भाकृअनुप
ICAR

CIBA

भाकृअनुप - केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान
ICAR - CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE

वार्षिक प्रतिवेदन 2014 - 15

Annual Report 2014 - 15

Front cover : Yanadi tribal woman displaying farmed crab *(Photo by T. Appala Naidu)*
(Photograph was taken during the harvest of mud crab demonstration farming at Nagayalanka, AP)

CIBA Logo description

- Logo depicts the graphical form of a fish and shrimp that derive from a DNA helix, depicting the core area of the Institution.
- The green and blue colours symbolize the fusion of ecology, environment, and blue waters.
- The usage of bold typography represents the stability and reliability of CIBA

केन्द्रीय खारा जलजीव अनुसंधान संस्थान के प्रतीक चिन्ह (लोगो) का विवरण

- प्रतीक चिन्ह डीएनए कुंडली से व्युत्पन्न मछली और झींगा के चित्रात्मक स्वरूप को दर्शाता है, जो संस्थान के मूल कार्य क्षेत्र को स्पष्ट करता है।
- हरे और नीले रंग पारिस्थितिकीय विलयन, पर्यावरण और जल के प्रतीक हैं।
- मुद्रण में मोटे अक्षरों का उपयोग संस्थान की स्थिरता तथा विश्वसनीयता का प्रतिनिधित्व करता है।

वार्षिक प्रतिवेदन

Annual Report

2014-15

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Published by	Dr. K. K. Vijayan Director
Editorial Committee	Dr. K. K. Vijayan Dr. S. V. Alavandi Dr. C. P. Balasubramanian Dr. Prassana Kumar Patil Dr. (Mrs.) Sherly Tomy Dr. Kumaraguru Vasagam Dr. (Mrs.) Krishna Sukumaran Mrs. K. Jacquline Shri S. Nagarajan
Secretarial assistance	Mrs. K. Subhashini Shri. K.G. Gopala Krishna Murthy
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Preface

It has been increasingly recognized that future of food security largely depends on the aquaculture production. With the world's population predicted to increase to 10.9 billion people by 2050, where in India itself would expected to be 1.6 billion, the need for increased food production is a major challenge, particularly in areas that have high rates of food insecurity. Aquaculture is well acknowledged as one of the few options that contribute significantly at global and national levels to food security and economic growth, if responsibly developed, practiced and maintained in a sustainable way.

The key for the successful development of sustainable aquaculture is multi-fold. It should address each component of supply chain starting from the ecosystem to market.

CIBA continued research on shrimp, mud crabs, seabass, cobia, pearlspot, mullets, milkfish and brackishwater ornamental fishes. Shrimp has been the mainstay of Indian brackishwater aquaculture; however, it requires high investment in terms of inputs and farm management. It has often been identified as an activity managed by large scale farmers. The major production of farmed shrimp is produced by this section of farmers whereas the majority, represented by the small scale farmers with less than 5 ha of rearing holding, has not been in the active regime of the sector. Therefore the opportunity to bring the coastal and rural poor to the sector, and weaving them with the large and small scale brackishwater farming has not been exploited at its best. Inclusiveness of this major segment of the coastal society is the real path for the sustainable development of brackishwater farming. As a part of an effort in this direction, last year we have successfully demonstrated mud crab and finfish culture to the tribal population of West Bengal, Andhra Pradesh and Gujarat, providing them an additional channel for nutrition and income generation.

Future of brackishwater aquaculture, particularly shrimp farming among the nations including India, largely depends on the sustainable mode of development, where the three pillars of the sector, namely profitability, environmental wellbeing and social balance need to be addressed. We have addressed this issue at several levels, system level, organismic and molecular levels. Biofloc technology offers aquaculture a sustainable tool to simultaneously address its environmental, social and economical issues concurrent with its growth. Our in-door and out-door experiments on 'periphyton-bio-floc' technology provided promising results, and technology packages are being tested at field levels at West Bengal, Andhra Pradesh and Tamil Nadu. Continuous control of reproduction under captivity has been the most elusive goal of shrimp aquaculture ever since its inception in 1970s, and it is the essential pre-requisite of selective breeding and genetic improvement of the aquacultured species. The progress made in the science of shrimp reproduction will pave the way to this goal. While disease issues at the grow-out production have been the most serious issues of shrimp aquaculture, the emerging health problem and associated reduction at the seed production level became rampant. Issue of the quality of hatchery produced seeds is a concern, and this

issue is being addressed by the team of aquaculture aquatic animal health specialists at CIBA.

Recent time has witnessed a spiraling cost on the fishmeal, adding on to the cost of formulated feeds and cost of production CIBA has given special focus on polyculture and integrated multi-trophic aquaculture system to optimize the ecosystem use. During the last year we have took major steps on developing farming technologies (hatchery and farm) for species at the lower level of food web (milkfish and mullet). Closing the life cycle of these herbivorous semi-fed species will help to minimize the aquaculture waste and diversify the brackishwater aquaculture, and enabling an aquaculture produce available for consumers in the range of ₹ 150 to 200/kg.

The year 2014-15 was another productive year for CIBA, and the Institute continued to showcase and transfer its packaged technologies through peer-reviewed publications, presentations in International and National seminars, training programs and participatory demonstration programs with stake holders.

We will continue to develop concrete results that can be widely disseminated, and strengthen CIBA's role as a national focal center for brackishwater aquaculture in India. Further, we look forward to new work plan to provide profitable, environmentally non-degradable and socially equitable brackishwater aquaculture technologies for our farmers and stakeholders, fostering partnership with other govt. and private agencies, on a public-private-partnership (PPP) mode.

Certainly, it is an opportunity to play the lead role as the Director of CIBA, the professional support and encouragement provided by Dr S. Ayyappan, Director General, ICAR & Secretary, DARE and Dr B. Meenakumari, former DDG (Fisheries) of ICAR is strongly appreciated, and we are most grateful for their keen enthusiasm and timely help. Further, I am pleased by the R&D achievements, and significant stride in the increasing number of MOUs during the past year, and it was made possible by the wholehearted support of my colleagues and staff of CIBA.

I hope that this report would make an excellent reading.

Dr K K Vijayan
Director

कार्यकारी सारांश

वर्ष 2014–15 के दौरान संस्थान ने खारा जल कृषि के विभिन्न पहलुओं पर ज्ञान प्राप्त किया एवं व्यापक रूप से खारा जलीय/ क्रस्टाशियन तथा व्यवसायिक रूप से महत्वपूर्ण 5 खारा जलीय मछलियों एवं 4 रंगीन मत्स्य प्रजातियों के प्रजनन, बीज उत्पादन, नर्सरी एवं संवर्धन हेतु प्रौद्योगिकियों का विकास किया।

नर्सरी एवं उत्पादन प्रणाली अनुसंधान

क्रस्टाशियन – *लिटो पेनियस वन्नामेई* हेतु पेरिफाइटन तथा बायोफ्लोक आधारित पालन प्रौद्योगिकी का विकास किया गया। सामान्य पालन प्रणाली की तुलना में बायोफ्लाक आधारित पालन प्रणाली के अंतर्गत 42 दिनों की *पी. वन्नामेई* के नर्सरी पालन में उच्च उत्तरजीविता दर (98. 68$\pm$ 1.31%) और वृद्धि दर (2.41$\pm$ 0.08 ग्रा.) प्राप्त की गई। इसी प्रकार सीमेंट के टैंकों में किए गए उत्पादन संबंधी प्रयोगों में परम्परागत स्वापोषित प्रणाली की उत्पादन दर 2.5 – 3.0 कि.ग्रा. प्रति घनमीटर की तुलना में बायोफ्लोक पोषित प्रणाली में उत्पादन दर 4.0 से 4.5 कि. ग्रा. प्रति घनमीटर (40 से 45 मेट्रिक टन प्रति हे.) प्राप्त हुआ।

मिट्टी के केकड़ों के उत्पादन के लिए एक तीन स्तरीय मॉड्यूलार पालन प्रणाली को विकसित किया गया जिसके अंतर्गत तीन माह की अवधि तक नर्सरी संवर्धन, चार माह तक वृद्धि की मध्यम अवधि तक पूर्ण वृद्धि के लिए तीन माह की अवधि पालन किया जाता है। इस पालन प्रणाली से उत्तरजीविता दर, उत्पादन क्षमता तथा किसानों को लिए अल्पावधि में त्वरित आर्थिक आय की प्राप्ति होती है। मिट्टी के केकड़ों की जलीय कृषि का निरूपण सोरलागोंधी गांव (नागय्यालंका, कृष्णा जिला, आन्ध्र प्रदेष) में किया गया। इसमें यह निरूपित किया गया कि कीचड़ के केकड़ों में चेलीपेड के प्रोपोडस को काट कर छोटा करने से स्वजातिभक्षिता प्रवृत्ति में कमी आती है जिससे यथावत् रखे गए केकड़ों की तुलना में उच्च उत्तरजीविता दर प्राप्त होती है।

पंख मीन – प्राकृतिक उत्पादकता को उपयोग में लाते हुए मछलीपट्टनम में तालाबों में सीबास का नर्सरी संवर्धन का मूल्यांकन तथा हापा आधारित नर्सरी संवर्धन परीक्षण किए गए। एक माह की अवधि में 1 से.मी. फ्राई को विपणन हेतु अंगुलिका आमाप तक संवर्धित किया गया। हापा आधारित नर्सरी संवर्धन का निरूपण केरल के त्रिस्सूर, तमिलनाडु के तिरूपल्लूर, गुजरात में नवसारी के ओंजल गांव में भी किया गया। एशियन सीबास का तालाबों एवं पिंजरों में पालन क्रमषः वेदारण्यम एवं त्रिस्सूर में किया गया। वेलंकनी और वेदारण्यम में कोबिया पालन पर किए गए निरूपणों से सूचित होता है कि यह प्रजाति 10 माह की अवधि में 2 कि. ग्रा. शारीरिक भार प्राप्त कर लेती है। परन्तु सूत्रीबद्ध आहार देने पर वृद्धि दर कम पायी गयी। मिल्क–फिष के 240 दिनों की पालन अवधि के दौरान सतह पर 20% तक परिपादप अधःस्तर फैलाने पर उत्पादन में 22% की वृद्धि हुई।

आन्ध्र प्रदेश के कृष्णा जिले में जिला स्तरीय जलजीव पालन विकास योजना को कार्यान्वित किया। यह निरूपित हुआ कि इस जिले में कुल 4037 हे. क्षेत्र अब भी पर्यावरणीय विनियमों का पालन करते हुए भावी विकास के लिए उपलब्ध है। परिदृष्य के मूल्यांकन से सूचित होता है कि वर्ष 2014 में 11880 हे. तालाबों में जलजीव पालन नहीं किया जा रहा है। इस प्रवृत्ति से इंगित होता है कि वर्ष 2009 में अप्रचलित तालाबों का अधिकतम क्षेत्रफल, 12494 हे., था।

जनन जीव विज्ञान, प्रजनन तथा डिम्ब संवर्धन

क्रस्टाशियन – कैद स्थितियों में *पिनियस इंडीकस* की परिपक्वता एवं निशेचन में षीघ्रता लाने में सेरोटोनिन (5–हाइड्रोएक्सट्राप्टामाइन, 5–एचटी) श्रेष्ट पायी गयी जो एक जीव जनित मोनियोमाइन सिगनलिंग मॉलिक्यूल है। मादा *पी. मॉनॉडॉन* के गमेटोजेनिक साइकल की विभिन्न अवस्थाओं के दौरान हेमोलिम्फ में वर्टीब्रेट प्रकार के सेक्स स्टेराइड प्रोफाइल से इन जीवों के जनन नियंत्रण में वर्टीब्रेट प्रकार के सेक्स स्टेराइड हार्मोन की भूमिका को अनिष्चित रूप से दर्शाया है।

पंख मीन – एशियन सीबास के प्रजनन हेतु 24 परीक्षण किए गए और वीएनएन मुक्त प्रजनकों से 8.5 लाख बीज उत्पन्न किए गए जिन्हें विभिन्न राज्यों के किसानों को आपूर्ति की गई। डिम्ब संवर्धन के दौरान ट्रिप्टोफान और इस्ट्रडिओल पूरक आहारों द्वारा स्वजातिभक्षिता को कम करने संबंधी अध्ययन किया गया और विभिन्न प्रकाश

स्पेकट्रम के प्रभाव का मूल्यांकन किया गया। प्रजनक मिल्कफिष (4.6 – 7.2 कि.ग्रा.) को 100 टन आरसीसी टैंक में रखकर बंद स्थितियों में मासिक तौर पर हॉरमोन एलएचआरएच पेलेट समावेषन से परिपक्वता प्राप्त की गई। हॉरमोन एवं लवणता में फेर बदल कर ग्रे मुल्लेट *मुगिल सिफालस* मछलियों को अण्डोत्सर्ग एवं अंडे देने हेतु प्रेरित किया गया। बंद स्थितियों में मादा *ग्रे मुल्लेट* के मांस पेषियों में एल.एच.आर.एच. पेलेट समावित करने पर 9.3 लाख अंडों का उत्पादन हुआ। *पर्लस्पाट इट्रोप्लस सुराटेनसिस* के बीज उत्पादन को परिश्कृत किया गया। प्रजनन बारंबारता में सुधार हेतु किए गए परीक्षणों में एक जोड़ी–पर्लस्पाट–मछलियों को चार माह की अवधि में औसत 17.6 ± 1.12 दिनों की अवधि में 6 बार प्रजनन कराया गया। आन्ध्र प्रदेष और तमिलनाडु के मत्स्यपालकों के लगभग 3000 से अधिक करीमीन बीजों की आपूर्ति की गई। रंगीन/अलंकारिक मछलियों जैसे *स्कैट, मोनोएंजेल्स, क्रिसेंट पर्च और आरेंज क्रोमाइड* के प्रजनन तथा बीज उत्पादन का प्रयास किया गया।

पोषण तथा आहार प्रबंधन

वृद्धि हेतु आहार – वृद्धि निश्पादन तथा पाचन एंजाइमों के आधार पर *पिनियस इंडीकस* में प्रोटीन आवष्यकता का आकलन 35% किया गया, इसी प्रकार के एक अध्ययन में *लिजा पारसिया* में प्रोटीन और लिपिड आवश्यकताओं क्रमषः 30% और 9% तक का आकलन किया गया। प्रभावकारी बाइंडर की खोज में मिश्रित ओलिगोसाकाराईड रेसिन युक्त एक नवीन पादप उप–उत्पाद की पहचान की गई जिसकी दक्ष बाइंडिंग क्षमता 0.5–0.75% समावेषन पर पाया है। *मुगिल सेफालस* के आहार में भावी पोशण तत्वों के स्रोत के रूप में 10 तक सीवीड/मेक्रो–अलगे *एन्टिरोमोरफा प्रोलिफेरा* के समावेषन तथा *पी. मॉनोडॉन* झींगों में 5 तक समवेषन को अनुकूलतम पाया गया।

ठोस अवस्था वाली चावल की भूसी की किण्वित उत्पाद, सूरजमुखी की खली, सरसों की खली और मूंग की छाल को *एम. सेफालस, एल. पारसिया, एल. टाडे, स्काटोफगस आरगस, मिस्टस गुलियो* तथा *पी. मॉनॉडॉन* की छोटी मछलियों के आहार में वृद्धि निश्पादन में बिना किसी समझौते के 50% तक सम्मिलित करने की सम्भावना देखी गई है। इसी प्रकार 1–1.5 % मन्नन ओलिगोसेक्काराइड का एशियन सीबास *एल.कैलकैरिफर* अंगुलिकाओं के विकास एवं उत्तरजीविता पर लाभदायक प्रभाव पाया गया है जिससे भावी जलीय कृषि में कार्यात्मक आहार हो सकता है।

डिम्ब एवं परिपक्वता हेतु आहार – पर्लस्पॉट जैसी कम अण्ड देने वाली मछली की परिपक्वता एवं डिम्ब संर्वधन हेतु विषेश आहार तैयार किया गया। प्रयोगों में देखा गया कि सूत्रीबद्ध आहार के साथ परिपादपों से मत्स्य लार्वा संवर्धन में लाभदायक प्रभाव पड़ता है। सीपी मोलस्क तथा क्रस्टाषियन व मछलियों की लार्वा अवस्था में आहार के रूप में सूक्ष्म षैवाल के विकास के लिए महत्वपूर्ण सूक्ष्म षैवाल प्रजातियों का मूल्यांकन किया गया।

जलीय जीव स्वास्थ्य

भारत में पाली जाने वाली झींगा प्रजातियों में फैलने वाली बीमारियों में वर्ष 2011 से आन्ध्र प्रदेष और तमिलनाडु के *वन्नामेई* फार्मों में रनिंग मोर्टालिटी सिन्ड्रोम रोग बड़े पैमाने पर व्याप्त है। मेटाजेनोमिक्स उपायों तथा पर्यावरण की भूमिका के मूल्यांकन के बावजूद इस सिण्ड्रोम के कारणों का पता लगना बाकी है। फार्म में पाले जाने वाली झींगों की अवरूद्ध वृद्धि एक और सिण्ड्रोम है जो भारत में झींगा पालन को प्रभावित कर रहा है। *पी. मॉनॉडॉन* और *एल. वन्नामेई* फार्मों में अवरूद्ध वृद्धि से प्रभावित 36% झींगों के नमूनों (एनत्र60) में आईएचएचएनवी पाया गया। अवरूद्ध वृद्धि से प्रभावित झींगों के नमूनों में से 42% नमूनों में *लेइमसिंह वायरस* पाया गया। तमिलनाडु और आन्ध्र प्रदेष के 6 जिलों में स्थित 75 झींगा फार्म तथा ओडिषा और पष्चिम बंगाल के 30 फार्मों में खारा जलजीव पालन में जलीय जीव रोगों की निगरानी से सूचित हुआ है कि तमिलनाडु और आन्ध्र प्रदेश में पाली जाने वाली *पी. वन्नामेई* झींगों में 15.3 % तक डब्ल्यूएसएसवी की व्याप्तता है तथा संक्रामक हाइपोडरमल एवं हेमाटोपोइएटिक निक्रोसिस वायरस की व्याप्तता 16.8% है। वन्नामेई फार्मों में विभिन्न प्रजातियों *(वी. मिमिकस, वी. कोलेरे, वी. एलगिनोलैटीकस, वी पाराहेमोलैटीकस, वी. रूमोइनसिस, वी. प्रोटियोलैटिकस, वी. कोराललिलैटिकस, वी. पासिनी, वी. केम्पबेल्ली, वी. चगासी* तथा *वी. रूमोइनसिस)* से होने वाली वाइब्रियोसिस रोग सर्व सामान्य है और ऐसा प्रतीत होता है यह रोग फार्म प्रबंधन पद्धतियों से संबंधित है। *एन्टिरोसाइटोजून हेपाटोपेनेई (ईएचपी)* एक मैक्रोस्पोरिडियन परजीवी है जिसे सर्वप्रथम वर्ष 2009 में थाइलैंड के ब्लाक टाइगर झींगा *पी. मॉनॉडॉन* में देखा गया। इस मैक्रोस्पोरिडियन परजीवी की व्याप्तता के लिए 30 झींगा फार्मों की जांच की गई और पीसीआर जांच से चार फार्म तथा हिस्टोपैथोलॉजी जांच से 10 फार्मों में यह परजीवी की उपस्थिति पाई गई। झींगा हैचरियों में जोइया कन्वर्षन तथा मृत्यु दर एक बड़ी समस्या है। जोइया सिण्ड्रोम से प्रभावित जीवों मे *वाइब्रियो एलगिनोलैटिकस, वी. मिमिकस* की प्रचुरता है। तथापि जोइया सिण्ड्रोम होने के वास्तविक कारणों को समझना अभी बाकी है। डब्ल्यूएसएसवी

आइसोलेट्स के जीनोटाइपिंग से सूचित हुआ है कि अधिकांश प्रकोपों का कारण 8 आरयू (रिपीट यूनिट) के साथ एक जीनोटाइप को माना जा सकता है। व्हाइट स्पॉट सिण्ड्रोम वायरस मुक्त भारतीय सफेद झींगों *पी. इंडीकस* के प्रजनकों को बीज उत्पादन हेतु विकसित करने के प्रयास को जारी रखा गया। डब्ल्यूएसएसवी सक्रमण के दौरान 20: झींगों को रोगनिरोधक के रूप में आरआर 2 या आरआर 2 के साथ वीपी28 दिए जाने पर सामान्य झीगों की तुलना में रोगनिरोधक दी गई झींगे लम्बे समय तक जीवित रहा।

जलीय पर्यावरण

वन्नामेई जलजीव पालन में उपज नष्ट होना तथा रोग समस्या, फसलों की बीच के अंतराल में कमी या न्यूनतम अन्तराल से संबंधित है। तालाब की तैयारी जब 30 से 45 दिनों तक बीएमपी से किए जाने पर उपज अच्छी होती है जब कि दो फसलों के बीच 3, 5 और 15 दिनों तक तालाब को सूखाने पर महत्पवूर्ण मापदंड जैसे मेटाबोलाइट्स तथा जल का गंदलापन तथा मृदा में जैविक कार्बन उच्च मात्रा में उपलब्ध होते हैं। तालाब की निचली सतह को अनुकूलतम बनाने के लिए आवश्यक खाने की अवधि को कम करने में आक्सीकरण कारक जैसे कैल्शियम आक्साइड और इसके बाद कैल्शियम तथा सोडियम क्लोराइड के साथ्स हाइड्रोजन पेराक्साइड तथा पोटैषियम परसल्फेट के साथ आलकली का उपयोग प्रभावी पाया गया। कंडालेरू क्रीक में *पी. वन्नामेई* की ग्रीस्मकालीन एवं शीतकालीन फसलों के दौरान किए गए पर्यावरणीय अनुमापन कार्यक्रम से स्पष्ट होता है कि क्रीक के जल मापदंड स्तर एवं झींगा फार्मों से जल निकासी जून–अगस्त तथा नवम्बर–जनवरी के दौरान अधिक होता है जो संयोग से झींगा उपज प्राप्ति की अवधि है। पूरक खनिजों पर प्रक्षेत्र में किए गए अध्ययन से स्पष्ट हुआ है कि लवणीयता दर 15 पीपीटी या उससे अधिक होने के बाद भी मत्स्य पालक आवश्यकता से अधिक खनिज पदार्थों का उपयोग कर रहें थे। वृद्धि एवं रोग निरोधक शक्ति के लिए सेलेनियम के महत्व को ध्यान में रखते हुए जैवउपलब्धता और आहार के माध्यम से इसे देने की सिफारिश की गई। *पी. वन्नामेई* पालन तालाबों से ग्रीन हाउस गैसों के रिसाव के दैनिक उतार चढ़ाव के अध्ययन से सूचित होता है कि प्रातः काल 04:00 बजे मिथेन और कार्बन डाइआक्साइड का उत्सर्जन अधिक होता है। इसके विपरीत रात की तुलना में दिन के समय में नाइट्रस आक्साइड का उत्सर्जन अधिक होता है। सीएच$_4$ और सीओ$_2$ उत्सर्जन का मृदा जैविक कार्बन और मैक्रोबियल बायोमास कार्बन से सकारात्मक सहसम्बद्ध है और अमोनिया, नाइट्रेट की उच्च मात्रा तथा कम घुलित आक्सीजन से संबंधित है जब कि मिथेन उत्सर्जन लवणीयता से विपरीत संबंध दर्शाता है। झींगा पालन तालाबों के तलछटों में मेथानोजेनिक आर्किया की विविधता एवं समृद्धि अधिक पायी गयी, उच्च लवणीयता वाले तालाबों में *मेथानोप्लानस, मेथानोकल्लेस, मेथानोजिनियम, मेथानोकोकस* spp समूह प्रचुर मात्रा में है जब कि कम लवणीयता वाले तालाबों में *मेथानोबैक्टिरियम, मेथानोसारसिना, मेथानोलोबस* एसपीपी की प्रचुरता है। झींगा पालन तालाबों की मृदा में कार्बन जमाव का आकलन किया गया और चार वर्षों की पालन अवधि में 8 फसलों के दौरान 2.4 टन प्रति हे. कार्बन का प्रच्छादन किया गया। तालाब की तैयारी के उपरान्त तालाब की मृदा में कुल कार्बन मात्रा में चार वर्षों की अवधि के दौरान काई विषेश अन्तर नहीं देखा गया। पॉट कल्चर प्रयोग में झींगा उपज निकाले गए तालाब की तलछटों तथा सामान्य मृदा से तैयार की गई खाद का मिर्ची फसल में खाद के रूप में उपयोग करने हेतु परीक्षण किया गया। सभी प्रकार के उपचारों में अंकुरण शत प्रतिशत रहा, वनस्पतिक विकास एवं फली उत्पत्ति सामान्य फसल में अच्छा रहा और इसके बाद का स्थान क्रमशः तालाबों के तलछटों एवं सामान्य मृदा से बनी खाद के उपयोग वाले फसलों का रहा। इससे तालाबों के तलछटों से कार्बन की क्षति के समाधान में भी सहायता मिलती है। कार्बन से समृद्ध *पी. वन्नामेई* झींगों के तालाब से उपज निकालने के बाद तलछटों से तैयार बायोचार को फास्फोरस चूषण क्षमता हेतु मूल्यांकित किया गया जिससे फास्फेट चूषण क्षमता 7.97 मि.ग्रा. प्रति ग्रा. बायोचार दर्ज किया गया और फास्फोरस चूषण गुणांक की समानता 0.13 पाई गई। बायोचार उच्च फास्फेट दर वाले अपरद जल के उपचार में उपयोगी है। समुद्री सतह का स्तर बढ़ने के कारण कृषि तथा जलीय कृषि का जलमग्न क्षेत्र अलपुज्जा जिले में 15,521 तथा 70 हे. आंका गया जब कि सूरत और नवसारी जिलों में इसे क्रमषः 296 एवं 153 हे. आंका गया। यद्यपि जलमग्न जलीय कृषि क्षेत्र बहुत कम है परन्तु जो कृषि क्षेत्र जलमग्न होने का अनुमान है वह क्षेत्र जल जीव पालन के लिए संभावित क्षेत्र बन सकता है।

आनुवांषिकी एवं जैवप्रौद्योगिकी

चेन्नई और पुरी से प्राप्त *पी. इंडीकस* झींगों के ट्रस मार्फोमेट्रिक मेजर्मेंट्स के आधार पर देखा गया कि इन सम्पदाओं में क्रमशः 63.1% नर झींगा तथा 69.8% मादा झींगे हैं। मादा झींगों की तुलना में नर झींगों में हेड–टू–टेल अनुपात अधिक पाया गया।

डब्ल्यूएसएसवी से संक्रमित *पी. मॉनॉडॉन* झींगों का ट्रांसक्रिप्टोम विष्लेशण तैयार किया गया ताकि डब्ल्यूएसएसवी संक्रमण के दौरान रोग निरोधक प्रतिक्रिया संबंधी व्यवस्था को उजागर किया जा सके। सामान्य झींगों एवं डब्ल्यूएसएसवी से संक्रमित झींगों से प्राप्त दोनों

ट्रांसक्रिप्टोम्स के कार्यात्मक श्रेणियों के तुलनात्मक विष्लेशण से ज्ञात हुआ है कि जैविक प्रक्रियाओं के अंतर्गत अभिव्यक्त यूनिजीन के लिए समान जीओ प्रोफाइल, आण्विक क्रियाएं तथा कार्यात्मक श्रेणियों के सेल्युलर काम्पोनेंट हैं।

जीनबैंक के टाइगर झींगे के ईएसटी डाटासेट का विश्लेषण किया गया ताकि वृद्धि से संबंधित कैंडिडेट जीन तथा रोग निरोधक प्रक्रिया वाले जीनों में एसएनपी की पहचान की जा सके। दो महत्वपूर्ण एसएनपी की पहचान की गई पहली कैथेपसिन बी जीन में जो प्रोटीन कार्य को विकृत कर सकता है और दूसरी बेटा–ट्यूबूलिन जीन में जो वृद्धि संबंधित जीनों में अपूर्ण प्रोटीन उत्पन्न कर सकता है। व्यवसायिक बीज उत्पादन हेतु प्रजनकों के चयन तथा वृद्धि गुणों के भावी विष्लेशण हेतु इन दोनों एसएनपी का उपयोग किया जा सकता है।

विस्तार एवं विकास

खाद्यान्न जैसे चावल का झींगों के मूल्य से तुलनात्मक विश्लेषण से सूचित होता है कि झींगों के मूल्य में अस्थिरता अधिक है। मूल्य परिवर्तन संबंधी आंकड़ों के विष्लेशण से स्पष्ट होता है कि झींगों के मूल्य परिवर्तन संकट की सहुलियत के लिए नियामक सहायता की आवश्यकता है। वर्ष 2014–15 के दौरान 50 काउंट वाले झींगों का घरेलू मूल्य 300–350 रूपए प्रति कि.ग्रा. रहा। झींगा उत्पादन करने वाले देशों के अंतर्राष्ट्रीय/घरेलू बाजारों में झींगों के मूल्य में उतार चढ़ाव तथा मांग व आपूर्ति पद्धतियों को प्रलेखित किया गया। वर्ष 1995 से 2014 तक के अंतर्राष्ट्रीय बाजारों से झींगों (30 काउंट) के आयात मूल्य संबंधी गौण आंकड़ों को एकत्रित किया गया ताकि स्थानीय फार्म गेट मूल्य का पूर्वानुमान लगाया जा सके। इन मॉडलों के उपयोग से जुलाई 2014 से जून 2015 तक की अवधि के लिए झींगों के मूल्यों का पूर्वानुमान किया गया।

कीचड़ वाले केकड़ों का पेन संरचनाओं में वृद्धि तथा प्रजनकों के आहार हेतु हैचरियों को आपूर्ति करने के लिए तमिलनाडु के कड्डलूर जिले के किल्लाई परिवारों द्वारा प्राकृतिक रूप से पॉलीकीट कृमियों के संग्रहण कार्य को भी प्रलेखित किया गया। हापा की सहायता से एशियन सीबास का नर्सरी संवर्धन तथा कीचड़ के केकड़ों के साथ सीबास का पालन में स्वयं सेवी समूहों में महिलाओं के योगदान का मूल्यांकन किया गया। सोसियो–इकोनोमिक्स एण्ड जेंडर एनालाईसिस के उपयोग से तमिलनाडु के तटीय क्षेत्र की महिलाओं की जीविका पर जलवायु एवं पर्यावरणीय बदलाव के प्रभाव का अध्ययन किया गया। तमिलनाडु के तटीय मछुआरों एवं जनजातियों का स्थानीय तकनीकी ज्ञान एवं मान्यताओं को प्रलेखित कर एक संकलन के रूप में प्रकाशित किया गया। मत्स्यकी विस्तार अधिकारियों तथा झींगा पालकों की सूचना आवश्यकताओं तथा सूचना मांग की पद्धतियों का अध्ययन किया गया और देखा गया कि झींगा पालकों के लिए सूचना का स्रोत अपने साथियों का समूह तथा तकनीकी स्रोतों से मोबाइल फोन पर वार्ता है जब कि मात्स्यकी विस्तार अधिकारी विभिन्न संस्थानों के प्रकाशनों पर निर्भर हैं। *पी. वन्नामेई* झींगा पालकों के मामलों पर अध्ययन से सूचित हुआ है कि पूर्व में सफल पालक समूहों की संगतता पी. वन्नामेई लाए जाने के बाद उन्नत बीजों की मांग तथा उत्पादन मात्रा में वृद्धि के कारण कमजोर हुई। गुजरात, तमिलनाडु, आन्ध्र प्रदेश तथा ओडिशा के प्रशिक्षणार्थियों का मानना है कि केन्द्रीय खारा जलजीव पालन संस्थान का *पी. वन्नामेई* झींगा पर प्रशिक्षण उनके ज्ञान वर्धन एवं कार्य कुशलता के लिए प्रभावकारी है। उनके अनुरोधों के अनुसार 29 सितम्बर, 2014 को कटक में तथा 10 अक्टूबर, 2014 को ओंगोल में ''प्रोडक्शन रिस्क्स इन *पी. वन्नामेई* फार्मिंग एण्ड बेटर मैनेजमेंट प्रैक्टीसेस'' विषय पर कार्यशालाओं का आयोजन किया गया। देश में *पी. वन्नामेई* झींगा फार्मों की तकनीकी दक्षता 0.9013 है अर्थात मत्स्य पालक डाले गए निवेशों से अधिकतम संभावित उत्पादन का 90% उत्पन्न करते हैं। यह पाया गया है कि नर्सरी पद्धति अन्य पालन पद्धतियों से बेहतर है। *पी. वन्नामेई* झींगा उत्पादन से संबंधित खतरों की पहचान की गई और उपयुक्त प्रबंधन पद्धतियों का सुझाव दिया गया। झींगा पालकों, प्रक्षेत्र विस्तार कार्यकर्ताओं तथा अन्य पणधारियों को प्रशिक्षण कार्यशालाओं के माध्यम से समस्याओं एवं इनके प्रबंधन उपायों से अवगत कराया गया। इसके अलावा प्रक्षेत्र विस्तार कार्यकर्ताओं के उपयोग के लिए *पी. वन्नामेई* झींगा पालन से संबंधित निरन्तर पूछे जाने वाले प्रश्न एवं इसके उत्तरों का एक बुकलेट तैयार कर वितरित किया गया।

विभिन्न प्रकार के मॉडलों जैसे मल्टी क्रैटेरिया डिसिजन मेकिंग मॉडल, फज्जी मॉडल, साफ्ट कम्प्यूटिंग मॉडल तथा रफ सेट मॉडल का तुलनात्मक विश्लेषण किया गया ताकि जलजीव पालन फार्मों का सर्वोत्कृश्ट स्थान का पता लगाया जा सके। रफ सेट मॉडल का कार्यान्वयन समय बहुत ही कम एवं जलजीव पालन की योजना तथा विकास के लिए विश्वसनीय पाया गया है। एमवाई एसक्यूएल डाटाबेस मैनेजमेंट सिस्टम के उपयोग से ''इंडीजिनस टेक्नीकल नालेड्ज सिस्टम इन एक्वाकल्चर'' तथा जलजीव पालन के परम्परागत ज्ञान के प्रलेखन हेतु पीएचपी लिपिकरण भाषा का डाटाबेस तैयार किया गया।

Executive summary

During 2014-15, CIBA generated knowledge on various aspects of brackishwater aquaculture and developed technologies encompassing breeding, seed production, nursery and grow-out production of brackishwater crustaceans, five commercially important brackishwater fishes and four ornamental species.

Nursery and Production System Research

Crustaceans - Periphyton and biofloc based farming technology for the rearing of *Penaeus vannamei* has been developed, and is under standardization and evaluation. After 42 days of nursery rearing of *P. vannamei*, significantly higher survival (98.68± 1.31 %) and growth (2.41± 0.08 g) were obtained in biofloc treatment to that of control (survival, 89.62± 1.33 %; growth, 1.92± 0.06 g). Similarly, in the grow-out production experiments carried out in cement tanks, a production level of 4 - 4.5 kg m^{-3} was achieved in biofloc treated group compared to 2.5- 3 kg m^{-3} in conventional autotrophic system. However, scaling up of the technology needs to be taken up in a phased manner. A three tire modular farming system for grow-out production of mud crab, comprising a three months nursery rearing, a four months of mid grow-out and three months of final grow-out system has been developed. This farming system enhances survival rate, production efficiency and faster economic returns to farmers providing profit within short period. Mud crab aquaculture was demonstrated in the estuarine mangrove ecosystem in Sorlagondhi village (Nagayalanka, Krishna District, Andhra Pradesh). It was demonstrated that trimming of propodus of cheliped during rearing period reduced cannibalism in mud crabs resulting in significantly higher survival rates as compared to the intact animals.

Finfishes- Nursery rearing of seabass in ponds using natural productivity was evaluated at Machilipatnam and hapa based nursery rearing trials were conducted. In one month duration 1 cm fry could be reared to fingerling sizes for marketing. Hapa based nursery rearing was also demonstrated at Thrissur Dist. Kerala, Thiruvallur district, Tamil Nadu, Onjal village, Navsari Gujrat. Grow-out of Asian seabass in ponds and cages was undertaken at Vedaranyam and Thrissur respectively. Farming demonstrations of cobia at Velankani and Vedaranyam, indicated that this species attains around 2 kg in 10 months. However, feeding with formulated feeds was found to yield lesser growth. In a 240 day grow-out trial of milkfish, provision of periphyton substrates to the extent of 20% of surface area resulted in 22% production increase.

Aquaculture development plan at the district level was carried out for Krishna district of Andhra Pradesh. It was demonstrated that a total of 4037 ha area is still available for further development adhering to environmental regulations. An assessment of the scenario indicated that disused aquaculture ponds of 11880 ha were present in 2014. The trend indicated that a maximum disuse of 13494 ha was present in the year 2009.

Comparative performance of production of banana shrimp, *P. merguiensis* with tiger shrimp, *P. monodon* was carried out at Danti (Navasari, Gujarat). Produciton of tiger shrimp was significantly higher than banana shrimp; however, the winter resilience of banana shrimp needs to be examined.

Reproductive biology, Breeding and Larval rearing

Crustaceans - Serotonin (5-hydroxytrptamine, 5-HT), a biogenic monoamine signaling molecule, was found to excellent in accelerating maturation and spawning in *Penaeus monodon* under captive conditions. Vertebrate-type sex steroid (17β-estradiol and 17α-hydroxyprogesterone) profile in the hemolymph during the various phases of gametogenic cycle in female *P. monodon* equivocally demonstrated the pivotal role of vertebrate type sex steroid hormone in the reproductive control of these animals.

Finfishes - In Asian seabass, a total of 24 breeding trials were conducted and 8.5 lakh seed produced from VNN free broodstocks were supplied to farmers from various states. Studies on reducing cannibalism during larval rearing through dietary supplementations of tryptophan and estradiol were undertaken and the effects on different light spectrum were evaluated. Significant progress was achieved in captive maturation of milkfish with the broodstock (4.6-7.2 kg) maintained in 100 t RCC tanks by monthly hormone LHRH a pellet implantations. Grey mullet *Mugil cephalus* was induced to ovulate and release eggs by hormonal and salinity manipulations. Captive female grey mullet (ova-diameter 527– 532 µm) after intramuscular implantation with LHRHa pellet released

9.3 lakh eggs. Seed production of Pearlspot *Etroplus suratensis* (karimeen) was further refined. Over 3000 numbers of Karimeen seeds were supplied to farmers of Andhra and Tamil Nadu. In the trials to improve the breeding frequency, a single pair could be made to spawn six times in a span of four months with at an interval of 17 days, with 1000-1500 fingerlings per spawning. About 2- 5 g fingerlings were also sold as ornamental fish at ₹ 20 per piece. A methodology was developed to overcome the constraints of parental care. Breeding and seed production of ornamental fishes *viz.* scat, mono angels, crescent perch and orange chromide were attempted.

Nutrition and Feed Management

Based on the growth performance and the activity profiles of digestive enzymes, protein requirement for *P. indicus* was optimized as 35%, in similar such study protein and lipid requirements for *Liza parsia* were optimized as 30% and 9% respectively. In search of effective feed binder, a plant by-product containing mixed polysaccharide resins was identified as efficient and cost effective binding agent at 0.5-0.75% inclusions. As a sustainable source of nutrient in formulated feeds, inclusion of seaweed, *Enteromorpha prolifera* at dietary level of 10% and 5% were found optimum for *Mugil cephalus* and *P. monodon* respectively. Use of solid state fermented products of rice bran, sunflower cake, mustard oil cake and mung husk in feeds of juveniles *M. cephalus*, *L. parsia, L. tade, Scatophagus argus, Mystus gulio* and *P. monodon* juveniles showed the possibility of dietary inclusion upto 50% without compromising the growth performance. As a functional feed component, mannan oligosaccharide (MOS) at 1-1.5% showed beneficial effects on the growth and survival of Asian seabass, *L. calcarifer* fingerlings.

A maturation feed developed for low fecund pearlspot fish under captive conditions demonstrated that highest fry yield (>2000 fry/spawning) and repeated spawning (average 4 spawning/ annum) could be achieved with green water system and formulated feed. Larval feed and feed management strategies tested in pearlspot larvae showed that, they could be reared successfully with maximum growth rate in periphyton based rearing system in combination with formulated feed. Comparison of nutrient profiles of wild and farmed *L. parsia* showed a significant difference in fat content (0.67 vs 8.73%) and fatty acid profile.

Aquatic Animal Health

Among the diseases affecting farmed shrimp in India, running mortality syndrome (RMS) has been widely prevalent in the vannamei farms in Andhra Pradesh (AP) and Tamil Nadu (TN) since 2011. However, the causative agent of this syndrome yet needs to be understood, despite efforts using metagenomics tools and evaluating environmental role. Stunted growth of farmed shrimp is another important syndrome affecting farmed shrimp in India. Infectious hypodermal and hematopoietic necrosis virus (IHHNV) was found to be associated with 36% of the stunted growth affected *P. monodon* and *P. vannamei* farms (n=60) samples. It is interesting to note that 42 % of the stunted *P. vannamei* samples were also positive for Laem Singh virus (LSNV). Surveillance of aquatic animal diseases in brackishwater aquaculture in 75 shrimp farms in six districts of Tamil Nadu (TN) and Andhra Pradesh (AP), and 39 farms in Odisha and West Bengal (WB) indicated that prevalence of WSSV in AP and TN was 15.3% and IHHNV in 16.8% of the farmed *P. vannamei*. Vibriosis caused by various species (*V. mimicus, V. cholerae, V. alginolyticus, V. litoralis, V. parahaemolyticus, V. rumoiensis, V. proteolyticus, V. coralliilyticus, V.pacinii,V. campbellii, V. chagasii* and *V. rumoiensis*) were common in vannamei farms and their occurrence appeared to be related to farm management practices. *Enterocytozoon hepatopenaei* (EHP) is a microsporidian parasite first described in black tiger shrimp *P. monodon* from Thailand in 2009. Samples from 30 shrimp farms were screened for the emerging microsporidian parasite and it was found that four farms were positive by PCR, while 10 farms were found to be positive by histopathology. In shrimp hatcheries, zoea conversion and mortalities were a major concern. *Vibrio alginolyticus, V. mimicus* were predominant in the Zoea II syndrome infected animals. However, the actual causative agent of zoea syndrome is yet to be understood. Genotyping of WSSV isolates indicated that majority of the outbreaks could be attributed to one genotype with 8 RU (repeat unit). Efforts to develop white spot syndrome virus free brooders of Indian white shrimp *P. indicus* for seed production were continued as an effort to develop indigenous broodstocks. Among the shrimp administered with siRNA targetting rr2 or combination of rr2 and VP28 as prophylactic, only 20% were found to survive marginally longer period than the control group upon challenge with WSSV.

Aquatic Environment

Crop failure and increased disease problems in vannamei aquaculture in Andhra Pradesh were related to reduced or minimal intercrop period. Pond preparation carried out with BMPs for 30-45 days had good production and successful crop, while critical parameters such as metabolites and turbidity in water and organic carbon in soil were significantly high in 3, 5 and 15 days of intercrop period. Oxidizing agents such as calcium oxide followed by calcium and sodium carbonate along with hydrogen peroxide and potassium persulphate

with alkali were effective in shortening the drying time required to achieve the optimum pond bottom condition. Environmental monitoring programme of *P. vannamei* farming during summer and winter crops on Kandaleru creek revealed that water quality characteristics such as total suspended solids (TSS) and total ammonia nitrogen (TAN) of the creek and shrimp farms discharge water were high during June-August and November-January coinciding with the timing of shrimp harvest. A field study on mineral supplementation indicated that at salinity levels of 15 ppt and above, farmers were applying higher quantity of minerals than required. Considering the fact that selenuim supplementation is important for growth and immunity, the bioavailability of their supplementation is recommended through feed. Investigations on the diurnal fluctuation of greenhouse gases emission from *P. vannamei* culture ponds indicated that methane and carbon dioxide emissions were high at 04:00 am in the morning. On the contrary, high values of nitrous oxide were recorded during the day as compared to night. CH_4 and CO_2 emissions positively correlated with soil organic carbon and microbial biomass carbon and associated with high values of ammonia, nitrite and low dissolved oxygen, whereas methane emission showed an inverse relationship with salinity. Diversity and richness of methanogenic archaea in shrimp culture pond sediment was found to be higher with *Methanoplanus, Methanoculles, Methanogenium, Methanococcus* spp. being the abundant group in high saline culture ponds, whereas *Methanobacterium, Methanosarcina, Methanolobus* spp. were abundant in low saline culture ponds.

Total carbon accumulation in shrimp culture pond soil was assessed and about 2.4 tons of carbon ha^{-1} was sequestered over eight crops spanning four years. Total carbon content of pond soil after pond preparation showed no significant difference over a four year period. In a pot culture experiment, compost prepared from harvested shrimp pond sediment and normal soil was tested for its potential as manure for chilli crop. Germination was 100% in all the treatments, vegetative growth and pod formation was good in control followed by compost prepared using pond sediment and normal soil. This also helps in mitigating the loss of carbon from pond sediment. Biochar prepared from carbon rich harvested pond sediment of *P. vannamei* shrimp ponds was evaluated for its phosphorous sorption capacity, found to be 7.97 mg phosphate sorption per gram of biochar and the affinity co-efficient for phosphorus sorption was 0.13. Biochar is useful to treat the wastewaters that are high in phosphate. The predicted inundation of agriculture and aquaculture area due to sea level rise in Alappuzha district is 15,521 and 70 ha whereas it is 296 and 153 ha in Surat and Navsari districts respectively. Though the submerged area under aquaculture is less, the agriculture area predicted to become submerged can become a potential area for brackishwater aquaculture.

Genetics and Biotechnology

The discriminant function derived based on truss morphometric measurements of Chennai and Puri stocks of *P. indicus* could correctly assign 63.1 % of male shrimp and 69.8 % of female shrimp to their respective stocks. The head-to-tail ratio of these stocks showed higher values in males compared to female shrimp.

Transcriptome analysis of WSSV challenged *P. monodon* was carried out to unravel the mechanisms of immune response during WSSV infection. Comparative analysis of the functional categories of both the transcriptomes obtained from control and WSSV infected shrimp revealed similar GO profile for the unigenes expressed under biological processes, molecular functions and to cellular component functional categories.

The EST datasets of tiger shrimp at Genbank were analysed to identify SNPs in growth-related candidate genes and immune response genes. Two important SNPs were detected, one in *cathepsin B* gene which might impair protein function and another in *beta-tubulin* gene that might produce incomplete protein among the growth related genes. These 2 SNP loci could be considered for future association analyses for growth traits as well as for broodstock selection for commercial seed production.

Social Science and Development

A comparative analysis of price movements with food grains such as rice versus shrimp indicated that the volatility was too high in shrimp prices. The price change data analysis has strongly showed the importance of regulatory support to ease the price risks against volatile price movements in shrimp prices. Domestic prices of shrimps remained on an average Rs.300 - 350/kg for 50 counts in reference markets during 2014-15. Global price movements and demand-supply patterns across importers and competing producer nations in international/ domestic markets were also documented. The secondary data on shrimp (30 counts) import prices collected from the international markets for the period 1995 - 2014 were used to generate local farm gate prices for forecasting. Using the models, the price of shrimp was forecast for the period from July 2014 to June 2015. However due to multiple parameters on market dynamics it is difficult to forecast shrimp prices.

Mud crab fattening in pens and natural collection of polycheate (*Nereis* sp) worms for supplying to

hatchery as broodstock feed by the *Irula* tribal families at Killai in Cuddalore district of Tamil Nadu was documented. The involvement of women SHGs in Asian seabass nursery rearing using hapas and polyculture of mud crabs along with seabass were assessed. The impact of climatic and environmental changes on the livelihoods of coastal women in Tamil Nadu was examined using socio-economics and gender analysis (SEAGA). Indigenous technical knowledge (ITK) and beliefs of coastal fishers and tribes in Tamil Nadu were documented and brought out as compilation.

The information needs and seeking behaviour of fishery extension officers and shrimp farmers was investigated and found that the dominant information source for farmers was their peer group and mobile phone interactions with technical persons, whereas, the fishery extension officers depend more on publications of various institutions. Case studies on *P. vannamei* shrimp farmer groups indicated that group cohesiveness of previously successful farmer groups had been weakened after the introduction of *P. vannamei* due to the demand for quality seed and enhanced volume of production. Trainees from Gujarat, Tamil Nadu, Andhra Pradesh and Odisha felt that CIBA's trainings on shrimp *P. vannamei* farming were effective in enhancing their knowledge and skill capacity. Based on their requests reinforcement training workshops on "Production risks in *P. vannamei* farming and Better Management Practices" was conducted on 29th September, 2014 at Cuttack, Odisha and 10th October, 2014 at Ongole, Andhra Pradesh.

The technical efficiency of *P. vannamei* farms in the country was 0.9013, which means that the farmer could produce 90% of the maximum possible output from the given inputs. It was found that nursery stocked systems had better performance than other farming systems.

The production oriented risk factors in *P. vannamei* farming were identified, assessed and suitable better management practices were suggested. The risk factors and their management measures were communicated to the farmers, field extension workers and other stakeholders through series of training workshops. Besides, a booklet on Frequently Asked Questions (FAQs) pertaining to *P. vannamei* shrimp farming along with answers, for the benefit of field level extension workers and farmers, was brought out and distributed.

Comparative analysis of different models such as multi criteria decision making model, fuzzy model, soft computing model and rough set model was done to find out optimal location of aquaculture farms. The execution time of rough set optimal location model was found to be very low and reliable for aquaculture planning and development. A database on "Indigenous Technical Knowledge System in Aquaculture" was developed using MySQL database management system and PHP scripting language for documenting the traditional knowledge in aquaculture.

Introduction

Brackishwater aquaculture, synonymously known as "coastal aquaculture", is a rapidly expanding agribusiness sector and plays an important role in the overall fisheries development and seafood production in India. With the estimated 1.2 million ha brackishwater area spread over the coastal states *viz.* West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Pondicherry, Kerala, Karnataka, Goa, Maharashtra and Gujarat, India retains different farming systems ranging from traditional Pokkkali culture to super intensive biofloc based recirculating systems. However, only around 10% of the potential area has been used for farming activities and hence scope for further expansion is vivid.

Being the seventh-largest economy in the world, India is the second largest producer of farmed fin and shell fishes. During the year 2013-14 the seafood export has recorded an all-time high in quantity, rupee value and export earnings. Frozen shrimp continued to be the major value item accounting for a share of 64% of the total dollar earnings (about Rs. 30,000 crores), with a contribution about 73.3% by farmed shrimp mainly from brackishwater aquaculture. This significant rise from just 53% in previous year to 64% was possible by production of *Penaeus vannamei* shrimp across major brackishwater shrimp farming states like Andhra Pradesh and Tamil Nadu.

Opportunities are vibrant for further expansion of brackishwater aquaculture. Due to dwindling availability of adequate freshwater, much of the expansion in aquaculture is expected to occur in brackishwater and marine environments. Brackishwater environments are highly biodiverse and more productive systems and are easily accessible to manoeuvre than open marine waters. As an added advantage, high tolerance of brackishwater flora and fauna for extremes of the water quality parameters make them more appropriate for farming under controlled conditions.

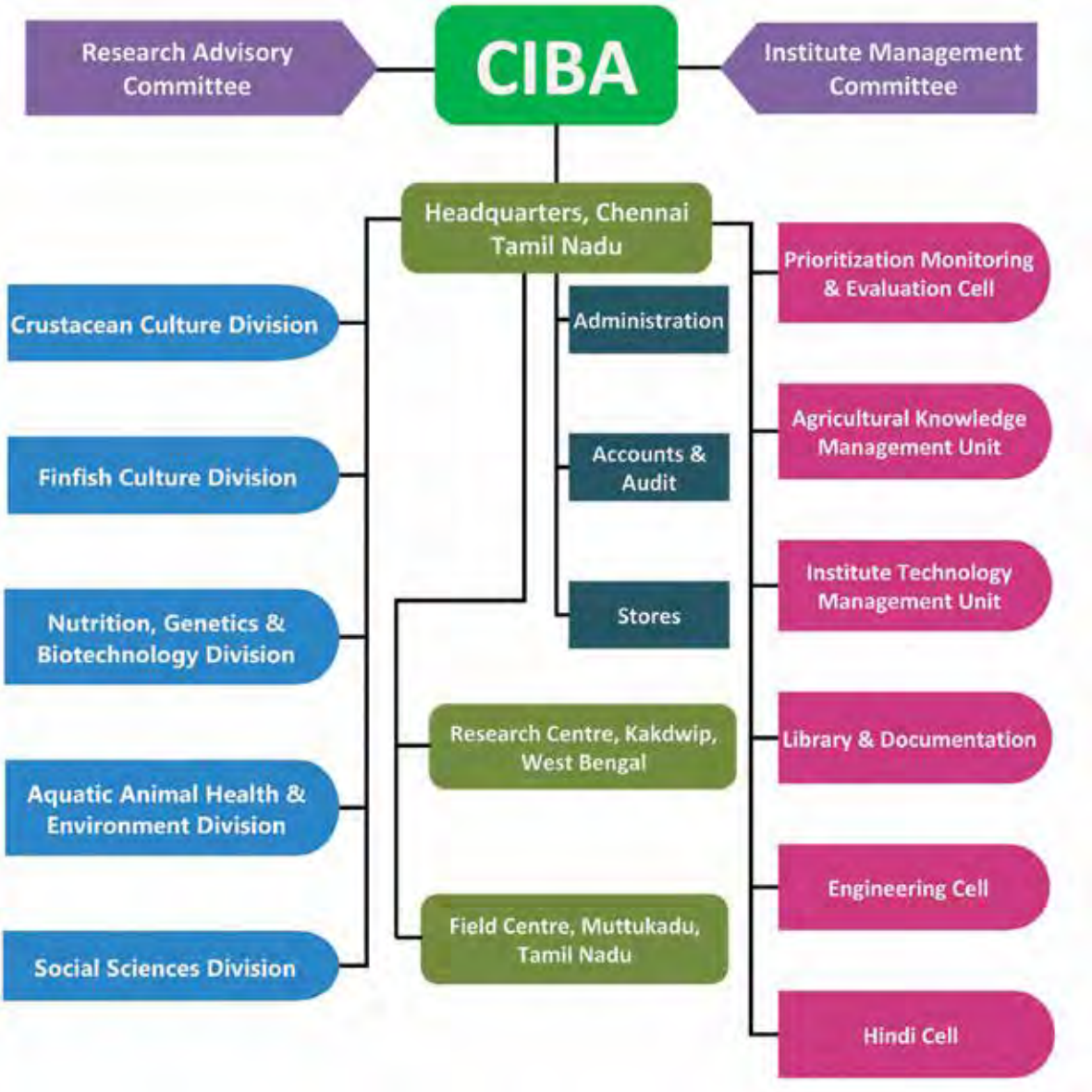
Central Institute of Brackishwater Aquaculture (ICAR-CIBA) established in April 1987 served as a nodal agency for the development of brackishwater aquaculture in this country. Serving the sector for more than 25 years, CIBA stands out as a premier national institute in brackishwater aquaculture research and is engaged in issues related to environment, seed and feed production, farm and hatchery construction, disease diagnosis, monitoring and advocating remedies etc. Attempts to develop innovative system based approaches integrating latest technological interventions for smart and sustainable production systems using less water, feed, energy and less manpower are part of CIBA's ongoing research programme. Besides production oriented research, CIBA also undertake research to preserve the valuable natural resources like land, water and energy, to have more sustainable, eco-friendly and socio-economically viable brackishwater aquaculture in this country.

CIBA being headquartered in Chennai, has a field station at Muttukadu, about 30 km south of Chennai and a Research Centre at Kakdwip in West Bengal. The research activities of the Institute are diverse in nature, starting from basic to applied and adoptive researches which were carried out under 14 in-house and 24 externally funded projects during 2014-15.

Mandate of CIBA

- To develop economically viable and environmentally sustainable culture technologies for finfish and shelfish in brackishwater systems in different agro-ecological regions.
- To meet emerging requirements of brackishwater aquaculture, carry out basic, strategic and applied research.
- To provide policy and planning support for socio-economic development.
- To undertake human resources development and transfer of technology programmes.
- Linkages with stakeholders in government and private sector within the country and overseas, partnership and R&D to achieve the sustainable growth of brackishwater aquaculture.

ORGANISATION CHART



Financial Statement 2014-15			(₹ in Lakhs)
Sub-Head	**BE**	**RE**	**Actual Expenditure**
PLAN			
Travelling Expenses	35.00	35.00	34.95
HRD		10.19	10.18
Contingency	515.00	383.00	382.92
Works	180.00	70.00	70.00
Equipments	200.00	95.00	95.00
Information Technology	15.00	15.00	15.00
Vehicles & Vessels	15.00	0.00	0.00
Miscellaneous expenses	35.00	6.81	6.79
Library	30.00	3.00	3.00
Furniture & Fixtures	5.00	3.00	3.00
TSP	20.00	14.00	13.99
Total	1050.00	635.00	634.83
NON-PLAN			
Equipments	0.00	2.00	1.91
Vehicles & Vessels	0.00	21.00	20.76
Furniture & Fixtures	0.00	3.00	2.97
Establishment	1050.00	1242.00	1241.95
O.T.A	0.20	0.20	0.09
Travelling Allowance	8.00	9.00	8.99
Research & Operational	20.00	22.00	21.85
Administrative Expenses	140.45	256.10	255.96
Miscellaneous	3.00	4.70	4.61
Sub Total	1221.65	1560.00	1559.09
Pension	700.00	876.15	875.77
Loans & Advances	7.00	7.00	7.00
Total	1928.65	2443.15	2441.86

Revenue Generation	(₹ in Lakhs)
Year	**Revenue Receipts**
2014-15	79.37

Official Language Implementation Programme

Official Language Implementation Committee meetings were held on 17.6.2014, 17.9.2014, 8.1.2015 and 27.3.2015 during the year 2014-15. Usage of Hindi in official correspondences, bilingual use of Hindi and English in files, publications in Hindi were reviewed in these four meetings. Hindi Pakhwada (Fortnight) was celebrated at the Headquarters during 16 - 30 September, 2014. Competitions in Hindi Noting and Drafting, Hindi Kavita path (Poem Recital), Hindi Prasnothari were held on 19.9.2014, 22.9.2014 and 25.9.2014. Hindi Day (Diwas) was held on 30.9.2014. Prizes were distributed to the winners of the Hindi Noting and Drafting, Hindi Kavita Path, Hindi Prasnothari competitions by the Director. A guest lecture on "Official Language Implementation" was delivered by a Hindi expert during the event. The Hindi Day celebrations were co-ordinated by Dr. Prem Kumar, Scientist & Member-Secretary, OLIC. Cash Awards have been handed over to three prize winners of CIBA Special Cash Incentive Scheme for the year 2013-14. Hindi week celebrations were held at KRC of CIBA, Kakdwip also.

