6–29.4 mg%, 2.80–3.86 mg%, 6.84–6.99, 0-6.65 milliequivalents of O_2/Kg fat and 0-2.69 milliequivalents of O_2/Kg fat, respectively.

Samples of Indian mackerel were collected from four nodal points such as landing centre, retail market, supermarket and local market on the same day. All the samples were in fresh and acceptable condition based on biochemical indices. In terms of microbiological quality, bacterial load was within the acceptable limit at all nodal points. Coliforms, *E. coli* and Enterobacteriaceae were highest in supermarket samples (3.81 log cfu/g). *S. aureus* was isolated from fish samples collected from local market (2.3 logcfu/g) and tested for antibiotic sensitivity and found that the isolates were resistant to ampicillin, vanomycin, oxacillin and erythromycin and two of the isolates showed enterotoxigencity. Other pathogens were found to be absent.

Samples of fish and fishery products collected from different handling points were monitored for prevalence of pathogenic bacteria and chemical contaminants. Presence of coagulase positive Staphylococci were recorded in supermarket and landing centers at a level of 2.1 log cfu/g and 1 log cfu/g, respectively. High level of cadmium (0.88 ppm) was noticed in squid samples collected from Vizhinjam coast, whereas δ-BHC was detected in the range of 9.1–15.6 ppb from Munambam samples.

Sample from fish landing centre

Dried fish samples collected from Veraval fish market were analyzed for presence of microbial hazards. Yeast and mold count in the dried fishery products ranged from 40 to 960 cfu/g whereas other pathogens were absent. Fluoride content of the ice samples collected from different locations was very high ranging from 10 to 32 ppm. Organophosphate pesticides like malathion, malaoxon, ethion, profenophos, parathion-ethyl, phenothoate, chloropyrifos ethyl, chlorofenvinphos, diazinon, dicholorovos, dimethoate, monocrotophos, acephate and quinalphos were detected below the prescribed LOQ level of 10 µg/Kg in water and fish samples collected from different locations in Kerala and Tamil Nadu.

Quality evaluation of smoked-cum-modified atmosphere packaged fishery products

A multiple barrier process involving treatment with liquid smoke, modified atmosphere packaging followed by chilling was developed for preservation of fishery products. Swordfish fillets were treated with 0.5% commercial liquid smoke for one hour and packed in trays with 60% Carbon dioxide, 35% nitrogen and 5% oxygen. Changes in spoilage profile based upon microbiological and chemical indices were monitored during chilled storage for 31 days and it was observed that Mesophilic bacterial count crossed the acceptable limit of 10^7 cfu/g in 19 days in MAP smoked fish (MAPS), whereas the limit was attained on 16^{th} day for air pack-not smoked fish (ANS), 17^{th} day for air packed-smoked fish (AS) and MAP-not smoked fish (MAPNS). Enterobacteriaceae count, histamine former count and Pseudomonas count in MAPS remained lower compared to other packs throughout the study. At point of rejection, *Brochothrix* count was lowest in MAPNS indicating a different microbial spoilage pattern in presence of smoke. Similarly lactic acid bacterial growth was found to be significantly retarded in MAP-smoked samples indicating a non-conventional succession of spoilage bacteria. Although TVBN crossed the acceptability limit of 25 mg% in 14 days in ANS samples, a maximum of 17.08 mg% was observed in MAP-smoked samples even after 31 days of storage.

Growth and survival of pathogens in liquid smoke treatment

Impact of liquid smoke treatment on the growth and survival of pathogenic bacteria in Yellowfin tuna chunks was carried out. Tuna chunks separately inoculated with pathogenic bacteria were exposed to different concentration of liquid smoke for varying soaking duration using RSM approach. The optimum conditions for minimum values of APC and *S. aureus* count was obtained at 4.4% smoking concentration and 360 min. soaking time and the corresponding desirability score was 0.83. Similarly, the optimum value for minimum count of APC, *S. aureus*, *Y. enterocolitica*, *L. monocytogenes* and *E. coli* was obtained at 4.42% liquid smoke concentration and 287 min. soaking time with a corresponding desirability score of 0.69.

Antimicrobial activity of liquid smoke (5%) was studied against 24 microbial groups by well diffusion method. Highest antimicrobial activity of (42 mm inhibition zone diameter) was recorded for *Listeria monocytogenes* followed by Enterococcus (36 mm). Among fungal groups, *Candia albicans* was found to be inhibited, whereas *S. cerevisae* was found to be resistant to liquid smoke at this concentration.

Mitigation measures: Application of chitosan-grafted derivatives

Efficacy of gallic acid-grafted chitosan (GAC), ferulic acid-grafted chitosan (FAC) and vanillic acid-grafted chitosan (VAC) in inhibiting growth of spoilage microflora in tuna chunks during chilled storage was evaluated. There was 3-4 log reduction of psychrotropic count in GAC, VAC and FAC samples, whereas mesophilic bacteria remained stable in VAC, but decreased by 3 logs in GAC. Lactic acid bacteria could not grow in GAC and FAC treated samples throughout the storage period of 28 days. Complete inhibition of *Pseudomonas* and *Brochothrix thermosphacta* was observed in GAC, implying its suitability as a potential additive for shelf life extension of fishery products.

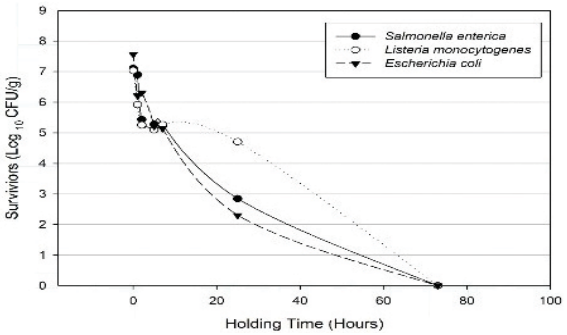
Development of biopolymer-based coatings

Three different combination of Chitosan-Essential Oil (CE) emulsion were prepared containing three different concentrations of Bay leaf essential oil (0.1%, 0.25% and 0.5%), referred as BL-1, BL-2 and BL-3. Seerfish chunks were separately coated with these emulsions and changes in microbial profile and chemical spoilage were evaluated under chilled storage. In untreated control samples, mesophilic and psychrophilic count crossed the acceptability

limit of 10^7 cfu/g in 13 days, whereas the same was breached in 39 days in BL-1 and never in 45 days for BL-2 and BL-3. Enterobacteriaceae count reduced to non-detectable levels in all three coated samples after 14 days. Typical spoilage indicators like *Pseudomonas* and *Brochothrix thermosphacta* were inhibited for the first 22 days of storage in BL-2 and BL-3 coated samples. Sensory and chemical analysis indicated that BL-3 samples were acceptable upto 26 days, whereas control, BL-1 and BL-2 samples were acceptable up to 7, 10 and 18 days, respectively. Antimicrobial assay indicated low to moderate activity. *Vibrio cholerae* and *E. coli* O157:H7 had highest inhibition, whereas *Listeria monocytogenes* was inhibited by emulsion containing 1% essential oil.

Validation of cold-fill process of fish pickle

Commercially prepared fish pickles were validated for cold-fill process subsequent to acidification. Based upon 21 CFR 114 USFDA regulation and FSMA, the safety of acidified foods such as fish pickle was established, which entailed 5 log reduction of *Escherichia coli* 0157:H7, *Salmonella enterica* and *Listeria monocytogenes*. Holding time was determined for 5 log reduction of *S. enterica*, *L. monocytogenes* and *E. coli* O157:H7 and Weibull Modelling was used for prediction of holding time.



The survival of *S. enterica*, *L. monocytogenes* and *E. coli* O157:H7 strains in acidified dry shark pickles

Effect of high pressure on quality changes of grey clam

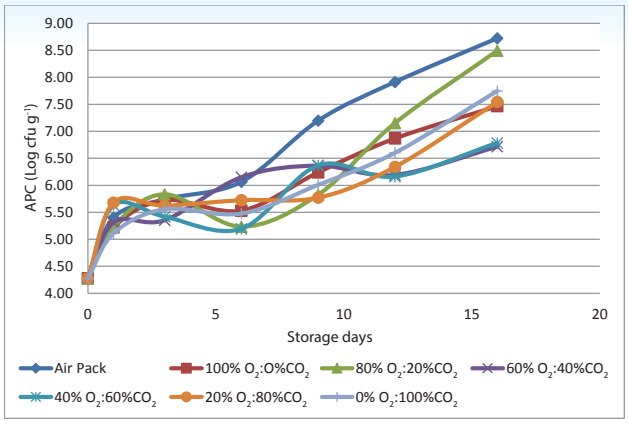
For the studies live grey clam (*Villorita cyprinoides*) was collected and washed in potable water, packed in double laminated films and high pressure was applied at two pressure levels of 200 MPa and 400 MPa. The maximum temperature obtained during the process was 29 °C. The pressure ramp rate was 450 MPa/min. and the holding time was five minutes. The meat of pressure-treated clam was removed from the shell in sterile condition and packed as 25 g each and stored in the chilled condition at 2-3 °C. Periodic analysis of the samples was conducted for the meat. The total volatile base nitrogen was seven for all the samples initially and it increased to 16.2, 16.8 and 28 for 400 MPa, 200 MPa and control samples after 22 days. Thiobarbituric values ranged from 0.22-0.29 malonaldehyde/kg initially and the increase after the storage period of 22 days was less than 0.86. High pressure (200 MPa and 400 MPa; holding time of 5 min.) could effectively eliminate the contaminating *E. coli* population to non-detectable levels. An extension of chilled storage life of 15 days was observed in HPP samples.

High pressure studies on gray clam

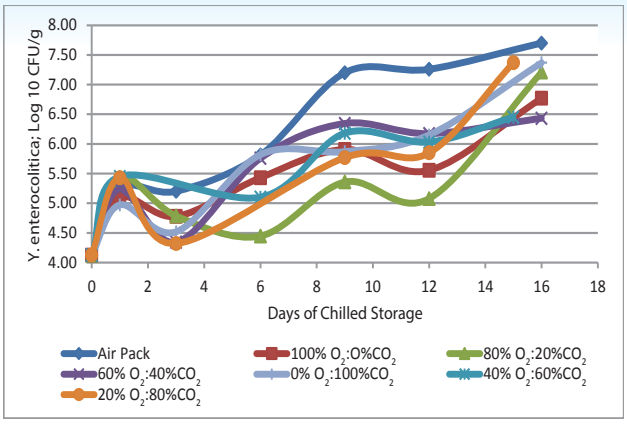
Impact of Modified Atmosphere Packaging on survival of *Y. enterocolitica*

The effect of different concentrations of O_2 and CO_2 on the survival of *Yersinia enterocolitica* was assessed in Indian oil sardine (*Sardinella longiceps*) during chilled storage (0-2 °C). Lowest increment in counts of *Y. enterocolitica* was observed for combination of 80:20 (CO_2:O_2).

Sardinella longiceps samples used for the study



Impact of MAP on Total Plate Count



Impact of MAP on *Yersinia enterocoltica* count

IgE binding capacity of protein extracts of Flower tail shrimp

For screening the allergic proteins of Flower tail shrimp (*Metapenaeus dobsonii*), IgE binding capacity of protein extracts in raw and cooked form were carried out by ELISA method. Clear IgE reactivity by sera of persons allergic to shrimp was observed in case of cooked extracts.

Survival of *Yersinia enterocolitica* and *Aeromonas hydrophila* during solar drying process

In solar drying process, the reduction in survival of *Yersinia enterocolitica* and *Aeromonas hydrophila* was studied. With the reduction of moisture content from 76% to 15%, *Y. enterocolitica* count reduced by 4.36 logs in *Ambasiss* sp. in 22 h, whereas the total bacterial load reduced by 1.17 log. Similarly, in *Nemipterus japonicas,* pre-inoculated with *Aeromonas hydrophila*, there was 5.27 log reduction of this species over 24 h, with the moisture content reducing from 78% to 14% and APC by 1.11 logs.

Evaluation of hygiene status in aquaculture sites and fish markets

Hygiene status of seven different contact surfaces in selected aquatic environments were monitored. Among the food contact surfaces studied in aquaculture sites, highest concentration of Enterrococci, total Coliforms, faecal Coliforms and *E. coli* obtained were 4 log cfu/cm^2, 1100 MPN/cm^2, 460 MPN/cm^2, 93 MPN/cm^2, respectively. All food contact surfaces (workers hand (male), workers hand (female), basin, platform, basket, weighing balance, cutting board, floor, and crate) in fish markets were sampled for hygiene indicator bacteria. *E. coli* was predominant in all the surfaces. Except from the swab samples taken from the palm of workers, none of the contact surfaces showed the presence of enterotoxigenic Staphylococcus.

Simulation of Staphylococcal enterotoxin production in dried fish

Growth and enterotoxin production potential of *S. aureus* during sun drying of white sardines (*Escualosa thoracta*) at different time intervals was studied. Fish was pre-inoculated at a concentration of 10^5 cfu/g and dried. Samples were withdrawn at every two hour interval for *S. aureus* count, APC, moisture content, water activity and enterotoxin analysis. Fish sample was dried for a period of 15 h to bring the water activity below 0.78 as per the revised specification of FSSAI for dried fish. Initial *S. aureus* count was 3.82 log cfu/g, which increased to 8.25 log cfu/g in 6 h and remained at 7.2 log cfu/g on 15th hour of drying. Water activity was reduced from 0.996 to 0.778 at the end of drying. Enterotoxin production was observed after 6 hrs

Samples of white sardine

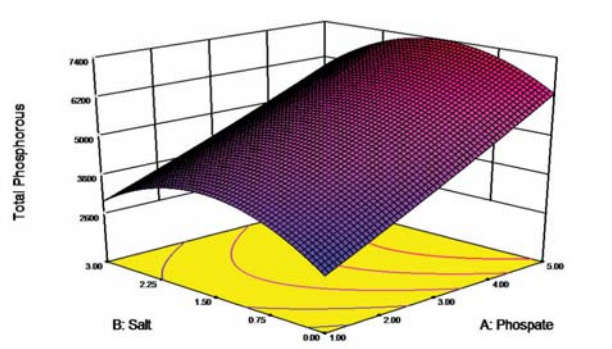
of inoculation when the *S. aureus* count reached 10^8 cfu/g, total bacterial load of 10^9 cfu/g, when water activity and moisture content was 0.968 and 54.79%, respectively.

Effect of organic acids on *Staphylococcus aureus*-contaminated fish during improvised drying

Inhibition studies on enterotoxin production in dried fish using organic acids was carried out. Lactic acid, acetic acid and propionic acid were used at 0.5, 1, 1.5 and 2% levels. Challenge studies in both natural condition and artificial medium was conducted using ATCC strain of *Staphylococcus aureus*. No enterotoxin was detected in fish treated with 1, 1.5 and 2% propionic acid. Although there was a sharp drop in *S. aureus* count, enterotoxin production could not be inhibited using acetic acid and lactic acid.

Evaluation of phosphate uptake in shrimp during different treatments

Indian white shrimp, peeled and undeveined (PUD) forms were treated with sodium tripolyphosphate (STPP) as per Response Surface Methodology to evaluate the phosphate uptake. The input variable were amount of phosphate (STPP 1-5%), salt (0-3%), treatment time (30-480 min.) and tissue to solution ratio (1:1 to 1:4). The uptake of phosphate was higher at experimental runs with phosphate concentration ≥2 times salt concentration, tissue to solution ratio 1:3-4 and at the 4th hour of the treatment. The optimum condition obtained from the Response Surface Analysis with a maximum allowable phosphate content as total phosphorous (as P mg/Kg) was 1.65% STPP with 0.15% salt and a tissue to treatment solution ratio of 1:3, for a dipping period of 7 hours.

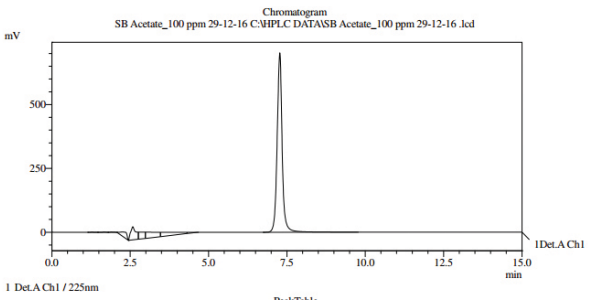


Response surface plot showing effect of phosphate treatment of shrimp

Phosphate dip treatment of shrimp

Standardization of protocols for determination of benzoate in processed fishery products

A specific and sensitive, HPLC-based standard operating procedure was developed for simultaneous quantification of sodium benzoate and potassium sorbate in fish and fishery products. The method developed has a linearity of 0.999, LoD-5mg/Kg, LoQ-50mg/Kg and a recovery of 90% for sodium benzoate. Fifty five samples collected by Food Safety Standards Authority of India (FSSAI) from various markets of Kerala state, such as Thiruvananthapuram, Kollam, Kozhikode and Ernakulam districts, consisting of 18 ice samples and 37 fish samples were analyzed for sodium benzoate. Five fish samples were found to be positive to the preservative but under BDL only. Sodium benzoate was not detected in none of the samples.



Chromatogram of 100 ppm sodium benzoate

MICROBIOLOGY FERMENTATION & BIOTECHNOLOGY

Research projects handled

Institute projects

- Molecular heterogeneity and bioprospecting of aquatic microbes for novel molecules and genes
- Assessing environmental aspects of fish, fish products and effects of chemical hazards
- Development of standard processes and protocols for innovative products from aquatic resources, shelf life modeling and assessment of energy use
- Development of high value byproducts from fish and shellfish processing discards
- Innovative product development for value addition, nutrient fortification and shelf life extension of farmed and wild freshwater and marine fish
- An assessment of the impact of S&T outputs of ICAR-CIFT on the socio-economic fabric of fisheries stakeholders

Externally funded projects

- Genetic diversity of *Clostridium botulinum* in seafoods and development of Lateral Flow Immune Assay (LFIA) for toxinotyping
- National surveillance programme on aquatic animal diseases
- Assessment of myctophid resources in the Arabian Sea and development of post harvest technologies
- Evaluating costs and benefits of prophylactic health products and novel alternatives on small-holder aquaculture farms in Asia and Africa

Most significant achievements

- *Salmonella* was prevalent in 41.1% of the 95 seafood samples collected from markets in and around Kochi.
- *V. cholerae* O1 Ogawa strains were isolated from well water of areas affected with cholera outbreak in Palakkad, Kerala.
- All MRSA isolates exhibited multi-drug resistance for three or more classes of antibiotics and 81.5% of the isolates of MRSA were enterotoxigenic.
- A new clone of MRSA, t15669-ST, was isolated from seafood, ice and water.
- Two Actinomycetes isolates out of 55 strains screened were found to have antibacterial activity against MRSA and identified as *Streptomyces* spp. and *Lysinibacillus* spp.
- Extensive genetic heterogeneity (55% to 100% similarity) was observed in *V. parahaemolyticus* isolated from marine fish by ERIC PCR.
- Thyme oil was found to inhibit amylase, caseinase, gelatinase and DNAse activity of *V. parahaemolyticus* and *V. cholerae* isolates at different concentrations.
- Bacteria from plastic dumping sites were able to reduce the weight of PVC by 43%.
- The LD_{50} value of 15 strains of *A. hydrophila* and nine strains each of *A. jandaei* and *A. veronii* isolated from farms with disease outbreak ranged between 10^2-10^3, 10^7 and 10^4-10^5, respectively in rohu fingerlings.
- Crude enzyme preparations of *P. elgii* was found to be effective as biocontrol agent for the control of fungal infestation in dried fish.

- *Vibrio parahaemolyticus* isolates from marine fish caught from the east coast showed varying levels of genetic heterogeneity (55% to 100% similarity). Majority of the *V. parahaemolyticus* isolates clustered at 80% similarity level.
- Multiplex Polymerase Chain Reaction (PCR) assay was standardized for the genes encoding the resistance for ESBL producing Enterobacteriaceae in seafood and their antimicrobial resistance pattern in seafood was assessed.

Chief findings

Institute projects

Molecular heterogeneity and bioprospecting of aquatic microbes for novel molecules and genes

Clostridium botulinum in seafood

Clostridium botulinum was detected in 10% out of the 96 samples (fresh and ready-to-cook), shellfish (fresh oyster meat, shrimp, frozen shellfish and crustaceans-shelled or not), fish products (canned fish, shrimp paste, prawn pickle, roasted shrimp, dried fish products, fish flakes/cutlet, crab stick, ready to cook and ready to eat fish products) screened.

Screening for *Salmonella*

Salmonella was prevalent in 41.1% of the 95 seafood samples collected from local fish markets in Kochi. *Salmonella enterica* subspecies *salama*, often associated with cold-blooded animals and cold environment, *Salmonella* Typhimurium and rough strains of *Salmonella* were identified from seafood. Salmonella was prevalent in 4.4% of the cultured fish and *Salmonella enterica* subspecies *enterica* Typhimurium (*S.* Typhimurium) was identified from the intestine of mullet.

Screening for *Listeria* and *Shigella*

Seventy nine (fish, shellfish, ice, ready-to-cook and ready-to-eat) samples screened for incidence of *L. monocytogenes* from retail markets of Ernakulam revealed that none of the samples were positive for *L. monocytogenes*. *Shigella* was not detected in 24 samples of seafood and four samples of ice screened.

Vibreo harveyi, Aeromonas spp. and *Edwardiella tarda* in cultured shrimp and fish

Screening of 58 samples from shrimp hatcheries and farms of Andhra Pradesh and Kerala revealed the presence of *V. harveyi* in eight post-larval samples. Eighty samples of fish, sediment and water screened revealed that all the samples were positive for *Aeromonas* and the species identified were *A. jandaii, A. veroni, A. hydrophila* and *A. enchelia*. The LD50 value of 15 strains of *A. hydrophila* and nine strains each of *A. jandaei* and *A. veronii* isolated from farms with disease outbreak ranged between 10^2-10^3, 10^7 and 10^4-10^5, respectively in rohu fingerlings. The LD50 value of five strains of *E. tarda* from diseased fish ranged between 10^4-$10^{5.}$

Vibrio cholerae in aquatic environment

Well water in areas affected with cholera outbreak in Palakkad, Kerala were found to be contaminated with *V. cholerae* O1 Ogawa strains. *V. cholerae* O1 Ogawa strains isolated from aquatic environments possessed different virulence and regulatory genes such as *ctxA, ctxB, tcp, zot, ace* and *toxR genes*. Genetic diversity of the strains were determined by molecular typing methods including ERIC, BOX PCR and PFGE.

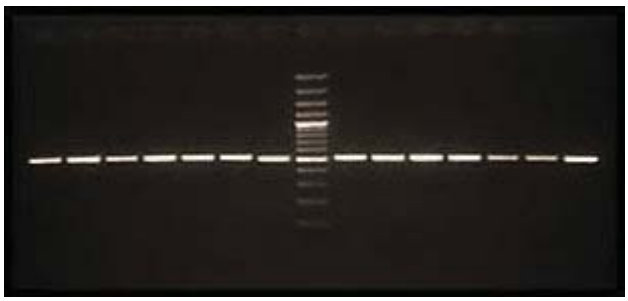
Antimicrobial resistance and molecular diversity of MRSA

Antimicrobial resistance profile of 65 MRSA isolates from seafood and aquatic environments revealed that ≥35% of

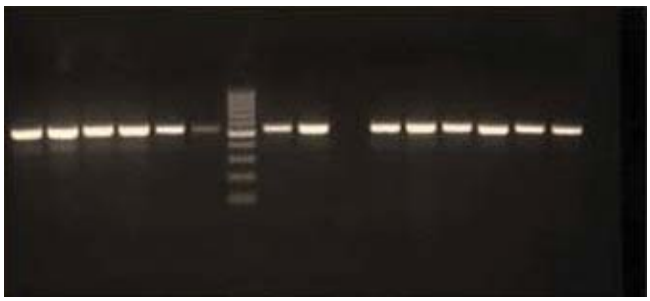
the isolates were resistant to macrolides. None of the isolates were resistant to chloramphenicol. All MRSA isolates exhibited multi-drug resistance for three or more classes of antibiotics.

Multi-drug resistance of MRSA

Among the 20 samples positive for MRSA, 85% of the isolates harbored capsular polysaccharide 5 gene *(cap5)* and 20% of the samples harboured capsular polysaccharide 8 gene *(cap8)*. The genes targeting clumping factor B (*clfB*) and Staphylococcal protein A (*spa*) were found in all the positive samples. Only 10% of the MRSA-positive samples harbored Panton-valentine leucocidin toxin gene (*pvl*) and toxic shock syndrome toxins gene (*tsst*) were prevalent in 5% of the positive samples. *pvl* and *tsst* genes were present only in seafood samples.



PCR targeting capsular polysaccharide 5 gene *(cap5)* in MRSA



PCR amplification of clumping factor B *(clfB)*

Out of 65 MRSA isolates, 81.5% of the isolates were enterotoxigenic. At least three genes of the enterotoxin gene clusters (*seg*, *sei*, *sem*, *sen* and *seo*) were present in 17 out of the 65 MRSA isolates. Other Staphylococcal enterotoxin genes identified were *sen*, *seo*, *sem*, *sei*, *seg*, *sec*, *seh*, *sel*, *ser* and *sed*.

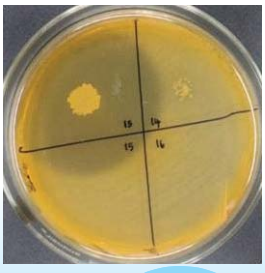
Studies on the accessory gene regulator polymorphism (*agr* typing) in MRSA isolates revealed that *agr* genetic background II accounted for 80% of the samples, followed by *agr* type I (25%) and *agr* type III (5%) and *agr* type IV was not detected in any of the MRSA-positive samples. *SCCmec* typing revealed that *SCCmec*V was the predominant one. The clonal profile of MRSA based on *spa* and MLST belonged to ST772-t657, ST5-t002, ST88-t186, ST5-t311, ST5-t334, ST8-t121, ST6-t711, ST1- t127 and a new clone STnew- t15669.

The new MRSA clone (t15669-STnew) identified in the study from seafood, ice and water (23 isolates) revealed an antibiotic resistance pattern only to β-lactams or (β-lactams + macrolides). Virulence profiling also showed that the new clone possessed capsular polysaccharide gene (*cap5*) and did not harbour *pvl* or *tsst* genes. The new clone belonged to *SCCmec* type II and *agr* type II.

Clonal analysis of MRSA revealed that New York/Japan clone, Bengal Bay clone and Paediatric clone or USA800 were prevalent in seafood and water. The clone t311 harboured diverse *se's*. Molecular source tracking of MRSA revealed their transmission from water or ice to seafood. Seafood and fishery environment were found to harbour MRSA of either HA or CA-MRSA type.

Bioactivity of marine Actinomycetes

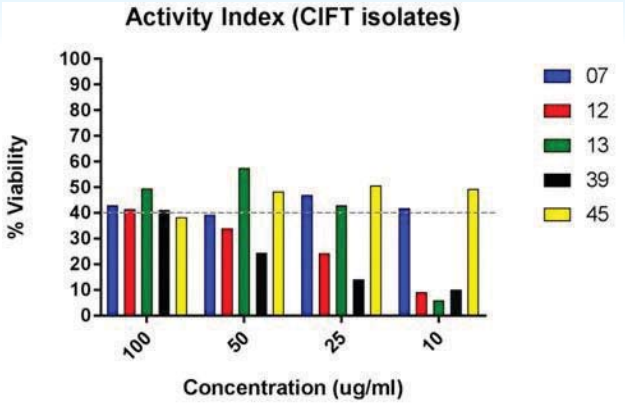
Two Actinomycetes isolates out of 55 strains screened, identified and as belonging to *Streptomyces* spp. and *Lysinibacillus* spp. were found to have high antibacterial activity against MRSA. The *cis* and *trans* type of PKS gene cluster was amplified from these two strains and cloned in vector.



Antibacterial activity of *Streptomyces* spp. against MRSA

Out of the 34 isolates of Actinomycetes isolated from marine sediment screened for their ability to inhibit Chikungunya virus by antiviral assay, six isolates showed inhibitory activity against the virus.

Fifty five Actinobacteria isolated from marine environment were tested for their lipase, amylase, protease and chitinolytic activity. Majority of the Actinobacteria showed lipase and amylase activities.



Activity index of Actinomycetes isolated from marine sediment against Chikungunya virus

Characterization of antifungal activity of *Paenibacillus elgii*

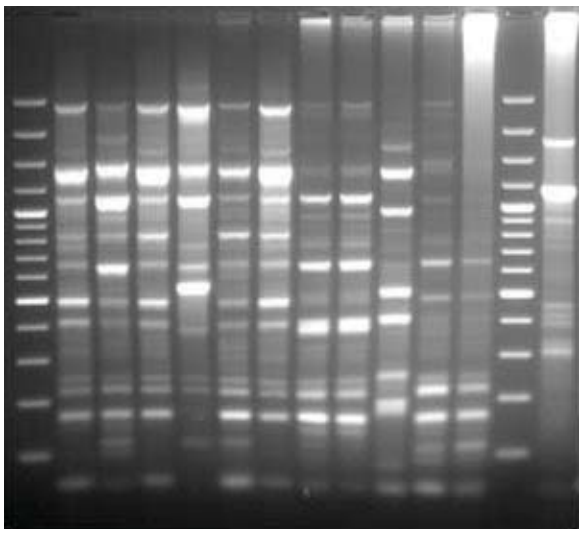
Antifungal fraction of *P. elgii* was purified and concentrated by butanol extraction of the culture supernatant followed by silica gel column chromatography. The purified fraction was confirmed by RP-HPLC. LC-MS analysis revealed that the peak is comprised of two fragments at 535 and 331 Da. Further structural information will be obtained by MS-MS.

Antifungal activity of butanol fraction of *Paenibacillus* strain

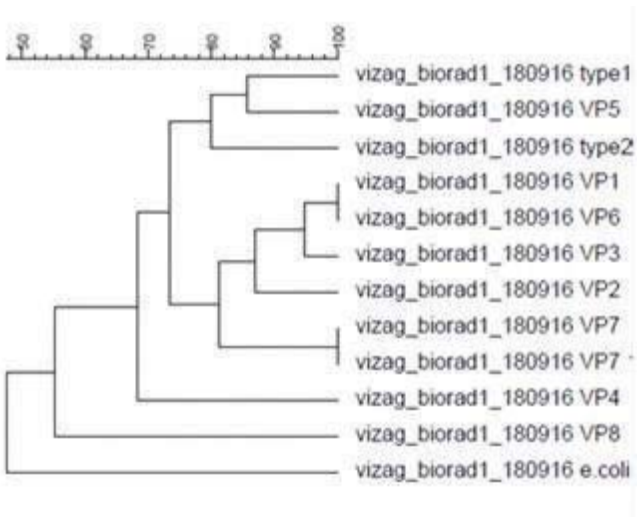
Dried fish samples sprayed with crude enzyme preparations of *P. elgii* were found to be effective as a biocontrol agent for the control of fungal infestation in dried fish. There was one log reduction in the fungal count after six hours from 3.11 x 10^4 to 1.19 x 10^3 and complete inhibition after 72 hours.

Genetic diversity of *Vibrio parahemolyticus*

Genetic heterogeneity of the *V. parahemolyticus* (n=8) isolates from marine fish from the east coast was tested by employing ERIC PCR and Cluster Analysis was carried out based on the unweighted pair group with arithmetic averages (UPGMA) using a position tolerance of 1%. Extensive genetic heterogeneity (55% to 100% similarity) was observed in *Vibrio parahaemolyticus* isolated from marine fish.



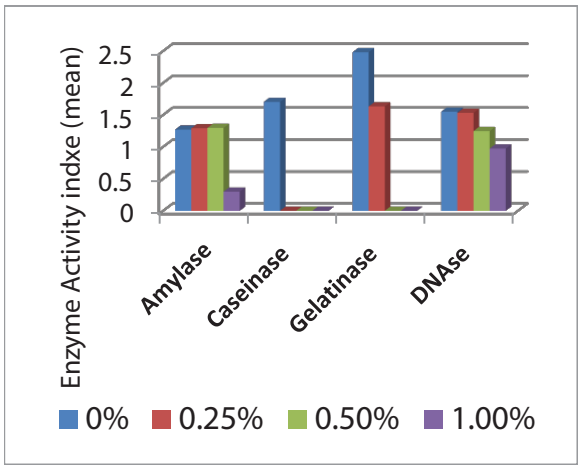
ERIC PCR for determining heterogeneity of *V. parahaemolyticus* isolated from fish



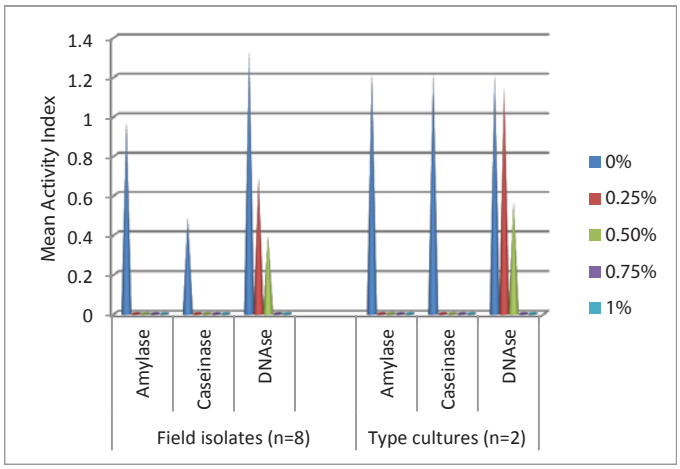
Dendrogram analysis of *V. parahaemolyticus*

Effect of thyme oil on the enzymatic activities of *V. parahaemolyticus*

The effect of thyme (*Thymus vulgaris*) oil employed at different levels (0.25%, 0.5% and 1%) on the enzymatic activity (amylase, caseinase, gelatinase and DNAse) of *V. parahaemolyticus* isolates (n=8) was tested. Thyme oil had relatively greater effect in inhibiting the proteolytic activity of *V. parahaemolyticus*. Caseinase activity of *V. parahaemolyticus* was completely inhibited at a thyme oil concentration of 0.25% whereas gelatinase activity was inhibited at 0.5% level. Amylolytic activity and DNAse activities of *V. parahaemolyticus* isolates decreased with increasing concentration of thyme oil but enzymatic activity was still observed at 1% thyme oil level.



Effect of thyme oil on enzyme activity of *V. parahaemolyticus*



Effect of thyme oil on the enymatic activitiy of *V. cholerae*

Plastic degrading activity of bacteria

Soil and water samples collected from soil dumping sites of Willingdon Island and Kakkanad, Kerala were incubated in minimal media for two months with HDPE, LDPE, PP, PVC and PP film as the sole source of carbon. Twenty one of the 134 plastic samples were found to have reduction in weight. There was a weight loss of 43% for PVC while the maximum weight reduction was 39% for PET. HDPE, LDPE and PP had weight reduction of less than 20%. Isolation of the plastic degrading bacteria is in progress.

Microarray for detection of shrimp viruses

Microarray for detection of IHHNV was attempted with four targets. Fluorescent signal from probe was improved by increasing the concentration of PCR product used for hybridization. Further improvement in the detection will be attempted by using Salmon Sperm DNA in hybridization solution with Denhardt's solution for both pre-hybridization and hybridization.

Isolation of ammonia oxidizing and biosurfactant producing bacteria

Ammonia oxidizing bacteria were isolated from two aquatic samples by enrichment using minimal salt growth medium and further sub-culturing in the same media. Ten isolates showing ammonia oxidizing capacity were identified as belonging to *Psuedomonas aeruginosa* and *Aeromonas* spp. Four out of 41 bacterial strains isolated from mangrove were found to have high biosurfactant production potential and were identified as belonging to *Achromobacters* spp. and *Pseudomonas* sps.

Enrichment of ammonia oxidizing bacteria

Isolation of sulphur oxidizing bacteria

Three bacterial isolates (SB1, SC10 and SD6), out of 96 isolates from four soil samples from mangrove environment which were found to have maximum reduction of pH in thiosulphate agar and production of sulphate ions were chosen for further analysis for their sulphur oxidation potential.

Microbiology of fermented fish products

Bacillus strains isolated from *Shidol* were identified using 12 biochemical tests as *B. licheniformis*, *B. brevis*, *B. pumilus* and *B. pasteuri*. *Clostridium bifermentans* was found to be the dominant anaerobic bacteria found in *Shidol*.

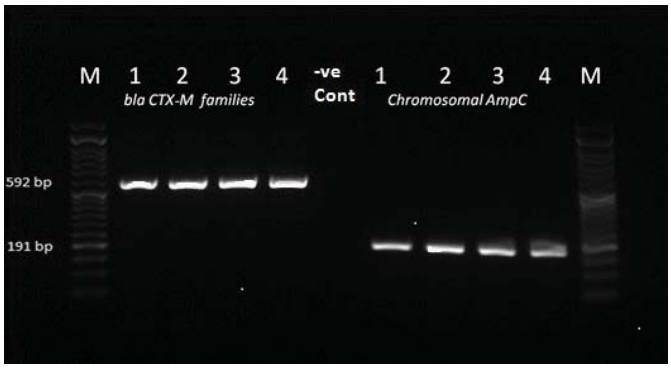
Antibacterial activity of Actinomycetes against MRSA

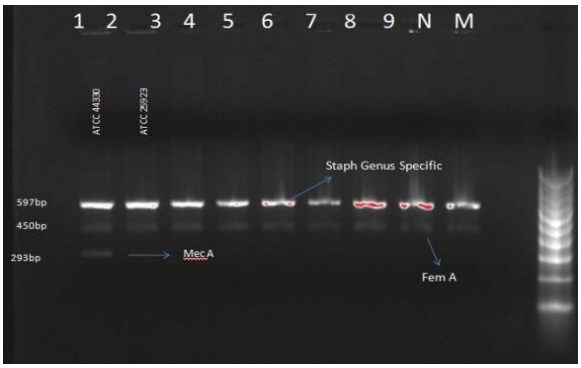
Sand was collected from five different locations of Vashi mangrove sea shore region and dried under shade. The dried sand was grinded and sieved. The samples were chemically treated and streaked over ISP 3 Media after proper dilution. Finally, all the plates were incubated at 28 °C and regularly monitored. After seven days of incubation, colonies were observed in the plates and were isolated again in ISP broth and incubated for five days for complete growth. The broth samples were centrifuged and screened for the antibacterial activity against various pathogens *viz. Salmonella*, *E. coli*, MRSA, *L. monocytogens*, *V. cholerae*, *V. parahaemolyticus* and *B. cereus*. Among these, eight isolates showed antibacterial activity against *S. aureus* and MRSA.

Assessing environmental aspects of fish, fishery products and effects of chemical hazards

Standardization of Multiplex Polymerase Chain Reaction assay for the genes encoding the resistance for ESBL producing Enterobacteriaceae in seafood

The epidemiology of coagulase positive Methicillin Resistant Staphylococci (MRS) and extended spectrum of Beta Lactum producing *E. coli* (ESBL) in fish were carried out and the incidence rate was found to be 2.43% and 1.66%, respectively. Molecular screening for the ESBL producing *E. coli* was checked by Multiplex Polymerase Chain Reaction (PCR) assay using the primers for the genes encoding the resistance for ESBL production *viz*., bla_{TEM-1}, bla_{SHV-1}, bla_{OX}, $bla_{CTXMgp2}$, $bla_{CTXMgp9}$, $bla_{CTXMgp25}$, bla_{CTX-M} families and chromosomal *AmpC* and few isolates were found to be positives for bla_{CTX-M} families (592bp) and chromosomal *AmpC* (191bp) genes.





PCR amplification of ESBL producing *E. coli* and MRSA isolates

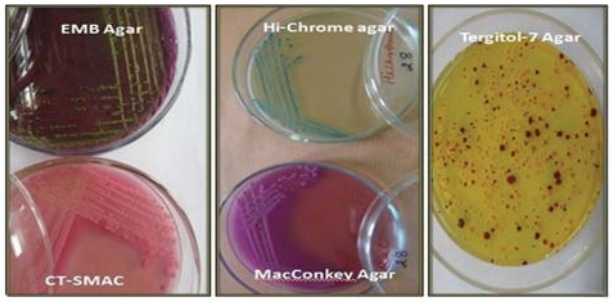
Antimicrobial resistant pattern of multi-drug resistant of bacterial pathogens in seafood from Veraval, Gujarat

Assessing the Multi Drug Resistant (MDR) Staphylococcal isolates from Gujarat: Total 17 bacterial isolates from seafood (n=32) along Veraval coast were biochemically identified as *Staphylococcus* sp. The antibiotic resistance pattern against 24 antibiotics were studied (Dodecca: Staphylococci 1 and 2, HiMedia, Mumbai). The higher level

of antimicrobials resistance pattern were with penicillin G (64.7%); piperacillin/tazobactam (58.8%); lomefloxacin (47%); pristinomycin (41%); azithromycin (35.2%); erythromycin (35.2%); clarithromycin (29.4%); clindamycin (23.5%); ciproflaxin (17.06%); gatifloxacin (17.06%); ampicillin/sulbactam (17.06%); cefoxitin (11.7%); linezoid (5.8%); ofloxacin (5.8%); moxfloxacin (5.8%); gentamycin (5.8%) and nitrofurantoin (5.8%).

The MDR Staphylococcal isolates were assessed based on the resistant to more than three classes of antimicrobial agents. Out of 17 isolates, nine isolates showed multi drug resistance to the tested antibiotics. The MDR rate is 52.9%.

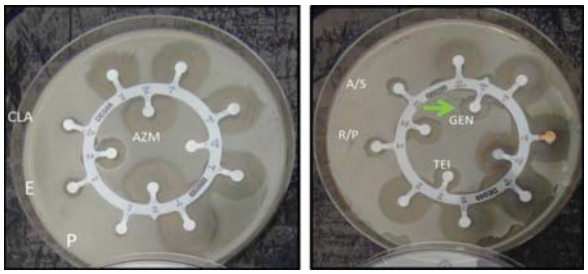
Antibiotic susceptibility of *E. coli* isolates from Gujarat: Antibiotic sensitivity test on 31 isolates of *E. coli* using 20 antibiotics were carried out. All isolates were sensitive to norfloxacin, levofloxacin, ciprofloxacin, tobramycin, amikacin and cefoxitin. Whereas, resistance was found for 13 antibiotics tested among these *E. coli* isolates. 19.35% of the *E. coli* isolates were multi-drug resistant.



Isolation and identification of *E. coli* isolates

Antimicrobial resistant patterns of *E. coli* isolates from seafood

Antibiotic susceptibility of coagulase negative Staphylococci from Gujarat: The isolation of coagulase negative Staphylococci (CoNS) from seafood (n=22) samples were carried out from Veraval region of Gujarat. About 31 numbers of CoNS were isolated and assessed for their antibiogram against 24 antimicrobial agents (Dodecca: Staphylococci 1 and 2, HiMedia, Mumbai, India) and its Minimum Inhibitory Concentration (MIC) with commercially available MIC readymade strips of amoxyclav, clindamycin, ciprofloxacin, erythromycin, gentamicin, methicillin, tetracycline and vancomycin with the antibiotic concentration of CLSI, 2015. The resistance patterns and MIC were interpreted according to CLSI Guidelines, 2015. The multi-drug resistant (MDR) Staphylococci was determined if found to be more than three classes of antimicrobial agents and found that more than 50% of the isolates were MDR. The MIC levels was found highest with oxacillin (51.61%), ciprofloxacin (38.71%), amoxyclav (35.48%) followed by erythromycin (6.45%), clindamycin (3.23%) and methicillin (3.23%). The intermediate resistance were also found among these isolates with vancomycin (38.71%), erythromycin (12.9%) and tetracycline (3.23%).



Antimicrobial resistant patterns of Staphylococcal isolates

Minimum inhibitory level of Staphylococcal isolates from seafood

BIOCHEMISTRY & NUTRITION

Research projects handled

Institute project

- Marine biomolecules characterization and utilization for nutraceutical, biomedical and industrial applications

Externally funded projects

- Nutrient profiling and evaluation of fish as a dietary component
- Exploration and assessment of demersal fishery resources along the continental slope of Indian Ocean and Indian EEZ
- Assessment of myctophid resources in the Arabian Sea and development of harvest and post harvest technologies
- Bio-modulation of marine biopolymers for the preparation of biomaterials of healthcare importance

Most significant achievements

- Fish oil rich in poly unsaturated fatty acid (PUFA) supplementation affect the mRNA and protein expression of enzymes of lipid metabolism. Mechanisms involved in the lipid lowering effect of PUFA-rich sardine oil were elucidated using RNA expression studies, western blotting and proteomic approaches.
- Thiamine-pyridoxine-vanillic acid-grafted chitosan showed stress mitigatory effect in stress-induced rats.
- Microencapsulation of squalene with maltodextrin and whey protein isolate gave an encapsulation efficiency of 96% and oxidative stability of more than four months. Anti-ulcerogenic effect of maltodextrin-encapsulated squalene was demonstrated.
- Chitosan–whey protein-encapsulated squalene was proved to be as good as gum Arabic for encapsulation of squalene. Cakes fortified with squalene microencapsulated with chitosan-whey protein complex had superior oxidative stability and textural quality.
- Developed a co-delivery system of betalain and PUFA by multiple emulsification and microencapsulation by spray drying.
- Supercritical fluid extraction of fucoxanthin and lipid from brown seaweed *Sargassum* sp. was attempted. Two seaweed-based products *viz*., Seaweed incorporated Juice-NutriDrink, and Seaweed-enriched fish soup powder were developed.
- Calcium and iron-fortified fish soup powder developed was tested among adolescent girls in West Jaintia Hills District, Meghalaya. The intervention resulted in a rise in haemoglobin levels in 96% of the subjects involved.

Chief findings

Institute project

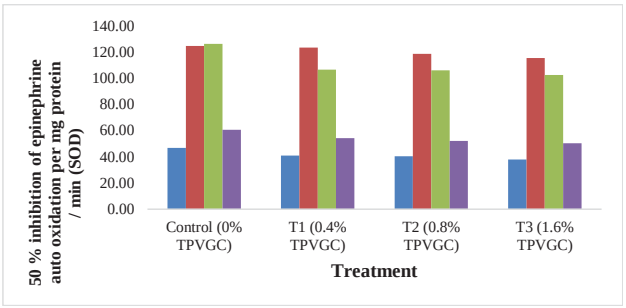
Marine biomolecules characterization and utilization for nutraceutical, biomedical and industrial applications

Cardio-protective effect of dietary supplementation of thiamine on myocardial infarction in female Wistar strain albino rats

Troponin–T, Serum LDH, CPK-MB, S-GOT, S-GPT, IgG, Homocysteine, Serum Myglobin exhibited significant ($p<0.05$) difference between the control and treatment groups. Dietary supplementation of thiamine and pyridoxine-loaded vanillic acid-grafted chitosan microparticles at 1.6% has protective effect on experimental myocardial infarction (MI). Troponin–T, a skeletal and smooth muscle protein is released into the blood stream during damage to the heart muscle. Troponin–T shows significant ($p<0.05$) difference between the control and treatment groups and higher Troponin–T activity was recorded in the control group and there was gradual decreasing trend in treatment group. Higher concentration of homocystein was recorded in the control group. On the other hand, dietary supplementation of TPVGC in the treatment groups caused lower level of homocystein concentration.

