Annual Report 2011-12

Central Institute of Brackishwater Aquaculture

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Frontcover

Cobia fish
(Rachycentron canadum)

Ornamental fish
(Scatophagus argus)

Banana shrimp
(Fenneropenaeus merguiensis)

White legged shrimp
(Litopenaeus vannamei)

Backcover

Organic shrimp pond at
Kakdwip Research Centre

वार्षिक प्रतिवेदन
Annual Report

2011-12

केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान

(भाकृअनुप/ICAR)

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Preface

Brackishwater aquaculture has witnessed a boom this year with the culture of Pacific white shrimp *Litopenaeus vannamei* firmly establishing in different parts of the country. As the lead institute that had carried out the risk assessment for introduction of vannamei and providing the technical expertise for developing farming guidelines and quarantine, we are happy to note that science has guided the controlled introduction of vannamei. The promising public private partnership that is emerging with regard to quarantine is a welcome development. There is a need by all stakeholders to maintain the momentum and to ensure that further development is made in a sustainable manner. With this in mind, CIBA has intensified its efforts at monitoring the disease and environmental status with regard to vannamei farming. Though there have been mortalities, our studies have clearly ruled out the presence of exotic pathogens. With diseases of unknown etiology striking vannamei culture in South East Asian countries, there is a need for constant vigil by all stakeholders and CIBA requests the co-operation of all shrimp farmers in providing timely information and samples of mortality cases so that the reasons for such cases could be identified.

Building on the success achieved last year, CIBA has been able to make a breakthrough in the breeding of cobia using pond grown stock which makes the technique easily adoptable by hatcheries, a feat not reported in India and successful in limited trials in other countries. Further work is in progress to refine this technology. The refinement in breeding of scat has led to the development of breeding and larval technology that can be adopted by the ornamental fish industry. The advancement made in the development of feed at CIBA has resulted in a large number of queries on commercialisation and requests for collaborative work with private sector which have been ably piloted by the Institute Technology Management Unit. The wider acceptance of banana shrimp by Gujarat farmers is the result of the dedicated work of CIBA Scientists and the collaboration with Navsari Agricultural University which has helped CIBA to make a mark in Gujarat. Our Kakdwip Centre continues to be a jewel in our crown and thanks to the hard work of the Scientists, has strengthened and validated many of CIBA technologies through on-station farm trials. The farm facilities have been further strengthened to take up CIBA's work on vannamei farming and further intensify the work on finfish polyculture. The work initiated on using biotechnological tools to comprehend the epidemiology of WSSV and in developing therapeutics has started paying dividends and in the coming year, we hope to make further inroads in understanding and controlling the disease. Similarly the use of hormonal and genetic interventions in the breeding of tiger shrimp will, in the coming years, help in developing the technology for domestication of this species which can be adopted by commercial hatcheries. Most of this would not have been possible without the support of NAIP, NFDB and DBT funded projects which have

paved the way for recruiting young researchers to pursue their Ph.D.programme. The other exciting results emerging are in the areas of our preparedness to meet climate change, nutrient profiling of our cultured species, understanding the mechanism of probiotics action, domestic market, use of mobile telephony, developing a package of livelihood options for women SHGs and many other aspects which are presented in this annual report.

Lastly, the Silver Jubilee Celebration of CIBA which culminated with the National Conference on "New Vistas in Indian Aquaculture" during 23-24th February, 2012 and Alumni Meet of all CIBA employees on 25th February 2012 indicated the wide spread support CIBA enjoys in the aquaculture sector, retired employees and institutional partners. All this work by CIBA would not be possible had it not been for the unstinted, invaluable support and encouragement of Dr. S. Ayyappan, Director General, ICAR and Secretary, DARE. We are thankful for the guidance and support of Dr. (Mrs.) B. Meenakumari, Deputy Director General (Fisheries) in many of our initiatives. The support provided by Dr. Madan Mohan, Assistant Director General (Marine Fisheries) and the Fisheries Division of ICAR is gratefully acknowledged. The strategic directions provided by Dr. S. D. Tripathi, Chairman, Research Advisory Committee (RAC) and other RAC members have honed the skills of CIBA to achieve the required focus. We are grateful for the feedback and support provided by our stakeholders which has helped in keeping CIBA's work extremely relevant to the needs of the sector. The commendable work by the CIBA family and its valuable contribution to the aquaculture sector would not have been possible without the dedication, hard work and team spirit of Scientists, Technicians, Administrative, Finance & Skilled Support Staff to whom I feel greatly indebted, since this has made my task both interesting and challenging.

A.G.Ponniah
Director

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कार्यकारी सारांश

पर्यावरणानुकूल एवं लागत प्रभावी प्रौद्योगिकियां

- पानी के शून्य विनिमय व्यवस्था में ***पी.मॉनोडॉन*** के तालाब ट्रायलों से यह स्पष्ट हुआ कि पेरीफाइटन वृद्धि हेतु खड़ी स्थिति में वेलॉन नेट का प्रयोग, कम निवेश पर्यावरणानुकूल झींगा पालन के लिए एक आशावादी विकल्प साबित होता है। इसमें FCR में हुई 13% की कमी से काफी अधिक आर्थिक लाभ होते हुए देखी जा सकती है।

- आन्ध्र प्रदेश में प्राप्त होनेवाली पानी व्यवस्था में ***एल. वन्नमेई*** पालन के अंतर्गत पानी के निकास पर अध्ययन किए गए तथा परिणामों से यह स्पष्ट कि pH, TSS और TAN, पानी के आऊट फॉल क्षेत्र में उचित श्रेणी में पाए गए जबकि कुल N और फॉस्फेट, आऊट क्षेत्र से 500 m की सीमाओं के अंदर पाए गए।

- ऐयरेशन की लागत कम करने की दिशा में मिट्टी एवं पानी के रेस्पिरेशन आकलन केलिए उचित पद्धति को मानकीकृत किया गया और रेस्पिरेशन दर स्लूइस गेट के पास अधिकतम पाया गया तथा किसानों ने ***वन्नमेई*** के 35 दिनों के पालन में एक औसत ऐयरेशन (4.23 HP) की वास्तविक आवश्यकता की तुलना में अधिक (6-8 HP) दे पाए।

- महिला टाइगर झींगा की परिपक्वता बढ़ाने केलिए हॉर्मोनल हस्तक्षेपों का विकास करने की दिशा में 17α हाईड्रॉक्सी पॉलीगेस्टरॉन के साथ किए अध्ययनों से यह स्पष्ट हुआ कि झींगे में ओवेरियन परिपक्वता पर आईस्टॉक हॉर्मोन के इन्हिबिटरी कंट्रोल को ओवरराइड नहीं करेगा लेकिन आईस्टॉक हॉर्मोनों को आंशिक रूप में निकालने से प्रभावशाली होगा। जीन अभिव्यक्ति के आधार पर (विटेल्लोजेनिन, विटेल्लोजेनिन रिसेप्टर, मोल्ट-इन्हिबिटिंग हॉर्मोन। और ।।) यह पाया गया कि सेरोटोनिन आईस्टॉक अब्लेशन का उपचार बेहतर था और टाइगर झींगे की उच्च ऊसाइट परिपक्वता प्राप्त हुई।

- निम्न एवं उच्च लवण युक्त झींगा खेती के लिए लागत प्रभावी खाद्य प्रदार्थों के विकास कार्य बनाए रखते हुए शोलीन के विभिन्न स्तरी के साथ सप्लिमेण्टेशन को मूल्यांकित किया गया तथा 1200 Mg/Kg के दर पर खाद्य पदार्थ शामिल करने से अच्छी वृद्धि और निम्न FCR प्राप्त हुए। उच्च लवण युक्त स्थितियों के संदर्भ में 0.4% विटामिन C शामिल करने से बेहतरीन वृद्धि और FCR प्राप्त हुआ। फिर भी, निम्न लवण युक्त स्थिति में विटामिन C डालने से कोई स्पष्ट सुधार नहीं दिखाई दिए।

बृहत् स्तर पर स्वास्थ्य देखरेख

- एपिफ्लूरसेन्स माइक्रोस्कोपी द्वारा खारा पानी तालाबों में वायरसों की गणना हेतुप्रोटोकॉल मानकीकृत किए गए। झींगा पालन तालाब, झींगा हैचरियों के खारा पानी सैम्पलों में वायरल की गिनती 1.3-1.5 x $10^5 ml^{-1}$ श्रेणी में तथा सेडिमेण्टों में 3.3-4.2 x $10^9 g^{-1}$ श्रेणी में पाए गए।

- ताप द्वारा मारे गए नोडावायरस वैक्सीन, इंट्रामस्कयूलर एवं इंट्रा पेरिटोनियल रूट, दोनों के माध्यम से सीबॉस शिशुओं को काफी सुरक्षा दे पाए।

- पैथेजेनिक ***वी.ऐनन्विल्लरस*** से बाह्य परत प्रोटीन को पृथक किया गया तथा सीबॉस को ***वी.ऐनन्विल्लरस*** को दूषण से बचाने केलिए सक्षम उम्मीदवार के रूप में उसका परीक्षण किया जा रहा है।

- WSSV प्रोटीन (VP28 और VP15 को बेइटों के रूप में प्रयोग करते हुए तथा उसे खमीर में अभिव्यक्त करते हुए, WSSV दूषण से बचाने केलिए झींगा इल्लियों की जिवंतता पर उनके प्रभाव का अध्ययन करने का प्रयास किया गया। जब इल्लियों को सीधे या

आर्टिमिया द्वारा खमीर खिलाया गया तो बेइट प्रोटीन, 72 घंटों के दूषण पश्चात् स्थिति से 96 घंटों तक की उच्च जीवंतता दर दे पाए। सामान्य कंट्रोल एवं वेक्टर कंट्रोल में जीवंतता में काफी भिन्नता देखी जा सकती है।

तेज़ गति की वृद्धि तथा रोग प्रतिरोध में वृद्धि

- इम्यूनिटी लक्षित करनेवाले हस्तक्षेप से झींगों में रोग प्रतिरोधता में बढ़ोत्तरी देखी जाती है। प्रोबयॉटिकों के अनुप्रयोग से टाइगर झींगों की इल्ली-स्थिति पश्चात् की स्थिति में जीवंतता बढ़ाने तथा इम्यून व्यवस्था में सुधार करने की दिशा में काफी सहायता मिली है। इम्यूनो-उत्प्रेरक आधारित सूक्ष्मजीवियाँ में सोडियम अल्जिनेट डालने पर उसकी वृद्धि तथा सफेद झींगों की जीवंतता में बढ़ोत्तरी देखी जाती है। दबाव के कारण कमज़ोर किए गए टाइगर झींगा ब्रूडस्टॉक में बीटा ग्लूकन के प्रयोग से परिपक्वता एवं स्पॉनिंग जल्दी हो गए जिससे प्रजन्यता निष्पादन में सुधार की प्रक्रिया में इम्यूनिटी की भूमिका की संभावना साबित करता है।

- पेनेइड झींगों के प्रजनन पर WSSV दूषण के प्रभाव से निम्नांकित परिणाम प्राप्त हुए। भारतीय सफेद झींगों में WSSV दूषण के संबंध में स्त्री विटेल्लोजेनिन (Vg) एवं थ्रॉम्बोस्पोडिन (TSP) जीनों की समयावधि अभिव्यक्ति से यह स्पष्ट होता है कि सामान्य रूप से Vg और TSP परिपक्वता एवं इल्ली विकास की प्रक्रिया में शामिल है, वे WSSV दूषण की प्रतिक्रिया में सक्रिय बन जाते हैं। टाइगर झींगों में परिपक्वता एवं स्पॉनिंग निष्पादन की प्रक्रिया पर WSSV दूषण के मूल्यांकन से यह स्पष्ट हुआ कि समय के बहुत बाद में विटेल्लोजेनिक ऊसाइटों की तुलना में समय से पहले परिपक्वता प्राप्ति की स्थिति, WSSV दूषण से अधिक प्रभावित है।