STAFF POSITION

The details of sanctioned, filled and vacant positions as on 31.03.2015 are as follows.

Category	Sanctioned	Filled	Vacant
Director (RMP)	1	1	-
Head of Division	4	3	1
Principal Scientist	1	0	1
Senior Scientist	10	7	3
Scientist	52	42	10
Technical Assistant	31	24	7
A.O	1	0	1
F.A.O	1	1	-
DD(OL)	1	0	1
A.A.O	3	3	-
J.A.O	1	1	-
Private Secretary	1	1	-
P.A	2	2	-
Stenographer Gr.III	1	2	(-)1 (excess)
Assistant	7	5	2
UDC	3	3	-
LDC	5	5	-
Skilled Support Staff	55	29	26
Total	180	129	53

On-going research projects

Crustacean Culture Division

Project Title 1	Technology upgradation and refinement for sustainable development of diversified systems and species of penaeid shrimp
Project Leader	**Dr. C. Gopal**
Project Location	**Chennai**

Sub-Project Title	**Sub-Project Leader**
Standardization of diversified shrimp reproductive performances, seed production and farming technology (*F. penicilattus, F. kuchensis, F. merguiensis* etc.)	Dr.C.Gopal
White shrimp taxonomical identification at different stages	Dr.C.P.Balasubramanian, Dr. P. Ravichandran, Ms. Christina, L.
Culture technology standardization (including BMP and biosecurity) for *P. vannamei*	Dr. A. Panigrahi, Dr. K. Ambasankar, Dr. J. Syamadayal, Dr. M. Kumaran, Dr. D.D. Vimala
Technology development for Artemia biomass production and processing for quality brood stock nutrition	Dr. C. Gopal, Ms. Pragyan Dash
Interventions for increasing the efficacy of shrimp farm waste water treatment system	Dr. M. Muralidhar, Dr. R. Saraswathy
Development and evaluation of harvesting and water filtration mechanisms for shrimp farms	Dr. M. Jayanthi
Engineering interventions for RAS with seaweeds integration, Green house based production system	Dr. P. Nila Rekha
Grow out trial of *P. vannamei* at KRC	Dr. Shyne Anand
Improved traditional farming system development and evaluation in West Bengal and Kerala	Dr. Shyne Anand
Estimation of salinity intrusion in subsurface water bodies in coastal watershed	Dr. P. Nila Rekha
Microbial monitoring at onstation grown *Litopenaeus vannamei* culture ponds	Dr. Sanjoy Das

Project Title 2	Scaling up of production system of mud crabs
Project Leader	Dr. C.P. Balasubramanian
Project Location	Chennai
Team	Dr.M. Jayanthi, Dr. A. Panigrahi, Smt. P.S. Shyne Anand, Dr. K.P. Jithendran, Dr.S. Kannappan, Dr. P. Ezhil Praveen

Project Title 3	Aquaculture planning, impact assessment and disease spread zoning using remote sensing and GIS
Project Leader	Dr.M.Jayanthi
Project Location	Chennai
Team	Dr.P. Ravichandran (upto 30.09.2014), Dr. C.P. Balasubramanian, Dr. M. Muralidhar, Dr. M. Kumaran

Project Title 4	Improvement of growth and reproductive traits in penaeid shrimp (*Feneropenaeus indicus*) through breeding, nutritional and environmental interventions
Project Leader	Dr. A. Panigrahi
Project Location	Chennai

Sub-Project Title	**Sub-Project Leader**
Evaluation of growth and reproductive traits in Indian white shrimp *Fenneropenaeus indicus*	Dr. G. Gopikrishna
Optimization of induced maturation, endocrine and nutritional control of female maturation, immune status of broodstock shrimp and its modulation in shrimp to produce better offspring	Dr. C.P. Balasubramanian
Diversified farming (Organic Periphyton & biofloc, RAS based farming) system development and evaluation and certification issues	Dr. A. Panigrahi

Project Title 5	Demonstration of improved culture technologies in shellfish and finfish aquaculture in Gujarat
Project Leader	Dr.C. Gopal
Project Location	Navsari Agricultural University, Navsari, Gujarat

Sub-Project Title	**Sub-Project Leader**
Species diversification in shellfish aquaculture	Dr. C. Gopal
Monitoring of environmental parameters in culture ponds and source wáter	Dr. M. Muralidhar
Demonstration of milkfish culture technologies	Dr. M. Kailasam
Studies on pond microbial dynamics in relation to probiotic application	Dr. P.K. Patil
Strengthening information infrastructure for aquaculture development through ICT	Dr. P.Mahalakshmi
Demonstration of asian seabass culture potential in farmer's ponds	Dr. Prem kumar
Demonstration of cage farming and establishment of knowledge centres in tribal areas (TSP)	Dr. C. Gopal

Project Title 6	Hydro geo chemical impacts of shrimp farming on coastal watershed
Project Location	Chennai
Funding Agency	Ministry of Water Resources
Principal Investigator	Dr.P.Nila Rekha
Co-Investigators	Dr. P. Ravichandran (upto 30.09.2014)

Project Title 7	Up-scaling of production technology and large scale field demonstration of indigenously developed immunostimulant CIBASTIM for penaeid shrimps
Project Location	Chennai
Funding Agency	National Fisheries Development Board
Principal Investigator	Dr C. Gopal
Co-Investigators	Dr. T. Ravisankar and Dr. P.K. Patil

Project Title 8	Molecular mechanism and steroidal control of reproductive maturation in commercially important shrimp *Penaeus monodon*
Project Location	Chennai
Funding Agency	Department of Biotechnology
Principal Investigator	Dr C.P. Balasubramanian
Co-Investigators	Dr. P. Ravichandran (upto 30.09.2014), Dr. J. Syama Dayal and Dr. Sherly Tomy

Project Title 9	Standardization of aerator usage in shrimp farming through improving the efficiency and operational pattern of the aeration systems use, automation and use of alternate energy source
Project Location	Chennai
Funding Agency	National Fisheries Development Board
Principal Investigator	Dr. M. Jayanthi
Co-Investigators	Dr. P. Ravichandran (upto 30.09.2014), Dr. M. Muralidhar, Dr. A. Panigrahi

Project Title 10	Technology refinement of nutrient dense nursery rearing of grow-out of *P. vannamei* in periphyton and biofloc based systems
Project Location	Chennai
Funding Agency	National Fisheries Development Board
Principal Investigator	Dr. A. Panigrahi
Co-Investigators	Dr. P. Ravichandran (upto 30.09.2014), Dr.C. Gopal, Dr J. Syama Dayal, Dr R.Saraswathy, Dr Shyne Anand

Project Title 11	Upgradation of breeding and culture technology of Indian white shrimp *Fenneropenaeus indicus* through stock evaluation and culture demonstration
Project Location	Chennai
Funding Agency	National Fisheries Development Board
Principal Investigator	Dr. A. Panigrahi
Co-Investigators	Dr. G. Gopikrishna, Dr.C.Gopal, Dr. S. Kannappan, Dr. Kumaraguru Vasagam, Dr. P. Mahalakshmi and Dr. K.Vinaya Kumar

Project Title 12	Development of integrated multitrophic aquaculture systems in Sindhudurg District, Maharashtra
Funding Agency	Ministry of Environment and Forest, GOI
Principal Investigator	Dr C.P. Balasubramanian
Co-Investigators	Dr. K.K. Vijayan, Dr. A. Panigrahi, Dr.K.P. Kumaraguru Vasagam, Dr. Krishna Sukumaran, Dr. P. Kumararaja

Finfish Culture Division

Project Title 13	Dissemination of technology on the seed production of Asian Seabass (*Lates calcarifer*) and development and refinement of seed production technology for other commercially important brackishwater fishes
Project Leader	Dr. M. Kailasam
Project Location	Chennai & Kakdwip

Sub-Project Title	**Sub-Project Leader**
Technology development for controlled breeding of pearl spot and genetic selection studies	Dr M. Natarajan
Technology development for controlled breeding of grey mullet *Mugil cephalus* and golden spot mullet *Liza parsia*	Dr M. Natarajan
Transfer of Seabass seed production technology	Dr. M. Kailasam, Shri Aritra Bera
Technology development for controlled breeding of Cobia *Rachycentron canadum*	Dr. M. Kailasam
Breeding of pearlspot in small net cages and RAS	Dr. Krishna Sukumaran, Ms. Babita
Monitoring water quality parameters in broodstock holding tanks and larval rearing systems	Dr. P. Kumararaja
Refinement of captive breeding technology for important Brackishwater ornamental fishes	Dr. Satyanarayana Sethi
Nursery rearing and growout culture of Asian seabass, grey mullet, milkfish, cobia and pearl spot at KRC	Dr. T.K. Ghoshal
Providing feed for broodstock and juvenile stages of Brackishwater fishes	Dr.K. Ambasankar
Health management of captive broodstock and juvenile stages of Brackishwater finfishes (seabass, cobia, mullets, milkfish, pearlspot and ornamental fishes)	Dr. Satyanarayana Sethi
Reproductive physiology of Brackishwater finfishes (*M. cephalus, Liza parsia* and *L. calcarifer*)	Dr. Premkumar
Establishing a captive broodstock of sand whiting *Sillago* sp.	Dr. Premkumar

Project Title 14	Improvement and validation of brackishwater fish culture technologies
Project Leader	Dr.M.Natarajan
Project Location	Chennai & Kakdwip

Sub-Project Title	Sub-Project Leader
Cage culture of asian seabass in open Brackishwater system	Dr. M. Kailasam
Nursery rearing and growout culture of seabass, cobia, milkfish, mullets and other Brackishwater fishes	Dr. M. Natarajan, Mr. Aritra Bera, Ms. Babita
Pond and cage culture of pearlspot	Dr. M. Natarajan
Secondary aquaculture in culture ponds	Dr. Krishna Sukumaran, Dr. Satyanarayana Sethi

Aquatic Animal Health and Environment Division

Project Title 15	Aquatic animal diseases and intervention tools for their management
Project Leader	Dr. S.V. Alavandi (since 12th September 2014), Dr. K. P. Jithendran (up to 11th September 2014)
Project Location	Chennai and Kakdwip

Sub-Project Title	Sub-Project Leader
Investigation of putative etiology of mass mortalities of farmed shrimp during early days of culture (DOC) using metagenomics	Dr. S.V. Alavandi
Microbial diversity of shrimp gut	Dr. S.V. Alavandi
Characterizing the role of WSSV during mixed pathogenic infection of shrimps	Dr. S.K. Otta
Investigations of IHHNV infection in shrimp and its pathogensis	Dr. P. Ezhil Praveena
Studies on the role of transglutaminase enzyme on growth and differentiation of shrimphaematopoietic (Hpt) stem cells	Dr. P.K. Patil
Relative contribution of different *Vibrio* species responsible for shrimp mortality along with WSSV infection	Dr. T. Bhuvaneswari
Investigations on effect of variability of environmental parameters on disease susceptibility	Dr. M. Poornima
Monitoring diseases of finfish in hatcheries and growout culture	Dr. M. Poornima
Study of occurrence of diseases at Brackishwater aquaculture system of West Bengal and Odisha	Dr. Sanjoy Das
Search for betanodavirus genotypes and their natural reassortants in finfish in grow-out culture and development of transmission model using zebra fish	Dr. K.P. Jithendran
Laboratory proficiency testing (LPT) programme for shrimp and fish viruses in collaboration with NACA/ANQAP (Australia)	Dr. K.P. Jithendran
Up-scaling production of bacteriophage and in-vivo experiments	Dr. Satheesha Avunje
Virulence and pathogenicity of *Vibrio harveyi* (challenge study on shrimp larval stages and analyses of mortality pattern and histopathology)	Ms. Vidya Rajendran
Investigation of Zoea II syndrome in shrimp hatcheries and running mortalities and stunted growth in shrimp farms: screening out samples positive for known pathogens	Mr. T. Sathish Kumar

Project Title 16	Develop environmental parameters monitoring tools and pond treatment technologies for brackishwater aquaculture
Project Leader	Dr. M. Muralidhar
Project Location	Chennai

Sub-Project Title	**Sub-Project Leader**
Development of water analysis kits and to conduct environmental monitoring programme of *P. vannamei* shrimp farming	Dr. M. Muralidhar
Development of nano sensors as early warning system for the detection of metabolites	Dr. R. Saraswathy
To study the bioremediation potential of the microorganisms as an initiative for product development	Dr. N. Lalitha
To develop and evaluate the treatments for pond bottom and water quality improvement	Dr. P. Kumararaja
Environmental investigations in *P. vannamei* culture ponds with respect to pond management practices and pond profile studies in shrimp and finfish culture ponds	Dr. M. Muralidhar

Project Title 17	Defense genes of tiger shrimp *(Penaeus monodon)* with respect to bacteria *(Vibrio harveyi)* and white spot syndrome virus (WSSV) infection
Project Location	Chennai
Funding Agency	National Fund for Basic, Strategic and Frontier Application Research in Agriculture (NFBSFARA), ICAR
Principal Investigator	Dr. Subhendu Kumar Otta
Co-Investigators	Dr. K.P. Jithendran and Dr. T. Bhuvaneswari

Project Title 18	Identification of etiology of monodon slow growth syndrome (MSGS) of black tiger shrimp in India and development of rapid growth tools
Project Location	Chennai
Funding Agency	Department of Biotechnology
Principal Investigator	Dr. M. Poornima
Co- Investigator	Dr.S.V.Alavandi and Dr. P. Mahalakshmi

Project Title 19	Development of white spot syndrome virus free shrimp brooders for seed production: using indigeneous shrimp, *Penaeus indicus* as a model
Project Location	Chennai
Funding Agency	Department of Biotechnology
Collaborating Centre	C. Abdul Hakeem College, Vellore
Principal Investigator	Dr. Subhendu Kumar Otta
Co-Investigators	Dr. A. Panigrahi, Dr. P. Ezhil Praveena

Project Title 20	National surveillance programme for aquatic animal diseases
Project Location	Chennai
Funding Agency	NFDB
Principal Investigator	Dr. Ezhil Praveena
Co-Investigators	Dr. K.P. Jithendran, Dr.T. Bhuvaneswari

Project Title 21	National Initiatives on Climate Resilient Agriculture (NICRA) – Impact of climate change on aquaculture and mitigation options for minimizing green house gases from aquaculture sector
Project Location	Chennai
Funding Agency	ICAR
Lead Centre	Central Research Institute for Dryland Agriculture
Principal Investigator	Dr.M.Muralidhar
Co-Investigators	Dr. M. Jayanthi, Dr. J. Syama Dayal, Dr. A. Panigrahi, Dr. M. Kumaran, Dr. R. Saraswathy, Shri J. Ashok Kumar, Dr. N. Lalitha, Dr. K. Vinay Kumar, Shri P. Kumararaja and Dr. A. Nagavel

Nutrition, Genetics and Biotechnology Division

Project Title 22	Newer feed resources and feed additives for development and improvement of shrimp and fish feeds
Project Leader	Dr.K. Ambasankar
Project Location	Chennai and Kakdwip

Sub-Project Title	**Sub-Project Leader**
Evaluate the residual effect of feed additive and to develop health promoting nutraceutical	Dr.K.Ambasankar
Develop formulated feed for pearlspot broodstock	Dr. K.P. Kumaraguru Vasagam
Develop cost effective feeds for *P. indicus*	Dr.J. Syama Dayal
Optimize the nutrients for *L. parsia*	Dr.T.K. Ghoshal
Explore newer sources of ingredients and to develop techniques for inclusion of value cost material	Dr. Debasis De
Nutritional characterization of micro algae	Mr. K.P. Sandeep

Project Title 23	Outreach activity on fish feed
Project Leader	Dr. K. Ambasankar
Project Location	**Chennai & Kakdwip**

Sub-Project Title	**Sub-Project Leader**
Demonstrate the CIBA developed feed technologies and popularize the farm made feed production	Dr. K. Ambasankar
Develop larval and nursery feeds for pearl spot	Dr. K.P. Kumaraguru Vasagam
Standardize feeding management strategies for growout culture of fish and shrimp	Dr. T.K. Ghoshal

Improve farm-made feed formulations and to use SSF to improve the nutritive value of ingredients of farm made feed	Dr. Debasis De
Maximum replacement of fish oil and fish meal through understanding the molecular mechanism underlaying the limitation	Dr. J. Syama Dayal
Design and fabricate low cost energy efficient automatic feeder for shrimp farm	Dr. P. Nila Rekha

Project Title 24	Outreach activity on nutrient profiling and evaluation of fish as a dietary component
Lead Centre	CIFRI, Barrackpore
Project Leader	**Dr.J.Syama Dayal**
Project Location	**Chennai**
Sub-Project Title	**Sub-Project Leader**
Nutrient profiling	Dr. J. Syama Dayal
Popularization	Dr. J. Syama Dayal

Project Title 25	Evaluation of genes and markers using biotechnological tools for improvement of economic traits in fish and shellfish
Project Leader	Dr. G. Gopikrishna
Project Location	Chennai
Sub-Project Title	**Sub-Project Leader**
Genetic characterization of tiger shrimp using microsatellites and species discrimination using SNPs	Dr.G.Gopikrishna, Dr. K. Vinaya Kumar
Analysis of transcriptome data in tiger shrimp	Dr. M.S. Shekhar
Evaluation of the effect of marine algae extracts during shrimp larviculture	Dr. S. Kannappan
Identification and characterization of molecular markers for economic traits and markers for sex discrimination	Dr. Sherly Tomy, Dr. K.P. Kumaraguru Vasagam
Testing SNPs in immune related genes for association to WSSV tolerance in tiger shrimp	Dr. B. Sivamani

Project Title 26	Outreach activity on fish genetic stocks
Lead Centre	NBFGR, Lucknow
Project Leader	Dr. G. Gopikrishna
Co-PI	Dr. K. Vinaya Kumar
Project Location	Chennai

Project Title 27	Molecular studies on sequential pathogenesis of WSSV and defense mechanism in *P. monodon*
Project Location	Chennai
Funding Agency	Department of Biotechnology
Principal Investigator	Dr. M.S.Shekhar
Co-Investigator	Dr. S.K. Otta

Project Title 28	Molecular mechanisms of gonad inhibiting hormone action on the control of egg maturation in the penaeid shrimp
Project Location	Chennai
Funding Agency	Department of Biotechnology
Principal Investigator	Dr. Sherly Tomy
Co-Investigator	Dr. S.K. Otta, Dr. C.P. Balasubramanian and Prof. T. Subramoniam

Project Title 29	Assessment of productivity and variation in nutritional characteristics of biofloc a sustainable feed for farmed aquatic animals
Project Location	Chennai
Funding Agency	Department of Science and Technology
Principal Investigator	Dr. K.P. Kumaraguru Vasagam
Co-Investigator	Dr. K. Ambasankar, Dr. J. Syama Dayal

Social Sciences Division

Project Title 30	Extension economics and informatics in brackishwater aquaculture
Project Leader	Dr. V.S. Chandrasekaran
Project Location	Chennai

Sub-Project Title	**Sub-Project Leader**
Assessment of present farming practices of fish pearl spot *Etroplus suratensis*	Dr. V.S. Chandrasekaran
Price analysis for major brackishwater species in domestic markets	Dr.T.Ravisankar
Gender assessment in aquaculture and allied aquaculture sectors and development of aqua tourism in coastal village	Dr.B.Shanthi
Assessment on tribal participation in aquaculture sectors in Tamil Nadu	Dr.B.Shanthi
Transfer of technology through ICT and capacity building	Dr.D.Deboral Vimala
Pragmatic approaches for aquaculture extension service	Dr.M.Kumaran
Application of information and communication technology for aquaculture development and its planning	Dr. P.Mahalakshmi
Computational approaches in brackishwater aquaculture research	Mr. J. Ashok Kumar
Organisation and conduct of extension and outreach activities of the Institute	Dr. V.S. Chandrasekaran

Project Title 31	Assessment on the impact of environmental changes on the livelihoods of coastal women in Tamil Nadu
Project Location	Chennai
Funding Agency	Indian Council of Social Science Research
Principal Investigator	Dr. B. Shanthi
Co-Investigators	Dr. P. Mahalakshmi, Dr. V.S. Chandrasekaran and Dr. T. Ravisankar

Project Title 32	Appraisal of evolving *Litopenaeus vannamei* culture systems and associated production risk for development of better management practices
Project Location	Chennai
Funding Agency	National Fisheries Development Board
Principal Investigator	Dr. M. Kumaran
	Dr.T.Ravisankar, Dr. D.Deboral Vimala and Mr. J. Ashok Kumar

Kakdwip Research Centre

Project Title 33	Sustainable integrated brackishwater aquaculture production of shrimp and fishes with focus on livelihood options for Sundarban farmers
Project Leader	Dr. T.K. Ghoshal
Project Location	Kakdwip

Sub-Project Title	Sub-Project Leader
To improve livelihood options of tribal farmers of Sundarban through brackishwater aquaculture and of natural productivity in bheries & polyfarming of finfish & shellfish	Dr. T.K. Ghoshal
To integrate autotrophic and heterotrophic system for sustainable shrimp and fish culture	Dr. P.S. Shyne Anand
Refinement of polyculture feed and demonstration trial in farmer's field	Dr. Debasis De
Standardization of culture technology for new brackishwater fish and shrimp species	Dr. Ashutosh D. Deo
Study the disease resistance pattern of shrimp cultured in biofloc system	Dr. Sanjoy Das

Project Title 34	Strategies for sustainable management of degraded coastal land and water for enhancing livelihood security of farming communities
Project Location	Kakdwip
Funding Agency	National Agricultural Innovation Project
Principal Investigator	Dr.T.K.Ghoshal
Co-Investigators	Dr.Debasis De, Dr. P.S. Shyne Anand, Dr.M.Kumaran and Dr.A. Panigrhai

Project Title 35	Productive, profitable and resilient agriculture and aquaculture systems
Project Location	Kakdwip
Funding Agency	WorldFish Center
Principal Investigator	Dr. T.K. Ghoshal
Co-Investigators	Dr. Ashutosh D. Deo

Project Title 36	Stock characterization, captive breeding, seed production and culture of hilsa (*Tenualosa ilisha*)
Project Location	Kakdwip
Funding Agency	National Fund for Basic, Strategic and Frontier Application Research in Agriculture (NFBSFARA), ICAR
Principal Investigator	Dr. Debasis De
Co-Investigators	Dr. P.S. Shyne Anand

Others

Project Title 37	Business Planning and Development (BPD) Unit at CIBA, Chennai
Project Location	Chennai
Funding Agency	National Agricultural Innovation Project
Principal Investigator	Dr. T. Ravisankar
Co-Investigators	Dr. P. Ravichandran upto 30.9.2014

Research Highlights

Brackishwater production system research

Milkfish harvest from farmers pond at Andhra Pradesh

Brackishwater production system research

CIBA has developed many technologies for breeding, seed production, nursery and grow- out production of brackishwater crustaceans and finfishes. Many of them are successfully adopted by aqua-farmers and other technologies are at the various stages of popularization. Continuous refinement of these technologies for making them more cost-effective has always been the objective of the institute. Further, the institute also focuses to develop new technologies for new cultivable species. In 2013-14, the grow-out production system program continued to refine and optimize different farming systems including monoculture and polyculture of brackishwater candidate species such as *Penaeus monodon*, *P. vannamei*, *Lates calcarifer*, *Scylla serrata, Etroplus suratensis, Rachycentron canadum, Chanos chanos, etc.*

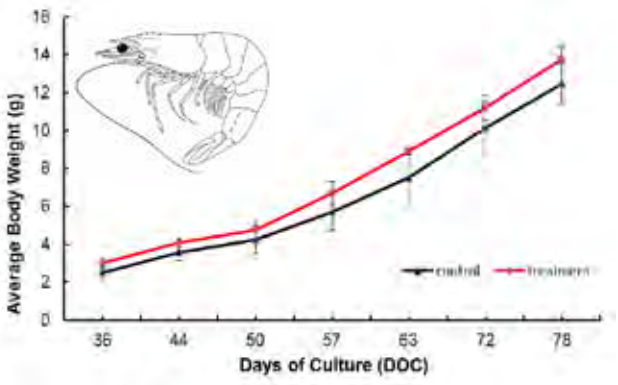
Biofloc and periphyton based farming technology for nursery and grow-out of *P. vannamei* has been developed. Average productivity after 90 days of rearing period was 2.25 mt.

Shrimp

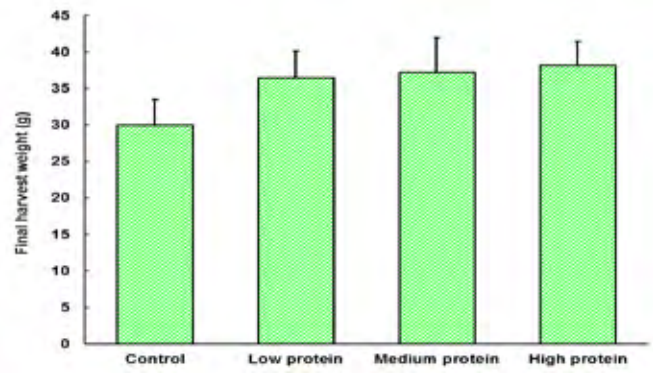
Periphyton and biofloc Based Farming Technology for *Penaeus vannamei*

It has long been demonstrated, mostly from freshwater ponds, that aquaculture production from ponds supplied with periphyton substrate is higher than that from substrate free ponds. In order to evaluate the production performance of *P. vannamei* in periphyton based pond system, a 90-day rearing experiment was carried out in Kakdwip Research Centre of CIBA. The experiment was conducted in triplicate in six grow out earthen ponds (0.54 to 0.56 h). At the end of 78 DOC, shrimps in treatment ponds recorded better growth performance in terms of average body weight (ABW) 13.9 g compared to 12.5 g in control ponds with an estimated FCR of 1.2. Average productivity after 90 days of rearing period was 2.25 mt (1.9-2.6 mt)

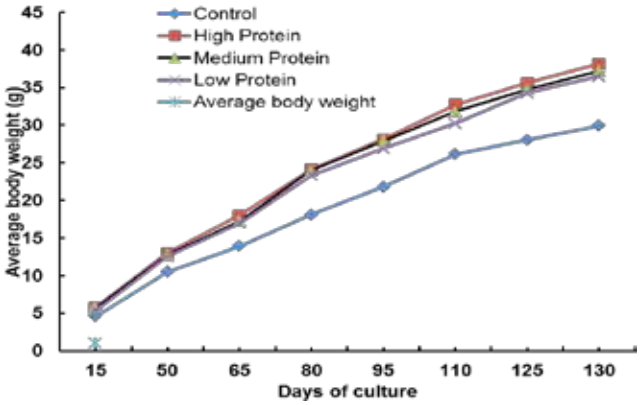
Further, moderately high density nursery rearing technology for *Penaeus vannamei* has been developed. Experiments were carried out to evaluate the production performance of substrate-based (periphyton), substrate-independent (bio-floc) and combination of both treatments. After 42 days of nursery rearing significantly higher survival (98.68 ± 1.31 %) and growth (2.41± 0.08g) was obtained in bio-floc treatment to that of control (survival: 89.62 ± 1.33 %; growth: 1.92 ±0.06g). Further, the results were compared with conventional auto trophic systems. The combination of both biofloc and periphyton systems was rated as the best in terms of survival and production. In another



Penaeus vannamei growh rate in peryphyton treated and control pond



Final harvesth weight of *Penaeus vannamei* fed with different levels of protein



Growth of *Penaeus vannamei* fed at various levels of protein

experiment, bio-floc based high density nursery rearing experiments were carried out with formulated feeds at different levels of protein (40%, 32% and 24%). No significant difference in the survival and growth was found among the treatments using feeds at different levels of protein. The average body weight (ABW) was higher in the Bio-floc treated groups (BFT (40%): 38.15 ± 3.36; BFT (32%):37.18 ± 4.84& BFT (24%): 36.48 ± 3.71) when compared to control group (29.91 ± 3.58).A production level of 4-4.5 kg/ m^3 (40 to 45 mt/ha) was achieved through this BFT system compared to 2.5 - 3 kg/ m^3 in conventional autotrophic system. The average productivity showed a significant improvement in biofloc treatment groups (32.6 to 52.6 % in) when compared with that of the control non-biofloc treatment group (22 - 27.6 % improvement in the average body weight; 8.7 - 19.6 % improvement in the survival rate and 10 - 31 % improvement in the FCR).

Organic aquaculture

Although organic aquaculture has been practiced in Asia since the past several decades, it is a new concept in modern aquaculture. The seafood farmed in the organic aquaculture systems, which is based on minimal use of off-farm inputs, promotes harmony between species and ecosystem, and at the same time fetches a premium price in the market. Twenty four farmers were selected for the demonstration, and successful culture trials have been carried out. The total production ranged from 200 to 500 kg per hectare with a FCR ranging from 1.1 to 1.9. Shrimp produced using CIBA organic feed was marked as organic shrimp. This demonstration has revealed the potential of organic shrimp culture that evinced keen interest in many aqua-farmers.

Harvest of Organic shrimp

An organic shrimp farm in Kerala

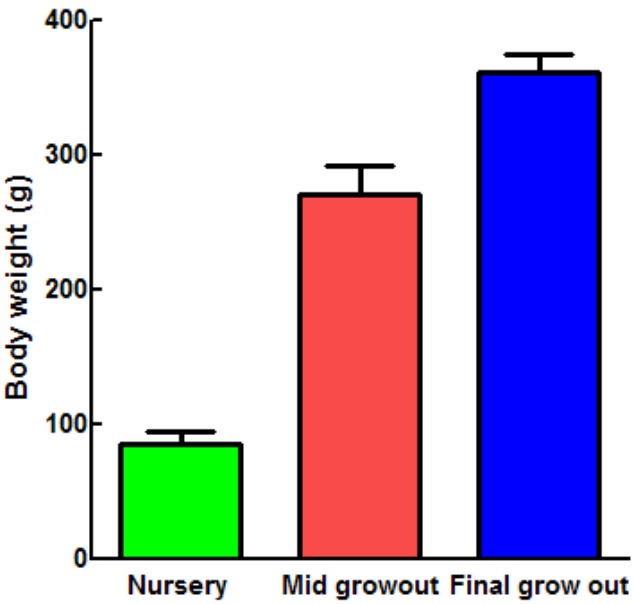
Mud crabs

Three tire modular farming system for mud crab (*Scylla serrata*) aquaculture

A three tire modular farming system comprising a three months nursery rearing and a four months of mid grow-out and three months of final grow-out system have been developed. Nursery rearing was carried out in MES, mid grow-out was carried in KRC experimental ponds and final grow-out was carried out in the farmers ponds. The farming characteristics of each module are given in figure. This form of modular production system seems to enhance the survival rate and production efficiency, and farmers would be able to get a profit within three to four months.

Mud crab aquaculture as rural livelihood diversification

Mud crab aquaculture was demonstrated in the estuarine mangrove ecosystem in Sorlagondhi village (Nagayalanka, Krishna District Andhra Pradesh). The beneficiaries of the demonstration program were the tribal population of the area, and they depend on the neighbouring mangrove ecosystem for fishing, mainly mud crab hunting. *In situ* training and demonstration classes were imparted and all the inputs for culture were provided by CIBA. Both fattening and grow out culture were carried out. For fattening, mud crabs at the post molt stage (soft shelled crabs) were stocked



Final body weight in the different production systems.

Restoration of old genus *Penaeus*

Since its inception in 1798, for almost 200 years, twenty seven species of shrimps were grouped in the genus *Penaeus*, until Perez Farfante and *Kensley* (1997) split this genus into six valid species (*Litopenaeus*, *Fenneropenaeus*, *Farfantepenaeus*, *Marsupenaeus*, *Penaeus* and *Melicertus*). Although the excellence of this work and effort made by these world renowned peaneid taxonomists were appreciated, there has been serious criticism against the unilateral decision of reassigning the genus from academia (Dall, 2007; Flegel, 2007, 2008) and from Private R and D (Fegan, 2015). It is generally acknowledged that in ideal taxonomy both morphological and molecular data should be in agreement. The evidences, both morphological and molecular, to split genus *Penaeus* (sensu lato: in broad sense) were found to be weak, and argument of Perez Farfante and Kensley to consider genus *Penaeus* as polyphyletic does not stand. The recent exhaustive study carried out by Ma *et al* (2011) equivocally showed that the reassignment of *Penaeus* genus into six genera is not valid. They argued based on mitochondrial and nuclear genome study that the old *Penaeus* genus is deemed to be most appropriate as morphological and molecular data are in agreement under the scheme. At this context, in this document and future publications from CIBA the old single-genus classification will be followed.

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in the pens or cages, the crabs became marketable within 20-30 days. For grow-out culture medium sized crabs of sub optimal size for export (below 150 g) were stocked and a culture for 7 months was carried out. The animals were fed with fish bycatch and crop was harvested from the 2nd month onwards. The demonstration trial was conducted in four tribal demonstration ponds (2400 m^2) with 70 crabs in each pond. The average initial stocking size was 120g. After 7 months of culture the tribal farmers harvested more than 100 kg with 62% survival with an economic benefit of Rs. 2500/- per family per month.

Trimming of propodus of chelipeds reduces cannibalism and increases survival

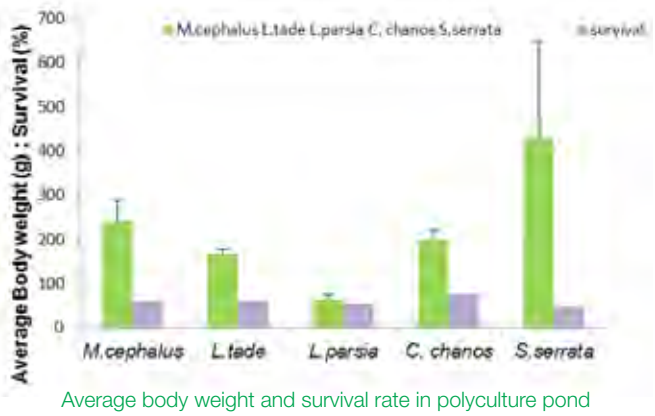
Cannibalism is one of the major bottlenecks that affect the successful culture of mud crabs. Further, it has been noticed that loss of entire chelipeds adversely affects the feeding behaviour, growth rate and marketability of the crab. To evaluate the effect of trimming of propodus of cheliped on cannibalism, experiments were carried out with or without trimmed propodus of cheliped. After 60 days of experiment it is revealed that trimming in the middle of cheliped's propodus, significantly increased ($P<0.05$) survival of crabs (88.88±19.25% vs 72.22±34.69%). However no significant difference in weight gain or growth rate was noticed among the treatment groups. The finding suggests that trimming of middle portion of propodus of cheliped reduces cannibalism among the crabs without affecting its growth rates.

Mud crab farming was demonstrated to tribal population of Nagayalanka. After 7 months of culture the tribal farmers harvested about 100 kg of crab with 62% survival. The economic benefits of Rs.2500/family/ month was obtained.

Polyculture of mud crab with milkfish and mullet

In order to evaluate the ideal species combination and economic feasibility for polyculture of mud crab in Sundarban (West Bengal) a polyculture experimental trial with milkfish and mullets *(L. parisa, L. tade* and *M. cephalus*) were carried out in KRC. The experiment was conducted with milkfish and mud crabs in first treatment and mullets and mud crabs in second treatment in triplicate in earthen ponds (100^2). Mud crabs, *S. serrata* juveniles (30-70g) obtained from Muttukadu Experimental Station were stocked at 1.5 number/m^2 in all six earthen ponds. Finfishes like *M. cephalus* (3g), *L. tade* (40g) and *L. parsia* (3 g) and *Chanos chanos* (40g) were also stocked at 1.5 number/m^2 in these ponds. The finfishes were fed with commercial floating pellet (crude protein 30%) at 2-3% body weight and mud crabs were fed with trash fish meal, molluscan meal and farm made feed at 5-8 %

Ovigerous crab from polyculture pond in KRC



Average body weight and survival rate in polyculture pond

body weight. Final analysis of all the six month grow out polyculture rearing, indicated the average survival of crab as 48 % with an ABW 430g and productivity of 1857 kg/ha. The mullets (grey mullet-242 g; *L. tade*-169g and *L. parsia*-64 g) recorded a total productivity of 1471.5 kg/ha (Grey mullet-765.91 kg/ha; *L. tade*-530.4 kg/ha and *L. parsia* -175.23 kg/ha, with 60 % survival, and milkfish recorded an ABW of 200.5 g with 77% survival and 2099.2 kg/ha. The average farm gate price for mullets species was Rs. 200/- kg and milkfish was Rs.120/- kg in West Bengal market. About 12-13% increase in revenue from sale was noticed in polyculture of mullets with mudcrabs compared to milkfish-mudcrab culture in West Bengal.

Banana and tiger shrimps

In order to evaluate the comparative production performance of banana shrimp, *P. merguiensis*, with tiger shrimp, *P. monodon*, a grow-out production trial was carried out at Danti (Navasari, Gujrat). Post larvae of both species were stocked at 20 no/m^2 in replicate, and the animals were fed with formulated feed. Although growth rate of both species were similar up to 75 days of culture period, significantly faster growth rate was observed for tiger shrimp (0.18 g/d) compared to banana shrimp (0.09 g/d). The growth slowing down in banana shrimp could be due to lowering of salinity because of heavy rainfall after 90 days of culture but favoured the growth of tiger shrimp. The production of tiger shrimp was higher (4947 kg/ha) as compared to banana shrimp (2053 kg/ha).

Co-culture of seaweed *Gracilaria verucosa* and *Penaeus vannamei*

In order to study the feasibility of the co-culture of *Gracilaria verucosa* with *P. vannamei*, an experimental trial was carried out at three different densities of seaweed (100g, 200g, 300g) in 1000 l tank. The stocking density of *P. vannamei* was uniform (30 no/m^2). It was found that, the average daily growth rate (DGR) in the treatment with biomass intensity of 100g was more with 1.28% when compared to intensities with 200g and 300g and DGR was found to be 0.75% and 0.55% respectively. All the treatment showed more weight gain and survival rate in comparison

Nursery rearing of seabass at Navsari, Gujarat

with the control. The best survival and weight gain of shrimp was found in treatment with 100g of seaweed *G. verrucosa* with 90% and 70.75% respectively.

Asian Seabass

Seabass farming in low saline aquaculture ponds

A nursery rearing experiments was carried out to evaluate the potential of seabass aquaculture in low saline (maximum salinity 8 ppt) coastal ponds at Vedaranyam (Nagapatinam, Tamil Nadu). A total of 15000 nos of seabass seed (TL 10 mm) were stocked in 0.3 ha pond and allowed to feed on naturally available zooplankton. After 45 days of rearing, a total 11,000 seabass (TL: 50-70 mm) were harvested from the pond. The farmer sold 8000 fingerlings to other farmers @ Rs.20/ per piece and obtained a revenue of Rs. 1,60,000/-. The farmer has stocked 3000 nos of fingerlings in another pond (area, 0.3 ha) for pre-grow-out culture and the fish were fed with live trash fishes such as *Tilapia*. After two months of culture, a total of 1200 no of 80-100 g size seabass could be obtained from the pond and these further stocked in 0.8 ha pond for grow out culture. In grow out culture pond, fishes were fed with live tilapia obtained locally. After 8-10 months, a total production of 700 kg, size range 1.2- 3.8 kg (avg. wt. 1.5 kg) was obtained and a productivity of 2.1 t ha^{-1} was recorded. At a farm gate price of Rs.325/kg the farmer generated a revenue of Rs.2,27,500. The production cost worked out was Rs.1,22,500/- and a profit of Rs.1,05,000 was obtained from the 0.3 ha culture pond.

Nursery rearing of seabass seed was demonstrated in low-saline ponds. Farmers were able to obtain revenue of Rs.1,60,000 after 45 days of nursery rearing.

Nursery rearing of seabass with farmers participation- a step towards development of seabass satellite rearing centres

Nursery rearing of seabass is an excellent livelihood option for farmers to generate profits within shorter durations of 45-60 days. Further, it is a step towards strengthening CIBA's initiate of developing satellite rearing centres of seabass at different locations of the country to bridge the distance between the hatchery and the farmers pond. In this respect, nursery rearing of Asian seabass fry was demonstrated at Garladibba village, Machilipattinam, Andhra Pradesh, Thrissur, Kerala, Thirvallur, Tamil Nadu and Onjal, Navsari district, Gujarat.

At Garladibba village, Machilipattinam, Andhra Pradesh, a total of 58,000 seabass seed in the size range from 8 to 12 mm supplied to farmer were stocked directly in the pond (area- 3 acres, salinity- 26 ppt) and fed with naturally available zooplankton collected from adjoining creek. The zooplankton species mainly consisted of *Acetes*

Asian seabass culture with farmer's participation at Vedaranyam, Tamil Nadu

Stocking of Asian seabass seed in hapas at Thiruvallur, Tamil Nadu

sp, crustacean larvae, small fish like *Ambasis* sp. After 30 days seabass seed, tl, 250- 750 mm were obtained. In the second batch a total of 47,000 nos of seabass seed (10 mm) were stocked in a pond (area, 6.0 acre, depth 1.5 - 2.0 m). After 15 days rearing the seed attained a size range of 20 - 60 mm.

In order to bridge the distance between the hatchery and farmers pond, satellite nursery rearing centres of seabass were initiated at different locations of the country.

At Thrissur dist., Kerala seabass nursery rearing demonstrations were conducted in 2x1x1 m hapas fixed within the pond system. Seabass fry (tl, 20 mm) were stocked in hapas @ 500 nos/ hapa. The seabass fry were fed on formulated feed mixed with fish meat initially and later,

Asian seabass farm at Thrissur, Kerala

Grading of Asian seabass larvae

the fry were completely weaned to the artificial feed. Grading was performed twice a week for size wise segregation and reducing cannibalism. Smaller fry were retained in hapas for further rearing. Seabass fry, 600 nos of shooters (approx. avg. wt. 5 g) were separated and stocked in the cages.

Seabass nursery rearing with farmers participation at Thrissur, Kerala

At Thiruvallur district, Tamil Nadu seabass nursery rearing was conducted in hapas fixed in low saline ponds. A total of 6500 nos of seabass seed (TL, 15 - 25 mm) were stocked @ 250-500 nos/hapa depending upon the seed size. Feeding was done with farm made nursery feed @ 5-8% initially, the feeding rate was later reduced to 5% body weight.

Asian seabass fingerling

Distribution of Asian seabass seeds to farmers at Navsari, Gujarat

Regular grading was performed twice a week. After 21 days rearing, a total of 5400 no seabass fry (size range 24 - 60 mm) were obtained.

In the nursery rearing experiment at Onjal, Navsari, Gujarat, nursery rearing trials were carried out in hapa nets (2x1x1 m; 20 no) erected in the farmer's pond. Seabass fry were stocked at the rate of 500 no/m^3 and the fishes were fed (CP 40 - 45%) with farm made feed (5-10% of body weight). After 55-60 days of rearing, the fry attained a size ranging from 50 to 100 mm with 30% survival rate. The main observation was that at 13 - 30 DOC higher salinity 42 - 47 ppt prevailed and caused the higher mortality (800-900 fry) whereas, during 40 - 59 DOC, salinity between 20 - 28 ppt, the survival (95 - 98%) was highest comprising of medium and big size fry (above

Seabass nursery rearing demonstration at Onjal village, Navsari, Gujarat

2.5 cm). Seabass fingerlings were harvested at the end of nursery rearing and sold to interested aqua farmers @ Rs.10-20/piece depending on the size of the fingerlings. An amount of Rs. 50,000 was realized out of seabass fingerlings sales form this trial. During the harvest, an interaction meet was organised on 7th August 2014 among aqua farmers at Onjal village, Navsari. The meeting was attended by 70 aqua farmers of Onjal, Aat, Samapore, Danti, Chizgam villages from Navsari district, and Bhagal, Mender villages of Valsad district.

Cobia

Nursery rearing and growout culture of cobia *Rachycentron canadum*

Nursery rearing of cobia, *Rachycentron canadum,* was conducted in earthen ponds (250 m^2) at MES (CIBA). A total of 350 nos of cobia seed (TL, 110 mm) were stocked and fed on trash fishes @ 3% body weight daily. After 120 DOC, the fishes attained a body weight of 180 - 380 g.

Further, with an objective of developing a pond based culture package for adoption by brackishwater farmers, a pond based growout culture of cobia was undertaken in farmers pond at Velankkanni and at Vedaranyam, Tamil Nadu. In the pond trial conducted at Velankani, cobia fingerlings (TL: 100 mm) were stocked in net cages. Feeding was done with pellet feed @ 3-5 % body weight per day. The fingerlings were reared for the initial 120 DOC within cages fixed in ponds and a body weight of 200-250g was attained. The fish were then released directly in to the grow-out pond and feeding was done @ 5% body weight daily. After 10 months of culture, cobia attained a final weight of 2000 - 2500 g. In the pond trial conducted at Vedaranyam cobia seed, 400 nos were stocked directly in the pond (salinity 16 to 29 ppt). The fish were fed on trash fish. After 10 months of culture the fish attained a body weight of 1800-2200 g.

Grow-out trial of cobia using trash fish and formulated feed

Cobia (*R. canadum*) grow-out trial was conducted in two 1500 m^2 ponds. Cobia fingerlings (113.7±4.5 mm, 12.04±0.56 g) were stocked @ 0.1 fish m^{-2}. Fishes were fed with formulated feed in one pond @ 6-15% of body wt. and trash fish in other pond @ 8-25% of biomass. After 300 days, fish fed formulated feed and trash fish attained a size of 886.7±47.4 g and 1830.0±122.6 g respectively. Signs of low-salinity stress and mortalities were seen during September to October at salinities around 5 ppt. The results indicate that cobia fed with trash fish showed better growth and condition than formulated feed and salinities above 10 ppt are more suitable for cobia culture.

Pond based cobia farming with farmers participation at Velankkanni and Vedaranyam, Tamil Nadu

Cobia performance parameters in formulated pellet and trash fish feeding systems in 300 days rearing

Parameters	Formulated pellet feed	Trash fish
Initial total length (mm)	113.7±4.50	113.7±4.50
Final total length (mm)	468.3±39.2^{b}	616.0±54.1^{a}
Initial fish weight (g)	12.04±0.56	12.04±0.56
Final fish weight (g)	886.7±47.4^{b}	1830±122.6^{a}
Daily weight gain (g day^{-1})	2.91±0.30^{b}	6.06±0.38^{a}
Specific growth rate (% day^{-1})	0.80±0.11^{b}	1.90±0.16^{a}
Condition factor (*K*)	0.64±0.02^{b}	0.91±0.03^{a}
Isometric exponent of LWR (*b*)	2.71±0.21^{b}	2.88±0.19^{a}

Means bearing different superscripts indicate statistically significant differences in a row ($p<0.05$); Values are expressed as mean ± SE of three replicate ponds

Mullets

Aquaculture of mullets using cost effective feed developed by CIBA

A demonstration of mullet culture (8 month duration) using formulated feed was carried out in a farmer's pond at Nagayalanka in Krishna District of Andhra Pradesh. A total of 4600 mullet seeds comprising *L. parsia* (4300) and *M. cephalus* (300) were stocked in a 0.35 ha pond. Feed containing 33% protein and 5.7% lipid was fed during the culture. A total of 442 kg (1271 kg/ha) of mullet was harvested with a survival of 93% and with an FCR of 2.1. This trial showcases the technical feasibility of mullet culture using formulated feed and the model holds immense promise for small and marginal farmers in this sector.

In another experiment on growout culture of grey mullet conducted in two ponds (water spread area 900 m^{2}) at KRC, CIBA advanced fingerlings (ABW, 59.56 ± 2.76 g, ABL, 185.2 ± 3.1 mm) were stocked @ 0.7 no m^{-2}. Fishes were fed with sinking pellet feed formulated by KRC of CIBA. After 390 days of culture,

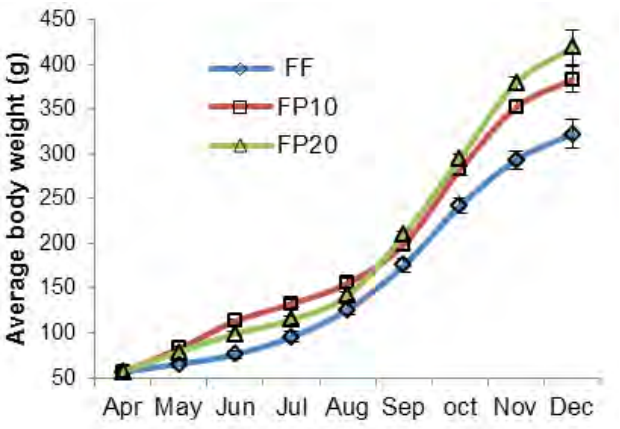
Harvest of mullet at Nagayalanka, Andhra Pradesh

fishes attained a final body 298.65± 22.96 g.

Effect of periphyton on milkfish growout culture

An experiment was conducted to assess the effect of varied periphyton substrate surface area on growth and production performances of milkfish. The treatments were feeding only (FF), feeding + periphyton substrate area equivalent to 10% of pond surface area (FP_{10}) and feeding + periphyton substrate area equivalent to 20% of pond surface area (FP_{20}) in triplicate ponds. White velon net (60/60 mesh, 1 m wide) were installed vertically with the support of bamboo poles as periphyton substrate. Fish fingerlings (210.5±27.3 mm, 56.38±4.71 g) were stocked at a density of 1 no m^{-2}. Feeding with floating pelletized feed formulated by CIBA, Chennai was done @ 7-2 % of estimated biomass. After 240 days of rearing, fishes were harvested at ABW of 322.33 ± 15.59, 383.27 ± 14.45 and 419.63 ± 19.44 g with survival of 84 ± 3, 91 ± 3 and 96 ± 2% in FF, FP_{10} and FP_{20} respectively. Production achieved were 2.71 ± 0.15, 3.46 ± 0.13 and 3.99 ± 0.12 tons/ ha in FF, FP_{10} and FP_{20} respectively. Highest growth and survival was observed in FP_{20}. Isometric growth and better condition of fish was recorded in FP_{20} respectively. Fish growth was 17 and 22 % more in FP_{10} and FP_{20}. Periphyton reduced FCR by 8 % in FP_{10} and 14% in FP_{20}.

A demonstration of mullet (*L. parsia* and *M. cephalus* culture using formulated feed was carried out in Krishna district (Andhra Pradesh) after 8 months of culture 1271 kg/ ha mullet was harvested with a survival of 97%.



Effect of periphyton on average body weight of milkfish during pond based growout culture

Grow-out in earthen pond: Grow-out experiment with different stocking density (0.25 and 0.5 no/m^2) of hilsa was being carried out in four brackishwater ponds in KRC of CIBA. After 439 days of culture, hilsa attained growth of 208.91 ± 17.95 g and 255.57±18.8 mm from initial body weight of 1.37±0.18 g and body length of 52.97±5.50 mm. Significant number of gravid female (stage-III) was found in the cultured pond indicating possibility of broodstock maturation in captivity.

Milkfish performance parameters in FF, FP10 and FP20 ponds after 240 days

Parameters	FF	FP_{10}	FP_{20}
Initial total length (mm)	215.8±2.4	213.2±03.4	215.9±02.8
Initial fish weight (g)	56.84±1.20	56.52±1.27	56.93±1.25
Final total length (mm)	$326.2±4.7^b$	$349.4±4.2^a$	$349.9±3.4^a$
Final fish weight (g)	$322.33 ± 15.59^c$	$383.27 ± 14.45^b$	$419.63 ± 19.44^a$
Daily weight gain (g day^{-1})	$1.11±0.28^c$	$1.36±0.32^b$	$1.51±0.40^a$
Specific growth rate (% day^{-1})	$0.88±0.11^c$	$1.11±0.16^b$	$1.19±0.14^a$
Condition factor (*K*)	$0.64±0.02^b$	$0.71±0.03^a$	$0.72±0.02^a$
Isometric exponent of LWR (*b*)	$2.96±0.21^c$	$3.01±0.19^b$	$3.15±0.18^a$
Survival (%)	$84.5±3.7^c$	$91.1±3.3^b$	$96.3±2.8^a$
Feed conversion ratio	$1.74±0.14^a$	$1.61±0.09^b$	$1.53±0.11^c$
Production (tons/ha)	$2.71±0.15^c$	$3.46±0.13^b$	$3.99±0.12^a$

Means bearing different superscripts indicate statistically significant differences in a row ($p<0.05$); Values are expressed as mean ± SE of three replicate ponds.

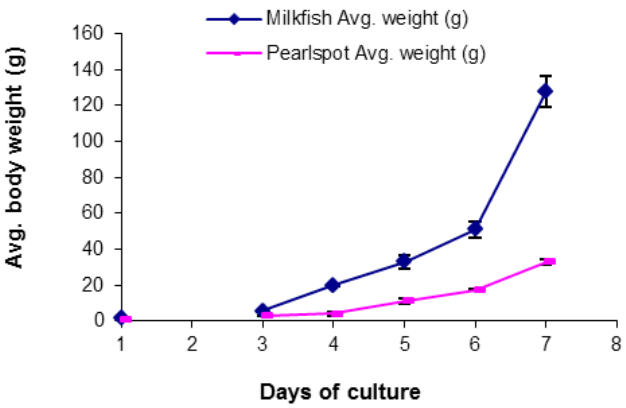
Growth performance and survival of hilsa in cement tanks containing brackishwater.

	Circular tank		Rectangular tank	
	With flow	Without flow	With flow	Without flow
Initial body wt. (g)	1.56 ± 0.32	1.48 ± 0.19	1.95 ± 0.34	1.52 ± 0.28
Body wt. at 60 days (g)	6.71 ± 0.80	10.13 ± 0.40	6.78 ± 0.88	11.96 ± 1.94
Survival (%)	10	30	0	15.38

Grow-out in cement tank: To study the feasibility of rearing hilsa in concrete tank, experiment was conducted in two different shaped concrete tank, rectangular and circular cement tanks (30 m). There were four treatments, i.e., circular concrete tank without flow, circular concrete tank with flow (2.08 m/min), rectangular concrete tank without flow and rectangular concrete tank with flow (2.08 m/min), In all the treatment groups water volume of 20000 l was maintained. Ten hilsa fry (body wt.1.48-1.95 g and body length 59.2- 71.8 mm) were stocked per tank. In all tanks 10 l algae (*Chlorella* sp., *Nanochloropsis* sp; 120-140 no. x 10^3/ml) and 10 l rotifer (120-130 no./ml) were offered per day as feed. After 60 days the growth of fish in both types of tanks without flow was more than that of in tanks with flow. Survival (%) was more in circular tanks without flow followed by circular tanks with flow and rectangular tank without flow. All the fishes died in rectangular tanks with flow after 60 days. From the experiment it was observed that artificial flow can affect the growth and survival of hilsa.

Polyculture of milkfish *Chanos chanos* and pearlspot *Etroplus suratensis*

CIBA aims at developing economical polyculture



Body weights attained by milkfish and pearlspot after 130 days of culture at Thiruvallur, Tamil Nadu

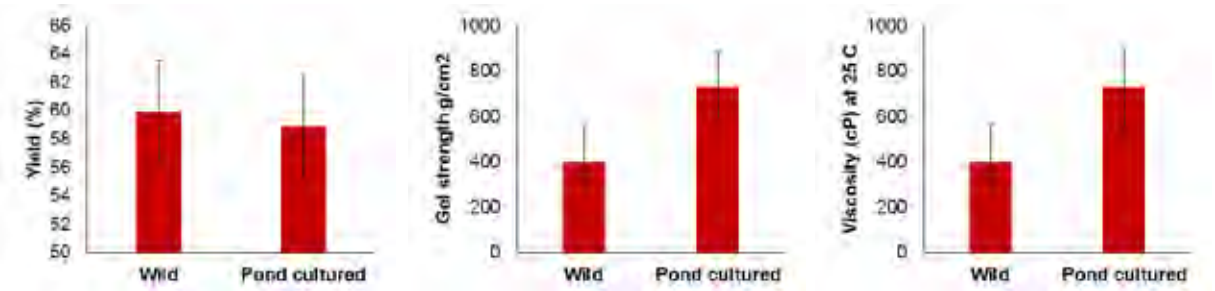
Harvesting polyculture ponds at Thiruvallur, Tamil Nadu

Farmed milkfish

models using different species combinations for facilitating farmers adoption based on the local conditions and market demand. Finfish polyculture using a combination of milkfish and pearlspot is being conducted in low saline ponds with farmers participation at Thiruvallur district, Tamil Nadu. Six hundred milkfish fry (avg. wt.- 1.53 g, avg. total length- 55.7 mm) and 500 no. pearlspot (avg. wt.- 0.82 g, avg. total length-36 mm) were stocked in a 700 m^2 (stocking density: 1.5 no/m^2). The body weight attained by milkfish and pearlspot were 127.90±8.42 g and 33.0±1.83 g after 130 DOC. The specific growth rates of milkfish and pearlspot were 3.4 % day^{-1} and 2.8 % day^{-1} respectively.