Stress mitigatory role of thiamine and pyridoxine-loaded vanillic acid-grafted chitosan microparticles in male Wistar strain albino rats

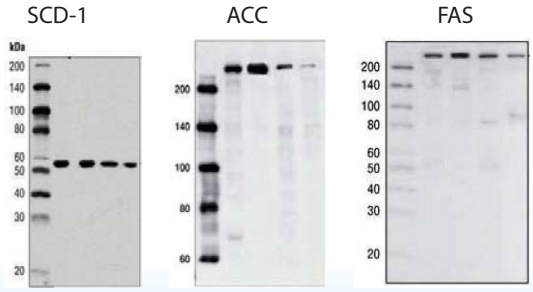
Metabolic responses assessed in terms of lactate dehydrogenase, malate dehydrogenase, Catalase, Superoxide dismutase (SOD) and Acetylcholine esterase (AChE) showed significant difference between control (higher activity) and treatment groups. Lowest AChE activity was observed in control, which increased gradually with the increasing level of thiamine and pyridoxine-loaded vanillic acid-grafted chitosan microparticles in the diet. SOD activity in male showed significant ($p<0.05$) difference among control and experimental groups and the activity showed decreasing trend with gradual increase in the inclusion graded level of TPVGC in the diet. Comparatively higher activity was found in kidney followed by liver, brain and muscle. The outcome of the present study reveals that dietary supplementation of thiamine and pyridoxine-loaded vanillic acid-grafted chitosan microparticles in the diet could be an effective means to enhance stamina of the animals during the swimming exercise and also has stress mitigatory role in the animals. Based on the performance of the developed product, we can confirm its application as novel ingredient of functional food or novel dietary supplement.



Impact of dietary supplementation of TPVGC on SOD activity in muscle, liver, kidney and brain tissue of male albino rats exposed to swimming stress

Elucidation of mechanisms of action of marine biomolecules - Polyunsaturated fatty acids

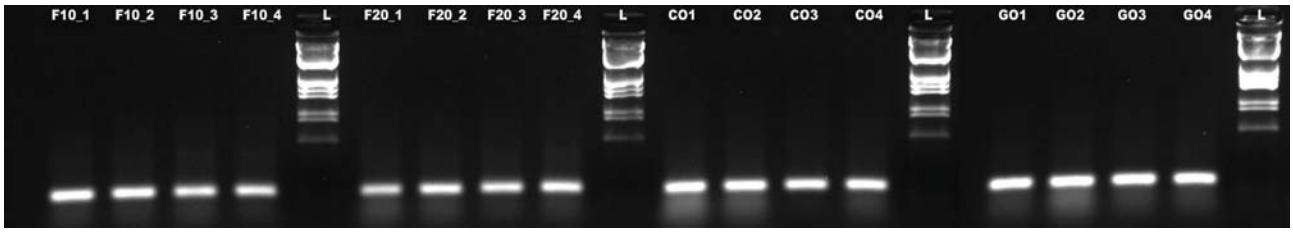
Studies were carried out in Wistar strain rats on RNA expression for determining the level of expression of four genes in liver, namely acetyl co a carboxylase (ACC) A and B, fatty acid synthase (FAS) and steroyl Co A desaturase-1 (SCD-1) in response to feeding of four different diets, namely groundnut oil (control), coconut oil and fish oil at 10 and 20%. Using Western Blotting Technique, the levels of the enzymes expressed by the mRNA in the liver namely ACC, FAS and SCD-1 were determined. The



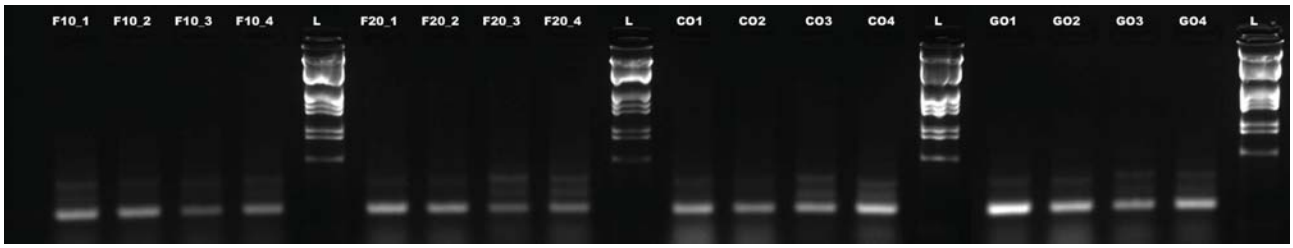
Western Blotting results

findings demonstrated that the levels of mRNA for ACC and FAS decreased and that of SCD-1 increased in groups of rats which were fed fish oil. Similarly fish oil feeding resulted in a decrease in the intensity of bands for ACC and FAS and an increase for SCD-1 as determined by Western Blot analysis of protein levels in rat livers. It was also interesting to note that the changes in the mRNA expression and the protein levels were dose-dependent. These proteins are potential targets to develop therapeutic strategies against lipid-related disorders.

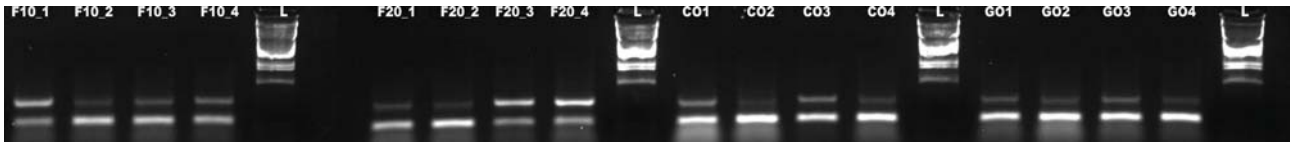
SCD mRNA Expression



ACC mRNA Expression



FAS mRNA Expression



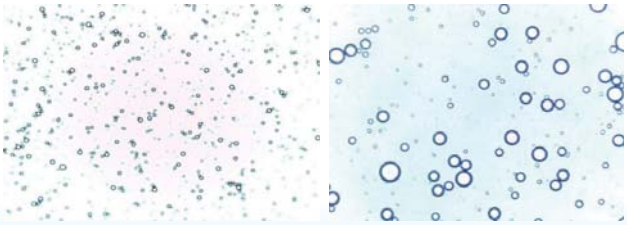
Northern Blotting results

Fish protein isolate from rohu by isoelectric solubilization and precipitation method

A procedure to prepare fish protein isolate from whole gutted rohu (*Labeo rohita*) using isoelectric solubilization and precipitation principle was developed. The extraction yield was 15%. The protein content of the isolate was 83% with negligible amount of fat (0.48%). Protein isolate could be considered as Type 1 protein concentrate for dietary supplement. The protein isolate was whitish in colour with a L* value of 64.59. Amino acid profile of the protein isolate showed proportional distribution of essential and non-essential amino acids. The protein isolate showed good emulsifying property (Emulsion stability index - 39.7%). Solubility of the protein ranged from 1.25-15 mg/mL depending on the pH.

Evaluation of the effects of different wall materials on the physico-chemical properties and oxidative stability of microencapsulated squalene

Microencapsulation of squalene using chitosan-whey protein isolate: For the preparation of emulsion, the wall materials (chitosan at 0.25, 0.5 and 1% and whey protein isolate at 10%) were evaluated. Among all emulsion preparations, emulsion with 10% WPI and 1% chitosan at 5.5 pH was found to be stable. Microstructure of the emulsion showed that the emulsions prepared



10X 40X

Microstructure of the emulsion

with 1% chitosan had smaller size and were visually free from any flocculation and aggregation and was used for the microencapsulation of squalene.

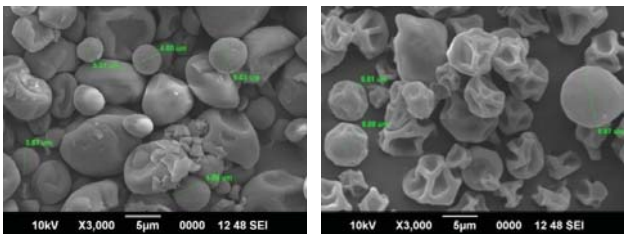
Microencapsulation of squalene using the optimized emulsion formulation: The conditions of inlet temperature of 170 °C and 16 rpm gave the maximum encapsulation efficiency and the powder yield were used for bulk production of encapsulated squalene powder and subjected to further characterization. The yield obtained was 87% while the encapsulation efficiency was 74%. Microcapsule characteristics like moisture (0.44%), solubility (57.78 to 74.07%) and Poly disperisty index (PDI-0.536) were determined. Particle size ranged from102.5 nm to 625.7 nm.

Functional food application of microencapsulated squalene: Oxidatively stable squalene microcapsules were used for development of functional food by enriching squalene powder in cake. The following three different treatments were prepared and compared: 1). Cake enriched with encapsulated squalene, 2). Cake enriched with non–encapsulated (pure) squalene, and 3). Cake without squalene as control. After product preparation, they were subjected to further characterization such as: nutrient profiling, oxidative stability, colour, texture, and sensory evaluation. Sensory analysis proved that cakes enriched with microencapsulated squalene scored higher in terms of appearance, colour, odor, texture, flavor and taste. Peroxide value of pure squalene-enriched cakes was 4.64 meqO_2/kg oil while that of cakes fortified with microencapsulated squalene was 2.5 meqO_2/kg oil, showing the protective effect of encapsulation against oxidation.

Comparative analysis of the physico-chemical attributes of squalene microcapsule prepared using different wall materials

Gum Arabic remains the most commonly used wall material for microencapsulation owing to its superior properties. Hence, squalene microcapsules prepared using chitosan-whey protein were compared with that of microcapsules prepared using gum Arabic in terms of their physico-chemical attributes.

External morphology of the microcapsules: Morphology of the microcapsules was analyzed with the help of scanning electron microscopy (SEM). Squalene microcapsules prepared using both the wall material were of spherical shape without apparent cracks and fissures. Gum Arabic-squalene microcapsules were smaller and showed smoother surface with fewer teeth or roughness. The microcapsules formed were of varying size too. This heterogeneity in particle size is a typical characteristic of spray-dried particles. The FTIR analysis confirmed the encapsulation of squalene with different wall materials.



SEM images of squalene microcapsule using gum Arabic and chitosan-whey protein complex

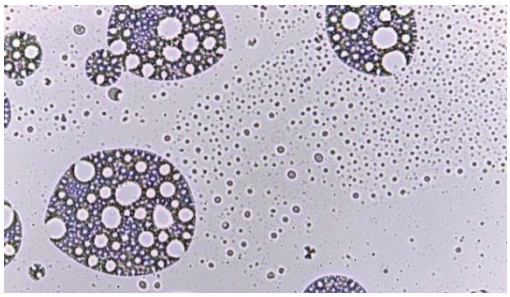
Thermogravimetric analysis (TGA): TGA is used to study the weight change of a material as a function of its temperature to assess thermal stability. Initial weight loss of 1.80-2.17% occurred between 74.02 to 206.64 °C for gum Arabic loaded with squalene whereas for chitosan-whey protein loaded squalene, an initial weight loss of 2.2% occurred between 66.21 to 161.85 °C. This initial weight loss may be attributed to the loss of bound water from the sample. Gum Arabic coating conferred thermal stability upto 451 °C whereas the chitosan-whey protein coating stabilized squalene upto 422 °C. The difference in the thermal stability conferred by the two wall materials is marginal. Taking into consideration the higher price and fluctuations in the availability associated with gum Arabic, chitosan–whey protein combination can be considered as a good wall material.

X-ray diffraction analysis (XRD): XRD is used to identify the crystallinity and to determine the structural stability of microparticles. XRD patterns with broad peaks indicate amorphous structures, because the molecules in the amorphous state are disordered and produce scattered bands. All samples had an amorphous structure, as indicated by large diffuse and broad peaks. Squalene encapsulated with gum Arabic exhibited marginally superior properties than chitosan-whey protein. However, all the physico-chemical properties of squalene microcapsule prepared with

chitosan–whey protein isolate were within the allowable limits. Hence chitosan–whey protein can also be considered equivalent to gum Arabic for encapsulation of squalene.

Development of a co-delivery system of betalain and PUFA: Multiple emulsification and microencapsulation by spray drying

Microencapsulation is one of the promising methods that can minimize oxidative deterioration of ω-3 oils by converting into a stable free-flowing powder. The co-delivery of betalain and PUFA in a water in oil in water (w/o/w) multiple emulsion by multiple emulsification and spray drying was investigated. Betalain formed the inner aqueous phase, PUFA formed the oil phase and chitosan-whey protein emulsifier combination formed the outer aqueous phase in a two-step emulsification procedure. The microstructure images of emulsion showed the typical water in oil in water (w/o/w) type emulsion structure.



Emulsion microstructure of water in oil in water (w/o/w) emulsion

Yield of encapsulated PUFA by spray-drying was ~58%. Moisture content of the powders varied between 0.17% and 1.87%. Loading efficiency of encapsulated powder was found to be 32.6g/100g powder and encapsulation efficiency was 87%. The zeta potential of the re-dispersed particles were obtained as -24.1mv. This indicates that the dispersion is fairly stable and the particles are negatively charged. The hydrodynamic Z average diameter was recorded as 2.34 µ.

Development of fortified foods, profiling, packaging, storage and stability determination

Fish soup powder was prepared by standardized procedure optimizing for the protein content. Nutrient profiling with respect to protein, lipid, amino acid, fatty acid and mineral content were carried out. When contaminant profiling was carried out, contaminants like pesticides, heavy metal residues and PAH, antibiotic residues were not detected. Storage and stability determination studies have shown that the product was safe for consumption with biochemical as well as microbiological parameters being well within limits. Packaging studies on fortified fish soup powder in ready to drink form with freshly added vegetables were also carried out.

Fortified fish soup

Animal experimentation to determine safety of consumption: Experiments were carried out to determine the safety of consumption of the fortified fish soup powder. The rats fed with fortified fish soup powder did not show any signs and symptoms of sickness and registered growth similar to that of the rats given control diet. Pilot scale production (15 Kg) of fortified soup powder was done in the Institute's Pilot Plant Facility. For testing of the developed fortified food in a population, Integrated Child Development Scheme, Jowai, West Jaintia Hills District, Meghalaya and Health Department, Jowai, Child Development Project Officer, Thadlaskein Block, Jowai, and ICAR-CIFT officials met on 21 November, 2016, on the occasion of World Fisheries Day to

Deputy Commissioner (2nd from right), West Jaintia Hills District, Meghalaya trying the fortified fish soup at the meeting organized to commemorate World Fisheries Day

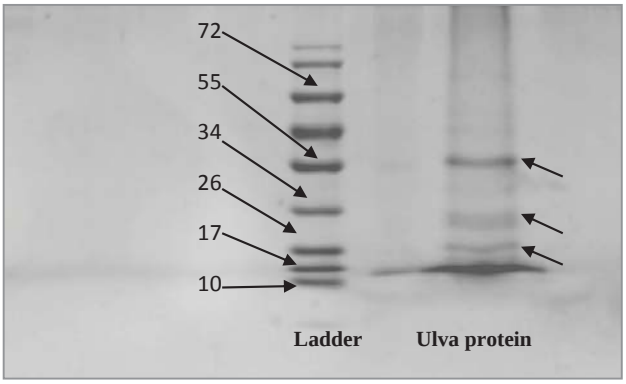
chalked out a one month programme of distributing fortified fish soup to 57 adolescent girls selected to improve their haemoglobin levels and health status. Fifty adolescent girls of 11-16 years were selected from three villages. They were provided with 100 mL of hot soup prepared with 10 g of fortified fish soup powder once every day for 30 days in a community setting. Statistical analysis showed that the changes in the levels of haemoglobin in the adolescent girls post-intervention with fortified fish soup powder were significant. Shelf life of fortified fish soup powder was evaluated over a period of six months in terms of degradative changes induced by microbial and chemical profile alterations. The mesophilic bacterial load remained static at 2.0-2.1x10^4 cfu/g indicating cessation of growth and spoilage. Coagulase positive Staphylococci and Staphylococcal enterotoxins were absent during the storage period. The water activity of this powdered product remained at 0.40-0.45, which indicated complete inhibition of microbial growth. The total volatile base nitrogen (TVBN) and Trimethyal amine (TMA) content were observed in the range of 49-70 mg% and 35-38.5 mg%, respectively. Overall, product was found to be acceptable by sensory, microbiological and chemical quality parameters.

Development of nutraceuticals for food applications from seaweeds: Nutritional significance of potentially edible seaweeds

Nine potentially edible tropical seaweeds from Saurashtra coast (Phaeophyta and Chlorophyta) were studied for their nutritional composition, mineral content and nutraceutical potential. The seaweeds considered for the studies were green seaweeds (*Ulva reticulata*, *Valoniopsis* sp., *Boodlea composite* and *Caulerapa sertularioides*) and brown seaweeds (*Sargassum johnstonii*, *Padina gymnospora*, *Padina tetrastromatica*, *Cystoseira indica* and *Dictyopteris australis*). On dry weight basis the protein, fat and carbohydrate content of green seaweed varied from 6.31 to 21.55%, 0.77 to 3.72% and 41.60 to 71.62%, respectively and for brown seaweed it varied from 8.53 to 13.88%, 0.34 to 2.56% and 54.01 to 70.36%, respectively. The estimation of mineral showed that seaweeds contained high amounts of the macro-minerals Na, K, Ca and Mg (2217.38-17092.62 mg/100) and trace elements Fe, Mn, Zn, Cu and Co (11.38-411.0 mg/100g). The sodium potassium ratios (Na/K) were below 2.5 and mostly remained near 1.5. The ion quotient i.e. molar ratio of $[Ca^{+2}] + [Na^{+}] / [Mg^{+2}] + [K^{+}]$ was recorded between 1.52 to 3.9 with the few exceptions.

Isolation and partial characterization of proteins extracted from *Ulva* sp.

Ulva lactuca was collected from Adri beach, near Veraval, air dried and milled in a grinder to achieve a homogeneous powder. Protein was extracted, quantified and precipitated using 80% acetone. The protein pellet was dissolved in 6N urea. The protein was further analyzed for its molecular mass range on 10% Poly acrylamide gel electrophoresis (PAGE). The PAGE clearly showed distinct band near 30 KD, 20 KD and 10 KD. Eventhough the PAGE is indicating presence of small peptides of 10 to 30 KD, the protein is not known. Therefore further characterization is required to unfold the proteins present and its possible use.



Poly acrylamide gel electrophoresis (PAGE) of protein extracted from *Ulva*

Fatty acid profile of seaweeds collected from Okha

Five species of seaweeds such as *Valoniopsis* spp., *Caulerapa sertularioides*, *Boodlea composite*, *Padina tetrastromatica* and *Cystoseira indica* were analyzed for their fatty acid composition. The results indicate that among the above five seaweed species C18:3 n3 was one of the most abundant fatty acid which in *Valoniopsis* was 17.20% and in *Caulerapa* 7.11%, whereas in brown seaweed it was 9.9% in *Padina* and 34.25% in *Polycladia*.

Supercritical carbon dioxide extraction of fucoxanthin and lipid from brown seaweed

Fucoxanthin and lipid-rich extract were obtained from brown seaweed (*Sargassum* sp.) by supercritical carbon dioxide extraction. A preliminary extraction was done with 5% co-solvent (ethanol), 250 bar extraction pressure, 40 °C temperature for 4.5 h. Fucoxanthin content was 1.5 mg/g of the extract. The extract was rich in saturated and unsaturated fatty acid. Total phenolic content in the extract was 5.04 mg gallic acid equivalents/g of sample. Total antioxidant activity of the extract was 26.16 mg ascorbic acid equivalent/g.

Physico-chemical and functional properties of dietary fibre from seaweeds

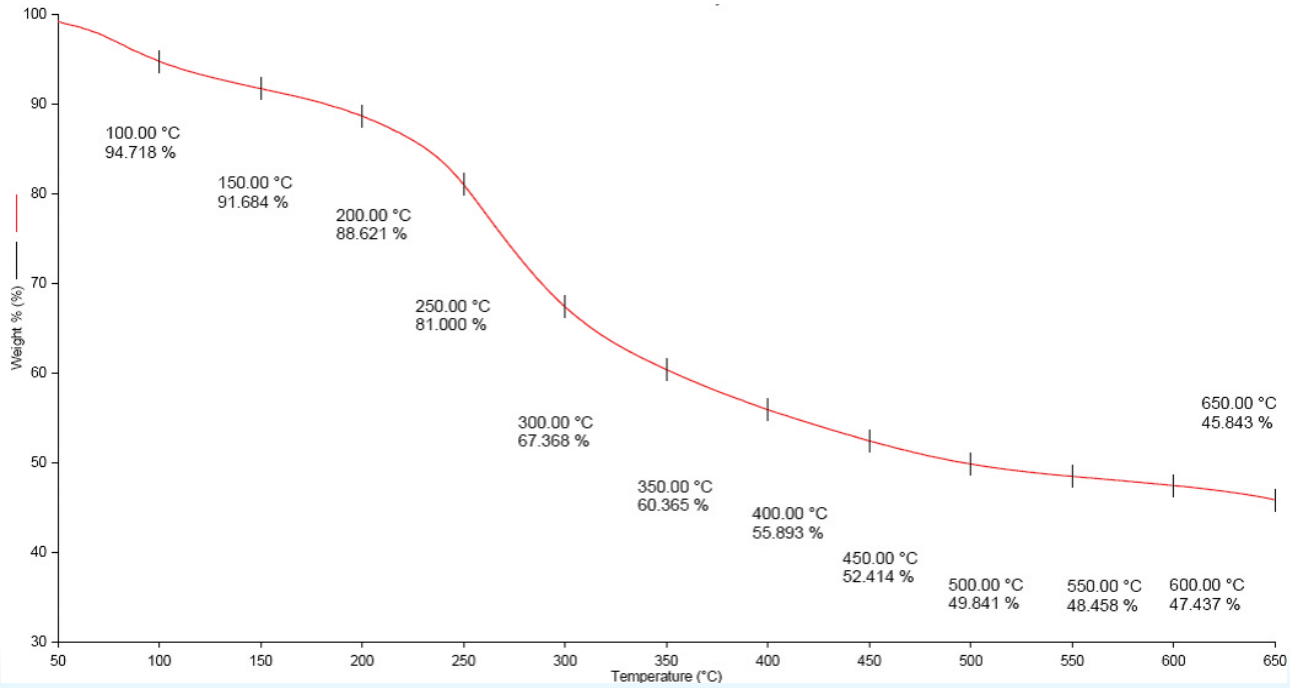
Dietary fibre from *G. edulis, S. wightii* and *U. lactuca* extracted under optimized conditions were analyzed for their physico-chemical and functional properties like FTIR analysis, hydration properties (water holding capacity and swelling capacity), oil holding capacity and antioxidant properties (total phenolic content, DPPH-free radical scavenging activity and reducing power assay). FTIR spectroscopy was performed in the 4500-400 cm^{-1} region for precise characterization of dietary fibre extracted under optimum extraction conditions. The general spectral profile of the dietary fibre was almost similar with minor changes in absorbance and/or wave numbers of characteristic bands.

Antibacterial activity of seaweeds

Acetone and chloroform extracts of *Ulva lactuca* were tested for antibacterial activity towards *Salmonella* Typhimurium, *Morganella morganii*, *E. coli*, *Listeria monocytogenes* and *Staphylococcus aureus*. The acetone extract of *U. lactuca* showed antibacterial activity towards *E. coli* (14 mm) and *V. cholerae* (11 mm). The acetone extraction was followed sequentially by chloroform extract. The chloroform extract of *U. lactuca* had peaks in visible (505, 610, 660 nm) and infrared (995, 1020 and 1100 nm) regions and showed antibacterial activity towards *V. cholera e* (22 mm).

Thermogravimetric analysis of polysaccharide extracted from *Polycladia indica*

The primary thermogram of polysaccharide isolated from *P. indica* showed thermal behavior and thermal stability of polysaccharide when heated at a rate of 10 °C/min. from 50 °C to 700 °C. The thermogram showed two mass loss events when heated. The early minor weight loss (50 °C to 250 °C) in the sample is attributed to the loss of absorbed

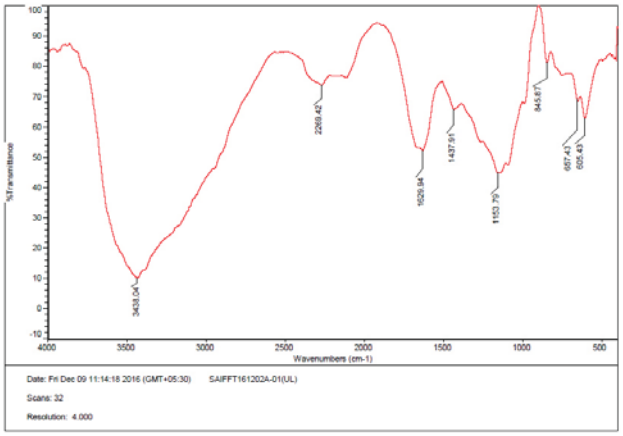


TGA thermograph of polysaccharide extracted from *Polycladia indica* (Heated from 50 °C to 700 °C at the rate of 10 °C/min.)

and structural water of biopolymers. The second weight loss event may be attributed to the actual decomposition of polysaccharide. The onset of weight loss process (250 °C) of polysaccharide shows that the extracted polysaccharide has good thermal stability.

Extraction of bioactive compounds like Ulvan polysaccharide

Fine white powder of Ulvan polysaccharide - a polymer that is known to have bioactive potential extracted from *Ulva lactuca* had a yield of 20%. Biochemical composition like Carbohydrate content (619 mg/g), Uronic acid content (59 mg/g), Protein content (0.002 mg/g), Sulphated polysaccharide content (33.8 mg/g) and antioxidant property (DPPH Scavenging Assay) (IC_{50}22.1 µg/ml) was determined. Elemental analysis ie. percentage of C (20.55±0.09), H (3.23±0.01), N (1.50±0.01), and S(9.07±0.58) was performed by combustion to evaluate the content of the major components present in the extracted Ulvan. Structural characterization of the Ulvan was done by FTIR. Thermal degradation and thermal transitions of the extracted compound were studied by Thermo Gravimetric Analysis (TGA) and Differential Scanning Calorimetry. Chemical characterization by elemental analysis and FTIR revealed that the extracted Ulvan is chemically similar to polysaccharides extracted from similar sources. The occurrence of sulphur of more than 9% and the peak corresponding to sulphate ions in the IR-spectra confirm that the extracted Ulvan is a sulphated polysaccharide. Spectrophotometric determination also revealed occurrence of uronic acids. A characteristic band at 3341.03 cm^{-1} corresponding to -OH groups, which is consistent with the structure of disaccharides is observed. Two bands at 1226.83 cm^{-1} and 789 cm^{-1} are indicatives to the bounds C-O-S of sulfated groups. The band 1629.94 cm^{-1} is allocated to the vibration of C=O of the uronic acid.



Infrared spectrum of Ulvan between 400 cm^{-1}

Extraction of bioactive fraction from seaweed and its use in fortification of fish soup powder

In the present study, *Ulva lactuca* was initially extracted with n-hexane, chloroform and water:ethanol mixture. Carbohydrate content (11.45 mg/100g), phenolic compounds (10.61 mg/100g) and flavanoid content (28.9 mg/100g) were high in ethanol: water extract. The extracts subjected to colour reactions revealed that water: ethanol extracted *U. lactuca* was rich in glycosides, carbohydrates, alkaloids etc. Hence this extract was fractionated by column chromatography using varying proportions of cyclohexane and ethyl acetate. Fraction 8 exhibited the maximum antioxidant potential based on the very low IC_{50} value obtained and also high content of total phenolic compounds and flavonoids.

Ulva lactuca seaweed

IC_{50} value of antioxidant activity, total phenolic componds and flavonoid content of *Ulva lactuca* fractions

IC_{50} (mg mL^{-1}) DPPH-free radical scavenging	TPC (mgGAEg^{-1})	FC (mg RE g^{-1})
0.881±0.024[a]	8.254±0.361[d]	33.094 ± 3.631[a]

For each treatment the means within the column by different letters are significantly different at $P < 0.05$. Each value is expressed as the means ±SE (n=3).

This fraction was used to fortify fish soup powder. In order to establish that consumption of seaweed extract was safe from toxicity point of view, acute toxicity tests were performed in mice. Fortification was evaluated from 10 to 50% and by sensory organoleptic scoring, 30% level of fortification was found most acceptable. Proximate composition, amino acid and fatty acid composition of the fortified soup powder were analyzed. Fortified soup powder was found to be rich in protein, essential amino acids and also essential fatty acids like EPA and DHA. Fortification at 30% level was found acceptable.

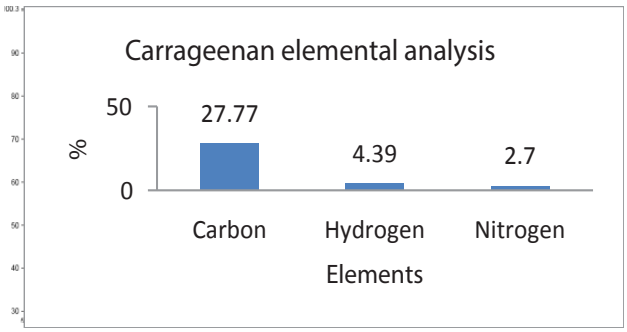
Fortified soup powder

Extraction of sulphated polysaccharide and its characterization

Sulphated polysaccharides from *Polycladia indica* and *Sargassam* sp. were extracted using enzyme extraction method. The enzymes used for extraction were Viscozyme and Protamex. The yield percentage of sulphated polysaccharide was between 5.5 to 6%, respectively. The study revealed that the polysaccharide extracted from seaweed *P. indica* has a typical fucoidian structure which contains sulphate group, uronic acid, D-galactose, glucronic, manuronic acid etc. The presence of different functionality especially O-acetyl group qualifies the polysaccharide as an efficient immuno-stimulant.

Extraction and characterization of carrageenan from *Kappaphycus* sp.

Carrageenan extracted from *Kappaphycus* sp. (red seaweed) was characterized using FTIR and thermal property and was analyzed using TGA and elemental analysis. Carbon, hydrogen and nitrogen were estimated through CHN/S analyzer. The FTIR spectra revealed broad spectra typical of almost all polysaccharides. The thermogram shows that the carrageenan is thermally stable. The elemental analysis shows that the extracted carrageenan contains 27.77% carbon, 4.39% hydrogen and 2.70% nitrogen.

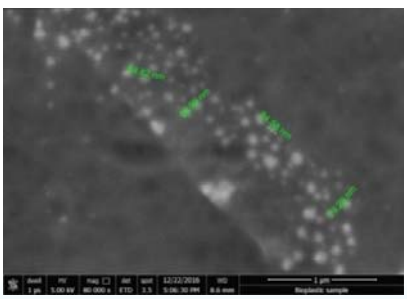


TGA analysis of carrageenan extracted from *Kappaphycus* sp.

Synthesis and characterization of seaweed extract based bio-plastic reinforced with silver nano particles

Agar film reinforced with silver nano particles was prepared using a solution casting method and their properties were characterized. FTIR analysis confirmed the formation of physical interactions between the polymer matrice and nano-particles. The SEM micrographs are in agreement with the results of FTIR and showed even distribution of silver

Silver nano particle-incorporated agar film

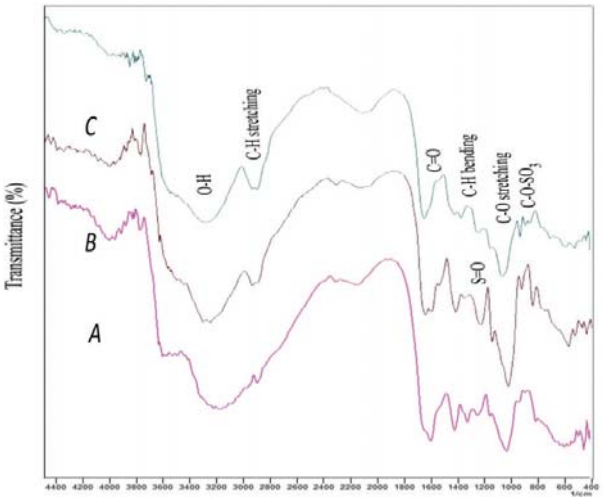


Scanning electron micrograph showing size of silver nano particles in the film

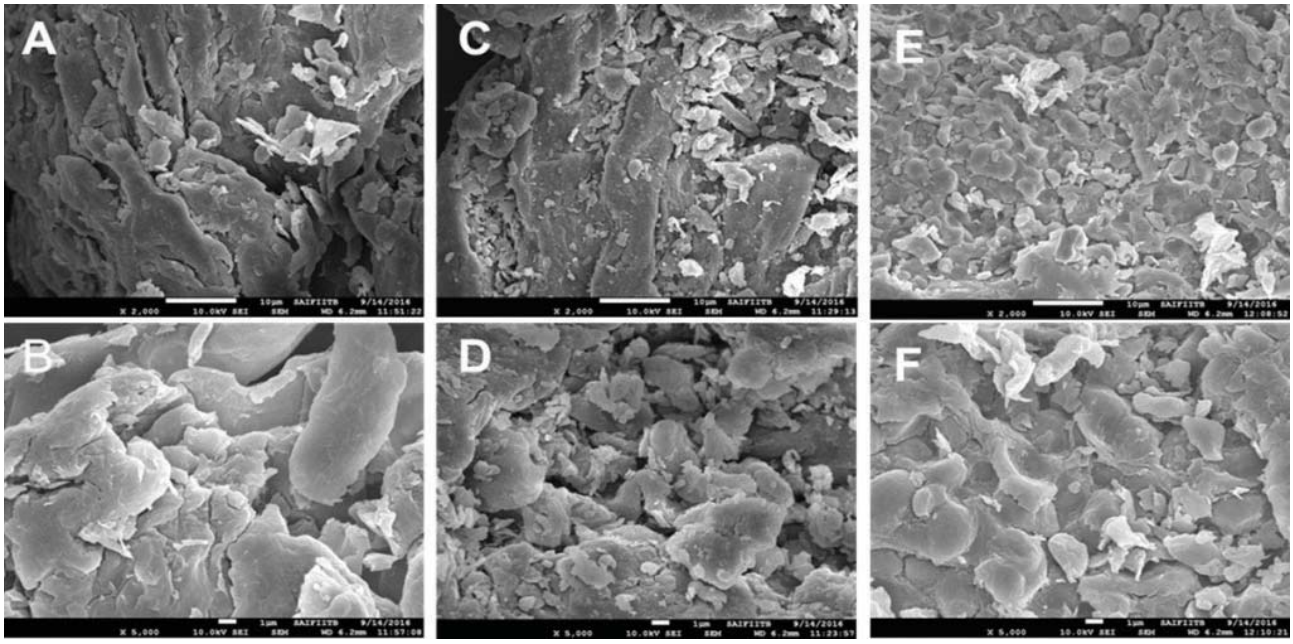
nano particles with particle size of 60 to 100 nm. Analysis showed the stability of the bio-polymer over a reasonable temperature range. The silver nano particle-incorporated agar film exhibited a distinctive antimicrobial activity. The microbial analysis also showed that silver nano particle-incorporated agar film has strong inhibition towards *Staphylococcus aureus* (ATCC 25923 and ATCC 43300) as well as emerging pathogens like MRSA.

Physico-chemical and functional properties of dietary fibre from seaweeds

Dietary fibre from *G. edulis, S. wightii* and *U. lactuca* extracted under optimized conditions were analyzed for their physico-chemical and functional properties. The highest water holding capacity and swelling capacity was found in dietary fibre extracted from *G. edulis* and the highest water holding capacity at 40 ºC was found in dietary fibre extracted from *S. wightii*. At a concentration of 30 mg/mL, the dietary fibre from *S. wightii* showed DPPH-free radical scavenging ability higher than 50%, whereas, dietary fibre from *U. lactuca* had higher reducing power followed by dietary fibre from *S. wightii* and *G. edulis*. FTIR spectral profile of the dietary fibre from *G. edulis, S. wightii* and *U. lactuca* were almost similar with minor changes in absorbance and/or wave numbers of characteristic bands. FTIR spectral profile revealed the presence of sulfate group in seaweed dietary fibre. SEM image of dietary fibre from *G. edulis* and *S. wightii* showed irregular, uneven and loosend surface with greater numbers of cracks and holes compared to dietary fibre from *U. lactuca*.



FTIR spectrum of dietary fibre extracted from A) *G. edulis*, B) *S. wightii* and C) *U. lactuca*

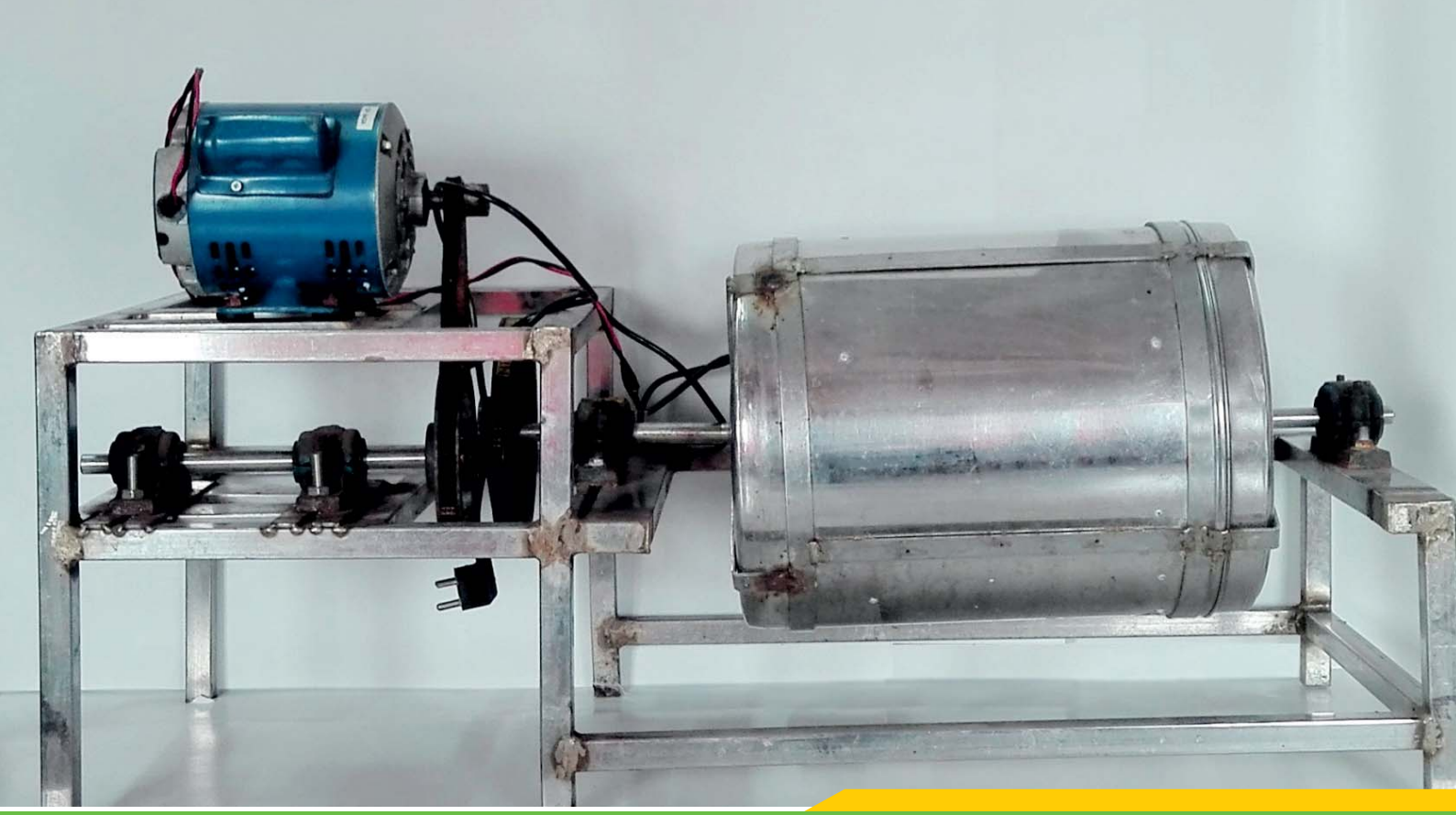


Scanning electron microscope image of the dietary fibre from (A) *G. edulis* x2000, (B) *G. edulis* x5000, (C) *S. wightii* x2000, (D) *S. wightii* x5000, (E) *U. lactuca* x2000 and (F) *U. lactuca* x5000

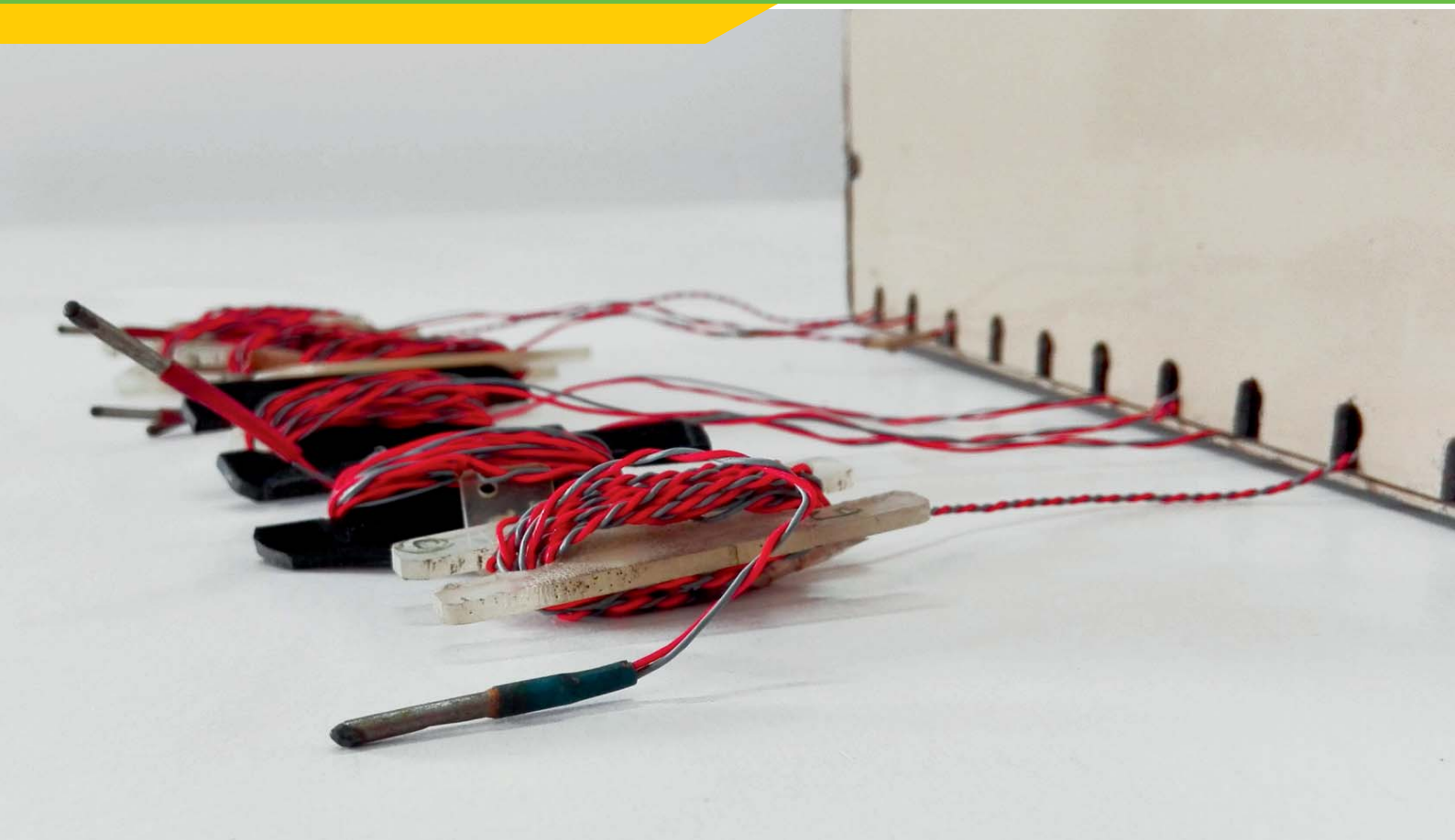
Antibacterial activity of seaweeds

Acetone and chloroform extracts of *Ulva lactuca* stored under refrigeration for six months were tested for antibacterial activity towards *Salmonella* Typhimurium, *Morganella morganii*, *E. coli*, *Listeria monocytogenes* and *Staphylococcus*

aureus. Absorption spectra of acetone extract had two peaks at 425 nm and 660 nm corresponding to chlorophyll a (430 nm and 662 nm). The acetone extract of *U. lactuca* showed antibacterial activity towards *E. coli* (14 mm) and *V. cholerae* (11 mm). The acetone extraction was followed sequentially by chloroform extract. The chloroform extract of *U. lactuca* had peaks in visible (505, 610 and 660 nm) and infrared (995, 1020 and 1100 nm) regions. The major peak in the visible region was at 660 nm. The chloroform extract showed antibacterial activity towards *V. cholerae* (22 mm), *Salmonella* (11 mm) and *E. coli* (11 mm).



ENGINEERING



Research project handled

Institute project

- Quality improvement of Indian fishing fleet and engineering interventions in post harvest sector

Most significant achievements

- Performance evaluation study of ICAR-CIFT solar dryers was conducted for various fishes (mackerel, sardine, nandan and solefish).
- A multi-purpose (fish drying, water heating and electricity generation) solar thermal conversion system with biomass water heater backup was designed and fabrication work is in progress.
- Redesigning of the existing ICAR-CIFT solar-LPG hybrid dryer has been completed.
- Preliminary trials were conducted for development of a fish freshness sensor by measuring colour of fish eye, flesh, skin and gill over one week storage period, and corresponding TMA, TVN values of fish flesh were also measured.
- A new portable household electrical dryer of 10 kg capacity was designed and fabricated. Initial testing has been completed and the dryer can be used for household or micro scale drying of fish and fishery products with lower capital investment. Also, provision for supplemental heating by solar power was incorporated in the design.

Chief findings

Institute project

Quality improvement of Indian fishing fleet and engineering interventions in post harvest sector

Skill deficiency analysis among FRB boat workers

Based on the skill analysis of FRP boat workers, preparation of a training module to equip them has been initiated for increasing quality of FRP boat construction. The module includes hands-on training for a duration of six months on FRP boat building with theoretical instructions from ICAR-CIFT. The programme is planned to be implemented under the Agri-Business Incubation Centre of the Institute and meets the national skill-training initiative. M/S Samudra Shipyard (P.) Ltd., Aroor has evinced interest to hand-hold the programme on a pilot scale.

Studies on boat construction, propellers and engines

Based on the collected propeller fabrication data and their analysis, an innovative method has been devised to assess the loads of propellers at the propeller manufacturer's end without the need to append the designs of boat or engine parameters. This method is expected to help fishermen to select correct propellers by utilizing the maximum available power in a boat and thereby to reduce fuel wastage. Field level validation of naturally aspirated engines with respect to their test-bed performances was taken up. Accordingly, validation procedure for naturally aspirated diesel engines was finalized.