- चेन्नई, तूत्तुकूडी, विशाखपट्टनम, परदीप, काकद्वीप, आंदमान, कोल्लम, मैंगलूर एवं रत्नगिरि को ट्रस्स मॉर्फोमेट्रिक मापों के आधार पर वर्गीकृक किए जा सकते हैं जिससे एक भिन्न स्टॉक संरचना की उपस्थिति का संकेत मिलता है।

- टाइगर झींगों में जीनों के बायोप्रॉस्पेक्टिंग तथा गैर-जैविक दबाव के प्रति सहन हेतु अल्लेले माइनिंग पर NAIP परियोजना के अंतर्गत लवण युक्त माध्यमों के प्रति ग्यारह जीनों की सहनशीलता का संकेत मिलता है : केचोल मीथाइल ट्रांसफरेज, सईप्लासिन, लईसाइल हईड्रॉक्सीलेज़, पी. मोनोडॉन इलोंन्गेशन फैक्टर (Pm - EF), ट्रांसपोज़ोन्स (Trn 7), क्रस्टीन्स, आइसोसिट्रेट डीहाइड्रोजनेज, अर्गिनीन कीनेज़ (Pen m2 अलर्जन, हाईपोथेटिकल प्रोटीन, सेरीन थ्रियोनीन कीनेज़ एवं यूनीक।

- लवण-युक्त दबाव-नियमित जीनों केलिए cDNA फ्रेग्मेण्टों का भण्डार तैयार करने केलिए सप्रेशन सब्ट्रेक्टिव हाइब्रडाइजेशन (SSH) किया गया। PCR उत्पाद 300-1500 bp साइज़ श्रेणी में थे।

प्रजाति एवं व्यवस्थाओं का वैविध्यीकरण

- हमारे देश में पहली बार तालाब में पले ब्रूडस्टॉक से कोबिया प्रजनन एवं इल्ली पालन सफलतापूर्वक किया गया।

- भारत में पहली बार खारा पानी श्रृंगार मत्स्य, स्पॉटेड स्केट केलिए नियंत्रित प्रजनन एवं इल्ली पालन किया गया।

- गुजरात में नवसरी जिले में स्थित दन्ती में किसानों के तालाबों में शरद के महीनों में बनाना-झींगा पालन निरूपित किया गया, परिणामस्वरूप 70% जीवंतता के साथ 113 दिनों में 1208 kg/ha प्राप्त हुआ तथा झींगों ने 9.9 kg का औसत साइज़ प्राप्त किया तथा FCR 1.28 था।

- इष्टतमीकरण प्रबंधन पद्धतियों के अंतर्गत ***लिटोपेनियस वन्नमेई*** पालन में स्टॉकिंग सघनता की तुलना से यह स्पष्ट हुआ कि इससे वृद्धि दर ही प्रभावित हुआ है, तालाब वातावरण प्रभावित नहीं हुआ। पालन एवं औसत शारीरिक वज़न के आधार पर 20-30 nos.m^2 स्टॉकिंग सघनता किसानों को अत्यधिक लाभ प्रदान करने के लिए इष्टतमीकृत किए गए।

- मिट्टी केंकडों के इल्लियों के बृहत् स्तर पर उत्पादन के प्रयास किए गए तथा अंतर्राष्ट्रीय स्तर पर रिपोर्ट किए गए उत्पादन स्तर प्राप्त हुआ। इसमें किसानों के तालाबों के केंकड़े घोंसले नर्सरी पालन में 63% जीवंतता रिकार्ड हुई है।

- परयुक्त मत्स्य या इन सुगंधित सामग्रियों से सूक्ष्मजीवियों (मत्स्य-मील के वज़न को 75% द्वारा प्रतिस्थापित करने केलिए) का प्रयोग करते हुए पृथक किए अच्छे स्ट्रेनों के सजीव सूक्ष्मजैविक मिश्रणों से जलीय खाद्य पदार्थों को उत्कृष्ट बनाने से मुल्लेटों में वृद्धि दर, FCR, PER के साथ गट सूक्ष्मजीवी जनसंख्या एवं पचन-योग्य एन्ज़ाइम क्रियाकलाप में सुधार होते दिखाई देता है।

- स्थानीय स्तर पर उपलब्ध अपरंपरागत खाद्य पदार्थों से निम्न लागत बहुपालन खाद्य पदार्थ तैयार किया गया, जिनका विकास पहले किया गया था, उन्हें परिष्कृत किया गया तथा छह खारापानी प्रजातियों के साथ किसान के तालाबों में निरूपित करने के प्रयास भी किए गए। 325 DOC के बाद, 0.88 FCR के साथ 3.14 tonnes/ha का उत्पादन हुआ तथा 2.0 लाख प्रति हेक्टेयर से भी अधिक कुल लाभ प्राप्त हुआ।

- भूरे मुल्लेट ***मुगिल सिफेलस***, पर्ल्सस्पॉट ***इट्रोप्लस सुरटेनसिस*** एवं टाइगर झींगा ***पेनेइस मोनोडॉन*** के साथ परयुक्त मत्स्य एवं शेल युक्त मत्स्य बहुपालन निरूपित किया गया। खेत में तैयार किए गए मत्स्य खाद्य पदार्थ तैयार किया गया और उसका अनुप्रयोग किया गया। 150 दिनों के बाद, टाइगर झींगों (ABW=42 g) तथा भूरे मुल्लेट (570 g) एवं 300 DOC के बाद पर्ल्सस्पॉट (100 g) का फसल किया गया। किसान को 1.69 लाख प्रति हेक्टेयर की कुल आमदनी से 2520 kg/ha का उत्पादन प्राप्त कर सके।

- सीबॉस खाद्य पदार्थ के लिए चिकन व्यर्थ-मील, कॉन प्रोटीन कॉन्सनट्रेट एवं पूर्ण वसा युक्त सोया जैसे तीन वैकल्पिक प्रोटीन स्रोतों का मूल्यांकन किया गया तथा इसके परिणामों से पता चलता है कि 5% पर चिकन व्यर्थ-मील को वृद्धि दर, FCR एवं जीवंतता खोए बिना खाद्य पदार्थ में शामिल किया जा सकता है।

सामाजिक-आर्थिके विश्लेषण तथा नीति एवं योजना को समर्थन

- वर्ष 2011 में सुंदरबनों के मैंग्रोव में रिमोट संवेदी अध्ययनों से यह स्पष्ट हुआ कि 40 वर्षों की अवधि में 1.4% के मैंग्रोव वनों की कुल हानि हुआ है तथा अन्य अध्ययनों से यह भी पता चला कि लवणता में वृद्धि, वनों का कटाव तथा अन्य मानवीय प्रभाव इस हानि के मुख्य कारण हैं; वन के सीमांतर क्षेत्र के केवल 266 हेक्टेयर (जो कुल मैंग्रोवों का 0.0001% होता है) मैंग्रोवों को जलकृषि केलिए लिया गया।

- वर्ष 1991 की अवधि में तमिलनाडु के कडलोर जिले में भूतल पानी की गुणवत्ता के GIS आधारित विश्लेषण से यह पता चलता है कि पोर्टो नोवो एवं टी.एस. पेट्टेई के कुँओं में कुल विघटित छोस पदार्थ एवं इलेक्ट्रिकल कंडक्टिंग मूल्य, जलकृषि से पूर्व 1991 वर्ष के मूल्यों से ज्यादा नहीं है।

- तमिलनाडु एवं आन्ध्र प्रदेश में सफेद झींगों की मांग हेतु मार्केट सर्वेक्षण से निर्यातकों द्वारा भुगतानित वन्नमेई के खेत द्वार दर एवं स्वदेशी मार्केट के दरों आकाश पाताल का अंतर है। यदि निम्न स्तर के कोल्ड भंडारण की सुविधाएं प्रदान की जाती हैं तो इससे उनके अनियमित फसलों को नियमित बनाने में समर्थन मिलेगा और वन्नमेई उत्पादक स्वदेशी मार्केट की मांग से लाभान्वित हो सकते हैं।

- मोबाइल फोन से तमिलनाडु में स्थित 300 जलकृषि/मत्स्य किसानों को मौसम पूर्वानुमान, प्रौद्योगिकी/समाचार, प्रशिक्षण कार्यक्रम एवं मार्केट सूचना प्रदान की गई।

- समुद्र तटवर्ती प्रदेशों के KVK उपयोगकर्ताओं के हित में जलकृषि में e-शिक्षण मौड्यूल का विकास की दिशा में KVK उपयोगकर्ता, तमिलनाडु के कट्टुपाक्कम, कांचीपुरम जिलों में आवश्यकताएं निर्धारित की गईं तथा सूचना आवस्यकताओं को श्रेणीबद्ध किया गया।

- केरल सरकार के मात्स्यिकी विभाग के माध्यम से सीबा द्वारा स्वयं सेवक दलों को प्रदत्त पर्ल्सस्पॉट सीड के वृद्धि दर निष्पादन एवं उत्पादन सक्षमता का अनुवीक्षण एवं मूल्यांकन किया गया। मत्स्यों की जलकृषि के 5 महीनों में 100-110 g वज़न प्राप्त किया।

- तमिलनाडु के कुलत्तुमेडु गांव, तोन्नेरी गांव एवं तिरुवल्लूर जिले के कट्टूर में तथा कांचीपुरम जिले में स्थित नवीन पेरुगुलत्तूर में 30 अनुसूचित जाति एवं जनजाति महिला स्वयं सेवक दलों में केंकड़ा मोटा करने की प्रक्रिया (घोंसलों में), केंक़डा मोटा करने की प्रक्रिया (बंद स्थिति में), केंकडा मोटा करने की प्रक्रिया (तालाबों में), खेत के मत्स्य खाद्य पदार्थों का विकास, श्रृंगारिक मत्स्य खेती, मूल्ययोजित मत्स्य उपभोगता उत्पाद विकास पर छह निरूपण कार्यक्रम आयोजित किया गए।

- तमिलनाडु के नागपट्टिनम जिले में स्थित अवरिकाडु में 188 किसानों को जागरूकता कार्यक्रमों द्वारा उत्तम प्रबंधन पद्धितोयों में प्रशिक्षण दिया गया।

- "खेती समुदायों में रोज़गार प्राप्ति सतत बनाने केलिए क्षतिग्रस्त समुद्र तटवर्ती भूमि एवं जल प्रदेशों में सतत प्रबंधन हेतु कार्यनीतियों" पर NAIP परियोजना के अंतर्गत सुंदरबनों के निम्न समुद्र तटवर्ती क्षेत्रों में स्थित क्षतिग्रस्त समुद्र तटवर्ती भूमि एवं जल प्रदेशों में 2.53 ha क्षेत्र युक्त 13 खारापानी तालाबों को खोदने के माध्यम से उत्पादकता में सुधार, दाना एवं मत्स्य कृषि केलिए 0.67 ha क्षेत्र के विकास के साथ, वैविध्यपूर्ण फसल शुरू करते हुए मशरूम कृषि एवं वर्मीकम्पोस्टिंग द्वारा विकास किया गया।

- तमिलनाडु में एक सफल किसान समिति, पामिनी नदी झींगा किसान समिति के केस-अध्ययन द्वारा सदस्य किसानों में तालाब तैयार करने से लेकर फसल तक की प्रक्रिया में संभाव्य विरोधास्पद बिन्दुओं (PCP) की पहचान की गई तथा उन्हें सुलझाने के लिए नवीन कार्यनीतियों का विकास किया गया। इन कार्यनीतियों को समिति की सफलता का आधार बताया जा सकता है।