Secondary aquaculture of seaweed *Kappaphycus alvarezii* and green mussel *Perna viridis* in pond system

With a view of developing an integrated brackishwater aquaculture, baseline experiments were conducted in brackishwater pond systems for culturing seaweeds and bivalves for assessing the growth, bioremediation potential and the quality of the product cultured in the system. An experiment was initiated for culture of seaweed *Kappaphycus alvarezii* in cages (1x1x0.75 m) to understand the relative suitability of different chambers of the hatchery discharge pond for seaweed culture. After 70 DOC, seaweed stocked in primary chamber showed disintegration (temperature, 25-29.6^{0}C, salinity-26-28 ppt, pH-7.24-7.42, TAN-0.23±0.09 mg L^{-1}) indicating that the primary chamber was unsuitable for the growth of *K. alvarezii.* Daily growth rates of 1.47% and 2.72% was recorded in the secondary and tertiary chamber (temperature, 25-29.1^{0}C, salinity-26-28 ppt, pH-7.49-7.46, TAN-0.36±0.06 mg L^{-1}) indicating that these water quality conditions were suitable for the growth of the seaweed. The estimated nitrogen uptake of *K. alvarezii* cultured in PVC mesh cage (1x1x0.5 m) in a pond system (salinity- 27-28 ppt, pH- 7.06- 7.28,



Quality indices, yield %, gel strength and viscosity of refined carrageenan extracted from cultured and wild seaweed *K. alvarezii*

Rope culture of green mussel *P. viridis* in a brackishwater pond at Muttukadu

TAN- 0.79- 0.83 mg L^{-1}, NO_2^-N- 0.053-0.06) after 30 DOC was 8.5 mg N day^{-1} m^{-2}. The nitrogen content, crude protein content, ether extract of the seaweed was found to be 1.758%, 10.99%, 0.55% respectively. Comparative quality evaluation conducted with the pond cultured and wild seaweed *K. alvarezii,* based on the yield, viscosity and gel strength of refined carrageenan extracted from the seaweeds, indicated that the quality of the cultured seaweed were similar to the wild marine samples.

Feasibility study on the rope culture of green mussel *P. viridis* was conducted in secondary discharge pond (temperature 25-30.1 ^{0}C, salinity- 26-28 ‰, pH- 7.44-7.65, TAN- 0.26±0.08 mgL^{-1}), at MES-CIBA. Green mussel (avg ini wt- 6±0.57 g) collected from

Farmed green mussel at MES

Edvanakadu, Ernakulam, were set on 0.5 ropes using cotton net bags @1 kg/m. Thirty such ropes were suspended on 3 poles. After 30 days of setting the average weight attained by the mussels was 13.1±1.5 g and the specific growth rate was 2.6 % day^{-1}.

Cage culture of seabass, pearl spot and milkfish

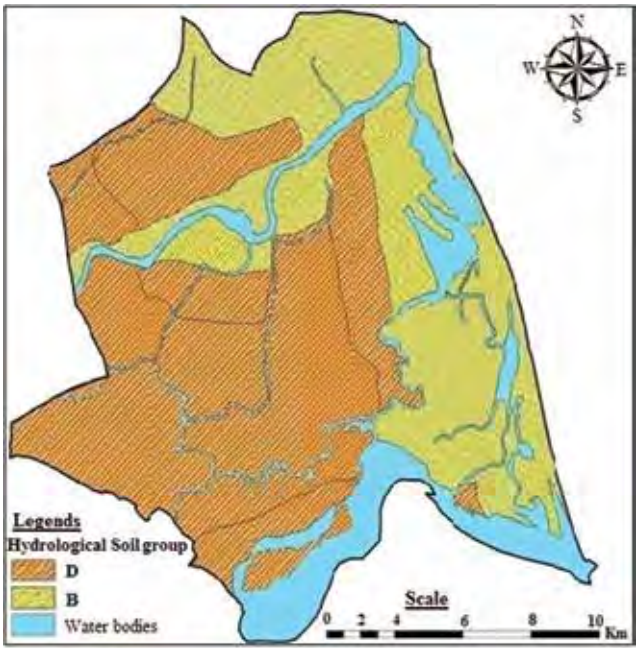
In order to popularize the cage culture of high value brackishwater finfishes in village ponds, culture demonstration was carried out in Navipardi and Valoti villages of Navasari district (Gujarat). A total of 12 cages in 1 tribal village were fabricated of different sizes; 2x2x1 m and 2x1x1 m and seabass (694 nos.) and pearlspot (1061 nos.) were stocked in cages. A total of 500 nos. of milkfish was stocked in the pond. After two to three months of culture period, a total amount of around Rs 75,000 was realized out of seabass, pearlspot and milkfish sales from the partial harvest.

Nutrient sequestering capacity of seaweeds

Nutrient sequestering capacity of seaweeds, *Gracilaria verrucosa, Kappaphycus alvarezii* and *Cladophora* sp, were estimated at three different concentrations of ammonia (5 ppm, 10 ppm, 15 ppm). The rate of biofiltering capacity was found to be more at lower concentration compared to higher concentrations. The concentration of ammonia in the treatments with *G. verrucosa* decreased significantly as compared to treatments with *K. alvarezii* and *Cladophora* sp. Conversely, the nitrite concentration was found to increase in all the three different nutrient loads.

Identification of artificial recharge location sites in the coastal watershed

Identification of artificial recharge locations and construction of rain water harvesting structures in those areas are important strategies for maintenance of soil and water quality. The study area was about 246 sq.km and has 2 rivers the Vellar and the Colleroon flowing through it. The satellite imagery and geo-reference map of the area were used to create the thematic maps like drainage, slope, soil, land use/land cover using ARCGIS. Drainage pattern of study area as indicated by the ASTER DEM image was used for stream ordering. Then the watershed boundary was interpolated. The region mainly have clay loam, loamy and sandy clay loam soil which has good water retention potential. The rainfall data collected from 4 rain gauge stations (three rain gauge stations (i.e) Chidambaram, Parangipettai and Annamalai Nagar fall within the study area and one station at Bhuvanagiri is close by) were used for this analysis. A thessien polygon was drawn to determine the area of influence of the rain station and the data was a used for the respective area for calculation of run-off. The Soil conservation service – curve number (SCS-CN) model was used.The SCS curve number was developed by the USDA Natural Resources Conservation Service to predict direct run-off or infiltration from excess rainfall. All the prepared thematic layers were overlaid using a set of logical condition to interpret spatial and attribute information and thereby identifying 3-5 suitable site for constructing rainwater harvesting structure. This project helped to prove that there was no buildup of salinity due to aquaculture in the vellar – colleroon watershed. But insitu salinity in some pockets of the watershed exists in the study area. This will also ensure environment friendly shrimp farming with suitable soil and water conservation strategies so that different stake holders (i.e) both agriculture, aquaculture and other activities co–exist without conflicts.



Idientifcation of recharge locations

Four locations in the velar watershed have been identified artificial discharge through rainwater harvesting.

Assessment of oxygen consumption rate, survival and growth of *Penaeus monodon* at different salinities

In order to optimize the aeration requirement in the grow-out production system, the oxygen consumption rate (OCR), survival and growth of *P. monodon* at various growth phases were evaluated at different

salinities. The oxygen consumption per gram of animal was low at 2.28 g in the first month. The survival was 93% in the first month in 30 and 40‰ and reduced to 80 % at 10 and 20 ppt and then reduced to 73 % at 0 ppt. The OCR was increased to 0.63 mg O_2/g/hr at 10, 20 and 30 ppt and 0.42 mg O_2/g/hr at 40 ppt while the weight was 3.20 g, 3.30 g, 3.0 g and 2.28 g at 10,20, 30 and 40 ppt respectively in the second month. The minimum oxygen consumption rate of 0.37 mg O_2/g/hr was observed at 30 ppt with the animal weight of 4.83 g and ammonia excretion of 0.26 ppm. In the second stage of evaluation, the survival was reduced to 66% at 0 ppt and the highest survival observed was 93% at 30 ppt. In other tanks OCR did not vary much, ranging from 0.42, 0.45, 0.48 and 0.56 mg O_2/g/hr, while the weight was 5.73 g at 10 ppt , 5.12 g at 20 ppt, 5.96 g at 40 ppt and 5.70 g at 0 ppt. The temperature in the experiment tanks ranged from 30.4 ^{0}C to 30.6 ^{0}C. In the third stage of evaluation, the weight of animal increased from 5.96 g to 8.70 g while the highest survival rate was 93 % at 30‰ and the lowest survival was 63 % at 0 ppt. The oxygen consumption rate was high 0.68 mg O_2/g/hr at 20 ppt and low level of OCR of 0.43 mg O_2/g/hr at 30 and 40 ppt with the ammonia excretion high level of 0.72 ppm at 40‰ and low level of 0.56 ppm 20‰ respectively. In the fourth stage of evaluation, the survival rate was reduced to 60% at 0 ppt. The highest level of survival observed was 90 % at 30 ppt. The minimum OCR of 0.64 mg o_2/g/hr was observed at 30‰ with the animal weight of 9.36 g and ammonia excretion level of 0.05 ppm. In other tanks OCR did not differ much, ranging from 0.78, 0.80, 1.02 and 1.05 mg O_2/g/hr while the weight was 8.43 g at 0 ppt, 7.24 g at 20 ppt, 7.17 g at 10 ppt and 7.61 g at 40 ppt.

The highest oxygen consumption rate (OCR) before harvest was observed at 40 ppt whereas lowest OCR was found 0 ppt.

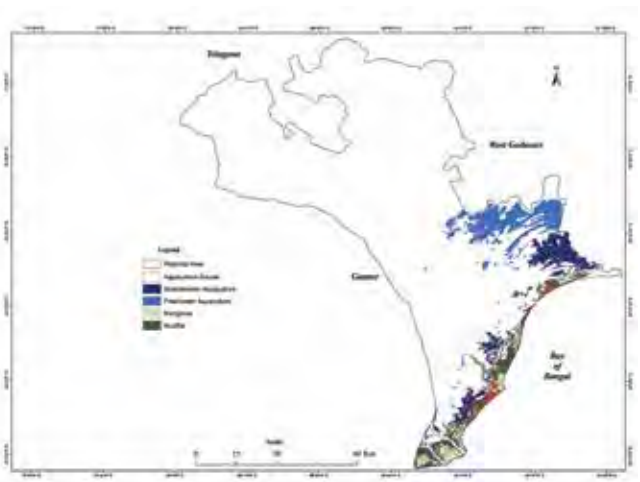
In the fifth stage of evaluation, the weight of animal from 8.0 g to 11.76 g while the highest survival rate was 87 % at 30 ppt and lowest survival rate was 60 % at 0 ppt .The OCR was high 0.94 mg O_2/g/hr at 20 ppt and low level of 0.65 mg o_2/g/hr at 30 ppt. The ammonia excretion was at high level of 0.07 ppm at 40 ppt and low level of 0.04 ppm at 20 ppt respectively. The temperature in the experimented tanks ranged from 29.8 ^{0}c at 0 ppt to 30.6 ^{0}c at 40 ppt .

In the sixth stage of evaluation, the measurements were taken before the harvest . The animal weight ranged from 9.16 g to 15.36 g. The highest oxygen consumption rate was 1.01 mg O_2/g/hr at 40 ppt with the animal weight and ammonia excretion level was 11.82 g and 0.08 ppm respectively. The lowest OCR was 0.30 mg o_2/g/hr at 0 ppt with the animal weight of 15.36 g, and animal ammonia excretion level of 0.07 ppm.The survival ranged from 53 % at 0 ppt, 67% at 10 and 20 ppt,73 % at 40 ppt and 87 % at 30 ppt. In all tanks except at 0 ppt where as it was reduced to 53 %.

District level planning for brackishwater aquaculture

Aquaculture planning at the district level is the process of preparing an integrated plan for the local government for the development of aquaculture taking into account the resources (natural, human and financial) available, risks involved, facilities available and covering the sectoral activities and schemes assigned to the district level and below. It is an important tool as districts the most suitable administrative unit for decentralized planning below the state level, it possesses the required heterogeneity and is small enough to undertake people in planning and implementation to improve productivity. To develop the plan for aquaculture development at a district level, Krishna district was selected due to the presence of the highest number of shrimp entrepreneurs having the maximum area under shrimp culture in Andhra Pradesh and frequent changes occurred due to changing scenario including the presence of maximum area of ponds in disuse. A total of 4037 ha area is still available for further development adhering to environmental regulations.

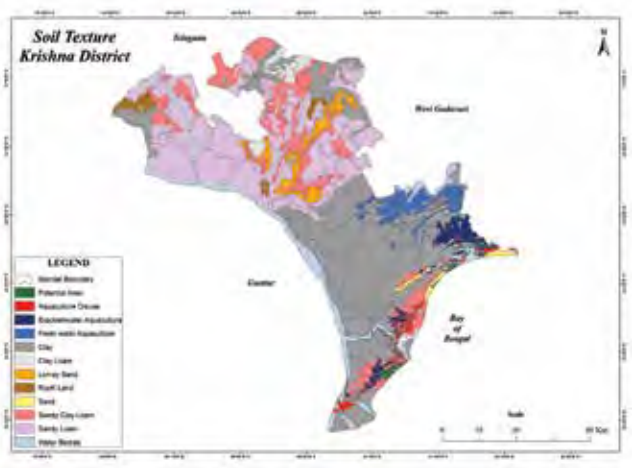
The suitability of brackishwater aquaculture sites is dependent on the soil texture. Among the different soil textures obtained from soil survey and land use



Suitable potential areas for aquaculture (Krishna, Andhra Pradesh)

organization map, clayey and clayey loam areas are the most preferred sites for shrimp farming due to their good water retention capacity and sand is least preferred due to its high seepage characteristics. In Krishna district, major area of the district have clay texture followed by sandy loam. Brackishwater aquaculture farms of 1431 ha and 5598 ha were located in the clay and clay loam soil

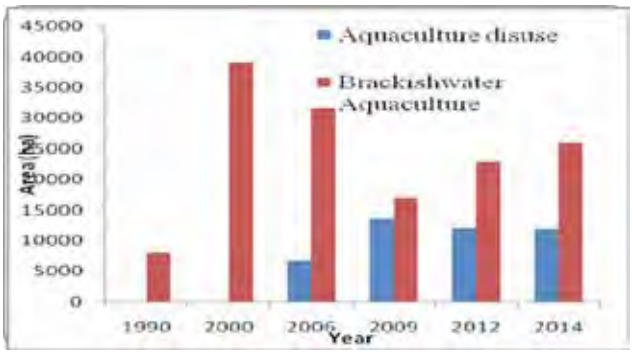
> Aquaculture planning at the district level is the process of preparing an integrated plan for the local development for the development of aquaculture taking into account the resources available, risks involved etc.



Soil texture in Krishna district

Disused aquaculture farms and its earlier land use

An assessment of the scenario of disused farms indicated that disused aquaculture ponds of 11880 ha were present in 2014. The trend indicated that the maximum disuse of 13494 ha was present in the year 2009. Though the introduction of *P. vannamei* has given relief to the sector in the country, there has not been much change in the Krishna district, with 33% of shrimp culture farms lying unused. Majority



Shrimp culture development and disuse in Krishna district

of the farmers are small farmers and not in a position to create the infrastructure requirements (effluent treatment system) to fulfil the licensing guidelines of *P. vannamei* culture. Unless the common facilities are created for a particular society or region through farmer participatory approach, the benefits of *P. vannamei* introduction will not reach small farmers.While making efforts for revival of aquaculture disused ponds, seepage control measures such as clay lining needs to be done to avoid the seepage of water

Sustainable Management of Degraded Coastal Land and Water for Enhancing Livelihood Security of Farming Communities

A total of 20.7 ha (N=113) of brackishwater area has been developed, and poly culture of *P. monodon*, *M. cephalus* and *L. tade* have been carried out. Farmers were provided with all the inputs such as fertilizers, seed and feed. The farmers obtained an average production of 1080 kg/ha with a net income of about ₹ 1,45,745 kg/ha. A total of 15. 8 ha of area were developed from paddy cum fish culture and farmers obtained production of 155 kg/ha of scampi and 560 kg/ha of fishes and 1745. 2 kg/ha of paddy. Farmers were able to earn extra income of ₹ 56 000/ha/yr.

Resilient intensified and diversified agriculture & aquaculture system

This research program aims to develop and introduce more productive, diversified and resilient agriculture/ aquaculture production system in the fresh/brackish water of the coastal zones of Ganges delta in order to uplift the rural poor households. Two forms of production systems, paddy cum fish culture and homestead production, were addressed. Objective of the project was to develop and introduce more productive, diversified and resilient agriculture/ aquaculture production systems in the fresh-brackish water coastal zones of the Ganges delta in Bangladesh and India, for the benefit of rural poor households. Paddy cum fish culture and homestead production systems were addressed for scientific interventions.

Paddy cum fish culture: For paddy-cum-fish culture, two types of land shaping (1. 20% pond with 80% of rice cultivation and 2. 30% of pond with 70% of rice cultivation) was considered. The total land area was 1333 m^2, and trial was carried out in triplicate. Salt tolerant paddy variety, “amalmana” was selected for cultivation in wet season.Culture of Indian Major Carps (IMC) and Giant Freshwater Prawn (GFP)

at stocking densities of 4000/ha and 1,500/ha, respectively was done with paddy. Ratio of stocked IMC was catla:rohu: mrigal=30:35:35. Two treatments were designed in the experiment: fish culture without selective harvest and fish culture with selective harvest. Pelleted feed (protein-24%, lipid 4%) was provided @ 2-5% of body weight of fish twice daily. The paddy field was fertilized by urea, DAP, muriate of potash (MOP) and single super phosphate (SSP). Pond was initially fertilized with lime @ 300 kg/ha and cow-dung @ 3000 kg/ha and thereafter with 3 ppm single super phosphate (SSP) and urea (SSP: urea = 1:1). Water fertilization schedule was modified and repeated at fortnightly intervals as per productivity of pond. Rearing duration of paddy and fish were 110 days (September-December) and 210 days (August-March) respectively.

Productivity of paddy and fish achieved was 2685and 2566 kg/ha and 846 and 783 kg/ha in 20% and 30% pond treatments, respectively. Greater fish productivity in 20% pond may be attributed to availability of greater land area for grazing during co-culture of paddy and fish compared to 30% pond with lesser grazing area for greater number of fishes. Lower paddy production in paddy cum fish culture with 30% pond area might be due to grazing pressure of greater number of fishes in lesser extent of land area. Higher nutrient profile and plankton population was also observed in water in 20% pond. About 11-14% productivity increment was observed in phase harvested ponds compared to non-phase harvested ponds.

* * *

Reproduction, breeding and larval rearing

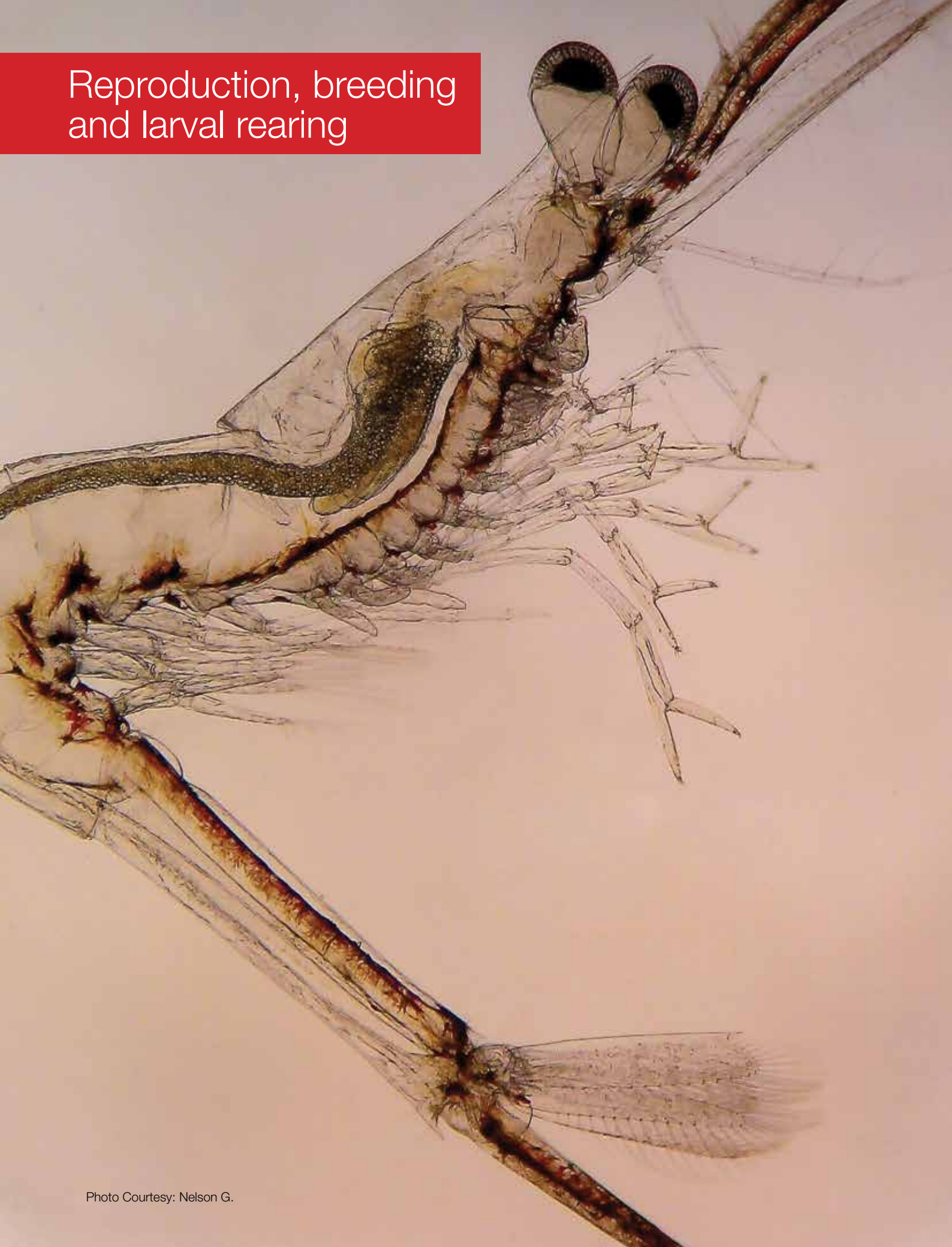
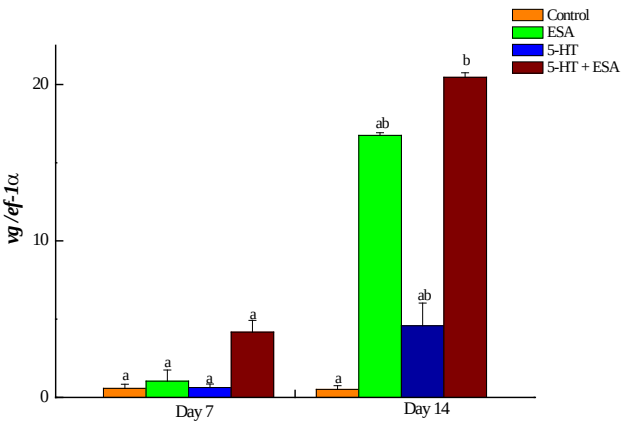


Photo Courtesy: Nelson G.

Reproduction, breeding and larval rearing

Shrimps

Reproductive maturation by biogenic amine, Serotonin: Serotonin (5-hydroxytrptamine, 5-HT), a biogenic monoamine signaling molecule, functions as

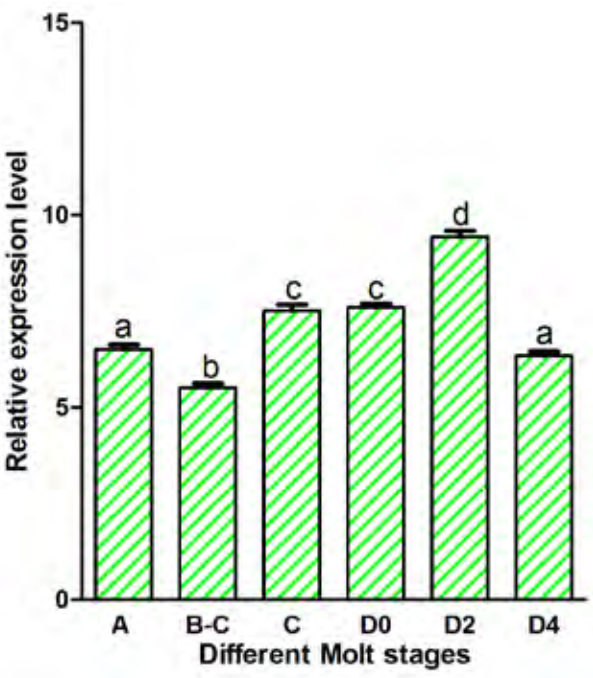


Changes in the transcript levels of *vg* in the ovary at different treatment group measured by quantitative RT-PCR.

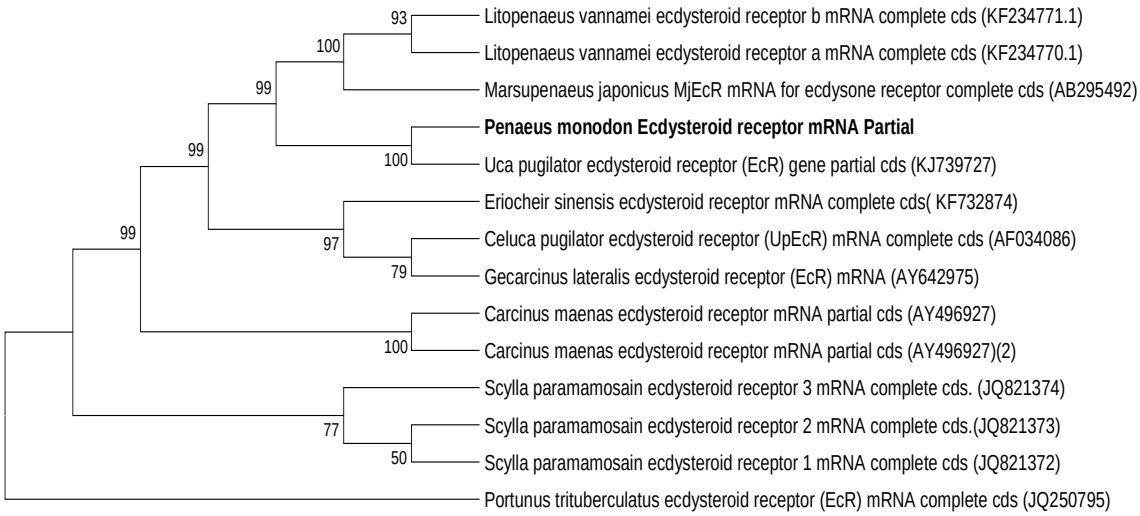
neurotransmitter, neuromodulator and neurohormone in several species. Experiments have been carried out to study the effect of serotonin on vitellogenin gene expression in tiger shrimp *P. monodon*. Females collected from wild were acclimatized to the experimental tank conditions. Animals screened negative for WSSV were divided into four experimental groups: 1) control, 2) Eyestalk ablated (ESA) 3) hormone alone (5-HT) and 4) hormone along with eyestalk ablation (5-HT plus hormone). The dose of hormone in all the groups were 50 µg/BW, and hormone was administrated on the 0 and 7th day. The *vg* transcripts exhibited a 4, 7 and a 20 fold increase in the 5-HT, ESA and 5-HT + ESA group respectively on 14th day. The *vgr* transcripts levels were significantly high in the 5-HT + ESA group. The transcripts exhibited a significant 2 fold increase on Day 7 and a 2.5 fold increase in Day 14 in the 5-HT group. The results confirm the stimulatory role of 5-HT on ovarian maturation in *F. indicus*. This could be probably by stimulating the release of gonad-stimulating hormone from brain and thoracic ganglion or by regulating the release of neuropeptides like CHH, RPCH from eyestalk which in turn play a role in ovarian development. Significantly higher levels of *vg* expression in ablated animals receiving serotonin indicate that lowering the levels of gonad inhibiting hormone has stronger effect on stimulating ovarian maturation.

Ovarian development and sex steroid profile during reproductive cycle: To assess the potential role of sex steroids, the profile of sex steroid in relation to ovarian cycle of *P. monodon* was characterized to establish the role of sex steroid in relation to reproductive cycle. The effect of eyestalk ablation on the hormone profile was also studied. The haemolymph profile of E_2 was significantly higher in early vitellogenic (65.4 ±10.5) and pre vitellogenic ovary (39.4 ±8.5) than other stages ($P<0.05$). On the contrary, hemolymph profile of progesterone was significantly higher in late vitellogenic and ripe stages than immature and previtellogenic stages ($P<0.05$). The hormone titres increased significantly after eyestalk ablation ($P<005$). The high levels of E_2 in vitellogenic females suggest that E_2 has a prominent role in the synthesis of vitellin as in vertebrates. Conversely, progesterone is found to have a different role in ovarian development other than synthesis of yolk protein. High level of sex steroid hormone titre after eyestalk ablation suggests that steroid hormone production is possibly controlled by eyestalk neuropeptides.

Ecdysteroid receptor cDNA cloning: A partial sequence of 157 bp of Ecdysteroid receptor of *P. monodon* was amplified, cloned and sequenced using degenerate primers. The sequence of this cDNA fragment was similar to corresponding sequence of



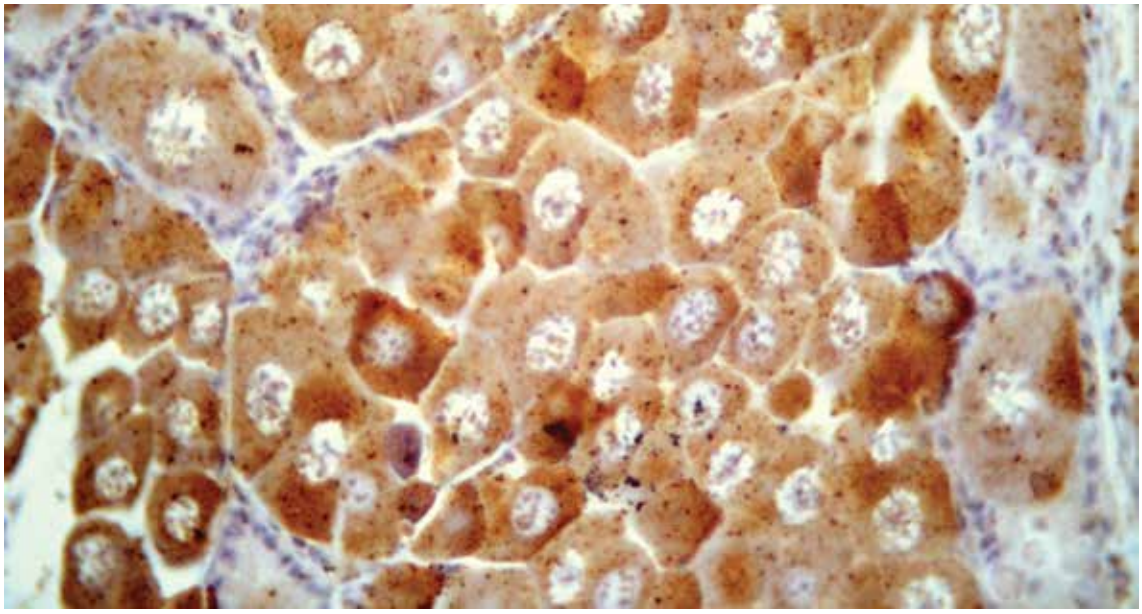
Relative abundance of ecdysteroid receptor in relation to the molt cycle of *P. monodon*



Phylogenetic tree of Ecdysteroid receptor of *Penaeus mondon*

P. vannamei and *P. japonicas*. Ecdysteroid receptors were found to be present in the tissues such as ovary, hepatopancreas, gills and muscles. However, RT PCR analysis did not indicate any particular pattern of expression profile in these tissues in relation to the ovarian maturation cycle. On the contrary in relation to the molt cycle of the broodstock, ovarian ecdysteroid receptor shows specific pattern. The ECR mRNA transcript showed significant up regulation in the ovary during the pre-molt stage D_{1-2} and D_{3-}

Immunohistochemistry: In another experiment, progesterone and ecdysteroid receptor were localized in ovarian tissues of *P. monodon* by immunohistochemistry. Immunorsponsive substances were brown and the present study detected the progesterone receptor and ecdysteroid receptor in oocytes of *P. monodon*. PR receptors were mainly localized in the periphery of oocytes of pre vitellogenic oocyte 1 stage however, they were found relatively less in the vitellogenic oocytes. ECR receptor were



Progesterone immunohistochemistry localization in *P. monodon*.

Ecdysteroid immunohistochemistry localization in *P. monodon*.

found mostly in the pre vitellogenic oocytes (stage 2 ovary). The up regulation of ecdysteroid receptor were found in the early and late pre molt stages. In penaeid shrimps active vitellogenesis is found in the pre molt stage and it further indicate that ecdysteroid has an active role in the reproductive maturation of *P. monodon*.

Evaluation of growth and reproductive traits in Indian white shrimp *Penaeus indicus*: Wild *P. indicus* adult shrimp induced to spawn through single pair mating and families produced were initially reared in the hatchery up to PL-30, and later transferred into hapas in a pond for culture. Their growth in pond was monitored fortnightly. Tagging, segregation of male and female, breeding for family production had to be performed because of the disease outbreak. However, the shrimp juveniles were lost due to WSSV infection. Furthermore, wild *P. indicus* adult shrimp induced to spawn through single pair mating and another five families produced were initially reared in the hatchery, and later transferred into hapas in a pond for larviculture to record the production and reproduction traits. Database about the growth traits of different families of *P. indicus* will be formed and also sex specific growth is to be recorded. Spawning efficacy increased significantly with ESA. Community breeding also ensured higher number of fertilized eggs and hatching rate compared to that of the single pair tanks. In both single pair and community based breeding experiments, polychaete response in inducing maturation and spawning is better (75% approx) compared to CIBA pellet feed (50 % appox). Community breeding is better in inducing maturity and spawning in *F. indicus* compared to single pair mating (62.5 % compared to 29.2 %) system.

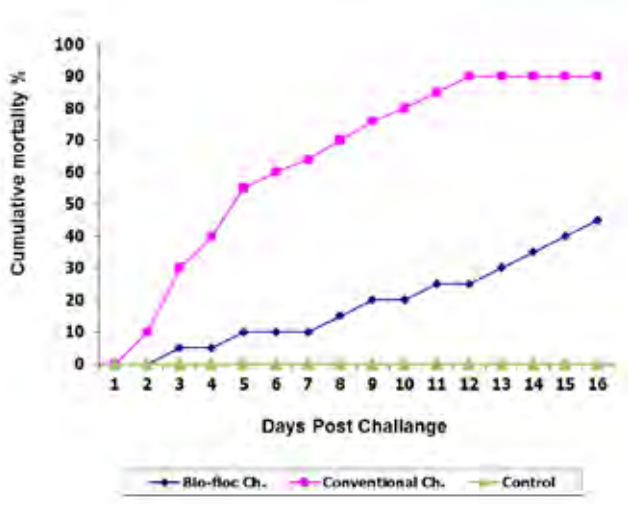
Community breeding is found to be better in inducing maturity and spawning in *P. indicus* compared to single pair mating.

Quality seed production through probiotic/biofloc intervention: Two experiments were conducted in *P. indicus* and *P. merguensis* to refine probiotic based seed production and larval/ juvenile performance evaluation *vis-a-vis* antibiotics. Probiotic based immunomodulations are being assessed by looking at cellular and molecular levels. *P. indicus* post larvae were exposed to different strains of probiotics (*Bacillus subtillis* and *Lactobacillus casei*, *Sacchromyses cerivisiae*). The experiment was conducted for six weeks in triplicate tanks (100 l). The survival was significantly ($p<0.05$) higher in three probiotic treated groups compared to the control group without any treatment. The cellular immune

parameters prophenoloxidase and total hemocyte count were found to be significantly higher in the probiotic fed groups compared to that of the control. In another experiment it indicates that the combination of microalgae with beneficial bacteria have shown significantly higher survival when compared to control group.

Disease resistance in shrimp reared in biofloc system: Three challenge trials were conducted at different stages of shrimp under biofloc. The cumulative percent mortality following the challenge with pathogenic *Vibrio parahemolyticus* in the biofloc groups was significantly reduced compared to that of the conventional group of shrimp. Results from other experiments with biofloc generated from two CHO sources showed a higher cellular immune parameters (ProPO activity, THC etc) and an up-regulation of expression of certain immune related genes explaining the possible immunomodulations and in turn giving better protection in the biofloc reared shrimp. Biofloc based nursery rearing also improves the immunity of shrimp as compared to that of the control group as observed from the immune gene expression study of phenoloxidase and crustin gene up-regulations. Biofloc based system improved the protective response of the shrimp in a challenging situation as observed from the pathogenic bacterial challenge study. The challenged trail revealed that, the mortality rate was higher in control group reaching upto 80 % of mortality in one week of time but in contrast the biofloc treated animals were showing only 38% of mortality in one week. In the experimental control (PBS injected) no infection and mortality were noticed. Biofloc technology approach which promises a healthy rearing system is increasingly identified as one possible solution for these disease problems.

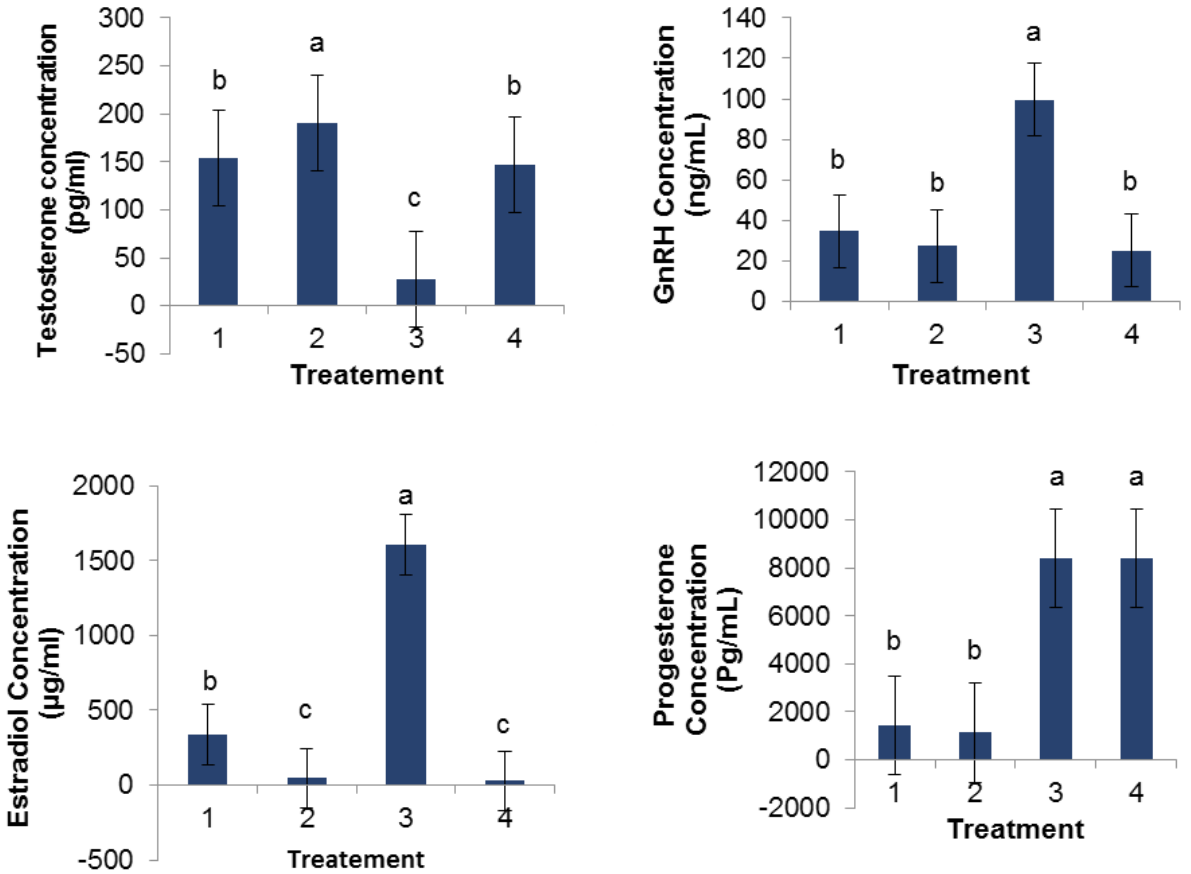
> …. dopaminergic inhibition is a major barrier along the reproductive axis causing reproductive dysfunction in captive grey mullet……



Cumulative mortality of shrimp *P. vannamei*. Post larvae Challenge against *Vibrio parahemolyticus* (control and biofloc) groups.

Finfishes

***In vivo* effect of LHRH agonist and dopamine antagonist (dom) implant on sex steroid production in female grey mullet:** Grey mullet *M. cephalus* requires hormonal interventions to overcome reproductive dysfunction especially with respect to final oocyte maturation (FOM) in captivity. An in vitro experiment was conducted to understand the effect of LHRH agonist, dopamine antagonist (dom) and a combination of both on secretion of different sex steroids in grey mullet for promoting FOM. Twelve wild caught grey mullets were divided equally into four treatment groups i) LHRHa (50µg/BW) cholesterol cellulose pellets ii) LHRHa cholesterol cellulose pellets + Dom (50µg/BW + 5mg/BW) iii) Dom (5mg/BW) iv) control group. After 48 hours of implantation serum and ovary samples were collected. The serum levels of LHRH, estradiol (E_2) , testosterone (T) and progesterone (P_4) were determined through ELISA. Results showed that the concentration of LHRH and E_2 in serum in the dopamine antagonist group were significantly higher than the other groups. Histological examination revealed that the dopamine antagonist treated group had a higher oocyte diameter than other groups. In conclusion, our data suggest that dopaminenrgic inhibition is a major barrier along the reproductive axis causing reproductive dysfunction in captive condition in grey mullet, therefore, the administration of dopamine antagonist alone may be helpful in overcoming reproductive dysfunction in captive grey mullets.



Serum hormone levels of grey mullet in response to treatments; LHRH agonist, dopamine antagonist (dom) and a combination of both LHRH agonist and dopamine antagonist (dom)

Fatty acid profiling of different maturity stages of ovary of grey mullet, *M. cephalus*: Fatty acid mobilization in the ovary of different maturity stages of the grey mullet was studied. Fatty acid profiling of three different maturity stages (pre vitellogenic/ immature, oocytes dia. < 200; vitellogenic/ maturing, 300-400 µm and post vitellogenic/ mature, >500 µm) were carried out through GC-MSMS. In the study, the major fatty acids in the ovary were found to be palmitic acid (SFA) and palmitoleic acid (MUFA). The amount of palmitic acid was found to decline as the stages progressed, and it was found to be highest in immature ovary (2.92%). Amongst MUFA, Palmitoleic acid was predominant and it was found to be highest in matured ovary (1.32%). Both linoleic acid (PUFA) and linoelaidic acid (PUFA) were found in immature ovary but not in maturing or matured ovary. Palmitic acid was the predominant saturated fatty acid and was found to be highest in immature female and lowest in matured female. This trend can be attributed to the negative feedback of palmitic acid on acetyl CoA carboxylase which prevents the conversion of acetyl CoA to malonyl CoA. Excess Acetyl CoA gets converted into cholesterol which subsequently acts as a precursor for synthesis of sex hormones. The overall percentage of mono-unsaturated fatty acid increased as the gonads ripen in female fishes and it was found to be highest in the matured stage, which can be due to the increased energy requirement for spawning. The percentage of polyunsaturated fatty acid, female gonads, was found to be highest in immature stage after which it declined. This is because polyunsaturated fatty acid is used for the synthesis of prostaglandin which in turn plays an important role for the development of sperm and ova.

Grey mullet *Mugil cephalus* - captive broodstock development and induced breeding trials Captive adult grey mullet broodstock (39 no, size range - 0.95 - 2.9 kg, females - 20 no males- 19 no) were maintained in two RCC tanks (100 t) with regular water exchange. Bath treatments, formalin 100 ppm and dichlorovos 0.75 ppm was used to treat ectoparasites, *Caligus* sp. and *Lernanthrophus* sp. Feeding was done twice

daily *ad lib.* with formulated mullet maturation feed. At monthly intervals, intra-muscular implantation with 17 α- methyl testosterone or LHRHa pellets for males and females respectively, was initiated from September 2014. Males attained oozing condition in October, and spermiation was observed to continue till the end of January 2015. Ovarian biopsies from females showed pre-vitellogenic or vitellogenic oocytes. Three females were observed with mean ova dia.- 20 -70 µm, stage II, pre-vitellogenic ova (transparent and in small clusters) and while 2 females were observed with mean ova dia.- 100– 200 µm, stage II / III, vitellogenic ova, (colour- yellow). The ova size gradually increased in size and maturity stage till December to 485 – 532, max 600 µm. A reduction in ova size was observed by the first week of January to 325 – 525 µm and resorbing ova were observed by the second to third week of the month. Five breeding trials were conducted in November and December 2014. Selected females having well developed oocytes received HCG or LHRHa treatments while males received 17α-MT or LHRHa. Partial success was obtained in one trial wherein female (1.58 kg) with initial ova diameters of 527- 532 µm was treated with LHRHa pellet and kept with two males (0.6, 0.9 kg) treated with 17α-MT pellets in a 10 t FRP recirculation tank (salinity-33 ppt, temperature 24-25 ^{0}C). The fish ovulated 48 h post-treatment and started egg release. The eggs were stripped and dry fertilized with freshly collected milt. A total of 9.3 lakh eggs were obtained, the final hydrated egg diameter was 750-850 µm with 30% eggs having more than one oil globule. Embryonic development did not take place.

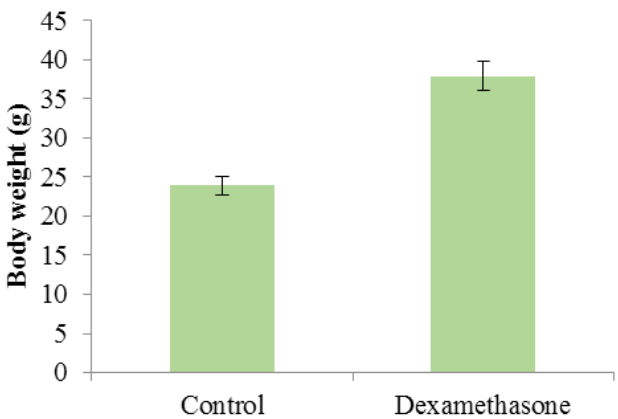
Partial success was obtained in 1 trial when female (1.3 kg) with initial ova diameters of 527-532 µm was treated with LHRH a pellet and kept with 2 males treated with 17α MT pellet.

Four other trials were conducted using a breeding set consisting of one female kept with 2 males in 10 t FRP recirculation tank, salinity , 31-33 ppt, temperature, 24-26 ^{o}C and iv) in 10 t FRP static system, 27-28 ppt and 24- 25^{0}C; i) female 1.75 kg, ova dia.- 518 µm, oozing males 0.78 & 0.87 kg; priming dose- HCG, injection (I) resolving dose LHRHa (I) ii) female 1.31 kg, ova dia.- 467 µm, oozing males 0.81 & 1.12 kg; priming dose- HCG (I), resolving dose LHRHa (P) iii) female 1.36 kg, avg. ova dia.- 523 µm, oozing males 1.1 & 1.2 kg; priming dose- HCG (I), resolving dose LHRHa (Pellet) iv) female 1.46 kg, avg. ova dia.- 503 µm, 2 non-oozing males 0.7 kg each; priming dose-LHRHa (P) for females and 17α-MT (P) for males.

Assay of sex hormones in the different maturity stages of Asian seabass (*Lates calcarifer*) during the spawning season

To understand the level of important sex hormones (estradiol, LHRH, testosterone and progesterone) in different maturity stages (transition, oozing male and mature female) of seabass, blood sample was collected form the jugular vein and serum was separated and stored at -80 ^{0}C till use. All the hormones were assayed using ELISA kit. Highest level of estradiol during the transition stage signified the use of estradiol for vitellogenesis to develop the oocytes. In case of mature female level of GnRH was significantly higher whereas testosterone was maximum in the oozing male. Progesterone was non-detectable in transition and mature male where as it was maximum in mature female which implies the role of the same for final oocyte maturation.

Development of sterile pearlspot for increased somatic growth: One of the major concern about pearlspot as a good candidate for aquaculture is linked to its slow growth rate. Induction of sterility has been reported to improve somatic growth rates in many studies in other finfish species. Hence, a study was conducted to induce sterility in pearlspot to see its potential for improving the somatic growth rates in the species. For inducing sterility dexamethsone was applied intraperitoneally @ 50 mg/ kg body weight in sub-adults of pearlspot. Dexamethasone treated sterile pearlspot showed higher growth rate than control. It



Body weight and total length of pearlspot in dexamethasone and control group

was observed that dexamethasone treated sub-adults had lower gonado-somatic index and underdeveloped gonadal tissues.

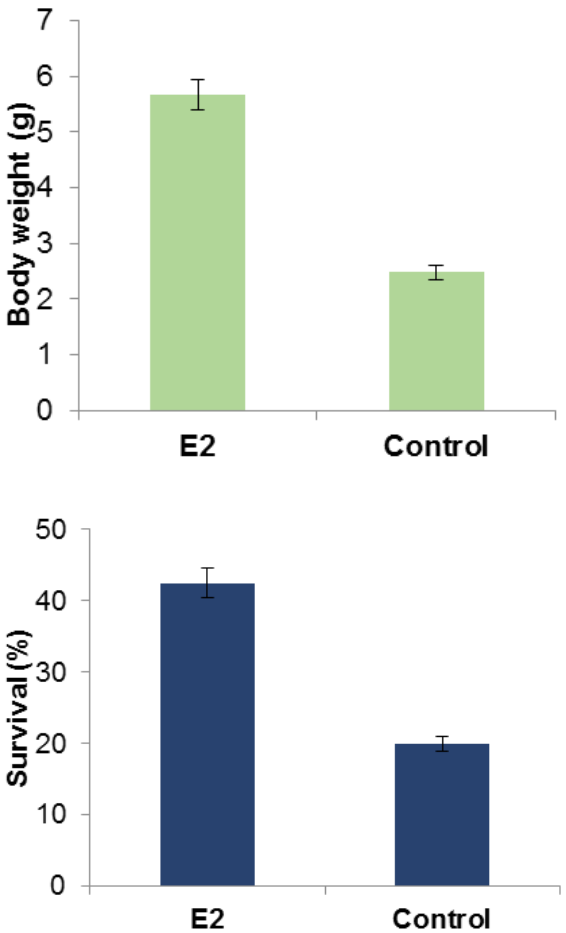
Asian seabass continues to be the prime brackishwater finfish candidate species among the farming community. Hence, we continue to set further milestones with respect to optimising the breeding and seed production protocols of Asian seabass over the significant achievements made in the past two decades. For this, a total broodstock of 73 Asian seabass *Lates calcarifer* (body wt. 2 - 8 kg) were maintained separately in two 100 ton capacity open RCC tanks as well as in two 10 ton capacity indoor recirculation FRP tanks attached with rapid sand filter and biological filter. Out of these, 18 fishes were procured from commercial farms near Vedaranyam, Tamil Nadu. Fishes were fed with trash fishes such as tilapia and sardines @ 3 - 5% body weight daily. In the outdoor tanks, bottom cleaning was performed on alternate days with 80 - 90% water exchange. As prophylactic treatment, fish were treated with 100 ppm formalin for one hour. Screening of the brooders for VNN was performed and the VNN free fish were taken for the breeding purpose.

… a total of 8.5 lakhs sebass seed were produced. Seeds were sold to 28 farmers in Gujarat, Andhra Pradesh, Tamil Nadu, Kerala and Odisha.

Breeding trials were conducted through hormone treatment as well as by natural spawning. A total of 24 breedings could be observed. The fertilization rate varied between 30 and 85% and the hatching rate could be estimated between 20 and 80%. Standard larval rearing protocols were followed and a total of 8.5 lakh seabass seed produced. The seed were sold to 28 farmers in Gujarat, Andhra Pradesh, Tamil Nadu, Kerala and Odisha. A total revenue of Rs. 6.76 lakh has been generated through seabass seed sales.

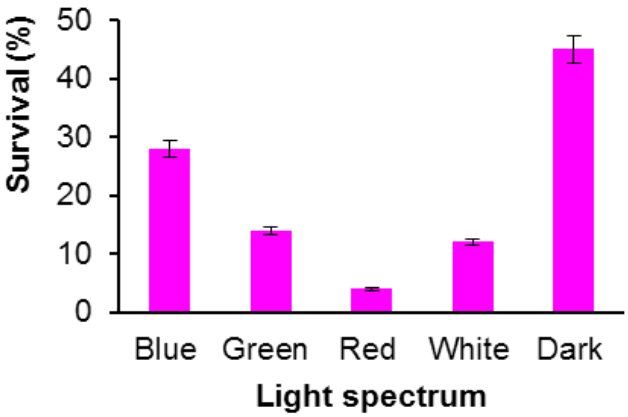
Pond based larval rearing of Asian seabass *Lates calcarifer*: A study was conducted for standardising the protocols for pond based larval rearing of Asian seabass *Lates calcarifer.* An earthen pond (area, 100 m^2) was used. The initial management included fertilisation and introduction of green algae. At the end of seven days of rearing, rotifer *Brachionus plicatilis* and newly hatched *Artemia* nauplii were stocked. On the 10^{th} day, a total of 4000 seabass larvae (10 day post hatch, size range from 30-35 mm) were stocked. After 21 days, a total of 1126 seabass fry (avg. size-24 mm) were harvested with a survival rate of 28.12%. This preliminary trial indicated the possibilities of carrying out larval rearing of seabass in fertilized pond system where suitable zooplanktons are maintained at required density.

Experiments on the effect of feed based estradiol application, tryptophan supplementation and varying light regimes on cannibalism in Asian seabass: The early life stages of Asian seabass exhibit size heterogeneity and cannibalism; these factors are inter-related and can result in significant reduction in the survival % during larval and nursery rearing. Cannibalism can be managed by understanding the influence of different abiotic and biotic factors; three experiments were conducted in this respect.



Larval survival % and seabass body weight in estradiol treated and control group

A 60 day study was conducted in Asian seabass, a protandrous hermaphrodite, for reduction of initial maleness by application of estradiol (E_2) @ 50 mg kg^{-1} through larval feed for reduction of cannibalistic behaviour, improving survival and growth. Estradiol



Survival (%) of Asian seabass larvae reared under different light spectrum

(E_2) incorporated feed was prepared by top coating of these chemical over the seabass larval feed. Grading was done twice a week. This experiment resulted in a 42.5 % larval survival and 5.67 g body weight after application of estradiol compared to 20% larval survival and 2.48 g body weight in control after two months. This approach will reduce cannibalism and produce female seabass well before their natural conversion during 3rd- 4th year of age.

A preliminary trail to control the cannibalism in seabass during nursery rearing was performed with graded level of tryptophan supplemented diet (0%, 0.5%, 1.0%, 1.5% and 2%). Fish fed with 1.5 % tryptophan supplemented diet recorded the maximum survival (34 ± 2.5 %) and lowest cannibalism percentage (12± 0.5 %) than the other groups. Lowest growth rate (215.72 ± 24 %) was recorded in the 2.0 % tryptophan supplemented diet. Tryptophan supplementation of 1.5% has significantly ($p<0.05$) reduced the coefficient of variation and size heterogeneity in seabass larvae during the nursery rearing.

A total of 2500 hatchery produced seed were supplied for pond culture demonstrations

The effect of different light spectrum was studied on cannibalism in Asian seabass which is a visual feeder. A 30 day experiment was conducted by providing different light spectrum *viz.,* red, green, blue, white and dark for continuous hours (24:00 h) in 100 l FRP tanks using 20 day old larvae stocked @ 150 larvae per tank. Feed was provided ad-libitum. Different light spectrums were maintained using 12 W LED light and no light was used for dark conditions. All the tanks were covered with thick black cloth to block any other light spectrum in the tank. Significantly higher survival, 45% was achieved under total dark conditions (0:24) leading to significantly lower mortality and cannibalism of 55 % and 25% respectively. Specific growth rate was found highest in red light spectrum due to high cannibalism and high mortality of 55% respectively. Weight gain and uniform larval size was achieved in case of complete absence of light.

Cobia broodstock pond

Hatchery produced cobia fingerlings

Cobia *Rachycentron canadum* - captive broodstock development breeding and seed production

The seed production system of cobia developed by CIBA is unique as it is based on the use of a pond based captive broodstock which may facilitate the technology adoption among entrepreneurs. A total of 22 cobia brooders (body wt.- 4-25 kg) were maintained in an earthen pond (area, 300m^2). Feeding was done with trash fish (tilapia and sardine) @ 5% body weight daily. At monthly intervals, examination of fish for parasites done and mechanical removal of external crustacean parasite *Argulus* was done. Three breeding trials were conducted using pond based captive brooders. Females having oocyte diameter

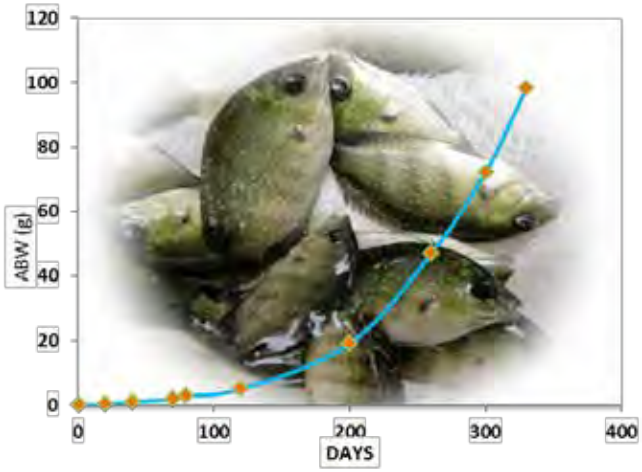
Preparation of hormone pellet for milkfish broodstock

Implantation of hormone pellet in milkfish broodstock

above 650µm were administered with HCG hormone @ 250 IU /kg body weight. The number of spawned eggs varied from 2.0-6.0 lakhs and a fertilization rate of 45 to 75% was recorded. Hatching rates were estimated between 60-80%. Cobia larvae were fed with rotifers *Brachionus plicatilis* initially followed by addition of *Artemia* nauplii. After 15 days post hatch, weaning diet was provided along with *Artemia* nauplii. After 45 days rearing, the cobia larvae attained an average size of 76 mm. A total of 2500 hatchery produced were supplied to the farmers for pond culture demonstrations.