A house hold survey in Alappuzha-Cherthala coastal villages and interactions with stakeholders were conducted in association with NETFISH (MPEDA) and Alleppey Social Service Society to introduce low cost solar dryers for the benefit of coastal fisherwomen. Two days training programme on "Improved fish drying practices" for fisherwomen of the selected villages from Alappuzha was organized by the Institute during 8-9 December, 2016.

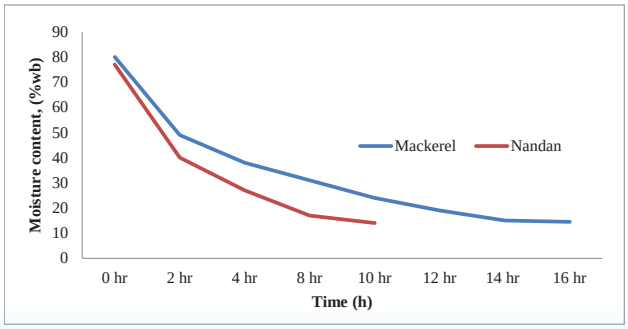
Performance evaluation study of ICAR-CIFT dryers

Performance evaluation of ICAR-CIFT dryers has been conducted in order to improve the efficiency of drying process. Experiments were conducted for different fishes (mackerel, sardine, nandan and solefish) in four types of ICAR-CIFT dryers, *viz*. solar cabinet dryer (electrical backup), electrical dryer, solar tunnel dryer and solar electrical-hybrid dryer.

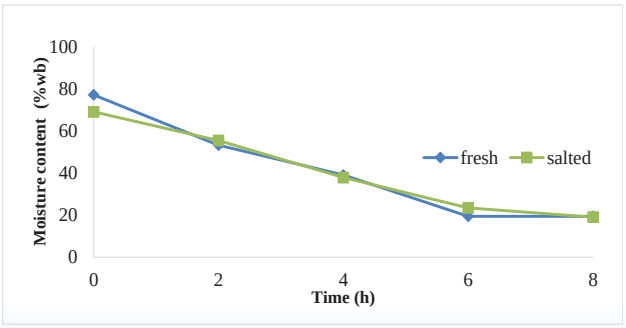
Drying process flow of mackerel fish in ICAR-CIFT solar dryer

Drying kinetics of various fishes in solar cabinet dryer with electrical backup

From the drying studies, it was observed that moisture content of mackerel reduced from the initial value of 80 (% wb) to final moisture content of 14.5% in 15 h time. Similarly, moisture content of nandan fish reduced from 77 (% wb) to 14 (%wb) in 10 hours. Sensory analysis of parameters of dried fish were conducted and found to be within the



Drying curve of mackerel and nandan in solar cabinet dryer



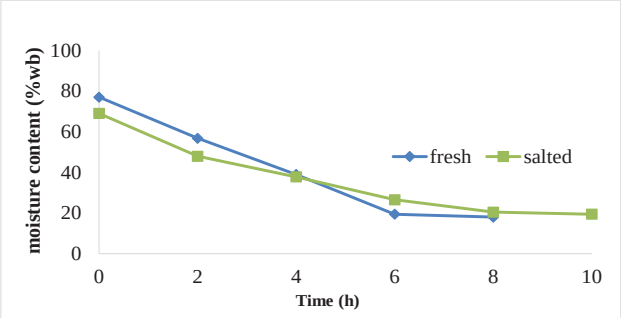
Drying curve for fresh and salted solefish in solar cabinet dryer

acceptable limits. Water activity of dried mackerel and nandan fish were 0.78 and 0.76 respectively, which were in turn indications of quality dried products.

Solefish was dried using solar cabinet dryer and found that attaining a final moisture content of 18-20% wb requires 8 h of drying time. The quality of drying was confirmed through measurement of water activity which were recorded as 0.70 for salted fish and 0.74 for fresh fish.

Drying kinetics of solefish in electrical dryer

Drying study of solefish in electrical dryer was conducted at 60 °C with average fish temperature of 58 °C. It was observed that drying time of 10 h is required to dry solefish to the optimum moisture content. Energy consumption was observed to be higher (1 kWh) in this dryer. The dried product showed uniform drying and better quality.



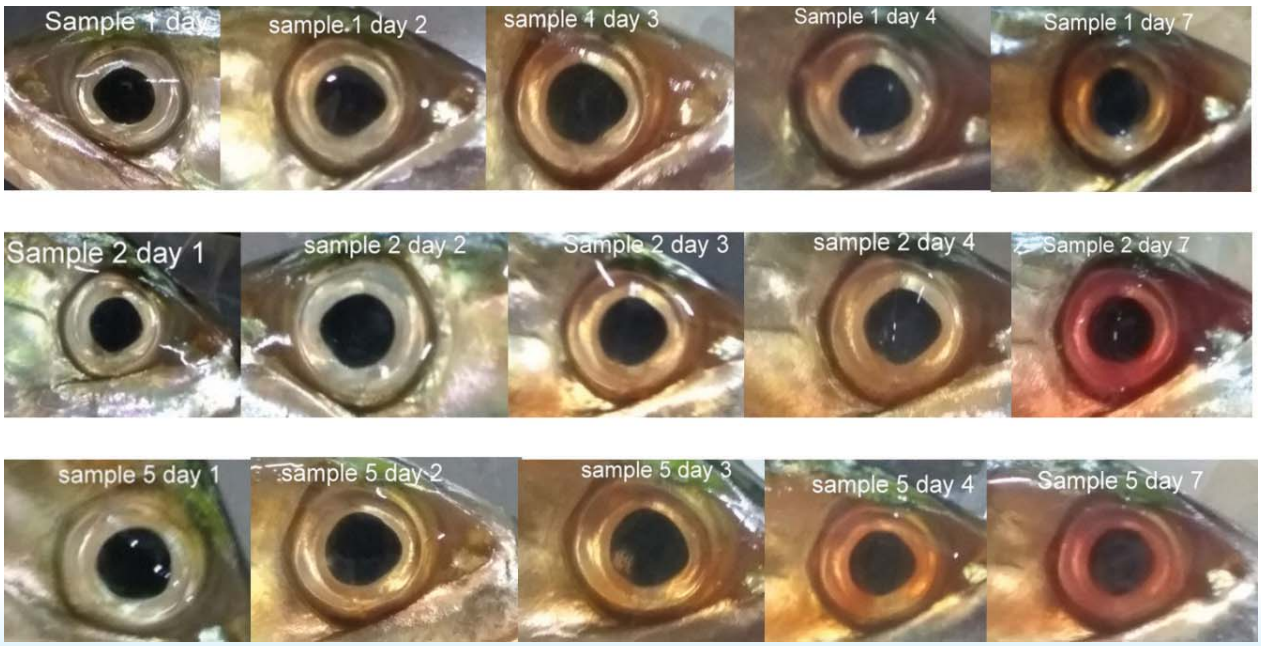
Drying curve for fresh and salted solefish in electric dryer

Drying characteristics of tunnel dryer

The average temperature of fish in the drying chamber was 45 °C. The average solar radiation was 350 W/m^2 and the time taken to complete drying of fish (<20 % MC) was three days. From the performance evaluation studies, it was concluded that the drying time depends on the type of fish used and conditions of drying. It was also observed that atmospheric conditions had lesser effect on drying process because of efficient electrical back up. In addition, preservation of colour, quality of food, quality of drying etc. of the dried product were observed in ICAR-CIFT dryers. The heating coil with automatic heating system helped to improve the quality of the dried product. Standardized specifications of each dryer with customized indicators for different types of fishes are under preparation.

Preliminary studies on fish freshness sensor development

Fish eye colour is one of the important parameters which determines the freshness of fish. Hence, studies on developing an electronic fish freshness sensor based on change in fish eye colour with respect to time have been



Images depicting gradual changes in the colour of fish eye with respect to time

initiated. Trials were conducted with mackerel to determine the daily variations in colour of eye, gill and skin during week-long storage. The colour changes in fish eye, gill and skin were observed as L^*, a^* and b^* values using Hunter colour flex meter at fixed wavelength of 330 nm. The results revealed that there is a clear trend in case of change in eye colour with respect to storage time for mackerel fish. Also, image analysis of fish eye colour revealed a significant colour changes in fish eye i.e. from transparent to reddish yellow colour over a week-long storage.

Portable household electrical dryer

A10 kg capacity portable household electrical dryer was designed and fabricated, which can effectively be used in micro and small scale fish processing units, household environments and laboratories for in-house drying of fish, fishery products and other agricultural products throughout the year. It can be installed inside the kitchen/room or laboratory with minimum accessories. The unique exhaust design helps to eliminate bad odours and an auto cut-off system for temperature ensures uniform and better quality dried products. The drying chamber consists of 10 trays made up of aluminium frame and stainless steel wire mesh for keeping the products. The ambient air is forced into the dryer by means of a fan located at the bottom, which subsequently gets heated by two electrical coils of 1500 W each. The resulting hot air passes through the drying chamber across the material to be dried. The maximum drying time required is around 6-7 h for fish and the maximum temperature attainable in the drying chamber is 50 °C.

Portable household electrical dryer

Other research activities undertaken

- Designed a system for cooking clam hygienically using steam generated by biomass fuel and also a system for separating clam meat from the shell after cooking. The work was carried out as part of the DST-project "Development of clam cluster and clam processing facility at Perumbalam Village, Alappuzha district, Kerala".
- A transport vehicle with kiosk for selling fish at consumer doorstep, having facilities for cleaning, de-scaling, cutting, display and refrigeration has been designed and fabricated.
- A setup of multipurpose (drying, water heating and electricity) solar thermal conversion system based on solar evacuated tube water collector and biomass heater furnace was fabricated and few parameters like temperature, RH etc. were monitored to optimize the fish drying conditions.
- A redesign for existing ICAR-CIFT solar hybrid dryer with LPG backup was prepared and renovation works initiated.

EXTENSION INFORMATION & STATISTICS

Research projects handled

Institute projects

- Modeling studies for estimation of revenue based capacity and valuation of selected fishing systems and fish supply chain analysis
- An assessment of the impact of S&T outputs of ICAR-CIFT on the socio-economic fabric of fisheries stakeholders
- Development of standard processes and protocols for innovative products from aquatic resources, shelf life modeling and assessment of energy use

Externally funded projects

- Indigenous Traditional Knowledge (ITKs) in marine fisheries sector of Kerala: Documentation and analysis
- Development of clam cluster and clam processing facility at Perumbalam village, Cherthala taluk, Alappuzha district, Kerala
- Assessment of role and impact of Fisheries Co-operatives in enhancing the livelihood and resources management capabilities of fisherfolk in India

Most significant achievements

- Economic input indicators of trawl fishery in Ernakulam showed that average operational cost during a fishing trip is: Operational costs including cost of diesel - ₹ 42,117, Engine oil - ₹ 525, Ice - ₹ 7000, Ration - ₹ 5000 and Repair and maintenance - ₹ 1000. The crew's share amounted to 40% of the owners' revenue. The trip-wise income from trawl fishing ranged from ₹ 17,750 to ₹ 70,800.
- Fish supply chain for three selected fish markets in Ernakulam revealed that the fish arrivals to these markets were from outside Kerala (Tamil Nadu, Andhra Pradesh, Odisha and Gujarat) besides local harbours and landing centres. The length of market chain is diverse ranging from 10 km to 60 km.
- The body mass index (BMI) status of the fisher respondents was compared using the WHO classification. The results showed that majority of adults were in the healthy weight group (64.71%). Among the respondents studied, 56% males and 73% females were falling in the healthy weight category. This also revealed that the gaps between healthy weight and obese were very narrow in males than in females.
- Fishermen perception on fishing capacity utilization at Puthiyappa, Kozhikode revealed that most important dimension is 'Increasing fishing pressure and cost'. It is followed by their concern about resource depletion and need for conservation. The same study at Kollam showed that the perception towards community participation in management was the most preferred among the five factors regulating the community resources, with a mean ranking score (MRS) of 4.83 followed by community sea rights (MRS-4.67) and *inter-intra* conflicts between different fish stakeholders with MRS of 4.60.
- The major impact indicators of Fishermen Co-operative Societies as perceived by the fishermen on various activities were compared for Kerala and Tamil Nadu. In Kerala activities undertaken by Fishermen Co-operative Societies had impacted on access to institutions (85.79%), production (76.70%), profit (73.26%), management (62.48%) and livelihood (52.91%). In Tamil Nadu, the figures were lesser in comparison to Kerala ranging from 53.82% for management to a low of 35.87% on livelihoods. The impacts were classified as high, moderate and low for various parameters.
- The inter-temporal energy consumption of seafood processing units showed a fluctuating trend over the

period of 2009–2017. The average estimated monthly energy consumption and the cost was 127987.30 Kwh units and ₹ 7,93,869.20, respectively. Short term energy forecasting of seafood processing plants was estimated using ARIMA (0,0,0) which showed a significant estimated value and standard deviation of 0.073.

- Completed documentation of all the S&T outputs of ICAR-CIFT (768 technologies), including all new/ improved technology products and processes consultancies and policy inputs was carried out. Assessed the technology transfer status of technologies and 43 were selected for impact assessment.
- Studied the modes of technology transfer of each of the S&T outputs for the past 20 years and categories were made. Completed profiling of technologies, based on their expected impact in field, mode of dissemination, intended beneficiary and nature of technology.
- Indicators of three types, technological, economic and social are finalized for assessing the impact of S&T outputs separately based on information gathered from concerned scientists and secondary information for developing impact assessment tool.
- Assessment tools are prepared separately for different categories of S&T outputs.

Chief findings

Institute projects

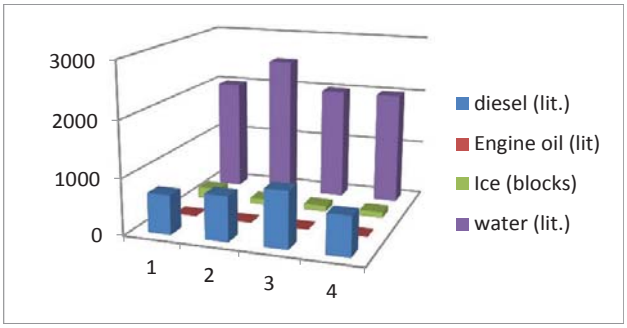
Modeling studies for estimation of revenue based capacity and valuation of selected fishing systems and fish supply chain analysis

Data collection on input details

A log book was prepared for collection of panel data on input-output based on fishing trips for estimation of fishing capacity in trawl fishery and was pre-tested at six landing centres *viz*., Beypore, Puthiyappa, Munambam, Cochin, Neendakara and Sakthikulangara. A log book was further translated in to Malayalam also.

Data on quantitative input indicators collected from steel trawlers (49 to 80 ft L_{OA}) operating from Cochin Fisheries Harbour, Kerala revealed that diesel use ranged from 7000 to 8000 litres, engine oil use was upto 5 litres, ice block usage was 100-200, water usage was 2000–2500 litres and crew members were 6 to 8 per trip.

The economic input indicators were diesel (₹ 42117), engine oil (₹ 525), ice (₹ 7000), ration (₹ 5000), repair and maintenance (₹ 1000), respectively per trip. The crew share amounted 40% of the owners' revenue. The trip – wise income from trawl fishing of the selected units was ₹ 34975, ₹ 4700, ₹ 70800 and ₹ 17750 during the month of January.



Input indicators - Quantitative aspects (trip-based)

Nutrient status of fishers' in Kerala

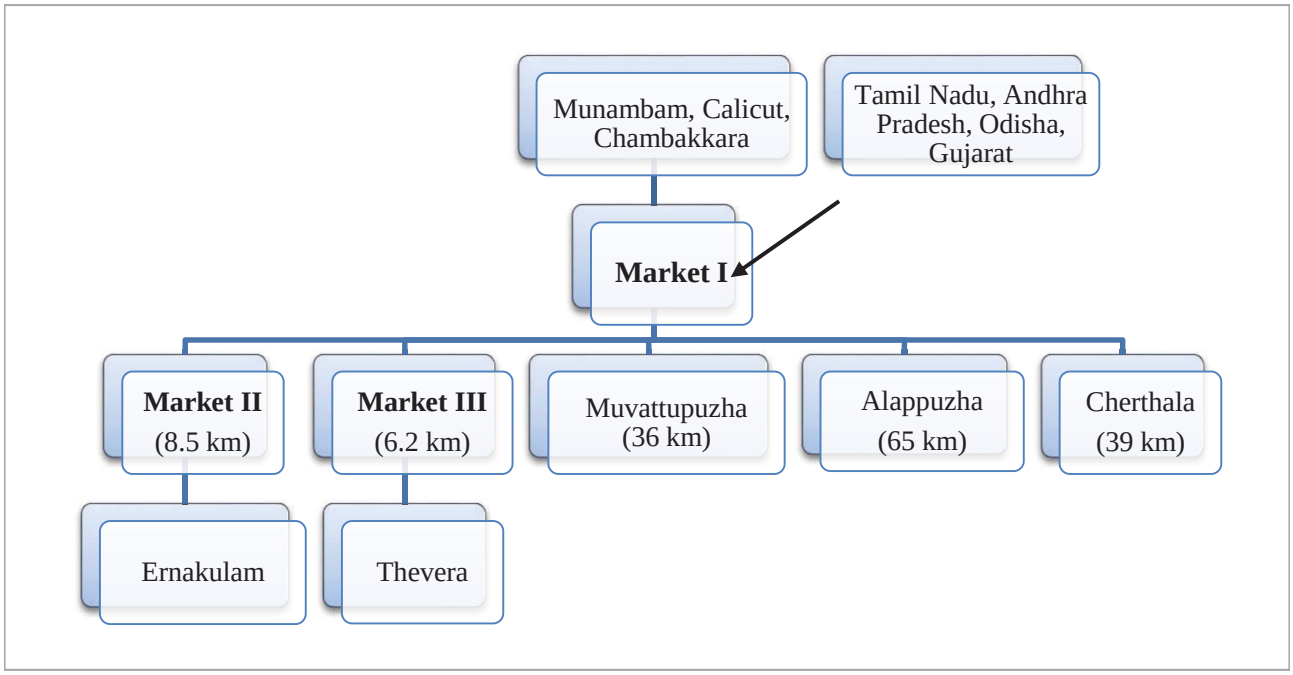
Food consumption pattern of fishers' at Vypin, Ernakulum district, Kerala was analyzed as part of nutritional status assessment. Fishers' spent 52.72% of expenditure on food revealing that fishers have moderate level of standard of living. As per Engle's Law of Expenditure, as income increases, the spending on food decreases. The curve showed an increasing trend which showed that fishers spend more than 50 per cent of the expenditure on food itself. The frequency of consumption showed that around 40 per cent of household take fish one to three times a day.

The nutritional status of 51 adult fishers in Vaadi village, Kollam district, Kerala was assessed (male - 25 and female

- 26). The body mass index (BMI) status of the respondents was compared using the WHO classification. The results showed that majority of adults were in the healthy weight category (64.71%). Among the respondents studied, 56% males and 73% females were falling in the healthy weight category. This also revealed that the gaps between healthy weight and obese were very narrow in males than females.

Market chain and market structure analysis in Ernakulam

The market structure and market chain of three fish markets were collected at Chambakkara (Market I), Ernakulam (Market II) and Thevera (Market III) markets. Fish arrivals to Market I was mainly from local areas, Tamil Nadu, Andhra Pradesh, Odisha and Gujarat. More than 50 per cent of fish arrivals were from Tamil Nadu, the major species being sardine. In Market II, fish arrivals were from Aluva and Chambakkara. And in Market III, arrivals were mainly from Market I. It was revealed that the Market I showed wider market chain than the rest of the markets. The length of market chain is diverse ranging from 10 km to 60 km.



Market chain of fish in the selected markets of Ernakulam

Fishermen perception on fishing capacity management in Kozhikode, Kerala

Perception of fishermen in Puthiappa, Kozhikode was collected on a 5 point Likert type continuum ranging from 'strongly disagree' to 'strongly agree' (Strongly Disagree = 1; Disagree = 2; Undecided = 3; Agree = 4; Strongly Agree = 5). Two statements related to fishing capacity utilization was presented to the fishermen. Highest mean ranks were accorded to the statements related to 'decline in fish catch over years', 'increase in operational cost over years' and 'economic loss due to excess fishing capacity' . Agreement was higher in case of statements like 'more boats than the capacity', 'increasing fishing pressure', 'fluctuation in market price' and 'degradation of resources'. Agreement was lowest in case of adequacy of government policies, adequacy of market information system and implementation of mesh size regulation. Agreement was not very high in case of trawl ban and area closure.

Further it was attempted to identify the major dimensions of their perception using factor analysis. Most important dimension was found to be 'increasing fishing pressure and cost'. The variables in this dimension were related to fishermen's concern about increasing number of boats (MRS-4.4) than the actual capacity and resultant increase in the fishing pressure (4.37). Also the incremental cost of operation is a major reason for worry (MRS=463). It is followed by their concern about resource depletion and need for conservation. It is reflected in the variables like reduction in catch

(MRS=4.8), resource depletion (MRS=4.3) and need for participatory regulatory measures (MRS=4.3). Third important dimension is related to policy measures like, mesh size regulation (MRS=2.7) and gear regulation (MRS=3.7). Fourth dimension is related to community involvement in resource management where community based management measures for preventing excessive fishing capacity (MRS=4.1) was perceived as important. Fifth dimension involved market factors like fluctuation in market price (MRS=4.33) and adequacy of market information (MRS=2.83).

Fishermen perception on fishing capacity management in Kollam, Kerala

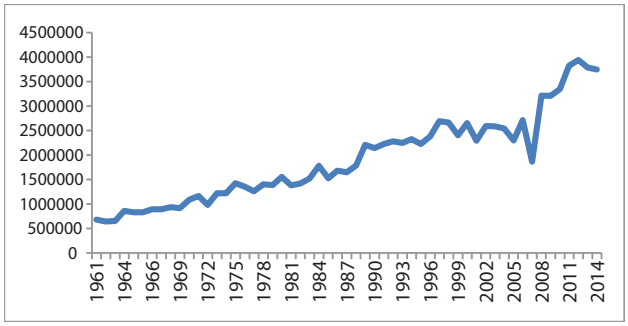
Perception study of fishermen related to fishing capacity utilization was conducted in Kollam district on the basis of five factors of perception selected through Focus Group Discussion (FGD) and meetings with stakeholders and scientists, *viz*.. Perception towards community participation in management, Perception towards technology efficiency, Perception towards resource conservation measures, Perception towards government policy interventions and, Perception towards the fish marketing.

In the case of perception towards the community participation in management; among the five factors, regulating the community resources was preferred most with a mean ranking score (MRS) of 4.83 followed by community sea rights (MRS-4.67) and *inter-intra* conflicts among different fish stakeholders with MRS of 4.60. With regard to the perception of fishers towards technology efficiency, it was found that recommendation on the vessel length and optimization of the engine horse power (h.p.) tops the preference with MRS of 4.63. Similarly, while dealing with fishermen's perception towards resource conservation measures, they were quite aware that the existing traditional fishery technologies are responsible for quick harnessing the fishery resources (MRS=1.43), while maximum MRS (4.63) was obtained for "excess fishing due to large scale entry of fishing vessels" which is the major cause of depletion of resources. In respect of perception towards fish marketing, fishermen are concerned about the wide fluctuation in market price of fishes with MRS of 4.38.

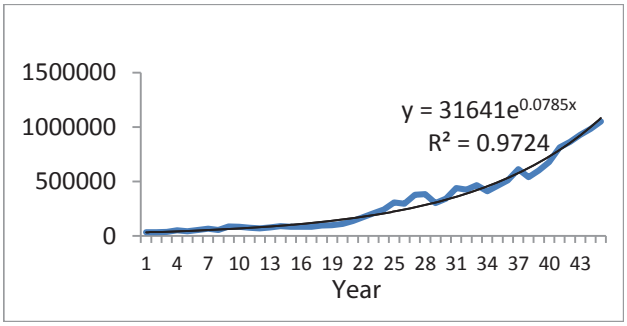
An assessment of the impact of S&T outputs of ICAR-CIFT on the socio-economic fabric of fisheries stakeholders

Assessing the macro-impact of S&T outputs

The time series data on marine fish production shows an increasing trend till 2004 and moving average trend afterwards, whereas in case of marine product exports, an exponential trend is exhibited. The deficit of raw material arisen during the recent years for exports has been compensated from the aquaculture sector.



Trend in marine fish production (MT)



Trend in marine product exports (1990-91 to 2015-16)

It is assumed that the S & T outputs from R & D institutions have aided in bringing in the manifold increase in exports during the recent years.

The Divisia Tornqvist Index for studying total factor productivity of fishery was identified to assess impact which

encompasses the returns and technology components :

$$\text{Input index} = \prod_i \left(\frac{X_{it}}{X_{i(t-i)}}\right)^{(S_{it}+S_{i(t-1)})^{1/2}}$$

where X_{it} and $X_{i(t-1)}$ are quantities of input i at time t and t-1 S_{it} and $S_{i(t-1)}$ are the share of input i in total cost and at time t and t-1.

$$\text{Output index} = \prod \left(\frac{Q_{jt}}{Q_{j(t-i)}}\right)^{(R_{jt}+R_{j(t-1)})^{1/2}}$$

where Q_{jt} and $Q_{j(t-1)}$ are quantities of resource j at time t and t-1 R_{jt} and $R_{j(t-1)}$ are the share of resources j in total revenue and at time t and t-1.

TFP index = Input index/Output index

Compilation of data and assessing the input and output components for estimating the TFP index is under progress.

Identification of women friendly technologies developed at ICAR-CIFT

Energy efficient driers, de-scaling machine, customised FRP canoes for fishing in lakes of NEH, customized FRP boats for small aquaculture farms and ponds, business models for women on fish-based business on fresh fish, dry fish, battered and breaded products, fish waste-based manure and omega-3 enriched poultry production, square mesh fabrication (Training) and value addition of fish to make coated products, chilled products, pickle, wafers, dry fish products and ready-to-eat products were the identified women friendly technologies. For studying the impact of these technologies, beneficiary profiling and separate assessment tool preparation is being done for different technologies.

EXTERNALLY FUNDED PROJECTS

National Agricultural Science Fund (NASF) Project

Green fishing systems for tropical seas

Experimental fishing onboard FV Sagar Harita

The 19.75 m energy efficient fishing vessel, FV Sagar Harita was launched on 18th April, 2016 by the Honorable Director General of ICAR, Dr. T. Mohapatra at the function held at Kochi. Multi-day fishing operations from 24 stations for high sea gillnetting and six stations for long lining were conducted so far. The fuel consumption details during each type of operations are monitored and recorded using fuel meter installed onboard for analysis and validation. Solar energy is used to meet 20% of the energy needs onboard. The fishing gear handling equipment such as split trawl winch, long line hauler, setter and gillnet hauler etc. are operational. The main engine power is 400 h.p.; which is 20% less than the similar class vessels having same principal particulars and the fuel consumption rate is less compared to other commercial vessels of same size. Analysis of energy consumption is being conducted. The average diesel consumption of the vessel was 42 liters/hr from the 22 deep sea experimental fishing operations.

Operational locations of F.V. Sagar Harita for high sea gillnetting and long line operations

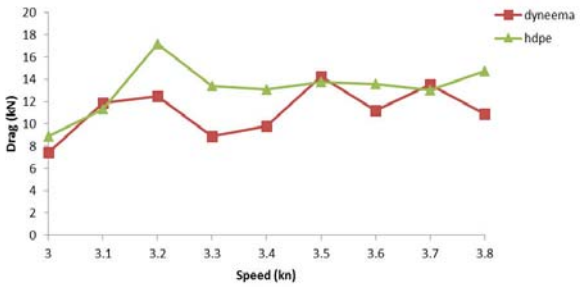
Low-drag trawls

Low-drag shrimp trawls (33 m head rope length) and fish trawls (27 m head rope length) were developed by optimizing the cutting rate and material substitution to reduce drag. Operations using these nets by commercial trawlers from Munambam and Vypin, Kerala showed a reduction of fuel consumption by 2.5%.

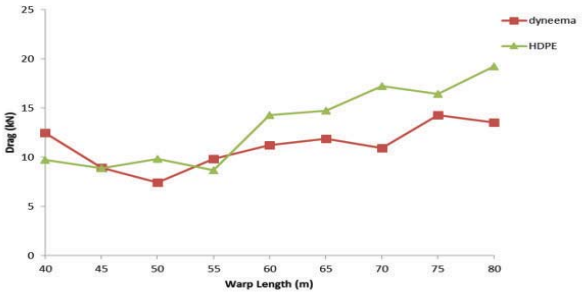
Low-drag trawl operation onboard FV Matsyakumari-II

Catch from law-drag trawls

Sl. No.	Trawl net	Material of fabrication	Twine dia. (mm)	Head rope length (m)	Tension (kN)	Reduction in drag
1	Fish Trawl	HDPE	1, 1.5, 1.25, 2	24.47	13.78	73.00%
2	Fish Trawl	UHMWPE	0.75, 0.85, 1	24	3.71	
3	Shrimp Trawl	HDPE	0.75, 1.25	33	13.5	55.56%
4	Shrimp Trawl	UHMWPE	1	33	7.5	



Speed vs Drag



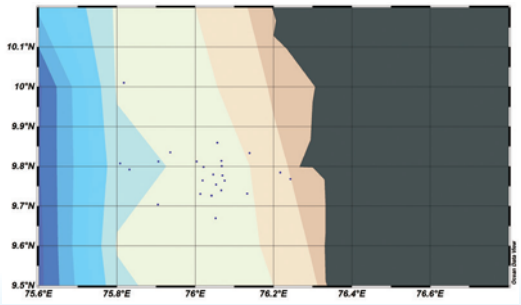
Warp length vs Drag

Square mesh panel

A square mesh panel of 1m X 1m dimension of approximately 8.5% total area of the codend was field tested along Cochin coast. A total of 15 hauls were carried out using the square mesh panel fitted net. Average catch in the codend was 6.23 kg/h and escapement from the panel was 0.15 kg/h (3.38% of total catch). The percentage escapement of top ten species through the meshes of the square mesh panel were, *Ambassis gymnocephalus* - 41.54, *Stolephorus* sp. – 33.39, *Metapenaeus dobsoni* – 20.96, *Oratosquilla nepa* – 10.89, *Alepes kleinii* – 9.94, *Uroteuthis* (*Photololigo*) *duvauceli* – 6.41, *Tetraodon pustulaes* (Puffer fish) – 4.16, *Alepes djedaba* – 3.12, *Secutor insidiator* – 2.89 and *Dussumieria acuta* – 2.89.

Field trials of gillnets and fishing lines with alternate materials

Catch characteristics of experimental gillnets made of new generation materials like Sapphire (7x3), STAR (No. 8) were compared with control gillnets made of polyamide (8x3) onboard Sagar Harita. The mesh sizes used were 135 and 140 mm since these are commonly used by traditional fishermen operating in the deeper waters off the eastern Arabian Sea. Results showed increased target catch in experimental nets and reduced bycatch (turtle and dolphin) compared to control nets. Even though tuna was the target catch (70-150 cm size range), a number of other high value fish species of commercial importance were also caught which included talang queenfish (*Scomberoides commersonianus*), followed by kingfish (*Scomberomorus commerson*), barracuda (*Sphyraena* spp.), dolphinfish (*Coryphaena hippurus*), Indo-Pacific sailfish (*Istiophorus platypterus*), thresher shark (*Alopias superciliosus*), silky shark (*Carcharhinus falciformis*) and other requiem sharks and mantas.

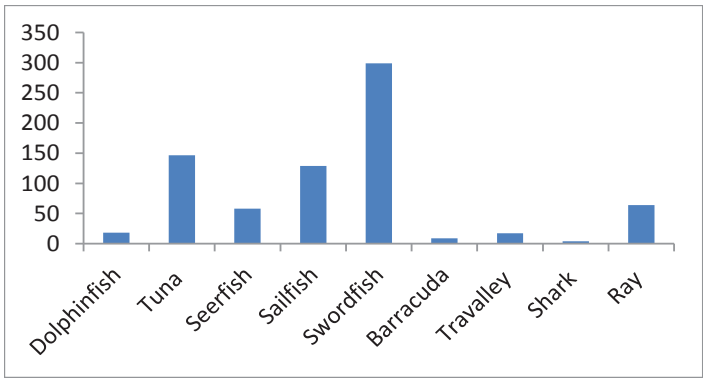


Gillnet operational track at eastern Arabian Sea

Gillnet operation from FV Sagar Harita

Tuna samples caught

Multi-location trials with another set of experimental and control nets with two high sea gillnetting groups of fishermen from Tamil Nadu (FIDO and SAFF) also showed results similar to that observed in the experimental operations.

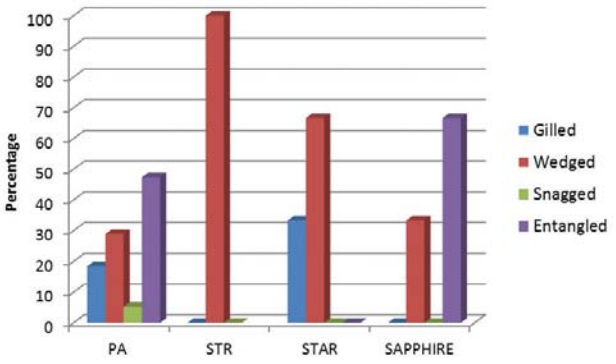


Catch details of multi-day high sea gillnetting with experimental nets in the eastern Arabian Sea

During the fishing trial, tuna (70-150 cm size range) was the target catch (18%) but maximum contribution was by other high value fish species (82%). One turtle (Hawksbills) weighing 50 kg was caught in the control net which was released back to the sea. STR and Sapphire gillnets each had contributed 37.5% of the total catch in experimental gillnets. STAR gillnets caught 25% of the catch. In control (PA) nets, maximum fish was caught by entangling followed by wedging. Among different materials, gilling was maximum in STAR fishing nets.

Catch details with various gillnets

CPUE (kg)	PA	STR	STAR	SAPPHIRE
Catch/haul	110	45	37.5	13.5
Catch/h of soaking	13.75	5.62	4.68	1.68



Catch details with various gillnets

Advanced long line fishing system

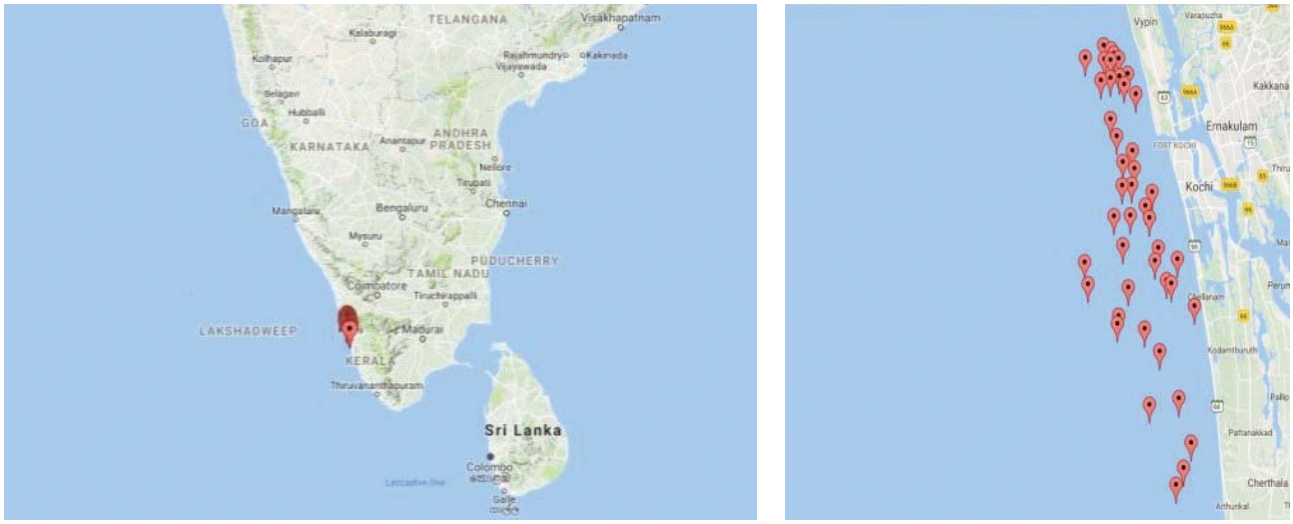
Multi-day fishing operations were carried out at a depth of 1500 to 1900 m in six fishing stations. A total of 150-270 hooks were deployed. One of the main objectives of this work was to evaluate the efficiency of circle hook in comparison to the J-hook using three different types of baits. Preliminary observations did not show significant difference in performance of "J" and "circle" hooks. Another set of experimental operation using advanced long line fishing system are being carried out by the high sea fishermen groups from Tamil Nadu for large pelagics for comparative analysis. The efficiency of circle hook and J-hook in long line fishery were determined in different fishing stations in selected areas.

Long line catch

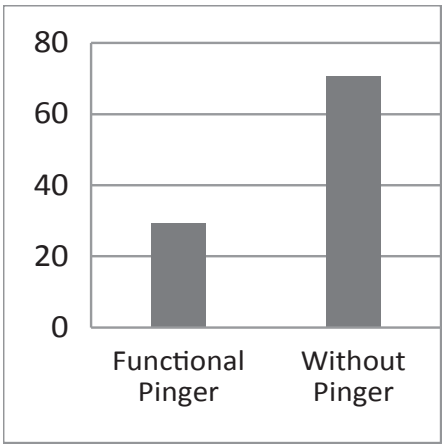
Long line operation in FV Sagar Harita

Acoustic pinger-assisted seine fishing

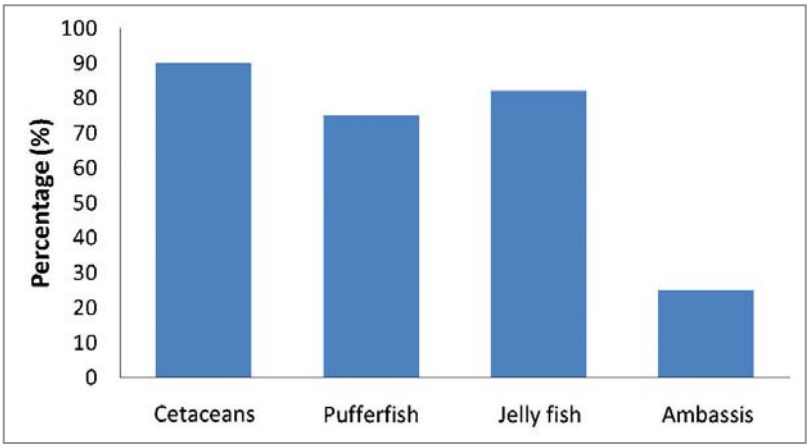
The pingers were deployed in a ring seine fishing vessel of 24 m length using fishing gear with a mesh size of 20 mm, hung length of 1010 m and hung depth 105 m, weight 2500 kg, prone to dolphin attack. A total of 44 fishing operations were carried out and the study shows a reduction in the marine mammal entanglement and depredation of the target fish caught. Experiments on commercial seines are being continued with variable frequency devices. Significant reductions in mammal entanglement and depredation was noticed when the ring seine (1010 m x 105 m, mesh size of 20 mm), weighing 2500 kg was fitted with pingers. A survey was also conducted along Kerala coast to assess the major causes of depredation.



Location of study of dolphin Interaction



Presence of dolphins (%)



Major causes for losses occurring in ring seine fishery

Centre for Marine Living Resources and Ecology (CMLRE) Projects

Exploration and assessment of demersal fishery resources along the continental slope (200-1200 m) of Indian EEZ and Central Indian Ocean

Analysis of cruise data: CPUE (Kg/h) Vs. cruise, depth, species and trawl design

Data for the four cruises undertaken during the project period was analyzed during the year. A total of 38 fishing operations were covered during the four cruises and 26 fishing operations were conducted with HSDT (CV) and 12

fishing operations were conducted with HOT nets. All operations were conducted at depths ranging from 100 m to 1000 m covering the geographical area of East coast, West coast and Central Indian Ocean from latitude 07 °N to 20 °N and longitude 74 °E to 87 °E. Deep sea demersal trawling was conducted in total 38 stations in depths ranging from 100 m to 1000 m along the South West, South East, North and East coast of India. The highest catch was recorded in Cruise No. 332 with CPUE (Kg/h) 57.54% and followed by Cruise No. 322 with CPUE (Kg/h) 30.29%, Cruise No. 338 with CPUE (Kg/h) 9% and Cruise No. 328 with CPUE (Kg/h) 2.9%. All operations were conducted at depths ranging from 100 m to 1000 m. A total of 10, 3, 10, 13 and 2 fishing operations were conducted at depths of 1000 m, 500 m, 300 m, 200 m and 100 m, respectively covering the geographical area from latitude 07 °N to 20 °N and longitude 74 °E to 87 °E.

The elevated catch was recorded at depth of 200 m with CPUE (Kg/h) 57.3% and followed by 300 m with CPUE (Kg/h) 35.25%, 1000 m with CPUE (Kg/h) 4.66%, 500 m with CPUE (Kg/h) 1.07% and 100 m with CPUE (Kg/h) 1.06%.

Catch details at various depth in various cruises

Depth (m)	No of stations	Cruise No. 322	Cruise No. 328	Cruise No. 332	Cruise No. 338	Total CPUE (kg/h)
100	2	0	322	0	0	322
200	13	8153.196	269.8	6330.875	2689.918	17443.788
300	10	0	0	10530.850	86.034	10616.884
500	3	0	248.3	75.764	0	324.064
1000	10	968.333	46.7	391.005	0	1406.038
Total weight of the species		9121.529	886.8	17328.490	2775.952	**30112.775**

Total catch recorded was 30112.77 kg of which teleostei group showed highest CPUE with 19322.92 kg/h, crustaceans were next with CPUE of 10200.44 kg/h, followed by groups elasmobranches - CPUE of 399.94 kg/h, molluscans – CPUE of 124.09 kg/h, coelenterates - CPUE of 55.21 kg/h, and echinoderms – CPUE of 10.04 kg/h.

Comparison of gear geometry measured during surveys with the HSDT CV (High Speed Demersal Trawl Crustacean Version) trawl and HOT (High Opening Trawl)

Trawl	No. of fishing operations	Depth	Average of CPUE (kg/hr)
HSDT (CV)	10	200	968.708
	2	300	222.685
	9	1000	132.393
HOT	3	200	896.639
	8	300	24.187
	1	1000	214.500

Proximate composition of selected deep sea fishes

Biochemical composition of moisture, protein, fat and ash in body muscle of deep water fishes *viz.*, *Alepocephalus bicolor*, *Narceteseri melas*, *Talismania longifilis*, *Chlorophthalmus bicornis*, *Lamprogrammus niger*, *Beryx splendens*, *Chelidoperca investigatoris*, *Neoepinnula orientalis*, *Cubiceps baxteri* and *Psenopsis cyanea* caught over a period of two years from three Cruises – No. 322, 332 and 338 of FORV (Fisheries Oceanographic Research Vessel), Sagar Sampada at a depth of 200–200 m depth was determined. In general, higher moisture content was noticed in *A. bicolour*, *N. orientalis*, *P. cyanea* and *T. longifilis,* where as protein content was higher in *Chlorophthalmus bicornis, Chelidoper cainvestigatoris* and *Cubiceps baxteri*. From Cruise No. 332, *A. bicolor*, *N. erimelas*, *L. niger*, *C. investigatoris*, *N. orientalis* and *P. cyanea* showed high fat content, whereas *Chlorophthalmus bicornis* and *Cubiceps baxteri* contained high fat in Cruise No. 322 and in Cruise No. 338, higher fat content was observed in *Talismania longifilis* and *Beryx splendens*. All the samples showed slight variations in moisture, fat, protein and ash content during different cruises.

Name of species	Moisture (%)	Protein (%)	Fat (%)	Ash (%)
A. bicolor	81.09±0.85	16.44±0.59	2.12±0.13	0.90±0.07
N. erimelas	80.80±1.62	16.54±0.78	1.25±0.25	1.23±0.11
T. longifilis	80.27±0.69	17.63±0.78	1.27±0.32	1.05±0.27
C. bicornis	75.78±0.64	21.47±0.28	1.29±0.16	1.18±0.12
L. niger	79.90±0.96	18.40±0.66	0.97±0.28	0.91±0.22
B. splendens	77.27±1.37	19.81±0.38	1.62±0.40	1.50±0.23
C. investigatoris	75.71±0.82	21.02±0.70	2.00±0.44	1.06±0.19
N. orientalis	78.47±1.28	19.23±0.58	1.41±0.13	0.79±0.12
C. baxterii	77.40±1.56	20.53±1.15	1.02±0.30	0.88±0.17
P. cyanea	79.85±0.76	18.33±0.55	1.13±0.20	0.73±0.14

Mean values (n=15) of proximate composition of demersal deep-sea fishes of all cruises

Heavy metal accumulation in deep water fishes

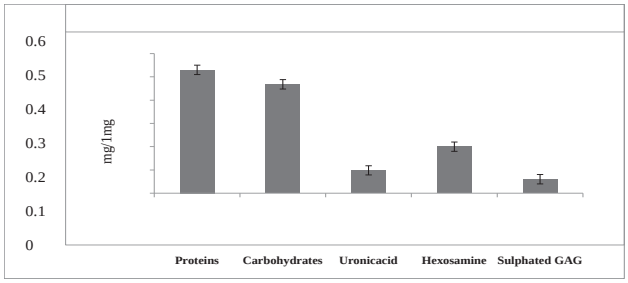
Fe, Zn, Cu, Co and Cr were found in higher quantities in deep sea fishes analyzed from three cruises. From all the three cruises, Fe content was higher in *B. splendens* (47.45 ppm) followed by C. *baxterii* (46.86 ppm). Lowest Fe concentration was observed in *L. niger* (26.04 ppm) and *C. investigatoris* (29.39 ppm). Cadmium, the toxic metal, was detected only in *L. niger* (0.03±0.01) and *C. baxteri* (0.01±0.01) for Cruise No. 322, in *N. erimelas* (0.86±0.03), *T. longifilis* (0.35±0.01), *L. niger* (0.12±0.02), *C. investigatoris* (0.21±0.03) and *N. orientalis* (0.06±0.01) for Cruise No. 332, and *N. erimelas* (1.05±0.02), *L. niger* (0.08±0.01), *C. investigatoris* (0.49±0.03), *C. baxterii* (0.07±0.02) and *P. cyanea* (1.43±0.04) for Cruise No. 338. Similarly Pb was also detected in negligible quantity in *T. longifilis* (0.13±0.02), *C. investigatoris* (0.07±0.01) and *C. baxterii* (0.19±0.03) for Cruise No. 332 and it was detected only in *L. niger* (0.06±0.02), *C. baxterii* (0.09±0.02) and *P. cyanea* (0.05±0.01).