- कम लवण तालाब में सीबॉस जलकृषि की पौष्टिकता प्रोफाइलिंग से वसा अम्ल 18:2n6, 18:1, 18:3 n3 के उच्च स्तर तथा EPA (ऐइकोसेपेन्टेनोइक अम्ल; 20:5 n-3) तथा DHA (डोकोसहेक्साएनोइक अम्ल; 22:6 n-3) के निम्न स्तर देखे गए तथा जब इसकी तुलना अधिक लवणायुक्त तालाब से की जाती है तो वह लवणता वसा अम्ल प्रोफाइलों को प्रभावित करते हुए दर्शाती है।

- उपभोक्ता की पसंद के सर्वेक्षण से स्पष्ट होता है कि मत्स्य खरीदते समय स्वाद और ताज़ापन बहुत महत्व रखते हैं और यह कि कई उपभोक्ता झींगों को स्वास्थ्य के लिए अच्छा नहीं मानते हैं जोकि झींगों की पौष्टिकता प्रोफाइलिंग के बिल्कुल विपरीत है और यह संकेत मिलता हैकि उसे खाए जानेवाले भाग में वसा का बहुत कम प्रतिशत (0.8 g) है, मांसाहारी भोजन में सबसे कम वसा पाया जाता है तथा कोलेस्ट्रॉल (170 mg) न कम है और न ही ज्यादा और यह अन्य पौष्टिक तत्वों में अत्यंत उत्कृष्ट माना जाता है।

Executive Summary

Environment friendly and cost effective technologies

- Pond trials in *Penaeus monodon* under zero water exchange system revealed the use of velon net as a vertical substrate for periphyton growth and proves to be a promising option for low input eco-friendly shrimp culture. The 13% reduction in FCR observed would result in significant economic gain.
- The impact of discharge water under *Litopenaeus vannamei* culture on the receiving water body was studied in Andhra Pradesh and the results indicated that pH, TSS and TAN were within the optimum range at outfall area itself whereas total N and phosphate were within the prescribed limits at 500 m from outfall area.
- For reducing the energy cost of aeration, the methodology for estimation of soil and water respiration was standardized and it was observed that the respiration rate was maximum near the sluice gate and the farmers on an average provided higher aeration (6 -8 HP) than the actual requirement (4.23 HP) at 35 days of culture of vannamei.
- In order to develop hormonal interventions for increasing maturation of female tiger shrimp, studies carried out with 17 á hydroxy progesterone indicated that it would not override the inhibitory control of the eyestalk hormone on ovarian maturation in shrimp, but would be effective with partial removal of the eyestalk hormones. Based on gene expression (vitellogenin, vitellogenin receptor, moult-inhibiting hormone I and II), it was found that the treatment serotonin + eye stalk ablation was superior and resulted in higher oocyte maturation of tiger shrimp
- Continuing the work to develop cost effective feeds for low and high saline shrimp farming, supplementation with different levels of choline was evaluated and inclusion @1200 mg/kg feed showed higher growth and lower FCR. With regard to high saline conditions, addition of 0.4% vitamin C resulted in better growth and FCR.; however no significant improvement was observed with vitamin C supplementation at low salinity.

Comprehensive health management

- Protocols for enumeration of viruses in brackishwater ponds were standardized by epifluorescence microscopy. The viral counts in brackishwater samples ranged from 1.6-4.9 x $10^7 ml^{-1}$ in shrimp culture ponds, 1.3-1.5 x $10^5 ml^{-1}$ in shrimp hatcheries and 3.3-4.2x $10^9 g^{-1}$ in sediments.
- Heat killed nodavirus vaccine was able to provide significant protection to seabass juveniles both by intramuscular and intra peritoneal routes.
- Outer membrane protein (OMP) has been isolated from pathogenic *Vibrio anguillarum* and is being tested as a potential candidate for vaccine against *V. anguillarum* infection in seabass.

- Using the WSSV proteins (VP28 and VP15) as baits and expressing these in yeast, attempt was made to study their effect on the survival of shrimp larvae against WSSV infection. When the larvae were either fed with yeast directly or through artemia, bait proteins conferred higher survival rate from 72 hours of post infection till 96 hours. The survival was significantly different from that of normal control and vector control.

Faster growth and increased disease resistance

- Interventions targeting immunity were found to increase shrimp disease resistance. Application of probiotics was helpful in increasing the survivability and improving the immune system of postlarvae of tiger shrimp. Addition of sodium alginate to bacterial based immunostimulant resulted in improved growth and survival of juvenile white shrimp. Beta glucan was found to advance maturation and spawning in tiger shrimp broodstock weakened by stress indicating the possible role of immunity in improving reproductive performance.

- The impact of WSSV infection on reproduction in penaeid shrimp have been highlighted by the following results. Time-course expression of female genes Vitellogenin (Vg) and Thrombospondin (TSP) in relation to WSSV infection in Indian white shrimp indicated that although Vg and TSP are usually involved in maturation and larval development, they also get activated in response to WSSV infection. Evaluation of WSSV infection on maturation and spawning performance of tiger shrimp indicated that early ripe stage is more susceptible to WSSV infection compared to late vitellogenic oocytes.

- Tiger shrimp stocks from Chennai, Tuticorin, Visakhapatnam, Paradip, Kakdwip, Andamans, Kollam, Mangalore and Ratnagiri could be differentiated based on truss morphometric measurements, indicating the presence of distinct stock structure.

- Under the NAIP project on bioprospecting of genes and allele mining for abiotic stress tolerance in tiger shrimp, the role of the following eleven genes in salinity tolerance was indicated: Catechol O-Methyl Transferase, Cyplasin, Lysyl hydroxylase, P. monodon Elongation Factor (Pm- EF), Transposons (Trn7), Crustins, Isocitrate dehydrogenase, Arginine kinase (Pen m2 allergen), Hypothetical protein, Serine threonine kinase and Unique.

- Suppression subtractive hybridization (SSH) was performed to generate libraries of cDNA fragments enriched for salinity stress-regulated genes. The PCR products were in the size range of 300-1500 bp.

Diversification of species and systems

- Breeding and larval rearing of cobia from pond reared broodstock was successfully achieved for the first time in our country.

- Controlled breeding and larval rearing for brackishwater ornamental fish, spotted scat was achieved for the first time in India.

- Banana shrimp culture demonstration conducted during winter months in a farmer's pond at Danti, Navsari district, Gujarat has resulted in 1208 kg/ha/113 days with 70 % survival and the shrimp attained an average size of 9.9 g. The FCR was 1.28.

- Comparison of stocking densities in *L. vannamei* culture under optimum management practices revealed that it affected only the growth rate but not the pond environment. Based on days of culture and average body weight, stocking densities of 20-30 nos./m^2 appear optimum to maximize the benefit to the farmers.

- Mass production of mud crab larvae was attempted and production as reported internationally achieved. Survival of 63 % was recorded in nursery rearing of crablets in farmers' ponds.

- Enrichment of aquafeed with live bacterial mixture of promising strains isolated from finfishes or fermented ingredients using these bacteria (to replace 75 % by weight of fish meal) was found to improve the growth rate, FCR, PER as well as gut microbial population and digestive enzyme activity of mullets.

- Low cost polyculture feed formulated with locally available unconventional feed ingredients which had been developed earlier has been refined and a demonstration trial was conducted in a farmer's pond with six brackishwater species. After 325 DOC, production of 3.14 tonnes/ha was realized with FCR of 0.88 and net profit of more than ₹2.0 lakhs/ha.

- Demonstration of finfish and shellfish polyculture was done with grey mullet *Mugil cephalus*, pearlspot *Etroplus suratensis* and tiger shrimp *Penaeus monodon*. Farm-made fish feed was prepared and applied. After 150 days tiger shrimp was harvested (ABW= 42 g) and grey mullet (570 g) and pearlspot (100 g) were harvested after 300 DOC. The farmer could realize production of 2520 kg/ha with net income of ₹1.69 lakh/ha.

- Three alternate protein sources for seabass feed, *viz*., chicken waste meal, corn protein concentrate and full fat soya were evaluated and the results indicate that chicken waste meal @ 5% could be incorporated in the feed without compromising growth, FCR and survival.

Socio-economic analysis and support to policy and planning

- Remote sensing study on mangroves of Sunderbans in 2011 showed a marginal net loss of mangrove forests by 1.4% during the 40-year period and other studies have indicated that increasing salinity, over-harvesting of timber and other human influences are the main reasons for this loss; only about 266 ha mangroves (which forms 0.001 % of total mangroves) outside forest boundary was converted for aquaculture.

- GIS based ground water quality analysis at Cuddalore district of Tamil Nadu showed that during 1991 itself the total dissolved solid and electrical conductivity values at the wells in Porto Novo and T.S. Pettai were high and after the advent of shrimp farming the values have not risen above the pre-aquaculture values of 1991.

- A market survey for demand of white shrimp in Tamil Nadu & Andhra Pradesh indicated a huge difference in the farm gate price of vannamei paid by exporters and domestic market prices. If mini cold storage facilities are created, this could support staggered harvest and domestic demand could be tapped by vannamei producers.
- Weather forecasts, technologies/news, training programmes and market information were disseminated through mobile phone (Voice Mail Service) to 300 aqua/fish farmers in Tamil Nadu.
- In order to develop e-Learning module in aquaculture and allied activities for users of coastal KVKs, a need assessment was carried out among the users of KVK, Kattupakkam, Kancheepuram district of Tamil Nadu and the ranking of the information needs was carried out.
- The growth performance and production potential of pearlspot seed from CIBA supplied to the Self Help Groups through the Department of Fisheries, Govt. of Kerala were monitored and assessed. The fish has attained 100-110 g in 5 months of culture.
- Six demonstration programmes were conducted on crab fattening (in pens), crab fattening (in cages), crab fattening (in ponds), farm made fish feed development, ornamental fish farming, value added fish food product development among 30 SC & ST WSHGs of Kulathumedu, Thonirevu and Kattur in Tiruvallur district and New Perugulathur in Kancheepuram district, Tamil Nadu.
- Around 188 farmers were trained through Awareness programme on Best Management practices in shrimp culture at Avarikadu in Nagapattinam district, Tamil Nadu.
- Under the NAIP project on 'Strategies for sustainable management of degraded coastal land and water for enhancing livelihood security of farming communities' the productivity of degraded land and water resources in low lying coastal areas of Sunderbans was improved by excavating 13 brackishwater ponds having an area of 2.53 ha, developing 0.67 ha for paddy-cum-fish cultivation, introduction of diversified crops, mushroom cultivation and vermicomposting.
- The case study of the Pamini River Shrimp Farmers Association in Tamil Nadu, a successful farmers association, revealed that they had identified potential conflict points (PCP) among the member farmers from pond preparation to harvest and has developed novel strategies to tackle them. The success of the association could be linked to these strategies.
- Nutrient profiling of seabass cultured in low saline pond indicated higher levels of fatty acids 18:2n6, 18:1, 18:3 n3 and decreased levels of EPA (eicosapentaenoic acid; 20:5 n-3) and DHA (docosahexaenoic acid; 22:6 n-3), when compared to high saline pond indicating that salinity influences fatty acid profile.
- Survey on consumer preferences indicated that taste and freshness form important factors while buying fish and that shrimp is not considered as a healthy food by most of the consumers which is in contrast to the nutrient profiling of shrimp which indicates that the edible portion has a very low fat percentage (0.8 g), the lowest among non-vegetarian foods and moderate amount of cholesterol (170 mg) and is very rich in other nutrients.