Milkfish, *Chanos chanos* - captive broodstock development and induced maturation

With a viewpoint of laying down a future roadmap for sustainable brackishwater aquaculture, CIBA is placing a major thrust on the development of breeding and seed production protocols of the major brackishwater herbivorous finfish species; the milkfish and the grey mullet. Hence efforts have been focused on developing a captive broodstock and its maturity induction. A total of 15 fish (size, 4.2-7.0 kg) are currently maintained in 100 t capacity RCC tank at MES-CIBA. Formulated maturation feed (size slow sinking pellet, 6.0 mm) was provided @ 3% body weight daily. LHRHa, hormone pellet @ 50µg/kg body weight, was implanted intramuscularly in all the fishes at monthly intervals from January 2015 onwards to accelerate the maturation. CIBA and Aditya fish hatchery, Kakinada have entered into an MOU to establish milkfish hatchery with CIBA as knowledge partner to facilitate sharing of knowledge, resources and expertise for captive milkfish breeding. A total of 50 milkfish brooders (size range, 2.5-4.0 kg) are being maintained at Aditya fish hatchery, Kakinada in a holding facility of 300 t capacity RCC tank. For inducing maturity LHRH-a hormone pellets were prepared and implanted @ 50 µg/kg of body weight. An anaesthetic dose of 300 ppm 2-phenoxy ethanol was used for handling and implantation. Gonadal biopsy was conducted to evaluate the stage of oocytes. All fishes were observed to be in the first stage of maturity, and 8-10 fishes had primary oocytes. Oozing milt was recorded in six fishes.



Growth performance of the F1 pearlspot from fry to adult fed formulated feed under tank conditions

Closing the lifecycle of pearlspot: Pearlspot has tremendous potential for selective breeding, and closing the life cycle of any fish under captive conditions is a criterion for selection programs. The F_1 young ones, obtained from the wild caught parents were separated from the parents and grown in periphyton based green water system, floating baskets and green water tanks of different sizes, as per the requirement in their different life stages. Later, from the tank reared stock, unsexed pre-adults were randomly stocked in five tanks (1 mt) each with 15 animals, and fed standard maturation diets. Once pair formation were observed, single pairs were isolated and allowed to spawn naturally in tanks. First spawning of the captive reared F_1 pearlspot was observed after 11 months and six days of age. Thereafter there were series of repeated spawning by 15 pairs (36 spawning). The results suggest that pearlspot can be bred in captivity for generations by using formulated diets and green water rearing system.

Breeding and seed production of pearlspot in cement tanks: Over 200 nos. of adult broodstock of both sexes (50 – 250 g) were being maintained in rectangular rigid PVC net cages (3 x 1 x 1 metre) and FRP circular tanks (1 and 5 t) with water flow-through facility. Commercial feed pellets (35% crude protein, 5% crude lipid, 4.5% crude fibre and 12% moisture) were fed to the broodstock *ad lib* in suspended trays. Periodic prophylactic treatments were given. Breeding sets comprising of selected males and females in the ratio of 6 females (size range 65 - 168 g) to 4 males (size range - 62-107 g) were allowed to spawn naturally in specially set up breeding systems (5 t RCC tanks with soil, seawater flow-through and terracotta substrates for egg attachment) and the larvae were collected and reared separately.

Pearlspot seed production in RAS system of 1 t tanks: We hypothesise that early larval separation that curtails the energy invested in parental care in pearlspot can be adopted as a strategy to reduce the breeding interval of pearlspot. In a four month study, it was possible to reduce the breeding interval to an average of 17.6 ±1.12 days. Six breedings by a single pair could be recorded resulting in production of 8000 larvae. Breeding intervals of 20, 15, 20, 15 and 18 days respectively were recorded. The number of larvae collected in each of these breeding were 1400, 1950, 1050, 950, 1350 and 1300 respectively indicating that early larval separation can be adopted as a potential strategy to reduce the breeding interval in pearlspot.

Eighteen successful spawning was achieved and the seed (approx. 2000 nos per batch) at various stages of development, *viz*. egg batches, wrigglers, swarming larvae and free swimming larvae were collected. Larval and nursery rearing protocol was further refined. *Chlorella* (green water) was found essential for larval survival. Rotifer and *Artemia* nauplii feeding followed with powdered feed (100 – 200 µm) was used for fry rearing. Pearlspot seed were supplied to farmers from Andhra and Tamil Nadu (3030 Nos.) and other experimental activities (total revenue Rs. 17,190/-).

Broodstock development and induced breeding of brackishwater ornamental fishes: The potential of brackishwater ornamental species is yet untapped in India. CIBA has been working on two commercially important brackishwater ornamental finfish species,

Breeding intervals and respective larval production by a pair of pearlspot

Brooders of Spotted Scat, *Scatophagus argus*

the spotted scat and moon fish. More recently, CIBA has successfully conducted breeding trials on orange chromide and crescent perch.

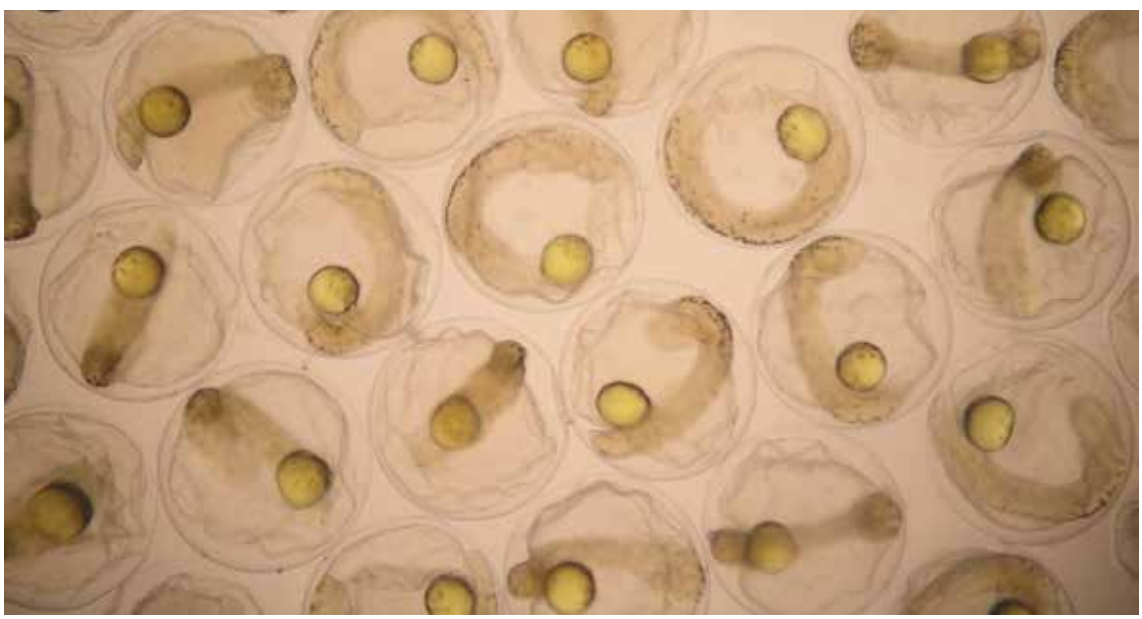
Spotted scat *Scatophagus argus* maintained under captivity were selected for induced breeding. A total of five sets of breeding trials were conducted, with female fish having oocyte diameter exceeding 400 µm and oozing males. Induced breeding trials were conducted by administering hCG and LHRHa as priming and resolving dose. The ovulated females were subjected for stripping of eggs and milt collected

Brooders of moon fish, *Monodactylus argenteus*

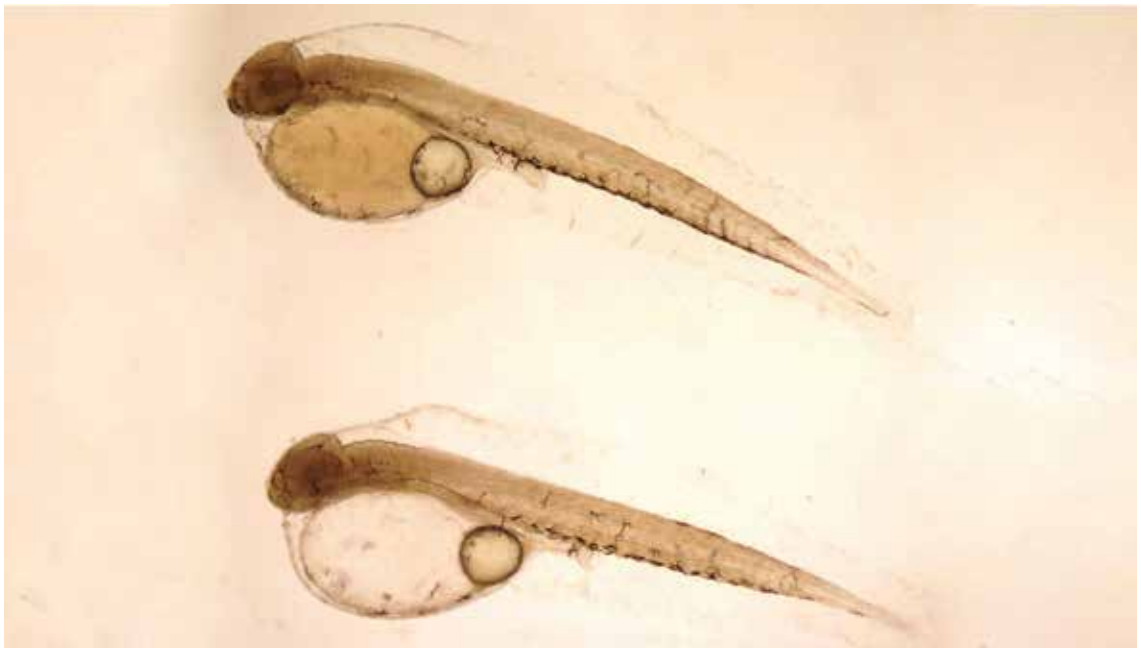
Broodstock of crescent perch *Terapon jarbua*

from the males were used for external fertilisation of the eggs. Out of five sets, three showed successful fertilisation and in two cases hatchlings were obtained. The larvae could be reared up to 15 days.

The moon fish *Monodactylus argenteus* maintained under captivity in the ponds were examined for maturation periodically. Oozing males could be obtained in the fishes having a body weight in the range from 45 to 60g. Breeding and larval rearing of a new candidate brackishwater ornamental/food fish species, *Terapon jarbua* (Crescent Bass, Crescent Perch or Tiger Bass), family–Terapontidae, order-Perciformes were successfully conducted. Mature males and females were collected from brackishwater



Embryonic development of cresent perch



Cresent perch, 1-day old larvae

pond and acclimatized to captive condition for a week in a flow through system (temperature, 25-27^{0}C; salinity, 25-27 ppt, pH, 7.5-8.2, dissolved oxygen, 6.0-7.5 mg L^{-1}). To assess the maturity, female fish were canulated and examined by applying gentle pressure near the abdominal region. Female having the oocyte diameter above 460µm were selected along with the oozing male. In the four breeding sets, a male-female of 2:1 was maintained. Of the four sets, two set were administered with HCG@300 IU kg^{-1} and other two sets were administered with LHRHa @ 75µg kg^{-1}, half the dose was given to the males. 36 h after injection, spawning started in all the sets (fertilized egg size: 750 µm), after 16-18 h of incubation hatching

Cresent perch, 52-days old fry

Breeding system of orange chromide

was observed. Hatchlings were of 2 mm size with the yolk sac length of 75µm and a single oil globule were observed. After 12 h post hatching, concentrated algae (*Chlorella salina.)* were introduced in the larval rearing tanks and after 48 h rotifer, *B. plicatilis* feeding was initiated. A total of more than 3 lakhs spawns (2 days old) were collected.

Breeding Facility for Orange Chromide, *Etroplus maculatus* in Fish Hatchery MES of CIBA

The Orange chromide, a species of fish endemic to freshwater and brackish streams, lagoons and estuaries in southern India and Sri Lanka was bred in captivity in 11 successful breeding trails and the larval

Brooders of orange chromide

Fertilized eggs of orange chromide attached to the substrate

rearing was conducted. A total of 247 live specimens (body wt., 6-10 g, tl, 60-90 mm) of orange chromide were collected from the freshwater tank of Kovalam and stocked in the rearing tanks. The fish were fed with pellet feed. Six sets each of four adult fish were stocked in a 6 number of 200 litre conical tanks. In each tank, earthen pots were placed vertically to act as a substrate for egg deposition. After 7 days of stocking the pairs, 86 numbers of larvae were collected from single pair of fishes and stocked in 100 litre FRP tank for larval rearing. Live food organisms such as chlorella and rotifer were introduced in the larval rearing tank to serve as feed for the larvae.

Larval rearing of hilsa: Mature females and males of Hilsa was caught from Hooghly river at Godakhali region (22.39°N, 88.14°E). Breeding was done by dry stripping. After fertilization, the fertilized eggs were observed under microscope for the developmental stages. Blastomere and morula stages were observed 5 hours after fertilization and blastodisk was observed about 7-8 hours after fertilization. Early embryo was observed at 8 - 9 hours after fertilization whereas tail bud stage was noticed at around 8 -12 hours. Tail free stage was observed at around 16 hours of fertilization. Late embryo was observed at around 18 hours. Complete hatching was observed at 22 hours after fertilization. Fertilization rate was 43.7% whereas hatching rate was 68.9%. Larvae were at four salinity levels (0.5‰, 1‰, 1.5‰, and 2‰) and under each salinity level with different treatment, e.g., antibiotic, anti-fungal and both. After 15 days, the survival of hilsa larvae was better (53.33%) in 1.5‰ salinity with combination of antibiotic and antifungal treatment.

* * *

Nutrition and feed technology

Top: **Spheronized larval feed**
Bottom: **Organic shrimp feed**

Nutrition and feed technology

Growth, wellbeing and reproduction of any aquatic animal primarily dependent upon an adequate supply of nutrient, irrespective of the culture system in which they are grown. Nutrition in synergy with ideal water quality is a key driver in realizing the maximum genetic potential for growth and reproduction in any aquatic species. Nutrient requirement beyond the natural feed contribution needs to be met with a nutritionally complete supplementary feeding to achieve the farming goals. Therefore, for maximal growth, fish nutrition needs to be tailored to each of the species and their stages of development. Not only feeds, feed management are also a critical element which results in effective delivery of nutrients to the cultured aquatic animals. The feed and its management cost are considered to be the highest recurrent cost in aquaculture, often ranging from 30% to 60%, depending on the intensity of the farming.

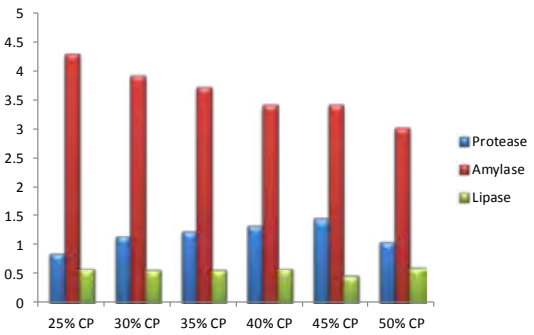
Research and market analysis anticipates the fish feed market to grow at a compounded annual growth rate (CAGR) of around 20 % up to year 2019. However, the more established shrimp feed market is forecast to post a CAGR of around 12 % during the same time period. This scenario is expected to create huge competition and demand for ingredients in the aquafeed industry. However, being a major player in agriculture, there exist an opportunity to face this situation with planning and judicious utilization of available resources. Research and efforts needs to be focused on alternate ingredients from terrestrial animal processing industry and agricultural by-products to increase the choices in the ingredient basket. CIBA has already initiated work on several sustainable alternate protein sources of plant and terrestrial origin and has shown promising choice of ingredients, even in formulations of carnivorous fish like Asian seabass.

Among the several feed ingredients, fishmeal is an important and costliest ingredient which is mainly sourced from wild capture fisheries. Our previous findings have shown that chances of replacing fishmeal and fish oil with other alternates sources. However, it requires proper understanding on aspects such as interactions with other nutrients, constraints in feed processing and their influences on final nutritional value of cultured fish/shrimp, particularly the long-chain omega-3 fatty acids. Although the necessity of more economical feeds is clear, it is understandable that fish feeds need to be cost-effective, eco-friendly and sustainable. In this scenario CIBA's research on aquaculture nutrition has been planned with the following objectives:

- To understand the nutritional physiology and nutritional requirements of the candidate species under varying environmental conditions and life stages.
- Development of species specific, environment friendly feeds using ingredients obtained from sustainable sources.
- Exploration of potential unconventional ingredients as sources of nutrients in grow-out feeds.
- Use of bioactive compounds as ingredients targeting specific functions in the target species (functional feeds).
- Fine tuning of feed management aspects and maximise nutrient delivery from supplementary feeding and better utilization of natural food organisms in the rearing system as source of nutrients for candidate species.
- Feed mediated nutrient fortification in the cultured organism, targeting human health.

Optimization of dietary nutrients for Indian white shrimp

Protein is a key and costliest nutrient in the aqua feeds, and their requirement varies significantly in respect to life stages and rearing environments for the same species. Influences of varying protein levels (25 - 50% CP protein) on growth parameters, digestive

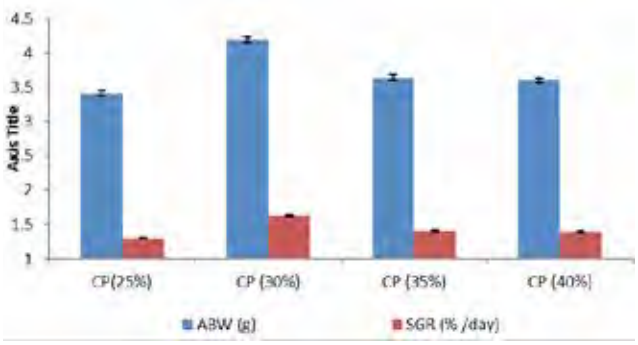


Effect of dietary protein level on digestive enzymes in *Penaeus indicus*

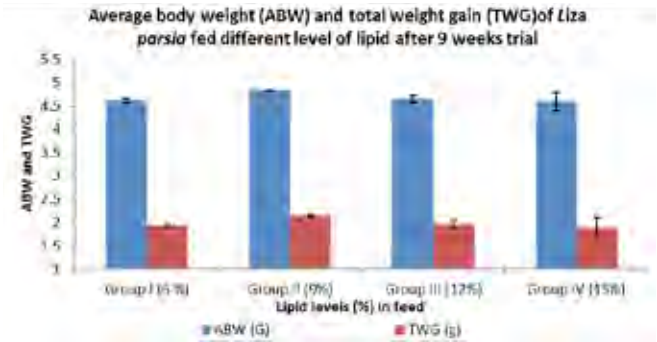
enzymes and the molecular mechanisms in juvenile Indian white shrimp, *P. indicus* (~1 g size) were tested. Based on the growth parameters, enzyme activity and nutrient retention values, it has been concluded that 35% CP is optimum for Indian white shrimp.

Optimization of dietary protein and lipid level for *Liza parsia* fry

To optimize the protein and lipid requirements of *L. parsia* fry, two experiments were conducted, one



Growth performance of *Liza parsia* fed different level of protein



Growth performance of *Liza parsia* fed different level of lipid in a 9 week trial

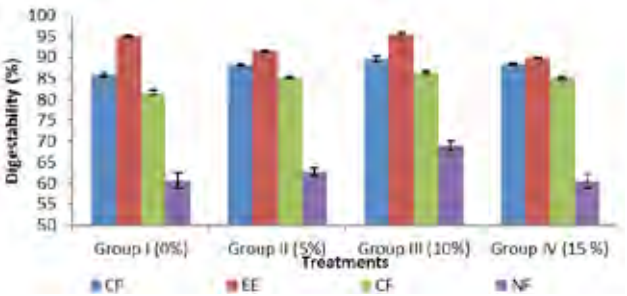
with varying protein levels (25, 30, 35, and 40%) and second with varying lipid levels (6, 9, 12 and 15% in an isoproteic diet with 30% CP). Both the trials were conducted for 9 weeks each with fish fry of 1.5 g average body weight. Specific growth rate was significantly higher ($P<0.05$) in fry fed with 30% protein. Though there were no statistically significant differences in growth performances among the treatments tested in lipid trial, overall better performance was observed with 9% dietary lipid level. Based on the observed growth and digestibility parameters, dietary level of 30% protein and 9% lipid were found to be optimum for the growth of *L. parsia* fry.

Plant by-product as a source of binder in shrimp feeds

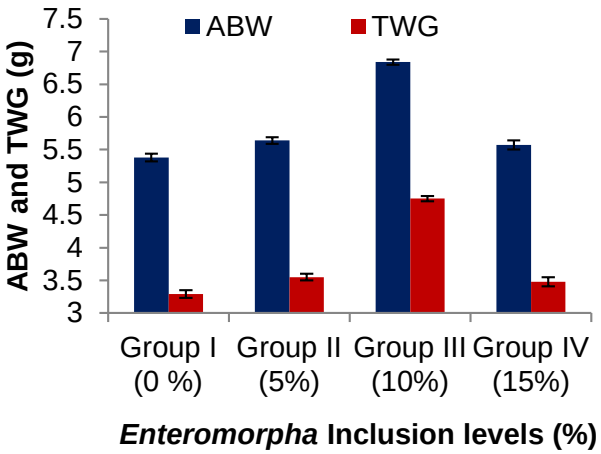
In aqua feed formulation binder is a critical element to ensure the physical intactness of the feed under the water. As an alternative for commercially used synthetic binders, a plant by-product containing natural polysaccharide resins was explored at various levels of 0.25, 0.50.75, 1.0 and 1.25 %. Results of the study revealed that, this plant byproduct containing mixed plant resins could act as a good binder at 0.5 - 0.75 % inclusion, and is comparable to the synthetic binder conventionally used in the shrimp feed.

Optimization of levels of seaweed *Enteromorpha prolifera* in diets of grey mullet and tiger shrimp

While ingredients of animal origin have served as the immediate replacements for fishmeal in aquaculture feeds, the possible use of seaweeds in future holds promise. As an initiative, optimum inclusion level of macro algae, *E. prolifera* in diet of *M. cephalus* and *P. monodon* was determined in two different experiments. Four different dietary inclusion levels (0, 5, 10 & 15 %) of *E. prolifera* in isoproteinous and isolipidic formulations were fed to juvenile grey mullet (ABW 2.09 g) and tiger shrimp (ABW 0.72 g), in a 9 week and 17 week feeding trials respectively.



Nutrient digestibility of *Mugil cephalus* fed different level of *Enteromorpha prolifera* in feed



Growth performance of *Penaeus monodon* fed different level of *Entermorpha prolifera in feed*

The growth performance and digestibility of nutrients indicated that *E. prolifera* can be incorporated at 10% and 5 % levels in diets of *M. cephalus* and *P. monodon* respectively.

Improvement of farm made feed using solid state fermented feed ingredients

Farm-made feeds always depend on locally sourced ingredients and man power for making the feed and application. Therefore it is always more economical

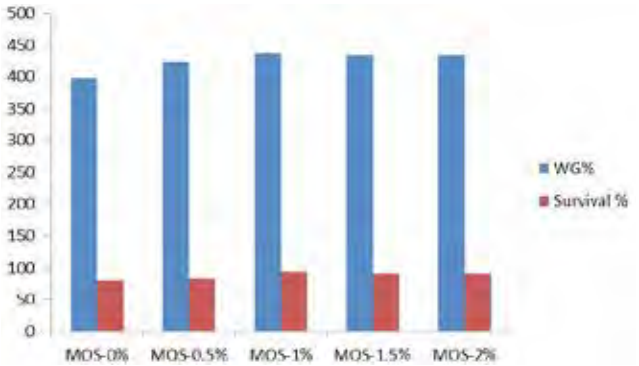
Digital solar powered automatic feeder

and sustainable. A 63 day long feeding experiment was conducted to know the potential of fermented ingredients as alternates for fishmeal in polyculture feed, and also to study the effect of live bacterial supplement in polyculture with juveniles of *M. cephalus* , *L. parsia, L. tade, Scatophagus argus, M. gulio* and *P. monodon* in tanks. Fishes were fed with diet containing either unfermented (control) or fermented ingredients such as rice bran, sunflower cake, mustard oil cake and mung husk along with fishmeal. For fermenting, two potential fish gut bacteria *Bacillus sp (DDKR)* and *Bacillus subtilis (DDKRC5)* were used. Results of the experiment on growth performance and digestibility revealed that fermented ingredients can replace fish meal up to 50% without significant reduction in performance.

Delivery of feed in required quantities at appropriate times based on the appetite of the target animal is critical in feed management. This can be achieved by digitally controlled feeder systems. Considering the remoteness of aqua farms and unstable power supply, it would be ideal if this system can run on solar energy. Considering this, a digital timer based automatic feeder, with four hour power backup and a solar panel were developed as an economically viable model.

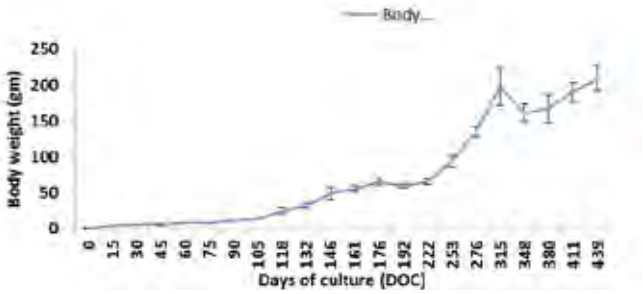
Functional feeds for seabass

The elements of functional feeds may be biologically active combinations that can positively alter the performance of cultured fish. It may be related to general physiology, immunity and gut health.



Growth and survival of seabass fingerlings fed MOS at different inclusion levels.

Manipulation of microbial population in the intestinal tract of aquatic animals through the use of prebiotics is the novel approach to improve the health of the animal. An attempt was made to study the beneficial effect of mannan oligosaccharide (MOS) (as prebiotic) and to ascertain the optimal level of dietary inclusion in *L. calcarifer*. A standard experimental diet formulated to contain five levels of MOS *viz*., 0, 0.5, 1.0, 1.5 and 2.0% was fed to seabass fingerlings (ABW of 8.13g) for 60 days. Fish fed 1% MOS showed significantly ($p<0.05$) higher final body weight, weight gain %, ADG, SGR, DGC and lower FCR than their lower inclusion levels. However there was no significant improvement on further increase in inclusion of MOS. Fingerlings fed with 1% MOS also showed significant improvements in haemoglobin, glucose, cholesterol and triglycerides.



Growth pattern of hilsa shad under captive conditions

Histological studies on the post MOS fed experimental fishes showed encouraging changes in hepatocytes of liver and intestinal villi with increased surface area for absorption of nutrients. Results of this study proved that dietary inclusion of MOS at 1 - 1.5% provided beneficial effect on growth and survival of seabass fingerlings.

Pond and tank rearing of Hilsa Shad

Hilsa shad, *Tenualosa ilisha* is one of the important food fishes in the Indo-Pacific region for its unique taste, flavor and culinary properties. In Kakdwip Center, CIBA, attempts are being made on artificial breeding and pond rearing of this fish in brackishwater conditions. Wild collected hilsa juveniles were reared in brackishwater ponds and cement tanks and studies were carried out on their feed preferences, growth performance and survival.

Specialty feeds for pearlspot maturation

Pearlspot is naturally a low fecund fish which has

Pearlspot breeding using green water system and formulated maturation diets: (in background - eggs, fry, fingerlings and tank sytem).

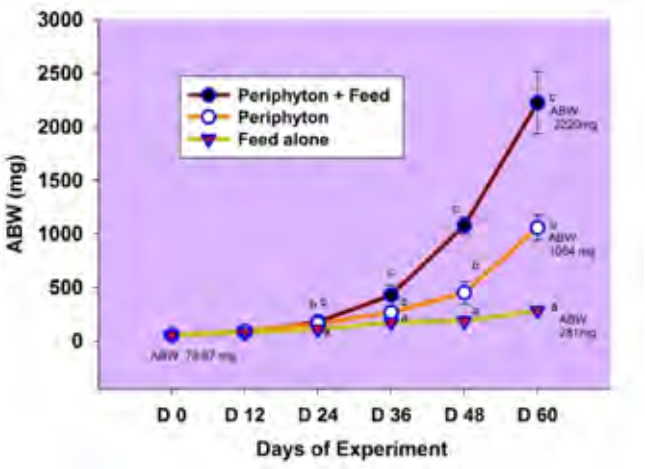
great potential for farming in varying salinities ranging from 0 to 30 ppt. We hypothesized that maximum reproductive potential can be realized with this cichlid fish through a suitable nutritional back-up. In the last two years we have been working on development of maturation diet for pearlspot and succeeded in breeding them as single pairs under captive conditions in small green water tanks using formulated feeds. Our studies showed that 12% crude lipid is optimum in exposing the maximum breeding performance of pearlspot. We have achieved recurrent spawning with single pairs. While average fry production per pair per spawning was around 2500, a highest fry yield recorded was 3480 per spawning. While average number of repeated spawning by single pair per year was around 4, a maximum of 8 repeated spawning was recorded with wild caught fishes.

Pearlspot seed production using formulated maturation feed in field conditions

Pearlspot being one of the top farmed candidate species in state of Kerala, we identified two breeding facilities for testing CIBA maturation feed. The objective was to know the influence of formulated maturation feed on breeding performance of the pearlspot and economics in real field conditions. A tank based hatchery produced 45000 seed using 24 kg of maturation feed and other farmer in pond based system produced 6000 seeds using 18 kg feed. The worked out feed cost per pearlspot seed produced was 5.8 paisa and 33 paisa in tank based and pond based systems respectively.

Specialty feeds and feeding pearlspot larvae

A growth trial was conducted for 60 days with 20 days old pearlspot fry (ABW 78.67 mg) to test the influences of feeds such as formulated feed, natural periphyton and periphyton+ formulated feed. There was significant differences ($p<0.05$) in weight gain of larvae among the treatment. The fry which grazed the periphyton in addition to the formulated feed showed a maximum weight gain as 2142 mg, while it was only 976 mg and 202 mg respectively in fry fed either periphyton or formulated feed alone. This indicates that, periphyton based rearing system and supplementary feeding with compounded feed would be apt model for rearing young pearlspot larvae in the absence of parental care.



Growth patterns of pearlspot larvae under different feeding strategies

Tank and pond based systems used to evaluate the formulated maturation feeds

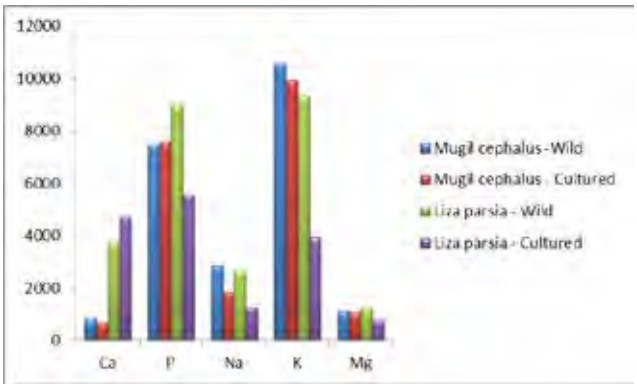
Nutritional characterization of micro algae

Micro algae have the potential to be used as live feeds for all the growth stages of bivalve molluscs, larval stages of crustaceans and fish. A thorough knowledge on nutritional characteristics and its dynamics is essential for better utilization of this resource in a judicious manner. The protein content of some of the microalgal species ranged from 29.73 to 39.88% in *Skeletonema costatum*, 29.73% in *Thalsssiosira pseudonana*, 19.37% in *Chaetoceros calcitrans*, 33.42 % in *Chlorella vulgaris*, 4.11% in *Nannochloropsis sp,* and 3.52% in *Dunaliella sp*., indicating that some of these species could be exploited as protein sources.

Nutrient profiling of finfish and shellfish

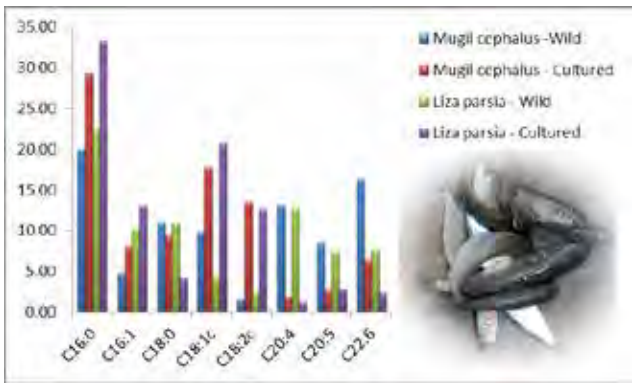
Fish represents the main source of long-chain omega-3 fatty acids (LC ω-3 FA) and protein in the human diet. Three of the candidate species such as *Scylla serrata*, *Mugil cephalus* and *Liza parsia* were collected from both cultured and wild sources and nutrient profiling was carried out.

The proximate compositions of wild and farmed mullets were significantly different. The lipid content was about 7 times higher in farmed *M. cephalus* (3.12%) than in the wild collected one (0.4%). In cultured *L. parsia* the lipid content was 13 times higher (8.73%) than the wild source (0.67%). Wide variations were also observed in the fatty acid and mineral profiles between wild and farmed sources of both mullet species.

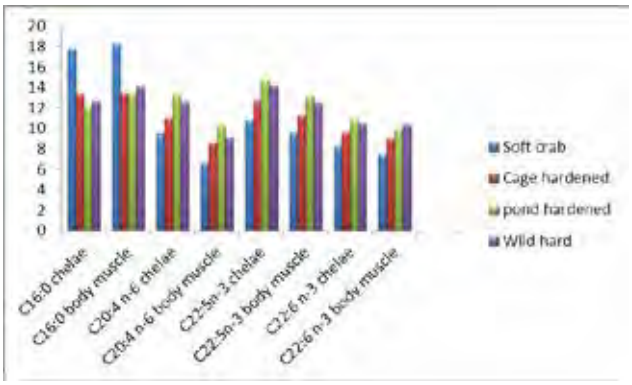


Major minerals of wild and farmed mullets, *Mugil cephalus* and *Liza parsia*

Compared to the hard crabs, soft crabs were significantly higher in moisture, and lower in protein and lipid content in both chelae and body muscles. There was not much difference in nutrient composition between hard crabs cultured and wild. Among the body parts in both soft and hard crabs, protein and lipid contents were slightly higher in body muscle compared to the chelae muscle.



Major fatty acid profiles of wild and farmed mullets, *Mugil cephalus* and *Liza parsia*



Major fatty acid profiles of water and hard mud crab chelae muscle and body muscle

Compared to hard crabs, soft crabs had significantly higher amounts of palmitic acid (C16:0) in both the muscles. However, arachidonic acid (C20:4n-6) and docosahexanoic acids were higher in chelae muscle compared to the body muscle in both soft and hard crabs.

* * *

Aquatic animal health and environment

Shrimp specimen showing black gill disease

Aquatic animal health and environment

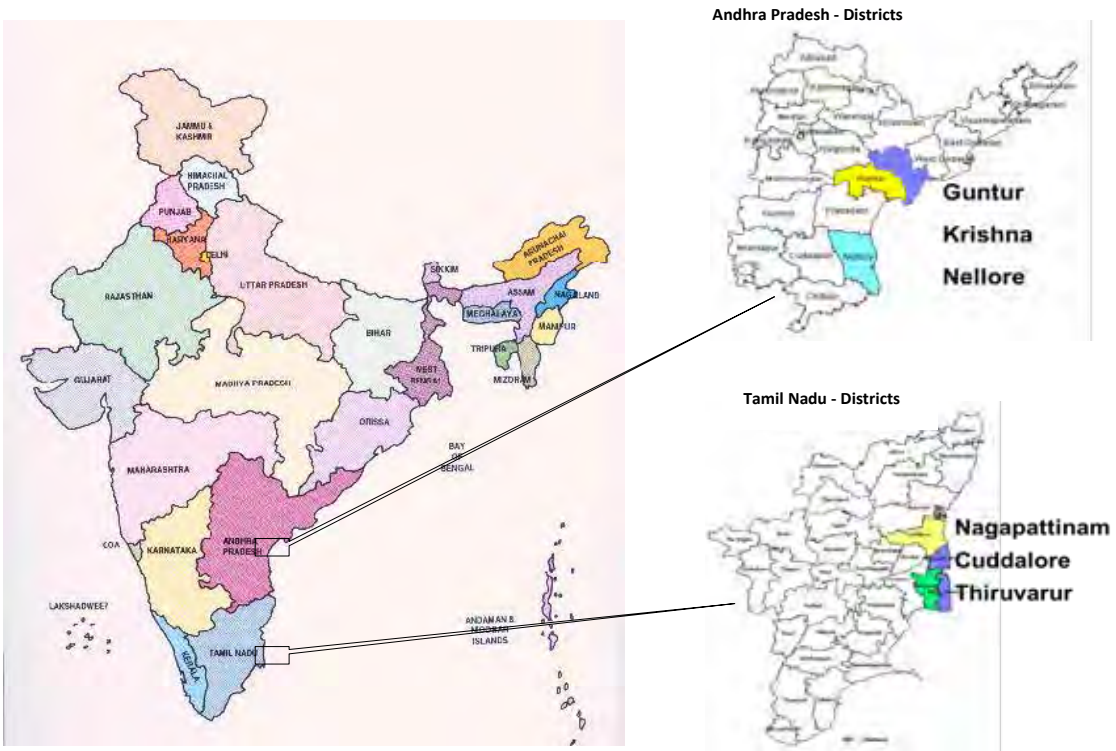
Five research projects are currently going on in the aquatic animal health related issues under the following three main themes. Additionally, the Institute also provides aquatic animal health related services to the fisheries sector.

1. Surveillance of Diseases in Aquaculture including finfish
    a. Major diseases in shrimp aquaculture
    i. White spot disease (WSD) of Shrimp
    ii. Running mortality syndrome of *P. vannamei*
    iii. Stunted growth of shrimp
    iv. Shrimp microsporidian parasite
    v. Zoea syndrome in *P. vannamei* hatcheries
2. Virulence of associated vibrios associated with shrimp
3. Development of prophylactic / therapeutic tools

Surveillance of Diseases in Aquaculture

Active surveillance of aquatic animal diseases in brackishwater aquaculture was carried out in three districts each in Tamil Nadu (TN) and Andhra Pradesh (AP) (Map showing districts in AP and TN under active aquatic animal disease surveillance). Passive surveillance of aquatic animal diseases was carried out in Odisha and West Bengal (WB). Prevalence of WSSV in AP and TN was 15.3% and IHHNV in 5.9% of the 75 farms examined. In West Bengal and Odisha, the prevalence of WSSV was detected in as many as 11 of 22 farm and a bherry. The IHHNV prevalence was low and could be detected in just two shrimp samples (one each from WB and Odisha), Out of 29 samples of wild stray crabs *Uca* spp. and *Sesarma* spp., which are frequently seen in and around the shrimp culture ponds, WSSV was detected in five samples and none of them were positive for IHHNV. The study revealed that the Indian shrimp farming sector was free from exotic diseases such as Taura syndrome (TS), yellow head disease (YHD), infectious myonecrosis (IMN) and acute hepatopancreatic and hematopoietic necrosis disease (AHPND) during 2014-2015.

A study on occurrence of IHHNV in wild caught *P. monodon* from four landing centres in east and west coast and Andaman and Nicobar (AN) islands and farmed *P. vannamei* drawn from various shrimp farms in TN, AP, Odisha and WB revealed that IHHNV was the single most widely distributed shrimp viral pathogens. Of the 231 samples examined, 106 samples (45.8%) were found to be positive.



Map showing districts in AP and TN under active aquatic animal disease surveillance.

Vibriosis caused by various species (*V. mimicus, V. cholerae, V. alginolyticus, V. litoralis, V. paraheamolyticus, V. rumoiensis, V. proteolyticus, V. coralliilyticus, V. pacinii, V. campbellii, V. chagasii* and *V. rumoiensis*) were common in vannamei farms and their occurrence appeared to be related to farm management practices. A recurrent outbreak of VNN was also diagnosed in one of the seabass hatchery under investigation severely affecting production cycle with 100% mortality during Jul-Aug 2014. Out of 32 samples including 15 shrimps, 5 soil and 12 water samples collected from West Bengal & Odisha, the presence of *V. parahaemolyticus* was detected in 9 shrimp, 4 soil and all the 12 water samples. About 180 bacterial isolates were characterized and 60 isolates were subjected to 16 S rDNA sequencing.

As part of the National Surveillance Programme for Aquatic Animal Diseases referral laboratoy, the molecular diagnostic techniques for exotic shrimp viruses such as TSV and YHV and viral nervous necrosis (VNN) of fish and AHPND of shrimp were standardised. The AAHED laboratory also participated in the laboratory proficiencey testing coordinated by Network of Aquaculture Centres in Asia Pacific (NACA) and Australian National Quality Assurance Programme (ANQAP) and the Animal Health Laboratory of Commonwealth Scientific and Industrial Research Organisation (CSIRO).

White spot disease (WSD) of Shrimp

Efforts to develop white spot syndrome virus free brooders for seed production using indigenous shrimp, *P. indicus* as a model were continued. Bacterially expressed dsRNA specific to VP28 and rr2 of WSSV were coated to feed in different combination; i) only VP28 (1 µg/g), ii) only rr2 (1 µg/g), and iii) combination of VP28 and rr2 (1 µg/g). Juveniles *of P. vannamei* (average 7g. size) were continuously fed with the respective diets for 10 days. Control animals were fed with normal commercial pellet feed. All the shrimps were challenged with WSSV on 11th day through oral route. Control animals and animals fed with VP28 had 100% mortality on 3 and half days after challenge. In the group, of shrimp fed with only rr2 or combination of rr2 and VP28, 20% of animals survived till 7 days.

In order to test combined effect of host and viral genes to provide protection through dsRNA treatment, cloning for the host genes Rab7 and Peritrophin were carried out. Brooders of *P. monodon* (tested negative for WSSV and IHHNV) were injected with VP28 dsRNA @ 50µg/shrimp. Eye stalk ablation was carried out after 48 hours of dsRNA treatment. The larvae from the treated broodstock are being monitored for long term effect of dsRNA.

In order to see the protective effect of IHHNV against WSSV during mixed infection, Juvenile *P. indicus* (7-8g in size) were initially infected by oral feeding with IHHNV and subsequently after 10, 20 and 30 days of post infection challenged with WSSV by oral feeding. All the shrimps, including virus free control had mortality within 72 hours of infection indicating no significant protective effect. However, *P. vannamei* reared in biofloc and grown to 22-25g size when challenged with WSSV with 20 and 30 days of IHHNV post infection had 5 days of extended survival compared to control and 10 days IHHNV post infected shrimps.

Genotyping of WSSV isolated (n=35) from different locations of east coast of India revealed that 75% of the isolates amplified for ORF 94 and 42% that of the isolates amplified for ORF 125. Among all the cases, the 8 RU (repeat unit) was more common (42%) followed by 9 RU (25%). From the study it was clear that genetic variation is seen among isolates from AP, TN and Odisha as well as within the same state. Moreover it was evident as majority of the outbreaks could be attributed to one isolate since 8 RU was more prevalent.

In order to know the effect of ammonia on WSSV infection in mud crab, bioassay experiments were carried out. Animals were subjected to ammonia stress (0.1 ppm and 0.2 ppm at pH 8.0±0.2 and salinity15 ppt) and challenged with WSSV. Mortalities were observed by 48 hrs and all treated animals died in 18 days. The tissue samples collected from both dead and survived animals were analysed by both PCR and Real Time PCR to know the WSSV infection copy numbers. All the treatment samples found first step positives and the copy number was found to be in the order of 10^4 - 10^{12}.

Running mortality syndrome of *P. vannamei*

Running Mortality Syndrome (RMS) has been widely prevalent in the vannamei farms in Andhra Pradesh (AP) and Tamil Nadu (TN) since 2011. The causative agent is yet to be identified. Epidemiological, environmental, bacteriological, biological, histopathological and metagenomic investigations were conducted in RMS affected farms (n=25) in AP and TN. The affected farms suffer continuous low-level mortalities during the culture period, resulting in low survival and productions. The disease has been loosely termed as RMS by the farming community. Generally mortalities start after a month or 40 days of culture (DOC); a portion of shrimp continue to survive and can grow to fully harvestable size.

Affected shrimp show patches of whitish musculature in the abdominal segments as a clinical sign.

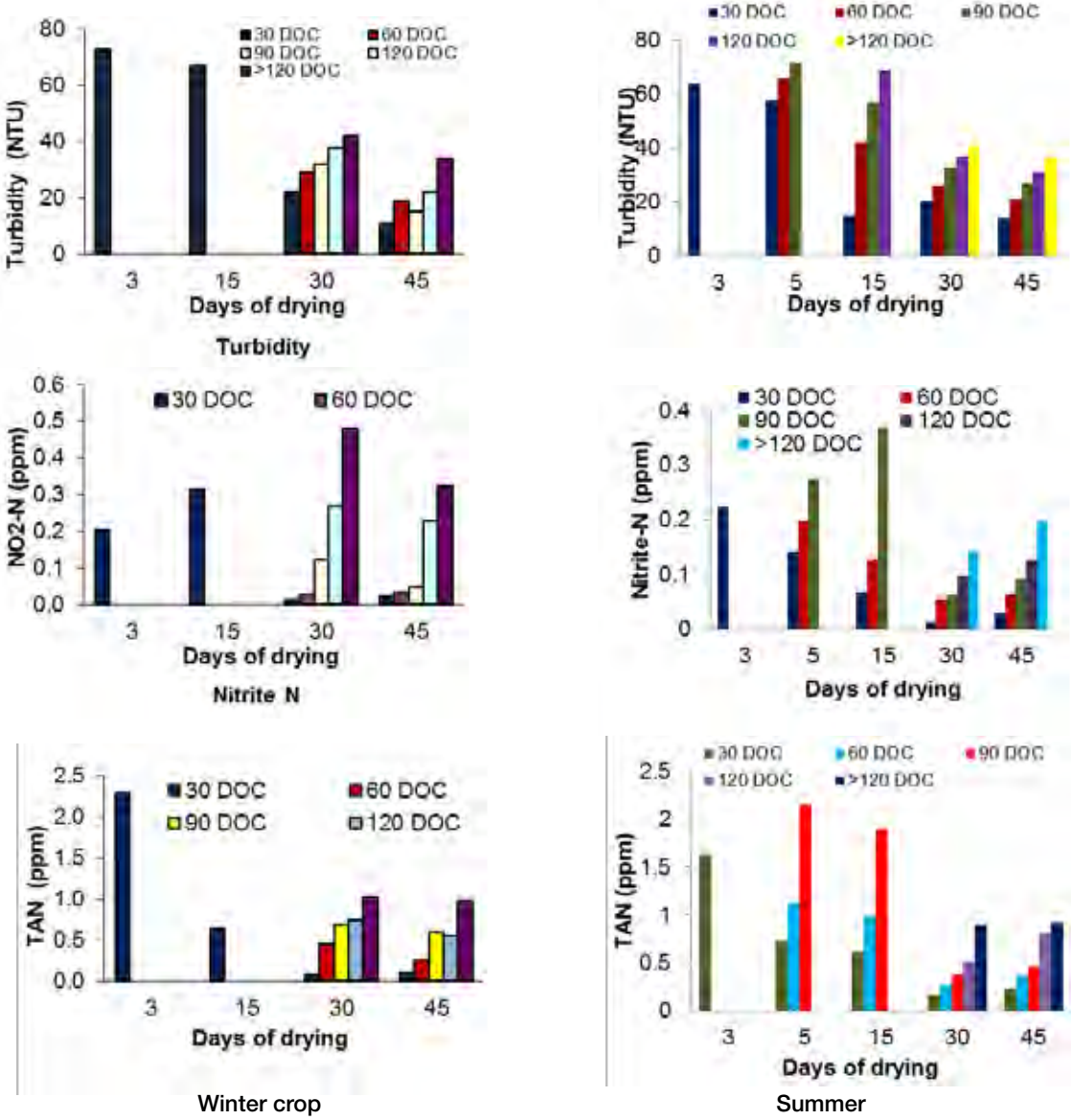
Shrimp crop harvested on emergency due to running mortality syndrome

Investigations have revealed no association with known shrimp viral infection. Shrimp from RMS affected ponds tested negative for WSSV, IHHNV, IMNV, TSV, YHV, MBV, HPV and PvNV. Bacteriological examination of haemolymph samples of RMS affected shrimp indicated predominance of *Vibrio* spp., such as *Vibrio parahaemolyticus* and *Vibrio azureus.* The population of anaerobic bacteria in the gut of RMS affected shrimp ranged from 72 - 252 x 10^{14} cfu mL^{-1} and were identified based on16S rRNA gene analysis as *Enterococcus faecium, E hirae*, and *Lactobacillus plantarum*. Bacterial diversity of RMS affected shrimp gut associated bacteria examined by denaturing gradient gel electrophoresis (DGGE) revealed a number of uncultured bacterial sequences. Hepatopancreas tissues from these shrimp were also subjected to metagenomic analysis. DNA was extracted, cloned in TOPO vector and *E. coli* DH 5α cells were transformed. Transformants were screened for inserts using M13 primers. Sequencing of 55 clones revealed presence of *Lactobacillus* and *Clostridium* like sequences, with the predominance of *Lactococcus garviae*. Histopathological examination of the hepatopancreas was largely normal. However, some samples showed karyomegaly and increased inter hepatopancreatic tubular space with haemolymph infiltration, muscle necrosis indicated by haemocytic infiltration and loosened lymphoid organ (LO) tubule cells and constricted lumen. Bioassay experiments carried out by feeding RMS affected shrimp tissue to healthy 13-14 g shrimp did not elicit any disease in the experimental shrimp. All the experimental animals were healthy and active even after two days of feeding RMS affected shrimp tissue and control animals. RMS affected shrimp showed recovery and appeared healthy and active after 6 days of transferring to wet lab in water with optimal parameters. Co-habitation experiment with healthy shrimp and the infected animals also failed to induce RMS. The study could not attribute any infectious aetiology to RMS.

In view of no evidence for the involvement of an infectious aetiology to RMS, the role of better management practices, especially with regard to pond preparation protocols adopted was investigated. The effect of pond drying period between two crops on the performance of succeeding crop was studied in summer and winter vannamei crops in Kavali Mandal, Nellore District, Andhra Pradesh. The values of critical parameters viz., TAN, NO_2-N and turbidity in water and organic carbon in soil (stress factors) were significantly high on days 3, 5 and 15 of drying compared to 30 and 45 days of drying and correlated with incidence of diseases and crop failure. Investigations carried out at CIBA so far indicate that improper pond preparation practices are the main reasons for running mortality syndrome in *P. vannamei* ponds.

Details of pond drying period and pond preparation practices on vannamei crop performance during summer and winter months

Parameter	Pond Drying Period								
	3 Days		5 days	15 Days		30 Days		45 Days	
Pond preparation practices	Water pumping and stocking		Water pumping and stocking	Sludge removal in wet condition, bleaching, and pumping water		Sludge removed, twice ploughing, liming, pumping water, bleaching and soil probiotics			
Stocking Density (no./m^2)	48 (SC)	50 (WC)	50 (SC)	50 (SC)	60 WC)	48 (SC)	40 (WC)	45 (SC)	45 (WC)
Shrimp health and Production	WSSV		RMS, white faecal matter and loose shell, 560 kg/ac	RMS, 480 kg/ac	WSSV	4.8 tons/ac	3.2 tons/Ac	4.4 tons tons/ac	4.13 tons/ac



Effect of pond drying period on metabolite concentration and turbidity in *P. vannamei* culture ponds during summer and winter crops

Stunted growth of shrimp

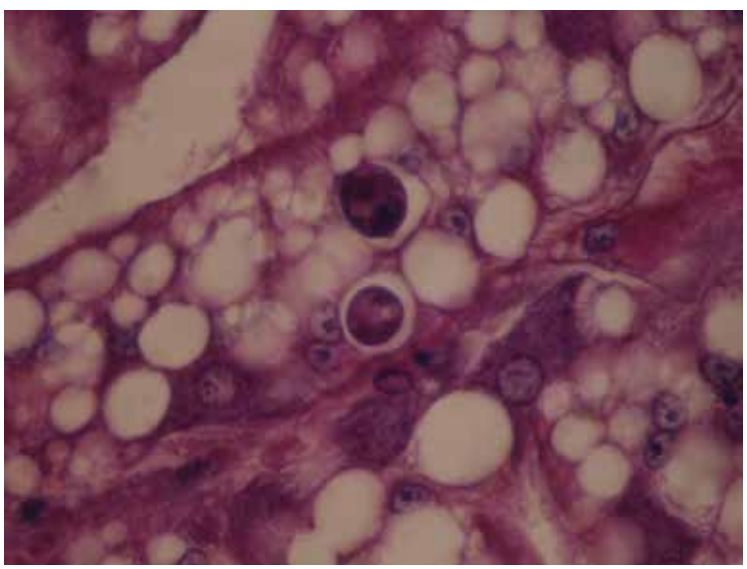
Stunted growth of farmed shrimp is another important syndrome affecting farmed shrimp in India. Shrimp samples (n=320) were collected from both *P. monodon* and *P vannamei* farms (n=60) ranging from 30 - 120 days of culture (DOC from AP, Gujarat, TN and WB) and 36% and 42% of *P. vannamei* samples affected by stunted growth were positive for IHHNV and LSNV respectively. Histopathology investigation carried out on MSGS shrimp showed pathognomonic lesions in different tissue observed especially destruction of organ of Bellonci in eyestalk. Two LSNV samples from *P. vannamei* were sequenced and showed 15 aa deletion when compared with earlier LSNV sequences from monodon. Although the precise etiology of MSGS remains elusive, it appears that IHHNV and LSNV appear to play some role in growth retardation in farmed *P. vannamei.*

Occurrence of shrimp microsporidian parasite

Enterocytozoon hepatopenaei (EHP) is a microsporidian parasite first described in black tiger shrimp *P. monodon* from Thailand in 2009. Although EHP does not appear to cause mortality, recent information from shrimp farmers in Southeast Asian countries indicates that it is associated with severe growth retardation in *P. vannamei*. In some of the shrimp farms in AP and Odisha, microsporidian parasitic infection was suspected as an emerging problem. Samples drawn from vannamei samples from 18 farms (Nellore, Krishna & Guntur in AP), 4 farms (Tiruvarur & Nagapattinam in TN) and one sample from Puri (Odisha) were tested for EHP by PCR, and samples from four farms were found positive by histopathology. Seven samples collected from KRC ponds also tested and found negative by PCR while histopathological examination revealed eosinophilic bodies in one of the samples. In total, samples from 30 shrimp farms were screened for the emerging microsporidian parasite and it was found that four farms were positive by PCR, while 10 farms were found to be positive by histopathology. Further sequencing and electron microscopic studies are in progress for confirmation.

Zoea syndrome in *P. vannamei* hatcheries

In shrimp hatcheries, zoea conversion and mortalities are a major concern. For investigation of the etiology of zoea syndrome larval samples from nine hatcheries from AP and TN were subjected to histopathology and screening for pathogens. Serial gross microscopic observation indicated the symptoms of the syndrome to be prominent after 36-48 hrs of zoea I stage which included arrest of peristaltic movement of gut, empty gut, no faecal strands, and disruptions of the intestinal epithelium. Zoea syndrome affected samples were negative for major shrimp viral pathogens such as WSSV, IHHNV, YHV, MBV, IMNV, HPV, CMNV, and TSV. However, bacteria such as *Vibrio alginolyticus, V. mimicus* were predominat in the Zoea II syndrome affected samples. Vacuolation in the cytoplasm, epithelial cell necrosis, disintegration of peritrophic membrane and detachment of epithelial cell in to the lumen were the prominent histological features indicating possible role of bacteria in this syndrome.



Occurrence of eosinophilic particles resembling enterocytozoan hepatopenaei (EHP) in the hepatopancreas of shrimp; Agarose gel picture showing PCR indicating amplification of putative EHP.

Virulence of vibrios associated with shrimp

Molecular typing of *V. alginolyticus* isolates was carried out by random amplified polymorphic DNA polymerase chain reaction (RAPD-PCR) and enterobacterial repetitive intergenic consensus PCR (ERIC-PCR). The isolates revealed high level of genetic diversity and it was clear that *V. alginolyticus* population in brackishwater environment was dominated by mixed and dispersed groups of environmentally adapted strains.

71 isolates *V. parahaemolyticus* from brackishwater aquaculture system of West Bengal and Odisha were examined by NACA PCR protocol using AP3 primer for acute hepatopancreatic necrotic disease (AHPND) strain specific amplicon of 336 bp. However, none of the isolates were positive for AHPND. Biochemically confirmed *V. parahaemolyticus* strains were screened for the virulence genes such as *gyr*B and *Vp*M genes. While all the isolates were positive for *toxR*, these isolates were negative for *tdh* and *trh*. Out of 71 *V. parahaemolyticus* isolates recovered from the brackishwater aquaculture system of West Bengal and Odisha, the presence of *toxR* gene was detected in 70 isolates as evidenced by visualization of 367 bp amplicon in PCR.