Name of species	Copper	Zinc	Iron	Cobalt	Cadmium	Lead
A. bicolor	19.73±0.80	24.61±0.50	33.15±1.56	2.61±0.22	BDL*	BDL
N. erimelas	17.54±0.49	23.51±0.25	35.52±1.07	1.22±0.08	0.64±0.02	BDL
T. longifilis	22.15±1.10	28.82±0.66	33.93±0.83	2.69±0.06	0.12±0.00	0.04±0.01
C. bicornis	20.96±0.48	20.62±0.68	34.03±0.66	2.60±0.16	BDL	BDL
L. niger	12.70±0.21	18.96±0.95	26.04±0.40	1.06±0.14	0.08±0.01	0.02±0.01
B. splendens	16.87±0.52	28.05±0.48	47.45±0.80	0.61±0.04	BDL	BDL
C. investigatoris	21.26±0.77	20.07±0.66	29.39±0.72	0.75±0.17	0.23±0.02	0.02±0.00
N. orientalis	25.57±0.97	17.17±0.43	33.97±0.80	0.95±0.07	0.02±0.00	BDL
C. baxterii	15.58±0.82	19.36±0.54	46.86±1.41	0.26±0.03	0.03±0.01	0.09±0.02
P. cyanea	24.97±0.93	19.47±0.84	37.99±1.13	1.90±0.06	0.48±0.01	0.02±0.00

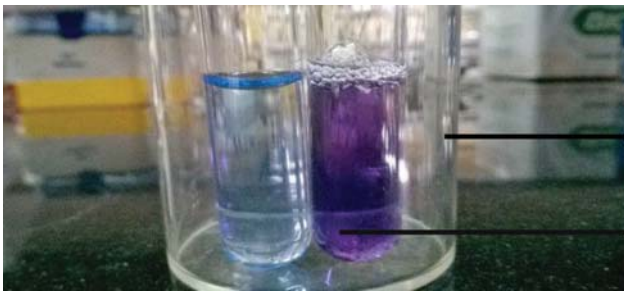
Mean values (n=15) of metal accumulation (ppm) of demersal deep sea fishes of all three cruises. *Below detection level

Isolation and characterization of proteoglycans and glycosamino glycans from deepsea shark

Proteoglycans (PGs) and associated glycosamino glycans (GAGs) were extracted from the cartilage tissues of shark (*Echinorhinus brucus*). Qualitative and quantitative analysis of PGs and GAGs isolates were done by spectroscopic, electrophoretic and chromatographic methods. Measurement of total sulfated GAGs was done by microplate reader method. Purification of PGs was done by an ion exchange chromatography using DEAE-sephacel followed by cellulose membrane-based dialysis. Purity of the isolated polysaccharides was evaluated and characterized by qualitative (Biuret method, DMMB assay, Wavelength scan of GAGs) and quantitative methods (Chemical composition analysis like Spectroscopic methods, UV/Visible spectroscopy, Microplate reader test for the measurement of total sulfated GAGs, Electrophoresis methods and Agarose Gel Electrophoresis)



Amount of chemical components (mg) present in 1 mg proteoglycan

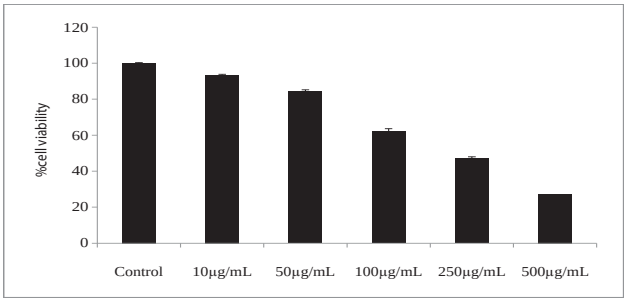


Isolation of proteoglycans (Violet-purplish colour produced shows the presence of proteoglycans in the sample)

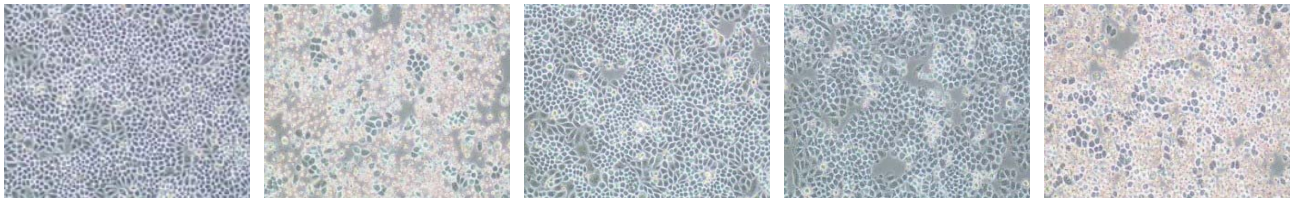
Proteoglycans purified by chromatography were shown to contain carbohydrate, protein, uronic acid, hexosamine and sulphated GAG content through UV/ Visible Spectroscopy.

Anticancer activity of proteoglycans against cervical cancer cell line

Cell viability and morphological analysis: Anticancer potential of the PGs, against the cervical cancer cell line (HeLa) was assayed by cell viability and morphological analysis, colony formation assay and chromatin condensation as confirmed by Hoechst 33342 nuclear staining. Apoptosis induction and cell cycle analysis were determined by FACS. The cell viability rates decreased with increasing concentrations of PGs in a dose-dependent manner.



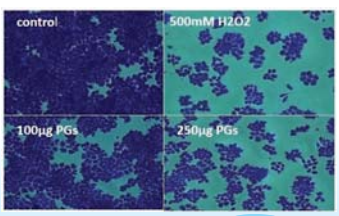
Different concentrations of PGs



Control | 500 µM H_2O_2 | PGS-10 µg/mL | PGS-100µg/mL | PGS-300µg/mL

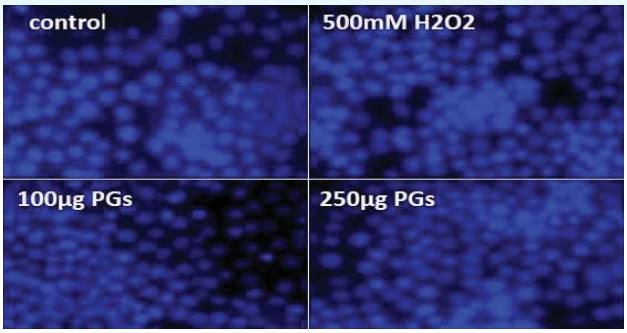
Morphological changes of HeLa cells treated with PGs3 under phase-contrast microscopy

Colony formation assay: Anti proliferative property of PGs inhibit the colony formation capacity, at above 200 µg/m. Colonies were photographed using phase-contrast microscope.



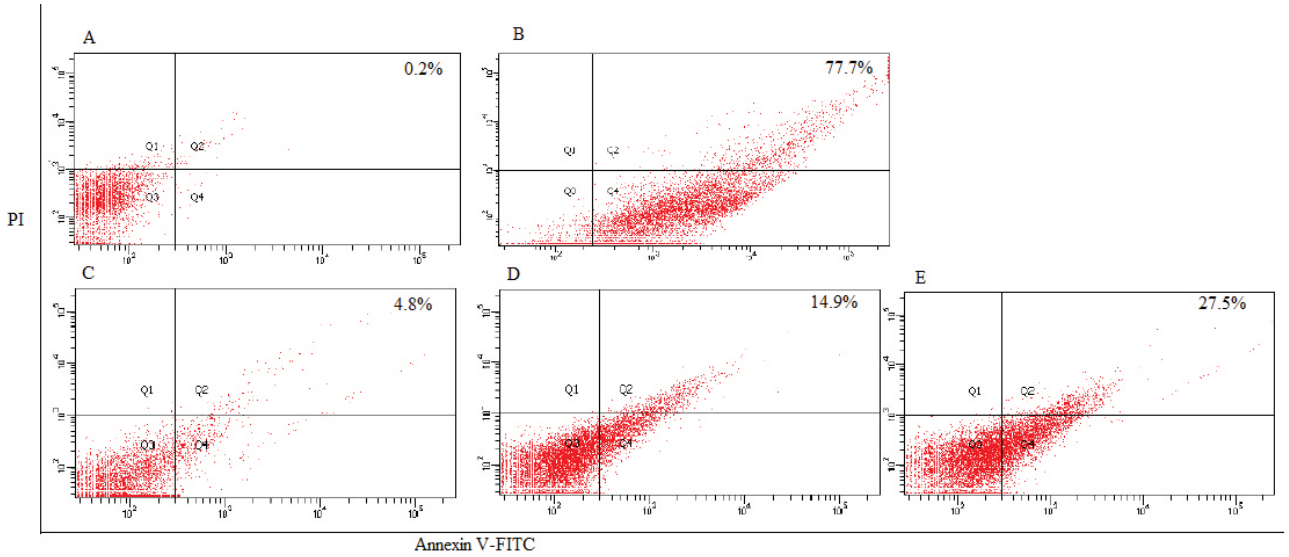
Phase contrast micrographs of HeLa cells

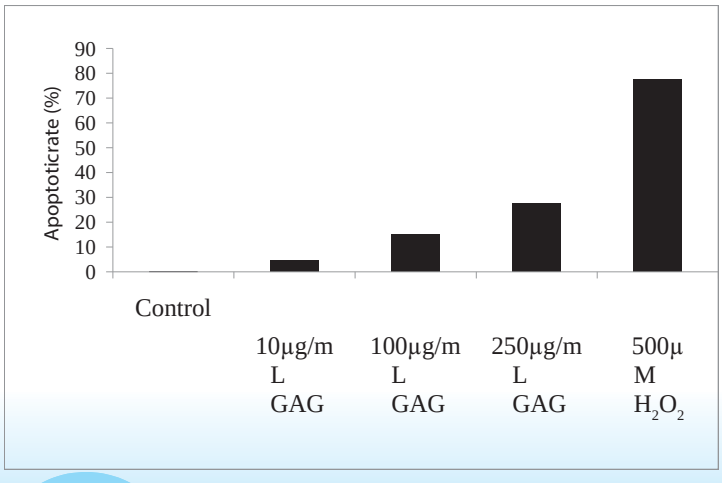
Chromatin condensation: The Hoechst 33342 staining was used for detection of chromatin condensation to determine DNA damage. Representative stained images are shown in figure. A number of apoptotic HeLa cells were displayed around and shrunken cell body and chromatin condensation inside the nucleus suggesting that PGs induced apoptosis. Control cells shows an intact uniform nucleus and H_2O_2 used as positive control with highly condensed chromatin.



Cell apoptosis observed using Hoechst 33342 staining: HeLa cells were treated with PGs-10 µg/mL-100µg/mL, 250µg/mL for 24 h. Untreated cells as negative control and H_2O_2 treated as positive control. Photographs were taken under a fluorescence microscope (200×, original magnification)

Apoptosis analysis: To further substantiate that PGs-induced apoptosis of HeLa cells, cells were stained with Annexin V-FITC and PI using Annexin V-FITC apoptosis kit (Cayman). Result of flow cytometry are shown in figure below. The lower right quadrant (Q4) depicts the percentage of early apoptotic cells (Annexin V-FITC-stained cells) and the upper right quadrant (Q2) represents the percentage of late apoptotic cells (Annexin V-FITC and PI-stained cells). The fully apoptotic cells are those in the lower right and upper right quadrants. H_2O_2 treated cells taken as positive control and untreated cells taken as negative control. No apoptotic cells were detected in the control group. However, after treatment with PGs at different concentrations of 10µg/mL, 100µg/mL, 250µg/mL and H_2O_2, ratio of apoptotic cells were 4.8%, 14.9%, 27.5% and 77.7%, respectively.



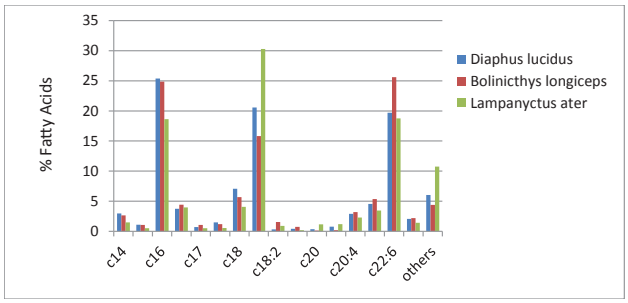


PGs-induced apoptosis in HeLa cells as determined by flow cytometry using Annexin FITC-PI staining method. The cells were treated with 10µg/mL, 100µg/mL, and 250µg/mL for 24 h depicted in figure as B, C and D treated as negative control and H_2O_2 treated as positive control for 24 h as A and B. PGS-induced apoptosis analyzed by flow cytometry. The lower right quadrant (Q4) indicates the percentage of early apoptotic cells (FITC-stained cells) and the upper right quadrant (Q2) indicates the percentage of late apoptotic cells (FITC+PI-stained cells)

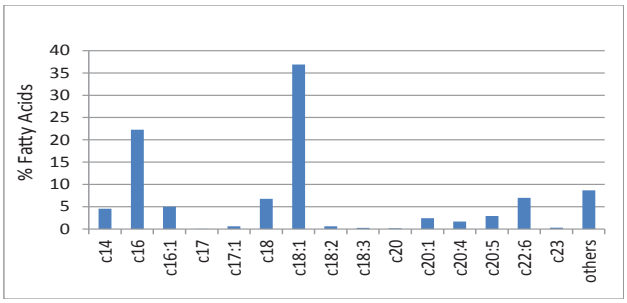
PGs-induced apoptosis rate shown by bar graph

Assessment of myctophid resources in Arabian Sea and development of harvest and post harvest technologies

Myctophid fishes caught during the cruise of FORV Sagar Sampada 344 leg 1 and leg 2 during the months of September to October, 2015 were assayed for the total fatty acid profiling. *Diaphus lucidus*, *Bolinicthys longiceps* and *Lampanyctus ater*, the three myctophid species analyzed contained EPA and DHA in considerable proportion.



Fatty acid composition of various myctophid species



Fatty acid composition of *Diaphus watasei*

Characterization of Harmful Algal Blooms along Indian Coast

The 120 fish samples analyzed for CTX toxicity includes nine different reef associated fishes like *Lutjanus bohar*, *Lutjanus argentimaculatus*, *Caranx* sp., *Sphyraena* sp., *Lethrinus* sp., *Otolithes* sp., *Epinephelus* sp. and *Aprion* sp. Mouse bioassay of 120 reef associated fish samples were carried out. Toxicity was reported from *Lutjanus* sp. and a total 12 number were identified as ciguatoxin positive.

Incidence of ciguatera fish poisoning from samples collected from Mangaluru and Kochi

In October, 2016 *Lutjanus bohar* samples collected from Mangaluru and Thoppumpady, Kochi were implicated in ciguatera fish poisoning. Nearly 200 workers from Baraka Fish factory and some residents of Natekal and Ullal, near Mangaluru were reported sick after eating the head portion. They were hospitalized with the symptoms of chest burning, abdominal pain, vomiting sensation, diarrhoea, pruritus of legs and hands, tingling sensation in throat and tip of the tongue, paraesthesia of the extremities, arthritis, difficulty to walk, weakness and cold allodynia. Samples of implicated species was brought to ICAR-CIFT laboratory for confirmation. Samples were confirmed for presence of Ciguatoxin by mouse bioassay and LC-MS-MS.

Examples of fishes used for ciguatoxin analysis

Development of standards

In collaboration with Food Safety and Standards Authority of India (FSSAI), the following standards/code of practice/ advisories were developed:

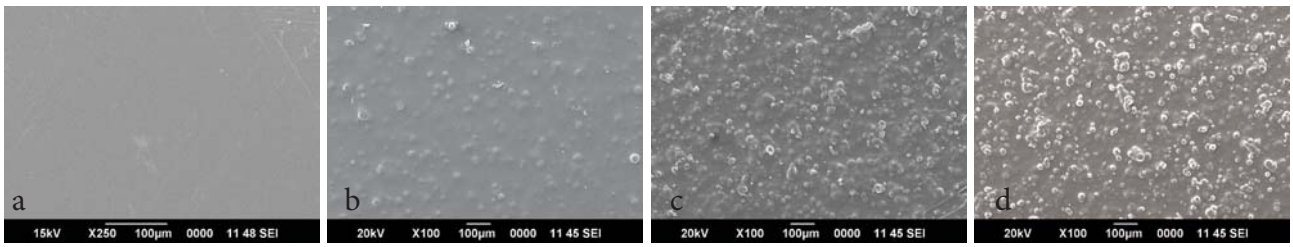
- Microbiological Standards of Fish and Fishery Products (Gazette Notification on 13 February, 2017)
- Vertical Standards on Smoked Fishery Products and Ready to Eat Fish Curry in Retort Pouches
- Code of Practice to Reduce PAH in Smoked Fishery Products
- Advisory on Ciguatoxin

Department of Biotechnology (DBT) Projects

Development of bioplastic based sustainable nano biocomposite food packaging - Sustain NanoPack

Development of PLA films incorporated with nanoclay dispersed thermoplastic starch

Nanoclay-dispersed-thermoplastic starch was effective as a filler in developing the biodegradable packaging material polylactic acid (PLA). PLA/thermoplastic starch (TPS) (10%, 20% and 30%) films were prepared using twin screw extruder that showed good processability up to 20% starch incorporation. Processing of 30% TPS/PLA was difficult due to increased loading and films were not uniform. PLA/TPS blend and virgin PLA films varied in processing parameters, morphology and thickness. Thickness of the films increased with increasing concentration of TPS addition. Thickness affected the mechanical characteristics and permeability of the film. The transparency of the film decreased by addition of thermoplastic starch. The surface morphology of the PLA film showed smooth surface under SEM. Surface roughness increased with increase in concentration of TPS. Nanoclay-dispersed-TPS imparted better mechanical properties, whereas increasing concentration of nanoclay dispersed TPS improved the tensile strength and elongation of virgin PLA.



SEM micrographs of (a) Virgin PLA, (b) PLA/10% TPS, (c) PLA/20% TPS and (d) PLA/30% TPS films

Anchovies packed in the PLA and LDPE films

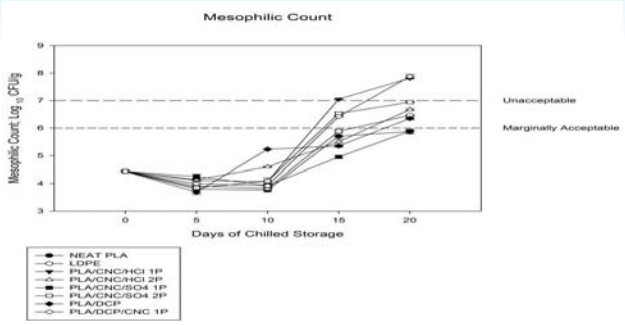
Nanoclay-dispersed-TPS improved the barrier properties of PLA films. Water vapour transmission rate and oxygen transmission rate decreased with increased concentration of TPS. PLA/10% TPS showed better barrier properties. These virgin PLA film, LDPE film, PLA/10% TPS and PLA/20% TPS films were tested as packaging films for anchovy. Ten percentage TPS incorporation was optimized as effective for preventing microbial growth and exhibiting better barrier properties.

PLA/CNC films application for storage of chilled prawns

Application of PLA films incorporating different concentrations of cellulose nanocrystals as fillers for chilled storage of prawns (*Metapeneaus dobsoni*) was evaluated. The films were developed at IIT - Guwahati by incorporating different concentrations of nanocellulose fillers and compatabiliers. The films were made into pouches and peeled and deveined prawns were packed for conducting shelf life evaluation in chilled condition. The prawns were stored at 2±1 °C and evaluated at timely intervals for different biochemical parameters.

Developed varieties of PLA/CNC films

The mesophilic count was determined for prawn during chilled storage in polylactic acid/cellular nanocrystal film developed using different acids and chemicals. The prawns packed in PLA films using PLA/CNC sulphuric acid (1%) was not suitable along with whey PLA.

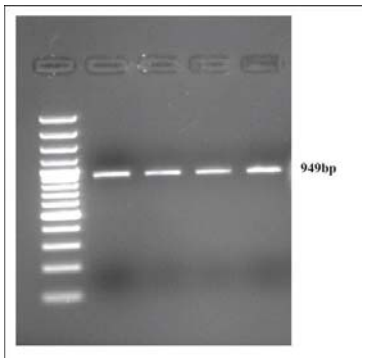


Genetic diversity of *Clostridium botulinum* in seafoods and development of Lateral Flow Immuno Assay (LFIA) for toxinotyping

Prevalence of *Clostridium botulinum* in seafoods

Fresh fish and processed fishery products collected from super markets in major cities in India including Bangaluru, Mumbai and Kochi were analyzed for the prevalence of *C. botulinum* types. Ninety six fish and fish products comprising of ready-to-eat (25), ready-to-cook (41), dried fish (9) and fresh fish (21) were analyzed using mouse bioassay. Preliminary screening by mouse bioassay of these enriched media resulted in 17 positive samples. Anaerobic isolation method using egg yolk media gave 250 presumptive isolates from these enrichment cultures. Isolated colonies on examination with mouse bioassay resulted in 20 positive isolates. After toxin neutralization tests, nine of them were confirmed as *C. botulinum*. The isolates were confirmed as *C. botulinum* by 16S rRNA sequencing. Amplification of the *BoNT* gene (*BoNT* A/B/E) was performed on the positive isolates to confirm the presence of Botulinum neurotoxin genes. Among these isolates, four were confirmed as *C. botulinum* Type A, four as *C. botulinum* Type B and one as *C. botulinum* Type E. This is the first report of occurrence of *C. botulinum* Type E from seafood in India. One isolate was found to carry both *BoNT* A and B genes. However the *BoNT* B was found to be inactive by toxin neutralization studies. The isolate with both *BoNT*/A and *BoNT*/B was reclassified as *C. botulinum* Type AB (Franciosa, 2004). This is the first report of occurrence of *C. botulinum* Type AB from India. Lateral Flow Immuno Assay kits (LFIA) were developed for the detection of *C. botulinum* in various food products and are currently under test trials to standardize sensitivity. LFIA can be used as a rapid sensitive detection test alternative to mouse bioassay.

Food samples collected from various cities for detection of *C. botulinum*



PCR amplification of *BoNT* B gene from *C. botulinum*

LFIA strips developed for detecting *C. botulinum* Type B

Evaluating costs and benefits of prophylactic health products and novel alternatives on small-holder aquaculture farms in Asia and Africa (Newton Fund Project in collaboration with U.K., Kenya and Bangladesh)

Survey of farm health management practices and prophylactic health products usage

Survey of farm health management practices and prophylactic health products (PHP) usage was conducted at 182 small-holder aquatic production systems in four districts of Andhra Pradesh including Nellore, East Godavari,

Srikakulam and West Godavari. The aspects surveyed were farm holding, production details, feed and feed additives (probiotics, vitamins/minerals/feed additives, antibiotics, disinfectants and pesticides), diagnostic support, biosecurity measures taken etc. Major findings of the survey were; 1) PHP use is wide-spread in surveyed regions, 2) Recommendations by consultants and technicians were found to influence decision making on the brand and quantity of PHPs used, and 3) Biosecurity measures were maintained in most of the farms surveyed.

A retail outlet of PHPs in Andhra Pradesh

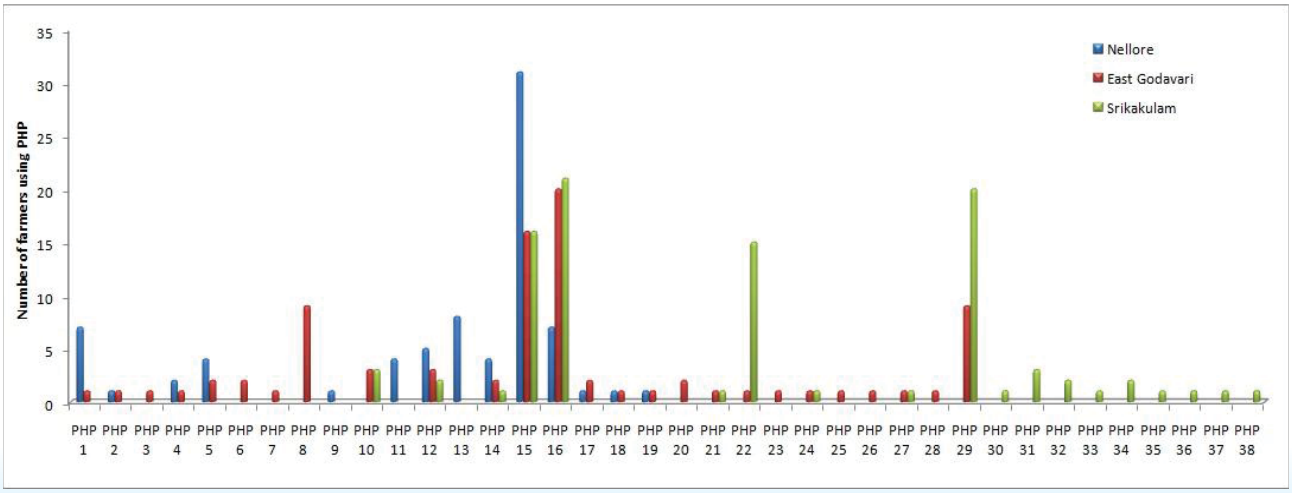
Value chain analysis for PHPs including regulatory assessment revealed that there is no governance, policy, regulatory systems, labelling or certification schemes for PHPs in market. There is no regulation in place in India for monitoring the quality of aquaculture PHPs except the current regulation of CAA insisting the absence of antibiotic residues.

Inventory of commercial PHPs

A database of 60 commercial PHPs from India was developed using Microsoft Access software. PHPs were categorized based on the microbial content provided on the label; 41.67% of the products had labels with microbial load and composition, 16.67% with microbial load only, 13.33% with microbial composition only and 28.33% without any information regarding the microbial load and composition. Project partners from UK provided 52 PHP samples from Bangladesh with details about product name, type of PHP, composition, form of product and targeted species. Data regarding the microbial load were not available for these samples.

Microbiological analysis of PHPs

The prime objective of the quality evaluation of commercial PHPs was to determine the accuracy of information on product labels with regard to the number of microorganisms present in the product. Culture viability was presumed to be a reasonable measure of product activity. An initial investigation on the microbial load of commercial PHPs from India and Bangladesh was performed. Only 36% of Indian products which claimed the microbial content along with concentration were consistent with their label. According to the declaration on food animal quality of Ministry of Agriculture and Co-operatives of Thailand, the acceptable number of probiotic microorganisms is 10^6 CFU/gm. About 46.5% of the Indian products and 68.2% of Bangladesh products samples were found to have recommended microbial load of 10^6cfu/g.



PHP usage among the farmers in Nellore, East Godavari and Sreekakulam

Visit of Indian scientist/project staff to partner lab in foreign countries

Principal Investigator of the project from India, Dr. Toms C. Joseph visited United Kingdom to participate in the project meeting and workshop held at the University of Sterling, UK during 19-21 June, 2016.

Visit of foreign scientists/students to ICAR-CIFT

Project team from UK, Dr. Francis Murray (PI, University of Sterling), Dr. Kenton Morgan (Co-PI, University of Liverpool) and Dr. Jamila Rizgalla (Post-Doctoral Fellow, University of Sterling) visited the aquaculture farms of Srikakulam, Visakhapatnam, Kakinada and Nellore during 31 January to 5 February, 2017 to study the aquaculture practices and value chain of PHPs in India.

Project team from UK visiting aquaculture farms in Andhra Pradesh

Department of Science and Technology (DST) Project

Development of clam cluster and clam processing facility at Perumbalam village, Cherthala taluk, Alappuzha district, Kerala

Cluster formation

Fourteen clusters have been identified of fishers engaged in the different activities of the clam fishery in the Perumbalam village. Five clusters have been formed, each with 15 members.

Capacity building programmes

Two training programmes for the clam clusters were conducted during 8-9 September, 2016 and 2 March, 2017 on aspects like depuration, cooking and value addition of clam meat. Sixty fishers including men and women participated in the training programmes.

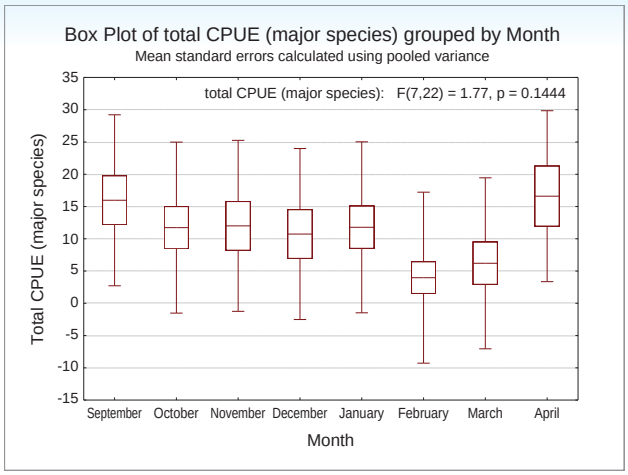
Indian National Centre for Ocean Information (INCOIOS) Project

Studies on the ecological linkages between plankton production and *Acetes* sp. abundance along Veraval coast, Gujarat

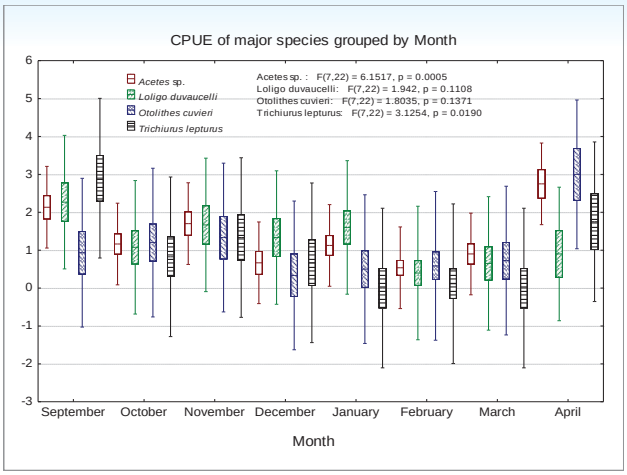
Results from 49 valid fishing operations carried out along Veraval coast had an average CPUE 12.87 kg/h. Jellyfish with an average CPUE of 2.62 kg/h was the most dominant species. The second most important species with an average CPUE of 1.18 kg/h was *Acetes* sp.

Significant variations were noticed in the quantities of *Acetes* sp. caught by trawlnet ($p<0.005$). The highest CPUE was noticed during the month of April (2.75±0.38s.e.), followed by the month of September (2.13±0.31s.e.). Chlorophyll and temperature were the most important factors determining the abundance of *Acetes* sp.

The fish species collected during the experimental fishing operations from harbours were used for deriving the relationships between the length and weight. Comparisons of the LW slopes were carried out to find if the relationships were different between years.



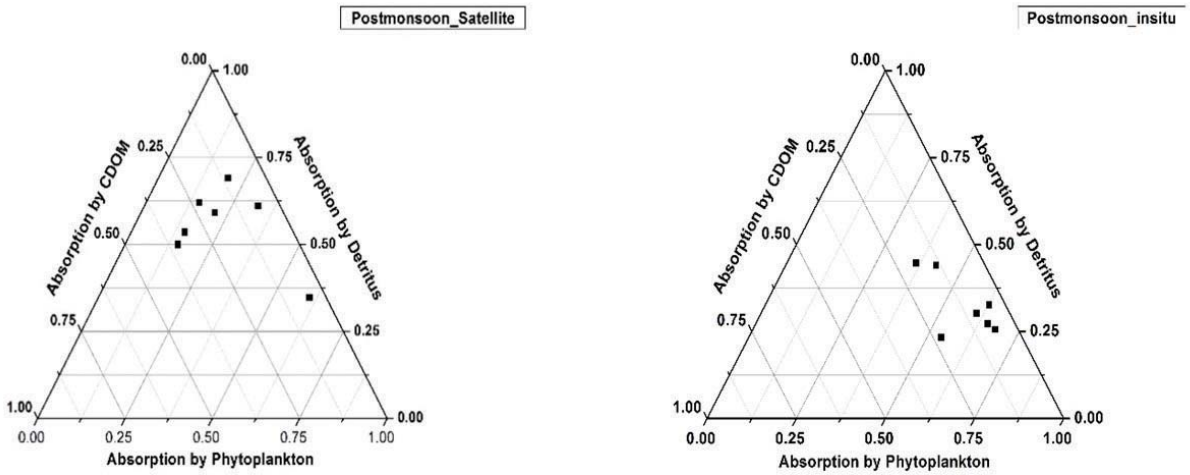
Variation in the total CPUE of all major species clubbed for different months



Variation in catches of four major species expressed as CPUE (CPUE kg/h[1]) caught during the experimental trawling operations

Retrieval of phytoplankton biomass and associated optical constituents based on long term bio-optical studies

Long term measurements of the Optically Active Substances (OAS) and their inherent properties were studied *in situ* for the first time along South-eastern Arabian Sea to gain an insight on their temporal dynamics for various remote sensing applications. Absorption by phytoplankton and detritus [(aph (440), ad (440)] varied by 3rd and 2nd orders of magnitude respectively while absorption by CDOM [aCDOM (440)] exhibited linear relationship over the years. aCDOM (440) increased from 2009-2015 and expected aCDOM (440) for the year 2050 is 0.6m^{-1} with a rate 0.0119m^{-1} yr^{-1}. Chlorophyll-a (Chl-a) varied sinusoidally with a period of 5-6 years and was highest during March. The indicator months have been identified for monitoring the specific OAS, *viz*.- January, February and December for Chl-a, January and February for aph (440) and May for aCDOM (440). Validation of satellite and *in situ* data showed that ad under-estimated *in situ* ad when the later was > 0.3 m^{-1}. Ternary analysis of OC-CCI derived IOP's during post-monsoon also showed increased contribution by ad (443). This study highlights that detritus is the major light absorber followed by phytoplankton and CDOM in the coastal waters off Kochi. These results have potential applications in developing bio-optical algorithms.

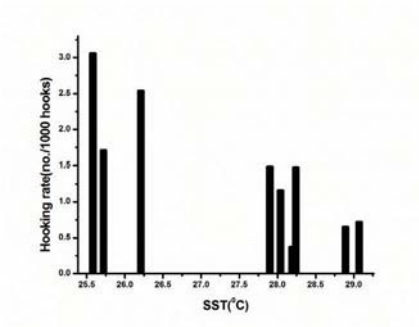


Percentile contribution of absorption by phytoplankton, CDOM and detritus for post-monsoon season derived from OC-CCI data

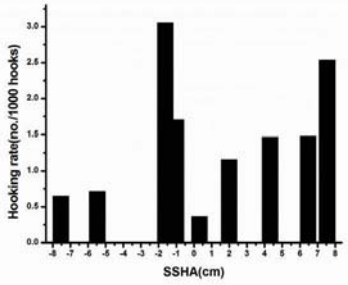
Validation of tuna advisories off east coast

Corelation of hooking rate of yellowfin tuna with oceanic parameters

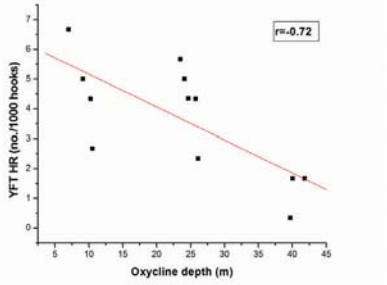
A total of 198 long line sets and 24 commercial fishing voyages were analyzed during the study period to estimate the hooking rate of long line catches comprising of yellowfin tuna (YFT) and correlated by using oceanic parameters such as Monthly Mean Sea Surface Temperature (MMSST), Monthly Mean Sea Surface Height Anomaly (MMSSHA) and Monthly Mean Mixed Layer Depth (MMMLD) during the period. Almost the entire catch of YFT during the study period was noticed to be caught when the MMSST was between 25.5 °C to 29.5 °C. The mean temperature of the sea water recorded was 27.53 °C with a standard deviation (SD) of 1.34 during the study period. Almost the entire catch of YFT was distributed when the MMSSHA was between +8 cm to -8 cm. Similarly, when the data was analyzed for monthly MMMLD, it was noticed that the YFT aggregates between depths of 12.88 to 46.61 m. High catches of YFT were recorded in the areas where MMMLD ranged between 35 m to 47 m. Catch data of YFT was for correlating with oxycline depth. The relationship between catch and oxycline showed a negative linear correlation. Correlation coefficient (r) between these two independent variables was -0.70.



Hooking rate V/s Sea Surface Temperature



Hooking rate V/s Sea Surface Height Anomaly



Linear relationship between HR of YFT and oxycline depth

Length and weight relationship of yellowfin tuna

Pooled length frequency data pertaining to 576 YFT (*Thunnus albacares*) individuals was collected from commercial long liners of Visakhapatnam. Analysis of the Fork Length (FL) measurements showed that the lengths of the individual specimen ranged from 18 to 132 cm with a mean fork length of 59.93 cm for total fish sampled. The weight range of total fish samples of YFT were between 589 g to 36,090 g with a mean weight of 5,380 g. In the present study, YFT exhibited negative allometric growth (b=2.9885).

Food and feeding habit of yellowfin tuna

The study of feeding habits of the yellowfin tuna was carried out in 136 specimens. Gut lengths ranged between 14-50 cm. The gut contents were analyzed and 16 taxa of prey items belonging to Crustacea (3 Genera), Cephalopoda (3 Genera) and Teleosts (10 Genera) were found. The percentage of IRI were the highest in case of squids, dominated mainly by *Loligo* sp. (% IRI= 95.98) and *Priacanthus* sp. (% IRI=1.68) followed by *Chirocentrus* sp. (% IRI= 0.7704). Lowest percentage of IRI was observed in *Stolephorus* sp. (% IRI=0.0013). IRI pertaining to various groups was observed as 96.47% for cephalopods, 3.49% for teleosts and 0.03 % for crustaceans.

Indigenous Traditional Knowledge (ITKs) in marine fisheries sector of Kerala: Documentation and analysis

Field level surveys

Field level surveys in nine coastal districts of Kerala, *viz*., Kasaragod, Kannur, Kozhikode, Malappuram, Thrissur, Ernakulam, Alappuzha, Kollam and Thiruvananthapuram were completed, covering 509 respondents. Focus Group Discussions with 194 respondents were also conducted.

Workshops

Two workshops with fishermen from Alappuzha and Thrissur were held at ICAR-CIFT on 29 and 30 June, 2016, respectively. Ten fishermen from fishing villages like Chethy, Arthungal, Andhakaranazhy and Vettakal of Alappuzha district and eight fishermen from Azhikode fishing village of Thrissur district participated in the workshop. In a participatory mode mapping of fishing grounds, identification of species, validation of lunar cycles and fishing and seasonal calendar were discussed.

A workshop on "Scientific validation of ITKs and strategizing dissemination of deliverables" was conducted on 2 March, 2017 to validate selected ITKs by the interaction between fishermen and scientists. Print and digital media experts gave inputs on strategizing the deliverables for popularization. Apart from fishermen, scientists from ICAR-CIFT, ICAR-CMFRI, CSIR-NIO and experts from various print and digital media participated.

Field level workshops

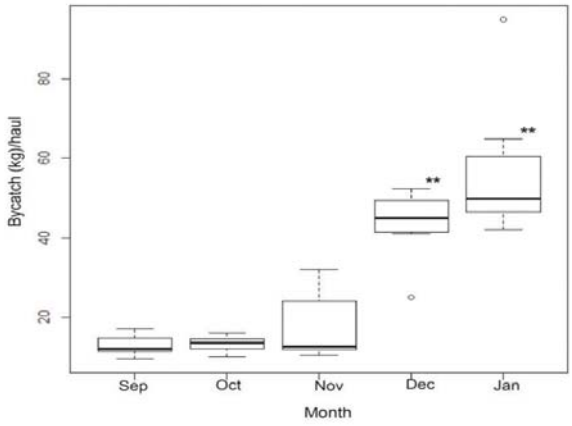
A total of seven field level workshops were conducted at Thrissur, Ernakulam, Alappuzha and Kollam to collect ITKs on various topics such as physical oceanographic and meteorological parameters, fishing techniques, fish processing and preservation and beliefs and practices.

UNDP-Global Environment Facility Project

Demonstration and field testing of bycatch reduction and juvenile excluder devices along Sindhudurg District, Maharashtra

Comparative analysis of square and diamond mesh codends

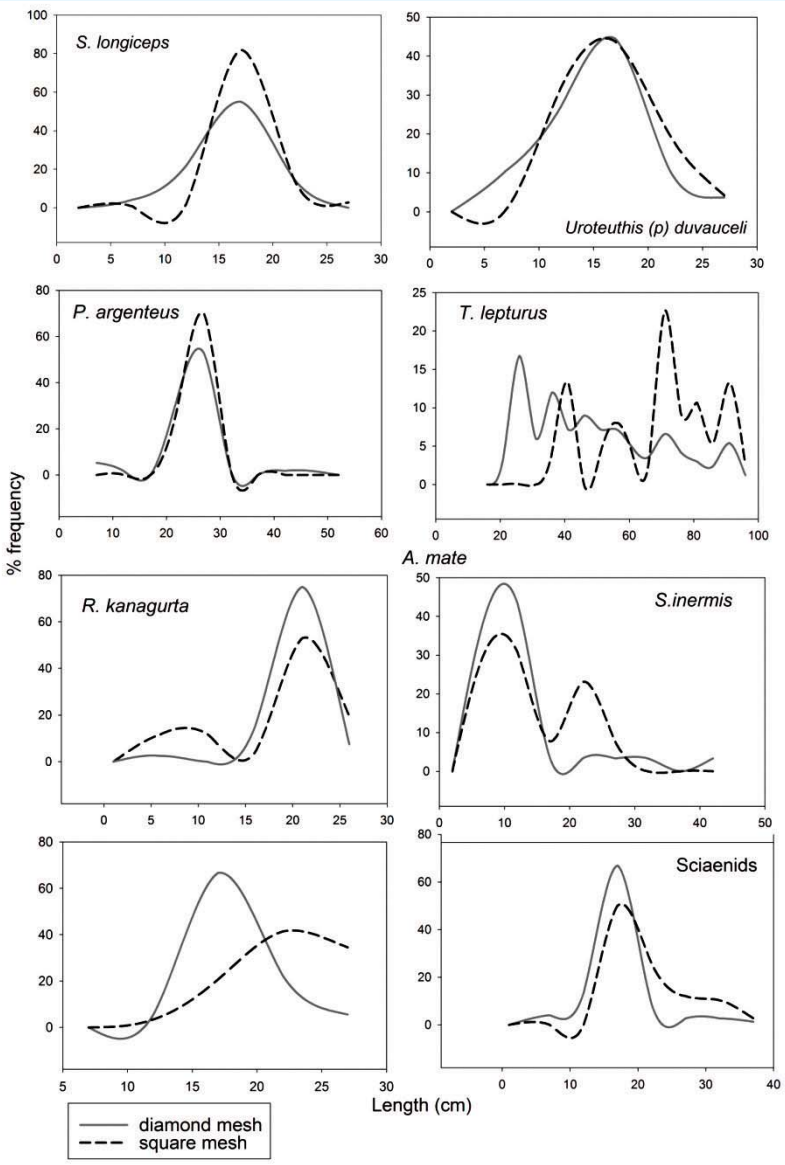
A total of 38 hauls using diamond mesh and 44 using square mesh codends were conducted along Sindhudurg coast. The mean CPUE (kg/h) for diamond mesh (18.77) and square mesh codend (19.48) fitted trawls, were not significantly different (Kruskal-Wallis chi-squared = 0.058711, df = 1, p-value = 0.81). The increase in mean length of 12 out of the 15 commercially important species studied increased by 7.85%. The rate of escapement was 0.76 kg per hour, from the square mesh codends, which is 3.9% of the total catch (2142.4 kg) retained and valued at INR 28.5 per haul. Bycatch generated per haul, was significantly higher during the months of December (43.5±9.3 SD) and January (56.3±17.1 SD) and the bycatch during months of September, October and November were less than 20.0 kg/haul.



Variation in the bycatch observed during the study period. The means which are significantly different are indicated as (**). The open circles are outliers and the box represents 25% and 75% quartiles. The thick line in the box is the mean.

Fabrication of square mesh codends

A total of 320 square mesh codends were fabricated for distribution to the trawl fishermen along Sindhudurg District, Maharashtra.



Size -frequency distribution of major species retained in the diamond and square mesh codends

National Fisheries Development Board (NFDB) Project

National Surveillance programme on aquatic animal diseases

As part of the project, disease surveillance was carried out in aquaculture farms in selected districts of Kerala during the year 2016-17. For the active surveillance programme, 540 finfish samples and 188 shellfish samples were collected from selected 50 farms representing five districts of Kerala (Palakkad, Thrissur, Ernakulam, Alappuzha and Kottayam). Except Alappuzha district, farms from all other districts were freshwater finfish farms. Fourteen imported frozen finfish and 26 shellfish products were also screened. The samples were tested for OIE-listed and non-listed pathogens such as KHV, SVCV from freshwater finfish and WSSV, MBV, HPV, IHHNV, YHV, IMNV, TSV, EHP and AHPND from brackish water shellfish by PCR. All the 540 pooled finfish samples from 40 farms were found to be negative for KHV and SVCV. Among 15 shellfish farms screened, the presence of WSSV was detected in seven farms and IHHNV was detected in two farms. The remaining pathogens tested could not be detected from any of the samples. From 26 imported frozen shrimp samples screened, three frozen *L. vannamei* samples were positive for WSSV (nested PCR positive) and the

remaining viruses could not be detected from the samples. All the 14 imported finfish samples tested were negative for KHV and SVCV. Water quality parameters, *viz*. temperature, salinity, PH, alkalinity, dissolved oxygen (DO), unionized ammonia, nitrate and nitrite, of all the farms were analyzed on site. Analysis revealed that 12 freshwater finfish farms had low DO (less than 3 mg/L).

Eight disease outbreak cases (three finfish farms and five shellfish farms) were investigated during the year. In finfish farms, the major cause of disease outbreak was due to low dissolved oxygen level (<3mg/L) and high concentration of unionized ammonia (>0.5mg/L) in farm water. In two shellfish farms, the cause of the disease outbreak was infection with WSSV, whereas combined infection with WSSV and IHHNV was found in one farm. Infection with luminescent *V. harveyi* was found to be the causative agent of disease problem in one shrimp hatchery. Pathogenic potential of these infectious agents were determined by infectivity studies.

WSSV Infected shrimp, *P. monodon* from aquaculture farm in Thrissur District

Disease outbreak in Red Bellied Pacu farm in Kottayam District due to ammonia toxicity (2 mg/L) and low dissolved oxygen (3 mg/L)

Two training programmes were organized under the Project for officials from Kerala State Fisheries Department and Agency for Development of Aquaculture, Kerala (ADAK), attended by 23 participants. A manual on "Disease diagnostics and disease management in aquaculture" was published as part of the training programme.