3

Introduction

Brackishwater aquaculture contributes immensely to food and nutritional security, provides substantial income to aquafarmers, generates employment and aids in productive utilization of marginal coastal lands to earn significant revenue from export of seafood. The major species for brackishwater aquaculture are shrimp, mudcrab and finfishes such as seabass, mullet, milk fish, grouper, cobia and pearlspot. Till 2011-12, the total area developed for brackishwater aquaculture is about 1.53 lakh ha. The total area under shrimp farming was about 1.23 lakh ha. Farmed shrimp production was about 2,16,494 MT which included 80,716 MT of *Litopenaeus vannamei*. About 91% of the shrimp farmers in the country have a holding of less than 2 ha, 6% between 2 to 5 ha and only 3% have >5 ha area. Sustainable brackishwater aquaculture implies adoption of environment friendly and cost-effective culture technologies by every stratum of farmers. Development and adoption of bio-secured farm practices, access to institutional credit, development of forward & backward linkages, infrastructure and favourable legislations and policies are the major issues which need to be addressed to promote sustainable brackishwater aquaculture.

Brackishwater aquaculture is traditionally practiced in West Bengal in *bheries*, locally known as "*bhasabhada* "and in *pokkali* ûelds of Kerala. The environmental issues of shrimp farm management have been of tremendous concern. Stocking density, feed and water management have played a crucial role in the determination of carrying capacity of the system. Hence, adoption of Better Management Practices (BMPs) would facilitate effective farm management and sustainable farm production. The Central Institute of Brackishwater Aquaculture (CIBA) is assiduously working on these cardinal principles for sustained shrimp farming and the orderly development of the sector.

The Central Institute of Brackishwater Aquaculture was established in April 1987 to serve as a nodal agency for the development of brackishwater aquaculture in the country. The headquarters of the Institute is located at Chennai with an Experimental Field Station at Muttukadu, about 30 km south of Chennai. The Institute has one Research Centre at Kakdwip in West Bengal. The Institute is headed by the Director and has 44 Scientists, 27 Technical, 26 Administrative and 37 Skilled Support Staff as on 31.3.2012.

Mandate

- To conduct research for development of techno-economically viable and sustainable culture system for finfish and shellfish in brackishwater
- To act as a repository of information on brackishwater fishery resources with a systematic database
- To undertake transfer of technology through training, education and extension programmes
- To provide consultancy services

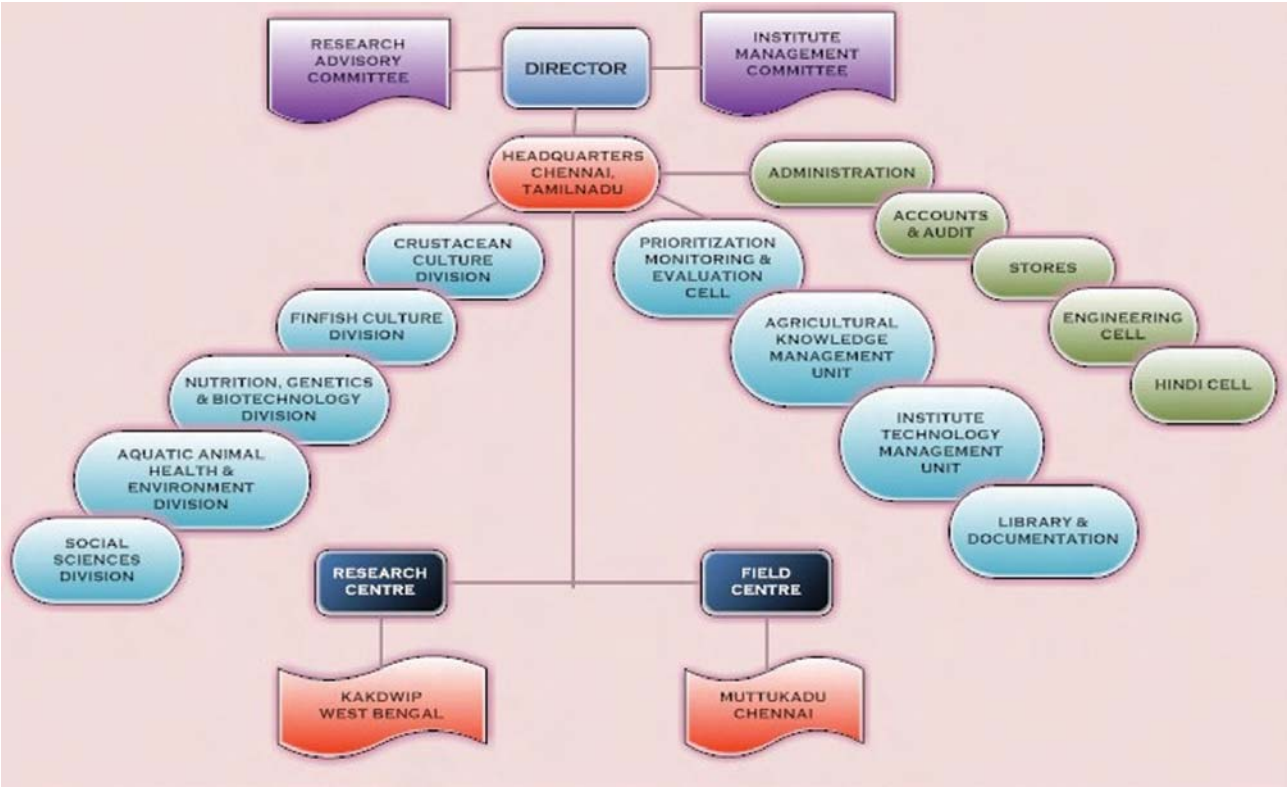
Organizational set-up

The research activities of the Institute are carried out under five Divisions, *viz*.,

- ❖ Crustacean Culture Division
- ❖ Finfish Culture Division
- ❖ Aquatic Animal Health and Environment Division
- ❖ Nutrition, Genetics and Biotechnology Division
- ❖ Social Sciences Division

The research activities of the Institute are diverse in nature, starting from basic to applied and adoptive research which was carried out through 12 in-house and 27 externally funded projects during 2011-12.

ORGANISATION CHART



Headquarters

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Financial Statement 2011-12

(₹ in lakhs)

Sub-Head	BE	RE	Actual Expenditure
Plan			
Travelling Expenses	23.00	23.00	23.00
HRD	5.00	5.00	5.00
Contingency	173.50	173.50	173.50
Works	190.00	233.20	197.32
Equipments	94.50	94.50	94.45
Information Technology	16.00	16.00	15.98
Others	20.00	20.00	19.97
Library	8.00	20.00	19.99
Furniture & Fixture	5.00	5.00	4.94
TSP	50.00	0.00	0.00
Total	**585.00**	**590.20**	**554.15**
Non-Plan			
Establishment	850.00	882.73	882.73
O.T.A	0.20	0.08	0.08
Travelling Expenses	6.00	6.00	6.00
Research & Operational	17.00	17.00	16.99
Administrative expenses	84.80	169.94	169.93
Miscellaneous	0.00	0.00	0.00
Sub total	**958.00**	**1075.75**	**1075.73**
Pension	105.00	110.00	109.98
Loans & Advances	7.00	7.00	4.39
Total	**1070.00**	**1192.75**	**1190.10**

Revenue generation

(₹ in lakhs)

Year	Target	Achievement
2011-12	**23.10**	**41.12**

Official Language Implementation Programme

During the year, four meetings of the Official Language Implementation Committee were held and the usage of Hindi in official correspondences, bilingual use of Hindi and English in files and publications in Hindi were reviewed. The Institute organized the Hindi Pakhwada celebrations during 14 - 28 September, 2011. As part of the celebration, Hindi Prashnothari (Question-Answer) competition was conducted on 16.09.2011 and a Hindi workshop was organized on 17.09.2011. Hindi Divas was also celebrated on 28.09.2011 and a Hindi Expert was invited who delivered a lecture on Official Language implementation. The Director, CIBA, awarded the prizes to the winners of Hindi Essay and the Hindi Prashnothari competitions on this day. Hindi Divas was celebrated at the Kakdwip Research Centre (KRC) on 20th September, 2011. Mr. Prakash Chandra Thakur, Assistant Director, Rajbhasha, Doordarshan Kolkata who was the Chief Guest, assured his help for implementation of Hindi work at KRC. On the occasion Hindi extempore and quiz competition were organised and all KRC staff actively participated and prizes were distributed to the winners.

STAFF POSITION

The details of sanctioned, filled and vacant positions as on 31.03.2012 are as follows.

Category	Sanctioned	Filled	Vacant
Director (RMP)	1	1	-
Head of Division	2	2	-
Principal Scientist	3	1	2
Senior Scientist	10	6	4
Scientist	52	37	15
Technical Assistant	31	28	3
Administrative Officer	1	1	-
Finance & Accounts Officer	1	1	-
Deputy Director (OL)	1	0	1
Assistant Administrative Officer	3	3	-
Junior Accounts Officer	1	1	-
Private Secretary	1	1	-
Personal Assistant	2	2	-
Stenographer Gr.III	1	2	1 (excess)
Assistant	7	6	1
Senior Clerk	3	3	-
Junior Clerk	5	6	1 (excess)
Skilled Support Staff	60	42	18
Total	**185**	**143**	**44**

Silver Jubilee Celebrations of CIBA

CIBA completed its 25th glorious year of research on brackishwater aquaculture. In commemoration of its Silver Jubilee Celebrations, CIBA organized a National Conference on "New Vistas in Indian Aquaculture" during 23-24 February, 2012 and Alumni Meet of all CIBA employees on 25th February 2012. On this occasion, the Aquatic Animal Health Testing Facility was inaugurated on 23rd February 2012 by Dr. M.S. Swaminathan, the former Director General of ICAR and Chairman of MSSRF, Chennai. The special guests on this occasion were Dr. (Mrs) B. Meenakumari, DDG (Fy.), Dr. E.G. Silas, Former Vice Chancellor, Kerala Agricultural University and Dr. R. Prabakaran, Vice Chancellor, TANUVAS, Chennai. The key note address was delivered by Dr. M. V. Gupta, Former ADG, WorldFish Center. In this National conference, along with inauguration, plenary and valedictory sessions, seven technical sessions were conducted. A total of 198 abstracts were received, of which 130 were oral and 68 were poster presentations. Paper presentations made in the conference were 119 oral (92%) and 55 (80%) posters.The plenary session was presided over by Dr. Balakrishna Pisupati, Chairman, National Biodiveristy Authority, Chennai on 24th February, 2012.

Visit of the Parliamentary Committee

The Parliamentary Committee on Agriculture headed by Shri Basudeb Acharya visited CIBA on 2nd July 2011 to discuss the research activities. Stakeholders and Fishery Officials from Tamil Nadu also had an interaction with the Parliamentary Committee. They also visited Muttukadu Experimental Station on 3rd July, 2011 where a detailed discussion on the research achievements of CIBA was held. The committe visited all the field facilities and appreciated the good work done by the scientists and other staff members of CIBA.

4

Research Achievements

CRUSTACEAN CULTURE DIVISION

Project Title (Institute)	Improvement of shrimp production and productivity through quality seed production and diversification into other shrimp species

Evaluation of probiotic based seed production

To evaluate the efficiency of probiotics in large scale larval rearing of *P. monodon,* postlarvae were reared using two commercial probiotics and one known probiotic strain bacteria, *Lactobacillus rhamnosus* @ 10^6 CFU/ml in comparison with antibiotic based rearing (chloramphenicol 1-2 ppm) and a control without any such exposure to either probiotics or antibiotics. The experiment was conducted in triplicate tanks (500 l) with 50,000 protozoea/tank for 6 weeks. Subsequently, after withdrawing the probiotics and antibiotics, the post larvae (PL-25) were challenged with a virulent pathogenic strain of *Vibrio anguillarum*. The performance of the larvae in terms of survival, growth and metamorphosis pattern were taken as criteria for the evaluation.