Antibiogram of *V. parahaemolyticus* isolates from the gut of shrimp indicated that all isolates were resistant to colistin (100%), three to amikacin (20%), two to amoxyclav (13%) and one to nalidixic acid. All the isolates were sensitive to ciprofloxacin, cephalothin, chloramphenicol, gentamicin, imipenem, minocyclin, meropenem, norfloxacin, ofloxacin and tetracycline. Multiple Antibiotic Resistance (MAR) index of *V. parahaemolyticus* isolates and it was found to be within the range 0.06 to 0.2.

Immersion challenge experiments by *V. parahaemolyticus* isolates failed to induce significant mortality even at the higher concentration of with 10^5 cfu $mL,^{-1}$ suggesting that these organisms may not be primary pathogens and the mortality observed under filed conditions indicate the possible role of other stress factors.

Further, the pathogenicity of *V. parahaemolyticus* was also tested in mud crabs and it was observed that the pathological changes were more prominent in the digestive gland compared to gills. Normal architecture of the gland was lost after 48 hrs and enlargement of inter-tubular spaces, vacoulisation, and liquefaction of outer hepatopancreatic regions, bacterial infiltration and small patches of necrosis was observed. Epithelial layer of gills were detached after 5^{th} day post infection. Histopathological studies demonstrated the virulence and pathogenicity of *V. parahaemolyticus* in mudcrabs also.

Fish Diseases

In a polyculture pond growing pearlspot (*Etroplus* sp.) along with indian major carps (IMC) and silver carp in Kannur district of Kerala, it was observed that only IMC were infected with bacterial diseases characterised by haemorrhagic lesions in the cloacal region. In another study 80% mortality was noticed due to isopod parasite, *Cymothoa indica* infection in the buccal cavity in cage cultured Asian seabass at Ashtamudi Lake (Kollam, Kerala).

Two of the nursery seabass samples (out of four nurseries (n=14; DOC 14 -20 days) and six farms (n=32; DOC 3- 5 months) from Krishna district in A.P. were found positive for VNN by RT- PCR. Forty fish samples (*Lates calcarifer, Chanos chanos* and *Mugil cephalus*) collected from Tamil Nadu, Andhra Pradesh and West Bengal were tested for betanodavirus and nine samples were positive for betanodavirus. Viral samples could be preserved on whatman FTA card for about a month at 4°C. The PCR products were

Wound infection in juvenile hilsa fish (*Tenualosa ilisha*)

cloned and sequenced for confirmation. Four fish samples confirmed to be positive for betanodavirus were subjected to complete sequencing of RNA2 for genotyping and all were found to have nucleotide homology with RGNNV genotype.

The protocol for preparation of L-15 growth medium, maintenance medium and cryopreservation medium for two of the fish cell lines, SISS and SISK derived from spleen and kidney of seabass was standardised. A strain of betanodavirus originally confirmed from an outbreak of VNN in seabass larvae was inoculated into these two cell lines. The cytopathic effect (CPE) caused by the viral isolate in SISS cell line characterized by cell disruption, and cell rounding and cell disruption from day ten onwards and complete disruption and cell death from day fifteen onwards. The CPE was not prominent in first and second passage in SISK cell line.

Bacteriological study of wound infection in juvenile Hilsa (*Tenualosa ilisha*) from the experimental yard could recover various bacterial species such as *Micrococcus luteus*, *Exiquobacterium* spp., *Corynebacterium propinquum*, *Bacillus* sp., *Acinetobacter* spp., *Pseudomonas alkaligenes*, *Staphylococcous hominis* and *Bacillus oleronius*. Bacteria were identified using phenotypic methods and 16S rRNA sequencing. The causative agent of wound infection is yet to be ascertained.

Parasite infestation by goose barnacles (stalked cirripeds) attached to the gill filaments was recorded in 20% of mud crabs from Pulicat area, Tamil Nadu. The intensity of infestation was more during November and December, 2014 than in January, 2015. However, when the crabs were reared in filtered sea water in the laboratory, the intensity of parasites was reduced significantly.

Development of prophylactic / therapeutic tools

Study on the efficacy of plant based immunostimulant @ 1.0g/kg feed as top dressing in *P. monodon* and *P. vannamei* grow out culture ponds showed significant improvement in average body weight (g), survival (%), FCR and production (kg/ha). Results suggest that the product can be effectively used as immunostimulant and growth promoters for grow out shrimp cultures and a commercial product can be developed.

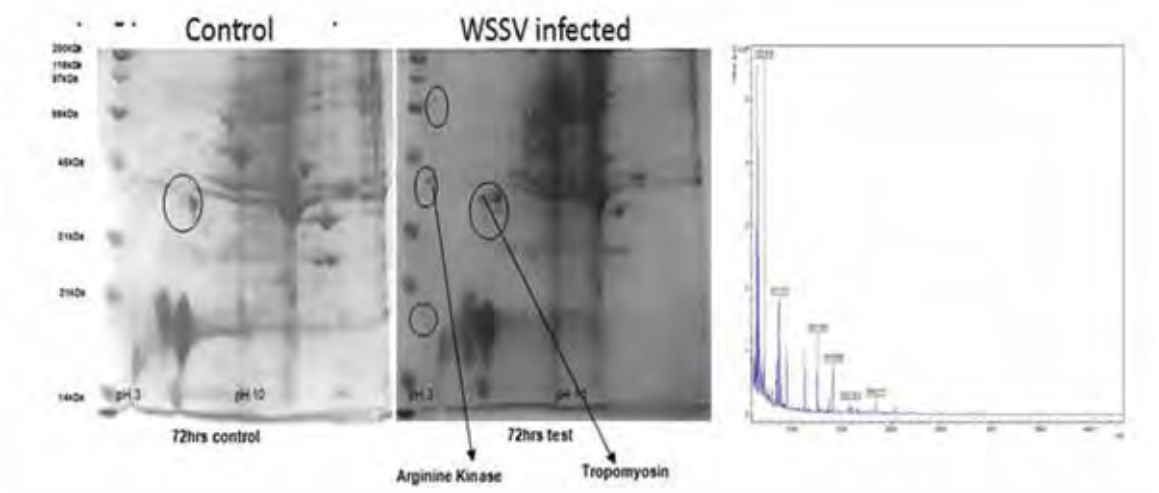
Novel approaches of biocontrol of luminescent bacterial disease in shrimp hatcheries was initiated. Host range of the bacteriophages isolated during previous years was examined against *V. harveyi*. Growth media and the kinetics of growth of host *V. harveyi* isolates and bacteriophages was studied. *V. harveyi* culture reached Log phase from 3h reached stationary phase concentration at 26h. Three inocula concentration showed similar rate of growth and hence lowest inoculum concentration was selected for further experiments. Work on standardizing the parameters for production of bacteriophages is in progress.

Response of shrimp to infection / virulence of pathogens

Response of juvenile tiger shrimp in terms of expression of immunity related proteins was examined. 2-D gel analysis of protein samples from tiger shrimp, *P. monodon* with respect to different time point infection with WSSV using MALDI-TOF analysis revealed that tropomyosin and arginine kinase were differentially expressed at 72 hours of post infection.

Efficacy of plant based immunostimulant on the average body weight (ABW), survival and production of *P. monodon* and *P. vannamei*

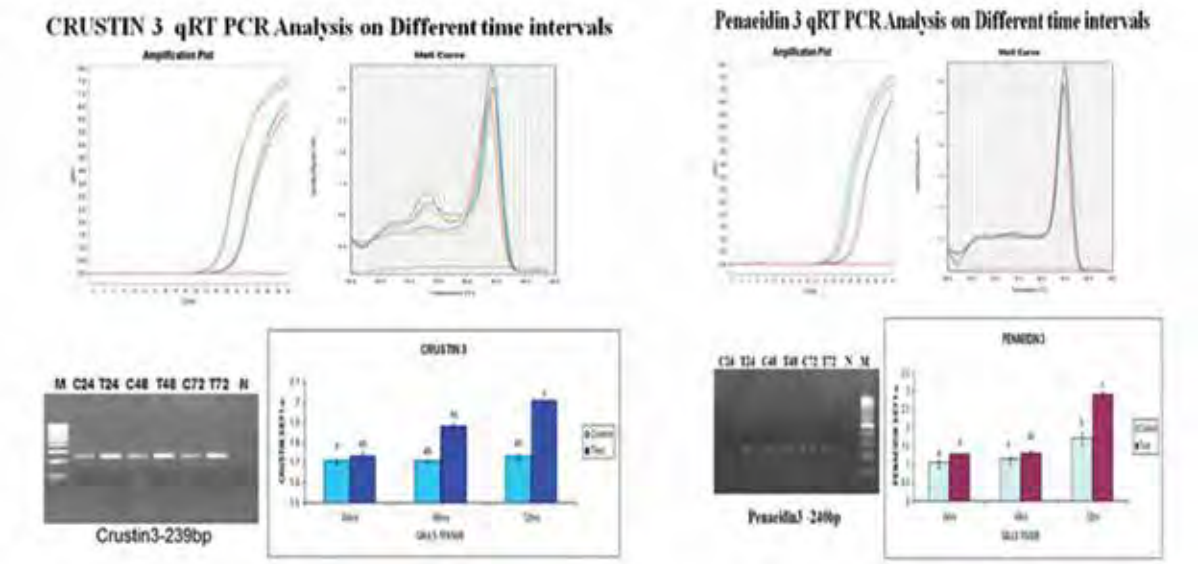
Species	*P. monodon*		*P. vannamei*	
	Treatment (n=9)	Control (n=9)	Treatment (n=12)	Control (n=12)
Area	0.85±0.15	0.65±0.05	0.98±0	1.01±0.03
Stocking	7.57±0.43	8.57±1.43	32.98±0.33	33.27±0.38
DOC	173±13	170.50±9.50	139.5±15.5	145±1.0
ABW	42.24^{a}±7.76	52.34^{b}±3.74	22.83^{a}±1.09	15.70^{b}±2.24
FCR	1.52^{a}±0.10	1.94^{b}±0.03	1.41±0.03	1.35±0.01
Survival	76.46^{a}±0.34	46.74^{b}±3.26	86.94^{a}±6.10	97.75^{b}±0.56
Production	2250^{a}±150	1673.75^{b}±155	6522.96^{a}±83.16	5617.14^{b}±260.41



2D acrylamide gel electrophoresis (A) MALD-TOFF chromatogram (B) of WSSV infected shrimp showing arginine kinase and tropomyosin expression.

In a similar way to analyse the differential expression of genes, both conventional RT-PCR and real time analysis were carried out for 22 defense genes such as crustin and penaeidin. While it was difficult to differentiate the expression pattern by conventional RT-PCR, real time PCR could differentiate clearly the differences at different time point intervals.

To study the sparing effect of defense genes, dsRNA for a specific gene was synthesized to knock it down. At the same time, the expression analysis of other genes was studied. Cloning and dsRNA production for Rab7, Toll and crustin was successfully carried out both by *in vivo* and *in vitro* methods. In one of the experiment, dsRab7 was injected to *P. monodon* and significant knock down of the gene was observed. In those Rab7 knocked down animals, down regulation of PmToll and PmRelish and up regulation of Pm crustin and PmIMD was observed. Study revealed interdependent expression of defence genes in *P. monodon.*



Quantitative RT PCR of immune genes in tiger shrimp upon WSSV infection at different time intervals

Environmental monitoring of *P. vannamei* shrimp farming

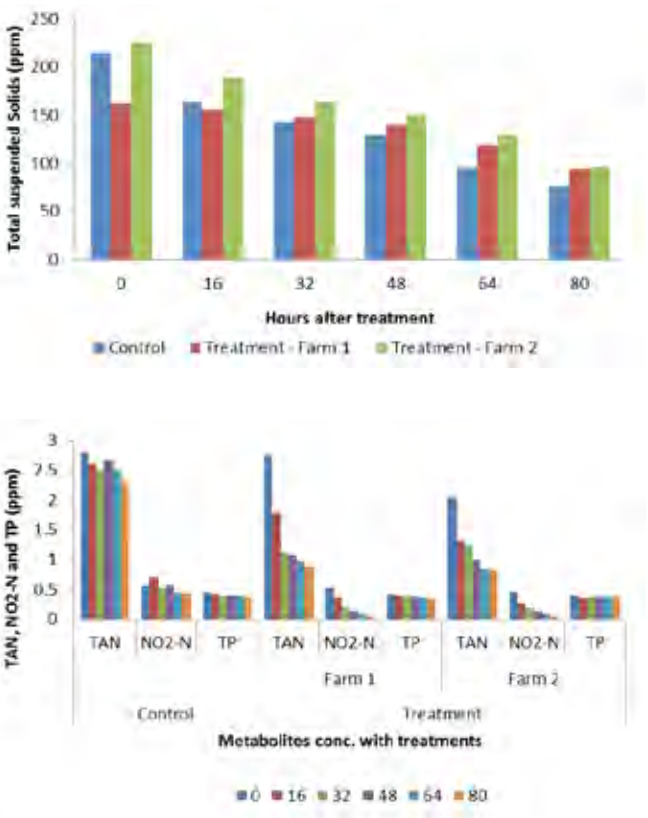
In order to assess the impact of increased area and intensified *P. vannamei* farming on receiving water

Sampling places on Kandaleru creek and shrimp farms covered under the environmental monitoring programme.

bodies and environment, environmental monitoring of *vannamei* shrimp farming was carried out during summer and winter crops on Kandaleru creek, Nellore District, AP. Database on water quality parameters of the creek and shrimp farms discharge water was obtained through collection and analysis of samples at month by intervals from 26 sampling points representing the points on the creek and shrimp farms discharges. The levels of water parameter were high during June-August and November-January months, coinciding with times of shrimp crop harvest. Away from outfall of the farms, parameters in creek were within the optimum range.

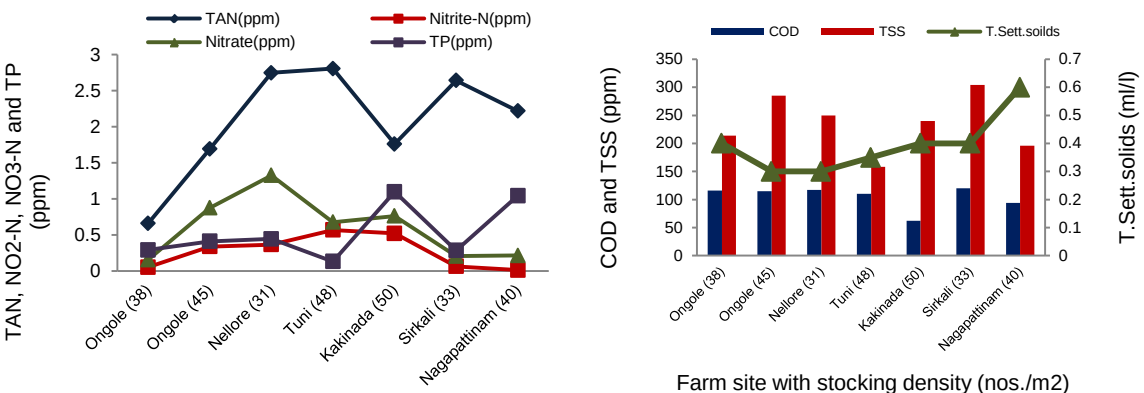
Impacts of brackishwater aquaculture on discharge water quality

Discharge water from different *P. vannamei* farming



Effect of probiotic on metabolites, nutrients and suspended solids concentration in discharge water

systems in AP and TN was characterized. The levels of metabolites, nutrients and suspended solids increased with stocking density (SD), while these parameters in well managed farms with high SD were within acceptable limits. The study also indicated that ponds with low stocking density also require better management, without which the concentration of metabolites would increase, affecting productivity.

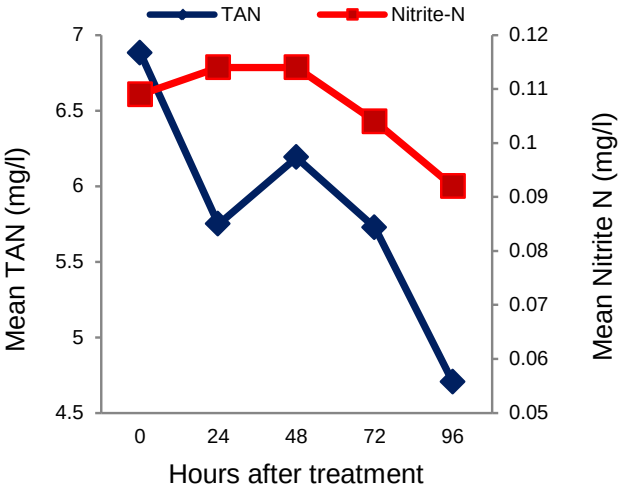


Discharge water quality from farms varying in stocking density

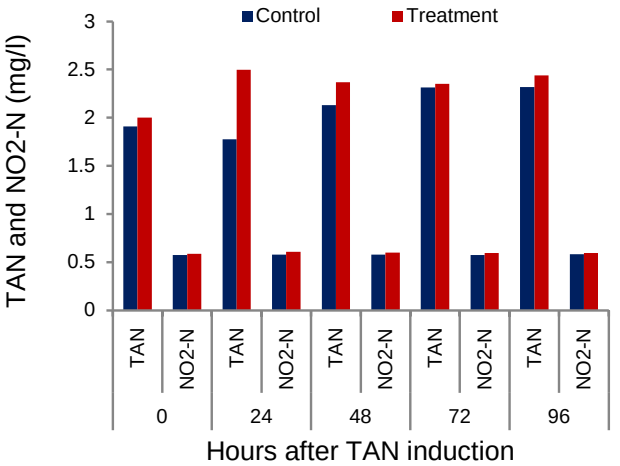
Discharge water of salinity 23-25 ppt from two commercial farms was treated with probiotic, commonly used for industry effluents @ 1.5 mg/l (effective dose derived through yard experiments) in discharge water treatment system (DWTS) pond. There was a decrease in total suspended and settleable solids in both treatment and control. Treatment was superior to control in decreasing TAN and nitrite N within 80 hours, but not phosphate.

Development of bioremediation protocols for ammonia mitigation in aquatic systems

Bioremediation potential of *Shewanella* isolates was evaluated in 35 ppt salinity water spiked with 0.5, 1.0, 1.5 and 2.0 ppm concentration of total ammonia nitrogen for three cycles, each of 96 hrs duration. It was found that *Shewanella sp* isolates were not efficient in the removal of ammonia, but nitrite levels were maintained or decreased indicating the possibility of combining with ammonia reducing bacteria. Ammonia oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB) enrichments obtained from under the AMAAS project of the Institute were revived in the Koops medium, maintained and checked for their efficiency in decreasing metabolite concentration at periodic intervals for three cycles, each cycle of 96 hour duration. Mean total ammonia nitrogen and nitrite nitrogen reduced from a level of 6.88 mg/l to 4.7 mg/l and 0.109 to 0.092 mg/l, respectively. Mass production protocols of these enrichments will be initiated after confirmation of the activity of AOB and NOB isolates in different saline waters.



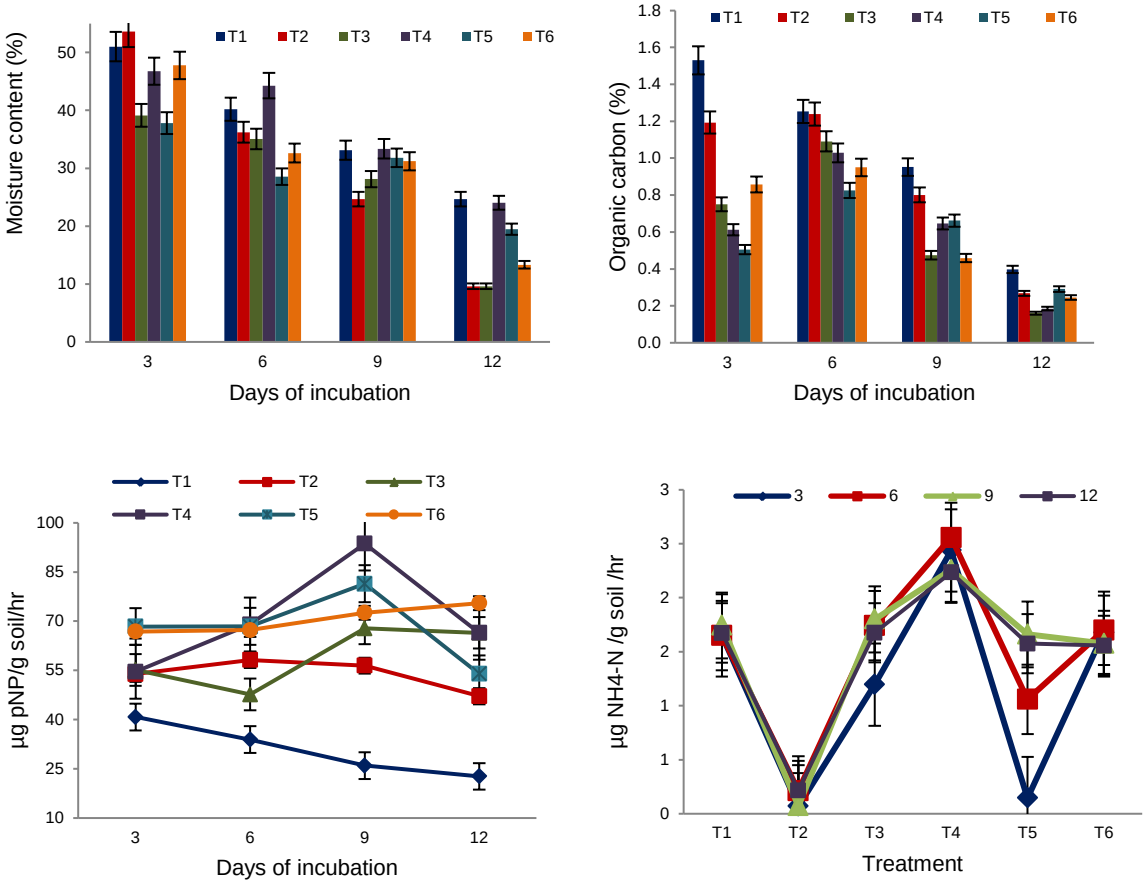
Activity of microbial consortium (AOB and NOB) on metabolites concentration



Bioremediation potential of *Shewanella* sp

Improvement of shrimp pond bottom sediment using oxidizing agents

Deterioration of aquaculture pond bottom conditions after about 50-60 DOC with increases in the redox potential of the sediments is commonly observed. Hence, experiments were carried out to examine if the pond bottom conditions could be improved using chemical interventions. Harvested pond sediment collected from *P. vannamei* shrimp farm was incubated at atmospheric temperature with oxidising agents singly and in combination with the objective of oxidising the unevenly dried pond bottom and also to decrease the pond drying period between the crops. The pond sediment properties determined at three days interval showed a significant ($p \leq 0.05$) reduction in moisture content from 52 to 7.2% and organic carbon content of the soil by 87% (from the initial content of 1.53%) with calcium oxide compared to 24.7% and 67% in control respectively after 12 days of incubation. In order to assess the effect of chemical treatment on nutrient mineralization, activities of enzymes involved in nitrogen (L-amidase) and phosphorous (alkaline phosphatase) was examined. The treatments enhanced the mineralization of nutrients by improving the enzyme activities. Potassium persulphate along with alkali resulted in maximum activities of both alkaline phosphatase (93.6 µg pNP g^{-1} soil hr^{-1}) and L-amidase (2.56 µg NH_4-N g^{-1} soil hr^{-1}). Alkaline phosphatase activity was maximum on 9th day of incubation in all treatments except in control where the activity decreased with the days of incubation, whereas amidase activity reached the peak on 6th day except in calcium carbonate along with hydrogen peroxide, where peak activity was observed on 9th day of incubation. Calcium oxide followed by calcium and sodium carbonate along with hydrogen peroxide and potassium persulphate with alkali were effective in shortening the drying time required to achieve the optimum pond bottom condition.



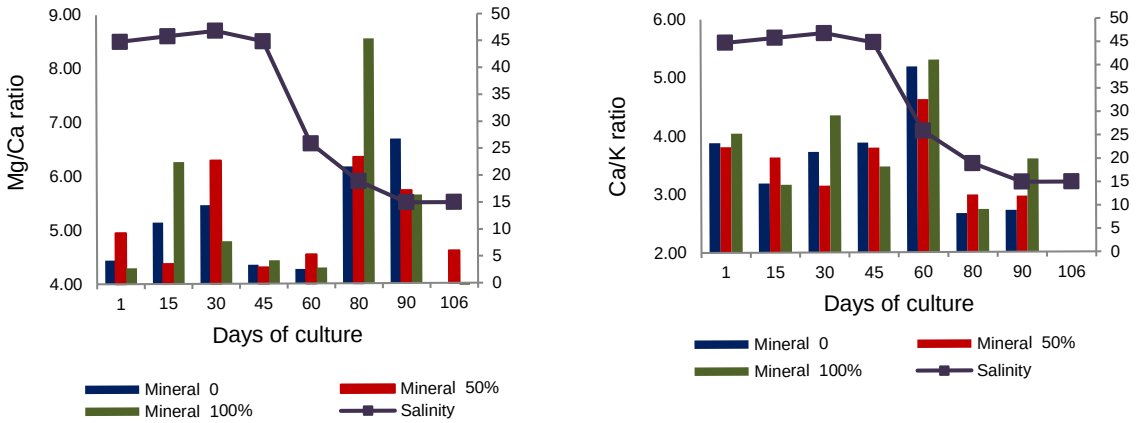
Effect of chemical treatments on moisture, organic carbon, alkaline phosphatase and L-amidase activities of pond sediment

Mineral supplementation in vannamei ponds

In order to answer the farmers questions on necessity of supplementation of minerals, a commercial mineral mixture was examined as per the recommend dose (@8 kg 10 doses), 50% of the recommended dose, i.e., @4 kg for 10 doses, and a control with no mineral application in *P. vannamei* culture ponds in duplicate at Samapore, Navsari District, Gujarat. The salinity

Effect of varying doses of minerals application on vannamei crop performance

	Control	50% recommended dose	100% recommended dose
Area (ha)	1	0.90	0.85
DOC	117	137	113
SD (nos./m^2)	20	21.25	21.40
ABW (g)	25.7	31.05	25.15
ADG (g)	0.22	0.23	0.22
Count	38.91	32.22	41.87
FCR	1.65	2.59	1.70
Survival (%)	67.50	65.00	72.00
Biomass harvested (kg)	3469.5	3916.56	3475.14
Production/ha	3469.5	4243.80	3895.29
Cost of mineral (Rs./kg production)	0	1.31	2.83

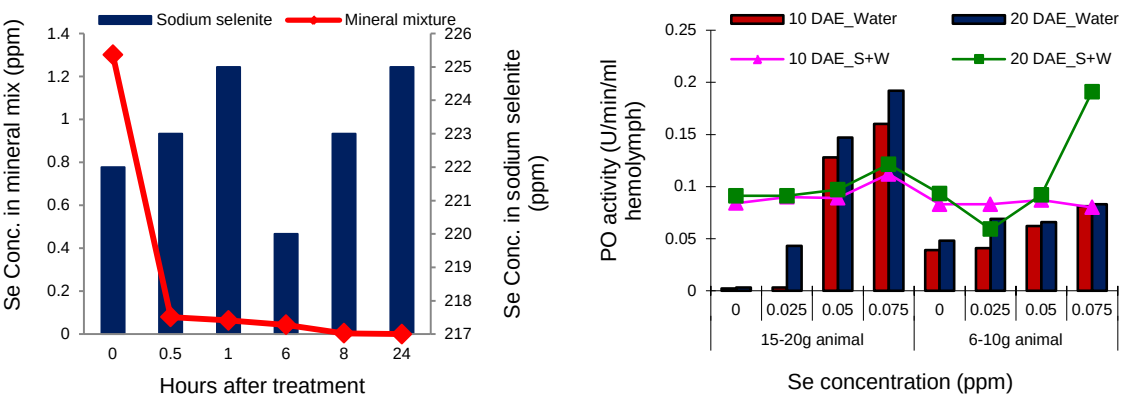


Ratios of mineral ions in culture ponds with varying quantities of mineral application *P. vannamei*

of the pond waters during the culture ranged from 45 ppt at the start of culture to 15 ppt at the time of harvest. Irrespective of the treatment and duration of culture, Mg:Ca and Ca:K ratios were above 4 and 2, respectively throughout the culture period and Na:K ratio ranged from 23 to 30 indicating that no correlation existed between these ratios and shrimp growth. The average shrimp production was high with 50% mineral treatment followed by 100% mineral and control treatments. The economics of treatment inferred that for every one ton of production, Rs.1.31 and 2.83 were spent with 50% and 100% mineral treatments. The study indicated that at salinity levels of 15 and above, application of minerals by farmers was often more than the required quantities.

Significance of selenium supplementation in shrimp culture

Selenium (Se) supplementation through commercial mineral mixtures is being followed for improving the immunity of shrimp. In order to test this hypothesis, availability of Se from commercially available mineral mixture and pure chemical (Sodium selenite) in water phase was evaluated at different water salinities (0, 2.5, 5, 10, 20 & 35 ppt). Se content in the commercial mineral mixture after acid digestion analysed with Cyclic Voltametry was 10 ppm, whereas its availability in water phase was very less (1.3 ppm) irrespective of salinity and decreased rapidly with time due to incomplete dissolution of mineral mixture. Conversely, availability of selenium from sodium selenite was about 223-227 ppm and there was no difference in concentration under different salinities and time intervals. Yard experiment was conducted with and without soil base for three weeks in two size groups of *P.vannamei* (6-10 g and 15-20 g) and four concentrations of selenium (0, 0.025, 0.05 and 0.075 ppm) to study the effect of Se on shrimp growth and immunological parameters. Survival rate of shrimp was marginally better with 90% in experimental tanks without soil base compared to 80% in tanks with soil base. There was no significant difference in the growth



Activity of *P. vannamei* at varying Selenium concentrations

of shrimps and phenol oxidase activity increased with increasing selenium concentration at the end of the experiment. As the availability of trace minerals in water through mineral mixture application was very less, their supplementation can be recommended through feed.

Impact of climate change on aquaculture

Risk Matrix of climate change events on brackishwater aquaculture

A risk matrix of climate change events and their impact on aquaculture generated based on a questionnaire based survey and focussed group workshops at Palghar (Maharastra), Goa, Kumta and Kundapur (Karnataka) indicated that high temperature and tidal amplitude significantly affected aquaculture in Kundapur, whereas, heavy rainfall during July-August and low temperature during December-March had implications to aquaculture in Goa. About 43-55% and 3.3 to 8.4% of farms were under moderate and very high vulnerable categories to aquaculture, respectively.

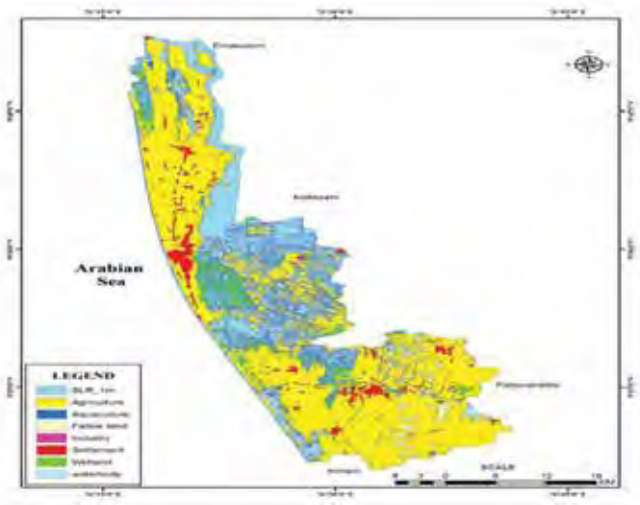
Risk Matrix of impact of climate change events on aquaculture climate in Maharashtra, Goa & Karnataka

Inundation of areas with 0.5 m sea level rise in Alappuzha District, Kerala

Assessment of extent of inundation due to sea level rise

Area of inundation of different land resources including aquaculture was predicted using geo spatial techniques at 50 cm and 100 cm of sea level rise

Consequences/ Likelihood	Disastrous (5)	Extremely Negative (4)	Moderately Negative (3)	Minor Negative (2)	Little Negative (1)
Certain (5)	High Temp & Tidal Amplitude (KUN) Low Temp. during Dec to March (GA)	Low Temp. in Dec (KUN & KUM)	Uneven Heavy RF between dry spells (MH) & High Temp (KUM)	Cloudy weather(KUN) High temp. (MH) Diurnal temp variations (KUM)	
Regular (4)	Heavy Rain (Jul-Aug) (GA)	High Tidal amplitude (GA)		Low Temp.(MH)	
Likely(3)			Diurnal Temp variations (GA)	Unseasonal Rainfall (KUN)	
Possible(2)				Flooding & Delayed onset of monsoon (KUN), Sudden rain & Extended rainy season (GA), Flood (KUM)	Uneven rain Fall & shifting of monsoon (KUM)
Rare (1)					High Tidal Amplitude (KUM)



Inundation of areas with 1 m sea level rise in Alappuzha District, Kerala

(SLR) for Alapuzha district, Kerala and Navsari & Surat districts of Gujarat. The predicted submerged area for agriculture and aquaculture in these districts at 1 m SLR was 15521 and 70 ha out of 101336 and 606 ha in Alapuzha district and 296 and 153 ha out of 155979 and 3109 ha in Surat and Navsari Districts, respectively. Though the submerged area under aquaculture is less, the agriculture area predicted to be submerged can be a potential area for brackishwater aquaculture.

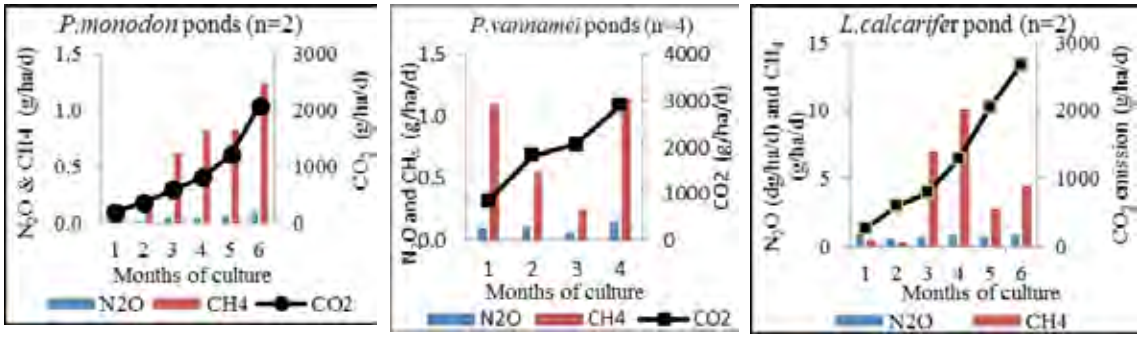
Contribution of aquaculture to global warming potential and mitigation options

Emission of greenhouse gases from different aquaculture systems

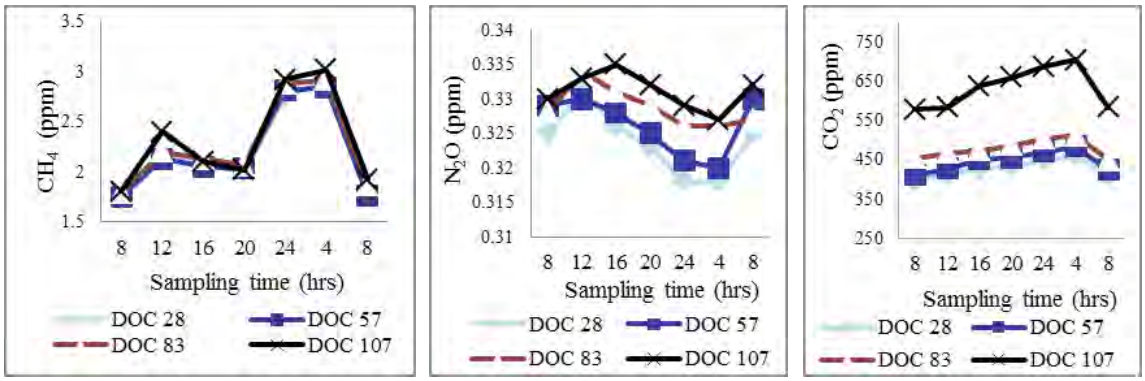
Emission of greenhouse gases (GHGs) was quantified from *P. monodon, P. vannamei* and Seabass cultured ponds. This has been the first of its kind of study from aquaculture sector from India and the data has been submitted to the First Biennial update report of Second National Communication (NATCOM). Emission of all the three GHGs, viz., carbon dioxide, methane and nitrous oxide increased with the days of culture in both shrimp and finfish cultured ponds, except for methane in Seabass *(L. calcarifer)* ponds. The salinity appeared to show inverse relationship with methane emission. Positive correlation of CO_2 and CH_4 was observed with soil organic carbon (OC) and microbial biomass carbon (MBC).

Diurnal fluctuation in the emission of greenhouse gases in *P. vannamei* culture ponds

Investigations on the diurnal fluctuation in the



Emission of greenhouse gases from shrimp and finfish culture ponds



Diurnal variation in the emission of greenhouse gases in *P. vannamei* culture ponds

emission greenhouse gases in the *P. vannamei* culture ponds with stocking density of 44 m^{-2} indicated that methane emissions were high at 4 hrs in the early morning due to anoxic conditions, which decreased at 8 hrs and again increased during day time depending on the temperature. Carbon dioxide emission increased gradually from 8 hrs during the day and higher value was recorded at 4 hrs in the morning. On the contrary, high values of nitrous oxide were recorded during the day compared to night. CH_4 and CO_2 emissions were positively correlated ($p \leq 0.05$) and values of these two GHGs were associated with high values of ammonia and nitrite and low dissolved oxygen.

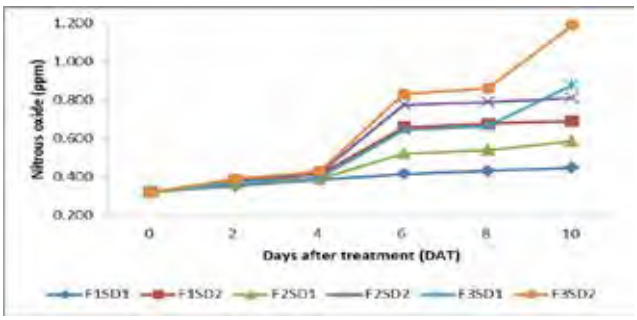
Factors affecting the emission of greenhouse gases

Yard experiments with shrimps in fabricated glass jars was carried out to investigate the role of salinity on the emission of GHGs. The study indicated an inverse relationship between salinity and methane emission, whereas no significant difference was noted with respect to N_2O and CO_2 emission.

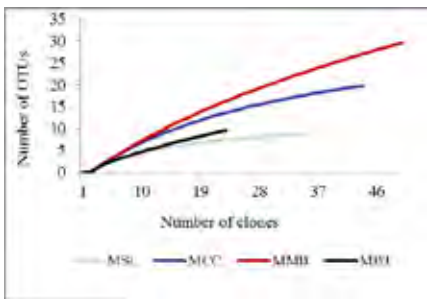
Effect of protein content of feed and stocking density on the emission of GHGs was examined in similar experimental set up. Three feeds with varying protein content (30%, 35% and 40%) were applied at two stocking densities (30 and 60 shrimp m^{-2}) in fabricated glass jars. Emission of all the three GHGs increased with the days of culture and a positive correlation was observed between the protein percentage of the feed and nitrous oxide emission.

Diversity and richness of methanogenic archaea in shrimp culture ponds

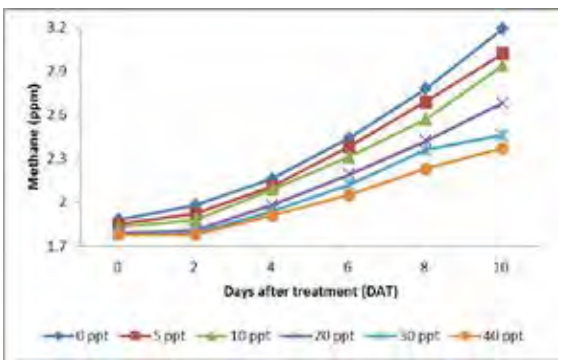
Diversity and richness of methanogenic archaea in shrimp culture ponds sediment was studied by Chao-1 richness estimator, Shannon index and by plotting rarefaction curves. There were potential differences in the distribution of methanogenic archaea in low and high saline water cultured ponds. Diversity and richness was found to be higher for methanomicrobiales (MMB) and methanococcales (MCC). MMB and MCC belonging to genera such as *Methanoplanus, Methanoculles, Methanogenium, Methanococcus* spp. were abundant group in high saline culture ponds, and methanobacteriales (MBT) and methanosarcinales (MSL) such as *Methanobacterium, Methanosarcina, Methanolobus* spp. predominated low saline culture ponds. Methanococcales were virtually absent in low saline sediments.



Effect of protein content in feed and stocking density on N_2O emission



Refaction curves generated from 16S rRNA clone libraries of methanomicrobiales (MMR), methanococcales (MCC), methanobacteriales (MBT) and methanosarcinales (MSL).



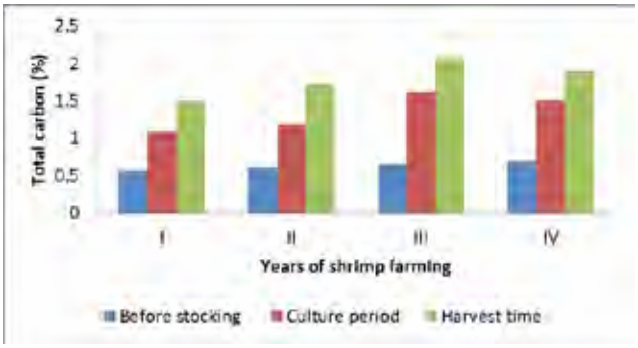
Experimental fabricated glass jars for studying emission of GHGs and effect of salinity on methane emission

Diversity and richness of methanobacteria in aquaculture ponds

Order	Phylotypes detected (No. of clones sampled)	Chao-1 estimator	Shannon index (H')
Methanomicrobiales	30 (49)	61.7	3.22
Methanococcales	20 (43)	26	2.81
Methanosarcinales	07 (35)	10	1.40
Methanobacteriales	10 (22)	17	1.77

Carbon sequestration potential of aquaculture ponds sediment

Total carbon accumulation in shrimp culture pond soil was assessed over a period of eight crops for four years. There was no significant difference with respect to the total carbon content of pond soil over a period of four years. The pond preparation practices like proper drying, tilling and application of lime materials helped in decreasing the accumulated carbon status of soil after harvest of every crop. An amount of 2.4 tons of carbon ha^{-1} was sequestered over a period of four years due to the increase in soil carbon status.



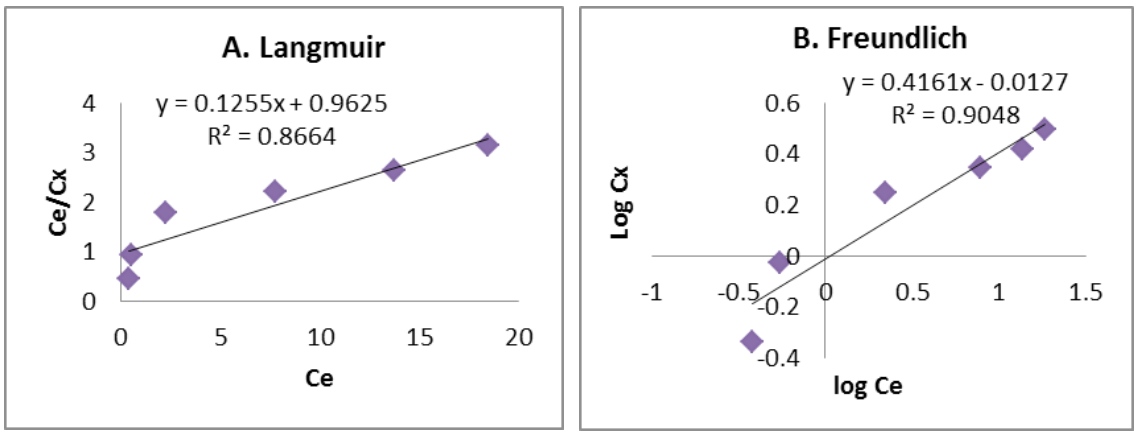
Total carbon status in shrimp culture pond soil over a period of four years

Sediment Biochar

Powdered Biochar

Bio-char for sequestering aquaculture pond sediment carbon

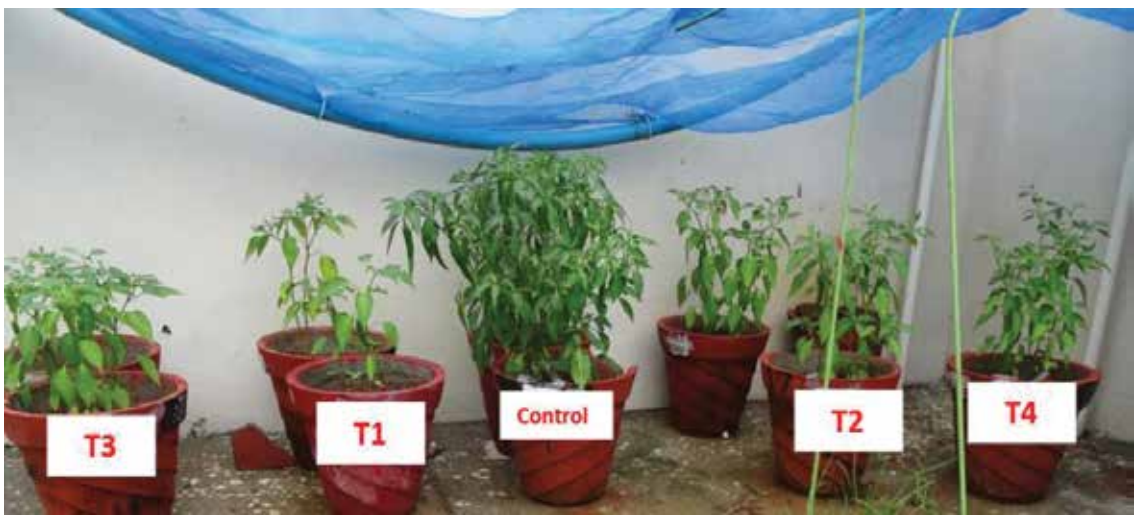
Biochar was prepared by slow pyrolysis process of carbon rich harvested pond sediment from *P. vannamei* ponds. The biochar synthesized was grounded, sieved through 2 mm sieve and kept in desiccator for further use. The biochar was evaluated for its phosphorous sorption capacity at varying phosphorus concentration. The adsorption data was fitted with Langmuir and Freundlich equation. The Langmuir maximum monolayer adsorption capacity was found to be 7.97 mg phosphate per gram of biochar and the affinity co-efficient for phosphorus sorption was 0.13 and would be useful in treating wastewaters high in phosphate.



Phosphorus sorption by biochar indicated by Langmuir's and Freundlich's equation

Evaluation of compost from pond sediment as manure in agriculture

Disposal of accumulated black pond sediment is one of the major issues confronting shrimp farmers. In order to develop mitigation measures, compost prepared from harvested shrimp pond sediment was tested for its potential as manure. Such compost was tested in pot culture experiment with Chilli plants in five treatments viz., recommended dose of manures and fertilisers as control, basal dose of organic manure replaced with compost of normal soil (T1) and pond sediment (T2), basal dose of organic manure and fertiliser replaced with compost of normal soil (T3) and pond sediment (T4). Analysis of soil samples at regular intervals indicated no significance difference among the treatments with respect to pH, EC and organic carbon content. Germination was 100% in all the treatments**,** vegetative growth and pod formation was good in control followed by compost prepared using pond sediment and normal soil. This also helps in mitigating the loss of carbon from pond sediment.



Effect of pond sediment compost as manure on chilli crop

Genetics and biotechnology

Genetics Lab, Headquarters, Chennai

Genetics and biotechnology

The Genetics and biotechnology division of CIBA utilizes state-of-the-art genomic analyses and cutting-edge technologies to discover candidate genes and understand the pathways in physiological process including growth, reproduction and disease resistance in penaeid shrimps. Approaches using bioinformatics and transcriptome analysis are employed to identify genes, microsatellites (SSR) and single nucleotide polymorphisms (SNPs) that are helpful in the selective breeding programmes.

Population genetics

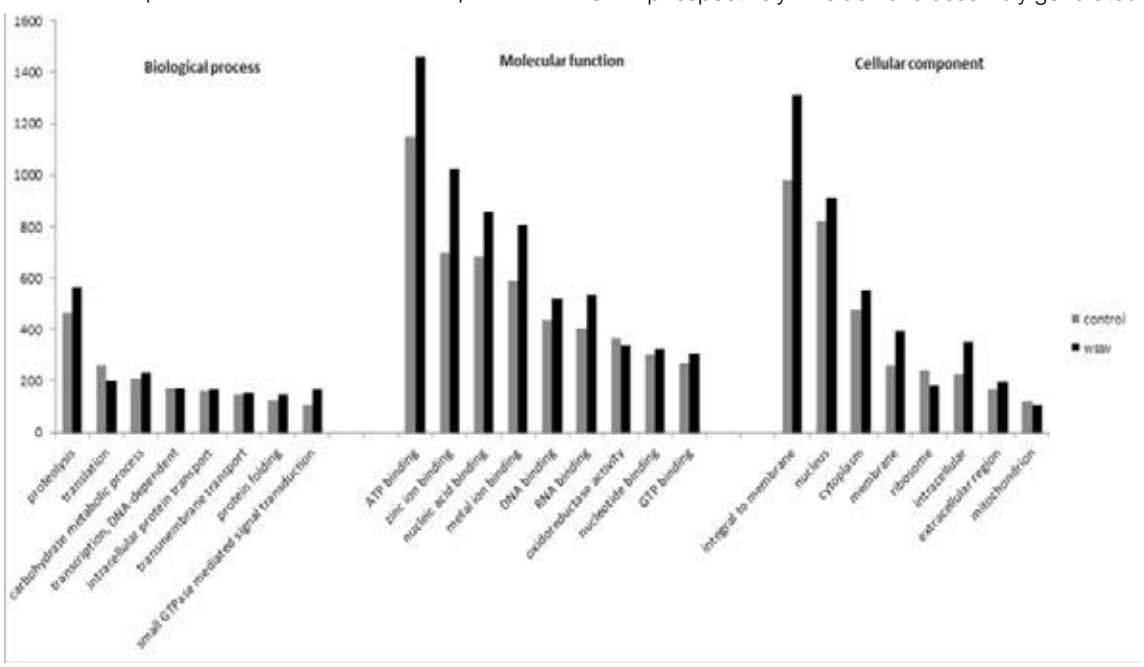
As a part of morphometric characterization, the specimens of Indian white shrimp were collected from Chennai (n=50) and Puri (n=58) coast. The digitized images of 108 shrimp specimens were utilized to generate 18 truss morphometric measurements using software tpsUtil, tpsDig and PAST based on ten landmarks identified on shrimp body. Size-corrected variables were then analyzed separately for each sex by discriminant function analysis in SPSS software (version 17.0). The effectiveness of size-correction was evident in non-significant correlations between truss measurements and total length. The data were analyzed by discriminant function analysis to test the suitability of estimated functions for stock assignment of unknown samples of shrimp. The developed discriminant function could correctly assign 63.1 % of male shrimp and 69.8 % of female shrimp to their respective stocks. During cross-validation, 61.5 % of male shrimp and 67.4 % of female shrimp were classified to original stocks. For the same specimens of these two stocks, head-to-tail ratio was estimated. The tail length was higher in males of both the stocks compared to female shrimp.

Head to tail ratio (mean ± SE) for specimens of Chennai and Puri stocks of Indian White shrimp (values in parenthesis indicate sample size)

Stock	Male	Female
Chennai	1.589 ± 0.027 (30)	1.352 ± 0.020 (20)
Puri	1.599 ± 0.021 (35)	1.474 ± 0.028 (23)

Transcriptome and immune gene expression analysis of white spot syndrome virus infected black tiger shrimp

The recent advances made in next-generation sequencing technologies have prompted the generation of the transcriptome as a high-throughput tool for gene expression profiling. The transcriptome of WSSV-challenged *P. monodon* was generated to unravel the mechanisms of immune response during WSSV infection. Total number of paired end 67.17 million and 68.73 raw reads were obtained from hepatopancreas of control and WSSV infected shrimp respectively. The *de novo* assembly generated



Gene Ontology analysis showing the number of unigenes from control and WSSV infected shrimp *P. monodon* belonging to biological process, molecular function and cellular components categories

a total of 45,437 contigs. A total of 15,758 (~37 %) transcripts from control shrimp and 18,251 (~ 40 %) transcripts from WSSV infected shrimp could be annotated. In both the transcriptomes, the highest number of unigenes belonged to molecular functional category, relating to ATP binding followed by unigenes belonging to proteolysis and proteins integral to membrane representing biological process and cellular component functional categories respectively. The differential gene expression analysis from WSSV infected shrimp transcriptome revealed 424 up regulated and 226 down-regulated genes. The unigenes of the two libraries, on similarity search showed similar species distribution. Among the 34,009 unigenes from both the libraries the highest match was observed with common water flea *Daphnia pulex* (*Leydig)* sequences (10.80%). The highest unigenes in control (716) and WSSV infected (671) shrimp were represented in the translation category of pathways associated with ribosome, aminoacyl-tRNA biosynthesis, RNA transport, mRNA surveillance and ribosome biogenesis. The carbohydrate metabolism and protein folding, sorting and degradation were the other major pathways identified in the transcriptome of *P. monodon*. KEGG analysis for identification of functional pathways revealed highest unigenes in the translation category of pathways. Comparative analysis of the functional categories of both the transcriptomes obtained from control and WSSV infected shrimp revealed similar GO profile for the unigenes expressed under biological processes, molecular functions and to cellular component functional categories.

Single nucleotide polymorphisms influencing growth of tiger shrimp

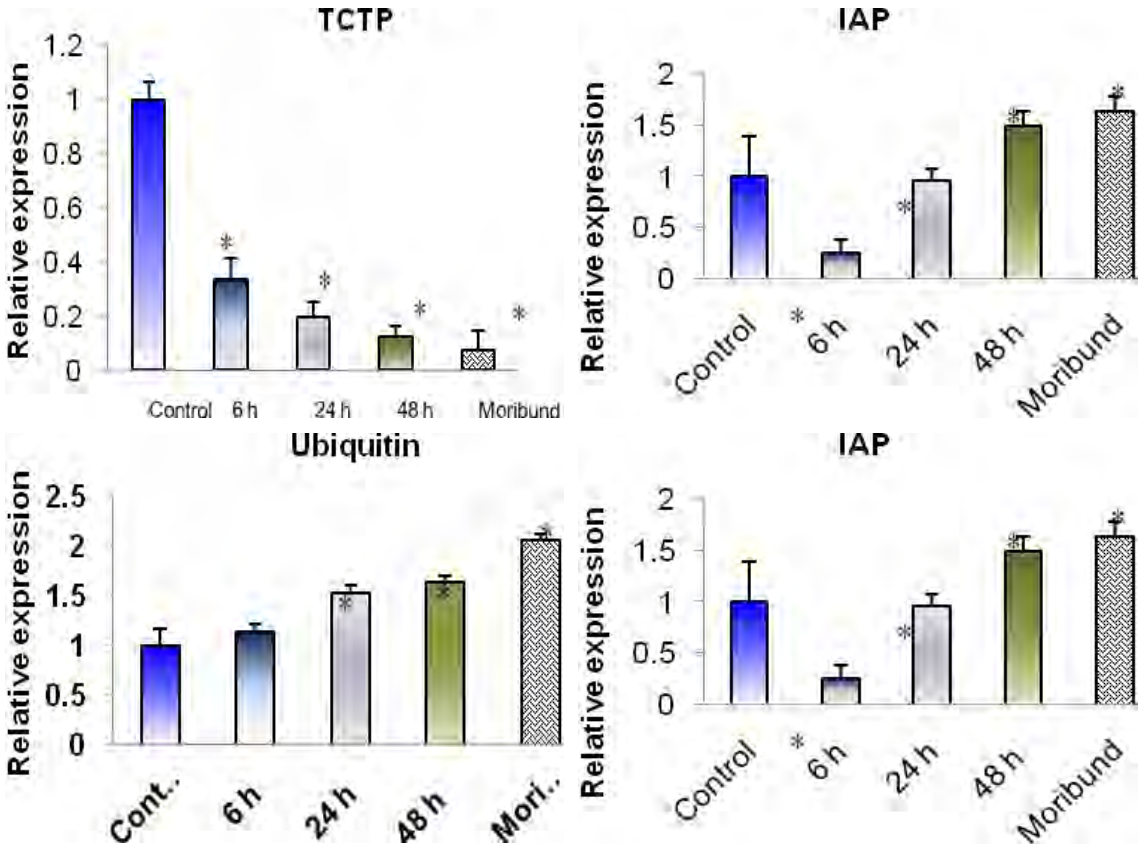
As the domestication and selective breeding of tiger shrimp is still a concern to the hatchery community, the Indian shrimp industry continues to depend on wild broodstock for seed production. Till date information on the quantitative trait loci does not exist for growth traits in tiger shrimp. The 39,397 expressed equence tags (EST) datasets at Genbank maintained by NCBI were exploited to identify single nucleotide polymorphisms (SNPs) in growth-related candidate genes of tiger shrimp and to comprehend their significance for future association studies. These ESTs were assembled to 3,773 contigs using CAP3 software. Putative SNPs were identified by manually screening the contigs in Notepad++ version 6.1.1 text editor with the following criteria; a) the contig should have at least four accessions at a SNP base, b) both the SNP alleles should be represented by at least 2 accessions and c) no other SNP should be present within 20 bases on either side of the putative SNP. Overall, 422 contigs were found to harbour SNPs whose gene identities were obtained after a similarity search using blast2go tool. Based on the gene identities of top blast sequence accessions and their probable functions, various growth-related candidate genes in shrimp were short-listed. A total of 8 mis-sense substitution SNPs coding for non-synonymous amino acids and one non-sense substitution SNP introducing chain termination codon in a total of 9 genes were documented. The likelihood of these non-synonymous SNPs to cause functional impact on the protein was individually estimated using the PANTHER classification system version 6.1 (www.pantherdb.org) based on substitution position-specific evolutionary conservation score (subPSEC) and $P_{deleterious}$ estimates. It was observed that the non-synonymous SNP in cathepsin B gene might impair protein function (subPSEC, -4.77 and $P_{deleterious}$, 0.85) and the SNP in beta-tubulin gene that introduces chain termination codon might produce incomplete protein. The genotype information of these 2 SNP loci is to beconsidered for future association analyses for growth traits as well as for broodstock selection in commercial seed production.