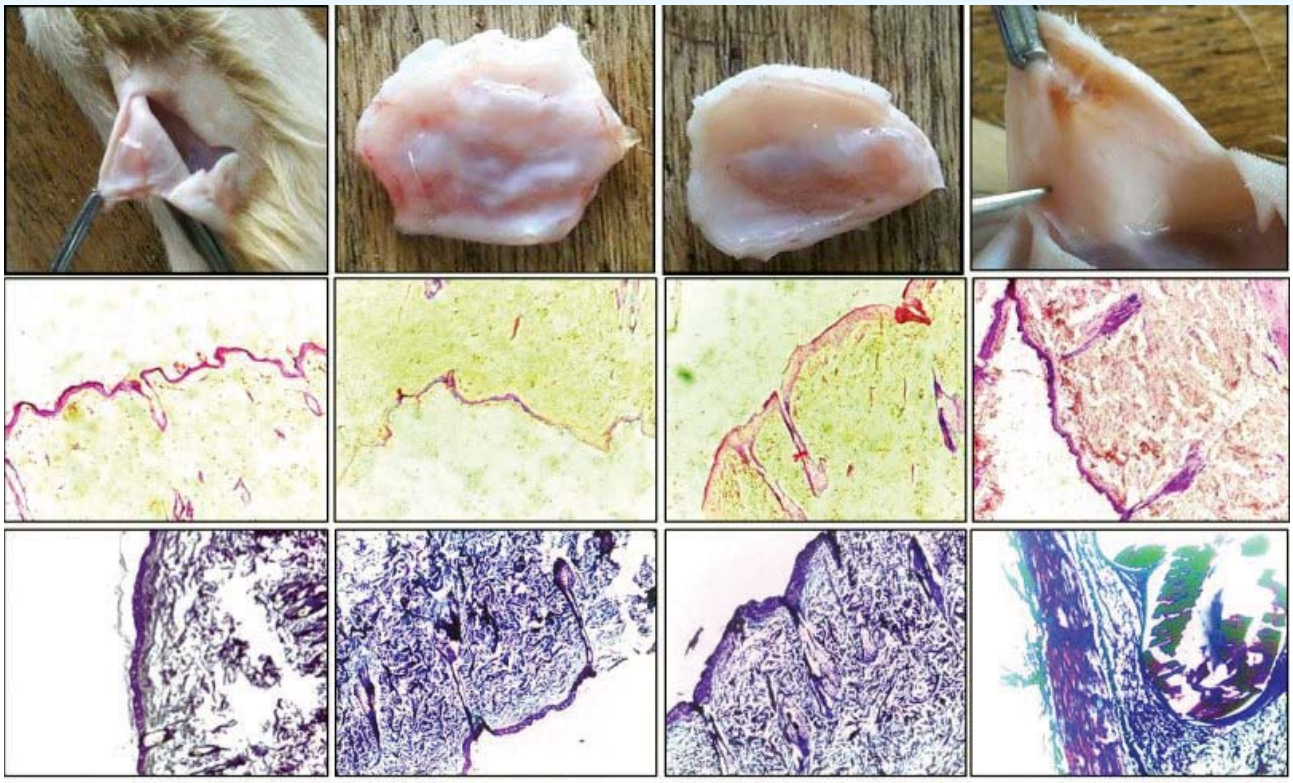
Training programme organized at ICAR-CIFT, Kochi

ICAR-National Fellow Project

Bio-modulation of marine biopolymers for the preparation of biomaterials of healthcare importance

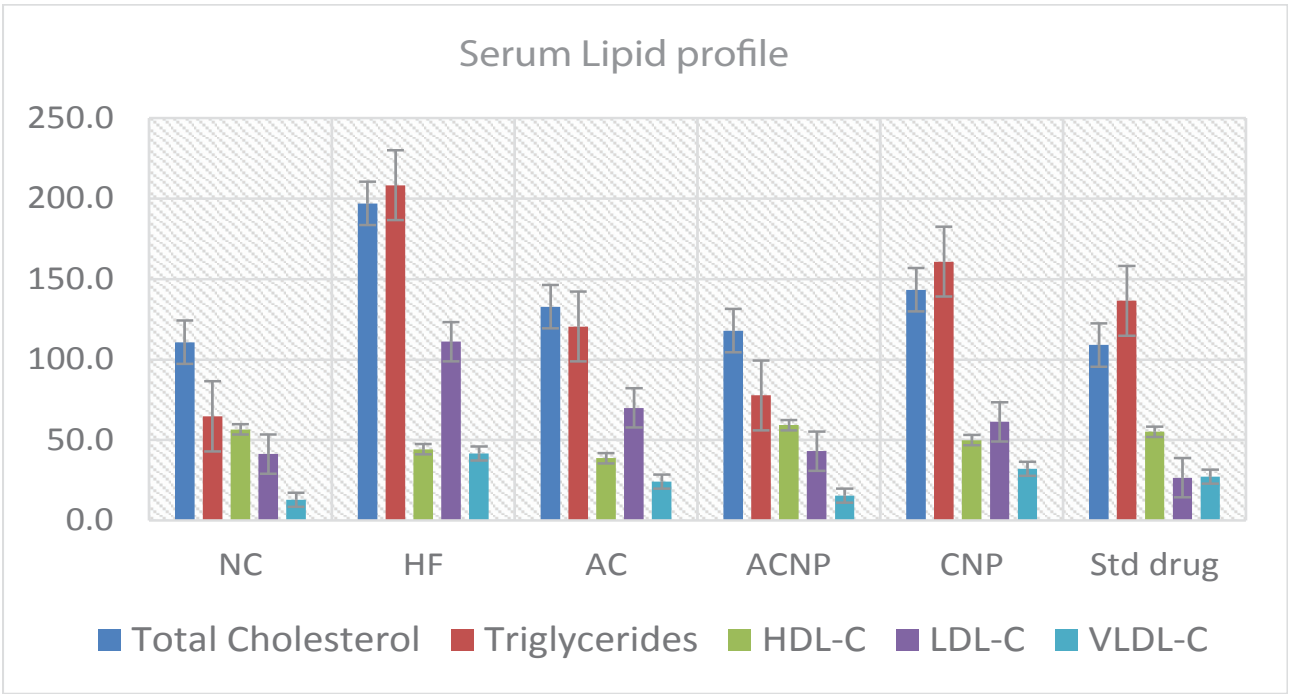
Histo-pathological evaluation of chitosan, chitosan/zinc acetate, chitosan/chondroitin sulphate and chitosan/zinc acetate/chondroitin sulphate films implanted in Wistar albino rats revealed good biocompatibility showing significant potential for biomedical applications.

Anthocyanin-loaded chitosan nano particles were developed and physico-chemical characterizations were carried out. *In vivo* evaluation on hypolipidemic potential of the developed nano particles in high fat-fed Wistar rats showed promising results.



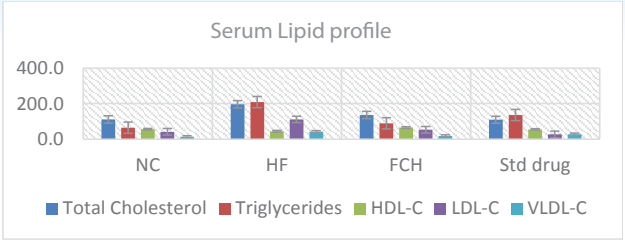
Chitosan | Chitosan-chondroitin suplhate | Chitosan-Zinc acetate | Chitosan-Zinc acetate chondroitin suplhate

Histo-pathological observations: Upper panel shows the gross appearance of excised tissue along with the implanted film after eight weeks of implantation. Middle panel shows light microscopic images of H&E stained tissues and lower panel shows the light microscopic images of Masson's trichrome stained tissues



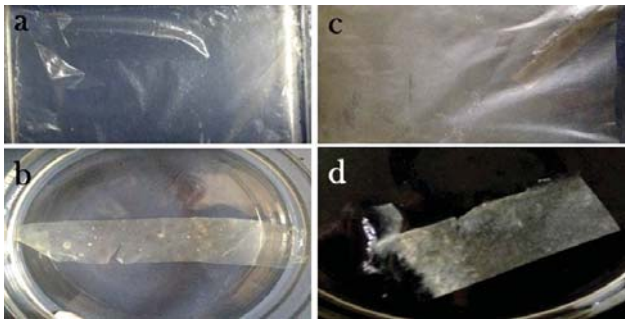
Graphical representation of serum levels of total cholesterol, triglycerides, HDL-cholesterol, LDL-cholesterol and VLDL-cholesterol

All the three experimental groups, anthocyanin-treated (AC), anthocyanin loaded chitosan nanoparticles (ACNP)-treated and chitosan nanoparticles (CNP)-treated groups were found to exert hypolipidemic effect. However, ACNP treated group exhibited the highest hypolipidemic effect. Moreover, there was a noticeable increase in HDL-cholesterol level in ACNP treated group. Physico-chemical characterization of collagen extract prepared from the air bladder of striped catfish (*Pangasius hypophthalmus*) revealed excellent purity, consisting predominantly of Type I collagen. Collagen hydrolysate prepared from shark skin (*Sphyrna emokkaran*) demonstrated to possess hypolipidemic activity in high fat fed Wistar rats.



Graphical representation of serum levels of total cholesterol, triglycerides, HDL-cholesterol, LDL-cholesterol, VLDL-cholesterol [NC-Normal control, HF- Hight fat, FCH-Fish collagen hydrolysate, Std drug- Standard drug (Statin)]

Fish collagen-based composite scaffolds for wound healing and skin tissue engineering applications were developed.



Collagen-based composite scaffolds using a combination of fish collagen (a & b) and Collagen-Alginate-Chitosan (CAC) (c & d)

Chitosan based gel/sol

Chitosan-based pain relieving balm

Chitosan-based gel sol was developed which was found to be useful for curing calluses and corns.

Chitosan-based balm with squalene as an active component was developed which was found to have pain relieving potential.

Export Inspection Council (EIC) Project

Preparation of pictorial guidelines based on freshness ratings for the species of fishes exported to European Union

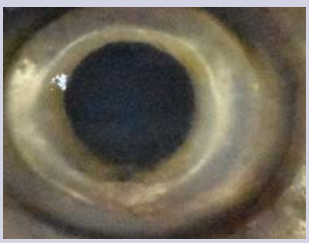
Development of pictorial guidelines for freshness indication in fish

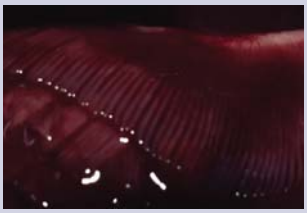
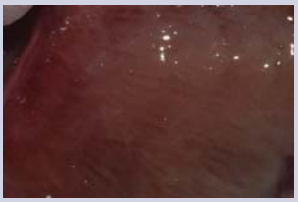
Development of pictorial guidelines based on the freshness ratings for the species of fishes exported to European Union was carried out at Kochi, Veraval, Mumbai and Visakhapatnam taking into account the predominance in landings. As per European Union guidelines, freshness category of fish species was graded as E, A and B for fish and cephalopods and E and A for shrimps. This gradation was assessed based on sensory parameters (Eyes, gill, operculum, skin, smell, flesh mucus and overall appearance), biochemical parameters (TVBN, TMA, TBA and pH) and microbiological qualities (APC, *Pseudomonas* count and H_2S producing bacteria count).

Pictorial guidelines have been developed for the following species:

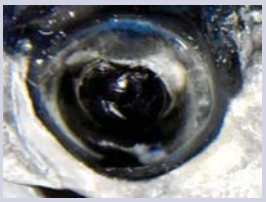
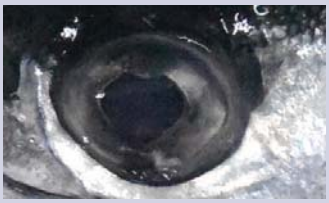
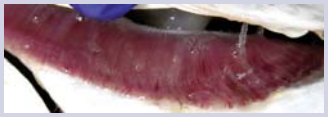
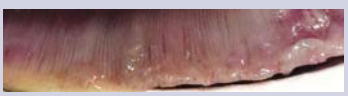
Centres	Species	
	Scientific name	**Common name**
Kochi (HQ)	*Thunnus albacore* *Sardinella longiceps* *Fenneropenaeus indicus* *Chanos chanos* *Auxis thazard* *Epinephelus malabaricus* *Macrobrachium rosenbergii* *Mugil cephalus* *Tylosurus crocodilus crocodilus* *Etroplus suratensis* *Scomberomorus commerson*	Yellowfin tuna Indian oil sardine Indian white prawn Milkfish Frigate tuna Malabar grouper Giant freshwater prawn Flathead grey mullet Hound needle fish Pearl Spot Spanish mackerel
Veraval	*Lepturacanthus savala* *Chirocentrus dorab* *Scomberomorus guttatas* *Sardinella fimbriata* *Sphyrna jello* *Loligo duavauceli* *Octopus vulnaris* *Megalaspis cordyla* *Scoliodon laticaudus*	Ribbon fish Wolf herring Seerfish Sardine Barracuda Squid Octopus Horse mackerel Shark
Visakhapatnam	*Labeo rohita* *Pentaprion longimanus* *Penna hiaanea* *Katsuwonus pelamis*	Rohu Silver biddy Donkey crocker Skipjack tuna
Mumbai	*Ompok pabda* *Otolithes ruber* *Johnius dussumieri* *Nemipterus japonicas* *Harpodon nehereus* *Priacanthus hamrur* *Coilia dussumieri* *Plicofollis dussumieri* *Lactarius lactarius*	Indian butter catfish Tiger tooth croaker Sin croaker Japanese threadfin bream Bombay duck Big eye/ Bulls eye fish Gold-spotted anchovy Black tip sea catfish False trevally

***Mugil cephalus* (Flathead grey mullet)**

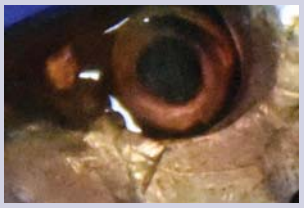
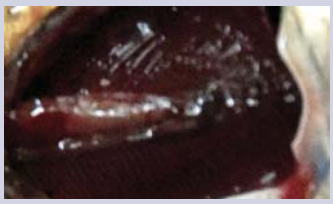
	E - (1st Day)	A - (2nd Day)	B – (4th Day)
Eyes	Convex, bright black pupil, clear silvery cornea	Convex, black pupil, clear cornea without silvery shine	Sunken, completely cloudy, ingression of blood in the cornea
			

Gill	Dark red, gill rackers visible	Dark red, gill rackers visible	Bleaching of gill with dark brown end
			

***Tylosurus crocodiles crocodilus* (Hound needle fish)**

	E - (1st Day)	**A - (3rd Day)**	**B - (5th Day)**
Skin	Dorsal lustrous, shiny, dark green appearance with glittering dots	Clear visibility of musculature structure up to pelvic fin, slight yellowish discolouration ventral side is having silver bars	Yellowish pigmentation increased towards caudal region
			
Eyes	Convex, black, bright pupil, bluish green pigmented cornea	Convex cloudy, black discolouration around the eyes	Cloudy, sunken
			
Gill	Bright, red and fresh slimy	Bleached, brownish red colouration	Mushy, thick brownish slime
			

***Sardinella longiceps* (Indian oil sardine)**

	E - (1st Day)	A - (3rd Day)	B - (4th Day)
Eyes	Convex, black bright pupil, transparent cornea	Convex, black bright pupil, slight yellowish cornea	Completely sunken, profuse immigration of blood, cornea dark reddish
			
Gill	No mucus, bright red	Dull red	Blackish brown in colour
			

National Bank for Agriculture and Rural Development (NABARD) Project

Assessment of role and impact of Fisheries Co-operatives in enhancing the livelihood and resource management capabilities of fisherfolk in India

The project covered two maritime states *viz*., Kerala and Tamil Nadu representing the West coast and East coast, respectively and had 435 respondents in Kerala and 453 members in Tamil Nadu in the districts of Kozhikode, Ernakulam, Thiruvananthapuram, Chennai, Nagapattinam and Kanyakumari, covering 17 Co-operative Societies.

Roles played by Fishermen Co-operatives in marine fisheries sector

The Fisheries Co-operatives in India provide credit and welfare services to the fishers. The co-operatives play an important role in promoting savings among fishermen through thrift. It also disseminates the information and knowledge regarding fisheries co-operatives support marketing through facilitating auction, providing price information etc.

Perception on roles of Fishermen Co-operatives by members

Fisher members of Kerala felt that co-operatives contributed more towards auctioning of fish catch and building capacities through market stabilization mechanisms. This is mainly by effective functioning of the auction system put in place by the Apex Body. Contrary to the perceptions of fisher members in Kerala, Tamil Nadu-based Fishermen Co-operatives were mainly playing roles in facilitating access to credit and providing disaster or natural hazard warnings and conflict management. The fisher members felt that the Societies were not doing enough to facilitate access to assets, inputs or markets.

Impact of fishery co-operative schemes for input delivery and marketing on the stakeholders

The major impact indicators as perceived by the fishermen on various activities compared for Kerala and Tamil Nadu indicated that in Kerala activities undertaken by Fishermen Co-operative Societies had impacted access to institutions

(85.79%), production (76.70%), profit (73.26%), management (62.48%) and livelihood (52.91%). In Tamil Nadu, the figures were lesser in comparison ranging from 53.82% for management to a low of 35.87% on livelihoods. The impacts were classified as high, moderate and low for various parameters.

Particulars	Kerala	Tamil Nadu
Access to institution	High impact	Moderate impact
Production	High impact	Low impact
Profit	High impact	Low impact
Management	Moderate impact	Moderate impact
Livelihood	Moderate impact	Low impact

Factors affecting the performance of Fishermen Co-operatives

It was found that four dimensions selected for the study, *viz*., finance, governance, services and capacity building can be used for assessing the performance of the Societies. The Fishermen Co-operatives in Kerala and Tamil Nadu were categorized based on the co-operatives performance index in the categories like, Early transition to growth (less than 50 points), Mid transition to growth (50 to 70 points) and Model (more than 70 points) and it was found among the 17 Co-operatives studied, most are still in the growth phase, either early or mid transition stages. Co-operatives in Kerala had fared better in terms of the index calculated.

Food and Agricultural Organization (FAO) Project

Assessment of food loss from selected gillnet and trammel net fisheries of India

Inception workshop of the project

An `Inception workshop' of the project was organized on 4th January, 2017 by inviting the project partners and various stakeholders of the project. The inaugural function was followed by a brainstorming session in which 37 delegates participated (Details given elsewhere in this report).

Participants of the Inception Workshop

Secondary data on the gillnet/trammel net fishing systems in Kerala, Tamil Nadu, Gujarat and Andhra Pradesh and the current knowledge about the food loss and gaps were collected. Eight sites were selected to conduct the primary data collection *viz*., quantitative and qualitative information on the losses occurring in the gillnet and trammel net fisheries (the where, who, when, how, what and why issues). Through the Fishermen Societies and the Department of Fisheries officials of the respective locations, initiated the primary data collection.

Quantified the number of non-motorized/motorized/ mechanized gillnet fishing units and important gillnet types in each study site. Sample frame prepared for individual fisherman interviews and measurement of gear. Sample size was fixed based on total number of gillnet/trammel net fishing units in each sector operating at each study site.

Indian Council of Agricultural Research (ICAR) Projects

Agri Business Incubation Centre

Technologies commercialized

The following technologies developed by the Institute were commercialized during the year:

- Production and retailing of hygienically dressed and packed fresh fish in Kerala
- Optimization of process conditions for the production of 12 ready-to-eat shelf life products
- Preparation of fish gravy paste in ready-to-cook form
- Evaluating the effectiveness of different training programmes conducted by NETFISH in the areas of fish quality management and sustainable fishing
- Validation of the fishing vessel engines
- Fabrication and installation of eco-friendly solar dryer for hygienic preservation of fish (CIFT DRYER SDL-55SM) developed by ICAR-CIFT
- Development of fish and shellfish silage and fertilizer for crop applications
- Production of chitin and chitosan
- Setting up fish processing and canning units

Collaborative research programmes

The Institute has done collaborative research programme on 'Developing chitin/chitosan-based plant boosters for agricultural applications' with M/S Marshal Marine Products, Erode, Tamil Nadu and on 'Promotion and acceleration of research in the field of cold water fisheries' with Tamil Nadu Fisheries University, Nagapattinam, Tamil Nadu.

Patents and other IPRs granted

ICAR-CIFT has successfully registered two trademarks, FERTIFISH® and FISHMAGIC®. Both the trademarks were published in Trademark Journal No:1741, in April, 2016 and will have validity up to June, 2022.

FERTIFISH® is registered under the trademark Class 1, as fish-based manure. Class 1 deals with chemical products used in industry, science and agriculture, including those that go to the making of products belonging to other classes.

FISHMAGIC® is registered under the trademark Class 35, as exclusive outlets for business management, business administration and office functions. Class 35 includes mainly services rendered by persons or organizations principally with the object of help in the working or management of a commercial undertaking, and/or help in the management of the business affairs or commercial functions of an industrial or commercial enterprise.

Other notable activities to promote innovation and entrepreneurship

The following programmes were organized during the period under report:

- Entrepreneurship development programmes in association with MACFAST College, Thiruvalla, Kerala during 24 October-18 November, 2016.
- Training programmes for women entrepreneurs, in association with Alleppey Diocesan Charitable and Social Welfare Society.
- Stakeholder's meeting with participation of seafood exporters and industry representatives at ICAR-CIFT, Kochi on 11 January, 2017.
- Sensitization workshop on 'Entrepreneurship development' in association with ICAR-NAARM, Hyderabad, KVASU, Pookode and KAU, Thrissur on 26 August, 2016.
- Workshop on 'Start-ups and innovation for agri-entrepreneurship' in association with ICAR-NBFGR, Lucknow.
- Fisheries Industry Meet in association with ICAR-CIFE, Mumbai on 4 March, 2017.
- Participated in 20th Annual Conference of Asian Science Park Association held during 19-22 October, 2016 at Hyderabad and showcased the prospective technologies of ICAR–CIFT.

Incubation activities

During the period a total of 10 entrepreneurs enrolled as Incubatees in the Centre. Nine consultancy agreements/ technology transfer MoUs were signed. About 170 students were given entrepreneurship development training and technology training was imparted to 55 entrepreneurs.

Nutrient profiling and evaluation of fish as a dietary component

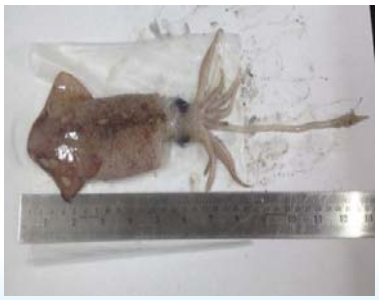
Database on deep sea fishes

Database on the biochemical composition of 21 deep sea fishes was generated (proximate composition, fatty acid and amino acid profile and mineral profile). It was noticed that these fishes are rich in aspartate, arginine, lysine and glutamate. These amino acids play major roles in modulating vascular endothelial function and neuronal function.

Exocoetus monocirrhus

Decapterus russelli

Epinephelus diacanthus

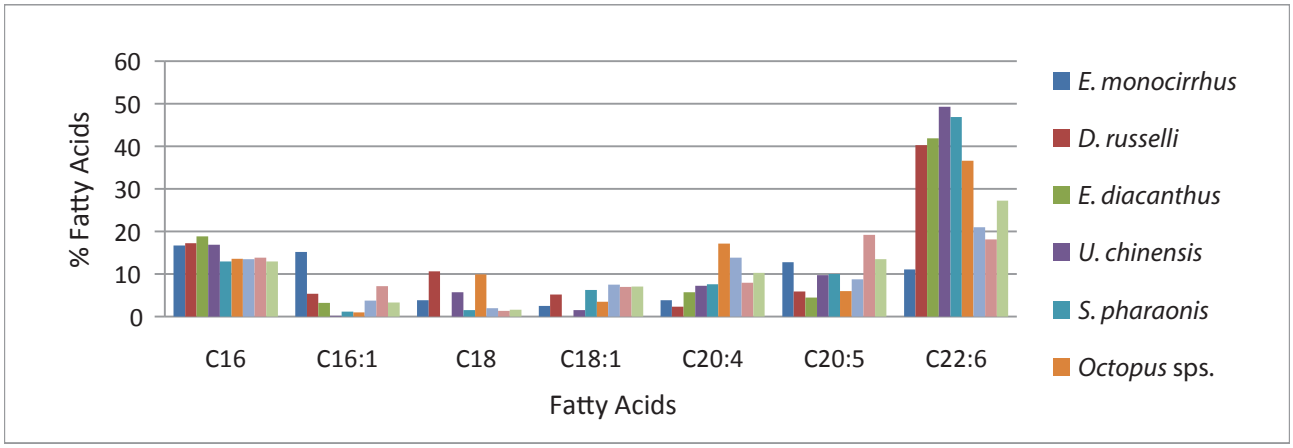


Uroteuthis chinensis

Sepia pharaonis

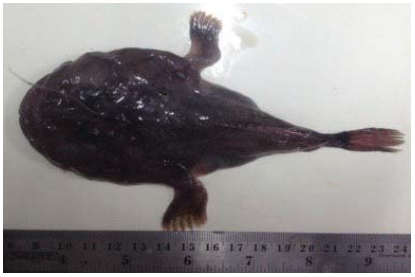
Octopus sp.

Elemental and mineral profiling of deep sea fishes have shown that they are rich in beneficial macro and trace elements. The gas chromatographic analysis on the fatty acid profiling of fishes have indicated the presence of rich amount of eicosa penta enoic acid and docosa hexa enoic acid. These fatty acids are reported to have beneficial effects on foetal development, proper neuronal and cellular functions and healthy aging.



Fatty acid profile of coastal fishes

Lophius piscatorius



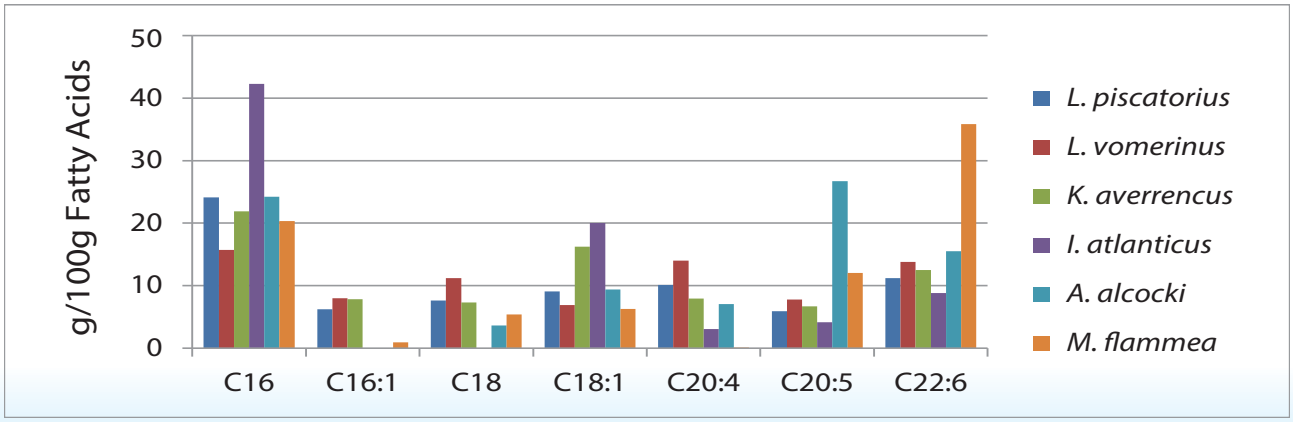
Lophius vomerinus

Kathetostoma averruncus

Idiacanthus atlanticus

Aristeus alcocki

Mastigoteuthis flammea

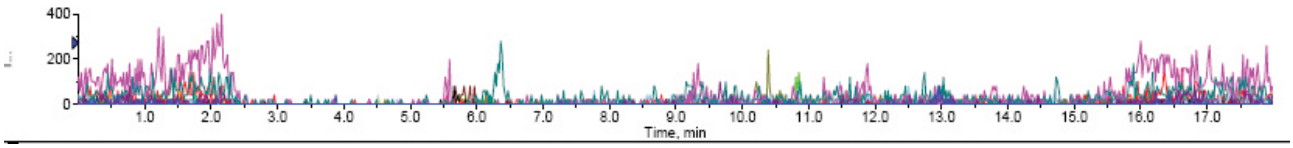


Fatty acid profile of deep sea fishes

All India Network Project on Fish Health

LC-MS/MS method optimization for analysis of tetracycline hydrochloride, chlortetracycline hydrochloride, oxy tetra cycline hydrochloride, trimethoprim, sulfadimethoxine, sulfamerazine, sulfadiazine, sulfamethazin, sulfamethizole etc. was carried out. Residue levels in fishes fed with oxy tetra cycline under experimental condition at different concentration were determined. Analysis of tetracyclines in shrimp samples collected from farms located at Edavanakkad and Kuzhippally, Ernakulam district was carried out. Tetracycline was absent in all the analyzed shrimp samples. A total of 161 test samples were received from three Institutes, *viz*. ICAR-CIBA, Chennai, ICAR-CIFA, Bhubaneswar and WBUFAS, Kolkata for OTC analysis.

Around 47 samples (18 water samples and 29 shrimp samples) from ICAR-CIBA were analyzed to detect the presence of oxy tetra cycline (OTC). Only in three samples OTC was at a concentration below 100 ppb. From ICAR-CIFA, 24 samples were analyzed from six experimental batches of rohu fish fingerlings/fries of which five were fed with 40 mg/kg, 80 mg/kg, 240 mg/kg, 400 mg/kg and 800 mg/kg of OTC respectively and one control batch fed with normal feed. Fingerlings/fries were collected at four different periods during the course of study (1st day, 10th day, 15th day and 20th day). Highest concentration of residual OTC found was 33.7 ng/mL (from the sample collected on 15th day, fed with 240 mg/Kg OTC). From WBUAFS, Kolkata, six experimental batches of tilapia fish fingerlings were analyzed. Five batches were fed with 40 mg/kg, 80 mg/kg, 240 mg/kg, 400 mg/kg and 800 mg/kg of OTC, respectively and one control batch fed with normal feed. Fingerlings were fed for 20 days and sampling was done on different time intervals ie. 1st day, 10th day, 20th day, 25th day and 35th day. The concentration of residual OTC increased up to 20th day and then declined. The concentration of residual OTC in the analyzed samples were in proportion with the concentration of OTC administered.



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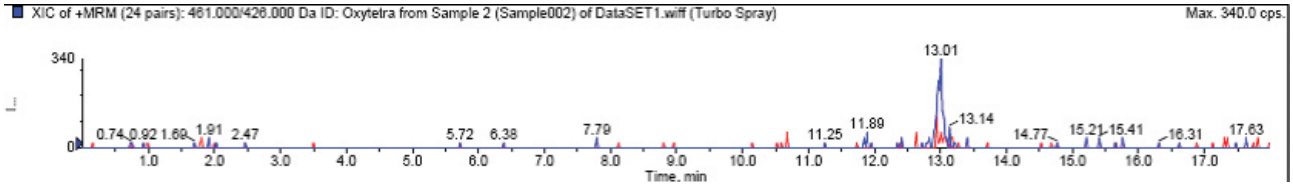
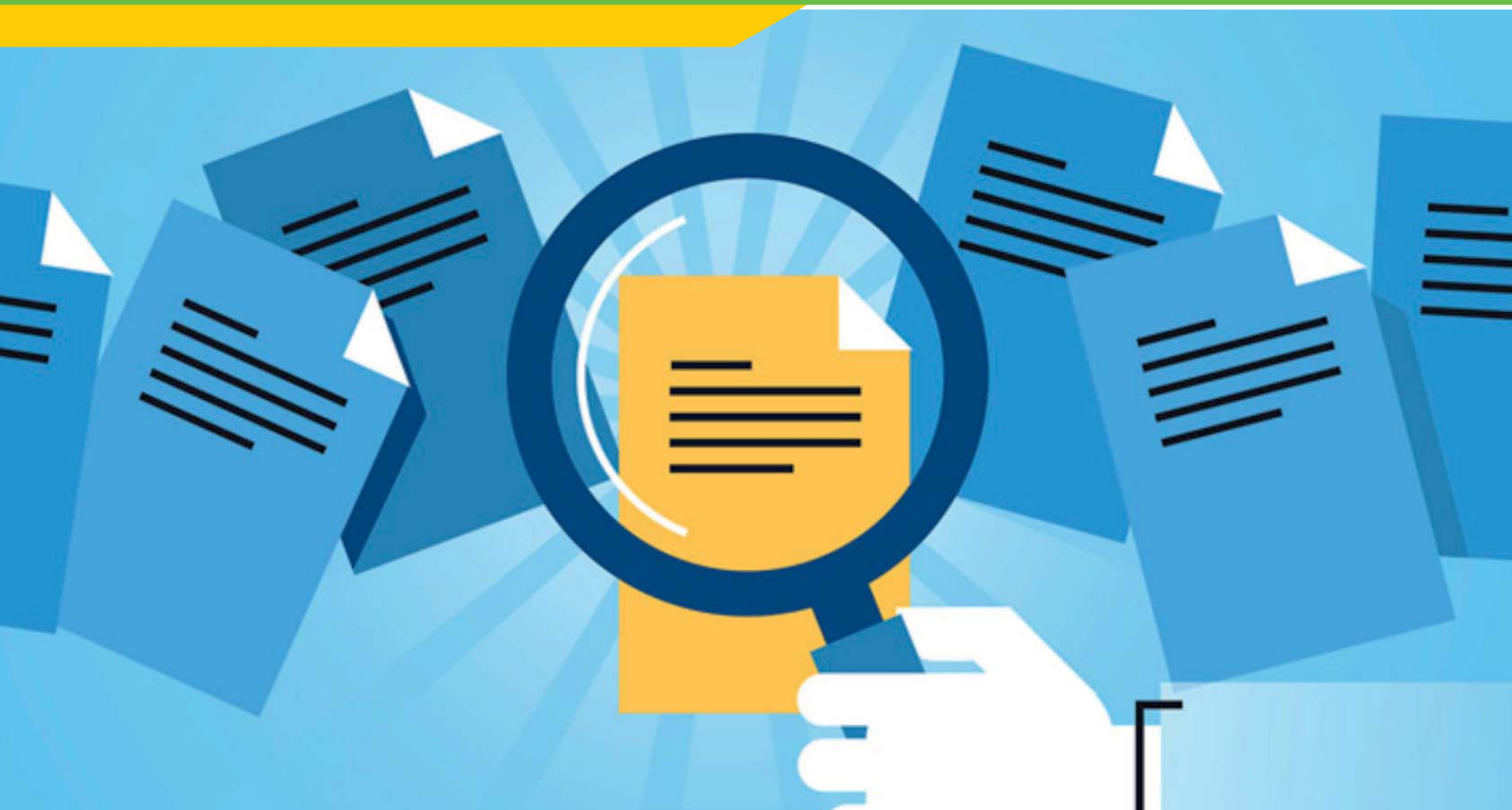


Sample

LC-MS/MS analysis of oxy tetra cycline

GENERAL INFORMATION



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Communicating Research Outcome

Participation in Symposia/Seminars/Workshops etc.

Scientists from the Headquarters and Research Centres participated in several national and international symposia, seminars and workshops. Some of the notable events were: National symposium on 'One health initiative to foster inter-sectoral collaboration for human and animal health' at G.B. Pant Univ. of Agriculture and Technology (26-28 April, 2016), 3rd Congress on 'Social entrepreneurship in aquaculture' at ICAR-CIFE, Mumbai (27-29 April, 2016), National seminar on 'Conservation, restoration and sustainable management of mangrove forests in India' at Visakhapatnam (15-17 June, 2016), International seminar on 'Marine pollution and environement' at CUSAT, Kochi (4-5 August, 2016), International conference on 'Emerging issues in quality and safety of fish and shellfish' at Anna University, Chennai (11-12 August, 2016), International conference on 'Agricultural sciences and technologies for sustainable productivity and nutritional security' at UAS, Bengaluru (25-27 August, 2016), International symposium on 'Microbial ecology and systematics' at CSIR-NCL, Pune (16-17 September, 2016), International seminar on 'New trends in Applied Chemistry' at Kochi (8-11 February, 2017) and XIII Agricultural Science Congress 2017 at UAS, Bengaluru (23-24 February, 2017). Papers on responsible fishing, nutritional aspects of fish, advancements in processing technologies, techniques for detection and diagnosis of pathogens, quality aspects in fish trade, socio-economic issues etc. were presented by Scientists, Technical Officers and Research Scholars of the Institute. The scientific meetings were attended by scientists, researchers, policy makers, students, teachers, administrators etc. and productive deliberations were held.

Training/Awareness Imparted

Sl. No.	Subject	No. of beneficiaries	Venue and date
1.	Development of a co-delivery system of betalain and PUFA: Multiple emulsification and microencapsulation by spray drying	1	Kochi (1 April – 24 September, 2016)
2.	Screening and production of biosurfactant from *Pseudomonas fluorescens*	1	Kochi (4 April – 2 July, 2016)
3.	Extraction of chitin from shrimp shell and its quality evaluation	1	Kochi (4 April – 4 July, 2016)
4.	Study on physical an mechanical properties of gelatin film incorporated with seaweed polysaccharides	1	Kochi (4 April – 4 July, 2016)
5.	Biochemical characterization of acid soluble collagen extracted and purified from swim bladder of *Labeo rohita*	1	Kochi (12 April – 24 September, 2016)
6.	Biochemical characterization of *Ulva lactuca* and its utilization for fortification of soup powder	1	Kochi (12 April – 24 September, 2016)
7.	Preparation and characterization of protein isolate from *Mystus gulio* and *Labeo rohita* by isolectric solubilization/precipitation	1	Kochi (12 April – 24 September, 2016)
8.	Cell toxicity activity of proteoglycans isolated from *Echinorhinus brucus* against HeLa cell line and characterization of its glycosaminoglycans	1	Kochi (12 April – 29 September, 2016)

Sl. No.	Subject	No. of beneficiaries	Venue and date
9.	Hygeinic handling of fish and development of value added fishery products	12	Veraval (13-18 April, 2016)
10.	Post harvest processing and value addition	2	Kochi (20 April – 20 May, 2016)
11.	Harvest and post harvest technologies	42	Padderu reservoir, Visakhapatnam (22 April, 2016 & 9 June, 2016)
12.	Prepration of value added fishery products	23	Kochi (22-23 April, 2016 & 22 November, 2016) & Mumbai (5-7 May, 2016)
13.	Transfer of technology programme	68	Usgaon, Maharashtra (25-27 April, 2016)
14.	Quality evaluation and shelf life prediction of tilapia under iced and chilled condition	1	Kochi (1 February – 1 May, 2016)
15.	HACCP concepts	41	Kochi (2-6 May, 2016 & 15-19 November, 2016)
16.	Microencapsulation of squalene using a protein polysaccharide complex for the development of functional food	1	Kochi (4 May – 31 July, 2016)
17.	Super critical carbon dioxide extraction of phytochemicals from brown seaweeds and olive leaves and evaluation of anti-oxidant potential	1	Kochi (4 May – 31 July, 2016)
18.	Laboratory methods for microbiological examination of seafood	53	Kochi (23 May – 4 June, 2016, 21 November – 3 December, 2016 & 6-18 February, 2017) & Visakhapatnam (21 November – 3 December, 2016)
19.	Preservative effect of chitosan and essential oil-based formations on shelf life extension of fishery products	1	Kochi (1 March – 31 May, 2016)
20.	Impact of liquid smoke on survival of bacterial pathogens and shelf life extension of fishery products	1	Kochi (1 March – 31 May, 2016)
21	Food processing technology	4	Kochi (1-30 June, 2016)
22.	Responsible fisheries and post harvest technologies	60	Cheppalakancheru and Mukka, Visakhapatnam (2 June, 2016), Mukka Konada (4 June, 2016) & Tippalavalasa Pedduru (9 June, 2016)
23.	Freezing and canning of fish	3	Kochi (13-15 June, 2016)
24.	Industrial training in fish processing	21	Kochi (13-27 June, 2016)
25.	Total quality assurance of seafoods		Mumbai (14-18 June, 2016)
26.	Hygenic handling of fish and preparation of value added fish products	30	Visakhapatnam (16-18 June, 2016)
27.	Value addition in fish	20	Kodinar, Gujarat (23-25 June, 2016)

Sl. No.	Subject	No. of beneficiaries	Venue and date
28.	Quality assurance in seafoods	4	Kochi (27-30 June, 2016, 19 September – 1 October, 2016 & 10-13 January, 2017) & Mumbai (6-13 September, 2016)
29.	Enzyme producing potential of Actinomycetes isolated from marine environement	1	Kochi (30 March – 29 June, 2016)
30.	Fish processing technology	26	Kochi (1-30 June, 2016, 5-6 September, 2016, 17 February – 3 March, 2017 & 6 March- 6 June, 2017)
31.	Biochemical techniques for fish quality analysis	18	Veraval (4-9 July, 2016)
32.	Microbial quality of seafood	3	Mumbai (4-9 July, 2016)
33.	Preparation and evaluation of fish pickle	3	Kochi (11-12 July, 2016)
34.	Isolation and antimicrobial sensitivity pattern of *Salmonella* from seafood	1	Kochi (11 July – 30 September, 2016)
35.	Production of chitin and chitosan	3	Kochi (13-14 July, 2016)
36.	Making of square mesh codends in trawl nets	40	Munambam, Kerala (23 July, 2016)
37.	Hygienic fish handling	52	Athirappally, Kerala (3 August, 2016)
38.	Fish processing and value addition	23	Kochi (3-5 August, 2016 & 16-19 January, 2017)
39.	General protocols and specific isolation techniques for pathogenic microorganisms	20	Kochi (3-7 August, 2016)
40.	Fisherwomen skill development programme on net making and mending	20	Kochi (8-12 August, 2016)
41.	Disease diagnostics and disease management in aquaculture	35	Kochi (29 August – 2 September, 2016 & 18-21 October, 2016)
42.	Isolation, characterization and functional properties of protein isolate from *Catla catla* and *Nemipterus japonicas* by isolectric solubilization/ precipitation	1	Kochi (1 March – 31 August, 2016)
43.	Fish canning technology	1	Kochi (5-6 September, 2016)
44.	Clam meat processing and preparation of value added fish products	16	Kochi (8-9 September, 2016)
45.	Fabrication of square mesh codends	80	Malvan, Maharashtra (28 September, 2016) & Devgad, Maharashtra (29 September, 2016)
46.	Preparation of value added fisheries products	40	Bheemunipatnam, A.P. (3 October, 2016)
47.	Hygeinic handling of fish and value added products	30	Visakhapatnam (5-7 October, 2016)
48.	ISO-22000 – HACCP for seafood industry	4	Kochi (17-28 October, 2016)

Sl. No.	Subject	No. of beneficiaries	Venue and date
49.	Hygeinic drying of fish, value added fishery products and marketing of fishery ptroducts	40	Bheemunipatnam, A.P. (31 October, 2016) & Chepala Thimmapuram, A.P. (2 November, 2016)
50.	Coated fishery products	1	Kochi (2-3 November, 2016)
51.	Lobster traps	30	Mandvi, Gujarat (10 November, 2016)
52.	Semi-pelagic trawling	35	Chapora, Goa (11-14 November, 2016)
53.	Extension methodologies for coastal fisheries	2	Kochi (15-26 November, 2016)
54.	Vaue added fish products	25	Alappuzha (22 November, 2016)
55.	Fabrication of CIFT-TED	70	Kasimedu Fishing Harbour, Chennai (25-26 November, 2016)
56.	Harvest and post harvest technologies	80	Desaipur village, Berhampur, Odisha (1-3 December, 2016)
57.	Preparation of value added fisheries products	50	Chinnaboddu Venkatayapalem, Kakinada (6 December, 2016)
58.	Preparation and quality evaluation of chitin, chitosan and glucosamine	3	Kochi (6-7 December, 2016)
59.	Improved fish driers	25	Kochi (8-9 December, 2016)
60.	Biocontrol of fungal contamination in fish by chitin degrading bacteria	2	Kochi (13-24 December, 2016)
61.	Hygienic preparation of dry fish and preparation of value added fishery products	30	Visakhapatnam (19-20 December, 2016)
62.	Assessment of fish quality and additives	20	Kochi (28 December, 2016)
63.	Fishing technology, fish processing, quality assurance, biochemistry and nutrition	13	Kochi (9-19 January, 2017)
64.	Modern analytical techniques in biochemistry	3	Kochi (10-21 January, 2017)
65.	Preparation of breaded and battered fish products	40	Kadamakudy, Ernakulam (24-25 January, 2017
66.	Extrucion process technology and product developement	5	Kochi (27-28 January, 2017)
67.	Preparation of value added fishery products from marine and inland resources	6	Mumbai (6-7 February, 2017)
68.	Development of fish and shrimp based value added products	3	Kochi (6-18 February, 2017)
69.	Value addition of fish and shellfishes, HACCP and quality assurance	14	Kochi (10-15 February, 2017)
70.	HACCP and fish processing technology	14	Kochi (10-18 February, 2017)
71.	Fish waste utilization	25	Thimmapuram village, Visakhapatnam (15-16 February, 2017)
72.	Hygienic handling of fish and value added fishery products	25	Visakhapatnam (15-17 February, 2017)

Sl. No.	Subject	No. of beneficiaries	Venue and date
73.	Quality assurance of fishery products	3	Kochi (16-18 February, 2017)
74.	Fish processing and food processing	18	Kochi (17 February – 17 March, 2017)
75.	Fish traps	21	Jambur village, Veraval (18 February, 2017)
76.	Production of chitin, chitosan and glucosamine hydrochloride	1	Kochi (27-28 February, 2017)
77.	Value added fish products	15	Kochi (28 February – 1 March, 2017)
78.	Food engineering including drying technology, heat and mass transfer, sensors and instrumentation	20	Kochi (6-17 March, 2017)
79.	Production of chitin, chitosan and glucosamine hydrochloride	2	Kochi (7-8 March, 2017)
80.	Advances in seafood processing and value addition	4	Mumbai (14-31 March, 2017)
81.	Quality evaluation of fish meal and oil	1	Kochi (20 March – 4 April, 2017)
82.	Heavy metal analysis	4	Viskahapatnam (20-24 March, 2017)
83.	Fabrication of CIFT-TED	20	Chennai (27-28 March, 2017)

Demonstration of hygienic fish handling at Mumbai


Training programme on Value added fishery products at Mumbai

Participatnts and faculty of training on Total quality assurance of seafoods at Mumbai


In-plant training at Kochi

Trainees from Gorai Fishermen Co-operative Society at Mumbai

Trainees on Heavy metal analysis with faculty at Visakhapatnam

Hygienic drying of fish, value added fishery products and marketing of fishery products at Bheemunipatnam

Hygienic drying of fish, value added fishery products and marketing of fishery products at Chepala Thimmapuram

Laboratory methods for microbiological examination of seafood - Participants and faculty at Visakhapatnam

Hygienic preparation of dry fish and value added fishery products at Thimmapuram

Hygienic handling of fish and value added fishery products at Visakhapatnam

Heavy metal analysis at Visakhapatnam – Participants and faculty

Fabrication of CIFT-TED at Chennai

Improved fish drying at Kochi

Preparation of value added fishery products at Desaipur, Odisha

Preparation of value added products at Thakazhi

Outreach programmes

Outreach training programmes

During the period (April 2016 to March 2017) a total of 24 training/awareness programmes on various aspects of harvest and post harvest technologies were conducted outside the Institute as indicated in screen in the previous Chapter on 'Training/Awareness Imparted'.

Exhibitions

The Institute participated in the following exhibitions during the period:

1. 'Punjab Fish Festival 2016', GADVASU Punjab Agricultural University, Ludhiana during 24-25 April, 2016.
2. Exhibition held in connection with International Day for Biological Diversity held at Mumbai on 22 May, 2016.
3. CUSAT Marine Fest – 'Propulzo-2016' at KMSME, CUSAT, Kochi during 28-30 July, 2016.
4. Exhibition held in connection with the International conference on 'Environmental sustainability for food security' at Sree Ayyappa College for Women, Chunkankadai, Nagercoil, Tamil Nadu during 22-24 September, 2016.
5. 20th India International Seafood Show-2016, Visakhapatnam during 23-25 September, 2016.
6. 'Matsya Mela', University of Agricultural Sciences, Dharward during 24-27 September, 2016.
7. 'Krishi Mela', ICAR-CPCRI Regional Station, Kayangulam on 29 September, 2016.
8. Exhibition held in connection with the 20th Annual Conference of Asian Park Association at Hyderabad during 19-22 October, 2016.