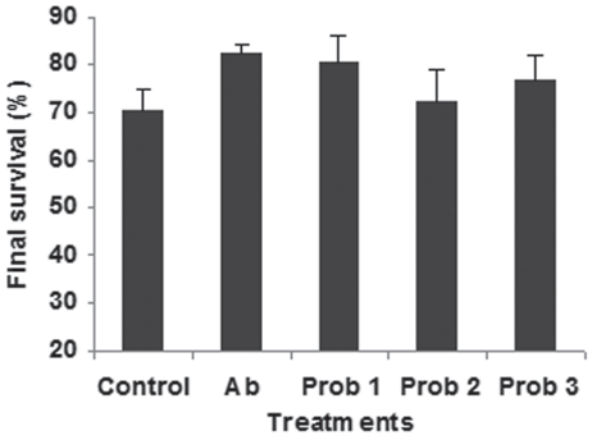


Fig. 1. Survival of tiger shrimp postlarvae without any treatment (control), with antibiotic (Ab) and with three probiotics (Prob 1, Prob 2, Prob 3) groups

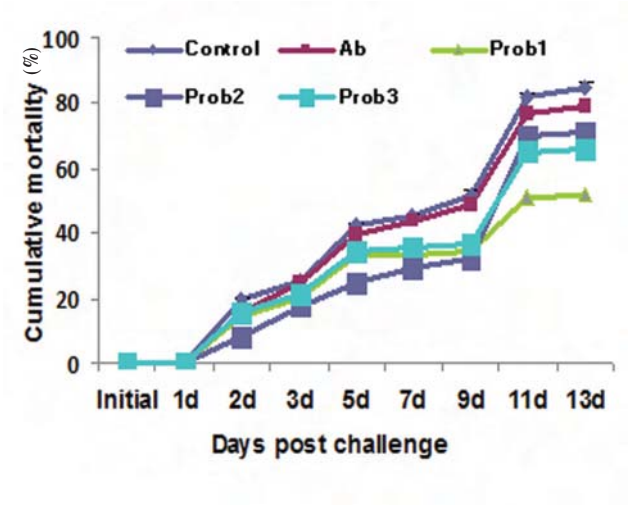


Fig. 2. Cumulative mortality percentage of tiger shrimp post larvae challenged

The survival was significantly ($P<0.05$) higher in the antibiotic group (82.21 %) and two of the three probiotic treated groups (80.29 and 76.38 %) of shrimp larvae compared to the control group (70.55 %) while rearing from mysis to PL-25 stage (Fig. 1).

Upon challenging with the pathogen, there was a significant difference ($P<0.01$) in the cumulative mortality rate between the probiotics fed and control group. In the control group, mortality rate reached up to 80 % within 13 days post challenge whereas in contrast, the mortality rate was significantly lower ($P< 0.01$), reaching up to 35 % of the stock in probiotics fed group. (Fig. 2).

This study establishes the probiotics superiority in shrimp hatchery larval production system compared to the use of antibiotics. Probiotics may modulate the functioning of immune system both at systemic and mucosal levels, thus giving protective response to the animal whereas antibiotics are known to bring immunosuppression.

Evaluation of disinfection system in shrimp hatchery for healthy seed production

To assess the effect of disinfection methods on survival and metamorphosis of shrimp larvae, an experiment was conducted with five treatments and three replications with completely randomized design. The growth and survival of *P. monodon* from Zoea to PL 20 in different treated water *viz*., seawater (T1), chlorination @ 10 ppm (T2), chlorination+ sand filtration (T3), sand filtration + cartridge filtration @ 5micron+ UV treated water (T4), chlorination + sand filtration + cartridge filtration @ 5 micron+ ozone treated water (T5) were recorded. The results indicated that the concentration of ammonia, nitrite and the bacterial load significantly decreased in treatments T2 and T4 and the bacterial load was almost zero after UV disinfection. The growth and survival were significantly high in both T4 and T5 emphasizing the requirement of either UV unit or ozonator in the hatchery (Fig. 3 a,b).

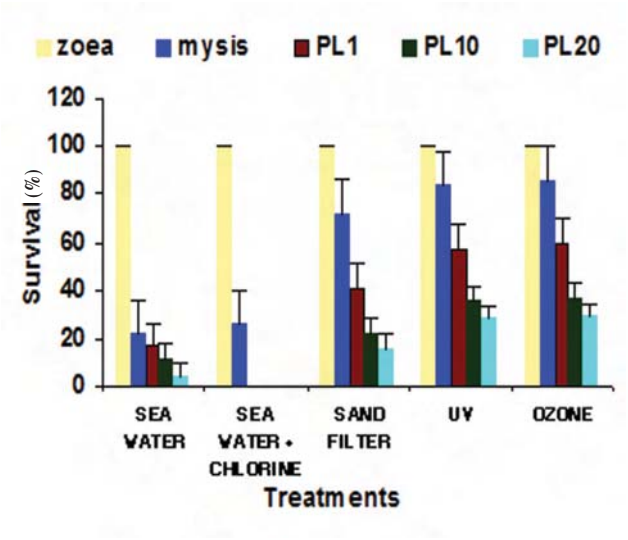


Fig. 3a. Overall survival of *P. monodon* in different treatments

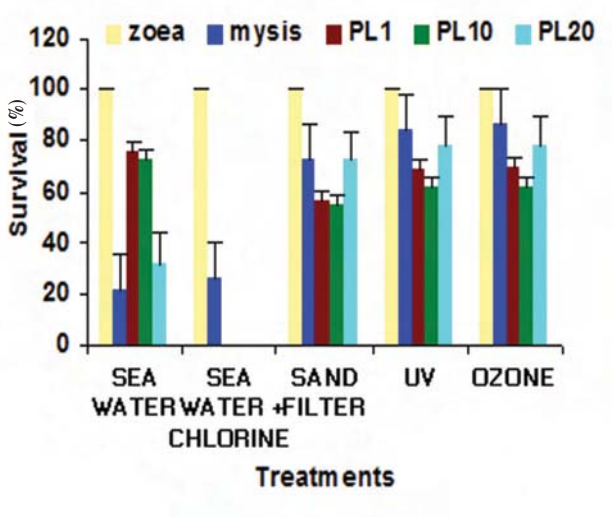


Fig. 3b. Stage wise survival of *P. monodon* in different treatments

Glucan use to improve reproductive performance of 'weak' tiger shrimp broodstock

A study was carried out to evaluate the effect of exogenous biomodulator, glucan on the reproductive performance of weak (due to collection stress) and healthy females of *Penaeus monodon.* Glucan @ 100 µl/100g was injected to each of the female shrimp before the eyestalk ablation was performed. The advancement in maturation and spawning was observed along with the other reproductive characteristics in all the four groups: weak (control & treated) and healthy (control & treated).

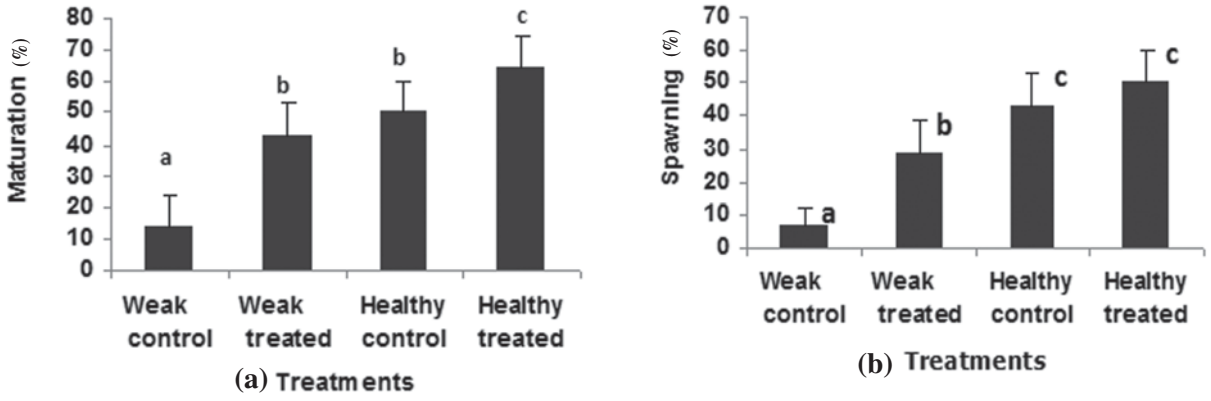


Fig 4. Improvement in % maturation (a) and spawning (b) when weak and healthy females of *Penaeus monodon* were treated with Glucan

The maturation rate of weak individuals on glucan administration was 199 % higher than weak control and the increase was statistically significant ($P < 0.01$); however the improvement was less pronounced (29%) in healthy (Fig. 4a.). The spawning rate was significantly ($P < 0.01$) improved in the weak group by 303 % over the control and this increase was not observed in the healthy group upon glucan administration (Fig. 4b). It is likely that weak broodstock were immunocompromised and biomodulators like beta glucan could increase the immunity and in turn improved reproductive performance in weak *P. monodon* broodstock.

Maturation diet impact on male tiger shrimp reproductive quality

The effect of formulated diet on the male reproductive quality of *P. monodon* was evaluated Earlier trials indicated that exclusive use of formulated diet drastically reduced the male reproductive quality variables. Two treatments, fresh feed (clam meat and squid 1:1) and mixture of fresh feed and formulated feed (clam meat, squid and formulated feed 1:1:2) were used. Spermatophore quality (spermatophore weight, spermatozoa number and rate of melanization, absence or presence of spermatophore in the ampullae) were evaluated after one month and compared with the initial base line values. None of the parameters evaluated were found to be significantly different between the treatments. Further, there was no difference between physiological parameters such as molt rate and spermatophore melanization between the treatments.

Melanized spermatophore (arrow)

Normal spermatophore

Serotonin on maturation performance of tiger shrimp females

The effect of serotonin (5 hydroxy tryptamane), a neurotransmitter, on oocyte maturation of tiger shrimp was evaluated. Fifty four wild females were divided into three experimental groups. One group received serotonin (5 HT) @ 50 µg/g body weight of the animal and they were unilaterally eyestalk ablated (ESA). The second group was administered the same concentration of serotonin without eye stalk ablation. The third group was unilaterally eyestalk ablated and used as the positive control. In the experimental groups, serotonin injection was given at weekly intervals. During the third week, all the animals were sacrificed and vitellogenic stages were studied at the macroscopic, cellular and molecular levels. At the macroscopic level, it was found that significantly higher proportion (44.4%) of the animals reached final stage of maturation in the group that received serotonin with eyestalk ablation. Although the animals that received serotonin alone did not show any sign of maturation, when observed *in vivo*, 22% of animals were observed to be vitellogenic. It could therefore be concluded that although serotonin acts as stimulatory hormone, the levels of inhibitory hormone should be removed through eyestalk ablation for the final maturation and spawning,

To gain further insight into the mechanisms of 5HT action in *P. monodon*, the changes in female reproduction associated genes were also analyzed. Specific primers for the reproduction associated genes namely vitellogenin (Vg), vitellogenin receptor (VgR), heat shock protein - 90 (HSP 90) were designed for tiger shrimp based on earlier reports in other penaeids. Semi-quantitative PCR analysis was carried out to examine the differential expression of these genes both in the control and test group using EFá as the internal control. On 28th day, the results revealed stronger bands in the mRNA levels of VgR and HSP90 in 5HT + ESA females. The intensity of expressions of mRNA levels was as follows: 5HT+ESA > 5HT > ESA (Fig. 5).

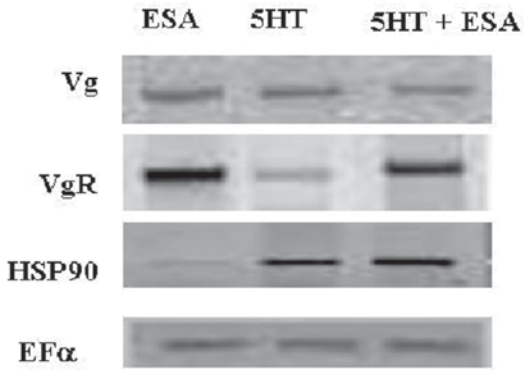


Fig. 5. Semi-quantitative PCR analysis of Vg, VgR, HSP90 and EFα in *Penaeus monodon*.