SNPs in candidate immune response genes of WSSV in tiger shrimp

Four immune response genes namely HSC70, Crustin, PPAE1 and PPAE2 were selected for identification of SNPs from the genomic DNA of tiger shrimp samples from Andamans, Kollam, Chennnai, Kakdwip, Paradip, Mangalore and Gujarat. The analysis of the obtained sequences revealed three SNPs in HSC70 [4014 (C/T); 4131 (C/T) and 4455 (C/T)] and a SNP in PPAE2 [1641 (G/C)]. These SNPs need to be explored for their possible role in disease resistance in shrimps through association studies.

Gene expression profiling of white spot syndrome virus infected black tiger shrimp by DNA microarray

The shrimp cDNAs were printed onto a microarray chip based on 40,059 unique sequences to identify differentially expressed genes in response to WSSV infection. A total of 19,780 differentially expressed genes were unraveled by microarray analysis. The gene expression analysis of the four apoptosis related genes (translationally controlled tumor protein (TCTP), inhibitor of apoptosis protein (IAP), ubiquitin conjugated enzyme E2 and caspase was carried out to decipher their functional role and in comprehending the molecular mechanisms by which they interact and involve in the apoptosis network that take place in WSSV infected shrimp. Real Time PCR revealed down-regulation of TCTP gene and caspase gene from early infection stage at 6 h to moribund stage of infection. The down-regulation of these genes



Gene expression analysis of apoptosis related genes in WSSV infected gill tissues of *P. monodon* at 6h, 24h, 48h and moribund stage of post infection.

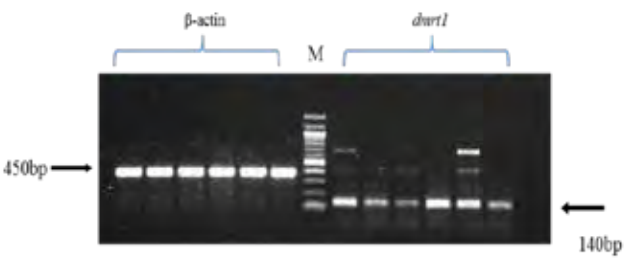
during infection indicates the role of WSSV induced apoptosis resulting in mortality of infected shrimp and apoptosis being a cause of shrimp mortality associated with infection.

Yeast two hybrid assay for GIH interacting proteins

Yeast-two hybrid assay to identify the GIH-protein interactions in regulating reproduction in shrimps was performed by co-transforming the bait construct pGBKT7-GIH and the shrimp cDNA library in pGADT7 in yeast strain AH109. Transformants were selected for growth on -Ade/-His/-Leu/-Trp plates containing X-α-gal. Plasmids extracted from blue positive colonies were amplified in *E. coli* DH5α and sequenced. One of the clones obtained was found to encode a protein tyrosine kinase. Their interaction needs to be confirmed by pull-down assay.

Sex differentiation in pearl spot

Identification of sex of fish is a pre-requisite for any breeding programme. In pearlspot, it is difficult to differentiate the sexes due to the absence of discriminatory morphological features. A male sex

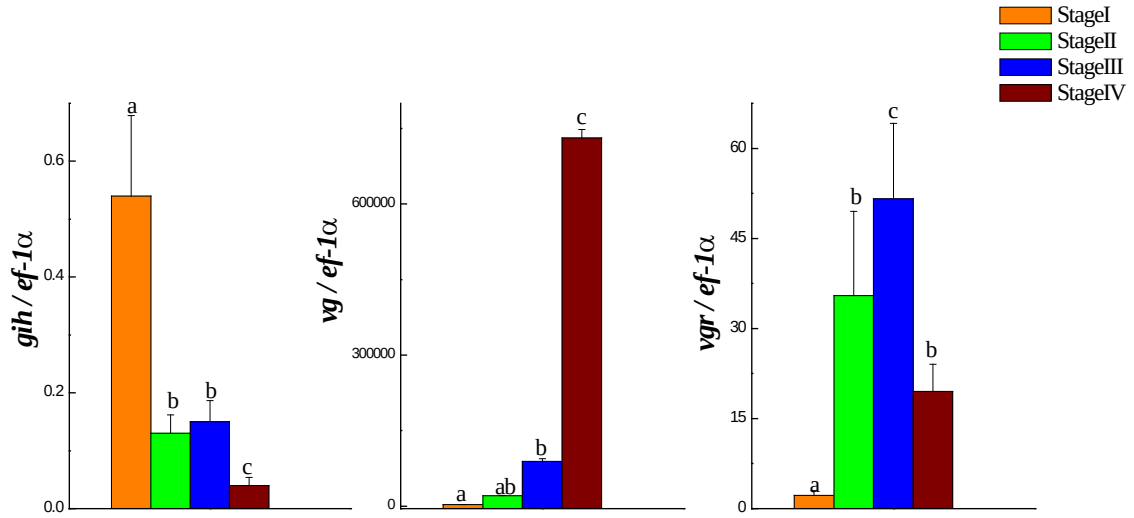


Semi-quantitative PCR analysis of gene expression in pearlspot: Lane 1-3:ovary; M- Molecular marker; Lane 4-6: testis.

determining gene *dmrt1* gene (140bp) was cloned and expressed. However, the gene was found to be expressed in both male and females, the expression being stronger in males.

Differential expression of GIH, vitellogenin and vitellogenin receptor in tiger shrimp

Quantitative PCR analysis of *gih* in thoracic ganglia indicated an expression profile similar to that observed in eyestalk with a significantly higher level of *gih* in immature (Stage I) animals and the level

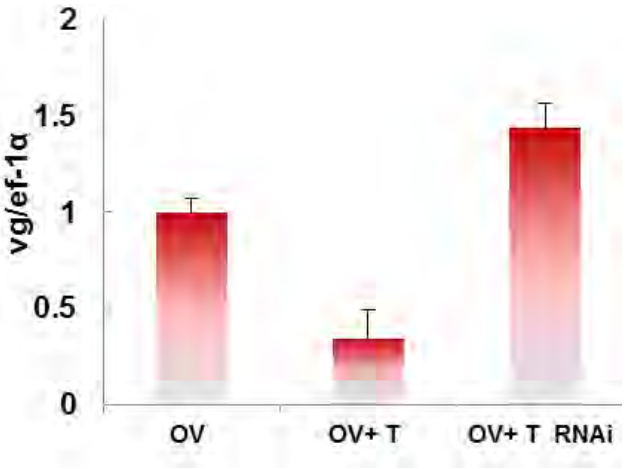


Relative gene expression profiles of *gih*, *vg* and *vgr* gene in the ovaries of *P. monodon* during different maturation stages.

dropping during the process of gonad maturation reaching the lowest in mature (Stage IV) animals. On the other hand, the relative expression of vitellogenin (*vg)* mRNA transcripts showed a significant increase from Stage I to Stage IV. The expression of *vg* in the IV stage was higher by 2-fold than at Stage I. The mRNA transcripts of vitellogenin receptor (*vgr)* also increased with maturation. The highest levels were observed at Stage III compared to Stage I followed by a decrease in the expression levels at Stage IV. The study confirms the negative role of *gih* in vitellogenesis of *P. monodon.*

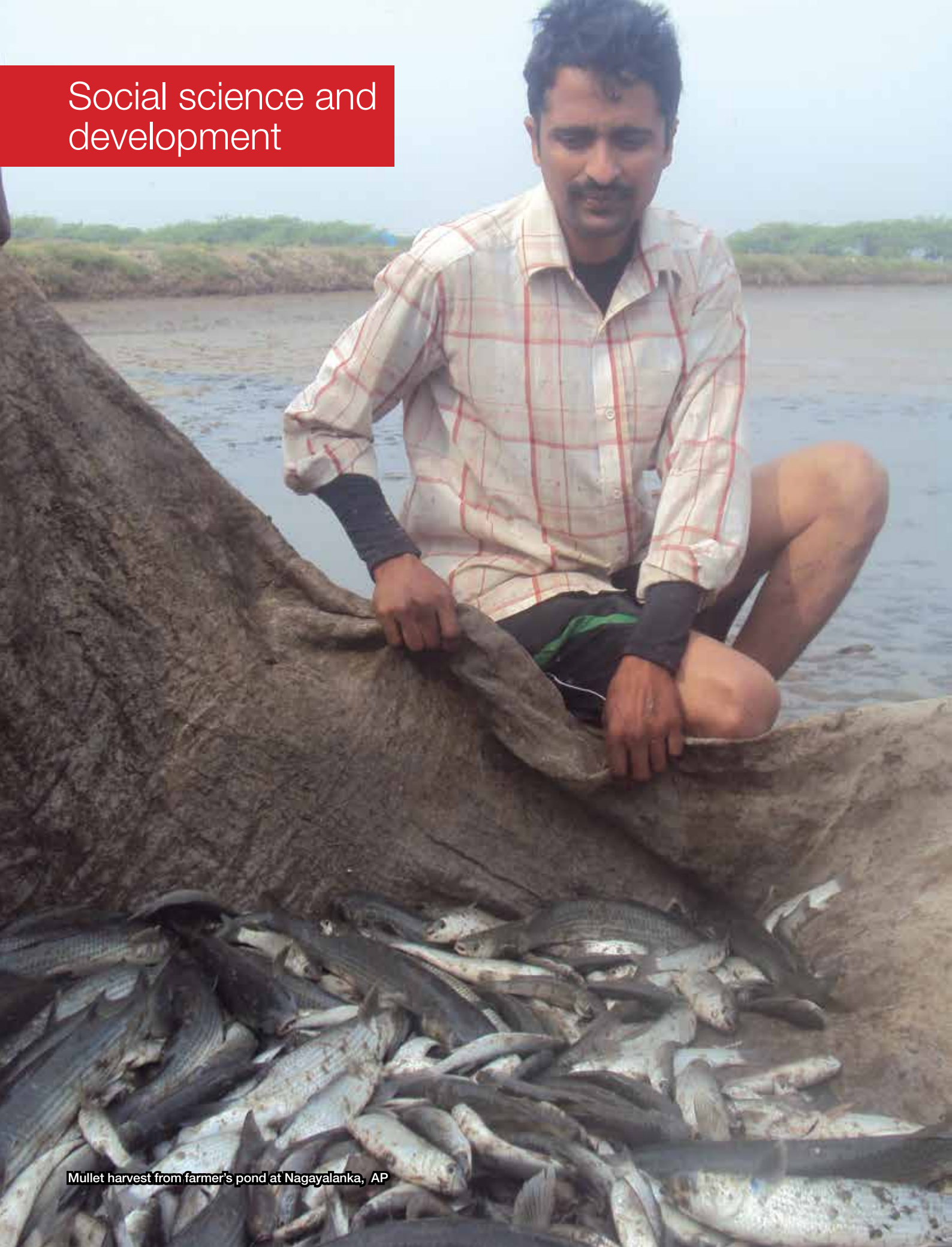
Double stranded RNA (dsRNA) mediated gene silencing of GIH in tiger shrimp

Partial sequence of *gih* was amplified and cloned between bi-directional T7 promoter of the LITMUS 38i-Vector and transformed into *E. coli* HT115 (DE3) strain which lacks the double-strand-specific RNaseIII. The efficacy of bacterially synthesized dsRNA in silencing *gih* expression was confirmed. *In vitro* analysis on the effect of dsRNA on *vg* mRNA expression in previtellogenic ovarian tissues co-cultured with thoracic ganglion (with and without dsRNA) indicated a significant increase in the *vg* transcript levels when dsRNA was added to the culture media confirming the negative role of *gih* in vitellogenesis of *P. monodon.*



Relative expression of *vg* transcripts following treatment with dsRNA. Ov: ovarian tissue; Ov + T: Ovarian tissue co-cultured with thoracic ganglion; Ov + T RNAi: Ovarian tissue co-cultured with thoracic ganglion treated with dsRNA.

Social science and development



Mullet harvest from farmer's pond at Nagayalanka, AP

Social Science and development

Participation of women in aquaculture

Involvement of women in aquaculture was documented in Kerala and AP states. A women self-help group (Sowbarnika SHG at Narakkal) developed and managed an aqua tourism centre, fish fertilizer unit and value added fish food processing units (SHGs at Munabam) with the support of the MATYSFED organization. Additionally they operated canteens and petty shops. The government of Kerala supported them with institutional credit under the TEAP scheme. Fish fertilizer prepared from fish waste was used for flowers, fruit trees and vegetable plants. A case study on entrepreneurship development through pearl spot farming was undertaken. One of the entrepreneurs received training and financial support from FFDA, had three fish ponds of 20 cents each and was involved in farming for 8 years. Artificial feeds prepared out of chicken waste and rice was used as the fish cultured were sold @ Rs.400 / kg and tilapia @ Rs. 200 / kg. Case studies on mussel farming and homestead ornamental fish farming by WSHGs in Thekkumbhagam Panchayat, Kollam, Kerala were also documented. Crab trading by a village as a whole with 300 coastal men and women at Pedavasala, dry fish sales at Ramanapallam, Thallarevu Mandal, East Godavari district and fish marketing at Jalapushpa Bhavan (Fish market) by Matsya Mithra Group (MMG) at Nellore in Andhra Pradesh were documented.

Participation of tribes in aquaculture in Tamil Nadu.

An assessment was made on the participation of tribal people of Tamil Nadu in aquaculture. Irula tribal families at Killai in Cuddalore district of Tamil Nadu were involved in crab fattening in pens, collection of polycheate (*Nereis* sp) worms, integrated mangrove fish farming in aquaculture and related activities. Similarly women self-help groups (WSHGs) were able to generate income by practicing seabass nursery rearing in hapas and polyculture of mud crabs and Asian seabass at Kulathumedu village, Pulicat, Tiruvallur district Tamil Nadu.

Impact of environmental changes on the livelihoods of coastal women in Tamil Nadu

Socio-economic and gender analysis (SEAGA) was carried out to understand the challenges faced by coastal women due to the climatic and environmental changes on their livelihoods. The three different tool-kits, namely development context, livelihood analysis and stakeholders priorities for development helped in understanding the farming systems, alternative livelihoods, income levels, various religions, community types, social events, environmental issues and institutional linkages. The SEAGA provided inputs for the development agencies to integrate socio-economic and gender issues in negotiations, policy actions and initiatives to be taken by the

Aqua tourism with brackishwater farming

governments and coastal communities to build adaptive measures towards the effects of environmental changes.

Two hundred coastal women beneficiaries were selected from the four coastal districts *viz*, Tiruvallur, Kancheepuram, Cuddalore and Nagapatinam, where the concentration of fisheries and aquaculture activities was relatively high and they were severely affected by tsunami and other environmental changes. Descriptive statistics and SWOT analysis indicated that gender, age and community of the respondents had an influence over their access to different sets of resources and livelihood assets. The quantum of drudgery to women increased after men's migration to urban areas. Lack of technical knowledge, migration of men, social taboos and beliefs, poor health status etc., were the main weaknesses. Unusual rainfall, floods, cyclone, change in water quality etc., were considered as threats. Women required access to technical training, credit and skill-development programmes to ensure their full participation in climate change initiatives. The implication of this study is that the existing strategies, mitigation techniques and knowledge are to be integrated with new techniques to help the coastal women to sustain their livelihoods during the impact of environmental changes at present and in future.

Traditional knowledge and beliefs of coastal fishers and tribes in Tamil Nadu

The coastal fishers and tribes of Tamil Nadu possessed a rich knowledge on various aspects including climate and environmental changes and its impact on fisheries and aquaculture sectors, beliefs on consuming fishes/ animals /plants, knowledge on culture of ornamental fish, crab collection and fattening, innovative farm-made feed for seabass nursery rearing in hapas, polyculture trials of the mud crab (*Scylla serrata*) and the Asian seabass (*Lates calcarifer*), polychaete worms and mollusc collections, jelly fish processing and mushroom consumption by tribals.

The coastal fishers and tribal beneficiaries in the coastal villages of Tamil Nadu *viz.,* Tiruvallur, Kancheepuram, Cuddalore and Nagapattinam expressed the opinion that major environmental changes occurred post-tsunami in 2004. The wind direction, its speed, water current, rainfall, seawater invasion into coastal villages are the major climatic and environmental parameters that have impacted fisheries and aquaculture.

For documenting the traditional knowledge in aquaculture a Linux based software was developed using MySQL. The system was designed using various identified attributes such as title of ITK, rationale, location, impact on user, broad use, adverse

Irula tribes carrying out collection of polycheate worms

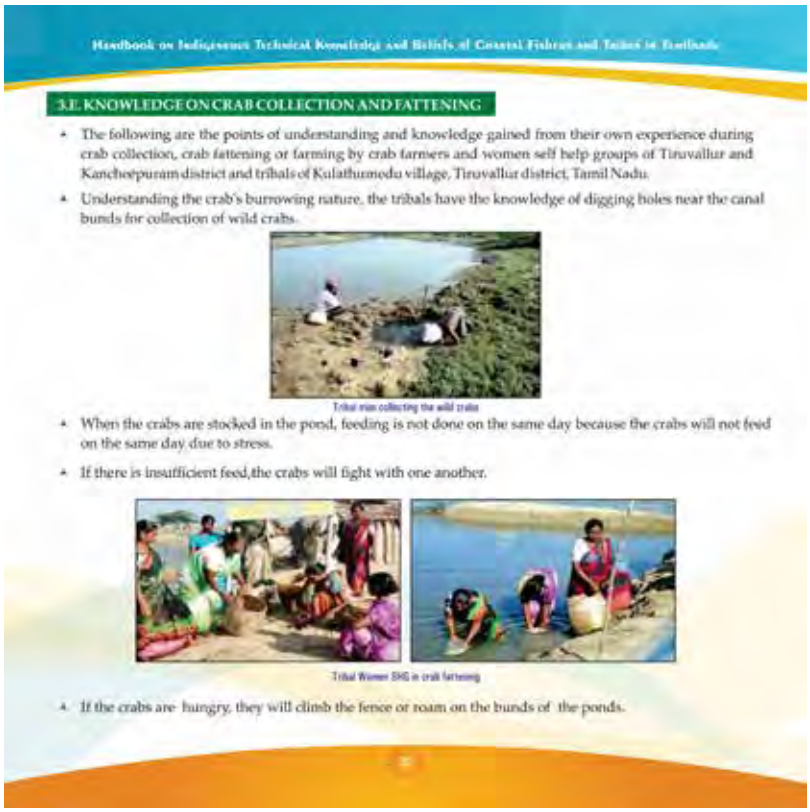
effect, materials used, target species, convenience, timeline, technical feasibility. In the system, search module is used to search and retrieve information based on users' keywords in the form of category-wise, location-wise, usage-wise and/or timeline-wise. The ITKs documented at West Bengal and Tamil Nadu was utilized for testing the system. These ITKs were divided into categories depending upon their approach for addressing the aspects of soil, water and productivity related, culture / management related, health related and environmental and climate changes. Although illustrations were based on the brackishwater culture practices and environmental / climate changes, system is general and can act as a model to capture and display the ITKs for all other aquaculture and fisheries sectors.

Demonstration of seabass and mud crab polyculture

Demonstrations of polyculture of mud crab with seabass farming in community pond and seabass nursery rearing in hapas in pond at Kulathumedu village, Pulicat, Tiruvallur district in Tamil Nadu were undertaken**.** A total of 2000 seabass fingerlings at a cost of Rs. 15/- per fingerling with 6-9 cm total length and 4-6 g body weight and a total of 1048 crabs (249.2 kg) ranging from 100 to 450 g of size at a cost of Rs.450 / kg were stocked in this pond. Locally available low value fishes fed to crab and seabass. Feeding was adjusted based on the standing biomass and fed @ 8-10% of the body weight of the stock. All the records including work schedules, sampling data, feeding and pond management were maintained by the beneficiaries. After three months of culture period, the seabass attained the total length from 13.5 cm to 24.5 cm (average 19.0 cm) and total weight ranging from 40 g to 180 g (average 110 g). A total of 217 seabass juvenile fishes were collected through partial harvesting and marketed. A total of 147 irula tribal people including 82 men and 65 women beneficiaries were trained. The total income realized out of this trial was Rs. 2,32,290/- This amount was deposited in the beneficiaries bank account. This intervention proves to be a good model of supplementary revenue generation portraying the community participation in adoption of common water bodies for fish farming.

Innovations in brackishwater aquaculture by farmers

Farmers are continually experimenting, adapting and innovating in order to minimize the cost and enhance the efficiency. Water recycling in low saline waters,


Handbook on Indigenous Technical Knowledge and Beliefs of Coastal Fishers and Tribes in Tamilnadu

3.E. KNOWLEDGE ON CRAB COLLECTION AND FATTENING

- The following are the points of understanding and knowledge gained from their own experience during crab collection, crab fattening or farming by crab farmers and women self help groups of Tiruvallur and Kancheepuram district and tribals of Kulathumedu village, Tiruvallur district, Tamil Nadu.
- Understanding the crab's burrowing nature, the tribals have the knowledge of digging holes near the canal bunds for collection of wild crabs.

Tribal man collecting the wild crabs

- When the crabs are stocked in the pond, feeding is not done on the same day because the crabs will not feed on the same day due to stress.
- If there is insufficient feed,the crabs will fight with one another.

Tribal Women SHG in crab fattening

- If the crabs are hungry, they will climb the fence or roam on the bunds of the ponds.

Published handbook on ITK - page displaying coastal fishers on crab collection

on-farm nursery, aeration related innovations, removal of iron in water using coconut coir in bamboo basket, and multi-layered filtration systems were notable innovations by the farmers.

The CIBA felicitated Mr.J.Sivagnanam, a progressive aquaculture farmer, who hails from Kattur village, Ponneri taluk in Tiruvallur district of Tamil Nadu as "Farmer-Innovator" for his innovative practices in *P. vannamei* farming during the World Food Day celebration on 16.10.2014. He introduced nursery rearing and water recycling in *P. vannamei* farming in his area and both these innovations were problem solving and economically advantageous. By adopting nursery it was possible to practice three cultures in a year with a production of 8.5-9.0 t/ha. He popularised this concept among the shrimp farmers in the nearby areas and presently about 30 *P. vannamei* shrimp farmers follow nursery rearing in Tiruvallur and Kanchipuram districts. Adoption of nursery rearing ensured seed quality and was cost-effective as seed could be procured during lean period. Survival and growth were very good in the main pond and the culture duration was shortened. Adoption of nursery helped him to harvest 20 g shrimp in 90 days (30 + 60 days in main pond). Recycling of pond water ensured quality rearing medium for the shrimp, minimised the input and energy (aeration) costs considerably and prevented the eutrophication of natural water bodies.

Marketing issues of brackishwater fish and shrimp

Analysis of marketing issues like quantum of demand and supply; prices of selected brackishwater species in national and international markets and prices in domestic markets was carried out based on secondary data obtained from international and national data sources of production, prices and exports. Global price fluctuations and demand supply patterns across importers and competing producer nations in international/ domestic markets were documented. Following are the major issues noticed in 2014-15.

Reduction in iron levels using coconut coir in bamboo basket innovated by shrimp farmer

Market prices for shrimp were found to have the normal dip in May, September and November months. April, October and January Months had the peaks price in 2014-15. Domestic prices of shrimps remained on an average Rs 300-350 / kg of 50 counts in reference markets. Shrimp prices, after a decline from June to December, 2014, have been rising since January 2015, in response to a global supply crunch. Trading prices for shrimp have also risen 6.5 per cent since January 2015. There was an average increase of 10-15% in prices in local markets during the last three months. Thailand production was less than 2,00,000 tonnes for 2014-15, which is lower than the earlier forecast of 2,50,000 tonnes. When an attempt was made to compare the price with food grains such as rice, the volatility was too high in shrimp prices.

Vietnam, suffering with serious attack of Early Mortality Syndrome (EMS), had imported roughly $1 billion worth shrimp from India in 2014-15 to meet their export commitments. Depreciation of India's Rupee against US$ and Euro has made its seafood products more lucrative for the USA and Europe consumers.

Forecasting shrimp prices

The secondary data on shrimp prices was collected from http://www.indexmundi.com and the 30 count prices from 1995 to 2014. As the farm gate prices in India follow the same trend present in the collected prices, the trends were taken to generate local farm gate prices of shrimp. Using the models, the prices of shrimp was forecast for the period of one year starting from July 2014 to June 2015. The forecast prices were found to be in agreement with the actual prices. But in long term they even fell below the lower boundary of the forecast prices. Hence the model could be used for forecasting the prices of shrimp.

***P. vannamei* group farming scenario**

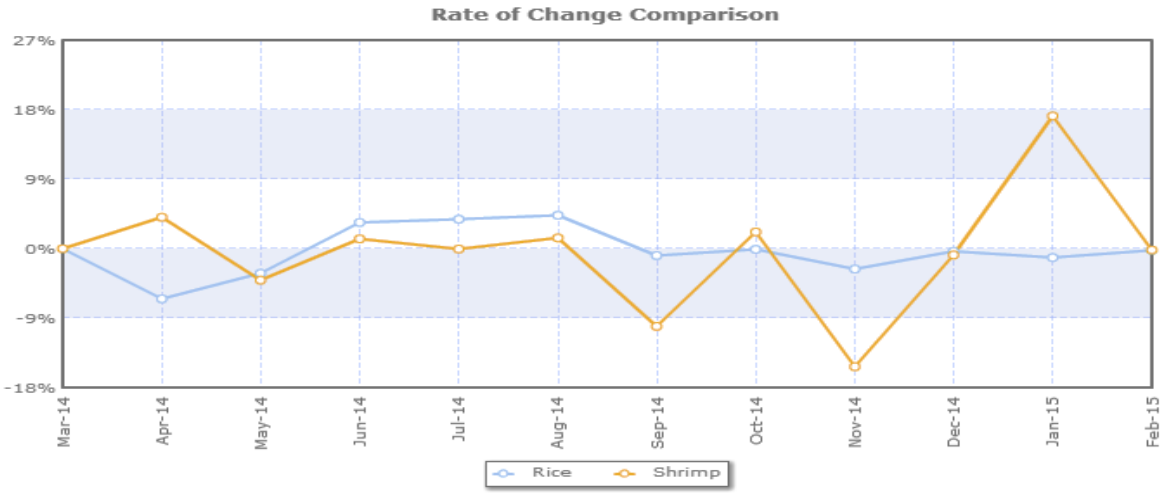
Review of six shrimp farmer groups in Tamil Nadu, Karnataka and Andhra Pradesh showed that group cohesiveness of previously successful farmer groups has been weakened after the introduction of *P. vannamei* due to the high demand for quality seed and enhanced volume of production. Among the six groups studied only three groups were able to plan the crop calendar but could not implement due to the difficulty in accessing the quality seed for the whole group from one or two reputed shrimp hatcheries. There is a scope to develop guidelines for translating a couple of dynamic shrimp farmer groups in to producer companies.

Identification of production risks of *P. vannamei* culture systems for improvement of the Better Management Practices (BMPs)

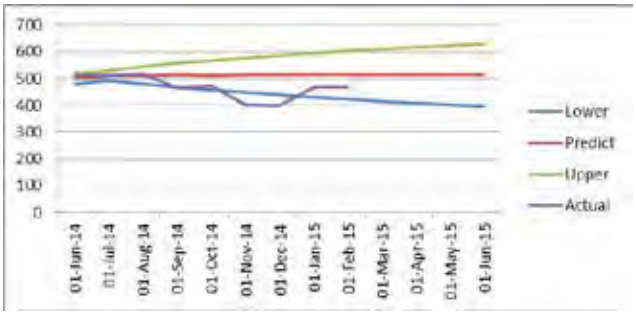
This project was implemented for two years from October 2012 to October 2014 with the objectives to assess the technical efficiency of *P. vannamei* culture systems and production related risks and to develop better management practices for *P. vannamei* farming. About 604 shrimp farmers across the coastal states were surveyed following proportionate random sampling design to collect primary data. In addition to the survey, five focus group discussions (FGD) were held in Odisha, Andhra Pradesh and Tamil Nadu, wherein group of progressive farmers (approximately 20 in each location) were invited for an in-depth discussion to identify production related risk factors and risk assessment. Altogether, a total of 700 shrimp farmers were contacted during the course of study for data collection and validation.

Present culture systems of *P. vannamei* farming and their technical efficiency

Farmers across the states were adopting different



Annual global % price change data of shrimp in comparison with rice



Predictions using shrimp price forecasting model compared with actual farm-gate prices.

kinds of culture systems. The subject matter specialists identified naturally existing entity as the main criterion to categorize culture system rather than manipulations in the technology adopted. Based on that preposition, salinity, inclusion of nursery phase, cropping intensity and source water were identified as the criteria for classification of the culture systems. However, within each system there were several technology based variations which may include stocking density, biofloc / periphyton, water exchange regime, aeration systems, pond design (earthen/HDPE lined), feeds and auto feeders and partial harvesting interventions.

Technical Efficiency (TE) reflects the ability of a farm to obtain maximum outputs from a given set of inputs (Farell, 1957). The TE was estimated by using stochastic frontier production function 4.1. The mean technical efficiency of *P. vannamei* farms was 0.9013 which means that the ability to obtain maximum results from the given inputs is 90%. It is seen that direct sea water farms, single cropping systems, lined ponds and nursery stocked systems had better performance.

Further it was found that the technical efficiencies of the *P. vannamei* farms differ significantly between the States, wherein, Gujarat state had the highest TE (94%), The brackishwater farms performed better than the low saline farms mainly because of the higher stocking and higher productivity vis-à-vis low saline systems. Direct sea water farms had better mean TE (0.94) followed by the groundwater (0.90) and creek waters (0.89). Technical efficiency of farms as per the cropping intensity has shown that farmers who have more than two crops in a year especially in low saline areas aimed at domestic market and produced minimum size (10-12 g) had the highest mean technical efficiency of 0.9874 followed by those who had one crop with a mean technical efficiency of 0.9099.

Risks factors in *P. vannamei* culture systems and their impact on production.

The framework adopted in this study to assess the production related risks and risk factors consisted of following four major components i) *Risk identification* – the process of identifying perceived hazards / risk factors that could potentially harm the *P. vannamei* culture; ii) *Risk assessment* – the process of evaluating the likelihood that a potential hazard will be realized and estimating economic consequences (impact) of its realization; iii) *Risk management* – the seeking of means to prevent or reduce either the likelihood or the consequences of it going wrong; and iv) *Risk communication* – the process by which stakeholders are consulted, information and opinions gathered and risk analysis results and management measures communicated.

About 33 risk factors spread over following 12 risk categories were identified from the primary data and focussed group discussions were conducted with the *P. vannamei* farmers.

The risk matrix of *P. vannamei* farming indicates that diseases, broodstock source, seed quality and stocking density were the major risks perceived by the shrimp farmers. White Spot Disease (WSD), Running Mortality Syndrome (RMS), White gut / white feaces, IHHNV, vibriosis, black gills and body cramp

Factors affecting *P. vannamei* group farming

Factor	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Crop planning	√	√	x	√	x	x
Collective Seed procurement	x	x	x	x	x	x
Restriction of Stocking density	√	x	x	x	x	x
Disease prevention	x	x	x	x	x	x
Collective marketing	x	x	x	x	x	x
Group Cohesiveness	√	x	x	x	x	x

Technical Efficiency (TE) of *P. vannamei* culture systems

Culture system	Group	Frequency	Mean TE
Salinity regime	Brackish	430	0.9050 ± 0.0590
	Low saline	174	0.8939 ± 0.0690
Source water	Creek	398	0.8982 ± 0.0615
	Ground water	174	0.9067 ± 0.0668
	Direct Sea water	32	0.9369 ± 0.0325
Cropping intensity	One Crop	234	0.9099 ± 0.0606
	Two Crops	362	0.8961 ± 0.0626
	More than two	8	0.9874 ± 0.0036
Pond system	Earthen Ponds	586	0.900 ± 0.0626
	Lined Ponds	18	0.952 ± 0.0395
Stocking method	Direct	574	0.9013 ± 0.063
	Nursery	30	0.9853 ± 0.009

were the diseases reported in *P. vannamei* farming. Among them WSD, RMS and white feaces were the major diseases causing 50-100% loss to the farmers. After the outbreak of Early Mortality Syndrome / Acute Hepatopancreatic Necrosis Disease (AHPND) in other shrimp farming countries the number of broodstock suppliers have come down to a single source and it is a great risk that about 180 plus *P. vannamei* registered hatcheries have to depend on a single broodstock source. The hatchery operators felt that the quality of broodstocks imported was poor and the expected survival rate could not be realized in the hatchery in addition to the Zoea-II conversion problem. Poor source water quality in terms of high temperature and bacterial load, the hatcheries used antibiotics to combat these problems resulting in poor seed quality. The other serious threat was the use of pond reared broodstocks for seed production. Inbreeding lead to size variations, immunity loss and susceptibility to known / unknown disease pathogens. Poor acclimatization, mixing of different spawning larvae and other stresses lead to poor seed quality. Further, the hatcheries did not provide seed samples for screening and testing. Due to the high demand for the seeds in the stocking season the farmers were left with no choice. On the other hand, farmers too stocked their ponds at high densities disproportionate to the carrying capacity of the pond and the infrastructure available. Poor seed quality and higher stocking coupled with poor feed management led to water quality problems like over bloom, turbidity and higher level of pond bottom metabolites which all together led to diseases and mortalities. Lack of sufficient gap between crops and poor pond preparations-inadequate drying and scrapping- led to higher organic load and creating anaerobic conditions in the pond led to mortalities. Further, shallow depths, poor compaction of dykes, lack of central drainage / sludge removal system were also deteriorated the water quality. Non-adoption of biosecurity measures like reservoir, fencing, disinfections, filtrations and restriction of mechanical carriers exposed the farms to higher level of cross contamination subsequently led to disease risks. Most of these risks are interconnected and one lead to the other.

Climatic parameters like high temperature and unusual diurnal temperature fluctuations increase the water temperature for which the vannamei shrimp is susceptible lead to mortalities especially RMS. Seasonal changes, unusual heavy rain and flash floods and cyclones posed serious risks to vannamei farming. The feed quality deteriorated due to high demand and the required level of protein was not found in the feeds supplied, leading to poor growth and size variations. Poor feed management in terms of rationing and timing also lead to water quality issues. Market forces and food safety issues like presence of antibiotics residues in the processed shrimps lead to market rejections which in turn affects the price and morale of the farmers. Besides these issues, social issues like agri-aqua inter-sectoral conflicts regarding ground water usage for vannamei culture and lack of labour availability and policy issues like inadequate regulations, lack of self-discipline among the hatchery operators and farmers also confronted the sustainability of *P. vannamei* farming.

Risk communication workshops were conducted at Odisha (29th Sep.2014), Andhra Pradesh (10th Oct.2014), Tamil Nadu & Karnataka (12-13th March,

LIKELIHOOD	IMPACT				
	Little Negative (1)	Minor Negative (2)	Moderately Negative (3)	Extremely Negative (4)	Disastrous (5)
Very High (5)				Broodstock & Seed quality/ seed tocking	
High (4)			Pond design / infrastructure &Climate	Pond preparation & Water quality	Diseases
Likely (3)		Feed quality / management	Market		
Low (2)		Food Safety & Social & Policy			
Very low (1)					

Risk matrix for *P. vannamei* farming: bright red: extremely high risk; red: high risk; yellow: moderate risk; light green: low risk; dark green: very low risk

2015), Goa (11th March, 2015) and Maharashtra (9th March, 2015) to sensitise shrimp farmers/ professionals, fishery officials and other stakeholders. Besides a booklet on Frequently Asked Questions (FAQs) pertaining to P. vannamei shrimp farming along with answers for the benefit of field level extension workers and farmers.

Better Management Practices vis-à-vis risk factors in *P. vannamei* farming

Farmers perceived that *P. vannamei* farming had 33 potential risk factors. Cluster analysis grouped the risk factors in to high, medium and low risk categories based on their probability of occurrence and impact. The high risk group had two risk factors, poor quality seed and high biomass exceeding the carrying capacity (CC) with very high probability of occurrence having calamitous impact on farming. The medium risk group had 18 risk factors with a likely probability of occurrence and having moderately negative impact (shallow pond depth, lack of sludge removal, poor pond dyke, lack of biosecurity, lack of sufficient drying, non-removal of black soil, pond reared broodstocks, lack of seed screening, poor acclimatization of the seed, high stocking density beyond the CC, poor feed management, inferior feed quality, low dissolved oxygen, higher load of bottom metabolites, deficiency in mineral nutrients, pathogen entry, stress factors, high input cost and low sale price). About 12 risk factors convened under low risk category with low probability of occurrence and minor negative impact (inadequate gap after disinfection, feeding at night times, high diurnal pH variations, higher water temperature, water turbidity, seasonal changes, extreme climatic events, food safety issues, inadequate labour, inter-sectoral conflicts and inadequate regulation).

Classification of aquaculture sites assisted by decision making model

A decision making model was developed and validated using twenty seven variables based on dominance based rough set theory and simple additive weighing method to select the optimal locations (aquasites) from a large number of alternate locales for development of aquaculture farming. After collecting the required information from 15 randomly selected aquasites from the study area, Krishna district, Andhra Pradesh, aquasites were first ranked using rough set based optimal location model and then the same aqua sites were ranked by observed average yield value per hectare (ha) for the last three crops. In addition, comparative analysis of different existing optimal location models (such as multi criteria decision making model, fuzzy model, soft computing model and rough set model) was done based on the execution time of the datasets. The correlation and execution time results showed that the rough set optimal location model is reliable for aquaculture development.

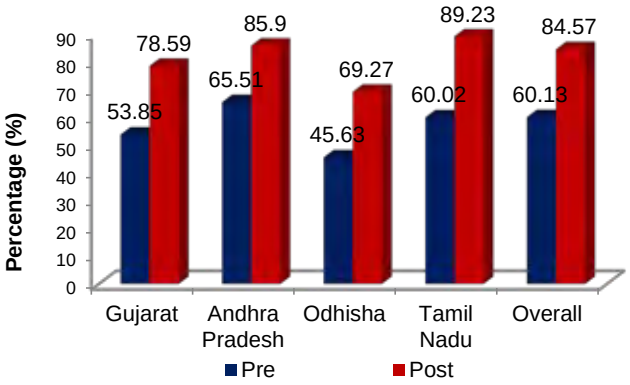
Impact of CIBA Technologies

An impact assessment of commercialized CIBA technologies was undertaken**.** A Report on impact of CIBA-Bismi feed with farm level benefits between user and non-user groups was compiled based on interviews and surveys conducted in Nagapattinam

and Ramanathapuram districts where the feed was commercially sold. The average benefit per ha to the farmer was (average production of tiger shrimp was 3127 kg/ha/crop production in survey area) was Rs. 23,452 by adopting this low cost technology. Low cost and CIBA / Government Institution's name associated with the technology were found to be the major factors of farmers' acceptance of the product and technology. 20 persons were directly employed in regular mode and about 350 persons were employed as casual laborers and off-factory feed supply chain. Limited operating capacity of factory (2,000 tonnes per annum) restricted feed availability in right time and right quantity to a number of farmers. This constraint is being overcome by nonexclusive licensing of CIBA feed technology to 10 private partners in the year 2014-15.

Impact of Institute's Training Programmes

A database on CIBA Training programmes was developed and being updated periodically. A rapid survey with 120 CIBA trainees from Gujarat, Tamil Nadu, Andhra Pradesh and Odisha showed that the trainees felt "strongly agreed" towards the effectiveness of the training on shrimp *P. vannamei* farming on their knowledge and skill capacity increasing to the tune of 24.48 % *vis-a-vis* their pre-training period. Based on the suggestions received, reinforcement training workshops were conducted on 'Production risks in *P. vannamei* farming and Better Management Practices" on 29th September, 2014 at Cuttack, Odisha and 10th October, 2014 at Ongole, Andhra Pradesh.



Impact of CIBA training on capacity enhancement

Information needs of shrimp farmers and fishery officials

A study conducted among the shrimp farmers in Ramanathapuram district of Tamil Nadu (N=167) indicated that the total information sources accessed by the farmers was 14.

The primary information source was farmers discussion groups, friends and mobile phones. The Input dealers and progressive farmers were also source of information for the farmers. With regard to the information-seeking behaviour of extension officials (N=42) in Tamil Nadu and Andhra Pradesh, indicated that the research wings of the respective DoF, MPEDA, printed publications of fishery R&D institutions, fisheries college, Coastal Aquaculture Authority and central research institutes of ICAR were the preferred information sources.

Relative frequency of information sources accessed by shrimp farmers

Sl.No	Source of information	Frequency	Rel. Freq	Ranking
1	Research Assistant	20	11.97	
2	Assistant Director of Fisheries	9	5.38	
3	Deputy Director of Fisheries	6	3.59	
4	Joint Director of Fisheries	0	0.00	
5	MPEDA	9	5.38	
6	Input Dealers	167	100	I
7	Friends	44	26.34	
8	Relatives	15	8.98	
9	Farmers Discussion Group	55	32.93	
10	Farm Magazines	4	2.39	
11	News Paper	6	5.38	
12	Progressive Farmer	167	100.00	I
13	Technicians	6	5.38	
14	Mobile Phones	46	27.54	

* * *

Human Resource Development (HRD) Trainings, Capacity Building and Skill Development

Trainings Programs Attended

International

Shri. G. Thiagarajan, Senior Technical Assistant, attended a training course on Broodstock Management in Aquaculture organized by NACA at Nha Trang University, Vietnam during 10 - 17 October, 2014.

National

Shri. Kunal Kalia, FAO, attended a training course on Financial management and audit sensitization at Institute of Secretariat Training and Management (ISTM), New Delhi during 20 - 24 May 2014.

Dr. Prem Kumar, Scientist, attended training on practical aspect of seafood safety organized by Central Institute of Fisheries Technology (CIFT), Cochin during 14 - 24 July, 2014.

Smt. E. Amudhavalli, Assistant, participated in special training programme for the employees of ICAR organised by the Institute of Secretariat Training and Management (ISTM), New Delhi during 10 - 21 November, 2014.

Dr. A. Satheesha Avunje, Scientist, attended training on Interfacing innovation and IPR for licensing and commercialization of technology in the changing global scenario with special reference to microbial genetic resources at National Bureau of Agriculturally Important Microorganisms (NBAIM), Mau during 18 - 20 December, 2014.

Dr. M. Muralidhar, Dr. M. Jayanthi, Principal Scientist, Dr. K.P. Kumaraguru vasagam, Senior Scientist and Dr. Krishna Sukumaran, Scientist, attended training on interactive training workshop on methods of valuation of ecosystem services at MRC of Central Marine Fisheries Research Institute, Chennai during 05 – 09 January, 2015.

Dr. P. S. Shyne Anand, Scientist, attended training on EU-India capacity building initiative for trade development organized by CITD and APEDA, Cochin during 03 – 06 February, 2015

Dr. A. Satheesha Avunje, Scientist, attended training programme on development of finfish cell lines for viral disease diagnosis at Peninsular and Marine Fish Genetic Resources Centre (PMFGR), NBFGR, Lucknow during 22 February – 01 March, 2015.

Dr. T. K. Ghoshal, Principal Scientist, attended a training on agro biodiversity conservation and sustainable livelihood at MS Swaminathan Research Foundation at Jeypore, Odisha during 24 – 28 February, 2015.

Training Programs Organized

The technologies/knowledge-base developed by the Institute were extended during the year to progressive fish farmers, private entrepreneurs, officials of state and central governments etc. through the following short-term training programmes.

Sl. No.	Training Programme	Duration	No. of participants
Headquarters			
1	Disease diagnostic methods in shrimp aquaculture – with a special reference to shrimp Early Mortality Syndrome (EMS)	9 May - 6 June, 2014	1
2	Hands on training on brackishwater finfish and mud crab breeding and seed production and culture.	3 - 5 July, 2014	1
3	Health Management Practices for Finfish and Shellfish of brackishwater environment	19 – 23 August, 2014	10
4	Seed production and culture of brackishwater finfishes	22 – 31 August, 2014	8
5	Training Workshop on Recent Developments in Brackishwater Aquaculture at Ramanathapuram in Tamil Nadu.	26 August, 2014	142
6	Production risks and better management practices of pacific white shrimp (*Litopenaeus vannamei)* farming at Cuttack, Odisha	29 August, 2014	60
7	Training on “Biofloc based farming” conducted at CIFA	3 - 10 September, 2014	25
8	Training on “Better Management Practices: Scientific approach for hatchery and grow-out shrimp/fish farming” conducted by DOF, Odisha at Bhubaneswar, Odisha.	27 September, 2014	50
9	Training on “Better Management Practices of pacific white shrimp (*Litopenaeus vannamei)* farming” 2014 at Odisha State Fisheries Conference hall, Cuttack.	29 September, 2014	40
10	Production risks and better management practices of pacific white shrimp (*Litopenaeus vannamei)* farming at Ongole in Andhra Pradesh	10 October, 2014	160
11	Advanced training in aquaculture nutrition and feed technology	19 - 28 February, 2015	4
12	Family farming opportunities for polyculture of brackishwater fin fishes in cage and ponds at Navsari Agricultural University, Navsari, Gujarat	25 - 27 February, 2015	50
13	Production risks and better management practices of pacific white shrimp (*Litopenaeus vannamei)* farming at Maharashtra (Palghar), Goa (Ela) and Karnataka (Kumta & Kundapura)	9 - 13 March, 2015	325
Kakdwip Research Centre			
1.	Diagnosis of Aquatic Animal Diseases for M. F. Sc students, CIFE, Mumbai	13 - 28 August, 2014	6
2.	Training programme on *P. vannamei* farming in Sundarbans”	19 - 23 August, 2014	6
3.	Eco-friendly brackishwater aquaculture	27 - 31 October, 2014	13
4.	An Overview of Brackishwater Aquaculture for B. F. Sc Students, W.B.	10 - 14 November, 2014	30

Parliamentary Standing Committee on Agriculture visit to CIBA, Chennai

Distribution of fish seeds by Hon'ble Shri Hukumdev Narayan Yadav, Chairman, Parliamentary Standing Committee on Agriculture

Study visit of the Parliamentary Standing Committee on Agriculture to Chennai during 30th January 2015 to 2nd February 2015

CIBA organized the study visit of the parliamentary standing committee on Agriculture, comprising thirteen Honorable Members of the Parliament, five Officers from the Lok Sabha Secretariat, two Officers from the ministry of Agriculture and three Officers from ICAR, New Delhi in Chennai from January 30 to February 2, 2015. The Chairman of the committee was Shri Hukumdev Narayan Yadav, Honorable Member of Parliament. The committee visited the various research facilities of CIBA at its Muttukkadu Experimental station (MES) and had a detailed insight into various research activities of the institute. About

Hon'ble MPs at CCD hatchery, CIBA MES during the visit of Parliamentary Standing Committee on Agriculture

Launching of ARYA programme by Hon'ble Director General, ICAR, Dr. S. Ayyappan at CIBA with the association of *The Hindu*

60000 seabass seed were distributed to aqua-farmers of Andhra Pradesh, Gujarat, Tamil Nadu and Odisha during their visit. After the tour to the various research facilities of MES, an informal meeting was conducted. Dr.K.K. Vijayan, Director, CIBA gave a brief presentation of CIBA's research initiatives to cater to the needs of the brackishwater aquaculture sector in the country. The delegates appreciated the practical and field oriented research undertaken by CIBA. Honorable Chairman of the committee, Shri Hukumdev Narayan Yadav in his concluding remark highlighted that CIBA should continue the excellent research work in the areas of brackishwater aquaculture and appreciated and congratulated the scientists of CIBA under the leadership of Director, Dr. K. K. Vijayan.

Participants at ARYA programme

Brainstorming session on Creating and sustaining interest in agriculure among the youth – NARS &The Hindu initiative held on 25th October 2014 at CIBA, Chennai.

This meeting was conducted in CIBA, Chennai as a joint initiative of NARS, and "The Hindu" to attract youth and sustain their interest in agriculture. This meeting was held in the presence of Dr. S. Ayyappan, DG, ICAR, Dr. Sreenath Dikshit, ICAR-Zonal Project Directorate, Bangalore, Dr. K.K. Vijayan, Director, CIBA, Mr.Rajiv C. Lochan, Managing Director, Mr.V.Jayant, Senior Managing Editor, and Mr.M.J.Prabhu, Agricultural Correspondent, The Hindu publications. Participants in this brainstorming event were Vice-Chancellors, Directors of Extension, Programme Directors, Farmers, agricultural entrepreneurs, scientific colleagues and the students.

Dr. S. Ayyappan, DG, ICAR, stressed that monsoon, market, mindset and media are to play a major role in agriculture development. He mentioned that by 2050, 50% of rural population 52% of works force would be engaged in agriculture and that 50% youth should be brought into agriculture sector. He also stressed upon the need for the TV channels to take up up programmes related to agriculture. Dr. Sreenath Dikshit, ICAR-Zonal Project Directorate, Bangalore explained that, the purpose of the brainstorming session is to evolve a basic plan for a mission mode project on a pilot basis for one to two years in the States of Tamil Nadu, Karnataka and Kerala particularly to attract rural youth towards agriculture and to inculcate the fundamental knowledge in agriculture including its allied enterprises among schoolchildren, in coordination with Krishi Vigyan Kendras.

Institute Workshops/Seminars/Meetings conducted by CIBA

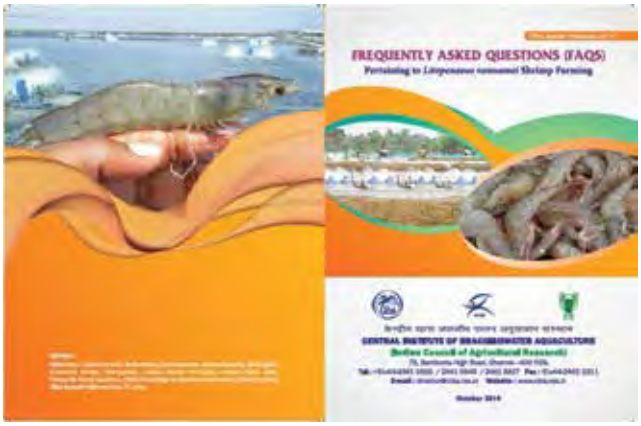
Workshop on "Nutritional Advantages of Shrimp with Focus on its Heart Healthy Lipid Elements" at CIBA, Chennai on 25th April 2014.

Workshop and interaction meet under 'TSP' in Sorlagondhi village in Krishna district, AP on 19th July 2014.

Workshop on "Aquaculture of Asian Seabass – Status and Way Forward for Commercial Production " was organized in collaboration with Fisheries Technocrats Forum, Chennai at CIBA, Chennai on 28th January 2015.

Training workshop on "Recent Developments in Brackishwater Aquaculture" at Ramanathapuram on 26th August 2014.

Trainning workshop on *L. vannamei* at Ongole, Andhra Pradesh



Training workshop on "Production Risks and Better Management Practices of Pacific White Shrimp (*Litopenaeus vannamei*) Farming" at Ongole, Andhra Pradesh on 10th October 2014.

Risk communication workshops were conducted at Odisha (29th September 2014), Andhra Pradesh (10th October 2014), Tamil Nadu, Karnataka (12-13th March, 2015), Goa (11th March, 2015) and Maharashtra (9th March, 2015) to sensitise shrimp farmers/ professionals, fishery officials and other stakeholders. A booklet on Frequently Asked Questions (FAQs) pertaining to *Litopenaeus vannamei* shrimp farming along with answers for the benefit of field level extension workers and farmers was released.

Capacity Building Programme on 'Climate Resilient Aquaculture'

Farmer's awareness Capacity building programme on 'Climate Resilient Aquaculture' was organized at Srikakulam, Andhra Pradesh on 4th March, 2015 under NICRA project. The programme was inaugurated by District Collector and felicitation addresses were given by Deputy Director of Fisheries, Srikakulam District and CEO, National Centre for Sustainable Aquaculture. About 140 farmers and stakeholders participated in the workshop. NICRA project studies related to the perception of climate change events and their impacts on aquaculture was explained to the farmers. The information on major climate change events being experienced in the district over the last 10 years was obtained. Adaptation measures and better management practices for climate resilient aquaculture was obtained.

Focus Group Workshops (FGWs) on "Impact of Climate Change on Aquaculture- Mitigations and Adaptations

Four FGWs on "Impact of Climate Change on Aquaculture: Mitigations and Adaptations" was organized at Palghar (Maharastra), Goa, Kumta and Kundapur (Karnataka) on 9th, 11th, 12th and 13th March, 2015 respectively under NICRA project. Totally 315 participants including all the stakeholders pertaining to brackishwater aquaculture attended these meetings. Important and notable climate change events being experienced by the farmers during the

Dr. P. Lakshmi Narasimham, Collector, Srikakulam District addressing the gathering

Scientists interaction with the farmers during FGW on 9th March at Palghar, Maharashtra

last 10 years and their impact on aquaculture both in terms of physical and economical on aquaculture were obtained for each district. The weather calendar and crop calendar in relation to month-wise weather events were mapped for each district. The participants were divided into three groups *viz.*, famers, technical and policy and based on the deliberations in each group, the adaptation measures to be followed by farmers, and the scientific and policy measures to be undertaken for climate resilient aquaculture were recorded. The production risks including climate risks that come upon during *Litopenaeus vannamei* farming and the Better Management Practices (BMPs) to be followed for minimising the risks were explained.

Dr. N.P. Singh, Director, ICAR Research Complex Goa addressing the gathering during FGW on 11th March at Goa

Dr. M. Kumaran, PS, CIBA, interacting with the farmers at FGW on 12th March at Kumta

During the open house farmers-scientist interaction, the problems being faced by the farmers during the culture and the solutions were discussed.

Farmers Interaction Meet

Awareness cum interaction meet on Asian seabass culture and commercial launch of seabass feed at Machilipatnam on 6th April 2014.

An interaction meeting was conducted among the coastal women and tribals beneficiaries of Kattur village and Kulathumedu village, Pulicat Tiruvallur district on 3rd June 2014.

Farmers-Scientists Interaction Meet on 7th October 2014 at Muttukadu Experimental Station of CIBA. The main objective of the programme was to create

Dr. M. Muralidhar, PI, NICRA addressing the gathering at FGW on 13th March at Kundapur

Farmers meet at Kakdwip on 9th December 2014

awareness on cost effective brackishwater culture technologies by providing technical advice and assistance to small scale farmers. On the same day, CIBA signed Memorandum of Understanding (MoU). This MoU was signed between the farmer Mr. J. Ramdas, M/s Seed fish farm (Thiruvallur District) and ICAR-CIBA at Muttukadu Experimental Station (MES), Muttukadu, Chennai for demonstration of finfish culture option.

Farmers Meet

Kakdwip Research Centre of CIBA organised Brackishwater Farmers Meet on 9th December 2014 with great enthusiasm. Dr. P. Ravichandran, Member Secretary, Coastal Aquaculture Authority of India, Chennai inaugurated brackishwater farmers meet. Dr. (Mrs) S. Bhattacharya, Joint Secretary, Department of Fisheries, West Bengal and Dr. K.K. Vijayan, Director, CIBA graced the occasion. Meeting was attended by

Distribution of low cost polyculture feed during farmers meet at Kakdwip 9th December 2014

Harvesting of milkfish from pond at CIBA KRC, Kakdwip

more than 200 participants including brackishwater farmers, stakeholders and entrepreneurs from South 24 Parganas, North 24 Parganas and Purba Midnapore District, West Bengal. Milkfish harvesting was also arranged as part of the farmers meet. A scientist-farmer interaction session was also held. Farmers were interested to know about the farming of pacific white shrimp *P. vannamei*, green mud crab culture, supply of seed for locally important brackishwater fishes like *Mugil cephalus, Liza tade and Liza parsia* etc. Farmers appealed CIBA to establish a seed bank and backyard hatchery for year round supply of quality fish seed

Stakeholders Interaction Meet

Stakeholders Interaction on "Research Priorities in Brackishwater Aquaculture and Way Forward" was conducted on 12th December 2014, at CIBA, Chennai to discuss on brackishwater aquaculture R&D requirements for the short-term and long-term

Harvest of shrimps reared in bio-floc based brackishwater rearing system

View of tribal beneficiaries at Sundarbans

future and the way forward. About 60 stakeholders representing all the coastal states attended the meeting.

Harvest Mela

Harvest mela of crab and seabass farmed was organised on 3rd April 2014 under the Polyculture trials of crab and seabass in the community pond of Irular tribals under CIBA-TSP 20/6 at Kulathumedu village, Pulicat, Tiruvallur district, Tamil Nadu.

A farmer-scientist interaction meet cum harvesting mela was organised at Muttukadu Experimental Station of CIBA on 5th July 2014. The meeting was attended by 180 participants belonging to all stakeholders including farmers, academicians, and representatives from the Society of Aquaculture Professionals, Chennai and scientific community.

A harvest mela for the biofloc based shrimp produced in the Institute farm, with the participation of local farmers and hatchery managers was organised on 28th September 2013.

A brainstorming session for creating and sustaining interest in agriculture among youth was jointly organized by The Hindu and National Agricultural Research System (NARS), was held on 25th October 2014 at CIBA, Chennai. The session was headed by Dr. S. Ayyappan, the Director General, ICAR & Secretary, DARE and Shri. Rajiv Lochan, the Managing Director and CEO, Kasturi and Sons, publishers of The Hindu, Chennai. Dr. T. Ravisankar, OIC, ITMU and team made the arrangements for the meeting.