9. Krishi Mela/Matsya Mela, University of Agricultural Sciences, Bengaluru on 21 October, 2016.
10. Exhibition held in connection with the National conference on 'Tropical crops for sustenance and welfare of tribal communities' at ICAR-CTCRI, Thiruvananthapuram during 20-22 October, 2016.
11. 'Mangrove Festival' at KUFOS, Kochi on 16 November, 2016.
12. Exhibition held in connection with National Seminar on 'Aquaculture diversification: The way forward for Blue Rvolution' at ICAR-CIFA, Bhubaneswar during 1-3 December, 2016.
13. Aquaculture Exhibition, ICAR-CIFA, Bhubaneswar during 8-10 December, 2016.
14. Exhibition held in connection with the ASA-ICCB at ICAR-CIARI, Port Blair, Andamans & Nicobar Islands during 8-10 December, 2016.
15. Exhibition held in connection with 8th Vibrant Gujarat Global Summit at Gandhi Nagar, Gujarat during10-13 January, 2017.
16. Exhibition held in connection with 29th Kerala Science Congress at Mar Thoma College, Thiruvalla during 26-30 January, 2017.
17. Exhibition held in connection with the Technology Week Celebrations at Krishi Vigyan Kendra, Amadalavalasa on 3 February, 2017.
18. 'Visakha Ustav' organized by Govt. of Andhra Pradesh at Visakhapatnam during 3-5 February, 2017.
19. Mega Fisheries Exhibition 2017 cum Farmers-Scientists Interaction at KVAFSU, Bidar, Vijayapura, Karnataka during 4-5 February, 2017.
20. Exhibition held in connection with Industry Meet held at ICAR-CIFE, Mumbai during 3-4 March, 2017.
21. Exhibition held in connection with National seminar on 'Priorities in fisheries and aquaculture' held at College of Fisheries, Rangeilunda, Odisha during 11-12 March, 2017.
22. Krishi Unnathi Mela – 2017 at New Delhi during 13-15 March, 2017.
23. Exhibition held in connection with Sate Level Camp and Seminar-cum-Fish Farmers Meet held at Nalagarh, Solan, Himachal Pradesh on 25 March, 2017.

Hon'ble Governor of Maharashtra, Shri C. Vidyasagar Rao visiting ICAR CIFT stall at Mumbai

Shri Prakash Javadekar, Minister of State, Ministry of Environment visiting ICAR-CIFT stall at Mumbai

Students visiting ICAR-CIFT stall at Nagercoil

DG (Fisheries), Andhra Pradesh visiting ICAR-CIFT stall at Visakhapatnam

Visitors appreciating ICAR-CIFT technologies

Matsya Mela at UAS, Dharward

Visitors in ICAR-CIFT stall at Mumbai

Kisan Mela/Matsya Mela at Shivamogga

Smt. U. Parvathy, Scientist interacting with visitors at Vijayapura

Visitors at exhibition at Mumbai

Dr. L.N. Murthy, Senior Scientist interacting with visitors at Solan

India International Seafood Show at Visakhapatnam

Dr. David Bergvinson, Director General, ICRISAT, India at the ICAR-CIFT stall at ASPA exhibition

Dr. C.N. Ravishankar, Director, ICAR-CIFT discussing with delegates at Bhubaneswar

Replies to technical queries

Technical queries received from the various categories of clients such as fish processors, technologists, entrepreneurs, Self Help Groups, Government organizations and fisherfolk were attended to. The queries were related to the topics such as harvest and post harvest technology of fish, participation in training programmes and payment of fees, technical guidance, analytical testing services, assistance under technology transfer programme etc.

Radio Talks

The Scientists and Technical Officers of the Institute gave the following radio talks during the period under report:

- Dr. G. Rajeswari, SIC, Visakhapatnam RC of ICAR-CIFT – Interview on 'Aavailability of deep sea fishery resources and its utilization oportunities' (In Telugu), AIR, Visakhapatnam on 21 August, 2016.
- Dr. G. Rajeswari, SIC, Visakhapatnam, RC of ICAR-CIFT – Mangement practices for sustainable fisheries (In Telugu), AIR, Visakhapatnam on 7 January, 2017.
- Dr. A.A. Zynudheen, HOD I/c, QAM, ICAR-CIFT, Kochi - Fishery wastes and uses (In Malayalam), AIR, Kochi on 15 February, 2017.
- Dr. U. Sreedhar, Principal Scientist, RC of ICAR-CIFT – Deep sea trawl resources in Indian EEZ (In Telugu), AIR, Visakhapatnam on 21 November, 2016.
- Dr. B. Madhusudana Rao, Principal Scientist, RC of ICAR-CIFT - Interview on 'Quality concerns in Indian fishery

exports' (In Telugu) through AIR, Visakhapatnam on 24 July, 2016.

- Dr. M.S. Kumar, Chief Technical Officer, RC of ICAR-CIFT – Interview on 'Interesting facts about marine mammals' (In Telugu), AIR, Visakhapatnam on 29 May, 2016.
- Dr. M.S. Kumar, Chief Technical Officer, RC of ICAR-CIFT – Is jellyfish eatable or poisonous? What are the uses of jellyfish? (In Telugu), AIR, Visakhapatnam on 14 February, 2017.

Doordarshan Programme

Dr. Manoj P. Samuel, HOD, Engg. Division attended a Farmer-Scientist Interface Programme entitled, "Krishiyude Athijeevanam" (Survival of Agriculture) of Doordarshan Kendra, Thrissur as a panel expert. The programme was telecasted on 25 March, 2017.

North East Hill (NEH) Region Programmes

At Umladhkur, Meghalaya: A one-day Demonstration programme on "Smoke curing of fish by hygienic and scientific methods using COFISKI" was held at Umladhkur, Amlarem Sub Division, West Jaintia Hills District Meghalaya on 19 November, 2016. The participants included fishers of both Umladhkur and Thangbuli villages. The programme benefited a total of 64 women fishers. A small cemented platform was also erected for the purpose of air drying of the fish before and after smoke curing. Smoke curing of fish was demonstrated including hygiene aspects in handling the post harvest fish. Shri Arun Kumar Kembhavi, IAS, Deputy Commissioner of West Jaintia Hills District of Meghalaya was the Chief Guest of the programme. The smoke curing of fish was carried in three batches. The most noted development of ICAR-CIFT intervention is that Smt. Alma, an active woman fisher of Umladhkur village started making fish pickles based on her training by ICAR-CIFT and started selling the product resulting in generating sustainable income.

Smt. Alma with fish pickle made with ICAR-CIFT technology

Tribal Sub Plan (TSP) Programmes

At Kodinar, Gujarat: A skill development programme on "Hygienic handling of fish and development of value added fishery products" was held Kodinar, Gujarat during 13–18 April, 2016. The beneficiaries of the training were tribal fisherfolks from 'Bharat Adim Juth Matsyadhyog Sahkari Mandali', a registered Society formed for the welfare of 'Siddi tribes' from Jambur, near Veraval, Gujarat. During the technical session the faculty of ICAR-CIFT took classes on Hygienic handling, Nutritional importance and Microbial quality of fish and fishery products. In the practical sessions hands on training on preparation of value added fishery products like fish pickle, fish ball, fish roll, good manufacturing practice for salted dried fish and operational procedure of solar drier for good quality dried fish etc. were given.

Demonstration in progress

At Pedderu reservoir, Visakhapatnam: A training cum demonstration programme was conducted at Pedderu reservoir, V. Madugula (Mandal), Visakhapatnam district, Andhra Pradesh on 22 April, 2016. The programme conducted in collaboration with Andhra Pradesh Fisheries Department featured lectures on the advances in fishing techniques that can be adopted in Pedderu reservoir for sustainable fishery and for enhancement of livelihood of the fishers and on the importance of icing and hygienic handling. Demonstration of foldable fish traps was also held. Sixty five tribal fishers attended the programme. Inputs for responsible fishing such as gillnets, foldable traps and insulated fish bags for preserving the quality of fish were distributed to the tribal fishers.

Dr. R. Raghu Prakash, Principal Scientist addressing the participants

At Usgaon, Maharashtra: A training cum transfer of technology programme to distribute and demonstrate coracles, FRP canoes and value added products for tribal fisherfolk at Usgaon, an inland fishing village in Thane district of Maharashtra was conducted during 25-27 April, 2016. Representatives and members of four Tribal Fishermen Co-operative Societies in Thane district *viz*. Usgaon, Kothare, Shirvanje and Vasai and Tribal women members from three self help groups from Usgaon *viz*. Bhartiya SHG, Savita SHG and Kranti SHG attended the programme. The hygienic way of deheading, descaling and fin removal was demonstrated to the participants. Filleting operation in order to get higher filleting yield was also shown to the tribal fisherwomen. Headgears, aprons, mouth pieces, cutting boards and knives were also provided to the fisherwomen.

Distribution of coracle to the beneficiary

At Athirappally, Kerala: A training programme on "Hygienic fish handling" was held at Perumpara Adivasi Colony, Athirappally, Thrissur, Kerala on 3 August, 2016. The programme was organized in collaboration with the Department of Fisheries, Kerala and Athirappally Gramma Panchayat. Different inputs for hygienic fish handling was also distributed among the fisherfolk. More than 50 tribal fisherfolk belonging to Sholayar, Adichithotti, Arayakkap, Perumpara and Peringalkuthu Adivasi colonies participated in the training programme.

Feedback session in progress

Chief Guest Shri Rabi Narayana Mishra, College of Fisheries, Berhampur distributing inputs to participants

At Desaipur, Odisha: A training programme was organized at Desaipur village of Gopalaganda reservoir, Ganjam dist., Odisha during 1-3 December, 2016. Field demonstration cum interactive sessions were also arranged for the harvest technologies developed by ICAR-CIFT. Gillnets designed and fabricated at ICAR-CIFT, were distributed to the fisherfolk. During the programme training was given in preparation of value added products such as fish pickle, fish cutlet and fish pakoda.

Mera Gaon, Mera Gaurav Programme

At Munambam, Ernakulam: As a part of "Mera Gaon, Mera Gaurav" activity, ICAR-CIFT, Kochi celebrated National Technology Day at Munambam, Ernakulam district on 6 May, 2016. The Vypin block Panchayath President Shri K.K. Joshi inaugurated the programme. Talks on 'Responsible fishing methods' and 'Fish value addition and fishery waste utilization' were also delivered by the Scientists. A video film on technologies developed at ICAR-CIFT was also screened for the participants. An interactive session was held at the end of the programme and the stakeholders expressed their training needs. A total 35 fishermen and fisherwomen participated in the programme in addition to 22 officials from various state departments and the local panchayaths.

Shri K.K. Joshi inaugurating the programme

At Thakazhi, Alappuzha: On 11 May, 2016, on the National Technology Day, a training programme on 'Preparation of fish cutlets, fish fingers and fish balls from the meat of low value fish' was arranged for the benefit of 30 participants at Thakazhi, Alappuzha district, Kerala as a part of "Mera Gaon, Mera Gaurav" programme. The participants included ladies from 'Kudumbasree' (SHG), Panchayat officials, officials from Krishi Bhavan and local villagers. As it was a demonstration cum training programme on the utilization of low value fish for the production of high value items, the programme was well appreciated by everyone who participated.


Demostration programme in progress

At Munambam, Ernakulam: Munambam, a coastal fishing village in Ernakulam which is under Pallipuram Panchayath has been adopted by ICAR-CIFT, Kochi under "Mera Gaon, Mera Gaurav" programme. Around 572 fishing vessels operate from Munambam fishing harbor and livelihood of thousands of fisherfolk is based on fisheries and allied activities in the village. The fisherfolk of the village are progressive and are adept in receiving technology interventions in their activities once convinced about the benefits. Also responsible fishing technologies developed by the Institute were popularized by distributing pamphlets and other publications. A training programme on 'Fabrication of square mesh codend' was organized on 23 July, 2016 at Munambam. Around 30 coastal fisherwomen and men participated in the training programme. One unit of square mesh codend gear was given to a fisherman of the village who came forward to conduct trials using the gear and provide regular feedback.

Demonstration of gear fabrication

At Chempu, Ernakulam: A stakeholders' meeting at Chempu village under the title, "Development of Chempu village - The possibilities" was conducted on 7 October, 2016 to elaborate on the present status of the village, its major issues and possibilities for future development. A livelihood analysis was made through interactive discussion with

representatives from different sectors like agriculture, fisheries, animal husbandry, dairy, artisans etc. The farmers' representatives from fisheries, agriculture and dairy described the problems faced by them in capture and culture of shrimp and fish, poor quality of canoes, poor income from clam fishery etc. Similarly, the issues in agriculture as well as dairy were also discussed. The meeting was followed by the interactive discussion in which the President of Women SHGs of Chempu, representatives of the Dairy Farmers' Society, President of Clam Collectors' Society, officials from the Veterinary Department, representatives of the different fishermen organizations of Chempu Panchayath, President of Paddy Farmers' Association, members from different women SHGs etc. actively participated.

Meeting in progress

Workshops/Short Courses/Seminars etc. conducted

Workshops on Indigenous Traditional Knowledge in Marine Fisheries: As a part of the ESSO-INCOIS Project on "Indigenous Traditional Knowledge (ITKs) in marine fisheries sector of Kerala: Documentation and analysis", two data validation workshops were conducted at ICAR-CIFT, Kochi during 29-30 June, 2016. Ten fishermen from Alappuzha district and nine fishermen from Thrissur district participated in the workshops. During the workshops, traditional knowledge data collected from the marine fishers of Alappuzha and Thrissur districts of Kerala were validated through different participatory approaches such as preparation of seasonal calendar and lunar calendar related to fishing and participatory mapping of fishing grounds. Vernacular names of different fishes in both the districts were also documented during the workshop. The workshops were organized in collaboration with Vijnana Bharati, New Delhi.

Preparation of seasonal calendar of fishing activity

Workshop on Energy Efficiency for Fisheries: A one day workshop on "Energy efficiency for fisheries" was held at ICAR-CIFT, Kochi on 14 July, 2016. The workshop was organized in collaboration with M/S Datamatrix Infotech (P.) Ltd., Kochi, ICAR-CIFT and MPEDA, Kochi. The workshop had 45 participants representing seafood exporters, scientists from ICAR-CIFT, MPEDA officials and officials from the Energy Management Centre, Kerala. Presentations included, 'An overview of the work carried out at ICAR-CIFT on energy efficient fish harvesting systems' and on 'The energy use pattern in post harvest fishery operations'. M/S Datamatrix has given a live demonstration of the Energy Monitoring and Reporting Platform. The platform was displayed with live energy data and key performance indicators from the fish processing / ancillary plants. Following the presentations, there was an interactive session with the representatives of the seafood industry.

Shri R. Thomas, Chairman, M/S Datamatrix speaking on the occasion

National Seminar on Seaweeds: Society of Fisheries Technologists (India), Kochi and ICAR-CIFT, Kochi jointly

organized a one-day National seminar on 'Seaweeds: A source of nutraceuticals, healthcare products and new materials - Future perspectives' at ICAR-CIFT, Kochi on 9 February, 2017. The Seminar gave an opportunity to discuss about the untapped natural resources available in Indian southern coast in the form of guest lectures and poster presentations on topics ranging from seaweed-based bio-functional compounds, seaweed cultivation, biodiversity of marine algae and biofuels. The Seminar was formally inaugurated by Dr. K. Gopakumar, former DDG (Fisheries), ICAR, New Delhi and currently Director, School of Aquatic Food Products and Technology, KUFOS, Kochi. The papers presented included Marine derived healthcare products and new materials, Production of bioactive natural products from marine algae, Prospects of seaweed cultivation, Large scale mariculture of seaweeds, Production of biofuels from seaweed, Importance of tapping seaweeds for biomolecules and Scopes and perspectives of seaweeds in the field of nutraceuticals and healthcare.

Dr. K. Gopakumar delivering the inaugural address. On the dais are Dr. K. Ashok Kumar, Dr. A.K. Siddhanta, Dr. T.K. Srinivasa Gopal, Dr. C.N. Ravishankar and Dr. Suseela Mathew

Dr. S. Karthikeyan inaugurating the seminar

National Seminar on Steps to Reduce Juvenile Incidence in Fisheries: The Society of Fisheries Technologists (India), Kochi and ICAR-CIFT, Kochi jointly organized an one-day National Seminar on "Mitigating juvenile incidence in fishing: The way forward" at ICAR-CIFT, Cochin on 25 March, 2017. The Seminar provided a platform to discuss various issues related to the resource status, incidence of juveniles in fishing systems and its impact on biodiversity and legislation to control juvenile fishing. The Seminar was formally inaugurated by Dr. S. Karthikeyan, IAS, Director of Fisheries, Govt. of Kerala. A total of six papers were presented during the Seminar which covered the Status of the marine resources, Biodiversity issues in capture fisheries, Bycatch issues in Hilsa fishery, Legislations to control juvenile incidence, Case study on the implementation of minimum legal mesh size in Kerala and The gear-based technical measures to reduce juvenile incidence in fishing gears. Researchers, academicians, policy makers, leaders of the fishermen community and students attended the technical sessions.

Inception Workshop of FAO Project: The Inception Workshop of the project on "Assessment of food loss from selected gillnet and trammel net fisheries of India" funded by FAO of the UN was held at ICAR-CIFT, Kochi on 4 January, 2017. Shri Shyam Bahadur Khadka, FAO representative of India inaugurated the programme and Dr. Yugraj Singh Yadava, Director, Bay of Bengal Programme–Inter Governmental Organization was the Guest of Honour. The Workshop was intended to fine tune the methodologies of the project by incorporating suggestions received during the brain storming session of the Workshop. The inaugural function was followed by the technical session which started with familiarization

Shri Shyam Bahadur Khadka inaugurating the programme. Also seen are Dr. C.N. Ravishankar, Dr. P. Pravin and Dr. Yugraj Singh Yadava

of the project to the participants and discussions on the socio-economical aspect of the project and about the expected project outcome.

Workshop on Myctophids: ICAR-CIFT, Kochi in association with the Kollam Trawler Operators' Association organized a one day Workshop on "Myctophids-A new fisheries resource from deep sea" at Neendakara, Kollam District of Kerala on 14 January, 2017. The programme was inaugurated by Smt. J. Mercy Kutty Amma, Hon'ble Minister for Fisheries, Harbour Engineering and Cashew Industry, Govt. of Kerala. The programme was followed by a technical session, in which a talk on "Responsible harvest and utilization of Myctophid resources" was delivered.

Smt. J. Mercy Kutty Amma delivering the inaugural address


Dr. Leela Edwin, HOD, Fishing Technology, ICAR-CIFT addressing the gathering

Workshop on Trap Fishing: A stakeholder workshop for the fishermen operating traps was conducted at Muttom, Kanyakumari, Tamil Nadu on 15 January, 2017. In the workshop the research activities and the role played by the Institute in the overall development of the fishing industry was explained and the advantages of trap fisheries over other fishing techniques was discussed. The formal session was followed by interaction between fishermen and scientists in which fishermen brought out their problems, difficulties and issues in the trap fishery which need further scientific investigations.

Workshop on Scientific Validation of Fisheries ITKs: A workshop on "Scientific validation of fisheries ITKs and strategizing dissemination of deliverables" was organized by ICAR–CIFT, Kochi on 2 March, 2017. Fishermen resource persons described traditional ways of fish identification and fishing practices. This was followed by interaction with scientists from CSIR-NIO, Kochi, ICAR-CIFT, Kochi and ICAR-CMFRI, Kochi on the topic. Experts from media gave insights into how the scientific information can be made into forms that is understandable to the common reader and viewer.


Deliberations in progress

Industry Meet: An Industry meet was organized by ZTMC-Agri Business Incubations Centres of ICAR-CIFT, Kochi, ICAR-CIFE, Mumbai, ICAR- CIBA, Chennai and ICAR-CIFA, Bhubaneswar on 4 March, 2017 at ICAR-CIFE, Mumbai. The objective of the Meet was to provide a platform for industry to update the potential technologies developed by the research institutes through interactions emphasizing further blue revolution in India. Dr. Sanjeev Saxena, ADG (IP&TM), ICAR presided over the function. Dr. C.N. Ravishankar, Director, ICAR-CIFT, detailed the role of ICAR-ABIs and their contribution in the development of Industries. There were presentations from all the participating ICAR Institutes. Ready reckoner for seafood pathogen identification and English/local language brochures on recent technologies developed by Mumbai Research Centre of ICAR-CIFT were released during the function. More than 100 delegates including officials from EIC, MPEDA, scientists, industry representatives, research scholars and ICAR-CIFE alumni from all over the country participated in the programme. In connection with the Industry Meet, an exhibition was also

Dr. C.N. Ravishankar, Director, ICAR-CIFT addressing the gathering

Participants of the programme along with Director and Heads of Divisions, ICAR-CIFT

arranged.

International Training Programme on ISO-22000 HACCP for Seafood Industry: ICAR-CIFT, Kochi organized a training programme on 'ISO-22000-HACCP for Seafood Industry' during 17-28 October, 2016. The programme was sponsored by ITEC, Ministry of External Affairs, Govt. of India under Technical Cooperation Scheme (TCS) of Colombo Plan For imparting comprehensive and integrated training to the participants of member countries of Colombo Plan to enhance their administrative and technical capabilities. Four overseas participants from Bangladesh, Bhutan and Afghanistan successfully participated in the programme.

International Capacity Building Programme on Fisheries Extension Methodologies: An international training programme on 'Extension Methodologies for Coastal Fisheries' sponsored by TCS of Colombo Plan was organized by ICAR-CIFT, Kochi during 15-26 November, 2016. Two participants from Bangladesh attended the programme. The training session covered various aspects of extension approaches like need assessment, problem prioritization, participatory techniques, entrepreneurship development, project monitoring and evaluation techniques, impact assessment methodologies and gender mainstreaming value chain analysis. Besides, technical sessions on various aspects relating to advanced technologies in fisheries sector like responsible harvesting, processing and quality assurance, food safety, HACCP, fish biodiversity conservation, technological innovations in nutraceuticals, emerging issues of pathogens and seafood trade were also included in the programme.

Director, ICAR-CIFT interacting with the participants

International training in Biochemistry: A training programme on 'Modern analytical methods in fish biochemistry' was organized at ICAR-CIFT, Kochi during 9-21 January, 2017 under the TCS Colombo Plan. Participants from

Participants of the programme along with Director and Heads of Divisions

three different countries under Colombo Plan *viz*. Bangladesh, Indonesia and Myanmar attended the programme. The programmes included both theory and practical exposure of trainees on various analytical methods in fish biochemistry. On 21 January, 2016, during the valedictory session of the programme, there was country presentations by the participants.

Training on Disease Diagnostics and Management in Aquaculture: In order to strengthen the skill of State Fishery Officials on disease diagnostic tools and methods in aquaculture, a training programme on "Disease diagnostics and management in aquaculture" was organized at ICAR-CIFT, Kochi during 18-21 October, 2016 under the National Surveillance Project on 'Aquatic Animal Diseases' funded by National Fisheries Development Board. A total of 23 officials from Department of Fisheries, Kerala and Agency for Development of Aquaculture (ADAK) participated. Hands on practical sessions were conducted on disease diagnosis.

Training in progress

Representations in committees

The following officials represented the Institute in various Committees/Board panels etc. in different capacities:

Dr. C.N. Ravishankar, Director

As Member

- Technical committee, Food Safety Standards Authority of India, New Delhi
- Technical committee, Fish and fishery products, BIS, New Delhi
- Editorial Board, Journal of Food Science and Technology, Association of Food Scientists and Technologists, CFTRI, Mysore
- Technical committee, Establishment of Incubation Centres, NFDB, Hyderabad
- Review committee of DBT, New Delhi for reviewing projects in post harvest technology of fish
- Technical committee, Lakshadweep Development Corporation Ltd., Kochi for setting up of tuna canning factory at Minicoy Island
- Consultant, NACA, Bangkok, Thailand
- National Business Incubation Association, USA
- Agrinnovate India Pvt. Ltd. for technology valuation and pricing of ICAR technologies

Dr. Suseela Mathew, Principal Scientist and Head, Biochemistry & Nutrition Division

As Member

- Academic Council of KUFOS, Kochi
- Reviewer of journals, Fishery Technology, Journal of Food Science & Technology, Indian Journal of Fisheries, Journal of Medicinal Food and Fishing Chimes
- External examiner, Mangaluru University, Mangaluru

Dr. K. Ashok Kumar, Principal Scientist and Head, Fish Processing Division

As Member

- Assessment panel of experts for approval of seafood processing plants for EU
- Assessment board for the approval of technologists for seafood processing plants constituted by EIC, Govt. of India
- Consultative committee for construction and modernization of fish markets with the financial assistance of NFDB, Hyderabad
- Expert group of Ministry of Agriculture for review of standard conditions for sanitary import of various fish/fishery products

Dr. M.M. Prasad, Principal Scientist and Head, Microbiology, Fermentation and Biotechnology Division

As Member

- Committee of AQUDIRECT.ORG
- Assessment panel of experts of Export Inspection Council and Marine Products Export Development Authority

Dr. Leela Edwin, Principal Scientist and Head, Fishing Technology Division

As Member

- Expert committee on Fisheries for amendment of KMFRA, Govt. of Kerala
- Expert committee on Fisheries for policy constitution, Govt. of Kerala
- National Research Advisory Committee of National Innovation Foundation, Gandhi Nagar, Gujarat
- National Steering Committee for Agriculture Sector, TIFAC, DST, Govt. of India
- Project Monitoring and Review Committee for the project, 'Solar enabled boats at Kanyakumari'

Dr. A.K. Mohanty, Principal Scientist and Head, Extension, Information and Statistics Division

As Member

- Editorial Board, IJHF
- Extension Education Council, KUFOS, Kochi
- Editor, Indian Research Journal of Extension Education

Dr. Manoj P. Samuel, Principal Scientist and Head, Engineering Division

As Member

- External examiner, KAU, Thrissur, Kelappaji College of Agril. Engg. & Technol., Thavanur
- Board of Studies, Vignan University, Guntur, A.P.
- Advisory Board, World Research Journal of Tropical Agriculture and Amity Journal of Agribusiness

Dr. A.A. Zynudheen, Principal Scientist and Head Incharge, Quality Assurance and Management Division

As Member

- Assessment panel of experts for approval of seafood processing plants for EU
- Board of Examiners, M.Sc. Industrial Fisheries, CUSAT, Kochi and M.Sc. Aquaculture, Calicut University, Kozhikode

Dr. G. Rajeswari, Principal Scientist and Scientist Incharge, Visakhapatnam Research Centre

As Member

- External examiner for M.Sc. students, Department of Marine Living Resources, Andhra University, Visakhapatnam
- Advisory committee for the Centre for Women's Studies, Andhra University, Visakhapatnam

Dr. G.K. Sivaraman, Senior Scientist and Scientist Incharge, Veraval Research Centre

As Chairman

- Town Official Language Implementation Committe, Veraval

As Member

- Assessment panel of experts for approval of seafood processing plants for EU
- Advisory Committee, Veraval Fisheries College, GAU, Junagadh
- ICAR-KVK Advisory Committee, Ambuja Cement Foundation, Kodinar
- Lokvani Radio Advisory Committee, ICAR-KVK, Ambuja Cement Foundation, Kodinar

Dr. L.N. Murthy, Senior Scientist and Scientist Incharge, Mumbai Research Centre

As Member

- Assessment panel of experts for approval of seafood processing plants for EU

Dr. R. Anandan, ICAR National Fellow and Principal Scientist

As Member

- Assessment panel of experts for approval of seafood processing plants for EU

- External examiner, Manonmaniyam Sundaranar University, Tirunelveli

Shri M. Nasser, Principal Scientist

As Member

- Inland Harbour Crafts and Fishing Vessel Sectional Committee, TED 18, BIS, New Delhi
- Transport Engineering Division Council, BIS, New Delhi

Dr. Saly N. Thomas, Principal Scientist

As Chairperson

- Sectional Committee TX18, Textile material for marine fishing purpose, BIS, New Delhi

As Member

- Expert committee constituted by Matsyafed, Kerala for the implementation of fish net factory at Thiruvananthapuram
- Institute Management Committee, ICAR-CMFRI, Kochi
- Assessment of Technical personnel for promotion, ICAR-CMFRI, Kochi
- Examination committee of Tamil Nadu Fisheries University, Chennai and M.G. University, Kottayam

Dr. M.P. Remesan, Principal Scientist

As Member

- Examination committee for M.Sc. Fisheries Engineering Technology, KUFOS, Kochi
- Chief Editor, Fishery Technology

Dr. Nikita Gopal, Principal Scientist

As Member

- Vice President, Gender in Aquaculture and Fisheries Section, Asian Fisheries Society

Dr. V. Geethalakshmi, Principal Scientist

As Member

- Examiner for Ph.D. course thesis evaluation in Biostatistics of NIMHANS, Bangaluru

Dr. Femeena Hassan, Principal Scientist

As Member

- Assessment panel of experts for approval of seafood processing plants for EU

Dr. J. Bindu, Principal Scientist

As Member

- Internal Complaints Committee, CIFNET, Kochi
- Passing Board, CUSAT, Kochi
- Assessment panel of experts for approval of seafood processing plants for EU
- Board of examiners, KUFOS, Kochi, CUSAT, Kochi, ICAR-CIFE, Mumbai, TNFU, Nagapattinam and KAU, Thrissur
- Registered guide, CUSAT, Kochi

Dr. S. Ashaleta, Principal Scientist

As Member

- MPEDA, Kochi

Dr. R. Raghu Prakash, Principal Scientist

As Member

- Expert Committee on implementation of ICAR-CIFT TED in Tamil Nadu

Dr. U. Sreedhar, Principal Scientist

As Member

- Examiner for CIFNET, Visakhapatnam
- Exmainer for College of Fisheries, Kawardha, Chhattisgarh
- Examiner for College of Fisheries, Ratnagiri, Maharashtra

Dr. George Ninan, Principal Scientist

As Member

- Assessment panel of experts for approval of seafood processing plants for EU
- Board of examiners, Calicut University, Calicut/ CUSAT, Kochi/MG University, Kottayam
- Subsidy Committee for setting up of cold storage facilities, MPEDA, Kochi

Dr. P. Muhamed Ashraf, Principal Scientist

As Member

- Departmental Promotion Committee of Coconut

Development Board, Kochi

- Exmaination committee, KUFOS, Kochi

Dr. B. Madhusudana Rao, Principal Scientist

As Member

- Assessment panel of experts of Export Inspection Council and Marine Products Export Development Authority

Dr. Toms C. Joseph, Principal Scientist

As Member

- Assessment panel of experts for approval of sea-food processing plants for EU
- Animal Ethics Committee, ICAR-CMFRI, Kochi
- Institutional biosafety committee, College of Veterinary and Animal Sciences, KAU, Thrissur
- Examiner and question paper setter for B.F.Sc. course, KUFOS, Kochi

Dr. S.K. Panda, Senior Scientist

As Chairman

- FSSAI Scientific panel on Fish and fishery products

As Member

- Assessment panel of experts for approval of sea-food processing plants for EU
- Expert group for drafting international standard (ISO/TC 234) on Traceability of shellfishes including crustacean and molluscs

Dr. K.K. Asha, Senior Scientist

As Member

- Assessment panel of experts for approval of sea-food processing plants for EU

Dr. V.R. Madhu, Senior Scientist

As Member

- Committee for introduction of marine ambulance service along the coastal districts of Kerala

Shri M.V. Baiju, Senior Scientist

As Member

- Expert committee of MPEDA, Kochi to provide subsidy for installation of insulated fish hold and re-frigetion onboard fishing vessles
- Board of Studies, KUFOS, Kochi
- Tender committee of Fishery Survey of India for the purchase of generators for the vessel 'Matsyavarshini'

Dr. C.O. Mohan, Senior Scientist

As Member

- Assessment panel of experts for approval of sea-food processing plants for EU
- Faculty, Marine Science, CUSAT, Kochi

Dr. S. Visnuvinayagam, Scientist

As Member

- Assessment panel of experts for approval of sea-food processing plants for EU

Dr. AK. Jha, Scientist

As Member

- Assessment panel of experts for approval of sea-food processing plants for EU
- Advisory Committee, Veraval Fisheries College, GAU, Junagadh

Dr. K.K. Prajith, Scientist

As Member

- Advisory Committee, Veraval Fisheries College, GAU, Junagadh

Kum. Jesmi Debbarma, Scientist

As Member

- Exmainer for College of Fisheries, Kawardha, Chhattisgarh
- Assessment panel of experts of Export Inspection Council and Marine Products Export Development Authority

Smt. S. Remya, Scientist

As Member

- Assessment panel of experts for approval of seafood processing plants for EU

- Advisory Committee, Veraval Fisheries College, GAU, Junagadh

Smt. V. Renuka, Scientist

As Member

- Assessment panel of experts forapproval of sea-food processing plants for EU
- Advisory Committee, Veraval Fisheries College, GAU, Junagadh

Shri C.G. Joshy, Scientist

As Member

- Faculty, course work for Ph.D. programmes, CUSAT, Kochi

Dr. P. Viji, Scientist

As Member

- Assessment panel of experts of Export Inspection Council and Marine Products Export Development Authority

Dr. P. K. Binsi, Scientist

As Member

- Assessment panel of experts for approval of sea-food processing plants for EU
- Research Advisory Committee of ICAR-CIFE, Mumbai for Masters and Ph.D. programme

Smt. U. Parvathy, Scientist

As Member

- Assessment panel of experts for approval of sea-food processing plants for EU
- ICAR-CIFT and NETFISH-MPEDA consultancy project for assessment of impact of NETFISH training programes

Smt. S.J. Laly, Scientist

As Member

- Assessment panel of experts for approval of sea-food processing plants for EU

Dr. Anuj Kumar, Scientist

As Member

- Assessment panel of experts for approval of sea-food processing plants for EU

Dr. Pankaj Kishore, Scientist

As Member

- Assessment panel of experts for approval of sea-food processing plants for EU

Dr. T.K. Anupama, Scientist

As Member

- Assessment panel of experts for approval of sea-food processing plants for EU

Smt E.R. Priya, Scientist

As Member

- Assessment panel of experts for approval of sea-food processing plants for EU

Dr. S. Murali, Scientist

As Member

- Physical varification committee of seafood processing units, MPEDA, Kochi

Dr. A.R.S. Menon, Chief Technical Officer

As Member

- Inter Media Publicity Co-ordination Committee (Kerala), Ministry of Information and Broadcasting, Govt. of India
- Editorial Board, Applied Science Periodicals, Siwan
- Editorial Board, International Journal of Lakes and Rivers
- Editorial Board as Chief Editor, Science India, Kochi

Shri C.R. Gokulan, Asst. Chief Technical Officer

As Member

- Committee constituted for selection of Mechanic (Group-C) at FSI, Marine Engineering Division
- Committee constituted for selection of Electrician of NIPHATT, Kochi
- Panel for Apprentice trainees in the discipline B. Tech. and Diploma (Mechanical, Electrical and Electronics)

Dr. Santhosh Alex, Senior Technical Officer

As Member

- Editor, 'Triveni', Inhouse journal of Kochi TOLIC

Shri P.S. Nobi, Technical Officer

As Member

- Central Joint Staff Committee (CJSC), ICAR, New Delhi
- ICAR Technical Anomaly Committee

Training and Capacity Building

Human resource development activities

During the period under report, the Human Resources Deveopment Cell of the Institute met many times and as recommended by the Cell 131 staff of the Institute participated in training programmes during the period (Scientific – 73, Technical – 47 and Administrative and Finance – 11). Further eight scientists and one technical personnel were sent abroad to attend workshops and conferences. Annual Training Plan for 2017-18 for all categories of staff was prepared and uploaded in the Institute website

Participatuion in trainings (Category-wise)

Sl. No.	Name(s) of participant(s)	Training attended	Venue and date
Category - Scientific			
1.	Dr. Saly N. Thomas	Sexual harassment at work place	ISTM, New Delhi 13-14 October, 2016
2.	Dr. Saly N. Thomas	Emotional intelligence at work place	COD, Hyderabad 30 January – 3 February, 2017
3.	Dr. M.P. Remesan	Self management through personal profiling	SAMETI, Thiruvananthapuram 9-12 August, 2016
4.	Dr. Toms C. Joseph	Effective implementation of training functions by HRD Nodal Officers of ICAR	ICAR-NAARM, Hyderabad 20-22 February, 2017
5.	Dr. J. Bindu Kum. Lekshmi R.G. Kumar	Synthesis and characterization of nanomaterial for agricultural applications	ICAR-CIRCOT, Mumbai 19-28 September, 2016
6.	Dr. V.R. Madhu	Species distribution modeling using MaxEnt	ISI, Kolkata 9-14 January, 2017
7.	Dr. S. Visnuvinayagam	Characterization of materials using X-ray diffractometer	ICAR-CIRCOT, Mumbai 19-21 December, 2016
8.	Shri C.G. Joshy	Research data repository for knowledge management	New Delhi 24-25 January, 2017
9.	Kum. Jesmi Debbarma	Advances in applications of nanotechnology	ICAR-CIRCOT, Mumbai 6-10 February, 2017
10.	Shri R.K. Nadella	Biotechnological and nano technological tools in aquatic animal health management	ICAR-CIFE, Mumbai 8-28 March, 2017
11.	Shri R.K. Renjith	Taxonomy of bivalves (Pelcipoda)	CUSAT, Kochi 11-14 May, 2016
12.	Shri Devnanda Uchoi Kum. H. Mandakini Devi	Chromatographic techniques (GC and LC): An analytical approach in food analysis	CSIR-CFTRI, Mysore 11-15 July, 2016
13.	Shri P.N. Jha	Agro-ecotourism: An emerging enterprise for agricultural diversification	ICAR-CCARI, Goa 5-20 Novemer, 2016

Sl. No.	Name(s) of participant(s)	Training attended	Venue and date
14.	Shri K. Sathish Kumar	Modern packaging trends in industry	KSPC, Kochi 9-10 November, 2016
15.	Shri S. Chinnadurai	Monitoring the structure and function of the pelagic ecosystem at regional sectors: Relevance for fisheries	ICAR-CMFRI, Kochi 1-2 October, 2016
16.	Smt. K. Sarika	Spectometric techniques (GC-MS, LC-MS, FTIR and NMR)	CSIR-CFTRI, Mysuru 3-7 October, 2017
17.	Dr. S. Murali	Designs and development of fish descaler cum cutter machine	IICPT, Thanjavur 18 May – 17 August, 2016
18.	Shri Abhay Kumar	Expression study of pluripotency maker genes in gold fish, *Carassius auratus*	ICAR-CIFE, Mumbai 18 May - 17 August, 2016
19.	Shri Abhay Kumar	Molecular biology and biotechnology for fisheries professionals	ICAR-CIFE, Mumbai 7 March – 6 June, 2017
20.	Shri S. Ezhil Nilavan	Studies on *Photobacterium damselae* infecting marine fungi	FC&RI, Thoothukudi 18 May - 17 August, 2016
21.	Shri S. Ezhil Nilavan	Current trends in molecular diagnosis for better health management in aquaculture	ICAR-CIFA, Bhubaneswar 5 February – 7 March, 2017
22.	Shri K.K. Anas	Evaluation of liquid smoke and chitosan treated *Pangasianodon hypophthalmus* for control of *Listeria monocytogenes*	ICAR-CIFE, Mumbai 18 May - 17 August, 2016
23.	Smt. V.A. Minimol	Isolation and molecular characterization of *Vibrio parahaemolyticus* in seafood and coastal environments from North Mumbai	ICAR-CIFE, Mumbai 18 May - 17 August, 2016
24.	Dr. D.S. Aniesrani Delfiya	Optimization of pre-treatment parameters for drying of carrot using solar-biomass hybrid dryer	ICAR-CIAE, Bhopal 21 November, 2016 - 18 February, 2017
25.	Smt. P.V. Alfiya	Modeling and quality evaluation of infrared assisted hot air drying of ginger	TNAU, Coimbatore 21 November, 2016 - 17 February, 2017
26.	Kum. Rehana Raj	Effect of fish protein hydrolysate (FPH) on the quality characteristics and stability of chicken cutlet	TNFU, Thoothukudi 21 November, 2016 - 17 February, 2017

Sl. No.	Name(s) of participant(s)	Training attended	Venue and date
27.	Shri V. Radhakrishnan Nair Dr. S. Visnuvinayagam Dr. A.K. Jha Shri V. Chandrasekar Smt. P. Jeyanthi Shri C.G. Joshy Dr. P.K. Binsi Dr. V. Murugadas Dr. K.K. Prajith Smt. S.J. Laly Smt. S. Remya Dr. P. Viji Smt. V. Renuka Dr. A. Jeyakumari Smt. U. Parvathy Kum. Jesmi Debbarma Shri G. Kamei Dr. Anuj Kumar Shri K.A. Basha Shri Devnanda Uchoi Dr. Pankaj Kishore Shri K. Sathish Kumar Shri S. Sreejith Kum. H. Mandakini Devi Dr. V.K. Sajesh Shri P.N. Jha Dr. K. Elavarasan Shri S. Ezhil Nilavan Smt. S.S. Greeshma Shri. E.R. Priya Shri S. Chinnadurai Shri C.S. Tejpal Smt. K. Sarika Smt. K.R. Sreelakshmi Kum. Lekshmi R.G. Kumar Dr. T.K. Anupama Smt. V.A. Minimol Smt. P.V. Alfiya Shri K.K. Anas Dr. S. Murali Dr. D.S. Aniesrani Delfiya Kum. Rehana Raj Dr. K. Rejula Smt. N. Manju Lekshmi	Professional skill enhancement of young scientists	ICAR-CIFT, Kochi 16-18 March, 2017

Sl. No.	Name(s) of participant(s)	Training attended	Venue and date
Category - Technical			
28.	Dr. A.R.S. Menon	Write-shop for success stories	MANAGE, Hyderabad 12-15 September, 2016
29.	Shri C.R. Gokulan	Organizational behavior in government	ISTM, New Delhi 1-5 August, 2016
30.	Dr. B. Ganesan	Training for CPCSEA nominees	NIAW, Haryana 24-26 May, 2016
31.	Shri Sibasis Guha	Motivation and positive thinking	ICAR-NAARM, Hyderabad 17-26 August, 2016
32.	Shri K.D. Jos Smt. K.S. Mythri	Analysis of experimental data	ICAR-NAARM, Hyderabad 18-23 August, 2016
33.	Shri V.K. Siddique	Refrigeration and air conditioning system – Operation, maintenance and energy conservation	KSPC, Kochi 22 December, 2016
34.	Shri V.K. Siddique	Duct design and green building concept	ATI, Hyderabad 13-17 March, 2017
35.	Shri C. Subhash Chandran Nair	Video shooting and editing	FTI, Bengaluru 6-17 February, 2017
36.	Shri K.D. Santhosh Shri V. Vipin Kumar	Communicating science	ICAR-CIFE, Mumbai 5-11 July, 2016
37.	Shri K.S. Babu	Advanced programming and operation on CNC Turn Mill Centre	ATI, Hyderabad 13-24 March, 2017
38.	Shri Tulsiram Waghmare	Microbial culture handling and maintenance	ICAR-NBAIM, Kusmaur 2-11 August, 2016
39.	Smt. N. Lekha	Spectometric techniques (GC-MS, LC-MS, FTIR and NMR)	CSIR-CFTRI, Mysuru 3-7 October, 2017
40.	Shri K.A. Nobi Varghese	Precision instrumentation in dairy research and food quality evaluation	SRS, ICAR-NDRI, Bengaluru 6-11 February, 2017
41.	Shri T. Jijoy Shri K.C. Anish Kumar Shri G. Vinod	Advanced instruments of water quality monitoring and testing	NIH, Roorke 16-20 January, 2017
42.	Shri Ajith V. Chellappan Shri V.N. Sreejith	Application of molecular techniques in aquatic food quality analysis	FC&RI, TNFU, Thoothukudi 14-23 March, 2017
43.	Shri V.N. Sreejith	The new microbiology	Spetses, Greece 24 August – 1 September, 2016
44.	Shri P. Suresh	Handling and care of laboratory animals	ICAR-NDRI, Karnal 19-24 September, 2016

Sl. No.	Name(s) of participant(s)	Training attended	Venue and date
45.	Smt. Vineetha Das Smt. K. Resmi	Good laboratory practices	SRS, ICAR-NDRI, Bengaluru 17-22 November, 2016
46.	Shri K. Ajeesh Shri Rahul Ravindran Smt. V. Sushmitha Shri T. Jijoy Smt. P.J. Mary Shri Ajith V. Chellappan Shri K.C.Anishkumar Smt. G. Archana Smt. Tessy Francis Shri G. Gopakumar Smt. N. Lekha Shri P. Suresh Shri V.N. Sreejith Smt. K. Reshmi Smt. U.P. Prinetha Smt. Vineetha Das Smt. P. Sruthi Shri Rakesh M. Raghavan Shri H.V. Pungera Shri H.U. Sida Shri Yogesh D. Kriplani Shri M. Prasanna Kumar Shri G. Bhushanam	Enhancing efficiency and behavioural skills of technical personnel	ICAR-CIFT, Kochi 7-10 November, 2016
Category - Administrative			
47.	Shri K.S. Sreekumaran	Public procurement	NIFM, Faridabad 30 May – 4 June, 2016
48.	Shri K.S. Sreekumaran	Team building and leadership	ISTM, New Delhi 30 January – 1 February, 2017
49.	Smt. M.J. Christina Joseph	Sexual harassment at work place	ISTM, New Delhi 13-14 October, 2016
50.	Smt. M.J. Christina Joseph Shri S. Sabukuttan Smt. G. Surya	Implementation of NIC's e-procurement solution through CPP Portal	ICAR-NAARM, Hyderabad 25-26 April, 2016
51.	Shri T. Viswanathan	Income tax	ISTM, New Delhi 4-5 July, 2016
52.	Smt. D.A.L. Satyanarayanamma Shri K.V. Mathai	Enhancing efficiency and behavioural skills	ICAR-NAARM, Hyderabad 24-30 November, 2016
53.	Smt. S. Kamalamma Smt. Anitha K. John	Enhancing efficiency and behavioural skills	ICAR-NAARM, Hyderabad 4-10 January, 2017

Trainings organized for various categories of employees

In-house Capacity Building Programme for Technical Staff: ICAR-CIFT, Kochi organized a four day in-house Training Programme on "Enhancing efficiency and behavioural skills of technical personnel" during 7-10 November, 2016 for technical staff up to the level T-4. A total of 23 technical persons; 18 from the Head Quarters and five from Veraval and Visakhapatnam Research Centres participated in the programme. The programme covered relevant lectures *viz*., Basics of laboratory safety techniques, Maintenance and handling of laboratory equipment, Basics of computer application and Excell Programming, Problem solving skills, Financial rules, Usage of Digital Library, Good laboratory practices, Technical service rules, Laboratory documentation and record keeping, Inter personnel skills and Time management, ISO 9001 and Enterprise Resource Planning (ERP) followed by hands-on training on different techniques.