WSSV and modulation of reproduction associated genes in Indian white shrimp

A study to understand the molecular responses of female reproductive genes in relation to WSSV infection in *Fenneropenaeus indicus* was carried out by analyzing the time-course expression of Vitellogenin (Vg) and Thrombospondin (TSP) genes. Adult female *F. indicus* in advanced stage (third) of maturation were collected from wild and used. The test groups (n=24) were injected with 100 µl of the viral stock diluted in TNE buffer (10^{-3} dilution), while the control (n=24) were injected with buffer devoid of the virus. Three animals were sampled at the beginning (0 hour) for the baseline data of gene expression profile analysis. Thereafter the animals were maintained for a further period of four days and sampling was carried out at 12, 24, 30, 36, 48 and 60 h post-infection. Semi-quantitative analysis of the expression of TSP indicated proportionate increase with the WSSV load. On the other hand, expression of Vg increased initially with the progress of WSSV infection (up to 30 h) and decreased subsequently with an increase in the viral load. The levels of both TSP and Vg decreased at 60 h post infection (Fig. 6).

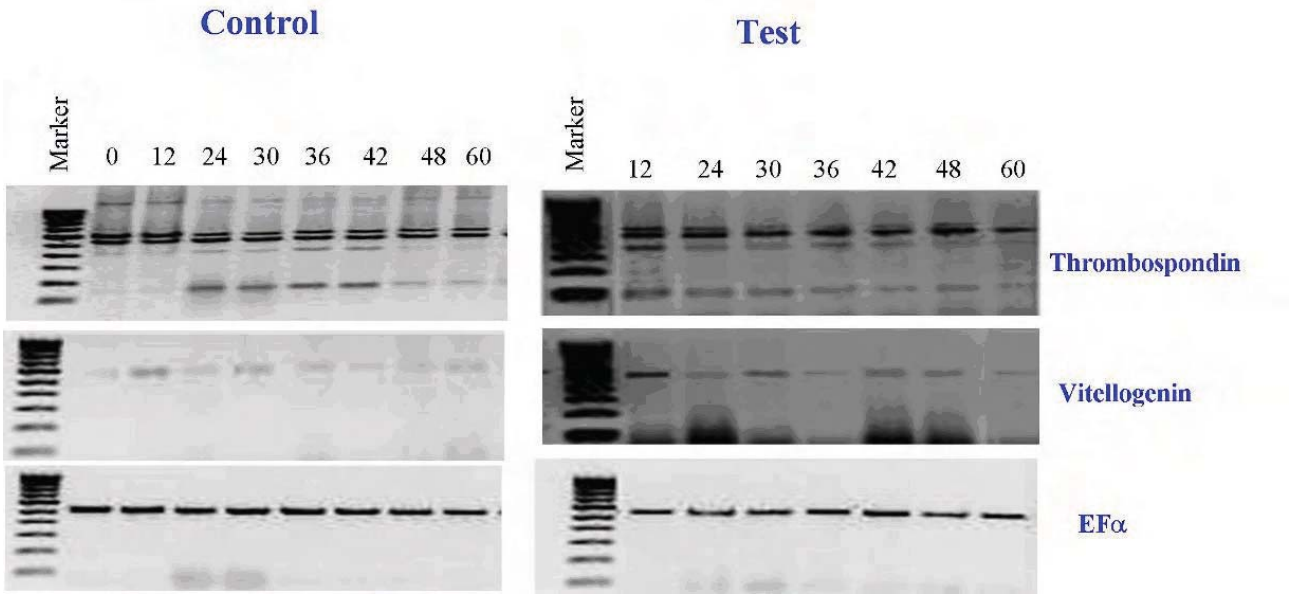


Fig. 6. Expression pattern of Thrombospondin, Vitellogenin and EF α (in control and WSSV challenged shrimp over a period of time -12, 24, 30, 36, 48 and 60 h post-infection)

Although Vg and TSP are usually involved in maturation and larval development, the current study suggested that they also get activated in response to WSSV infection. The results indicate a possible dual role for the genes in reproduction and in the anti-WSSV innate immunity in *F. indicus* shrimp.

Impact of WSSV on maturation and spawning performance of tiger shrimp

To differentiate the mode of vertical transmission of WSSV in *Penaeus monodon* i.e., trans-ovum or trans-ovarian, an *in vitro* model has been developed for tiger shrimp ovary at different stages of maturation. Explants (0.5 cm^2) were dissected from the ovary (late vitellogenic and early ripe) and incubated in sterile M199 containing 100 UI/ml penicillin and 100 µg/ml streptomycin in 24 well culture plate. In the infectious group, WSSV inoculum containing 1000, 5000 and 10000 copies were added whereas PBS was added to the control group. Tissues were diagnosed for WSSV after 7 and 24 hours incubation using histological and molecular techniques. The PCR results indicated that after 7 hours, both late vitellogenic and early ripe ovaries were negative for WSSV in first step but in second step, early ripe ovary was positive. After 24 hours both the ovarian stages were positive for WSSV in first step itself. This clearly indicates that early ripe stage is more susceptible to WSSV infection compared to late vitellogenic oocytes. Light microscopy revealed typical cowdry type A bodies or hypertrophy of nucleus indicating the presence of WSSV (Fig. 7).

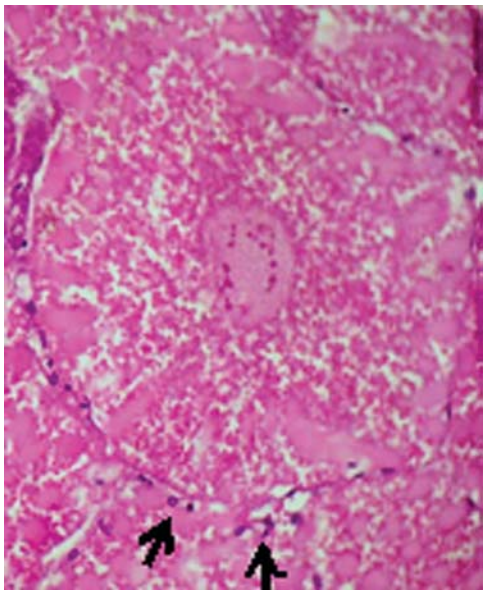


Fig. 7. Histology of oocytes co cultured with WSSV. Arrow- after 24 h incubation showing hypertrophy of nucleus

Litopenaeus vannamei growth under different stocking densities

Litopenaeus vannamei culture at different stocking densities (10, 20, 25, 30, 35 and 63 nos./m^2) was monitored for management practices, growth, soil and water quality parameters. In all the farms, bio-security protocols were practiced, probiotics were applied once in 10 days and water exchange was not done throughout the culture period except for topping up of water. Feed conversion ratio (FCR) was 1 to 1.2 for all the stocking densities except for 63 nos./m^2 (1.8). An average body weight (ABW) of 30 g was achieved within 90-100 days in 10-30 nos./m^2, whereas a similar ABW was achieved after 140 days of culture in 63 nos./m^2. The growth rate per day was high at 10 and 20 nos./m^2 followed by 25 and 30 nos./m^2. (Table 1). The water and soil parameters were in optimum range at all the stocking densities. Stocking density thus affected only the growth rate and not the pond environment if cultured under optimum management practices. Based on days of culture and average body weight, stocking densities of 20-30 nos./m^2 appeared to be optimum to maximize the benefit to the farmers.

Table 1. *L. vannamei* culture details under different stocking density

	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6
Stocking density (m^2)	10	20	25	30	35	63
DOC	92	81	82	81	86	140
Aeration (hrs/day)	4	8	8	8	8	8-16
FCR	1	1.2	1.2	1.2	1.2	1.8
Survival rate (%)	94	98.9	82	80.5	94.5	83
ABW (g)	32.26	28.35	26.1	24.66	22.05	29.5
Growth rate/day	0.3506	0.35	0.318	0.304	0.256	0.211
Total harvest (t/ha)	3.03	4.6	5.38	7.1	7.35	16.9

Effectiveness of shrimp farm discharge water treatment system

Evaluation of the effectiveness of existing discharge water treatment system (DWTS) was continued in four CAA approved *L.vannamei* cultured farms. The farms are located one each at Nagapattinam District of Tamil Nadu, Chinnaganjam and Tangutur in Prakasam Disrict and Tuni in East Godavari District of Andhra Pradesh with stocking density of 60, 50, 30 and 60 nos./m^2 respectively. The crop had a delayed harvest in all the farms between 150 and 165 days of culture. The discharge water from the harvested ponds in all the farms was pumped into DWTS after releasing the surface water from ponds through sluice gate and the water quality monitored for 60 hours compared to 48 hours followed last year in the DWTS evaluation studies. The pH of water in DWTS ranged from 7.4-7.7, 7.1-7.5, 7.2 -7.6 and 7.9-8.2 and the salinity ranged between 24-25, 36-37, 35-36 and 3-5 ppt, in farms 1, 2, 3 and 4 respectively. The concentration of settled solids decreased to 0.1 ml/l and nil within 32 to 36 and 44 to 60 hours respectively, whereas total suspended concentration decreased to less than 100 ppm within 48 hours and got further reduced by 60 hours (Fig. 8). The total N and phosphate levels did not get reduced to standard levels prescribed for the discharge waters in all the farms except for phosphate in farm 2. The studies showed that there was not much improvement in water quality even after 60 h with respect to reduction in nutrients concentration.

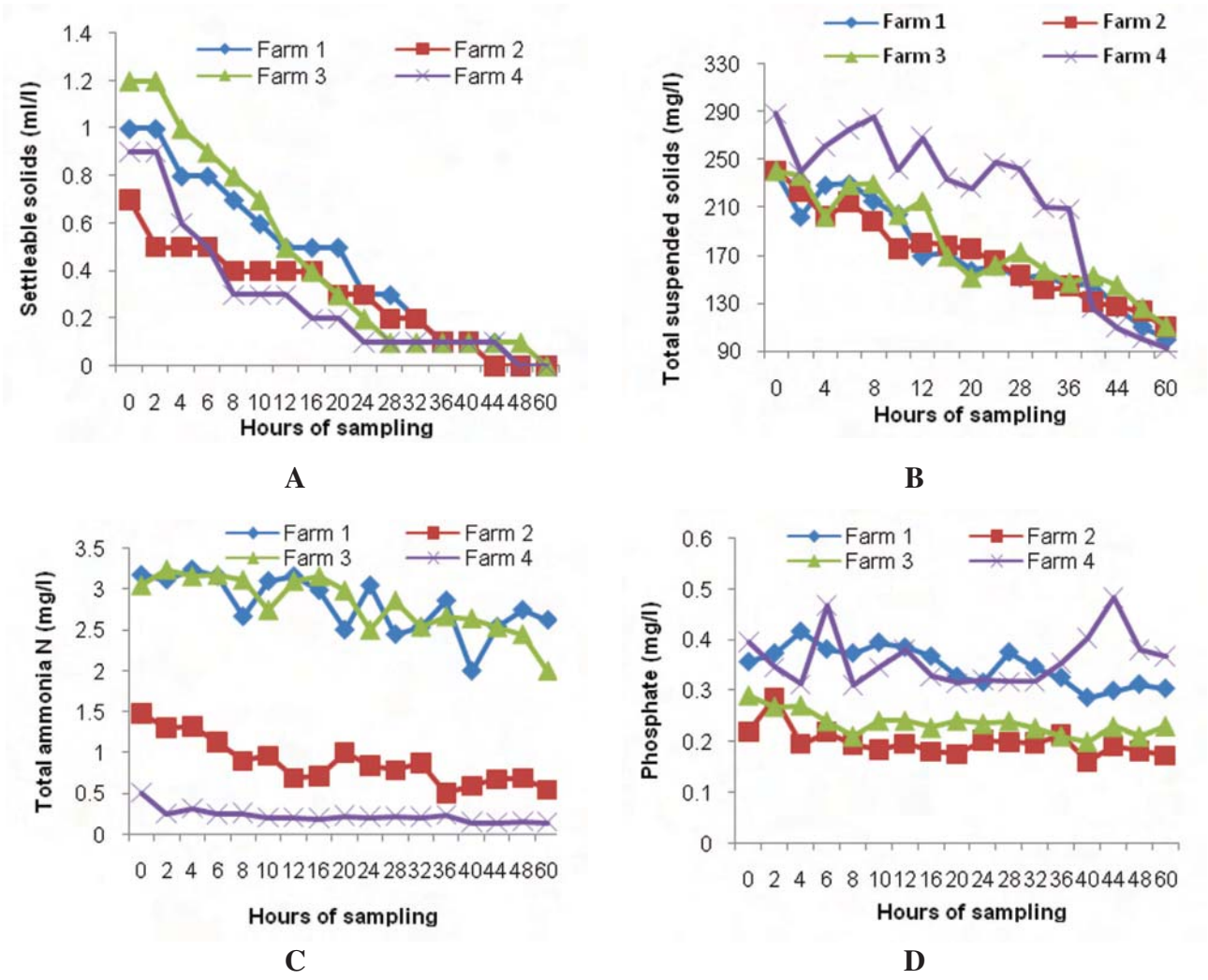


Fig. 8. Hourly changes in water quality parameters in shrimp farm discharge water treatment system (A. Settleable solids B. Total suspended solids C. Total ammonia nitrogen D. Phosphate)