A field day and harvest mela was conducted on 10th December, 2014 under Tribal Sub-Plan (TSP) scheme entitled "Sustainable Livelihood Improvement of Tribal Communities in Coastal Districts of West Bengal" at village Manmathapur-Mundapara, South 24 Parganas, West Bengal. Dr. K.K. Vijayan, Director, Central Institute of Brackishwater Aquaculture and Dr. M. Natarajan, Principal Scientist and SIC, Finfish culture division, CIBA, Chennai headed the program. Local Gram Panchayat Pradhan, Karmadhakshya and Panchayat Member and scientists from Kakdwip Research Center of CIBA participated in the program. One hundred and sixty villagers belonging to tribal community attended the function. In the interaction session, tribal farmers expressed their happiness and expressed interest for introducing scientific freshwater aquaculture, renovation of ponds, brick pitching of approach road, introduction of piggery, duckery and for increased number of aquaculture demonstrations.

Selling of harvested mudcrab to the vendor at Kulathumedu

Success Stories

Demonstration of polyculture of mud-crab with seabass farming in community pond and seabass nursery rearing in hapas in pond at Kulathumedu village, Pulicat, Tiruvallur district was undertaken. A total of 2000 nos. of seabass fingerlings at a cost of Rs. 15/- per fingerling with 6-9 cm total length and 4-6 g body weight and a total of 1048 nos. of crabs (249.2 kg) ranging from 100– 450 g of size at a cost of Rs.450/kg were stocked in this pond. Locally available low value fishes fed were to the crabs and seabass. Feeding was adjusted based on the standing biomass @ 8-10% of the total body weight. Feeding was carried out by both men and women using a boat and from shore by broadcasting at different feeding points in the pond. Regular sampling of seabass and crab was carried out once in 15 days to assess the growth and to check the health of the stock. All the records including work schedules, sampling data, feeding and pond management were maintained by the beneficiaries. After three months of culture period, the seabass attained total length of 135 mm to 245 mm (average 190 mm) and total weight ranged from 40-180 g (avg. wt.- 110 g). A total of 217 seabass juveniles were collected through partial harvesting and marketed. A total of 147 irular tribal people both men (82 nos.) and women (65 nos.) beneficiaries were trained and benefited. The total profit realized out of this trial was Rs. 2,32,290/- This amount was deposited in the beneficiaries bank account. This intervention proves to be a good model of supplementary revenue generation portraying the community participation in adoption of common water bodies for fish farming.

CIBA Foundation Day

The 27th Foundation day of the Central Institute of Brackishwater Aquaculture (CIBA, ICAR) was celebrated on 1st April 2014 at the institute head-quarters at Chennai. Dr. E. Vivekanadan, Emeritus Scientist, CMFRI, Chennai was the chief guest of the function. Dr. V.S. Chandrasekaran, Principal Scientist & Scientist-in-Charge, Social Sciences Division of CIBA welcomed the gathering. Dr. A.G. Ponniah, Director, CIBA, in his initial remarks highlighted the significance of celebrating the CIBA Foundation Day and stressed on CIBA's vision to address the needs of the brackishwater aquafarmers in the years to come. He also reviewed the growth of CIBA as a small field unit, years back and now, an organisation with full-fledged facilities having many research programmes and activities in brackishwater aquaculture.

CIBA Foundation Day celebration on 1st April 2014

Farm Innovators Day

The "Brackishwater Aquaculture Farm Innovators Day" was celebrated in connection with the World Food Day jointly by the Central Institute of Brackishwater Aquaculture (CIBA) and the Madras Research Centre (MRC) of Central Marine Fisheries Research Institute (CMFRI) Chennai on 16th October 2014 at CIBA Head Quarters in Chennai. The function was graced by Dr. M. Vijayakumaran, former Principal Scientist of CMFRI and NIOT, Chennai as Chief Guest and presided by Dr. K.K. Vijayan the CIBA Director. Dr. K. Vijayakumaran, the Scientist-in-Charge, of the MRC of CMFRI welcomed the gathering. The chief guest Dr. M. Vijayakumaran in his speech described about

Innovative farmer Mr. Sivagnanam speaking on the Farm Innovators Day celebration

Dr. T.K. Ghoshal addressing farmers in Krishi Mela during 21-23rd January 2015

the importance of production of food, the fishery resources from marine and coastal waters, capture and culture of fishes and other aquatic organisms. Dr. Vijayan in his presidential address emphasized that aquaculture has to contribute much more to meet the fish food requirements in the coming days.

National Science Day

"National Science Day" was celebrated in an aqua-farm at Kattur village, Ponneri Thaluk, Thiruvallur District of Tamil Nadu on 4th March 2015 to commemorate the great invention of Sir C.V. Raman on "Raman Effect". The theme of the National Science

Sri M. Pakhira, Hon'ble Minister for Sundarban Affairs at CIBA stall

Day this year is "Science for Nation Building". Nearly 68 farmers attended the programme.

Women's Day

Women staff of CIBA celebrated the Women's Day 2015 on 7th March 2015. The celebration started with the special address by Dr. K.K. Vijayan, Director, CIBA and Dr. V.P. Sriram from M.V. Diabetes Centre delivered a talk on "Diabetics". Different competitions were organized for the staff members of CIBA. All staff members and research scholars participated in the above said competitions and won various prizes, which were distributed by the Director, CIBA and Heads & SICs of the divisions.

ICAR-Industry Day

ICAR-Industry Interface Workshop 2014 was celebrated on 16th July, 2014 at headquarters, CIBA. Eminent personalities Shri. P. Sanjay Gandhi, Additional Govt. Pleader, High Court of Madras & President, IPR Attorney Association and Prof. Ranjith Oomen Abraham, The Tamil Nadu Dr. Ambedkar Law University gave lectures on "General Prospectives of Trademarks Law" and "Patent Rules and Regulations in India" to create awareness on trademarks, advantages of trademark registration, modern developments of trademarks, patentable inventions, provisional and complete specifications of patent applications, patent drafting, PCT applications (Patent Cooperation Treaty) and International Searching Authority (ISA). An essay contest was held before on 08.07.2014 as part of the ICAR Industry Day Celebration on the topics 'Patenting and Public Welfare' and 'Intellectual Property Rights and Public Funding'. Shri. P. Sanjay Gandhi, Additional Govt. Pleader, High Court of Madras distributed the cash prizes and certificates to the prize winners and participants. Totally 76 participants attended the programme.

Radio Talk

An interview on *L vannmei* culture, in Tamil was given by Dr. D. Deboral Vimala covering pond preparation, seed selection and stocking, feeding and feed management, soil and water quality management, health management and record keeping for the benefit of the farming community which was pre-recorded on 06.01.15 at 3.00 pm at All India Radio, Chennai for a duration of 30 minutes, was broadcasted on 30.1.15, 6.05 pm in 10 minutes.

Exhibitions

- KRC of CIBA participated in the Gramin Mela organized by Dakshin Chandanpiri Vivekananda Welfare Society, Namkhana during 4-5th April 2014.
- CIBA participated in exhibition organized in connection with 10th Indian Fisheries and Aquaculture Forum (10ifaf) - towards Responsible Aquaculture and Sustainable Fisheries, at NBFGR, Lucknow during 12-15th November 2014.
- CIBA participated in exhibition organized in connection at the XII Agricultural Science Congress-2015 held at NDRI, Karnal, during 3-6th February, 2015.
- KRC of CIBA participated in the Mati, Krishi, Udyan Palan Matsya Samabai-O-Prani Sampad Mela at Kakdwip during 21-23rd January 2015.
- CIBA participated in the Chennai Science Festival exhibition at Queen Mary's College, Chennai from 26th February 2015 to 1st March 2015 to showcase the research activities of CIBA for the benefit of the farming community and the public.
- KRC of CIBA participated in the Fish Festival, Odisha 2015 at Janata Maidan, Bhubaneswar during 5-8th March, 2015.

Awards and Recognitions

Kumararaja, P., Manjaiah, K.M. received Best oral presentation award for "Adsorptive removal of heavy metals from aqueous solutions by starch-g-poly (acrylic acid)/sodium bentonite composite" in National Conference on "Advances in Process Engineering" (CAPE 2014) organized by IIChE student Chapter, SASTRA University, Thanjavur during 10-11th October 2014.

Kumararaja, P., Manjaiah, K.M., Datta, S.C. received Best paper award the for "Modified bentonite for adsorptive removal of heavy metals from aqueous system" in the National conference on "Applied Chemical Sciences and Materials Technology" (ACSMT 2014) organized by Department of Chemistry, Bharathidasan Institute of Technology, Anna University, Tiruchirappalli during 17-18th October 2014.

Saikrithi, P., James, N., Balasubramanian, C.P., Otta, S.K., Subramoniam, T., Sherly Tomy received the second prize for the poster presentation for "Interaction between gonad inhibiting hormone and protein tyrosine kinase in *Penaeus monodon* using yeast two hybrid assay: probable role in regulating vitellogenesis" at National Conference on Bioactive Peptides- Application in Veterinary, Medical and Food Sciences (NBAP-TANUVAS) organized by Department of Animal Biotechnology, TANUVAS, Chennai on 18th December 2014.

Vasanth, M., Muralidhar, M., Saraswathy, R., Syama Dayal, J., Lalitha, N., Kumararaja, P., Jayanthi, M., Nagavel, A., Shanmugakarthik, J. received Best poster award for "Diurnal fluctuation of greenhouse gases emission from *L.vannamei* culture ponds" in the International symposium MECOS2 Marine Ecosystems, Challenges and Opportunities, organized by Marine Biological Association of India, Kochi, Kerala during 2-5th December 2014.

Saikrithi, P., James, N., Balasubramanian, C.P., Sherly Tomy received the Best paper award for "Differential expression of ovarian gene transcripts in *Penaeus monodon* following 5-Hydroxytryptamine treatment" in the International Symposium on Marine Ecosystems Challenges and Opportunities (MECOS2) organized by Marine Biological Association of India, Cochin during 2-5th December 2014.

Thulasi, D., Muralidhar, M., Vinayakumar, K., Lalitha, N., Saraswathy, R., Vasanth, M., Nagavel, A. received the Best paper award for "Abundance and diversity of methanogenic archaea in shrimp ponds" in the 2nd international conference on bio-resource and stress management organized at PJTSAU, Hyderabad during 7-10th January 2015.

Sukumaran, K., Kailasam, M., Prem Kumar received the Best poster presentation award for "Alternate aquaculture based livelihood options for inland fishers: seed production of pearlspot and small scale cage culture of Asian seabass in open waters" in the XII Agricultural Science Congress 2015 held at ICAR-National Dairy Research Institute, Karnal during 3-6th February 2015.

Shyne Anand, P.S. received Best poster presentation award for "Periphyton based shrimp culture – An ecofriendly shrimp farming in Sundarban" in the XII Agricultural Science Congress 2015 held at ICAR-National Dairy Research Institute, Karnal during 3-6th February 2015.

Ghoshal, T.K. was awarded certificate from ACCESS Development Services in recognition of the case study titled "Women in Homestead Vegetable Farming-Case Study of Enhanced Household Income" in Sitaram Rao Livelihoods India Case Study Competition 2014 as a co-author.

Special Achiever for the year 2014

Dr. P. Mahalakshmi, Senior Scientist awarded with Letter of Appreciation for "Special Achiever for the

year 2014" for her exemplary performance at various national/international events and in recognition of meritorious academic performance on 22nd April, 2014 at the VIT University, Vellore during the University Day 2014.

ICAR award for Outstanding Interdisciplinary Team Research in Agricultural and Allied Sciences

CIBA scientists led by **Dr. B. Shanthi**, Principal Scientist have been conferred with the Outstanding Interdisciplinary Team Research in Agricultural and Allied Sciences – 2011-12" by the Indian Council of Agricultural Research (ICAR) on 29th July 2014. The team comprises of Dr. B. Shanthi, Dr. M. Krishnan, Dr. V. S. Chandrasekaran, Dr. C. P. Balasubramanian, Dr. K. Ambasankar and Dr. S. Kannappan.

IRAJ Excellent paper award

Dr. P. Mahalakshmi, Senior Scientist, was awarded "IRAJ Excellent Paper Award" for the research paper entitled "Rough set based optimal location model for aquaculture development" for the category best presentation and best content at the IRF International Conference held at Chennai on 17th August 2014.

Japan Young Scientist Award

Dr. G. Biswas received Alltech Japan Young Scientist 2013 Award on 3rd October 2014 at Kagoshima, Japan. He also received certificate of appreciation for Dr. T.V.R. Pillay and Dr. M. V. Gupta Young Scientist 2013 Award by the Professional Fisheries Graduates' Forum, Mumbai on 12th November 2014 at NBFGR, Lucknow.

Ph.D. Programme

Scientists

- **Shri P. Kumararaja** was awarded Ph.D. Degree in Soil Science and Agricultural Chemistry from Indian Agricultural Research Institute (IARI), New Delhi on 11th February, 2015 for his thesis entitled "Modified clay minerals as heavy metal adsorbents and their effect on metal uptake by crops" under the guidance of Dr. K.M. Manjaiah, Principal Scientist, Division of Soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi

Technical Officer

- **Shri J. Joseph Sahaya Rajan,** Senior Technical Officer was awarded Ph.D. Degree by the University of Madras with effect from 11th September 2014 for his thesis entitled "Molecular and pathogenic characterization of *Escherichia coli* isolated from brackishwater environment" under the guidance of Dr. T.C. Santiago, Principal Scientist (Retd.), Aquatic Animal Health and Environment Division.

Research Scholars

- **Shri N. Dinesh Kumar** was awarded Ph.D. Degree by the University of Madras with effect from 27th August 2014 for his thesis entitled "Diversity of nitrifying and denitrifying prokaryotes in brackishwater ecosystems of India" under the guidance of Dr. Alavandi, Principal Scientist & Head, Aquatic Animal Health and Environment Division.

- **Shri H. Imran Khan** was awarded Ph.D. Degree by the University of Madras with effect from 26th November 2014 for his thesis entitled "Studies on the fishmeal and fish oil replacement in the presence of lysolecithin in the diet of tiger shrimp, *Penaeus monodon"* under the guidance of Dr. J. Syama Dayal, Principal Scientist, Nutrition Group.

- **Shri R. Singaravel** was awarded Ph.D. Degree by the University of Madras with effect from 29th December 2014 for his thesis entitled "Molecular and virulence characterization of *Salmonella typhi* isolated from brackishwater

ecosystems of India" under the guidance of Dr. T.C. Santiago, Principal Scientist (Retd.), Aquatic Animal Health and Environment Division.

- **Shri S. Ramakrishnan** was awarded Ph.D. Degree by the University of Madras with effect from 9th January 2015 for his thesis entitled "Cloning, expression and characterization of azurin and chitinase genes from *Vibrio alginolyticus*" under the guidance of Dr. T.C. Santiago, Principal Scientist (Retd.), Aquatic Animal Health and Environment Division.

- **Shri D. L. Mohanlal** was awarded Ph.D. Degree by the University of Madras with effect from 16th March 2015 for his thesis entitled "Molecular basis of vitellogenesis in giant tiger shrimp *Penaeus monodon* (Fabricius, 1798)" under the guidance of Dr. C.P. Balasubramanian, Principal Scientist, Crustacean Culture Division

Linkages and Collaborations

The Institute maintained linkages with the following national and international organizations

National

ICAR Institutes

- Central Institute of Fisheries Education, Mumbai
- Central Institute of Freshwater Aquaculture, Bhubaneswar
- Central Marine Fisheries Research Institute, Cochin
- Central Agricultural Research Institute, Port Blair
- Central Inland Fisheries Research Institute, Barrackpore
- Central Institute of Fisheries Technology, Cochin
- Central Research Institute for Dryland Agriculture, Hyderabad
- Directorate of Seed Research, Mau
- Directorate of Research on Women in Agriculture, Bhubaneswar
- National Academy for Agricultural Research Management, Hyderabad
- National Bureau of Agriculturally Important Microorganisms, Mau
- National Bureau of Fish Genetic Resources, Lucknow

Other Institutes / SAUs / State Agriculture Departments

- Agricultural & Processed Food Products Export Development Authority, New Delhi
- Center for Advanced Studies in Marine Biology, Annamalai University, Parangipettai
- Coastal Aquaculture Authority, Chennai
- College of Fisheries, University of Agricultural Sciences, Mangalore
- College of Fisheries, Sri Venkateswara Veterinary University, Muthukur
- Dept. of Horticulture, Govt. of Tamil Nadu, Chennai.
- Dept. of Animal Husbandry, Govt. of Tamil Nadu, Chennai.
- Department of Animal Husbandry, Dairying and Fisheries, New Delhi
- Department of Biotechnology, New Delhi
- Fisheries College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Thoothukudi
- Ministry of Science and Technology, New Delhi
- Ministry of Water Resources, New Delhi
- Marine Products Export Development Authority, Cochin
- Navsari Agricultural University, Navsari, Gujarat
- National Fisheries Development Board, Hyderabad
- National Institute of Ocean technology, Chennai
- Tamil Nadu Veterinary and Animal Sciences University, Chennai
- Tamil Nadu Agricultural University, Coimbatore
- University of Madras, Chennai
- West Bengal University of Animal and Fisheries Sciences, Kolkata

State Fisheries Departments/BFDAs

The Institute has well established linkages with State Fisheries Depts. /BFDAs mainly for transfer of technology programmes.

International

WorldFish Centre, Malaysia

A project entitled “Productive, profitable and resilient agriculture and aquaculture systems” has been undertaken under CGIAR – CPWF at, Kakdwip, West Bengal

Publications, participation in conferences, meetings, workshops and symposia

Institute Publication list

Annual Report 2013-14
Training Calendar 2014-15
CIBA at a Glance
Vision 2050

CIBA Technology Series

- Culture technology for banana shrimp, *Fenneropenaeus merguiensis* (No. 12)
- CIBASTIM technology for immune stimulation and growth promotion in shrimp (No.13)
- Identification of disused shrimp ponds using multi temporal satellite data and geographical information system (No.14)

CIBA Special Publication

- English-Hindi Glossary on Fisheries Science and Aquaculture (CIBA Special Publication No.72)
- Handbook on Indigenous technical knowledge and beliefs of coastal fishers and tribes in Tamil Nadu (CIBA Special Publication No.72A)
- Training Manual on Disease Diagnostics methods in shrimp aquaculture - with special reference to shrimp early mortality syndrome (EMS) (CIBA Special Publication No.73)
- Training manual on Health practices for finfish and shellfish of brakishwater Environment (CIBA Special Publication No.74)
- Seed production and culture of brackishwater finfishes (CIBA Special Publication No.75)
- Handbook on Socio-economic and gender analysis for assessing the impact of environmental changes on the livelihoods of coastal women in Tamil Nadu (CIBA Special Publication No.76)
- Frequently Asked Questions (FAQs) – Pertaining to Litopenaeus vannamei Shrimp Farming (CIBA Special Publication No.77)

e-Publication

- Sterility and its implication in tilapia aquaculture: a review CIBA (e-publication Series No-28)

List of Publications

Refereed Journals

1. Alavandi, S.V., Bharathi, A.R., Kumar, S.S., Dineshkumar, N., Saravanakumar, C., Rajan, J.J.S., 2015. Tangential flow ultrafiltration for detection of white spot syndrome virus (WSSV) in shrimp pond water. J. Virol. Methods 218, 7-13.
2. Anand, P.S.S., Pillai, S.M., Kumar, S., Panigrahi, A., Ravichandran, P., Ponniah, A.G., Ghoshal, T.K., 2014. Growth, survival and length weight relationship of *Fenneropenaeus merguiensis* at two different stocking densities in low saline zero water exchange brackishwater ponds. Indian J. Geo-Mar. Sci. 43(10), 1-12.
3. Bilen, S., Biswas, G., Otsuyama, S., Kono, T., Sakai, M., Hikima, J., 2014. Inflammatory responses in the Japanese pufferfish (*Takifugu rubripes*) head kidney cells stimulated with an inflammasome-inducing agent, nigericin. Dev. Comp. Immunol. 46, 222–230.
4. Bilen, S., Yılmaz, S., Bilen, A.M., Biswas, G., 2014. Effects of dietary incorporation of tetra (*Cotinus coggygria*) extract on immune response and resistance to *Aeromonas hydrophila* in koi carp (*Cyprinus carpio*). Isr. J. Aquacult.- Bamidgeh 66, 1–6.
5. Dineshkumar, N., Saravanakumar, C., Vasanth, C., Muralidhar, M., Alavandi, S.V., 2014. Genetic and physiological characterization of denitrifying bacteria from brackishwater shrimp culture ponds of India. Int. Biodeterior. Biodegradation 92, 49-56.
6. Fernandes, J., Pal, A.K., Kumar, P., Chandrachoodan, P.P., Akhtar, M.S., 2015. Combined effect of heat shock and chlorine fails to elicit acquired thermal tolerance in *Labeo rohita* spawns. Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci. DOI 10.1007/s40011-014-0478-5.
7. John, K.R., George, M.R. Jeyatha, B., Saravanakumar, R., Sundar, P., Jithendran, K.P., Koppang, E.O., 2014. Isolation and characterization of Indian betanodavirus strain from infected farm-reared Asian seabass *Lates calcarifer* (Bloch, 1790) juveniles. Aquacul. Res., 45, 1481-1488.
8. Kizhakudan, S.J., Raja, S., Gupta, K.S., Vivekanandan, E. Kizhakudan, J.E., Sethi, S.N., Geetha, R., 2014. Correlation between changes in sea surface temperature and fish catch along Tamil Nadu coast of India-An indication of impact of climate change on fisheries, Indian J. Fish., 61(3), 111-115.
9. Kono, T., Fall, J., Korenaga, H., Sudhakaran, R., Biswas, G., Mekata, T., Itami, T., Sakai, M., 2014. Recombinant VP28 produced by cell-free technique confers protection in kuruma shrimp (*Marsupenaeus japonicus*) against white spot syndrome virus. Turk. J. Fish. Aquat. Sci., 14, 547-555.
10. Kumar, N., Minhas, P.S., Ambasankar, K., Krishnani, K.K., Rana, R.S., 2014. Dieatary lecithin potentiates thermal tolerance and cellular stress protection of Milkfish (*Chanos chanos*) reared under low dose endosulfan- induced stress. J. Therm. Biol. 46, 40-46.
11. Kumar, P., Pal, A.K., Sahu, N.P., Jha, A.K., Priya, P., 2014. Biochemical and physiological stress responses to heat shock and their recovery in *Labeo rohita* fingerlings. Proc. Natl. Acad. Sci. India Sect. B Biol. Sci. DOI 10.1007/s40011-014-0357-0
12. Kumar, P., Thirunavukkarasu, A.R., Kailasam, M., Sukumaran, K., Subburaj, R., Thiagarajan, G., Natarajan, M., 2015. Gonadal development and steroid hormone profile of wild caught grey mullet (*Mugil cephalus*), Biol. Rhythm Res., DOI: 10.1080/09291016.2015.1034974.
13. Kumaran, M., Ravichandran, P., Ponniah, A.G., Kumar, J.A., Vimala, D.D., Chandrasekaran, V.S., 2015. Extension methodology for assessing effectiveness of shrimp farmer groups, Indian J. Fish. 62 (1), 116-123.
14. Mahalakshmi, P., Gopal, C., Muralidhar, M., Kailasam, M., Kumar, P., Patil, P.K., Solanki, H.G., Borichangar, R.V., Vanza, J.G., 2014. Needs assessment of tribal and aqua farmers for disseminating aquacultural information though ICT in Gujarat. APRN J. Sci. Tech. 4(6), 371-376.
15. Mahalakshmi, P., Ganesan, K., 2015. Mamdani fuzzy rule based model for classification of aqua sites for aquaculture development, Indian J. Fish. 62(1),110-115.
16. Mahalakshmi, P., Panigrahi, A., Ravisankar, T., Kumar, J.A., Shanthi, B., 2014. Multi-criteria decision making for identification of optimal location for aquaculture development, Int. J. Adv. Sci. Eng. Tech., 2(3), 11-14.
17. Mahalakshmi, P., Ponniah, A.G., Krishnan, M., 2014. Aquaculture knowledge dissemination through information and communication technology projects: e-learning module approach, Fish. Technol. 51, 220-224.

18. Madhavi, M., Kailasam, M., Mohanlal, D., 2015. Ultrastructure of spermatozoa of the spotted scat (*Scatophagus argus*, Linnaeus) observed by scanning and transmission electron microscopy. Anim. Reprod. Sci. 153, 69-75.

19. Madhavi, M., Kailasam, M., Thirunavukkarasu, A.R., Kumar, P., Subburaj, R., Vijayan, R., Thiagarajan, G., 2014. Influence of salinity on survival and growth of early juveniles of spotted scat *Scatophagus argus* (Linnaeus, 1766). Indian J. Innov. Dev. 3(2), 23-26.

20. Meenakshi, M., Pillai, S.M., Gopal, C., Kumar, K.V., 2014. Evaluation of spermatophore quality between wild and captive reared banana shrimp, *Fenneropenaeus merguiensis* adult males during captivity. J. Exp. Zool. India 17(2), 457-468.

21. Merlin, J. R., Mohanlal, D. L., C. P. Balasubramanian, Sherly Tomy, Subramoniam, T., , Ravichandran, P., Ponniah, A. G., Gopal, C., and Vijayan, K. K. 2015. Induction of vitellogenesis and reproductive maturation in tigershrimp, *Penaeus monodon* by 17ß-estradiol and 17α-hydroxyprogesterone: *in vivo* and *in vitro* studies. Invertebrate Reproduction and Development http://dx.doi.org/10.1080/07924259.2015.1051192

22. Mondal, S.K., Kumar, A., Dubey, P.P., Sivamani, B., Dutt, T., 2014. Estimation of variance and genetic parameters for pre-weaning weights of individual landrace X desi synthetic piglets, J. Appl. Anim. Res. 42(3), 338-344.

23. Preetha, R., Vijayan, K.K., Jayapraksh, N.S., Alavandi, S.V., Santiago, T.C., Singh, I.S.B., 2015. Optimization of culture conditions for mass production of the probiotics pseudomonas MCCB 102 and 103 antagonistic to pathogenic vibrios in aquaculture. Probiotics & Antimicro. Prot. DOI 10.1007/s12602-015-9185-7.

24. Rameshkumar, D., Sanjuktha, M., Rajan, J.J.S., Bharathi, R.A., Santiago, T.C., Alavandi, S.V., Poornima. M., 2014. Development of SYBR green based real time PCR assay for detection of monodon baculovirus in *Penaeus monodon*. J Virol Methods 205, 81-86.

25. Robinson, N.A., Gopikrishna, G., Baranski, M., Katneni, V.K., Shekhar, M.S., Shanmugakarthik, J., Jothivel, S., Gopal, C., Ravichandran, P., Gitterle, T., Ponniah, A.G., 2014. QTL for white spot syndrome virus resistance and the sex-determining locus in the Indian black tiger shrimp (*Penaeus monodon*). *BMC Genomics,* 15**,** 731.

26. Satapathy, S., Shukla, S.P., Sandeep, K.P., Singh, A.R., Sharma, N., 2015. Evaluation of the performance of an algal bioreactor for silver nanoparticle production. J. Appl. Phycol., DOI 10.1007/s10811-014-0311-9.

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28. Sethi, S.N., Kokane, M.R., Otta, S.K., Sethi, G., 2015. First record of ragged sea hare, *Bursatella leachii* Blainville, 1817 Opisthobranchia: Euopisthobranchia: Aplysiidae) in Pulicat lake, East Coast of India. Mar. Biodivers. Rec. (8) e-34, 1-3.

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31. Shekhar, M.S., Ponniah, A.G., 2014. Recent insights into host pathogen interaction in white spot syndrome virus infected penaeid shrimp. J. Fish Dis. DOI 10.1111/jfd.12279

32. Sindhupriya, M., Saravanan, P., Otta, S.K., Amarnath, C.B., Arulraj, R., Bhuvaneswari, T., Praveena, E.P., Jithendran, K.P., Ponniah A.G., 2014. White spot syndrome virus (WSSV) genome stability maintained over 6 passages through 3 different penaeid shrimp species. Dis. Aquat. Organ. 111, 23-29.

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34. Sonmez, A.Y., Bilen, S., Alak, G., Hisar, O., Yanık, T., Biswas, G., 2015. Growth performance and antioxidant enzyme activities in rainbow trout (*Oncorhynchus mykiss*) juveniles fed diets supplemented with sage, mint and thyme oils. Fish Physiol. Biochem., 41, 165-175.

35. Sreekanth, G.B., Chakraborty, S.K., Jaiswar, A.K., Renjith, R., Kumar, K.R., Sandeep, K.P., Vaisakh, G., Ail, S.S., Lekshmi, N.M., Pazhayamadom, D.G., 2015. Can the *Nemipterus japonicus* stocks along Indian coast be differentiated using morphometric analysis? Indian J. Geo-Mar. Sci., 44(4), http://www.niscair.res.in/jinfo/IJMS/IJMS-Forthcoming-Articles/IJMS-PR-April%202015/MS%202390%20Edited.pdf.

36. Sukumaran, K., Thirunavukkarasu, A.R., Kailasam, M., Kumar, P., Subburaj, R., Thiagarajan, G., 2014. Pre-growout culture of asian seabass *Lates calcarifer* (bloch) in low volume cage in brackishwater Ashtamudi lake under participatory mode with traditional fisherman. J. Aquat. Biol. Fish., 2, 265-269.

37. Sunil, N., Pandravada, S.R., Natarajan, S., Reddy, J., Chakrabarty, S.K., Kumar, J.A., Bisht, I.S., 2014. Diversity in the landraces of green gram [*Vigna radiata* (L) R. Wilczek] collected from tribal communities of peninsular India. J. Biodivers. 114, 392-400.

38. Taju, G., Madan, N., Majeed, A.S., Kumar, T.R., Thamizhvanan, S., Otta, S.K., Hameed, A.S.S., 2015. Immune responses of whiteleg shrimp, *Litopenaeus vannamei* (Boone, 1931), to bacterially expressed dsRNA specific to VP28 gene of white spot syndrome virus. J. Fish Dis. DOI 10.1111/jfd.12256

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Popular Articles

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2. Chandrsekaran, V.S., Shanthi, B., Kumaran, M., Vijayan, K.K., 2014. Livelihood development through coastal brackishwater aquaculture: In: Chauhan, R.S. (Ed.) National conference on

challenges for sustainability of natural resources and environment with emphasis on aquatic ecosystem for livelihood security, 10-12th October, 2014 at College of Fisheries, G.B. Pant University of Agriculture & Technology, Pantnagar, Souvenir and Abstracts pp. 22-26.

3. Churchil, R.R., Praveena, P.E., 2014. Maintenance of poultry birds during rainy season (in Tamil). Vellan vaniga ulagam 2014 pp. 60-63.
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Participation in Conferences, Meetings, Workshops and Symposia

International

1. Workshop on CGIAR/CPWF Ganges Basin Development Sciences organized by The WorldFish Centre-Dhaka, Bangladesh at Dhaka during 30th April 2014 to 6th May 2014 –Dr. Asuthosh D. Deo.
2. 10th Asia-Pacific Marine Biotechnology Conference held at Taipei, Taiwan during 4–8th May 2014 - Dr. G. Biswas.
3. Meeting on Early Mortality Syndrome (EMS) of Shrimp held at Kuala Lumpur, Malaysia on 4th October 2014 – Dr. S.K. Otta.
4. Conference on "Revitalizing the Ganges Coastal Zone" under the auspices of CGIAR Water, Land and Ecosystem (WLE) co-ordinated Research Program organized by WorldFish Centre, Dhaka, Bangladesh during 18-23rd October 2014 - Dr. T.K. Ghoshal.

National

Dr. C. Gopal, Director I/C

5. Research Advisory Committee Meeting of CIBA organized by CIBA at Chennai on 11th April 2014.
6. Interactive meeting of the ICAR Directors and Vice-chancellors of Agricultural Universities held at A.P.Shinde Hall, NASC Complex, New Delhi organized by ICAR, New Delhi on 28th April 2104.
7. XXIV Meeting of the ICAR Regional Committee No.VIII held at Central Tuber Crops Research Institute, Trivandrum organized by ICAR, New Delhi on 2-3rd May April 2104.

8. Meeting on presentation of NAIP foreign training at NAIP, ICAR, New Delhi organized by ICAR, New Delhi on 15th May 2104.
9. Meeting with Kuwait Institute of Scientific Research (KISR) Team to discuss opportunities for research cooperation between KISR and ICAR Institutes, organized at National Institute of Ocean Technology (NIOT), Goa on 21st May 2014.
10. 1st Meeting of the Quinquennial Review Team (QRT) of CIBA at CIBA, Chennai on 29-30th May 2014.
11. Directors' Conference at A.P.Shinde Auditorium, NASC, New Delhi organized by ICAR, New Delhi on 5-6th June 2014.
12. Workshop on Impact of capacity building programs under NAIP, jointly organized by NAIP and IFPRI at A.P.Shinde Auditorium, NASC, New Delhi on 6th June 2014.
13. Asia Pacific Fishery Commission (APFIC) 5th Regional Consultative Forum Meeting (RCFM) organized by Ministry of Agriculture, DAHDF, Govt. of India held at Hyderabad on 19-21st June 2014.
14. IVRI EFC meeting of Platform on Vaccines and Diagnostics held at ICAR, New Delhi organized by ICAR, New Delhi on 8th July 2014.
15. XII Plan EFC meeting for consideration of Plan schemes of DARE/ ICAR, under the chairmanship of the Secretary, DARE & ICAR organized by ICAR, New Delhi on 15-17th July 2014.
16. QRT meeting at to Kakdwip Research Centre of CIBA, Kakdwip organized by CIBA on 22-23rd July 2014.
17. ICAR Director's and Vice-chancellors meeting held at NASC Complex, New Delhi organized by ICAR, New Delhi on 29th July, 2014.

Dr. K.K. Vijayan, Director

18. National Level Steering Committee Meeting for the First Ocean Science Congress 2015 Held at Govt. Guest House, Ernakulam organized by Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi on 23rd August 2014.
19. Interaction Meeting of Dr. Jose Graziano da Silva, Director General, FAO with Senior Officers in the Ministry of Agriculture, ICAR Headquarters and leaders of Indian NARES including Vice Chancellor of Agricultural Universities and Directors of ICAR Institutes held at A.P.Shinde Symposium Hall, NASC, New Delhi on 8th September 2014.
20. 49th Executive Committee Meeting and 21st Annual General Body Meeting of Rajiv Gandhi Centre for Aquaculture held at The Marine Products Export Development Authority, Kochi organized by RGCA, Sirkazhi on 29th September 2014.
21. Fisheries Development Workshop for the officers of NABARD organized by NABARD held at Fortune Murali Park Hotel, Vijayawada on 15th October 2014.
22. NAAS Silver Jubilee National Symposium on Indian Fisheries and Aquaculture : 25 Years of Achievements and way forward held at Central Institute of Fisheries Education, Mumbai organized by CIFE , Mumbai on 21-22nd October 2014.
23. Selection Committee Meeting for the selection of "Director (Technical)" in Coastal Aquaculture Authority (CAA), Chennai organized by CAA, Chennai on 7th November 2014.
24. 10th Indian Fisheries and Aquaculture Forum organized by National Bureau of Fish Genetics Resources at Lucknow on 12th November 2014.
25. Division-wise Meetings to review the status of Vision 2050 document, under the chairmanship of Secretary, DARE and Director General, ICAR held at Mahatma Jyotiba Phule Hall (CR-I), Ground Floor, Krishi Bhavan, New Delhi orgnaised by ICAR, New Delhi on 19th November 2014.
26. International Symposium on Marine Ecosystems – Challenges and Opportunities (MECOS2) organized by Marine Biological Association of India during 2-5th December 2014 at Dream Hotel, Kochi.
27. Institute Management Committee Meeting of CIBA held at CIBA Headquarters, Chennai on 18th December 2015.
28. Executive Development Programme on "Leadership Development" at Hyderabad organized by NAARM, Hyderabad on 19-23rd January 2015.
29. World Ocean Science Congress 2015 (WOSC) held at Kochi organized by Swadeshi Science Movement, Vijnana Bharati, Kerala chapter and Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi on 5th February 2015.
30. 12th Agricultural Science Congress (ASC) at National Dairy Research Institute, Karnal organized by National Academy of Agricultural Science (NAAS), New Delhi on 6th February 2015.
31. Seminar on Fisheries Sector & Coastal Development organized in connection with 4th International Kerala Study Congress at Kochi by AKG Studies and Research Centre, Trivandrum on 17th February 2015.
32. Aqua Aquaria 2015, at Vijayawada organized by MPEDA, Kochi on 20-21st February 2015.
33. Training Programme on 'Family Farming Opportunities for Polyculture of Brackishwater Finfishes in Cage and Ponds' and Harvest Mela at Navipadi Village, Navsari under Tribal Sub Plan (TSP) on 28th February 2015.
34. Meeting with stakeholders connected with shrimp culture in Andhra Pradesh, convened by the Principal Secretary to Government, Animal Husbandry, Dairying and Fisheries, Govt. of Andhra Pradesh, at A.P. Secretariat, Hyderabad on 9th March 2015.
35. Interactive workshop for the shrimp farmers of Kerala towards developing a Kerala model for L.vannamei culture, organized by Kerala University of Fisheries & Ocean Studies, Kochi on 15th March 2015.
36. Meeting with Chairman, MPEDA regarding possible collaboration on brackishwater aquaculture activities at MPEDA, Kochi on 23rd March 2015.

Participation in Workshops/Seminar/Meeting by Scientists

37. Meeting with Principal Secretary, Department of Fisheries, Govt. of West Bengal to provide technology for setting up of fish feed plant in West Bengal organized by Directorate of Fisheries, Govt. of West Bengal, Salt Lake on 8th April, 2014 - Dr. T.K. Ghoshal.
38. CAC meeting of NAIP project on Bioprospecting of genes and allele mining for abiotic stress tolerance at NRCPB, New Delhi on 23rd April 2014 - Dr. Shashi Shekhar.
39. One day workshop on Nutritional Advantages of Shrimp with focus on its Heart Healthy Lipid Elements held at CIBA, Chennai on 25th April 2014 – Dr. D. Deboral Vimala, Dr. P. Ezhil Praveena, Dr. T. Bhuvaneswari, Dr. M. Poornima.
40. Review meeting of NAIP with World Bank team at CIFA Bhubaneswar during 29th April to 1st May, 2014 - Dr. T.K. Ghoshal.
41. Workshop on 'GHG inventory and carbon budget for Indian Agriculture' during 7-8th May, 2014 – Dr. M. Muralidhar.
42. Review meeting on outreach activity, ICAR, Fisheries SMD, during 9th May 2014. Dr. K. Ambasankar.
43. Training workshop on Zebrafish Model System: Development and Genetics organised by the Department of Genetic Engineering held at SRM University, Kattankulathur, Chennai during 12-13th May, 2014 – Dr. Sherly Tomy.
44. Workshop on 'Impact of capacity building programs under NAIP' jointly organized by NAIP and IFRI held at NAAS complex New Delhi on 6-7th June 2014– Dr M.S. Shekhar**,** Dr. P.K. Patil, Dr. Sanjoy Das.
45. Meeting with WorldFish Centre Officials, Bangladesh for WFC project at CIFE, Kolkata on 8-9th June, 2014 - Dr. T.K. Ghoshal.
46. Aquaculture Chennai – 2014: Sustainable Shrimp Farming – Way Forward held at Chennai from 13-14th June 2014 – Dr. V.S. Chandrasekaran, Dr. D. Deboral Vimala, Dr. M. Muralidhar, Dr. M. Jayanthi, Dr. C.P. Balasubramanian, Dr. S. Kannappan, Dr. A. Panigrahi, Dr. P. Nila Rekha, Dr. K. Ambasankar, Dr. J. Syama Dayal, Dr. M. Kumaran, Dr. P.K. Patil, Dr. S.K. Otta,

Dr. Sherly Tomy, Dr. K.P. Kumaraguru vasagam, Dr. P. Ezhil Praveena, Dr. T. Bhuvaneswari.

47. Workshop organized by MoEF on 21st June, 2014 at CRIDA, Hyderabad to submit the Biennial Update Report (BUR) to NATCOM which contains information related to the national greenhouse gases inventory, mitigation actions initiated and also an update of constraints and gaps for achieving the objectives of the UNFCCC – Dr. M. Muralidhar.
48. Review meeting of Hilsa project with DDG (Fishery), ICAR on 26th June 2014 at CIFRI, Barrackpore - Dr. Debasis De.
49. Regional Committee Meeting at CIFRI, Barrackpore during 27-28th June, 2014 - Dr. T.K. Ghoshal.
50. Third Annual Review workshop of NICRA Project at New Delhi during 3-5th July, 2014 – Dr. M. Muralidhar.
51. Fifth Advisory Committee Meeting of NFBSFARA Project on Stock Characterization, captive breeding, seed production and culture of Hilsa (*Tenualosa ilisha*) during 8 -9th July 2014 at CIFRI, Barrackpore- Dr. Debasis De.
52. XXI Annual convention of Indian Society of Veterinary Immunology and Biotechnology and International Symposium on Livestock Diseases affecting Livelihood options and Global trade – strategies and solutions conference held at Madras Veterinary College, Chennai from 17-19th July 2014 – Dr. P. Ezhil Praveena.
53. Meeting for preparation of inventory of agriculture technologies for West Bengal and Andaman & Nicobar Islands organized at Zonal Project Directorate Office, Kolkata on 19th July, 2014 - Dr. T.K. Ghoshal.
54. Brainstorming Session on Insects related to Veterinary and Fisheries Sciences at NBAII, Bangalore on 2nd August, 2014 – Dr. Satyanarayana Sethi.
55. National Workshop on 'Implementation of livestock/meat traceability system in India' organized by National Research Centre on Meat, Hyderabad on 4th August 2014 – Dr. P.K. Patil.
56. Workshop on PME in Agricultural Research Projects organized by NAARM, Hyderabad during 4-8th August, 2014 – Dr. R. Saraswathy.
57. Interaction meet and demonstration programme on nursery rearing of Asian seabass held at Onjal, Navsari, Gujarat on 7th August 2014 - Dr. Premkumar.
58. 11th IRF International Conference held at Chennai on 17th August 2014 – Dr. P. Mahalakhsmi.
59. Review meeting of members of fishery group organized at Zonal Project Directorate Office, Kolkata on 22nd August 2014 - Dr. T.K. Ghoshal.
60. One day workshop on "Techniques and applications of transmission electron microscopy" organized by Department of Electron Microscopy, Cancer Institute, Chennai on 22nd August 2014 –Dr. Prem Kumar.
61. Training workshop on "Recent Developments in Brackishwater Aquaculture'" held at Ramanathapuram on 26th August 2014– Dr. T. Bhuvaneswari.
62. Conference on Investment Opportunities in Fisheries Sector of West Bengal organized by Indian Chamber of Commerce, Kolkata on 28th August 2014 - Dr. T.K. Ghoshal.
63. Meeting for preparation of perspective plan for fisheries development in West Bengal organized by CIFRI, Barrackpore on 30th August 2014 - Dr. T.K. Ghoshal.
64. Brainstorming workshop on technology interventions in brackishwater aquaculture held during 5th September 2014 at Kakinada, Andhra Pradesh – Dr. M. Poornima.
65. Meeting on 'Discussion on priorities for projects identified or programming under 'Chemical and Waste' focal area in the global environment facility 6th cycle on 9th September, 2014 at MoEF, Delhi – Dr. M. Muralidhar.
66. 3rd International Conference on Hydrology and Meteorology organized by OMICS group, Hyderabad during 15-16th September, 2014 – Dr. P. Kumararaja.
67. 2nd International Conference on Animal and Dairy Sciences" held at Hyderbad, on 15-17th September 2014. Dr K.P. Kumaraguru vasagam and Dr. K. Vinaya Kumar.
68. Second Co-ordination Committee Meeting of NFBSFARA project Stock characterization, captive breeding, seed production and culture of hilsa (*Tenualosa ilisha*) on 18th September 2014 at Krishi Anusandhan Bhavan-II, New Delhi- Dr. Debasis De
69. Meeting of the Scientific Advisory Committee of Sasya Shyamala Krishi Vigyan Kendra, Ramkrishna Mission Vivekananda University, Kolkata-150 organized by SSKVK, Kolkata on 19th September 2014 - Dr. T.K. Ghoshal.
70. Seminar on Right to Information Act, 2005 conducted by ISTM, New Delhi on 25th September 2014 - Dr. V.S. Chandrasekaran.
71. Emerging Environmental and Advanced Oxidation Technologies for Energy, Environment and Sustainability (EEAOTEES-2014) organized by Anna University, Chennai during 29-30th September, 2014 – Dr. P. Kumararaja
72. One day Post Conference Workshop on "Advanced Oxidation Technology" - Skill Training and Demonstration (AOT – 2014) organized by Centre for Environmental Studies, Department of Chemistry and Centre with Potential for Excellence in Environmental Sciences at Anna University, Chennai on 1st October, 2014 – Dr. P. Kumararaja.
73. One day Workshop on "Production Risks and better management practices of Pacific white shrimp farming" held at Ongole, Andhra Pradesh on 10th October 2014 - Dr. S.K. Otta.
74. Advances in Process Engineering (CAPE 2014) organized by IIChE student Chapter, SASTRA University, Thanjavur during 10-11th October, 2014- Dr. P. Kumararaja.
75. National Conference on Challenges for Sustainability of Natural Resources and Environment with emphasis on "Aquatic ecosystem for livelihood security" during 10-12th October 2014 at College of Fisheries, G. B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand - Dr. V.S. Chandrasekaran.
76. Applied Chemical Sciences and Materials Technology (ACSMT 2014) organized by Department of Chemistry, Bharathidasan Institute of Technology, Anna University, Tiruchirappalli during 17-18th October, 2014 - Dr. P. Kumararaja.
77. Indian Fisheries and Aquaculture 25 years of achievement and way forward held at CIFE, Mumbai during 21-22nd October 2014 – Dr. P. Ravichandran, Dr. G. Gopikrishna, Dr. S.V. Alavandi, Dr. C.P. Balasubramanian.
78. Brainstorming Session on 'Creating and sustaining interest in agriculture among the youth – The Hindu-NARS initiative on 25th October, 2014 – Dr. M. Muralidhar.
79. Scientific Advisory Committee Meeting of Ramkrishna Ashram Krishi Vigyan Kendra, Nimpith, West Bengal organized at RAKVK, Nimpith on 28th October, 2014 - Dr. T.K. Ghoshal.
80. Workshop on Open access to Agricultural knowledge for inclusive growth and development at NAARM, Hyderbad in partnership with GFAR-FAO during 29-30th October 2014 at Hyderabad – Dr. K.P.Jithendran..
81. Indo-Norwegian Co-operation – Joint workshop on Aquaculture held at Mumbai on 30th October 2014 – Dr. M.S. Shekhar.
82. Special session on *P. vannamei* farming: preparedness for a better future' organized by the SAP on 8th November, 2015 at Chennai – Dr. V.S. Chandrasekaran, Dr. M. Jayanthi, Dr. C.P. Balasubramanian Dr. M. Kumaran, Dr. J. Syama Dayal.
83. 10th Indian Fisheries and Aquaculture (10ifaf) Conference held at NBFGR, Lucknow on 12-15th November, 2014 – Dr. M. Natarajan, Dr. K.P. Jithendran, Dr. M.Kailasam, Dr. B Shanthi, Dr. C.P. Balasubramanian, Dr. M.S. Shekhar, Dr. A. Panigrahi, Dr. Nila Rekha, Dr. K.Ambasanakar, Dr. J.Syama Dayal, Dr. T.K. Ghoshal, Dr. Debasis De, Dr. M. Poornima, Dr. P. Mahalakshmi, Dr. Sathyanarana Sethi, Dr. S.K. Otta, Dr. Sherly Tomy, Dr. K.P. Kumaraguru vasagam, Dr. P. Ezhil Praveena, Dr. P.S. Shyne Anand, Dr. Krishna Sukumaran, Dr. Sujit Kumar, Dr. T. Bhuvaneswari, Dr. Prem Kumar, Dr. P. Kumararaja.

84. International Workshop on "Disease surveillance" held at NBFGR, Lucknow on 14th November 2014 – Dr. K.P. Jithendran, Dr. S.K. Otta, Dr. P. Ezhil Praveena, Dr. T. Bhuvaneswari.
85. Brain storming session for biotechnology solutions in aquaculture organized by Dept. Biotechnology, Govt. Gujarat on 18th Nov 2014 at Gandhinagar, Gujarat – Dr. P.K. Patil.
86. Mid-term Review Workshop in respect of Achievements for RFD 2014-2015 of Fisheries RSCs (Institutes) on 20th November, 2015 at New Delhi – Dr. M. Muralidhar.
87. International Conference on Frontiers in comparative endocrinology and neurobiology 2014 held at University of Hyderabad during 25-28th November 2014 - Dr. Premkumar.
88. Seminar on Protection of IPR and Biodiversity: Opportunities and Challenges for the Industry and Stakeholders organized by the Tamil Nadu Technology Development and Promotion Center at Chennai on 28th November 2014 – Dr. M.S. Shekhar.
89. Brainstorming workshop on 'Climate Resilient Villages' at CRIDA on 29th November, 2014 – Dr. M. Muralidhar.
90. FAO moderated e-conference on rural advisory services for family farms during 1-18th December 2014 (RAS-L@LISTSERV.FAO.ORG) - Dr. M. Kumaran.
91. World Soil Day organised by IRS Chennai Chapter and Centre for Remote Sensing of Satyabahama University on 5th December 2014 – Dr. M. Muralidhar.
92. International Symposium on Marine ecosystems: challenges and opportunities (MECOS-2) held at CMFRI, Cochin during 2-5th December 2014 – Dr. M. Muralidhar, Dr. M. Jayanthi, Dr. C.P. Balasubramanian, Dr. M.S. Shekhar, Dr. S. Kannappan, Dr. J. Syama Dayal, Dr. R. Saraswathy, Dr. Sherly Tomy, Dr. Sathyanarana Sethi, Dr. Prem Kumar, Dr. B. Sivamani.
93. Green Engineering and Technologies for Sustainable Future (NGCET 2014) organized by Department of Petrochemical Technology, Bharathidasan Institute of Technology, Anna University, Tiruchirappalli during 5-6th December, 2014- Dr. P. Kumararaja.
94. Brackishwater Aquaculture Meet organized at KRC of CIBA, Kakdwip on 9th December 2014 - Dr. Debasis De.
95. Special meeting of the Advisory Committee on Hilsa conservation and research organized by CIFE, Kolkata on 17th December 2014 - Dr. T.K. Ghoshal.
96. National Conference on "Bioactive peptides - Application in Veterinary, Medical and Food sciences (NBAP-TANUVAS-2014)" organized by the Department of Animal Biotechnology, Madras Veterinary college held at Chennai during 18th to 19th December 2014 – Ms Vidya Rajendran.
97. Third Indian Biodiversity Congress (IBC 2014) organized by SRM University, Chennai during 18-20th December, 2014 – Dr. N. Lalitha.
98. Brainstorming Session on aquaculture certification organised by FAO and NAAS held at New Delhi on 29-30th December 2014 – Dr. S.V. Alavandi, Dr. S.K. Otta.
99. Bengal Global Business Summit organized by West Bengal State Govt. on 7th January, 2015 - Dr. T.K. Ghoshal.
100. Second international conference on bio-resource and stress management organized by PJTSAU, Hyderabad during 7-10th January, 2015 – Dr. N. Lalitha.
101 Initiation-cum-meeting: Workshop for finalization of work program for Outreach Activity on fish genetic stocks during 12th plan period at NBFGR, Lucknow on 8th January 2015 – Dr. M.S. Shekhar, Dr. K. Vinaya Kumar.
102 Sixth Indian Youth Science Congress during 19-21st January, 2015 organised by MSSRF at Acharya Nagarjuna University, Guntur, AP – Dr. M. Muralidhar.
103 National Seminar on 'Soil Resilience 2015' during 21-22nd January, 2015 at Agricultural College and Research Institute, Madurai – Dr. M. Muralidhar.
104 WAS Meeting on "Advanced Vannamei shrimp farming strategies and international success stories" at Chennai on 24th January 2015 – Dr. S.V. Alavandi, Dr. M. Jayanthi, Dr. C.P. Balasubramanian, Dr. P. Nila Rekha, Dr. A. Panigrahi, Mr. K.P. Sandeep, Ms. Pragyan Dash
105 12th Agricultural Science Congress on sustainable livelihood security for smallholder farmers held at NDRI, Karnal during 27-31st January 2015 - Dr. P.S. Shyne Anand.
106 Multi-Stakeholder Consultation on 'Issues and concerns for sustainable management of coastal and marine ecosystem' organized by MSSRF during 28-29th January 2015 at Chennai – Dr. S.V. Alavandi, Dr. M. Jayanthi Dr. M. Muralidhar, Ms. Babita, Ms. Pragyan Dash.
107 National Convention of Grameen Gyan Abhiyan (Mission 2007) with the theme "Role of Information Communication Technologies (ICT) in Achieving Sustainable Development Goals and Zero Hunger Challenge. (Mission 2007: Every Village a Knowledge Centre) during 2-4th February 2015 - Dr. D. Deboral Vimala.
108 XII Agricultural Science Congress-2015 on Sustainable Livelihood Security for smallholder farmers held at NDRI, KARNAL, during 3-6th February, 2015 - Dr. M. Kumaran, Dr. Krishna Sukumaran, Dr. P.S. Shyne Anand, Dr. Sujeet Kumar.
109 INDIA BIO 2015 Conference held at Bangalore during 9-11th February 2015 – Dr. M.S. Shekhar, Dr. K. Vinaya Kumar, Dr. B. Sivamani.
110 Meeting for Discussion on Development of project Identification Forms (PIFs) for accessing Global Environment Facility (GEF) 6th cycle funds organized by MOEF & Climate Change, in New Delhi on 11th February 2015 – Dr. M. Muralidhar Dr. R. Saraswathy.
111 Annual Review meeting of National Agricultural Science Fund (NASF) on 10-12th February 2015 at NASC complex, New Delhi - Dr. Debasis De.
112 Millennium Alliance Innovation Workshop on 'Round 3' organized by the Centre for Entrepreneurship Development, Anna University, Chennai on 17th February, 2015 – Dr. P. Kumararaja.
113 First meeting of the CAA committee to suggest amendments to rules and guidelines on 20th February at Chennai – Dr. M. Muralidhar.
114 Sandpit Workshop on Global Research Partnership in Aquaculture organised by Rajiv Gandhi Centre for Biotechnology at Trivandrum during 23-27th February 2015 – Dr. M.S. Shekhar.
115 Harvest Mela for hapa nursery reared seabass fingerlings at Navipadi village, Navsari, Gujarat on 28th February 2015 at Gujarat - Dr. Premkumar.
116 International Conference on Environment and Ecology (ICEE-2015) during 2-4th March 2015 at Science City, Kolkata - Dr. Debasis De, Dr. Sanjoy Das.
117 18th Scientific Advisory Committee workshop of the KVK, Kattupakkam, Kanchipuram district, Tamil Nadu on 7th March 2015 - Dr. M. Kumaran.
118 Workshop on Climate change and coastal aquaculture: Impact and Adaptations measures for resilience held at Palghar, Maharashtra on 9th March 2015- Dr. Premkumar.
101 Workshop on Climate change and coastal aquaculture: Impact and Adaptations measures for resilience held at Goa on 11th March 2015 - Dr. Premkumar.
119 Project review meeting of Center for Agricultural Bioinformatics (CABin) at IASRI, New Delhi during 13-14th March 2015 – Mr. J. Ashokkumar.
120 Expert consultation on 'Climate Variability and Resilience in Inland Fisheries' organized by CIFRI on 18th March, 2015 at Kolkata. – Dr. M. Muralidhar.
121 Three day intensive training workshop on "Innovative/Best practices in NeGP-Agriculture & Allied sectors" conducted by Center for innovations in public systems (CIPS) at Port Blair, Andaman & Nicobar islands held during 24- 26th March, 2015 – Dr. M. Jayanthi, Mr. J. Ashokkumar.

Consultancies, technology development and transfer

The Business Planning and Development Unit of CIBA supported by ICAR-NAIP was in operation till 30th June 2014. The ICAR funded scheme on "Intellectual Property Management and Transfer/ Commercialization of Agricultural Technology Scheme (Up-scaling of existing components i.e. Intellectual Property Right (IPR)" was continued through the year 2014-15. Fourteen MoUs were signed with different agencies for technology transfer/commercialization and Intellectual property management.

SHRIMP FEED PRODUCTION AND PROCESSING TECHNOLOGY

Memorandum of Understanding (MoU) for Technology Transfer on Shrimp Feed Processing and Production was signed with Mr. Tapan Das, M.K. Feeds (Pvt.) Ltd., Kolkata on 7th May 2014 at, CIBA, Chennai.

Mr. Tapan Das, M.K. Feeds, a progressive shrimp farmer in Kolkata region, decided to go for the shrimp feed mill of their own after realizing the huge demand of shrimp feed in their own farms and other farmers in his surroundings. They expect that their cost of production can be significantly reduced, by trapping the locally available ingredient resources.

Under this MoU, CIBA will provide technology for installation of feed manufacturing machineries, formulations of shrimp feed using locally sourced feed ingredients and feed processing technology.