Dr. C.N. Ravishankar, Director distributing certificates

Hands on training by Dr. V. Geethalakshmi, Principal Scientist

In-house Training Programme on Professional Skill Enhancement of Young Scientists: ICAR-CIFT, Kochi conducted an In-house training programme on "Professional skill enhancement of young scientists" during 16-18 March, 2017. The programme was attended by 46 Scientists from the Head Quarters and Research Centres at Veraval, Visakhapatnam and Mumbai. In various sessions of the three day programme, there were lectures from faculty of ICAR-CIFT, other ICAR Institutions and subject matter experts invited from outside the state. The topics discussed were: Documentation of research, Commercialization of research, How to write popular articles, How to write a lot?, Enterprise Resource Planning (ERP), Financial rules/Purchase procedures, Statistics in research, Plagiarism in scientific writing, General administrative rules/ARS rules, Introduction to research methodology, Data collection, analysis and presentation, Ethics in research and How to write a research paper?, Writing for media, Motivation and Personnel effectiveness. Most of the sessions were a mixture of theory and practical group/individual exercises.

Participants with Director Dr. C.N. Ravishankar and faculty

Pre-training evaluation

HRD fund allocation and utilization

The total fund allocated under HRD for the year 2016-17 was ₹ 8.50 Lakhs and the utilization is ₹ 8.40 Lakhs.

Visits Abroad

Dr. Leela Edwin, Principal Scientist and Head, Fishing Technology Division, ICAR-CIFT, Kochi attended the Expert Consultation on Marking of Fishing Gear, organized by the Food and Agricultural Organization (FAO), Rome during 4-7 April, 2016. During the meeting guidelines were developed to assist countries in implementing FAO Code of Conduct for Responsible Fisheries by developing and applying a system for the marking of fishing gear. The Expert Consultation was attended by 18 experts in their personal capacity and four resource persons from different countries. Dr. Leela Edwin presented inputs on fishing gear and marking in India.

Dr. Leela Edwin (Second from left) with other participants of the meeting

Dr. A.A. Zynudheen, Principal Scientist and Head I/c, Quality Assurance and Management Division, ICAR-CIFT, Kochi attended the Indo-Norwegian Joint Workshop on Bio-economy (INJWB) organized by Norwegian Institute of Bio-economy Research (NIBIO) during 6-7 September, 2016 at Oslo, Norway. INJWB was one of the main steps jointly initiated by Norway and India to develop future roadmap for bio-economy cooperation between the two countries in relevant sectors that includes: Agriculture; Forestry, Food processing and packaging, Bio-medicines (krill, proteins, plan-based products etc.); Pharmaceuticals, Bio-energy (Biogas, Algae etc.), and Fisheries and Aquaculture (Marine and inland). Dr. Zynudheen also delivered a talk on "Utilization of fishery wastes and developing new products" and on the research programmes of ICAR-CIFT in the Workshop.

Dr. Zynudheen making the presentation

Dr. Nikita Gopal making the presentation

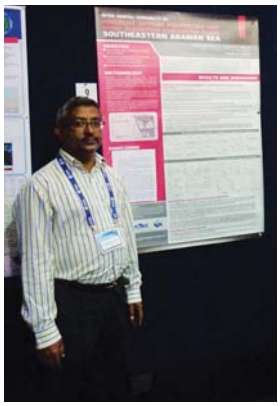
Dr. Nikita Gopal, Principal Scientist, Extension, Information and Statistics Division, ICAR-CIFT, Kochi attended 11th Asian Fisheries and Aquaculture Forum organized by the Asian Fisheries Society in association

with NACA and Department of Fisheries, Thailand and the 5th Global Symposium on Gender in Aquaculture and Fisheries (GAF5) held at Bangkok, Thailand during 3-7 August, 2016. She presented the Symposium recommendations during the Forum Plenary and chaired the Special Session on "Regional Updates on Gender in Fisheries and Aquaculture" in which she also presented a paper titled, 'An update on gender in aquaculture and fisheries value chains in India'. She also attended the first GAF-101 Training Workshop on "Theorizing Gender in Aquaculture and Fisheries Research" and the Gender Networks Meeting held on 3 August, 2016. Dr. Nikita Gopal also attended the Global Conference on 'Climate Change Adaptation for Fisheries and Aquaculture' during 8-10 August, 2016 at Bangkok.

Dr. Femeena Hassan, Principal Scientist, Quality Assurance and Management Division, ICAR-CIFT, Kochi attended the 11th Asian Fisheries and Aquaculture Forum held at Bangkok, Thailand during 3-7 August, 2016. She presented a research paper entitled, "Quality and shelf life upscaling on chilled storage of Japanese thredfin bream (*Nemipterus japonicas*) incorporating green tea (*Camelia sinensis*) extract in icing medium" authored by Femeena Hassan, K.V. Nija and V. Geethalakshmi.

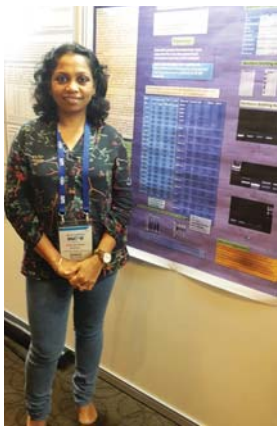
Dr. Femeena Hassan making the presentation

Dr. P. Muhamed Ashraf, Principal Scientist, Fishing Technology Division, ICAR-CIFT, Kochi attended the International Workshop on "Colour and light in the ocean from earth observation" held at European Space Research Institute, European Space Agency (ESA), Frascati, Rome, Italy during 6-8 September, 2016. He made a poster presentation on a research paper entitled, "Inter annual variability of inherent optical properties and CDOM algorithm evaluation along South-eastern Arabian Sea" authored by P. Muhamed Ashraf, V.P. Souda, P. Minu and Aneesh A. Lotliker.



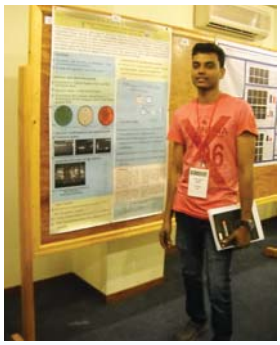
Dr. Muhamed Ashraf displaying the poster

Dr. K.K. Asha, Senior Scientist, Biochemistry and Nutrition Division, ICAR-CIFT, Kochi attended the 15th Annual Congress, HUPO-2016 held at Taipei International Convention Center, Taipei, Taiwan during 18-22 September, 2016. She presented a poster entitled, "Investigations into the effect of fish oil on enzymes of lipid metabolism: A proteomics approach" authored by K.K. Asha, Raja Swaminathan, K. Raj Kumar, Niladri S. Chatterjee, Suseela Mathew, C.S. Tejpal, Lekshmi R.G. Kumar and R. Anandan.


Dr. Asha displaying the poster

Dr. Niladri Sekhar Chatterjee, Scientist, Biochemistry and Nutrition Division, ICAR-CIFT, Kochi was deputed to undergo the Overseas Post Doctoral Fellowship instituted by Science and Engineering Research Board, Department of Science and Technology, Govt. of India for a period of 12 months from 6 January, 2017 onwards.

Shri V.N. Sreejith, Technician, Microbiology, Fermentation and Biotechnology Division, ICAR-CIFT, Kochi was deputed to Spetses, Greece to attend the European Molecular Biology Organization/The Federation of the European Biochemical Societies (EMBO/FEBS) summer course on "The New Microbiology" jointly organized by Pasteus Institute, France and Harvard Medical School, USA during 24 August to 1 September, 2016. He made a poster presentation entitled, "Characterization of *fur* regulation in *Vibrio paraheaelyticus*" authored by V.N. Sreejith, Toms C. Joseph and K.V. Lalitha.


Shri Sreejith displaying the poster

Linkages/Partnerships

Collaboration with other institutes

Local Institutions in the area other than ICAR Institutes

- Goa Shipyard Ltd., Goa
- Marine Products Export Development Authority, Kochi
- Export Inspection Agency, Kochi, Visakhapatnam, Veraval and Mumbai
- Naval, Physical and Oceanographic Laboratory, Kochi
- Fishery Survey of India
- National Institute of Oceanography, Goa and Kochi
- Central Institute of Fisheries Nautical Engineering and Training, Kochi
- Kerala Fishermen's Co-operative Federation (MATSYAFED), Thiruvananthapuram
- National Institute of Fisheries Post Harvest Technology and Training, Kochi
- Kerala State Pollution Control Board, Kochi
- Cochin University of Science and Technology, Kochi
- Kerala Biotechnology Commission, Thiruvananthapuram
- Kerala University of Fisheries and Ocean Studies, Kochi
- State Fisheries Departments of Kerala, Karnataka, Tamil Nadu, Telangana, Andhra Pradesh, Odisha, West Bengal, Jharkhand, Bihar, Manipur, Tripura, Meghalaya and Arunachal Pradesh

National Institutes and Agricultural Universities

- Agricultural Universities
- Ministry of Agriculture and Farmers Welfare
- Ministry of Food Processing Industries
- Department of Ocean Development
- Department of Biotechnology
- Department of Science and Technology
- Department of Electronics
- Indian Institute of Technology, Chennai and Kharagpur
- State Fisheries Departments
- Union Territory of Lakshadweep
- Kerala Water Authority
- Science and Technology Entrepreneurship Development Project
- Bureau of Indian Standards
- Industries Department, Andaman & Nicobar Administration
- Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram
- College of Fisheries, Mangaluru and Thoothukudi
- National Research Centre on Plant Biotechnology, Thiruvananthapuram
- Institute of Microbial Technology, Chandigarh
- ICAR-Central Marine Fisheries Research Institute, Kochi
- ICAR-Central Institute of Fisheries Education, Mumbai
- National Institute of Cholera and Enteric Diseases, Kolkata
- ICAR-National Bureau of Fish Genetic Resources Research Centre, Kochi
- INCOIS, Hyderabad
- Marine Products Export Development Authority, Kochi
- Andhra University, Visakhapatnam
- Amity University, Noida
- JNTU, Hyderabad
- Sri Venkateswara Veterinary University, Tirupati
- State Institite of Fisheries Technlogy, Kakinada
- M.V.K.R. Fisheries Polytechnic, Bhavadevarapalli, A.P.
- P.S.G. College of Arts and Science, Coimbatore
- Annamalai University, Annamalai Nagar
- Bharathiyar University, Coimbatore

Private Sector

- M/S Garware Wall Ropes Ltd., Pune

- M/S DSM India Ltd., Mumbai

International Institutions

- Food and Agriculture Organization (FAO), Rome
- Bay of Bengal Programme
- Asia Pacific Fisheries Commission
- INFOFISH
- Australian National Quality Assurance Programme, Australia

Extension and Development Agencies

- Central Social Welfare Board
- South Indian Federation of Fishermen Societies, Thiruvananthapuram
- AFPRD, Hyderabad
- Kanyakumari District Fishermen Sangam's Federation
- Bharat Sevak Samaj, Thiruvananthapuram
- Small Industries Development Bank of India
- Matsya Mahila Vedi, Chellanam
- Alleppey Diocesan Charitable and Social Welfare Society, Alappuzha
- Vanitha Matsya Thozilali Bank, Neendakara
- Kerala Industrial and Technical Consultancy Organization
- Avani Agro Society, North Paravur, Ernakulam
- Kerala State Women's Development Corporation Ltd., Thiruvananthapuram
- Chellanam Panchayat SC/ST Co-operative Society Ltd., Kochi
- Development Action through Self Help Network
- Agency for Development of Aquaculture in Kerala
- Kudumbasree Community Development Society, Pallipuram
- New Dolphin Mechanized Fishing Boat Operators Welfare Association, Visakhapatnam
- Swarna Andhra Mechanized Boat Owners Association, Visakhapatnam
- A.P. Mechanized Boat Operators Association, Visakhapatnam
- Pattuvam Inland Fishermen Co-operative Society, Kannur
- Chellanam-Kandakadavu Fishermen Development and Welfare Co-operative Society, Kochi
- Karnataka Fisheries Development Corporation, Bengaluru
- Triptisagar Society for Fishermen Ltd., Jafarabad, Gujarat
- Gandhi Smaraka Seva Kendram, Alappuzha
- Kottappuram Integrated Development Society, Kodungalloor
- MS Swaminathan Research Foundation, Chennai
- EGREE Foundation
- OXFAM
- District Youth Fisheries Welfare Association, Visakhapatnam

Consultancies

During the period the Institute signed the following consultancy agreements with various firms:

- **With M/S Sree Visakha Deepsea Fishing Technocrats Co-operative Marketing Society Ltd., Visakhapatnam** for providing expertise for setting up of a fish processing unit for production of value added fish products. The consultancy agreement document was handed over to Capt. Venkateswarlu, President of the Society.
- **With M/S Power Solutions Business, Ashok Leyland Ltd.** for providing technical assistance for validation of the engine(s) for fishing vessel applications.

Handing over of DPR to the President, Sree Vishaka Deep sea Fishing Technocrats Co-operative Marketing Society Ltd., Visakhapatnam

- **With NETFISH, MPEDA, Kochi** for providing technical assistance in evaluating the effectiveness of different training programmes conducted by NETFISH in the areas of fish quality management and sustainable fishing. The MoU was signed jointly by Dr. C.N. Ravishankar, Director, ICAR-CIFT and Dr. Joice V. Thomas, Chief Executive, NETFISH-MPEDA.
- **With M/S Ashok Leyland Pvt. Ltd.** for validation of two diesel engines of 205 h.p. and inter cool 160 h.p. turbo charged engines for fishing vessel applications.
- **With Shri Ratan Kumar Yumnam, Chilabondha, Sonitpur, Assam** for providing technical assistance for the fabrication and installation of eco-friendly solar dryer for hygienic preservation of fish (CIFT Dryer SDL-55 SM).
- **With M/S Marshall Marine Products, Erode** for collaborative research on developing chitin/chitosan-based plant boosters for agricultural applications through the Agri Business Incubator of the Institute. The products will undergo extensive field trials in different locations with the help of ICAR Institutes before the commercial production.
- **With M/S San Isidro, Palluruthy, Kochi** for providing technical advice for the development of fish and shellfish silage for crop application. The MoU was signed jointly by Dr. C.N. Ravishankar, Director, ICAR-CIFT and Shri Jeffin Jose, M/S San Isidro.
- **With M/S Yanmar India Pvt. Ltd., Maharashtra** for validation of engines for fishing vessel applications. The MoU was signed jointly by Dr. C.N. Ravishankar, Director, ICAR-CIFT and Shri Amit Jawrekar, Senior Engineer, M/S Yanmar India Pvt. Ltd.
- **With M/S FAB Dye Kem Pvt. Ltd., Kochi** for providing technical advice and assistance relating to the transfer of know-how for the production of chitin and chitosan. The MoU was signed jointly by Dr. C.N. Ravishankar, Director, ICAR-CIFT and Shri Koshy Thomas, Director, M/S FAB Dye Kem Pvt. Ltd., Cochin.
- **With Department of Fisheries, Govt. of Himachal Pradesh** for setting up of canning and fish processing unit with the technical consultancy of ICAR-CIFT on 9 January, 2017 in presence of Shri Thakur Singh Bharmouri, Hon'ble Minister of Forest and Fisheries, Govt. of Himachal Pradesh.

Dr. C.N. Ravishankar, Director, ICAR-CIFT handing over the MoU to Shri Vikram Suthakar, M/S Marshal Marine Products

Dr. C.N. Ravishankar, Director, ICAR-CIFT greeting Shri Jeffin Jose, M/S San Isidro

Director ICAR-CIFT exchanging MoU with Shri Koshy Thomas, M/S Fab Dye Chem

Exchange of MoU between Shri Gurucharan Singh and Dr. C.N. Ravishankar (Also seen is Shri Thakur Singh Bharmouri)

- **With Self Employed Women's Association (SEWA)** for documentation of roles women play in fisheries and periodic information for better formulation of rural employment strategies for the rights and access to aquatic resourses for the sustenance of livelihood.

Dr. C. N. Ravishankar, Director ICAR- CIFT and Dr. Sonia George, Coordinator, SEWA exchanging the MoU

Analytical services

The Headquarters and Research Centres of the Institute undertook testing samples of different types of raw materials and products received from various organizations, State and Central Government departments and entrepreneurs and issued reports on their quality. The samples tested included fresh and frozen fish and shellfish products, byproducts, prawn larvae from hatcheries, swabs from processing tables and workers' hands, chemicals, salt, water, ice, packaging materials etc. Type testing of marine diesel engines was also carried out and performance certificates were issued to the concerned manufacturers in addition to calibration of mercury, alcohol and digital thermometers received from different fish processing plants and the industry. Samples were tested in the different laboratories at Headquarters and Research Centres and test reports were sent to the concerned.

Past year in the life of ICAR-CIFT

Events

Launching of Fuel Efficient Multi-Purpose Fishing Vessel: The 19.75 m multi-purpose fishing vessel, FV Sagar Harita, built under the project "Green Fishing Systems for the Tropical Seas" funded by National Agricultural Science Fund was officially launched by Dr. T. Mohapatra, Secretary (DARE) and DG (ICAR) in a function organized by ICAR-CIFT at CIFNET auditorium on 18 April, 2016. Dr. J.K. Jena, DDG (Fy.), ICAR, New Delhi presided over the function and Rear Adm. Shekhar Mital, NM, IN (Retd.), Chairman & Managing Director, Goa Shipyard Ltd., Goa, Ms. Leena Nair, IAS, Chairperson, MPEDA, Kochi, Dr. K. Gopakumar, Former DDG (Fy), ICAR, Shri Chhabilendra Roul, IAS, Additional Secretary (DARE) & Secretary (ICAR), New Delhi addressed the gathering. Dr. P. Pravin, ADG (M.Fy.), ICAR, New Delhi, Dr. A. Gopalakrishnan, Director, ICAR-CMFRI, Kochi, Dr. P.K. Agrawal, ADG (NASF) and Shri R.C. Sinha, Director, CIFNET, Kochi also offered felicitations. Dr. C.N. Ravishankar, Director, ICAR-CIFT welcomed the gathering and Dr. Leela Edwin, PI of the GFSTS project and HOD, FT, ICAR-CIFT proposed vote of thanks. The vessel was launched by Smt. Kalpana Mohapatra, wife of Dr. Mohapatra in the presence of the dignitaries at NIPHATT Jetty, Kochi.

Dr. Mohapatra addressing the gathering and officially declaring the launching of the vessel

Launching of the vessel by Smt. Kalpana Mohapatra

Visit of Secretary (DARE) & Director General (ICAR): Dr. T. Mohapatra, Secretary, DARE and DG, ICAR, New Delhi visited ICAR-CIFT, Kochi on 18 April, 2016. He was accompanied by Shri Chhabilendra Roul, IAS, Additional Secretary (DARE) and Secretary (ICAR), Dr. J.K. Jena, DDG (Fy.), ICAR and Dr. P. Pravin, ADG (M.Fy.), ICAR. The formal function was presided over by Dr. C.N. Ravishankar, Director of the Institute. Shri Roul, Dr. Jena and Dr. Pravin also addressed the gathering. The dignitaries also visited the various research laboratories of the Institute .

The dignitaries visiting the gear fabrication laboratories

Visit of Minister of State, Govt. of Maharashtra: Shri Deepak Kesarkar, Hon'ble Minister of State for Home (Rural), Finance & Planning, Govt. of Maharashtra visited ICAR-CIFT, Kochi on 20 September, 2016 and had interaction with Heads of Divisions with an objective to make use of the improved technologies evolved by ICAR-CIFT for the development of harvesting and post harvesting sectors of fishery in Maharashtra.

Minister in discussion with the Director and Heads of Divisions

Visit of Financial Advisor and Additional Secretary (DARE/ICAR): Shri S.K. Singh, Financial Advisor and Addl. Secretary (DARE/ICAR) visited ICAR-CIFT, Kochi on 23 September, 2016 and addressed the staff of the Institute.

Shri S.K. Singh visiting the laboratories

Visit of DDG (Fisheries Science), ICAR: Dr. J.K. Jena, Deputy Director General (Fisheries Science), ICAR, New Delhi visited ICAR-CIFT, Kochi on 27 September, 2016 and interacted with scientific, technical, administrative and supporting staff in separate sessions to share their ideas and suggestions with regard to various research and developmental issues pertaining to the growth of the Institute.

Dr. J.K. Jena, DDG (Fisheries Sciences) addressing the staff

Visit of Chairperson, National Biodiversity Authority: Dr. B. Meenakumari, Chairperson, National Biodiversity Authority, Chennai visited ICAR-CIFT, Kochi on 19 September, 2016 to discuss issues of conservation, sustainable use of biological resource and fair equitable sharing of benefits of use arising out of the utilization of biological resources related to fishery sector.

Dr. B. Meenakumari discussing with Director and Heads of Divisions

Visit of Minister of Fisheries, Govt. of Kerala: Hon'ble Minister of Fisheries, Harbour Engineering and Cashew Industries, Govt. of Kerala Smt. J. Mercy Kutty Amma visited ICAR-CIFT, Kochi on 18 February, 2017 to get

acquainted with the technological achievements of the Institute for addressing various problems related to harvest and post harvest sector in fishery in the state. Being impressed with ICAR-CIFT technologies during her laboratory visit, she urged the scientists of the Institute to come up with novel technologies to improve the livelihood security of large scale fisher population of the state and expressed her desire to collaborate with ICAR-CIFT.

Smt. J. Mercy Kutty Amma addressing the staff of ICAR-CIFT

The Minister interacting with scientists regarding craft and gear materials

Release of publication: The book entitled, "Advances in marine natural products and nutraceutical research" published by ICAR-CIFT, Kochi was formally released by Shri Radha Mohan Singh, Hon'ble Minister for Agriculture and Farmers Welfare, Govt. of India during the 88th Annual General Body Meeting of ICAR held at New Delhi on 14 February, 2017. The book edited by Suseela Mathew, R. Anandan, K.K. Asha, N.S. Chatterjee, C.S. Tejpal, R.G.K. Lekshmi and A.R.S. Menon deals with current trends and advances in the marine natural products and nutraceutical industry, both in India and abroad.

Release of the publication by Hon'ble Union Minister

Meetings

Research Advisory Committee Meeting: The 17th Meeting of the Research Advisory Committee of the Institute under the Chairmanship of Dr. Bhaskaran Manimaran was held at ICAR-CIFT, Kochi on 22 February, 2017. The RAC deliberated on the works in progress and thrust areas of research keeping in view, the mandate and vision of the Institute and made recommendations.

RAC meeting in progress

Institute Research Council Meeting: The Annual Research Council Meeting of the Institute was held during 13-15 March, 2017 to discuss about the ongoing research projects of the Institute and to finalize the new research programmes. Accordingly 17 new research projects were approved for initiation during April, 2017.

IRC meeting in progress

FAO-ICAR Meeting on Antimicrobial Resistance: A meeting of researchers on "Identification of research priorities in veterinary sector for antimicrobial resistance

(AMR)" was organized at ICAR-CIFT, Kochi during 27-28 March, 2017 to discuss the research needs, capabilities and priorities for AMR in India and mechanism to disseminate these across the country. The meeting was attended by experts from different parts of the country constituting scientists from Fisheries Institutes of ICAR namely, CIFT, CIFA, CIBA and CMFRI and Professors from different Veterinary and Medical Colleges. At the end of the group discussion, 21 concept notes were proposed and presented by the groups on the selected theme to the panel of experts.

Dr. C.N. Ravishankar, Director, ICAR-CIFT speaking on the occasion

Group discussion in progress

Celebrations

Institute Foundation Day: The Institute celebrated its 59th Foundation Day on 29 April, 2016, Dr. K. Gopakumar, former Deputy Director General (Fisheries), ICAR, New Delhi was the Chief Guest of the day. Dr. C.N. Ravishankar, Director presided over the function. Representatives of the different categories of the retired staff of the Institute, namely Shri Krishna Iyer (Scientific), Shri Subramanian (Technical), Shri Shanmughan (Administrative) and Shri Kunjan (Skilled Support) were also honoured on the occasion. Dr. Suseela Mathew, HOD, B&N welcomed the gathering while Shri P.J. Davis, SAO proposed vote of thanks. The function ended with a variety entertainment programme staged by the staff.

Dr. K. Gopakumar inaugurating the celebrations

Anti Terrorism Day: Anti Terrorism Day was observed on 20 May, 2016. The Director and staff of the Institute assembled together and took Anti Terrorism Day Pledge.

International Day of Yoga: The International Day of Yoga was celebrated on 21 June, 2016 at the ICAR-CIFT Head Quarters and its Research Centres. The Yoga celebrations at the Headquarters included a talk on the "The significance and importance of Yoga in our daily life" by Shri Kaithapram Vasudevan Namboothiri, Director, Patanjali Yoga Research and Training Centre, Kochi. Mass Yoga performance by staff based on the Common Yoga Protocol of the Ministry of AYUSH was also held.

At Visakapatanam Research Centre of ICAR-CIFT on 20 June, 2016 an introductory session of Yoga was conducted. As part of this a video on Yoga was also screened. A Yoga session of around 60 minutes was organized on 21 June with the theme "Yoga for Harmony and Peace". All the officers and staff of the Centre took part enthusiastically and practiced various Asanas of Yoga and Pranayama. Yoga trainers Shri Kalyan Chakravarthy, Kum. K.S. Sushma and Shri Shiva Satya Sai Varma from Yoga Village, Andhra University demonstrated various Yoga postures and explained the correct way of doing Asanas.

At Kochi

At Visakapatanam

At Veraval

At Mumbai

At the Veraval Research Centre of ICAR-CIFT programmes were organized during 17- 21 June, 2016. On 17 June, 2017 screening of a short film on Yoga entitled "Yoga-Harmony with nature" was held. On 18 June an essay competition was arranged on the subject "Importance of Yoga in our daily life". A theory session on Yoga was arranged on 20 June to get an over view of the practical session on 21 June. Shri M. Thakar Abhay Kumar, Shree Somanth Sanskrit University, Veraval was the resource person for the session.

At Mumbai Research Centre of ICAR-CIFT on 21 June, 2016, Dr. (Captain) P. Chatterjee, Physician and Yoga practitioner and Smt. Rekha Chatterjee, a trained Yoga teacher were the Chief Guests. The classes were followed by Yoga demonstration explaining specifically which technique is helpful in relieving different diseases like arthritis, diabetes, hormonal problems etc.

National Sadbhavana Diwas: The Institute celebrated 'National Sadbhavana Diwas' on 20 August, 2016 in connection with observance of 'Communal Harmony Fortnight'. The staff of the Institute assembled together and took Sadbhavana Day Pledge.

'Onam': The state harvest festival 'Onam', was celebrated by Institute Recreation Club at ICAR-CIFT, Kochi on 6 September, 2016 with pomp and gaiety. Floral carpet competition was held in the morning followed by traditional 'Sadya' (feast). Dr. Sreevalsan J. Menon, renowned musician was the Chief Guest for the function held in the afternoon. A cultural programme was also arranged.

Dr. Sreevalsan J. Menon inaugurating the celebrations

World Fisheries Day

World Fisheries Day was celebrated on 21 November, 2016 at the Head Quarters and Research Centres. The function at Kochi was attended by more than 85 college students from nearby colleges of Kochi along with scientists, staff of the Institute and two international trainees from Bangladesh. The Chief Guest of the function was Smt. Soumini Jain, Hon'ble Mayor of Cochin Corporation. On the occasion, a seminar on "Need for conservation of fishery resources" was also organized followed by an open quiz competition among the students. There were lectures on 'World Fisheries Day - Experience of ICAR-CIFT in responsible fisheries' and on 'Water resource management'.

Smt. Soumini Jain delivering the inaugural address

Director distributing prizes to winning team of quiz competition

At the Visakhapatnam Research Centre of ICAR-CIFT a 13 day's training programme on "Laboratory methods for microbiological examination of seafood" was conducted in which 18 participants representing seafood processing plants located in different parts of Andhra Pradesh participated. Further, an awareness programme on "Hygienic handling of fish" was organized at the 'Mera Gaon, Mera Gaurav' adopted village Mangamaripeta in Bheemunipatnam Mandal, Visakhapatnam with support of NETFISH-MPEDA, Fisherfolk Foundation and District Fishermen's Youth Welfare Association (DFYWA). The programme was attended by 50 fisherwomen. The Visakhapatnam Research Centre also participated in the exhibition organized by the State Fisheries Department at Srikakulam on 21 November, 2016. A demonstration programme on preparation of value added products from low cost fishes was also arranged in the stall.

Dr. Vesavila, Fisheries Consultant speaking on the occasion

At the Veraval Research Centre of ICAR-CIFT a one day awareness programme on "Responsible fishing and quality improvement" was organized on 21 November, 2016. During the technical session, presentations were made on "Major commercially exploited species and need for conservation", "Hygienic handling of fishes for quality improvement" and "Energy efficient responsible fishing techniques for artisanal fishermen". A total of 22 fishermen from Jaleshwar, ICAR-CIFT adopted village under 'Mera Gaon, Mera Gaurav' programme participated in the programme. During the programme, Shri Musungara Hasambhai Jummabhai, Winner, ICAR-Pandit Deen Dayal Upadhyay Antyodaya Krishi Puruskar - 2015 was honored.

Shri Jummabhai, award winning farmer being felicitated

At the Mumbai Research Centre World Fisheries Day was celebrated with an open house. About 50 students from I.E.S. Navi Mumbai High School, Vashi visited the Centre. An exhibition was organized on the occasion show-casing the technologies developed by ICAR-CIFT in harvest and post harvest fishery sector. Students were given an opportunity to visit different laboratories. An interactive session was also arranged to sensitize them about the importance of fisheries for liveli-hood development and highlighted the scope and opportunities of fisheries education in India and abroad.

Exhibition organized during World Fisheries Day celebrations

At Alappuzha, one day workshop on "Fishery-based business enterprises for coastal area" was jointly organized by NETFISH, MPEDA and ICAR-CIFT with the local support of an NGO, ADC&SW, Alappuzha. Thirty women representatives from different SHGs spreading over the four coastal villages of Alappuzha attended the programme. During the technical session a lecture on the 'Entrepreneurial options in fisheries for coastal women' was also given.

At Jowai, Meghalaya, a one day awareness programme on "The importance of fish in diet" was organized on 21 November, 2016. The programme was jointly organized by ICAR-CIFT, Kochi, ICAR-RC for NEH, Meghalaya, Department of Fisheries, Meghalaya and Office of Deputy Commissioner, West Jaintia Hills District. The programme was attended by 59 participants. A publication on "Importance of fish in diet" was released on the occasion. The fish soup fortified with calcium and iron was distributed to all dignitaries. A quiz programme based on nutritional importance of fish was conducted for the participants.

Shri Ram Singh, IAS delivering the Chief Guest's address

Agricultural Education Day Celebrations

On 3 December, 2016 ICAR-CIFT, Kochi celebrated the "Agricultural Education Day" by organizing one day seminar on "Importance of agricultural education in India" for school students followed by a Farmers-Scientists interaction cum demonstration programme for the fisherwomen. Hands-on training programme on "Women self-employment through improved techniques of fish processing and value addition" was organized for the women SHGs (Kudumbasree) of Thoppumpady area of Willingdon Island, Kochi. The programme was attended by 25 women members from seven SHGs. In the afternoon, a Farmers-Scientists Interaction Programme was organized to provide instant solutions to various problems faced by the fisher community on a common platform.

On the same day, another one day seminar was held on "Importance of agricultural education in India" for the higher secondary students at Kendriya Vidyalaya, Port Trust, Willingdon Island, Kochi to highlight the significance of agricultural research, education and extension in various spheres of agricultural sciences and motivate the students to put their best efforts in shaping their career in the field of fishery science. Lectures on various topics like 'Role of ICAR-CIFT for fishery sector development', 'Improved technologies in fisheries', 'Technological advancements in Indian Agriculture' and 'Career opportunities in agricultural education' were delivered in the programme. More than 80 students from Class XI and XII of the school attended the seminar along with some teaching staff of the school.

Swachch Pakhwada: At ICAR-CIFT, Kochi 'Swachh Pakhwada' was observed during 16-30 May, 2016. The fortnight-

Hands on training in progress

Students-Scientists interaction in progress

long celebrations started with a pledge. A quiz programme was organized on 19 May, 2016. Eminent social activist and environmentalist Prof. S. Sitaraman, delivered a guest lecture on 23 May, 2016 on 'Role of public and government in conserving environment'. A cleanliness drive at General Hospital, Karuvelipady was conducted on 26 May, 2016. An awareness programme for fishermen was also conducted at Cochin Fisheries Harbor on 28 May, 2016. The Pakhwada was again celebrated during 16-31 October, 2016. A joint cleanliness drive was undertaken at the residential quarters of ICAR-CIFT in which the staff and residents including children actively participated. As part of the celebrations different competitions were held for the students of Puthenthode Government Higher Secondary School including elocution, essay writing, quiz and painting on relevant topics like environment, pollution, responsibility of youth towards hygiene and sanitation, conservation of natural resources, etc. A cleanliness drive was also conducted at Relief Settlement, Palluruthy in Ernakulam district. Further, an awareness programme was held in the village Kannamaly on 24 October, 2016. A team of scientists interacted with the fishermen with regard to the village hygiene and sanitation and other essential amenities for their day-to-day livelihood sustenance. Another awareness programme for school children of Puthenthode Government Higher Secondary School was conducted on 25 October, 2016. A total of 100 students participated in the various competitions, and prizes were distributed to winners during the programme. There was a cleanliness drive at Palluruthy Relief Shelter by ICAR-CIFT in association with Peoples Council for Social Justice, Kochi on 28 October, 2016. More than 100 inmates of the Rehabilitation Centre belonging to different parts of the country participated in the cleanliness drive. On 31 October, 2016 the water tanks of the Institute were cleaned by the staff of ICAR-CIFT.

At the Visakhapatnam Research Centre of ICAR-CIFT intensive cleanliness campaign in the Institute premises was conducted. "Swatch Pakhwada" was also observed at the fishing harbor, Visakhapatnam on 27 October, 2016. On 28 October, 2016, the cleanliness drive was held at Pandurangapuram Beach, adjoining the Centre. The same day, staff of the Institute took out a rally from the Center to beach road carrying banners and placards to create awareness about cleanliness among the citizens.

Administering Swatchhata pledge at ICAR-CIFT residential premises

Cleanliness drive at fishing harbor

Vigilance Awareness Week: Vigilance Awareness Week was celebrated at ICAR-CIFT, Kochi and its Research Centres during the period 31 October to 5 November, 2016. The observance of the week commenced with a pledge administered by the Director to the staff on 31 October, 2016. At ICAR-CIFT, Kochi on 5 November, 2016, Dr. Alexander Jacob, IPS, Former Director General of Police, Kerala and Nodal Officer, National Police University delivered a talk on "Vigilance and anti-corruption". At Veraval Research Centre of ICAR-CIFT Dr. D. Divu, Scientist Inchrage, Veraval Regional Station of ICAR-CMFRI was the Chief Guest who gave a talk on 'Public participation in promoting integrity and eradicating corruption'.

Session in progress at Kochi (L to R: Dr. Saly N. Thomas, Dr. Alexander Jacob, IPS, Dr. C.N. Ravishankar and Shri P.J. Davis)

National Unity Day: 'Rashtriya Ekta Diwas' was observed at the Institute and the Research Centres on 31 October, 2016 with a pledge administered by the Director to the staff of the Institute.

Constitution Day: Constitution Day was celebrated on 26 November, 2016 as a part of the birth anniversary celebrations of Dr. B.R. Ambedkar with a pledge taken by the staff at the Head Quarters and the Research Centres.

National Productivity Week: The Institute celebrated National Productivity Week during 12-18 February, 2017. As part of it an invited talk on "From waste to profit through Reduce, Recycle, Reuse" was delivered by Dr. N.C. Induchoodan, IFS at ICAR-CIFT, Kochi on 14 February, 2017. At Visakhapatnam Research Centre of ICAR-CIFT an awareness programme on 'Fish waste utilization' was conducted during15-16 February, 2017. Twenty five fisherwomen from Thimmapuram village, Visakhapatnam were trained on the process of preparation of fish silage using fish waste. A leaflet on the process of preparation (In Telugu) was also distributed


Dr. Induchoodan delivering the lecture at Kochi

International Women's Day Celebrations: ICAR-CIFT, Kochi celebrated International Women's Day on 8 March, 2017. Smt. Neena Kurup, Malayalam cine actress and television personality was the Chief Guest of the day. As part of the celebrations, a home-made video encouraging all to do their might towards reducing the gender gap was played in the Institute lobby. A couple of pull up posters with important messages like stopping gender stereotyping etc. were also displayed. Also a couple of videos signifying the importance of the day were screened during the function that also included a performance of a traditional dance form called "Margam Kali" by a team of women staff of ICAR-CIFT.

Smt. Neena Kurup addressing the gathering

Awards and Recognitions

Cash Award to ICAR-CIFT: ICAR-CIFT, Kochi received a cash award of ₹ 5 Lakhs instituted by Ministry of Agriculture, Govt. of India for "Pushing Cashless Economy Goals" among the ICAR Institutes. The award was received by Dr. C.N. Ravishankar, Director, ICAR-CIFT from Shri Radha Mohan Singh, Hon'ble Minister for Agriculture and Farmers Welfare, Govt. of India during Annual Conference of Vice Chancellors of Agricultural Universities and Directors of ICAR Institutes held at New Delhi on 14 February, 2017. ICAR-CIFT achieved the goal within the stipulated period of one week.

Dr. C.N. Ravishankar receiving the award from Shri Radha Mohan Singh

Honour to ICAR-CIFT by Chief Minister of Kerala: Hon'ble Chief Minister of Kerala Shri Pinarayi Vijayan honoured ICAR-CIFT in recognition of the technical consultancy rendered by the Institute for design and development of laboratory at MILMA and getting NABL accreditation as per ISO/IEC 17025: 2005 Laboratory Quality Management System. On behalf of Director, ICAR-CIFT, Dr. T.V. Sankar, Principal Scientist and NABL Manager received the honour from the Chief Minister of Kerala on the occasion of the dedication of the Chemical and Microbiological Laboratory to the State Dairy Department, Govt. of Kerala at a function held at Thiruvananthapuram on 7 September, 2016.

Shri Pinarayi Vijayan handing over mementoe to Dr. T.V Sankar

Recognition for ICAR-CIFT, Kochi: ICAR-CIFT, Kochi has been recognized as a National Referral Laboratory for Fish and Fishery Products by Food Safety and Standards Authority of India (FSSAI) under Ministry of Health and Family Welfare, Government of India. This is a major achievement for ICAR-CIFT. As being referral laboratory in fish and fishery products, it would have a greater role in framing policy issues related to quality and safety of domestically marketed products. The referral laboratory would have a major role in capacity development across the country by organizing professional training, workshops and seminars for food analysts and laboratory personnel in the states specified by the Food Safety and Standards Authority of India.

Team award for ICAR-CIFT Scientists: The team of Scientists comprising of Dr. Suseela Mathew, Dr. A.A. Zynudheen, Dr. R Anandan, Dr. George Ninan, Dr. K.K. Asha and Dr. N.S. Chatterjee representing both Biochemistry & Nutrition and Fish Processing Divisions of ICAR-CIFT, Kochi bagged the K. Chidambaram Memorial Annual Award-2015 for their significant contribution towards the development of processes, methodologies and products of nutritional and health significance from marine sources. The award was presented by Dr. K.K. Vijayan, Director, ICAR-CIBA, Chennai at a function held at Chennai on 16 July, 2016. The award has been instituted by the Fisheries Technocrats' Forum, Chennai.

The award winning team with other dignitaries (L to R: Dr. Chatterjee, Dr. Zynudheen, Dr. Asha and Dr. Suseela Mathew)

Commendation Medal Award: Dr. Manoj P. Samuel, Principal Scientist and Head, Engineering Division, ICAR-CIFT,

Kochi received the "Commendation Medal Award" instituted by the Indian Society of Agricultural Engineers (ISAE) for the year 2016. The award for the contributions made to the field of soil and water conservation engineering for the last 20 years was presented during the inaugural session of 51th ISAE Annual Convention held at CCSHAU, Hisar, Haryana on16 February, 2017.

Prof. N.C. Patel, VC, Anand Agricultural University conferring the award to Dr. Manoj

Certificates of Appreciation: Dr. Nikita Gopal, Principal Scientist was awarded by the Asian Fisheries Society Certificates of Appreciation for her overall contribution to the Organizing Committee of the 5th Global Symposium on Gender in Aquaculture and Fisheries (GAF5) and leadership of the programme; for editorial leadership in publishing the outputs of GAF5, and in recognition of her contribution to the 11th AFAF as a member of the Scientific Committee. The award was presented to Dr. Nikita during 11th Asian Fisheries and Aquaculture Forum and the 5th Global Symposium on Gender in Aquaculture and Fisheries (GAF5) held at Bangkok, Thailand during 3-7 August, 2016.

Best Scientific Paper in Fishery Technology Journal: The research paper entitled 'Supercritical carbon dioxide extraction of PUFA rich oil from freeze dried tuna red meat' authored by R. Yathavamoorthi, C.T. Nithin, T.R. Ananthanarayanan, Suseela Mathew, J. Bindu, R. Anandan and T.K. Srinivasa Gopal bagged the award for best scientific paper published in Fishery Technology Journal during the year 2015. The team received the award during the Annual General Body Meeting of Society of Fisheries Technologist (India) held at ICAR-CIFT, Kochi on 20 July, 2016.

The award winning team

Best Paper Awards: The following research papers presented in various Symposia/Seminars during the period under report won the Best Paper Awards:

- 'Efficacy of Indian Borage leaf extract in stabilizing omega-3 enriched soup powder' by Lekshmi R.G. Kumar, K. Jayathilakan, K. Sarika, E.R. Priya, S.S. Greeshma, C.S. Tejpal, N.S. Chatterjee, K.V. Vishnu, K.K. Asha, R. Anandan and Suseela Mathew - National conference on Application of natural products and opportunities ahead at B.S. Abdur Rahman University, Chennai during 2-3 August, 2016.
- 'Physico-chemical and sensory characterization of meat from a deep-sea fish, starry flying gurnard (*Dactylopytena peterseni*)' by K. Elavarasan, Anuj Kumar, Devananda Uchoi, H. Mandakini Devi, C.S. Tejpal, K. Sathish Kumar, George Ninan and A.A. Zynudheen - International conference on Emerging issues in quality and safety of fish and shellfish at TNFU, Chennai during 11-12 August, 2016.
- 'Indigenous Traditional Knowledge (ITK) in marine capture fisheries: A case study in Thrissur district, Kerala, India' by Diana Benjamin, K.M. Mrudula, Arathy Ashok, S. Sreejith, Sumisha Velloth, J. Bindu and Nikita Gopal - 26th Swadeshi Science Congress-National Seminar on Blue Growth at ICAR-CMFRI, Kochi during 7-9 November, 2016.
- 'Evolution of agri-business incubation ecosystem in NARS for promoting agri-entrepreneurship' by P. Subhash, K. Srinivas, Manoj P. Samuel and Kalpana Sastry - 76th Annual Conference of Indian Society of Agricultural Economics at AAU, Jorhat during 21-23 November, 2016.
- 'Construction of fishing canoes with coconut wood – A techno economic analysis' by Leela Edwin, M.V. Baiju, J.P. James, R.A Roshan, K.L. Chitralekha, V.R. Madhu and Nikita Gopal - 3rd International symposium on Coconut research and development at ICAR-CPCRI, Kasaragod during 10-12 December, 2016.

Best Poster Awards: The following research papers presented in various Symposia/Seminars during the period under report won the Best Poster Awards:

- 'Qualitative lipid profiling using targeted precursor ion and neutral loss scan on electron spray ionization-quadrupole-linear ion trap platform: Authentication of two different types of fish oils' by N.S. Chatterjee, K.V. Vishnu, Akansha Singh, K.K. Ajeeshkumar, R. Anandan, K. Ashok Kumar and Suseela Mathew - Annual Conference of AOAC International at New Delhi during 11-12 November, 2016.
- 'Effect of sardine oil loaded microparticle on metabolic and immune responses and attenuation of doxorubicin induced cardiotoxicity in cardiomyoblast cell lines' by K.V. Vishnu, K.K. Ajeeshkumar, N.S. Chatterjee, R.G.K. Lekshmi, B. Ganesan, C.S. Tejpal, K. Shyni and Suseela Mathew - 8th International Conference on Clinical Nutrition at Dubai during 8-10 December, 2016.

Sahitya Ratna Puraskar-2016: Dr. Santhosh Alex, Senior Technical Officer of ICAR-CIFT, Kochi received 'Sahitya Ratna Puraskar-2016' from Sahitya Sangom, a reputed Literary Organization based in Bangalore for his contribution to Hindi literature by means of translation and creative writing. Dr. Santhosh has published 23 books in Hindi, English and Malayalam which includes poetry, translations and criticism. Dr. Santhosh received the honour from Shri Rajendra Vyas, Editor, Rajasthan Patrika, Bangaluru on 18 December, 2016.

Dr. Santhosh receiving the award from Shri Rajendra Vyas

Achievements in ICAR Sports Meet: In the ICAR Zonal Sports Meet held at Hyderabad during 22-26 August, 2016, Smt. Tessy Francis, Senior Tech. Asst., ICAR-CIFT, Kochi was the Winner in Chess while Shri K.R. Rajasaravanan, Skilled Support Staff became the Winner in Carroms. Besides Smt. V. Renuka, Scientist, Veraval Research Centre of ICAR-CIFT secured third position in High Jump in the tournaments.

Smt. Tessy Francis and Shri Rajasaravanan receiving the trophy

Post Graduate Studies

Shri V.K. Sajesh, Scientist, Extension, Information and Statistics Division, ICAR-CIFT, Kochi was awarded Ph.D. in Agricultural Extension for the thesis entitled "Pluralism in agricultural extension and convergence: An analysis" from Indian Agricultural Research Institute (IARI) , New Delhi (Deemed University).

Smt. T.K. Anupama, Scientist, Quality Assurance & Management Division, ICAR-CIFT, Kochi was awarded the Degree of Doctor of Philosophy in Post Harvest Technology for the thesis entitled "Bacterial flora in surimi wastewater during different stages of treatment" under the guidance of Dr. B.B. Nayak, Principal Scientist & Head, Fisheries Resources, Harvest and Post Harvest Technology Division from ICAR-Central Institute of Fisheries Education, Mumbai (Deemed University).

Shri Renju Ravi, Research Scholar of Fishing Technology Division, ICAR-CIFT, Kochi was awarded Ph.D. in Fisheries Science by Faculty of Marine Sciences, Cochin University of Science and Technology, Kochi for his thesis titled "Studies on structural changes and life cycle assessment in mechanized trawl fishing operations of Kerala". He did his research under the guidance and supervision of Dr. Leela Edwin, Head & Principal Scientist, Fishing Technology Division, ICAR-CIFT, Kochi.

Shri S.S. Shaju, Research Scholar of Fishing Technology Division, ICAR-CIFT, Kochi has been awarded Ph.D. in Fisheries Science by Faculty of Marine Sciences, Cochin University of Science and Technology, Kochi for his thesis titled "Studies on bio-geochemistry, bio-optical properties and satellite validation of coastal waters of south-eastern Arabian Sea". He did his research under the guidance and supervision of Dr. B. Meenakumari, Former Director ICAR-CIFT, Kochi and Former DDG (Fisheries), ICAR, New Delhi.