Improving the efficiency of CIBASTIM

Studies to enhance the efficacy of the CIBASTIM through incorporation of adjuvants were carried out with the inclusion of sodium alginate in different concentrations (0, 0.05, 0.1, 0.15, 0.2, 0.25 % / kg feed). A 45 days trial in juvenile Indian white shrimp of 4.5 -5.5g showed that sodium alginate at 0.05% / kg feed along with immunostimulant showed highest growth (25.83%), survival (90.5%) and when challenged with *Vibrio harveyi* (100µl/ x10^2 cfu/ml) showed highest survival (66.67% survival post 3 days challenge). Also the immune elicitors such as prophenoloxidase was highest (42.56 units/ mg protein) compared to all other treatment groups. The study has indicated that addition of sodium alginate at 0.05% / kg feed improves the efficiency of CIBASTIM.

Project Title (Institute)	**Scaling up of production system of mud crabs**

Larval rearing experiments

Experiments to develop a protocol for mass production of mud crab *Scylla serrata* juveniles were carried out. Three larval rearing experiments were conducted in a semi intensive culture system - a

hybrid rearing system of intensive, extensive and mesocosm culture system. About 100,000 to 150,000 zoea 1 (Z_1) larvae were reared in 5000 L FRP tank containing 1000 L of filtered sea water (30-35‰). The water was not exchanged till the Z_2 stage (5 days post hatch). Phytoplankton *Chlorella* spp was added @ 200 X 10^3 cells per ml twice daily in the culture tank to maintain green medium and feed for rotifer throughout the initial culture period. Larvae were fed rotifer throughout the culture cycle, whereas *Artemia* were given from Z_3 (10 days post hatch). A total of 6486 megalopa were cultured from three culture cycles with a maximum of 2886 megalopa per cycle (2.9%). This study indicates that survival rate of mud crab larvae from Zoea 1 to megalopa is comparable to that reported internationally. This technique can further be refined by optimizing the feeding schedule and managing cannibalism by size grading and provision of appropriate shelters

Development of larval identification key

As morphological descriptions of larvae of mud crabs are scarce, there is no clarity in the identification of larval stages. A key based on the morphological characteristics was developed and are summarized in Table 2 and Fig. 9.

Table 2. Summary of the morphological characteristics of five zoeal stages of mud crab, *Scylla serrata*

Stage	Description
Zoea 1	Eyes are sessile; 5 abdominal somites only; Furca of telson with three pair of spines (3+3)
Zoea 2	Eyes stalked; Furca of telson with an additional pair of spines at the middle (4+4)
Zoea 3	Six abdominal somites, appearance of pleopod buds
Zoea 4	Furca of telson with median spine; total number of inner spine at the furca of telson becomes (4+1+4). Pleopods are distinct on the abdominal osmiets 2+6
Zoea 5	Distinct pereopods, well developed pleopods with setae; Furca of telson with an additional inner spine (5+5)

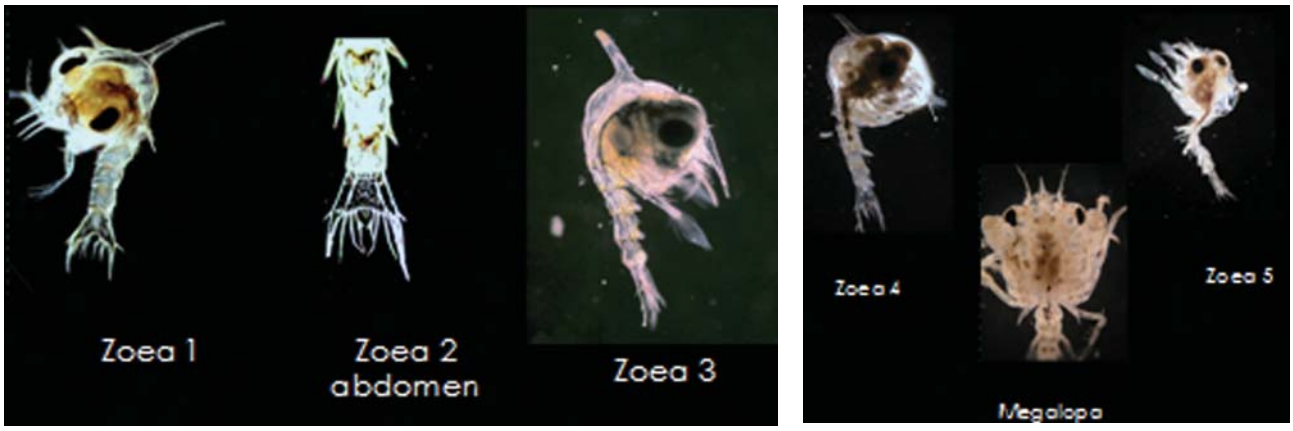


Fig. 9. Larval stages of *Scylla serrata*

Effect of salinity on survival of juvenile mud crab *S. serrata*

An experiment was conducted to evaluate the effect of salinity on survival of mud crab *S. serrata.* Instar 2 crablets of average weight 0.009 g were reared at different salinity (5, 10, 15, 20 and 35‰) for 21 days. The crablets were reared in 100 L FRP tanks at a density of 10 individuals per tank and each treatment was in triplicate. The animals were fed minced clam meat to satiation each day, and water exchange carried out on alternate days. Although survival was significantly higher on 7th day in 10,15 and 20 ppt, it was not significantly different among the treatments by 21st day.(Fig. 10).

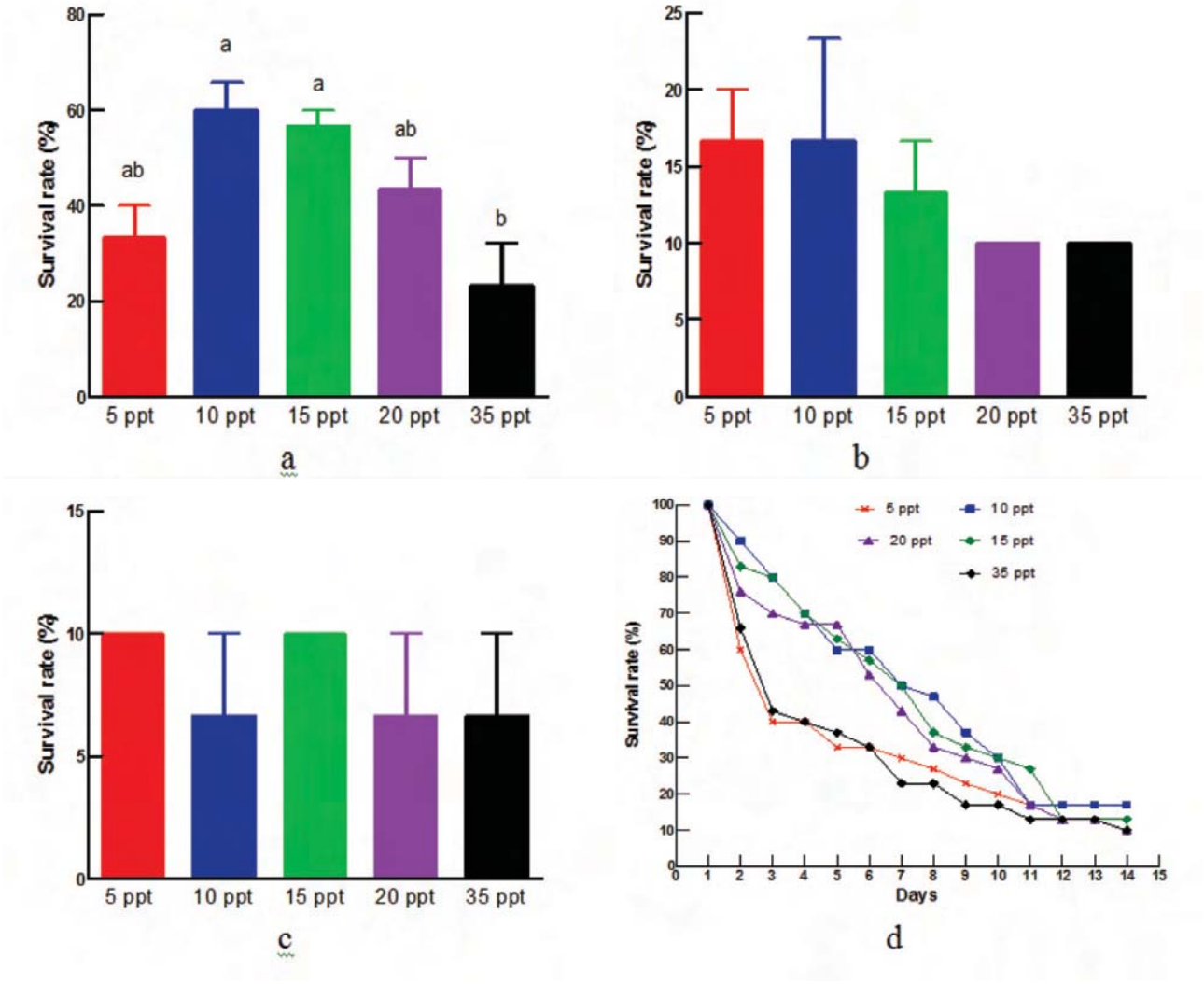


Fig. 10. Effect of salinity on survival of juveniles of *Scylla serrata:* a) 7th day, b) 14th day, c) 21st day, d) over all effect

On farm grow-out trials of nursery reared juveniles

As a part of popularization of mud crab culture in West Bengal, on-farm grow-out trials were carried out in a farmer's pond. A total of 1000 juveniles of *S. serrata* (57 mm; ABW 37g) produced at the Muttukadu Experimental Station were transported to KRC, stocked @ 8 nos./m^2 and reared for six months. Animals were fed fish and small shrimp. The total production was 273 kg/1000 m^2 with a survival of 63%.

Project Title (Institute)	Development of techniques to quantify the impacts scenario between environment and aquaculture using remote sensing and GIS

Assessment of impact of aquaculture development on mangroves using RS and GIS

The impact of brackishwater aquaculture development on Sundarban mangrove ecosystem was studied using remote sensing satellite data of different time periods. The Sundarban mangroves lie between Bangladesh and India, extending from the Hooghly River to the Baleswar River in Bangladesh. The forest lies on the delta of the Ganges, Brahmaputra, and Meghna Rivers.