ENERGY EFFICIENT AERATORS

Memorandum of Understanding (MoU) for the Consultancy service for evaluation and refinement of energy efficient aerators was signed with Mr.Chakravarthy, Eesavyasa Technologies Pvt Ltd, Ground floor, 11-6-56A, GSR Estates, opp: IDPL Factory, Moosepet, Balanagar, Hyderabad on 19th July 2014

EVALUATING ISPHAGULA BY PRODUCTS AS BINDERS FOR SHRIMP FEED

Memorandum of Understanding (MoU) for Evaluating Isphagula by products as binders for shrimp feed was signed with Mr.Anil Saraf, Hydrochem Products, Kolkata on 14th August 2014

Hydrochem Products is a private firm involved in manufacturing and sales of several products related to water and agriculture. They are major processor and distributer of Isphagul based product in India.

MoU signing for technology transfer on shrimp feed processing and production with M/s. M K Feeds Pvt. Ltd.

Ispaghula plant

They want to use Ispaghula husk, a byproduct of Psyllium plant as organic binder in shrimp feeds.

Under this MoU CIBA assisted Hydrochem Products in evaluating Isphagula husk as a plant based organic binder in shrimp feed formulations and compared with synthetic binders widely used in commercial shrimp feeds.

SHRIMP HATCHERY ESTABLISHMENT

Memorandum of Understanding (MoU) for Consultancy Service for Shrimp Hatchery Establishment was signed with Mr. Anil Bhai Patel, Neer Aquaculture Exports (Pvt.) Ltd, 11, Sargam Apartment, Kashibaugh Society, Opp.Agriculture University, Eru Road, Vijayalpore Road, Navsari, Gujarat on 28th August 2014 at Conference Room, CIBA, Chennai

BRACKISHWATER AQUACULTURE OPTIONS

Memorandum of Understanding (MoU) for Demonstration of Brackishwater Aquaculture Options was signed with Mr.J.Ramdas, Indian Seed Fish Farm, Thiruvallur, Tamilnadu, on 7th October 2014 at Muttukadu Experimental Station of CIBA, Chennai.

Mr.J.Ramdas, proprietor, Indian Seed Fish Farm is a progressive farmer in Thiruvallur involved in carp seed production and rearing them up to fingerling size. He is more interested in diversification of the existing aquaculture in his surroundings. Realizing the potential of brackishwater fishes for the higher market price and sturdiness of fishes to adopt in different salinities, he approached CIBA.

MoU covers the demonstration of polyculture of brackishwater finfishes in low saline waters. CIBA will give inputs such as feed, seed and technology for the farming of milkfish, pearlspot and seabass in low saline waters in phased manner.

Signing of MoU with M/s. Neer Aquaculture Exports Pvt. Ltd. for consultancy service for shrimp hatchery estabilishment

MoU signing for demonstration of brackishwater aquaculture options with M/s. Indian Seed Fish Farm

SOLAR POWERED TIMER CONTROLLED AUTOMATIC FEEDER

On 7th October 2014 CIBA signed Memorandum of Understanding (MoU) with two progressive farmers Mr.G.P.Babu, Chennai and Mr.K.P.Kumar, Ponneri who volunteered for evaluating the efficacy of the automatic feeders developed by CIBA in their farms.

DEVELOPMENT OF PROBIOTICS AND DISINFECTANTS

MoU has been signed on on 7th November 2014 for providing consultancy services to Rajshree Biosolutions, Theni, Tamil Nadu to develop probiotics and disinfectants for use in shrimp aquaculture. Under this project institute will provide the technical

MoU signing for shrimp larval feed technology demonstration with M/s. Maritech

MoU signing for consultancy service for development of probiotics with M/s. Rajshree Biosolutions

knowhow for developing Gut probiotics, Soil probiotics and Water probiotics for application in grow out shrimp cultures. Additionally, the technical guidance will also be provided for developing disinfectants for use in shrimp aquaculture. The consultancy period is for the period of 4 years and valued at 4 lakhs and extendable with payment of 2 lakhs per year.

SHRIMP LARVAL FEED DEMONSTRATION AND TECHNOLOGY TRANSFER

Memorandum of Understanding (MoU) for Shrimp Larval Feed Demonstration and Technology Transfer was signed with Dr. S. Santhana Krishnan, Maritech, Chennai on 7th November 2014 at, CIBA, Chennai.

MoU for collabrative research on milkfish breeding with M/s. Aditya Fish Hatcheries

Technology tranfer MoU on shrimp feed processing and production with M/s. Poshak Bio Research Pvt. Ltd.

Marine Technologies being a Governing Member, Global Aquaculture Alliance, has been involved in development, implementing and operating of aquaculture projects developing and operating aquaculture projects in India, Malaysia, Sri Lanka, Tanzania and Saudi Arabia since 1989.

Under this MoU, CIBA will provide technology for formulations of shrimp larval feed for their different developmental stages and processing technology for its large scale production. In the first phase CIBA will provide prepared feed for demonstration of the feed performance in commercial hatcheries and Maritech will share the datum collected from the hatcheries.

MILKFISH CULTURE

Memorandum of Understanding (MoU) for Collaborative Research on Milkfish Culture was signed with Dr. P. Arun Padiyar Aditya Fish Hatcheries, Konapapapeta village, U. Kothapalle Mandal, East

MoU signing with Biomettha Eco Research for setting up Aqua Diagnostic Lab

MoU for transfer of CIBASTIM technology on exclusive basis with M/s. Rajshree Biosolutions

Godavari, Andhra Pradesh on 11th December 2014 at Conference Room, CIBA, Chennai

SHRIMP FEED PROCESSING AND PRODUCTION

Memorandum of Understanding (MoU) for Technology Transfer on Shrimp Feed Processing and Production was signed with, Poshak Bio Research Pvt Ltd, Gujarat on 11th February 2015 at CIBA, Chennai.

Poshak Bio Research Pvt Ltd. a private feed company interested in shrimp feed processing and production technology. They estimated that there is lot fishmeal and other agriculture byproducts in that region for meeting the shrimp feed requirement of the Gujarat coast. Considering the growing shrimp farming industry in Gujarat they want to set up a feed mill.

This MoU will facilitate CIBA to provide assistance to Poshak Bio Research on installation of shrimp feed manufacturing machineries; formulations of shrimp feed using locally sourced feed ingredients and feed processing using Ring Die pelletizer.

CONSULTANCY SERVICES FOR SETTING UP AQUA DIAGNOSTIC LABORATORY

MoU has been signed with Biomettha Eco Research, Chennai for setting up Aqua Diagnostic Laboratory at Medhur, Ponneri, Chennai. The consultancy services will cover helping the company to set up commercial laboratory for conducting physico-chemical and microbial parameters in shrimp aquaculture systems. The consultancy period is for the period of one year and valued at Rs.50,000/-. In the second phase consultancy will be taken up for establishing PCR testing laboratory for diagnosis of shrimp diseases.

TRANSFER OF CIBASTIM TECHNOLOGY ON EXCLUSIVE BASIS

Memorandum of Understanding (MoU) for The Transfer of CIBASTIM Technology on Exclusive Basis was signed with Mr. Aditya Krishna Pathy, Managing Partner, Rajshree Biosolutions, Coimbatore on 24th February 2015 at Chennai. Rajshree Biosolutions is involved in manufacture and supply of biological and organic products for agriculture and aquaculture.

The technology to prepare microbial based immunostimulant 'CIBASTIM' which improves growth, survival and immunity in shrimps has been already commercialized to Rajshree Biosolutions on non-exclusive basis for a period of three years. After evaluation of the product and test marketing by the firm, the firm requested for exclusive license to the use of technology that will benefit the farmers.

SUSTAINABLE MODEL OF BRACKISHWATER AQUACULTURE

In an effort to utilize this huge potential of brackishwater aquaculture resources in the Kerala State, the Central Institute of Brackishwater Aquaculture (CIBA) has signed Memorandum of Understanding (MoU) with the Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi, for conducting joint research for development of a sustainable model of brackishwater aquaculture on 12th March 2015. As per the agreement, technical assistance will be extended

MoU for conducting joint research for development of sustainable model for backishwater aquaculture with KUFOS, Kochi

by CIBA for undertaking research and development programmes on diversified brackishwater farming practices in the State in partnership with KUFOS in Kerala to develop sustainable model for potential brackishwater resources, which cover an area of around 1,43,696 hectares, along with adjacent low-lying fields and mangrove swamps. As a first step in this programme, CIBA started extending technical assistance first scientific *P. vannamei* culture initiated at fisheries research station of KUFOS, Puduvype on 15th March 2015. Apart from initiating knowledge partnership for research with KUFOS, the partners

Summary of revenue earned & SHARED 2014 & 2015

Item	M.K. Feeds (Pvt. Ltd) Kolkata	Neer Aquaculture Exports (p) Ltd, Navsari	Rajshree Biosolutions, Theni	Marine Technologies, Chennai	Poshak Bio Research Pvt Ltd, Gujarat.	INMETTA, Chennai	Rajshree Biosolutions, Coimbatore	Total
Total receipt (A)	561800	449440	449440	28090	674160	56180	1123600	**3342710**
Service Tax (B)	61800	49440	49440	3090	74160	6180	123600	367710
Amount due to ICAR for augmenting IP management(C)	168540	134832	134832	8427	202248	16854	337080	1002813
Net revenue/ benefit money to be shared as Incentive (X)	331460	265168	265168	16573	397752	33146	662920	1972187
ICAR Scientists/innovator/and other team members	198876	159100	159100	9943.8	238651	19887	397752	1183312
ICAR Institution(s) (includes 5% of net revenue/benefit money for staff welfare)	82865	66292	66292	4143.25	99438	8286	165730	493046
ICAR headquarters (includes 5% of net revenue/benefit money for staff welfare)	49719	39775	39775	2485.95	59662	4971	99438	295828
Scientific/project team	198876	159100	159100	9943.8	238651	19887	397752	**1183312**

Revenue generation from technology commercialization

will cooperate to conduct research, train farmers and develop sustainable technologies for brackish water farming practices suitable to the state.

Training, consultancy, contract research in ICAR system (1997) and ICAR guidelines for Intellectual property management and technology transfer/ commercialization (2006) have laid a broad canvas for operation of PPP in ICAR institutes. ICAR-CIBA has experimented in PPP with industries since 2002 with licensing of WSSV kit with Bangalore Genei Private Limited. The successful transfer of tiger shrimp feed formulation with Bismi feeds, Nagapattinam was another milestone.

There has been considerable growth in the commercialization of technologies generated by CIBA during 2009 to 2015. The trend is expected to continue in coming years also as commercial enquiries are continuing to pour in. The performance of CIBA under NAIP funded Business Planning and Development sub project was evaluated by NAIP.

In terms of performance matrix CIBA scored 53 points occupying third position among second phase of 12 NAIP- BPDs (Source: NAIP Final Report 2014). CIBA stood in second place in terms of number of technologies commercialized and the amount of technology fee realized per technology. In terms of

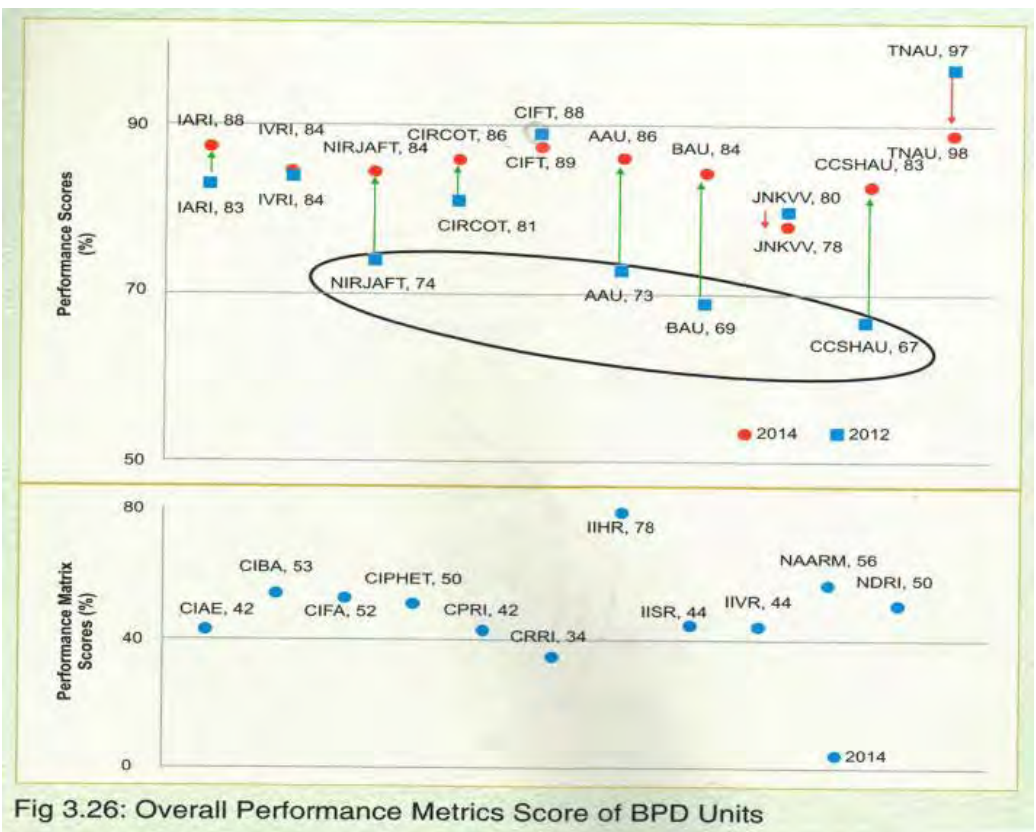
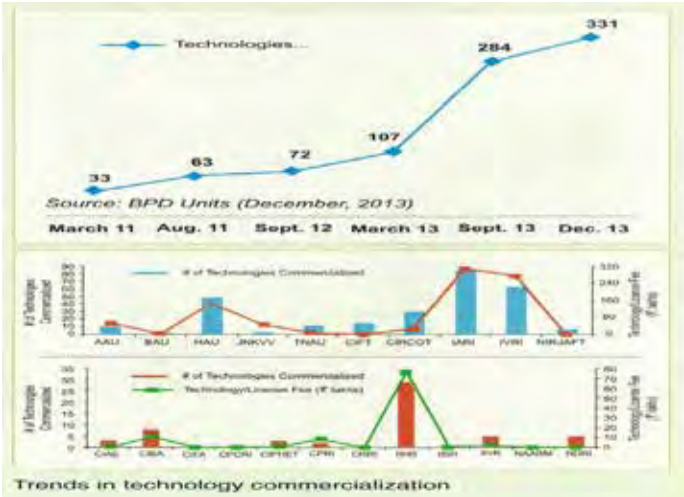


Fig 3.26: Overall Performance Metrics Score of BPD Units

Performance matrix of CIBA BPD



Technologies commercialized and revenue realized per technology

Table Revenue Generated by BPD Units

BPD Units & Locations	2010-11	2011-12	2012-13	2013-14	2014-15	Total
ZTM-BPD Units			(Rs. in lakh)			
ZTM-BPD Unit, IARI, New Delhi	40.95	296.21	172.49	294.64	-	804.30
ZTM-BPD Unit, IVRI, Izatnagar	212.18	29.65	351.91	55.97	-	649.80
ZTM-BPD Unit, CIRCOT, Mumbai	37.09	31.67	39.37	54.13	-	162.26
ZTM-BPD Unit, NIRJAFT, Kolkata	1.20	1.45	6.09	7.67	-	16.42
BPD units						
BPD unit, IIHR, Bangalore	-	-	-	132.95	23.24	156.20
BPD unit, NDRI, Karnal	-	-	94.10	52.54	-	146.64
BPD unit, CIBA, Chennai	**-**	**-**	**-**	**12.57**	**5.67**	**18.24**
BPD unit, NAARM, Hyderabad	-	-	-	16.72	-	16.72
BPD unit, CIFA, Bhubaneswar	-	-	-	5.30	-	5.30
BPD unit, CIPHET, Ludhiana	-	-	-	3.80	-	3.80
BPD unit, IIVR, Varanasi	-	-	-	3.60	-	3.60
BPD unit, CIAE, Bhopal	-	-	-	3.41	-	3.41
BPD unit, IISR, Calicut	-	-	-	2.56	-	2.56
BPD unit, CRRI, Cuttack	-	-	-	2.44	-	2.44
BPD unit, CPCRI, Kasargod	-	-	-	0.73	0.32	1.05
BPD unit, CPRI, Shimla	-	-	-	8.99	-	8.99
BPD unit, AAU, Anand	16.01	11.34	14.83	11.44	0.16	53.78
BPD unit, BAU, Ranchi	1.02	2.92	79.98	102.34	-	186.27
BPD unit, JNKVV, Jabalpur	7.42	20.73	31.33	33.35	-	92.83
BPD unit, TNAU, Coimbatore	7.47	20.81	14.25	4.91	-	47.44
BPD unit, CCS HAU, Hisar	5.15	25.50	10.02	24.55	2.43	67.65
Total						**2468.84**

(Source: NAIP Final Report 2014)

total revenue generated CIBA BPD stood at third position among 17 BPDs.

Activities related to Intellectual Property Rights Management

The following works were completed regarding Intellectual Property Rights management of Institute's research output:

a. Patents:

- Hearing on our patent application number 370/CHE/2006 entitled "A Method of Fish Disease Diagnosis Using Rabbit Anti-Mullet (Ram) Serum to Detect Fish Antibodies in Different Brackishwater Fish and Its Applications Thereof" was held on 17/06/2014
- Hearing on our patent application number 2021/CHE/2008 entitled "Molecular Tool for Detection of Chemolithoautotrophic Bacteria" was held on 26/09/2014
- Hearing on our patent application number 369/CHE/2006 entitled "Maximum Percent Recovery and Detection of Organo-Chlorine and Organo-Phosphorous Pesticides Together from Brackishwater/Coastal Water" was held on 19/03/2015.

b. Trademarks

We have filed three trademark applications for registration. The details are as below.

i) Benefits generated from technology commercialization:

ICAR share (Rs. 7,05,591/-) from the benefit generated from the technology commercialization was remitted through electronic transfer RTGS mode to the account of secretary, ICAR, SBI saving a/c no. 30660407919, IFSC code SBIN 0000691. An intimation of the payment was sent to the Dy. Director (finance), accounts – I section, room no. 518, Krishi Bhavan, New Delhi-110001.

The following remittance has been made to the Council as per details furnished below.

S. No	Trade Mark	No. of classes	Date of Filing/ Registration	Application status	Allotted application number
1.	CIBA ICAR	6	30.12.2014	Awaiting for examination	2871665
2.	CIBASTIM	1	05.02.2015	Awaiting for examination	2893376
3.	GREEN SHRIMP FEED-BT (GSF-BT)	1	05.02.2015	Awaiting for examination	2893377

S. No.	Break up of ICAR Remittance	Refunds related to Previous year	Refunds related to current year	Amount (in Rs.)	Total amount remitted to Council
1.	Unspent of IPR Scheme	-	-	-	
2.	Staff Welfare Fund (5% of net revenue*)	-	98,609/-	98,609/- (A)	
3.	10% of net revenue*	-	1,97,219/-	1,97,219/- (B)	Rs. 7,05,591/- (A+B+C-D)
4.	Institutional charges	-		-	
5.	30% of the Gross Revenue to ICAR for augmenting IP management	-	10,02,813/-	10,02,813/-(C)	
6.	Arrear amount paid to RAs	-	5,93,050/-	5,93,050/- (D)	

*Net revenue: Rs.19,72,187/-

Research and Administrative Meetings

RESEARCH ADVISORY COMMITTEE

The Research Advisory Committee of CIBA was constituted by ICAR (Council's order F.No.18-6/2007-ASR-I dated 22.7.2013) for a period of three years with effect from 25 July 2013:

Chairman	Dr.M.V.Gupta
Members	Dr. (Mrs.) Krishna Srinath
	Mr. Udaya Ram Jyothy
	Dr. R. A.Selvakumar
	Dr. P. A. LokaBharati
	Dr. Sridhar Sivasubbu
	Dr. Madan Mohan
	Dr. A.G. Ponniah
Member Secretary	Dr. P. Ravichandran

The 19th meeting of the Research Advisory Committee (RAC) of CIBA was held on 11th April 2014 at CIBA Headquarters, CIBA, Chennai

INSTITUTE RESEARCH COUNCIL

The Institute Research Council (IRC) of CIBA has been constituted as follows:

Chairman	Dr. A.G. Ponniah
Members	Assistant Director General (M.Fy.), ICAR, New Delhi
	Dr. C. Gopal
	Dr. G. Gopikrishna
	Dr. S. V. Alavandi
	Dr. V. S.Chandrasekaran
	Dr. M. Muralidhar
	Dr. K. Ambasankar
	Principal Investigators of all the projects
Member Secretary	Dr. P. Ravichandran

The 30th IRC Meeting was held on 21st and 22nd April 2014 and the progress of research work was reviewed.

Dr. M.V. Gupta, Chairman, RAC interacting with scientists

INSTITUTE MANAGEMENT COMMITTEE

The Institute Management Committee has been constituted as follows :

Chairman	**Director**
Members	Dr. Madan Mohan, ADG (M.Fy.)
	The Dean, TANUVAS, Chennai
	The Commissioner of Fisheries, Gujarat
	Dr. K. K. Lal
	Shri Ali Hussain
	Shri Ajitsinha Bajirao Patil
	Dr. T. V. Sankar
	Dr A. K. Pal
	Dr. G. Maheswarudu
Co-opted Members	Shri. Kunal Kalia, FAO
	Shri. R. Kandamani, AAO
	Smt. V. Usharani, AAO
	Dr. T. Ravisankar, Principal Scientist & Head of Office

The 44th IMC meeting held on 25th June 2014 and 45th meeting on 18th December 2014.

INSTITUTE JOINT STAFF COUNCIL

The composition of the Institute Joint Staff Council (reconstituted by CIBA for a period of three years up to 18.02.2016 vide Office Order F.No.13-1/2012-Admn. Dated 19.02.2013) is as follows:

Official Side

Chairman	**Director, CIBA**
Members	Dr. G. Gopikrishna, P.S. & HOD NGBD
	Dr. M. Muralidhar, P.S.
	Dr. M. Kumaran, P.S.
	Shri. Kunal Kalia, FAO
	Shri. R. G. Ramesh, A.A.O.

Staff Side

Secretary	Shri, N. Jagan Mohan Raj, Sr. Technical Asst.
Members	Shri D. M. Ramesh Babu, Sr. Technical Asst.
	Shri R. Kandamani, A.A.O.
	Shri P. Srikanth, UDC
	Shri S. Kuppan, Skilled Support Staff
	Shri M. Pichandi, Skilled Support Staff

(Shri P. Srikanth, UDC, Member, IJSC is also a member of CJSC of ICAR)

The first IJSC Meeting for the year 2014-15 was held on 17th April 2014

GRIEVANCE COMMITTEE

The composition of the Institute Grievance Committee (reconstituted by CIBA for a period of two years with effect from 1st December 2013 vide Office Order F.No.6(2)/2007-Admn. Dated 23.11.2013) is as follows:

Chairman	**Dr. K. K. Vijayan**
Official Side	
Members	Shri. Kunal Kalia, FAO
Member Secretary	Shri. R. G. Ramesh, AAO
Elected Members	
Scientific Member	Dr. J. Syama Dayal, PS Dr. Nila Rekha, PS
Technical Member	Dr. A. Nagavel, Senior Technical Officer
Administrative Member	Mrs. Usha Rani, AAO Shri. A. Manoharan, Assistant
Staff Member	Shri. M. Pichandi, Skilled Support Staff

WOMEN COMPLAINT COMMITTEE

Women Complaint Committee has been constituted as follows:

Chairman	**Dr. R. Saraswathy**
Members	Dr. Prasanna Kumar Patil
	Dr. Sherly Tomy
	Dr. Vinaya Kumar Katneni
	Shri. S. Nagarajan
	Smt. E. Mary Desouza
External Member	Dr. Lita Sunder, Madras Christian College

Services and Assignments

Services in Committees

Dr. K. K. Vijayan, Director

Member, Executive Committee and Governing Body, Rajiv Gandhi Centre for Aquaculture (MPEDA), Mayiladuthurai.

Member, ICAR Regional Committee No.VIII

Member, Scientific Advisory Committee for Dr.Perumal Krishi Vigyan Kendra

Executive Committee Member, National Centre for Sustainable Aquaculture (NaCSA)

Member, Committee for protection of fish germplasm through registration and documentation, constituted by ICAR

Member, Scientific Advisory Committee, Krishi Vigyan Kendra, Tiruvallur.

Member, State Level Committee on Animal Genetic Resources (SLCAnGR), constituted by Department of Animal Husbandry & Veterinary Services, Government of Tamil Nadu, Chennai

Member, Board of Management of Tamil Nadu Fisheries University, Nagapattinam.

Board of Management of Tamil Nadu Veterinary and Animal Sciences University, Chennai

Member, Committee for examining the issues related to establishment of SPF *Penaeus monodon* Multiplication centre at Srikakulam, Andhra Pradesh, under the Chairmanship of Joint Secretary (Fy.), DAHD&F with DDG (Fy.), ICAR

Member, Committee to finalize the guidelines for setting up Multiplication Centres (MCs) for Specific Pathogen Free (SPF) *Litopenaeus vannamei* and *Penaeus monodon* and make recommendations on policies to govern setting up and operation of such MCs in the country, constituted by DAHDF, Ministry of Agriculture, Govt. of India.

Member, Advisory Committee on Hilsa Conservation and Research

Member, Academic Council of Central Institute of Fisheries Education, Mumbai

Member, Governing Body of State Fisheries Resource Management Society (FIRMA), Thiruvananthapuram

Member, Advisory Board for Fisheries Sector Development, constituted by Special Chief Secretary (Planning), Planning Department, Govt. of Andhra Pradesh

Member, National Advisory Committee of Marine Ecosystems Challenges and Opportunities (MECOS), Kochi.

Dr. C. Gopal, Principal Scientist

Member for the preliminary meeting convened by the Chairman, QRT (2009-2014) with DDG (Fy) ICAR, ADG (Mar.) and Director CIBA at New Delhi

Dr. G. Gopikrishna, Principal Scientist

External examiner to conduct the Ph.D. viva-voce examination in the Department of Biotechnology, C. Abdul Hakeem College, Melvisharam, Vellore

Member Secretary, QRT (2009-2014)

Dr. S.V.Alavandi, Principal Scientist

Provided guidelines for the import of exotic seabass fingerlings, the import of shrimp additives and to examine and report the health status of shrimp broodstock raised in RGCA multiplication centre to the Ministry of Agriculture, Govt. of India.

Aquaculture inputs/comments for the import were provided to Commissioner of Fisheries, Ministry of Agriculture and Animal Husbandry.

Member of Curriculum Committee of Kerala University of Fisheries and Ocean Sciences (KUFOS), Panagad, Kerala for setting up M.Sc Marine Microbiology syllabus.

UGC Advisory Committee Nominee for Special Assistance Programme (SAP) to the Department of Microbiology, University of Delhi South Campus, New Delhi.

DBT Biosafety Committee Nominee for the Entomology Research Institute, Loyola College, Chennai.

Member of the single source purchase committee for the Department of Veterinary Microbiology, TANVAS, Chennai

Dr.M. Natarajan, Principal Scientist

Chairman of the Best Thesis Award Committee of Professional Fisheries Graduates Forum.

Observer for ASRB's Assistant Director (Official Language) Examination at Madras Veterinary College, Chennai

Expert Member for the workshop on India Aquaculture Pathfinder 2015 – Blue paper forum at Bangaluru

Resource person at the Winter School on Empowerment of fish farmers and entrepreneurship

development at Fisheries Research and Information Centre (Inland), Bangalore.

Dr.V.S.Chandrasekaran, Principal Scientist

Special Invitee for the meeting of the Board of Studies in Oceanography and Coastal Area Studies of the Alagappa University, Karaikudi

Member of Board of Studies in Marine Biology of the faculty of Marine Sciences, CAS in Marine Biology, Annamalai University.

Panel Member for the School of Management Studies Research and Development Meetings at Vel Tech Dr. RR & SR Technical University, Avadi, Chennai.

Member of the IMC meeting at CIFRI, Barrackpore

External expert in the Selection Committee for the recruitment process (interviews) of the Tamil Nadu Fisheries University (TNFU).

External Examiner for the Ph.D Viva Voce Examination at the Department of Zoology, Govt. Arts College (Autonomous under the Bharathidasan University), Kumbakonam

External Examiner for the Viva Voce Examination of the Doctoral thesis work in Sathyabama University, Chennai.

External Examiner for the two Ph.D Viva Voce Examinations at Suganthi Devadason Marine Research Institute (SDMRI), Tuticorin.

Dr. M. Muralidhar, Principal Scientist

Panel member of Technical Session "Addressing challenges of coastal ecosystem" in 6th Indian Youth Science Congress at Acharya Nagarjuna University, Guntur, Andhra Pradesh.

Expert member of Coastal Aquaculture Authority Committee to suggest amendments to rules.

Management Representative for ISO 9001:2008 organized the Surveillance Audit by Intetek Company.

Dr. M. Kailasam, Principal Scientist

Member, State level Technical Committee of FIMSUL, Department of Fisheries, Government of Tamil Nadu

Dr. T.K. Ghoshal, Principal Scientist

External Member of selection committee for Central Soil Salinity Research Institute (ICAR), Canning Town, Kolkata

Expert Member for Selection Committee, W.B.U.A.F.S., Kolkata

Dr. Debasis De, Principal Scientist

Co-Coordinator of the training programme on 'An Overview of Brackishwater Aquaculture' to B.F.Sc. students of West Bengal University of Animal & Fishery Sciences.

Co-Coordinator of the training programme on 'Diagnosis of Aquatic Animal Diseases' to M.F.Sc. students of CIFE.

Dr. R. Saraswathy, Principal Scientist

Expert member in the selection committee for selection of consultant for environmental monitoring in CAA.

Dr.P.K.Patil, Senior Scientist

Coordinator for the Farmers Interaction Meet at NAU, Navsari, Gujarat

Dr. Sherly Tomy, Senior Scientist

Member of the Institute Management Committee of NBFGR, Lucknow.

Doctoral Committee Member, SRM University

Dr. S.K. Otta, Senior Scientist

Invited Speaker by Godrej Pvt. Ltd to deliver talk for the Awareness Programme on Emerging Shrimp Disease at Akividu and Bhimavaram, AP

Coordinator for the Farmers Interaction Meet at NAU, Navsari, Gujarat

Invited Speaker by Godrej Pvt. Ltd to deliver talk for the Awareness Programme on Emerging Shrimp Disease at Surat, Gujarat

Analysed sample and submitted report for feed samples submitted by Animal Quarantine Certification Services, Chennai

Invited as the Guest Speaker at ICAR sponsored Short Training Programme at Fisheries College and Research Station, Tuthukodi

Coordinated the Workshop on "Production Risks and better management practices of Pacific white shrimp farming" at Ongole, AP

Invited by the Ministry of Agriculture to visit RGCA, Vishakhapatnam to collect and analyze sample from vannamei multiplication center.

Dr. K.P. Kumaraguru vasagam, Senior Scientist

Doctoral Committee Member for SRM University and B.S. Abdur Rahman University, Chennai.

Invited speaker in B.S. Abdur Rahman University, Chennai

Dr. Sathyanarayan Sethi, Senior Scientist

Reviewer for the Indian Journal of Fisheries, aquaculture Research and indian Journal of Geo-marine Sciences

Dr. Prem Kumar, Scientist

Doctoral Committee Member, Sathyabama University

Reviewer for the Indian Journal of Fisheries

Distinguished visitors

Headquarters

Sl. No.	Details of visitors	Date of visit
1.	Dr. E. Vivekanadan, Emeritus Scientist, CMFRI, Chennai	01. 04. 2014
2.	Dr. D. K. Mishra, Senior Cardiothoracic Surgeon, Apollo Hospitals, Chennai	25. 04. 2014
3.	Dr. P. Kalaiselvi, Assistant Professor, Dept. of Medical Biochemistry, University of Madras	25. 04. 2014
4.	Dr. Faiza Yousif Al Yemani, Executive Director, Environment & Life Sciences Research Centre, KSIR, Kuwait	23. 05. 2014
5.	Dr. Aws AlGhunaim, Senior Research Associate, KSIR, Kuwait	23. 05. 2014
6.	Dr. P. Paul Pandian, Executive Director, NFDB	05. 07. 2014
7.	Shri. P. Sanjay Gandhi, Additional Govt. Pleader, High Court of Madras & President, IPR Attorney Association	16. 07. 2014
8.	Prof. Ranjith Oomen Abraham, from the Tamil Nadu Dr. Ambedkar Law University, Chennai	16. 07. 2014
9.	Mr. Anilbhai L. Patel, Neer Aquaculture Exports Private Ltd., Navsari, Gujarat	28. 08. 2014
10.	Dr. M. Vijayakumaran, Former Principal Scientist of CMFRI and NIOT, Chennai	16. 10. 2014
11.	Dr. S. Ayyappan, the Director General, ICAR & Secretary, DARE	25. 10. 2014
12.	Shri. Rajiv Lochan, the Managing Director and CEO, Kasturi and Sons, publishers of The Hindu, Chennai	25. 10. 2014
13.	Parliamentary Committee on Agriculture , New Delhi	30. 01. 2015
14.	Mr. Jayeshbhai K Patel of Poshak Bio Research Pvt Ltd	11. 02. 2015
15.	Mr. Maghimai Marcus INMETTA, Pulicat, Tamil Nadu	11. 02. 2015
16.	Dr. V. P. Sriram, M. V. Diabetes Centre	07. 03. 2015

Kakdwip Research Centre

1.	Dr. Manjurul Karim, Project Leader (WFC)	09. 06. 2014
2.	Mr. Kazi Ahmed Kabir, Technical Specialist (Aquaculture) WFC	09. 06. 2014
3.	Mrs. Sukti Sita, Asst. Secretary of Minister of Fisheries, Govt. of West Bengal	09. 12. 2014
4.	Dr. Sankho Bandhopadhyay, Asst, Director of Fisheries	09. 12. 2014

Personnel

Director: Dr. K. K. Vijayan

Headquarters

Heads of Divisions

Dr. C. Gopal, Crustacean Culture Division

Dr. G. Gopikrishna, Nutrition, Genetics & Biotechnology Division

Dr. S. V. Alavandi, Aquatic Animal Health & Environment Division

Principal Scientists

Dr. P. Ravichandran (VRS on 30.09.2014)
Dr. M. Natarajan
Dr. K. P. Jithendran
Dr. V. S. Chandrasekaran
Dr. T. Ravisankar
Dr. M. Muralidhar
Dr. (Mrs.) M. Jayanthi
Dr. (Mrs.) B. Shanthi
Dr. C. P. Balasubramanian
Dr. M. Kailasam
Dr. (Mrs.) D. Deboral Vimala
Dr. M. Shashi Shekhar
Dr. S. Kannappan
Dr. (Mrs.) P. Nila Rekha
Dr. K. Ambasankar
Dr. J. Syama Dayal
Dr. Akshaya Panigrahi
Dr. M. Kumaran

Senior Scientists

Dr. (Mrs.) M. Poornima
Dr. (Mrs.) R. Saraswathy
Dr. Prasanna Kumar Patil
Dr. (Mrs.) Sherly Tomy
Dr. Subhendu Kumar Otta
Dr. K. P. Kumaraguru vasagam
Dr. Satyanarayan Sethi
Dr. (Mrs.) P. Mahalakshmi

Scientist (Senior Scale)

Shri Ashok Kumar Jangam

Scientists

Dr. K. Vinaya Kumar
Dr. R. Ananda Raja (on study leave)
Dr. (Mrs.) Krishna Sukumaran
Dr. (Mrs.) Ezhil Praveena
Dr. (Mrs.) T. Bhuvaneswari
Dr. (Mrs.) N. Lalitha
Dr. P. Kumararaja
Dr. B. Sivamani
Dr. (Mrs.) Vidya Rajendran (Joined on 09. 04. 2014)
Dr. Satheesha Avunje (Joined on 09. 04. 2014)
Shri K. P. Sandeep (Joined on 09. 04. 2014)
Ms. Pragyan Dash (Joined on 09. 04. 2014)
Ms. Babita (Joined on 09. 04. 2014)
Shri Aritra Bera (Joined on 09. 04. 2014)
Shri T. Sathish Kumar (Joined on 09. 04. 2014)

Chief Technical Officer

Shri R. Elankovan

Assistant Chief Technical Officers

Dr. S. Sivagnanam
Shri D. Rajababu
Shri M. Shenbagakumar
Shri R. Puthiavan
Mrs. K. Jacquline

Senior Technical Officers

Dr. Joseph Sahayarajan
Shri S. Stanline
Dr. A. Nagavel
Shri R. Subburaj
Shri S. Nagarajan
Shri S. Rajamanickam

Senior Technical Assistants

Shri N. Ramesh
Shri S. Saminathan
Shri N. Jagan Mohan Raj
Shri R. Balakumaran (Driver)
Shri D. M. Ramesh Babu
Shri G. Thiagarajan

Technical Assistants

Shri K. Paranthaman (Driver)
Shri K. Karaian

Senior Technician

Shri K. V. Delli Rao

Administrative and Finance

Finance & Accounts Officer

Shri Kunal Kalia

Assistant Administrative Officers

Shri R. G. Ramesh
Shri R. Kandamani
Mrs. V. Usharani

Junior Accounts Officer

Mrs. K. Nandhini

Personal Assistants

Mrs. S. Nalini
Shri K. G. Gopala Krishna Murthy

Assistants

Shri S. Pari
Shri A. Manoharan
Mrs. E. Amudhavalli
Shri A. Sekar

Stenographer Gr. III

Mrs. K. Hemalatha
Mrs. K. Subhashini

Upper Division Clerks

Mrs. E. Mary Desouza
Shri P. Srikanth
Mrs. R. Vetrichelvi

Lower Division Clerks

Shri B. Palanivelmurugan
Mrs. M. Mathuramuthu Bala
Mrs. B. Prasanna Devi
Shri R. Kumaresan
Shri A. Paul Peter

Skilled Support Staff

Shri M. Santhosam
Shri N. Harinathan
Shri V. Jeevanantham
Shri K. Nithyanandam
Shri V. M. Dhanapal
Shri V. Kumar
Shri E. Manoharan
Shri C. Saravanan
Shri S. Kuppan
Shri M. Pichandi
Shri S. Selvababu
Shri D. Senthilkumaran
Shri C. Ragu
Shri P. G. Samuvel
Shri M. Sakthivel
Shri R. Mathivanan
Shri R. Indra Kumar
Shri G. Dayalan
Shri Kanaka Prasad
Mrs. S. Premavathi
Shri J. Murugan

Kakdwip Research Centre

Principal Scientist & Officer-in-charge

Dr. T. K. Ghoshal

Senior Scientists

Dr. Debasis De
Dr. Sanjoy Das

Scientists

Dr. Gouranga Biswas (Joined on 28.03.2015 after completion of study leave)
Dr. Prem Kumar (transferred to KRC, Kakdwip on 23.03.2015)
Dr. Sujeet Kumar (On study leave w.e.f. 30.07.2013)
Dr. (Mrs.) P. S. Shyne Anand (Transferred from KRC, Kakdwip to headquarters on 18.03.15)
Ms. Christina Lalramchhani (Joined on 09. 04. 2014 and transferred to KRC, Kakdwip on 17.11.2014)

Senior Technical Assistant

Shri P. S. Samanta

Technical Assistant

Mrs. Chanda Mazumder

Administrative Staff

Private Secretary

Shri S.K.Halder

Assistant

Shri S.K.Bindu

Skilled Support Staff

Shri Rash Behari Das (Retired on 31.05.2014)
Shri Narendra Nath Jana
Shri Nayan Tara Dalui
Shri Amar Gharami (Retired on 30.11.2014)
Shri Krishna Pada Naskar
Mrs. Lakshmi Rani Bhuiya
Shri Uttam Kumar Santra
Shri Purna Chandra Das

Redeployed Staff from PRC of CIBA, Puri to CIFA, Bhubaneswar

Technical Assistant

Shri P. C. Mohanty, T-2 (Driver)

Skilled Support Staff

Shri Premananda Bisoi
Shri Maharaga Majhi

Infrastructure Development

- Construction of first floor in Trainee's hostel at CIBA Hqrs, Chennai.
- Repair and Renovation of painting work for inside of the main laboratory building at CIBA Hqrs, R.A.Puram, Chennai.
- Installation, testing and commissioning of LED signage at CIBA Hqrs, R.A.Puram, Chennai..
- Construction of Compound wall and Security room at MES of CIBA, Muttukadu, Chennai.
- Construction of compound wall and fencing in C Sector at KRC of CIBA, Kakdwip, West Bengal.
- Repair and replacement of electrical wirings in the farm area (Sector-A), providing transformer between A and B sector and electrical load distribution works in the office building at KRC of CIBA, Kakdwip, West Bengal .
- Renovation of existing electrical supply to pumps, aerators, water supply systems including farm lighting in sector- C of KRC of CIBA, Kakdwip
- Construction of drain at the back side of office building & wet lab. i/c repair of verandas, canopy and front side of office building at KRC of CIBA, Kakdwip, West Bengal.
- Plumbing work for water and air line in live feed culture unit under NFBSFRA project at KRC of CIBA, Kakdwip, West Bengal.
- Electrical installation for live feed culture unit (Indoor and Outdoor) under NFBSFARA project at KRC of CIBA, Kakdwip, West Bengal.
- Renovation of laboratory in the first floor under NFBSFRA project at KRC of CIBA, Kakdwip, West Bengal.
- Plumbing work for flow through system under NFBSFARA project at KRC of CIBA, Kakdwip, West Bengal.

Library and Documentation

Library holdings

CIBA procured 35 new books on various aspects of brackishwater aquaculture including official language books in 2014-15. 16 national journals including vernacular language journals for the headquarters and 16 national journals for Kakdwip Research Centre of CIBA Library were subscribed. The library holdings as on 31.03.2015 are given below.

Online access to CeRA journals and document delivery service

CIBA has established online connectivity for the Consortium for electronic Resources in Agriculture (CeRA) journals subscribed by the Directorate of Knowledge Management in Agriculture (ICAR - DKMA) in the Institute's headquarters and KRC of CIBA for the year 2014-15. Under CeRA - Document Delivery Request (DDR) CIBA library shared the photocopies of various journal articles requested from other ICAR institutes, scientists and research scholars.

Exchange services

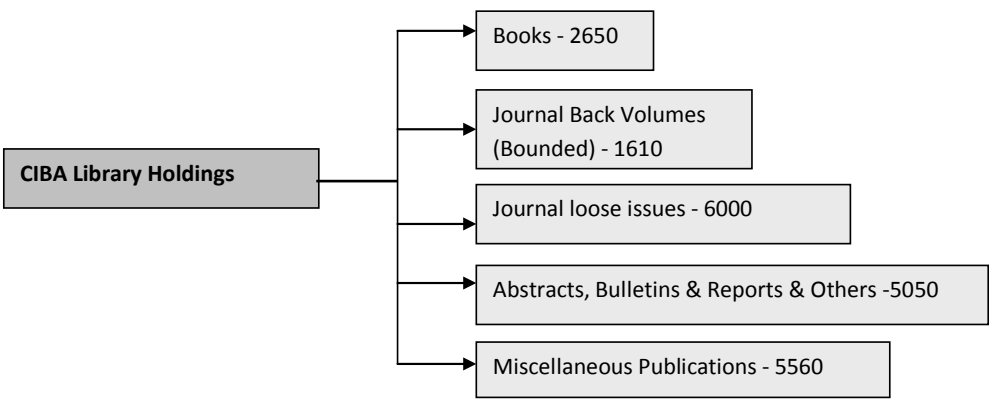
CIBA library maintained exchange relationship with national and international organizations working on fisheries and aquaculture on mutual interest. The library maintained the free mailing of institute's annual report and other institute publications to various research organizations, universities and other agencies to give greater propaganda to the institute's research and development programmes.

Information Services to the Stakeholders

CIBA library acted as a reference library by providing access to the reference books and journals available in the library to the scientific personnel of other research organizations, academicians, university/ college students, research scholars, stakeholders and other related visitors. The library provided reprographic service (photocopying) to the users on nominal payment basis.

Utilization of funds

During this year a total of Rs 3.00 lakhs under plan funds was utilized towards the renewal of subscription to journals and procurement of new books for headquarters and KRC library of CIBA.



Results-Framework Document (RFD) for Central Institute of Brackishwater Aquaculture (2013-2014)

Results-Framework Document (RFD)
for
Central Institute of Brackishwater Aquaculture
(2013-2014)

Address : 75, Santhome High Road, Raja Annamalaipuram,
Chennai-600028 (Tamil Nadu)
Website ID : http://www.ciba.res.in

Section 1:
Vision, Mission, Objectives and Functions

Vision

Environmentally sustainable, economically viable and socially acceptable brackishwater aquaculture, that increases the earnings of small scale fish farmers and provides quality produce to meet the diversified requirements of the consumers.

Mission

Further science to develop cost-effective technologies and facilitate growth of brackishwater aquaculture in an environmentally sustainable and socially acceptable manner.

Objectives

1. Enhancing production and productivity of brackishwater aquaculture systems

Functions

1. To develop economically viable and environmentally sustainable culture technolog ies for finfish and shellfish in brackishwater systems in different agro-ecological regions.
2. To meet emerging requirements of brackishwater aquaculture, carry out basic and strategic research.
3. To evaluate economically important brackishwater biological resources for their commercial utilization.
4. To provide policy and planning support for socio-economic development, through environmentally sustainable brackishwater aquaculture.
5. To undertake human resources development and transfer of technology programmes through training and extension and to provide consultancy service.

Section 2: Inter se Priorities among Key Objectives, Success indicators and Targets

S. No.	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target / Criteria Value				
							Excellent	Very Good	Good	Fair	Poor
							100%	90%	80%	70%	60%
1	Enhancing production and productivity of brackishwater aquaculture systems	89	Improvement of culture technologies for crustaceans & fin fishes	Seed and feed production protocols; grow-out testing trials	Number	20.00	45	40	35	30	25
				Environment and socio-economic interventions; status and impact assessment	Number	15.00	25	20	15	10	5
				Disease diagnosis and therapeutics; genetic markers and genes for economic traits	Number	20.00	20	15	10	5	0
			Technical and policy support to stakeholders	Quality seed	Lakh	14.00	20	15	10	5	0
				Trainings, interactions, demonstrations, technical advisories, extension materials	Number	15.00	35	30	25	20	15
				Commercialization, consultancy, patents and copy rights	Number	5.00	4	3	2	1	0
	* Efficient Functioning of the RFD System	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2.00	15/05/13	16/05/13	17/05/13	20/05/13	21/05/13
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1.00	01/05/13	02/05/13	05/05/13	06/05/13	07/05/13
	* Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2.00	100	95	90	85	80
			Prepare an action plan for Innovation	On-time submission	Date	2.00	30/07/13	10/08/13	20/08/13	30/08/13	10/09/13
	* Improving internal efficiency / responsiveness / service delivery of Ministry / Department	4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2.00	100	95	90	85	80
				Independent Audit of implementation of public grievance redressal system	%	2.00	100	95	90	85	80
	* Mandatory Objective(s)										

Section 3: Trend values of success indicators

S. No.	Objectives	Actions	Success Indicators	Unit	Actual Value for FY 2011-2012	Actual Value for FY 2012-2013	Target Value for FY 2013-2014	Projected Values for FY 2014-2015	Projected Values for FY 2015-2016
1	Enhancing production and productivity of brackishwater aquaculture systems	Improvement of culture technologies for crustaceans & fin fishes	Seed and feed production protocols; grow-out testing trials	Number	68	60	40	47	49
			Environment and socio-economic interventions; status and impact assessment	Number	30	37	20	22	24
			Disease diagnosis and therapeutics; genetic markers and genes for economic traits	Number	34	34	15	16	17
		Technical and policy support to stakeholders	Quality seed	lakh	21	22.25	15	17	20
			Trainings, interactions, demonstrations, technical advisories, extension materials	Number	64	66	30	35	40
			Commercialization, consultancy, patents and copy rights	Number	3	6	3	3	3
	Efficient functioning of the RFD system	Timely submission of draft RFD (2013-14) for approval	On-time submission	Date			16/05/2013		
		Timely submission of results for RFD (2012-13)	On-time submission	Date			02/05/2013		
	Administrative reforms	Implement ISO 9001 as per the approved action plan	% Implementation	%			95		
		Prepare an action plan for innovation	On-time submission	Date			10/08/2013		
	Improving internal efficiency / responsiveness / service delivery of ministry / department	Implementation of sevottam	Independent audit of implementation of citizen's charter	%			95		
			Independent audit of implementation of public grievance redressal system	%			95		

Section 4: Acronyms

S.No	Acronym	Description
1	BMP	Better Management Practices
2	CAA	Coastal Aquaculture Authority
3	KVK	Krishi Vigyan Kendra
4	MPEDA	Marine Product Export Development Authority
5	NFDB	National Fisheries Development Board
6	PPP	Public Private Partnership
7	SPF	Specific Pathogen Free
8	SHG	Self Help Group
9	MoU	Memorandum of Understanding

Section 4: Description and definition of success indicators and proposed measurement methodology

S.No.	Success indicator	Description	Definition	Measurement	General comments
1	Seed and feed production protocols; grow-out testing trials	The number of seed production trials, number of on-station/ on-farm grow-out trials and number of nutritional intervention trials for candidate species, Asian seabass, tiger shrimp, Indian white shrimp, Pacific white legged shrimp, grey mullet, pearl spot, banana shrimp, milkfish, cobia, ornamental fish etc.	Any attempt to produce seed from candidate species is taken as a seed production trial. Any culture activity at station or field to demonstrate in-house technologies is defined as a grow-out trial. Any change in feed quality or quantity is considered as a nutritional intervention.	Number	This activity is essential for refinement/ verification and validation of hatchery and culture technology.
2	Environment and socio-economic interventions; status and impact assessment	Interventions for understanding pond based environmental management, and impact of environment and/or climate change on brackishwater aquaculture and vice versa. Reports on district aquaculture plans, socio-economic status and Self Help Groups (SHG) adopted.	Any experiment carried out to study or prove the influence of environmental parameters on aquaculture is defined as environmental intervention. Various reports concerning socio-economic status of stakeholders, impact of environment on brackishwater aquaculture and vice-versa and field studies would be prepared.	Number	This activity is essential for understanding the impact of environment on brackishwater aquaculture and vice-versa.
3	Disease diagnosis and therapeutics; genetic markers and genes for economic traits	Disease investigation surveys (hatchery & pond units surveyed), refinement of diagnostics, prophylactics and therapeutics protocols (kits and products), genetic markers and genes associated with economic traits in candidate species	A survey undertaken in hatcheries and ponds to monitor disease is defined as disease investigation survey. Any intervention tested to develop or refine either diagnostics or therapeutic protocols. The number of genes or markers studied in relation to economic traits of candidate species.	Number	This activity is essential to investigate the new emerging diseases and to develop diagnostics.
4	Quality seed	Quantum of quality seed produced for aquaculture species (in lakhs).	Actual number of quality seed produced	Number	To make quality seed available to farmers and entrepreneurs.
5	Trainings, interactions, demonstrations, technical advisories, extension materials	Training and interactions (farmers meets/ stakeholder meets/ workshops/ symposia/ exhibitions), technologies demonstrated, advisories (farmers-technical, science and technology and policy briefs), extension materials (e-learning modules, audio-visual aids) generated	Number of trainings conducted, number of advisories and extension materials prepared.	Number	This activity is to train stakeholders on various aspects of brackishwater aquaculture
6	Commercialization, consultancy, patents and copy rights	Technologies commercialized (Public Private Partnerships, PPP), consultancies undertaken, patents and copy rights (software, web tools) obtained will be enumerated	Tested and validated interventions that were transferred to stakeholders are considered as technologies.	Number	

Section 5: Specific performance requirements from other departments

Location Type	State	Organization Type	Organization Name	Relevant Success Indicator	What is your requirement from this organization	Justification for this requirement	Please quantify your requirement from this organization	What happens if your requirements is not met
Across country	Coastal states	Department	CAA/NFDB/MPEDA/ All State Depts. of Fisheries	Trainings, interactions, demonstrations, technical advisories, extension materials	Nomination of officials (200 persons in 2013-14)	Nominations for different training programmes	200 trainees need to be nominated	Trainees trained-number will come down
Across country	All	Private & Department	Private entrepreneurs & Patent office	Commercialization, consultancy, patents and copy rights	Co-operation for speedy clearance of MOUs and applications	Speedy clearance of MoUs and applications	Speedy clearance	The achievements may come down

Section 6: Outcome / Impact of activities of organization

S. No.	Outcome/ Impact of organization	Jointly responsible for influencing this outcome/impact with the following organization (s)/ ministries	Success indicators	Unit	2011-12	2012-13	2013-14	2014-15	2015-16
1	Increased production of farmed shrimps through BMPs/SPF seeds	MPEDA/ State Depts. of Fisheries/ NFDB	National shrimp production	Ton (in lakh)	2.2	2.5	2.8	3.0	3.0
2	Cost effective shrimp farming through low cost feeds/ other inputs	PPP (E.g.)CIBA feed @ Rs 5 less / kg of feed	Reduction in cost of production	Rs. (in lakh)	90	110	120	120	120
3	Human resource development	NFDB, State Depts. of Fisheries, KVKs and Private sector	Trainees	No.	1487	1000	1000	1000	1000

Annual (April 1, 2013 to March 31, 2014) Performance Evaluation Report in respect of RFD 2013-2014 of RSCs i.e. Institutes

Name of the Division: Fisheries
Name of the Institution: Central Institute of Brackishwater Aquaculture, Chennai
RFD Nodal Officer of the RSC: Dr. M. Muralidhar, Principal Scientist

S. No.	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target / Criteria Value					Achievements	Percent achieved against target values of 90% Col.	Performance	
							Excellent	Very Good	Good	Fair	Poor			Raw Score	Weighted Score
							100%	90%	80%	70%	60%				
1	Enhancing production and productivity of brackishwater aquaculture systems	89	Improvement of culturetechnologies for crustaceans & fin fishes	Seed and feed production protocols; grow-out testing trials	Number	20.00	45	40	35	30	25	45	112.5	100	20
				Environment and socio-economic interventions; status and impact assessment	Number	15.00	25	20	15	10	5	26	130	100	15
				Disease diagnosis and therapeutics; genetic markers and genes for economic traits	Number	20.00	20	15	10	5	0	20	133.3	100	20
			Technical and policy support to stakeholders	Quality seed	Lakh	14.00	20	15	10	5	0	20.055	133.7	100	14
				Trainings, interactions, demonstrations, technical advisories, extension materials	Number	15.00	35	30	25	20	15	47	156.7	100	15
				Commercialization, consultancy, patents and copy rights	Number	5.00	4	3	2	1	0	4	133.3	100	5
	* Efficient Functioning of the RFD System	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2.00	15/05/13	16/05/13	17/05/13	20/05/13	21/05/13	14/05/13	100	100	2
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1.00	01/05/13	02/05/13	05/05/13	06/05/13	07/05/13	05/04/13	100	100	1
	* Administra	4	Implement ISO 9001	% Implementation	%	2.00	100	95	90	85	80	100	100	100	2

S. No.	Objectives	Weigh t	Actions	Success Indicators	Unit	Weight	Target / Criteria Value					Achi eve men ts	Percent achieved against target values of 90% Col.	Performance	
							Excellent	Very Good	Good	Fair	Poor			Raw Score	Weighted Score
							100%	90%	80%	70%	60%				
1	Enhancing production and productivity of brackishwat er aquaculture systems	89	Improvem ent of culturetech nologies for crustacean s & fin fishes	Seed and feed production protocols; grow-out testing trials	Numb er	20.00	45	40	35	30	25	45	112.5	100	20
				Environment and socio-economic interventions; status and impact assessment	Numb er	15.00	25	20	15	10	5	26	130	100	15
				Disease diagnosis and therapeutics; genetic markers and genes for economic traits	Numb er	20.00	20	15	10	5	0	20	133.3	100	20
			Technical and policy support to stakehold ers	Quality seed	Lakh	14.00	20	15	10	5	0	20.0 55	133.7	100	14
				Trainings, interactions, demonstrations, technical advisories, extension materials	Numb er	15.00	35	30	25	20	15	47	156.7	100	15
				Commercialization, consultancy, patents and copy rights	Numb er	5.00	4	3	2	1	0	4	133.3	100	5
	tive Reforms		as per the approved action plan												
			Prepare an action plan for Innovation	On-time submission	Date	2.00	30/07/13	10/08 /13	20/08 /13	30/0 8/13	10/0 9/13	05/ 09/1 3	65	65	1.3
	* Improving internal efficiency /responsiv eness / service delivery of Ministry / Departme nt	4	Implement ation of Sevottam	Independent Audit of Implementation of Citizen s Charter	%	2.00	100	95	90	85	80	100	100	100	2
				Independent Audit of implementn of public grievance redressal system	%	2.00	100	95	90	85	80	100	100	100	2

* Mandatory Objective(s) .

Total Score: 99.3

Rating: Excellent

Back cover : Three generations of a farming family displaying cultured Asian seabass fish 

Contact Address:

Headquarters

ICAR-Central Institute of Brackishwater Aquaculture
75, Santhome High Road
Raja Annamalaipuram
Chennai 600 028

Telephone	:	Director (Personal)	044-24617523
		EPABX	044-24616948, 24618817
			044-24610565, 24611062
			Fax: 0091-044-24610311
E-mail	:	director.ciba@icar.gov.in, director@ciba.res.in	
Web site	:	www.ciba.res.in	

Muttukadu Experimental Station of CIBA

Kovalam Post
Muttukadu 603 112
Tamil Nadu
Telephone : 044-27472344, 044-27472061

Kakdwip Research Centre of CIBA

24, Parganas District (South)
Kakdwip 743 347
West Bengal
Telephone : 03210-255072
Fax : 03210-255072
E-mail : krckakdwip@yahoo.co.in

ICAR- Central Institute of Brackishwater Aquaculture
ISO 9001:2008
(Indian Council of Agricultural Research)
75, Santhome High Road, RA Puram, Chennai 600 028
www.ciba.res.in