Important Visitors

- Dr. T. Mohapatra, Secretry, DARE and Director General, ICAR, Shri Chhabilendra Roul, IAS, Additional Secretary (DARE) and Secretary (ICAR), Dr. J.K. Jena, DDG (Fisheries Science), ICAR and Dr. P. Pravin, ADG (Marine Fisheries), ICAR, New Delhi (Kochi on 18 April, 2016)
- Shri Deepak Kesarkar, Hon'ble Minister of State for Home (Rural), Finance & Planning, Govt. of Maharashtra (Kochi on 20 September, 2016)
- Smt. J. Mercy Kutty Amma, Minister for Harbour Engineering and Cashew Industries, Govt. of Kerala (Kochi on 18 February, 2017)

Smt. J. Mercy Kutty Amma at Kochi

- Shri S.K. Singh, Financial Advisor and Additional Secretary (DARE/ICAR), New Delhi (Kochi on 23 September, 2016)
- Dr. B. Meenakumari, Chairperson, National Biodiversity Board, Chennai (Kochi on 19 September, 2016)
- Dr. J.K. Jena, DDG (Fisheries Science), ICAR, New Delhi (Visakhapatnam on 15 October, 2016)
- Shri Thakur Singh Bharmouri, Minister of Forest and Fisheries, Govt. of Himachal Pradesh and Shri Gurcharan Singh, Director, Department of Fisheries, Govt. of Himachal Pradesh (Kochi on 9 January, 2017)
- Dr. Ajay Kumar, IAS, Gir Somnath District (Veraval on 6 February, 2017)
- Dr. S. Karthikeyan, IAS, Director of Fisheries, Govt. of Kerala (Kochi on 25 March, 2017)

Dr. J.K. Jena at Visakhapatnam

Shri Thakur Singh Bharmouri at Kochi

Agricultural Technology Information Centre

At ATIC, arrangements were made for the visitors such as fisherpersons, students, technologists and officials. Analytical samples were received at ATIC and test reports were sent after analysis. Various priced publications and value added fishery products were sold through ATIC. Various technical queries received regarding training and other extension activities were replied.

Administration

The Administration Section deals with recruitment, service and policy matters, discipline, staff welfare, land and building, procurement of stores, budget expenditure, settlement of claims etc.

During the period under report, the following Committees met for purposes as shown below:

1. Departmental Promotion Committee : 4 times
2. Departmental Selection Committee : Nil
3. Assessment Committee : 2 times
4. Career Advancement Committee : 3 times
5. Modified ACP Committee : Once
6. Selection test : Nil

Category	Promotion	Declaration of probation & Confirmation	Granting MACP
Scientific	13	20	-
Technical	22	-	-
Administrative	5	4	-
Supporting	-	-	2
Auxiliary	-	-	1

Priority setting, Monitoring and Evaluation Cell

The PME Cell dealt with the following technical matters during the year:

Verification of CAS reports of Scientists: The PME Cell verifies the Career Assessment Reports submitted by Scientists for their promotion and gives due recommendations.

Submission of monthly, quarterly and half yearly reports: Monthly reports on the important activities of the Institute and significant research findings were compiled and sent to ICAR regularly for inclusion in the ICAR monthly report to the Cabinet Secretariat and the report to PMO. Quarterly and six monthly reports on the targets and achievements of the Institute comprising both research and financial aspects were regularly furnished to the Council.

Publication of the scientific papers: The scientific research papers meant for publication in research journals and for presentation in Symposia/Seminars by scientists of the Institute were arranged for reviewing and plagiarism checking and further approval of the recommended papers communicated.

Institute Research Council: The Institute Research Council meeting was conducted twice to review the progress achieved in the ongoing research projects of the Institute during 2015-16 and 2016-17. The Institute Research Project Document for the year 2016-17 and 2017-18 were compiled and brought out for discussion at the Meeting. The House discussed in detail the ongoing, new and completed research projects, apart from the various ad hoc projects.

PERMISnet and PIMS-ICAR: The PME Cell helps in maintaining the Personal Management Information System network (PERMISnet–II) of ICAR up-to-date. Through the Project Information Management System (PIMS-ICAR) software, the Institute research projects are being computerized and uploaded online.

Publication of newsletter and other reports: Four issues of CIFT Newsletter and two issues of Fish Tech Reporter were published during the period. Besides, the Institute Annual Report 2015-16 and Research Highlights 2015-16 (bilingual) were also brought out.

Other technical matters: The Cell continued to answer queries on various technical matters received from other organizations and individuals. The queries received by the CTO, PME Cell in the additional capacity of Public Relations Officer, as well as from the feedback option in the Institute Website were attended to. Further, materials for various publications like ICAR News/ICAR Reporter, Agrinews, Fishing Chimes, MPEDA Newsletter, Seafood News, Aqua International, Sea Queen, ICAR Web page etc. were forwarded regularly for publication. Besides, the PME Cell functions as the nodal point for releasing Press Releases and Reports.

Official Language Implementation

Rajbhasha Puraskar' to ICAR-CIFT

ICAR-CIFT, Kochi received 'Rajarshi Tandon Rajbhasha Puraskar' for the year 2014-15. ICAR-CIFT bagged this award for best Official Language Implementation among the ICAR Institutions in the Region 'C'. The award was received by Dr. C.N. Ravishankar, Director, Dr. Santosh Alex and Dr. P. Shankar, Senior Technical Officers from Shri Purushottam Rupala, Union Minister of State for Agriculture, Farmers Welfare and Panchayati Raj and Shri Sudarshan Bhagat, Union Minister of State for Agriculture and Farmers Welfare during the ICAR Foundation Day Celebrations held at Vigyan Bhavan, New Delhi on 16 July, 2016. Dr. T. Mohapatra, Secretary, DARE & DG, ICAR was also present on the occasion. This is the Seventh time ICAR-CIFT is receiving the Rajarshi Tandon Award.

Receieving the award (L to R: Dr. T. Mohapatra, Dr. C.N. Ravishankar, Shri Purushottam Rupala, Shri Sudarshan Bhagat, Dr. P. Shankar and Dr. Santhosh Alex)

TOLIC Award to ICAR-CIFT

ICAR-CIFT, Kochi received Kochi TOLIC Rajbhasha Rolling Trophy for best Hindi Implementation for the year 2015-16. The award was received by Dr. Suseela Mathew, Director In-charge & HOD, B&N from Shri R.C. Sinha, Director, CIFNET during the TOLIC meeting held on 18 January, 2017 at CIFNET, Kochi.

Dr. Suseela Mathew receiving the award from Shri R.C. Sinha

Visit of Parliamentary Committee of Official Language Implementation

The Second Sub Committee of Parliament on Official Language inspected ICAR-CIFT office on 8 April, 2016. Dr. Satyanarayan Jatiya, M.P. (Rajya Sabha) was the Deputy Chairman of the Committee. The other members were Dr. Prasanna Kumar Patsani, M.P. (Lok Sabha), Shri Tarun Vijay, M.P. (Rajya Sabha), Shri Laxminaraya Yadav, M.P. (Lok Sabha), Dr. Sunil Baliram Gaikwad, M.P. (Lok Sabha), Shri Vashistha Narain Singh, M.P. (Rajya Sabha), Kum. Abhilasha Misra, Hindi Officer and Shri Nikhil Arora, Senior Translator from OL Implementation Cell.

The Institute received a letter of appreciation from Shri Tarun Vijay, M.P. for the exceptional work done in implementing Official Language (Hindi). The letter also praised about 'Jaladhi' – the in house publication in Official Language.

Meeting in progress

Official Language Workshop

The following Official Language Workshops were conducted at the Head Quarters during the period under report:

1. For 20 Technical Officers on 1 June, 2016. Shri K.K. Ramachandran, Asst. Director (OL), Office of Income Tax, Kochi was the resource person for the workshop.

2. For 22 Administrative Officers and Assistants on 28 July, 2016. Shri Mithilesh Srivastsav, DGM, Corporate Office,

BSNL, New Delhi was the resource person for the workshop.

3. For 15 Supporting Staff on 4 November, 2016. Smt. T.P. Leena, Hindi Translator, Fishery Survey of India, Kochi was the resource person for the workshop.

4. For 17 Scientists on 19 January, 2017. Shri P. Vijayakumar, Deputy Director (Implementation), (Retd.), Ministry of Home Affairs, Govt of India was the resource person for the workshop.

Hindi Chetana Mass-2016: ICAR-CIFT, Kochi celebrated 'Chetana Mass-2016' during the period 10 August to 3 September, 2016. Different competitions like Singing, Quiz, Essay Writing, Cross word, News reading, Poster presentation etc. were conducted among the staff during the month-long celebrations. The valedictory function was held on 19 September, 2016 which was graced by Shri Deepak Kumar Gulati, Zonal Director, Fishery Survey of India, Cochin Base as the Chief Guest. He also distributed prizes to the winners of various competitions.

Shri Gulati delivering the Chief Guest's address

'Rajbhasha Prathibha Puraskar' to Smt. Asha Gopalan

'Rajbhasha Prathibha Puraskar' to Shri Aravind S. Kalangutkar

At the 'Hindi Pakwada celebrations' at the Visakhapatnam Research Centre during 14-27 September, 2016 various competitions including singing, talk, skit etc. were conducted and prizes were distributed. Shri Amit Sharma, Senior Manager, Andhra Bank, Visakhapatnam was the Chief Guest for the valedictory function on 27 September, 2016.

A Hindi skit enacted by Staff on the occasion of Hindi Pakwada celebrations at Visakhapatnam

As part of the 'Hindi speech series' three speeches were conducted as follows:sRegional Ocean Governance Framework, Implementation of the United Nations Convention on the Law of the Sea (UNCLOS) and its Related Instruments in the Southeast Asian Seas and the Indian Ocean – Dr. U. Sreedhar, Principal Scientist (5 June, 2016)

- Indian administration set-up - Shri Vaikundha Pradhan, Assistant Chief Technical Officer (16 March, 2017)
- Swatch Bharat - Shri M. Prasanna Kumar, Senior Technical Assistant (17 June, 2017)

Hindi Pakhwada was also celebrated at Veraval Research Centre of ICAR-CIFT during 1-14 September, 2016. Various competitions such as Quiz, Essay writing, Antakshari, Drawing, Elocution and Hindi Song were conducted during period.

Hindi Pakhwada celebrations at Veraval

Hindi Week was celebrated at the Mumbai Research Centre of ICAR-CIFT during 12-17 September, 2016. A Hindi Workshop was also conducted on 3 September, 2016. Smt. Susmitha Bhattacharya, Deputy Director,

Official Language Implementation Committee, Navi Mumbai explained the importance of implementation of Hindi in scientific, technical and administrative works.

Prize for ICAR-CIFT staff in Joint TOLIC competitions

Shri Paras Nath Jha, Scientist, FT Division secured first place in Essay writing competition conducted by TOLIC.

Library

Library is playing a vital role in providing services to support the information needs of the scientific community of the Institute. The library is well equipped with modern facilities and resources in the form of online databases, CD-ROMs, DVDs, books, e-journals, e-standards, theses, reports etc. During the period under report, library acquired 49 books and 10 scientific periodicals. Online databases *viz*., ASFA (Aquatic Science and Fisheries Abstracts) and Indian Standards in DVD have also been acquired.

Library Portal: The library home page provides electronic access to bibliographic databases and full text documents. Bibliographic databases have been developed using WINISIS and search interfaces have been developed using 'GenISISweb'.

Digital Repository: Digitization of the Institute publications and putting them in the open digital repository is an important activity of the library. During the period 137 documents have been digitized and added to the repository. At present the digital repository holds 2,224 digital documents.

Remote access to e-resources: Remote access to subscribed e-resources has been provided to the users. The users are getting access to IP protected resources outside the campus also *via*. the library's list of online resources. The facility is also available to the faculty members of the Research Centres.

Consortium of e-Resources on Agriculture (CeRA): More than 2,000 journals are available online through CeRA. Library has supplied copies of 436 articles under DDR (Document Delivery Request) facility of CeRA.

IAMSLIC membership: The library is a member of The International Association of Aquatic and Marine Science Libraries and Information Centers (IAMSLIC) and is part of the Inter-library Loan Programme, with more than 90 member libraries from more than 25 countries offering materials to other member libraries *via*. Inter-library loan and document delivery.

ASFA Input Centre: The library in association with NIO, Goa continued to act as a National Input Centre of ASFA (Aquatic Science and Fisheries Abstracts) database.

Agricultural Knowledge Management Unit

Agricultural Knowledge Management Unit (AKMU) caters to meet the ICT needs of the Institute by providing and maintaining the internet, email, video conferencing and other computer related facilities. AKMU also periodically updates Institute Website and Personnel Management Information System Network (PERMISnet) of the employees of the Institute. AKMU provides internet connectivity to nearly 250 systems through LAN and wifi connectivity to nearly 200 users. ICAR-CIFT is presently connected with 1000 mbps lease line under National Knowledge Network (NKN) provided by Govt. of India and 10 mbps ILL from BSNL to provide all the ICT services for the employees of the Institute.

During the period under report, an inhouse training programme on ICAR ERP system was organized and coordinated by AKMU for the Scientific, Technical, Administrative and Skilled Support Staff of the Institute.

AKMU provides K7 Enterprise Security through the server for protecting from malware threats and other external sources of threats, thus improving the ICT efficiency. It also acts as a gateway to protect from intrusion attacks to

prevent the leakage of confidential data by adding 193 clients in the system. AKMU properly manages ICAR-CIFT Website and it is available in the url www.cift.res.in. It highlights the overall research activities and achievements of the Institute and act as an interface between the Institute and end users. The contents of the Institute Website are periodically updated. The information on training programmes, recruitments of temporary staff, tender notices and other circulars of the Institute are periodically uploaded in the Institute Website to create transparency of the working condition. The IP-based video conferencing facility is being operated and maintained effectively by AKMU. The facility is being used for monitoring and evaluating research programmes in the Research Centres of the Institute and also other organizations.

AKMU is maintaining and updating of Personnel Management Information System Network (PERMISnet-II) of the Institute. It contains personal, professional and referential attributes of personnel along with information on plan-wise cadre strength and institutional parameters for different categories of staff.

NABL Activities

ICAR-CIFT laboratories were accredited to ISO/IEC: 17025:2005 in the year 2005 and the quality system is in position since last 12 years. The NABL surveillance audit was conducted during 24-25 September, 2016 and the accreditation was extended up to 14 December, 2018. The NABL recommended scope for accreditation is 106 parameters which include 83 parameters in Chemical, 17 parameters in Biological and Six parameters in Mechanical field. Inter-laboratory comparison was carried out for biological parameters in fish, chemical parameters in fish and in water during the year 2016. During the period under report a total of 1,218 samples including NABL, Non-NABL, ILC and customs samples were analyzed and the total revenue of ₹ 40.90 lakhs was realized.

Committees

Quinqennial Review Team

Chairman: Dr. S.D. Tripathi, Former Director, ICAR-CIFE, Mumbai

Members

1. Dr. K. Venkatesh Murthy, Senior Principal Scientist, CSIR-CFTRI, Mysore
2. Dr. V.C. George, Director, Aquaculture Department, SH College, Kochi
3. Prof. B.A. Shamsunder, College of Fisheries, Mangaluru
4. Dr. Krishna Srinath, Former Director, ICAR-DRWA, Bhubaneswar
5. Shri S.S. Rajpathak, Vice President, M/S Garware Wall Ropes Ltd., Pune

Member Secretary: Dr. Leela Edwin, Principal Scientist, ICAR-CIFT

Research Advisory Committee

Chairman: Dr. Bhaskaran Manimaran, Former Vice Chancellor, TNFU, Nagapattinam

Members

1. Dr. B. Hanumanthappa, Professor, College of Fisheries, Mangaluru
2. Dr. Sajan George, Former Dean, KUFOS, Kochi
3. Dr. Sreenath Dixit, Director, ATARI, Bengaluru
4. Dr. K.S.M.S. Raghava Rao, Head, Food Engineering, CSIR-CFTRI, Mysuru
5. Shri P.P. Surendran, DGM, Matsyafed, Thiruvananthapuram
6. Dr. P. Pravin, Asst. Director General (M. Fy.), ICAR, New Delhi
7. Dr. C.N. Ravishankar, Director, ICAR-CIFT

Member Secretary: Dr. R. Anandan, Principal Scientist, ICAR-CIFT

Institute Management Committee

Chairman: Dr. C.N. Ravishankar, Director, ICAR-CIFT

Members

1. Dr. V.V. Kulkarni, Director, ICAR-NRC on Meat, Hyderabad

2. Dr. S. Samantha, Principal Scientist, ICAR-CIFRI, Barrackpore
3. Dr. V. Kripa, HOD, FEMD, ICAR-CMFRI, Kochi
4. Adv. Ranjeet Srinivas, Alappuzha
5. Shri K. Radha Madhavan, Kozhikode
6. Dr. T.V. Sankar, Principal Scientist, ICAR-CIFT
7. Dr. P. Pravin, Assistant Director General (M. Fy.), ICAR, New Delhi
8. Shri T.D.S. Prakash, Finance and Accounts Officer, ICAR-CPCRI, Kasaragod

Member Secretary: Shri P.J. Davis, Senior Administrative Officer, ICAR-CIFT

Grievance Cell

Chairman: Dr. C.N. Ravishankar, Director, ICAR-CIFT

Members

1. Dr. Suseela Mathew, HOD, B&N
2. Shri P.J. Davis, Senior Administrative Officer
3. Shri P.P. Anil Kumar, Asst. Finance & Accounts Officer
4. Dr. M.P. Remesan, Principal Scientist
5. Shri H.V. Pungera, Senior Tech. Asst.
6. Shri D.L. Pattanaik, Lower Division Clerk
7. Shri P. Raghavan, Skilled Support Staff
8. Shri M.V. Rajan, Auxillary Staff

Member Secretary: Shri T. Viswanathan, Asst. Admn. Officer, ICAR-CIFT

Institute Joint Staff Council

Chairman: Dr. C.N. Ravishankar, Director, ICAR-CIFT

Members (Official side)

1. Dr. Suseela Mathew, HOD, B&N
2. Dr. A.A. Zynudheen, Hod I/c, QAM
3. Dr. M.P. Remesan, Principal Scientist
4. Smt. M.J. Christina Joseph, Administrative Officer
5. Assistant Finance & Accounts Officer

Secretary (Official Side)

Shri P.J. Davis, Senior Administrative Officer

Members (Staff Side)

1. Shri G. Vinod, Technician
2. Shri K.B. Subukuttan, Assistant
4. Shri P.K. Somasekharan Nair, Assistant
5. Shri K.K. Karthikeyan, Skilled Support Staff
6. Shri P.N. Nikhil Das, Skilled Support Staff

Secretary (Staff Side)

Shri P.S. Nobi, Tech. Officer

On-going Research Projects

Institute Projects

Sl. No	Name of Project	Principal Investigator	Location of Project	Co-Investigators	
1.	Innovative product development for value addition, nutrient fortification and shelf life extension of farmed and wild freshwater and marine fish	Dr. B. Madhusudana Rao	Visakhapatnam, Mumbai & Kochi	Visakhapatnam Mumbai Kochi	Dr. M.M. Prasad Kum. Jesmi Debbarma Dr. P. Viji Dr. P.P.N. Vijayakaumar* Dr. L.N. Murthy Smt. T. Muthulakshmi Shri S. Ezhil Nilavan
2.	Development of standard processes and protocols for innovative products from aquatic resources, shelf life modeling and assessment of energy use	Dr. George Ninan	Kochi, Veraval, Visakhapatnam & Mumbai	Kochi	Dr. C.N. Ravishankar Dr. K.V. Lalitha Dr. A.A. Zynudheen Dr. J. Bindu Dr. C.O. Mohan Dr. P.K. Binsi

Sl. No	Name of Project	Principal Investigator	Location of Project	Co-Investigators	
					Shri C.G. Joshy Smt. P. Jeyanthi Kum. H. Mandakini Devi Shri S. Sreejith Dr. Anuj Kumar Smt. S.J. Laly Dr. K. Elavarasan Smt. K. Sarika Shri Devananda Uchoi Dr. T.K. Anupama Smt. S.S. Greeshma Smt. V.A. Minimol Smt. K.R. Sreelakhsmi
				Veraval	Dr. A.K. Jha Smt. V. Renuka Smt. S. Remya
				Visakhapatnam	Dr. P. Viji
				Mumabi	Dr. S. Visnuvinayagam Dr. A. Jeyakumari Smt. U. Parvathy
3.	Development of high value byproducts from fish and shellfish processing dis-cards	Dr. A.A. Zynudheen	Kochi, Visakhapaam, Veraval & Mumbai	Kochi	Dr. George Ninan Dr. S.K. Panda Dr. P.K. Binsi Dr. V. Murugadas Shri C.G. Joshy Kum. H. Mandakini Devi Dr. Anuj Kumar Shri S. Sreejith Smt. S.J. Laly Smt. K. Sarika Dr. K. Elavarasan Shri Devnanda Uchoi Smt. E.R. Priya Smt. K.R. Sreelakshmi
				Visakhapatnam	Dr. B. Madhusudana Rao Kum. Jesmi Debbarma
				Veraval	Dr. A.K. Jha Smt. V. Renuka Smt. S. Remya
				Mumbai	Dr. L.N. Murthy Dr. S. Visnuvinayagam Dr. A. Jeyakumari Smt. U. Parvathy

Sl. No	Name of Project	Principal Investigator	Location of Project	Co-Investigators	
4.	Investigations on fish behavior and responsible fishing systems	Dr. V.R. Madhu	Kochi, Visakhapatnam & Veraval	Kochi Visakhapatnam Veraval	Dr. Leela Edwin Dr. Saly N. Thomas Dr. P. Pravin Dr. M.P. Remesan Shri M.V. Baiju Smt. Arathy Ashok Shri S. Chinndurai Shri R.K. Renjith Shri P.N. Jha Dr. G. Rajeswari Dr. R. Raghu Prakash Dr. U. Sreedhar Dr. K.K. Prajith Shri G. Kamei
5.	Design development and standardization of deep sea fishing vessel and gear systems for commercial operation	Shri M.V. Baiju	Kochi, Visakhapatnam & Veraval	Kochi Visakhapatnam Veraval	Dr. Saly. N. Thomas Dr. M.P. Remesan Shri P.N. Jha Shri R.K. Renjith Dr. R. Raghu Prakash Dr. U. Sreedhar Dr. K.K. Prajith
6.	Marine biomolecules – Characterization and utilization for neutraceutical, biomedical and industrial applications	Dr. K.K. Asha	Kochi, Visakhapatnam & Veraval	Kochi Visakhapatnam Veraval	Dr. Suseela Mathew Dr. R. Anandan Dr. George Ninan Dr. Femeena Hassan Dr. S.K. Panda Dr. C.O. Mohan Shri C.G. Joshy Dr. N.S. Chatterjee Shri C.S. Tejpal Kum. Lekshmi R.G. Kumar Shri K.K. Anas Dr. Raja Swaminathan (ICAR-NBFGR, Kochi) Dr. B. Madhusudana Rao Kum. Jesmi Debbarma Dr. A.K. Jha
7.	Modeling studies for estimation of revenue based capacity and valuation of selected fishing systems and fish supply chain analysis	Smt. P. Jeyanthi	Kochi & Veraval	Kochi Veraval	Dr. A.K. Mohanty Dr. Nikita Gopal Dr. V. Geethalakshmi Shri V. Radhakrishnan Nair Shri V. Chandrasekar Smt. Arathy Ashok Dr. V.K. Sajesh Shri G. Kamei

Sl. No	Name of Project	Principal Investigator	Location of Project	Co-Investigators	
8.	An assessment of the impact of S&T outputs of ICAR-CIFT on the socio-economic fabric of fisheries stakeholders	Dr. S. Ashaletha	Kochi	Kochi	Dr. A.K. Mohanty Dr. V. Geethalakshmi Shri V. Radhakrishnan Nair Shri V. Chandrasekar Smt. Arathy Ashok Dr. V.K. Sjesh Dr. K. Rejula
9.	Molecular heterogeneity and bioprospecting of aquatic and fish bacteria for novel molecules and genes	Dr. Toms C. Joseph	Kochi, Visakhapatnam, Veraval, Mumbai & Thiruvananthapuram	Kochi Visakhapatnam Veraval Mumbai Thiruvananthapuram	Dr. K.V. Lalitha Dr. M.M. Prasad Dr. K.K. Asha Shri V. Radhakrishnan Nair Dr. V. Murugadas Shri K.A. Basha Shri R.K. Nadella Smt. S.S. Greeshma Smt. T. Muthulakshmi Dr. M.A. Pradeep (ICAR-CMFRI, Kochi) Dr. Raja Swaminathan (ICAR-NBFGR, Kochi) Dr. B. Madhusudana Rao Dr. G.K. Sivaraman Dr. S. Visnuvinayagam Dr. E. Sreekumar (RGCBT, Thiruvananthapuram) Dr. R. Ajaykumar (RGCBT, Thiruvananthapuram) Dr. Santhosh Mundayoor (RGCBT, Thiruvananthapuram)
10.	Quality improvement of Indian fishing fleet and engineering interventions in post harvest sector	Shri M. Nasser	Kochi	Kochi	Dr. Manoj P. Sameul Dr. S. Ashaletha Dr. V. Geethalakshmi Shri Ankur Nagori Dr. S. Murali Dr. D.S. Aniesrani Delfiya Smt. P.V. Alfiya
11.	Enhancement of life of fishing materials using nanotechnology	Dr. P. Muhamed Ashraf	Kochi	Kochi	Dr. Leela Edwin Dr. Saly N. Thomas Shri S. Chinnadurai

Sl. No	Name of Project	Principal Investigator	Location of Project	Co-Investigators	
12.	Assessing environmental aspects of fish, fishery products and effects of chemical hazards	Dr. G.K. Sivaraman	Veraval, Kochi & Mumbai	Veraval Kochi Mumbai	Dr. A.K. Jha Smt. V. Renuka Smt. S. Remya Dr. M.M. Prasad Shri R.K. Nadella Shri K.A. Basha Dr. L.N. Murthy Dr. S. Visnuvinayagam Dr. A. Jeyakumari Smt. U. Parvathy
13.	Food safety hazards of fish and fishery products: Assessment and mitigation measures	Dr. S.K. Panda	Kochi, Veraval & Visakhapatnam	Kochi Veraval Visakhapatnam	Dr. K. Ashok Kumar Dr. T.V. Sankar Dr. Femeena Hassan Dr. J. Bindu Dr. C.O. Mohan Smt. S.J. Laly Dr. N.S. Chatterjee Dr. Pankaj Kishore Dr. T.K. Anupama Smt. E.R. Priya Smt. V.A. Minimol Dr. G.K. Sivaraman Dr. B. Madhusudana Rao
Externally Funded Projects					
National Agricultural Science Fund (NASF) Project					
14.	Green fishing systems for tropical seas	Dr. Leela Edwin	Kochi, Goa, Pune & Mumbai	Kochi Goa Pune Mumbai	Dr. Saly N. Thomas Dr. M.P. Remesan Shri M.V. Baiju Dr. V.R. Madhu Shri P.S. Muhammed Sherif* Smt. K.A. Sayana* Smt. Leena Raphael* Shri Rithin Joseph* Shri P.K. Mahato* Shri V.T. Antony* Smt. Jolsana Jeevan* Shri H. Unnikrishnan* Shri S. Vinayak Karma* Shri K.R. Harikrishnan* Shri B.K. Upadhyay Shri Ashok Naik Shri Sanjay V. Raut Shri Kishore Darda Kum. Margot Wunnikvan Shri Rakesh Gaikwad

Sl. No	Name of Project	Principal Investigator	Location of Project	Co-Investigators	
Centre for Marine Living Resources and Ecology (CMLRE) Projects					
15.	Exploration and assessment of demersal fishery resources along the continental slope (200-1200 m) of Indian EEZ and central Indian Ocean	Dr. U. Sreedhar	Visakhapatnam, Mumbai & Kochi	Visakhapatnam Mumbai Kochi	Dr. G. Rajeswari Dr. R. Raghu Prakash Dr. P. Viji Shri B. Prema Raju* Kum. S. Lavanya* Shri K. Rushinadha Rao* Dr. L.N. Murthy Dr. Suseela Mathew Shri K.K. Ajeesh Kumar* Shri K.V. Vishnu*
16.	Assessment of myctophid resources in the Arabian sea and development of harvest and post harvest technologies	Dr. M.P. Remesan	Kochi, Visakhapatnam & Veraval	Kochi Visakhapatnam Veraval	Dr. R. Anandan Dr. George Ninan Dr. A.A. Zynudheen Shri R.K. Nadella Shri R. Navaneethan* Shri M.M. Lijin Nambiar* Smt. R.Jayarani* Dr. G. Rajeswari Dr. R. Raghu Prakash Dr. K.K. Prajith
17.	Characterization of harmful algal blooms along Indian coast	Dr. K. Ashok Kumar	Kochi	Kochi	Dr. T.V. Sankar Dr. R. Anandan Dr. S.K. Panda Kum. R. Rajisha* Kum. Rose Mary Mathew*
Department of Biotechnology (DBT) Projects					
18.	Development of bioplastic based sustainable nanobiocomposites food packaging –"Sustain Nanopack"	Dr. J. Bindu	Kochi	Kochi	Dr. S.K. Panda Kum. R. Vidhya*
19.	Genetic diversity of *Clostridium botulinum* in seafoods and development of Lateral Flow Immuno Assay (LFIA) for toxinotyoping	Dr. K.V. Lalitha Dr. Tom C. Joseph	Kochi	Kochi	Shri Arun Jyothi* Smt. Athira Vidyadharan* Kum. Reethu Sara Anil*
20.	Evaluating costs and benefits of prophylactic health products and novel alternatives on smallholder aquaculture farms in Asia and Africa	Dr. Toms C. Joseph	Kochi	Kochi	Shri Bibin Das* Kum. T.R. Lakshmi*

Sl. No	Name of Project	Principal Investigator	Location of Project	Co-Investigators	
Department of Science and Technology (DST) Project					
21.	Development of clam cluster and clam processing facility at Perumbalam village, Thycatuserry block, Cherthala taluk, Alappuzha	Dr. Nikita Gopal	Kochi	Kochi	Dr. J. Bindu Shri V. Chandrasekar Shri S. Sreejith Kum. K.H Sreedevi* Shri James J. Pulikottil*
Indian National Centre for Ocean Information (INCOIS) Projects					
22.	Studies on ecological linkages between plankton production and *Acetes* sp. along Gujarat coast	Dr. V.R. Madhu	Veraval	Veraval	Dr. K.K. Prajith Kum. Vadher Kiran* Shri Muchhal Haresh*
23.	Retrieval of phytoplankton and associated optical constituents based on long term bio-optical studies	Dr. P. Muhamed Ashraf	Kochi	Kochi	Smt. P. Minu* Smt. V.P. Souda*
24.	Validation of tuna advisories off east coast	Dr. U. Sreedhar	Visakhapatnam	Visakhapatnam	Shri R. Uma Maheswara Rao* Shri D. Dhananjay*
25.	Indigenous traditional knowledge (ITKs) in marine fisheries sector of Kerala: Documentation and analysis	Dr. Nikita Gopal	Kochi	Kochi	Dr. J. Bindu Dr. V.K. Sajesh Shri S. Sreejith Kum. T.A. Alfreeda* Kum. M.V. Neelima* Shri Jiswin Joseph* Kum. K.M. Mrudula* Kum. Sumisha Velloth (Vijnana Bharati, New Delhi)*
UNDP-Global Environment Facility Project					
26.	Demonstration and field testing of bycatch reduction and juvenile excluder devices along Sindhudurg district, Maharashtra	Dr. V.R. Madhu	Maharashtra	Maharashtra	Shri P.S. Khanolkar* Shri P.S. Dudhwadkar* Shri H.B. Redkar*
National Fisheries Development Board (NFDB) Project					
27.	National surveillance programme for aquatic animal diseases	Dr. K.V. Lalitha Dr. V. Murugadas	Kochi	Kochi	Dr. Toms C. Joseph Shri K.A. Basha Dr. S. Ashaletha Shri P.G. Akhil Nath* Shri P. Shaheer*
ICAR-National Fellow Project					
28.	Biomodulation of marine biopolymers for the preparation of biomaterials of healthcare importance	Dr. R. Anandan	Kochi	Kochi	Dr. P.R. Sreerekha* Smt. Divya K. Vijayan*

Sl. No	Name of Project	Principal Investigator	Location of Project	Co-Investigators	
Export Inspection Council of India (EICI) Project					
29.	Preparation of pictorial guidelines based on freshness ratings for the species of fishes exported to European Union	Dr. T.V. Sankar Dr. K. Ashok Kumar	Kochi, Visakhapatnam, Veraval & Mumbai	Kochi Visakhapatnam Veraval Mumbai	Dr. S.K. Panda Dr. Pankaj Kishore Dr. B. Madhusudana Rao Dr. A.K. Jha Dr. L.N. Murthy
National Bank for Agriculture and Rural Development (NABARD) Project					
30.	Assessment of role and impact of fisheries cooperatives in enhancing the livelihood and resource management capabilities of fisherfolk in India	Dr. Nikita Gopal	Kochi	Kochi	Smt. P. Jeyanthi Shri V. Chandrasekar Smt. Arathy Ashok Shri G. Jayesh*
Food and Agricultural Organization (FAO) Project					
31.	Assessment of food loss from selected gillnet and trammel net fiseries in India	Dr. Saly N. Thomas	Kochi, Veraval & Kakinada	Kochi Veraval Kakinada	Dr. Leela Edwin Shri S. Chinnadurai Dr. K.K. Prajith Dr. V. Salarama (ICM, Kakinada)
Indian Council of Agricultural Research (ICAR) Projects					
32.	Agri-business Incubation	Dr. George Ninan	Kochi, Visakhapatnam & Mumbai	Kochi Visakhapatnam Mumbai	Dr. C.O. Mohan Dr. N.S. Chatterjee Smt. Elizabeth Paul* Shri C. Shyam Kumar* Shri A.C. Praveen* Smt. P.R. Sudha* Smt. E.B. Lovely* Dr. B. Madhusudana Rao Dr. L.N. Murthy
33.	Nutrient profiling and evaluation of fish as a dietary component	Dr. R. Anandan	Kochi, Veraval & Mumbai	Kochi Veraval Mumbai	Dr. Suseela Mathew Dr. K.K. Asha Dr. N.S. Chatterjee Shri C.S. Tejpal Kum. Lekshmi R.G. Kumar Shri K.K. Anas Smt. Divya K. Vijayan* Smt. R. Jayarani* Dr. G.K. Sivaraman Dr. A.K. Jha Smt. V. Renuka Dr. A. Jeyakumari
34.	All India Network project on Fish health	Dr. K. Ashok Kumar	Kochi	Kochi	Dr. S.K. Panda Smt. S.J. Laly

* Research Fellow

List of Personnel in ICAR-CIFT

(As on 31st March, 2017)

Managerial Personnel

Director: Dr. C.N. Ravishankar

Heads of Division

Biochemistry and Nutrition Division	:	Dr. Suseela Mathew, Principal Scientist
Fish Processing Division	:	Dr. K. Ashok Kumar, Principal Scientist
Microbiology, Fermentation & Biotechnology	:	Dr. M.M. Prasad, Principal Scientist
Fishing Technology Division	:	Dr. Leela Edwin, Principal Scientist
Extension Information & Statistics Division	:	Dr. A.K. Mohanty, Principal Scientist
Engineering Division	:	Dr. Manoj P. Samuel, Principal Scientist
Quality Assurance and Management Division I/c	:	Dr. A.A. Zynudheen, Principal Scientist

Senior Administrative Officer	:	Shri P.J. Davis
Finance & Accounts Officer	:	Shri K.S. Sreekumaran

Visakhapatnam Research Centre	:	Dr. G. Rajeswari, Principal Scientist
Veraval Research Centre	:	Dr. G.K. Sivaraman, Senior Scientist
Mumbai Research Centre	:	Dr. L.N. Murthy, Senior Scientist

Other Personnel

Headquarters, Cochin

Scientific Personnel

Principal Scientist

1. Shri M. Nasser
2. Dr. T.V. Sankar
3. Dr. Saly N. Thomas
4. Dr. M.P. Remesan
5. Dr. Nikita Gopal
6. Dr. V. Geethalakshmi
7. Dr. S. Ashaletha
8. Dr. R. Anandan
9. Dr. A.A. Zynudheen
10. Dr. J. Bindu
11. Dr. P. Muhamed Ashraf
12. Dr. Femeena Hassan
13. Dr. George Ninan
14. Dr. Toms C. Joseph

Senior Scientist

1. Dr. K.K. Asha
2. Dr. S.K. Panda
3. Dr. V.R. Madhu
4. Shri M.V. Baiju
5. Dr. C.O. Mohan
6. Dr. M.V. Sajeev

Scientist

1. Shri V. Radhakrishnan Nair
2. Smt P. Jeyanthi
3. Dr. P.K. Binsi
4. Dr. V. Murugadas
5. Shri C.G. Joshy
6. Shri V. Chandrasekar
7. Dr. V.K. Sajesh
8. Smt. S.J. Laly
9. Dr. N.S. Chatterjee
10. Dr. Pankaj Kishore
11. Shri K.A. Basha
12. Shri R.K. Nadella
13. Shri S. Sreejith
14. Dr. T.K. Anupama
15. Kum. Hanjabam Mandakini Devi
16. Dr. Anuj Kumar
17. Shri R.K. Renjith
18. Smt. K.R. Sreelakshmi
19. Kum. Lekshmi R.G. Kumar
20. Smt. E.R. Priya
21. Smt. K. Sarika
22. Shri P.N. Jha
23. Smt. T. Muthulakshmi
24. Smt. S.S. Greeshma
25. Shri C.S. Tejpal
26. Dr. K. Elavarasan
27. Shri S. Chinnadurai
28. Shri Devananda Uchoi
29. Shri K. Sathish Kumar
30. Dr. S. Murali
31. Shri K.K. Anas
32. Shri Abhay Kumar
33. Shri S. Ezhil Nilavan
34. Smt. V.S. Minimol
35. Smt. PV. Alfiya
36. Kum. Rehana Raj
37. Dr. D.S. Aniesrani Delfiya
38. Dr. K. Rejula

Technical Personnel

Chief Technical Officer

1. Dr. A.R.S. Menon

Assistant Chief Technical Officer

1. Shri C.R. Gokulan
2. Smt. K.B. Beena
3. Smt. P.K. Shyma
4. Dr. M. Baiju
5. Smt. T. Silaja
6. Shri T.V. Bhaskaran

Senior Technical Officer

1. Smt. M. Rekha
2. Shri K.D. Jos
3. Dr. B. Ganesan
4. Smt. K.K. Kala
5. Dr. Santhosh Alex
6. Shri Sibasis Guha
7. Shri P.S. Babu
8. Shri G. Omanakuttan Nair
9. Smt. G. Remani
10. Dr. P. Shankar
11. Dr. Ancy Sebastian
12. Smt. K.G. Sasikala

Technical Officer

1. Shri K.B. Thampi Pillai
2. Smt V.C. Mary
3. Shri P.T. Viswambharan
4. Shri V.N. Dileepkumar
7. Shri C. Subash Chandran Nair
8. Shri Aravind S. Kalangutkar
9. Shri R. Arockia Samy
10. Shri P.S. Nobi
11. Shri K.C. Gopalan
12. Smt. K.S. Mythri
13. Shri A.K. Naik
14. Shri T.P. Haridasan
15. Smt. P.K. Geetha
16. Shri Sajith K. Jose
17. Shri P.V. Sajeevan
18. Smt. P.A. Jaya
19. Shri V.K. Siddique
20. Shri T. Mathai
21. Shri T.B. Assisse Francis
22. Shri G. Gopakumar

Senior Technical Assistant

1. Smt. N. Lekha
2. Shri K.S. Babu
3. Shri P. Bhaskaran
4. Smt. Bindu Joseph
5. Shri T.P. Saju
6. Smt. N.C. Shyla
7. Shri P.D. Padmaraj
8. Smt. Tessy Francis
9. Shri P.S. Sunil Kumar
10. Shri N. Sunil

Technical Assistant

1. Shri K.V. Mohanan
2. Shri C.K. Suresh
3. Shri K. Dinesh Prabhu
4. Shri P.A. Aneesh
5. Shri K.D. Santhosh
6. Shri K.A. Noby Varghese
7. Smt. Vineetha Das
8. Shri V. Vipin Kumar
9. Shri T. Jijoy
10. Smt. P. Sruthi
11. Shri Rahul Ravindran
12. Smt. U.P. Prinetha
13. Shri Rakesh M. Raghavan
14. Smt. V. Sushmitha

Senior Technician

1. Shri K.C. Anish Kumar
2. Shri Ajith V. Chellappan
3. Shri G. Vinod
4. Shri K. Ajeesh
5. Smt. Anu Mary Jose
6. Smt. G. Archana
7. Smt. P.J. Mary
8. Shri P. Suresh
9. Shri M.T. Udayakumar

Technician

1. Shri K. Nakulan
2. Smt. K. Reshmi
3. Shri V.N. Sreejith

Administrative Personnel

Adminstrative Officer

1. Smt. M.J. Christina Joseph

Assistant Administrative Officer

1. Smt. Pushpalatha Viswambharan
2. Shri P. Krishna Kumar
3. Shri T. Viswanathan
4. Shri K.B. Sabukuttan

Assistant Finance & Accounts Officer

1. Shri P.P. Anil Kumar

Private Secretary

1. Shri P.K. Reghu
2. Smt. S. Kamalama

Assistant

1. Smt. T.D. Usheem
2. Shri K.K. Sasi
3. Smt. T.K. Shyma
4. Smt. V.S. Aleyamma
5. Smt. G.N. Sarada
6. Shri C.K. Sukumaran
7. Smt. V.K. Raji
8. Smt. K. Renuka
9. Shri K. Das
10. Shri P.K. Somasekharan Nair
11. Smt. G. Surya
12. Smt. Nilina Elais
13. Smt. N.R. Akhila
14. Smt. Asha Gopalan
15. Smt. A.R. Raji
16. Shri P. Mani
17. Smt. Jaya Das
18. Smt. E. Jyothilakshmy
19. Smt. P.R. Mini
20. Shri T.N. Shaji
21. Shri Santhosh Mohan
22. Smt. Shiji John

Personal Assistant

1. Smt. N. Leena
2. Shri K.V. Mathai
3. Shri R.D. Goswami
4. Smt. Anitha K. John

Upper Division Clerk

1. Shri P.G. David
2. Smt. K.V. Suseela
3. Shri T.D. Bijoy

Lower Division Clerk

1. Shri P.P. George
2. Smt. Subin George
3. Smt. Suni Surendran
4. Kum K.S. Sobha
5. Kum. T. Deepa
6. Shri G.S. Sahoo
7. Shri Deu Umesh Aroskar

Supporting Personnel

Skilled Support Staff

1. Shri P.A. Sivan
2. Shri G.B. Mahanandia
3. Shri P.V. Raju
5. Shri A.V. Chandrasekharan
6. Shri M.M. Radhakrishnan
7. Shri K.K. Karthikeyan
8. Smt. U.K. Bhanumathy
9. Shri T.K. Rajappan
10. Shri O.P. Radhakrishnan
11. Shri P. Raghavan
12. Shri T.M. Balan
13. Shri V. Deepak Vin
14. Smt. P.T. Mary Vinitha
15. Shri K.R. Rajasaravanan
16. Shri K. Thinakaran
17. Shri P.N. Nikhil Das
18. Shri A. Vinod
19. Shri K.S. Ajith
20. Shri S.N. Dash

Auxiliary Staff

1. Shri M.V. Rajan

Visakhapatnam Research Centre

Scientific Personnel

Principal Scientist

1. Dr. R. Raghu Prakash
2. Dr. U. Sreedhar
3. Dr. B. Madhusudana Rao

Scientist

1. Kum. Jesmi Debbarma
2. Dr. P. Viji

Technical Personnel

Chief Technical Officer

1. Dr. M.S. Kumar

Asst. Chief Technical Officer

1. Shri B.K. Pradhan

Senior Technical Officer

1. Shri A.K. Panigrahi

Technical Officer

1. Shri Damodar Rout
2. Shri P. Radhakrishna
3. Shri H.S. Bag

Senior Technical Assistant

1. Shri M. Prasanna Kumar

Technical Assistant

1. Shri P.H. Dhiju Das

Technician

1. Shri G. Bhushanam

Administrative Personnel

Assistant Administrative Officer

1. Shri M.N. Vinodh Kumar

Personal Assistant

1. Smt. D.A.L. Satyanarayanamma

Upper Division Clerk

1. Shri D.L. Pattanaik

Lower Division Clerk

1. Shri Amit Vengraj
2. Shri Ramesh Mirdha

Supporting Personnel

Skilled Support Staff

1. Shri Sanyasi Ganik
2. Shri M.S. Prabhakar Rao
3. Smt. Nalla Naveena
4. Smt. Gyana Netri Nag
5. Shri S.K. Mehar
6. Shri T.N. Banchoor
7. Shri Kedar Meher
8. Shri Jaisingh Oram

Veraval Research Centre

Scientific Personnel

Scientist

1. Dr. A.K. Jha
2. Smt. S. Remya
3. Smt. V. Renuka
4. Dr. K.K. Prajith
5. Shri G. Kamei

Technical Personnel

Assistant Chief Technical Officer

1. Shri J.B. Paradwa

Senior Technical Assistant

1. Shri H.V. Pungera
2. Shri S.H. Ummer Bhai

Technical Assistant

1. Shri G. Kingsely
2. Kum. Nimmy S. Kumar

Senior Technician

1. Shri Y.D. Kriplani
2. Shri J.B. Malmadi

Administrative Personnel

Assistant Administrative Officer

1 Shri M.M. Damodara

Assistant

1. Shri D.P. Parmar

Upper Division Clerk

1. Shri M. Arockia Shaji

Supporting Personnel

Skilled Support Staff

1. Shri D.K. Viram
2. Shri R.N. Gosai
3. Shri A.M. Vala
4. Shri M.K. Kana
5. Smt. Harshaban A. Joshi
6. Smt. Pushpaben P. Chudasama
7. Shri N.K. Masani
8. Smt. Motiben K. Fofandi
9. Shri P. Ramakrishna

Auxiliary Staff

1. Shri J.K. Khodidas
2. Smt. Veena Sreedhar Narkar

Mumbai Research Centre

Scientific Personnel

Scientist

1. Dr. S. Visnuvinayagam
2. Dr. A. Jeyakumari
3. Smt. U. Parvathy

Technical Personnel

Assistant Chief Technical Officer

1. Smt. Sangeetha D. Gaikwad
2. Smt. Triveni G. Adiga

Technical Assistant

1. Smt. Priyanka Ajay Nakhawa

Senior Technician

1. Shri T.A. Waghmare

Administrative Personnel

Assistant

1. Shri A.N. Agawane

Supporting Personnel

Skilled Support Staff

1. Shri V.S. Salvi
2. Smt. Priyanka P. Bait

Science is a beautiful gift to humanity; we should not distort it.

-A. P. J. Abdul Kalam

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