Multi-temporal satellite data of different sensors using MSS, TM and LISS III needed a geometric correction error to avoid biases in mangrove forest classification and change analysis. Each image was reprojected to polyconic projection as the Sundarbans fall across two Universal Transverse Mercator (UTM) zones. The mosaic was created for each decade data.

In the mosaic image, the smooth bright red colour indicates the dense mangrove forests and blue colour indicates the sea and creeks. The complex intersections of tidal waterways or channels are clearly visible in the imagery. The wide spread red color in landward side are agriculture lands. Regular square or rectangular shaped blocks in dark blue or bluish grey are aquaculture farms. For the mapping, mangroves and aquaculture farms were delineated for three data sets pertaining to the year 1975-77, 1989-90 and 2010-11.

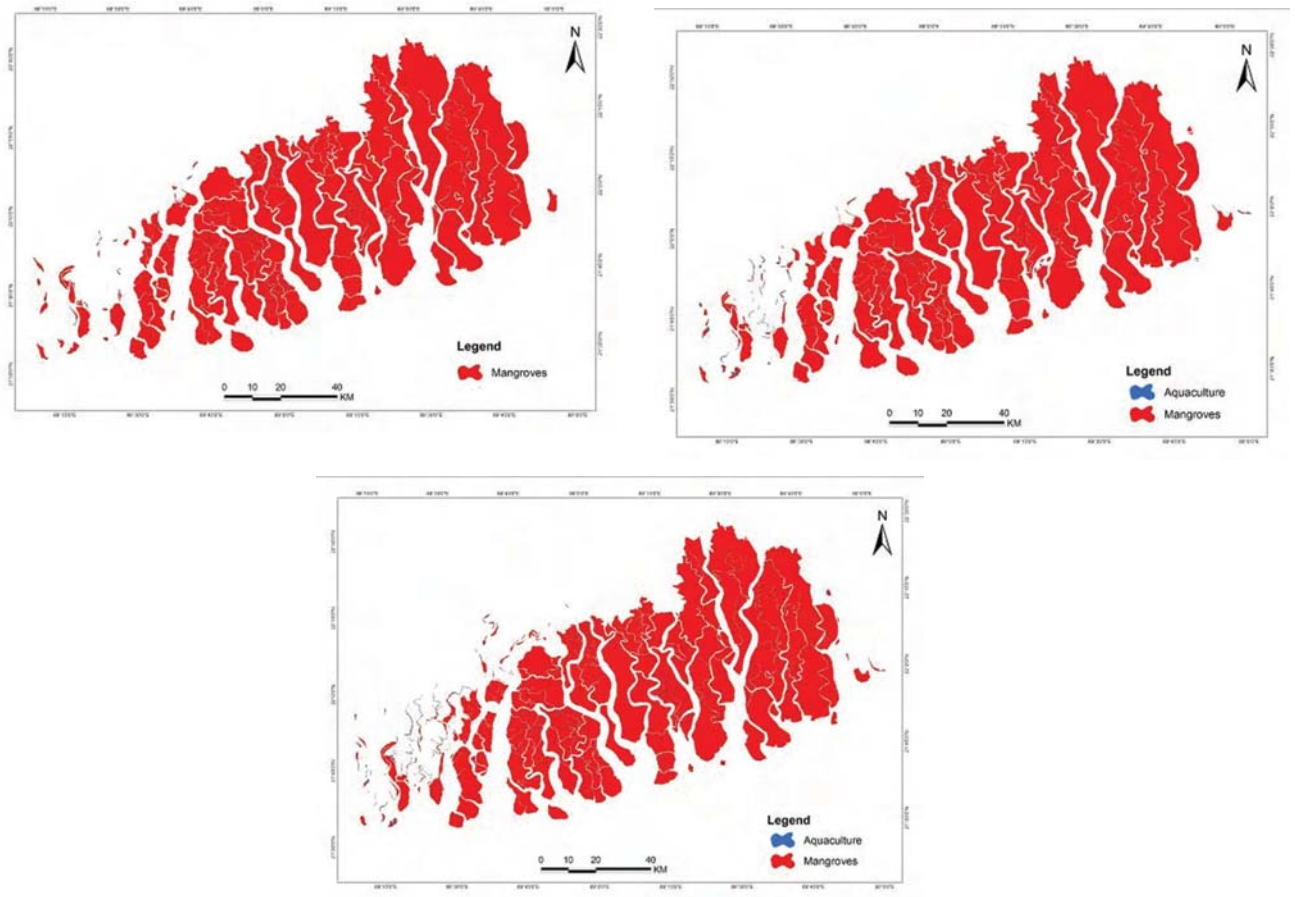


Fig. 11. Mangroves and nearby aquaculture farms in different periods (a) 1975-77 (b) 1989-90 and (c) 2010-2011

The mangrove maps of three decades are depicted in Fig. 11. Aquaculture farms are shown in blue colour; due to the very small area developed, it is not clearly visible and the rectangular box indicates the area where aquaculture has been developed. From the 1970s to 2011s, mangrove forest in the Sundarbans decreased by 1.4%. The rate of change, however, was not uniform from the 1970s to 1990s and from 1990s to 2011s. From the 1970s to 1990s, mangrove forest area actually reduced by 0.2 % and from 1990s to 2011, it decreased further by 1.2 %. The major reduction in mangroves was due to flooding. During the same period, regeneration of mangroves was noticed in different land classes. Similar patterns of change were observed from the 1970s to 1990s and also from 1990s to 2011.

On the India side of the Sundarbans, the mangroves have increased from 2080 km^2 to 2120 km^2 in 1990 and further increased to 2153 km^2 in 2011. The major change appears approximately 14 km east of Kisoripur. In the 1970s image, 1100 ha of mangrove forest, interspersed with open flooded areas, extended approximately 4 km inland from the Matla/Bidya River. By 1990s, the portion of that particular patch of mangrove forest appears to have been lost. The aquaculture farms of 54136 ha was developed in 2011 and the mangroves of 266 ha (0.001 % of total mangroves) outside the forest boundary was converted for aquaculture.

Again, the net mangrove loss over the whole of the Sundarbans is about 1.4 % as the numerous areas of loss are counterbalanced by areas of gain. Most of this is observed in areas where new land formed through deposition has become vegetated. The mangrove area of 420 ha in Jilla forest block on the northern forest boundary of the India side was regenerated from 1990 to 2011. Studies by different researchers indicate that increasing salinity, over-harvesting of timber, and other human influences are the main reasons for the degradation of the Sundarbans mangroves. Apart from the salinity and timber harvesting, 'top dying disease' was also affecting the mangroves along Bangladesh. This study indicated that aquaculture played an insignificant role in changing mangrove status, and any change observed is mainly due to natural processes such as water inundation and land deposition.

Assessment of long term changes in shore line in the East Coast

Shoreline change evaluations are based on comparing the previous decadal shorelines, from satellite imageries with recent shoreline and ground truth verification. The aim of this study is to develop standardized methods for mapping shoreline movement so that predictions can be made on its impact on coastal resources due to shoreline erosion and accretion which could be brought about due to climate change. The changes in Tamil Nadu coast was observed using MSS, TM, LISS III senor data pertaining to 1970s, 1980s and 2000s. It was observed that the changes are varying from 0.01m to the maximum of 11m at Nagapatnam district. This indicated the dynamic nature of shore and need for monitoring the shore line changes periodically along the ecologically important ecosystems to develop strategies and action plans for its protection.

Impact of extreme climatic events on aquaculture

Study to assess the changes in daily mean temperature (TM) in coastal states in the past few decades was carried out as a prelude to comprehend their impact on aquaculture. The Indian Meteorological Department (IMD) 1°×1° gridded dataset prepared by the National Climate Centre of the IMD, Pune, India, for the period of 1969-2005 were used in the study. Out of about 1120 grid values of maximum, minimum and mean temperature available for the Indian coastal states 129 grids having the time series temperature data of 35 years were used for the study. The mean temperature was taken for the analysis of change in trend and extremes. The analysis indicated that in the East Coast, mean climatology

increased by 0.48^{0}C for Tamil Nadu, 0.33^{0}C for Andhra Pradesh, 0.07^{0}C for Orissa and 0.57^{0}C for West Bengal. In the West coast, it increased by 0.46^{0}C for Kerala, 0.41^{0}C for Karnataka, 0.30^{0}C for Maharashtra, 0.43^{0}C for Gujarat. A steep increase during summer in the twentieth century was observed, due to unprecedented warming in the last decade.

The severity of the climate change cannot be derived from the temperature trends alone. The concern is more on the occurrence of extremes of temperature. From the analysis, a sudden increase in temperature was observed in Andhra Pradesh (four stations namely, , Hanamkonda -1, Machilipatnam -2, Ongole -3, and Ganavaram -4) during 16 May to 11 June 2003 and this was compared with the last 100 years temperature data (Fig. 12). As water temperature can have a direct impact on spawning and survival of larvae and juveniles, it will affect aquaculture adversely. Even if such events are considered as isolated incidences, adaptation of appropriate strategies and mitigation policies, if any, are needed for the minimization of loss of natural resources and life.

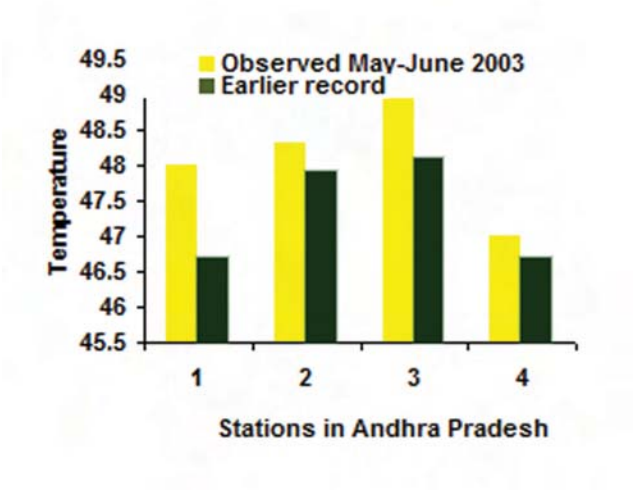


Fig. 12. Extreme heat waves observed in Andhra Pradesh in 2003 compared with earlier 100 years data

Project Title (Institute)	Collaborative project on brackishwater aquaculture development in Gujarat

Monsoon crop of *Penaeus monodon*

To evaluate the performance of tiger shrimp *Penaeus monodon* under comparatively less saline and lower temperature period than the summer months, culture was carried out for 130 days during the last week of July till the first week of December 2011 in three ponds of 1500 m^2 each at Danti farm, Navsari Agricultural University, Gujarat. The ponds were prepared as per the standard procedures and the tiger shrimp postlarvae from CIBA hatchery were stocked @15 nos./m^2 and fed with commercial feed. Average body weight, production, survival and FCR for the crop were 29.2 g, 2775 kg/ha, 61.5% and 1.57, respectively. The difference in production between the ponds was due to variation in survival rate. Pond 2 and 3 had poor survival of 50 and 53% compared to 81% in pond 1 (Table 3) due to infestation with other organisms like *Acetes* sp. and mud skippers. This demonstration showed that a production rate of 2-3 tons/ha at stocking density of 15 nos./m^2 is achievable even if the culture starts in July by following better management practices.

Table 3. Tiger shrimp production details at Danti farm, Navsari

Sr No.	Particulars	Pond No. 1	Pond No. 2	Pond No. 3
1	Stocking density (nos./m^2)	15	15	15
2	Survival (%)	81	50	53
3	ABW (g)	28.6	30.3	28.6
4	Count	35	33	35
5	ADG (g)	0.22	0.23	0.22
6	Biomass harvested (kg/0.15 ha)	558	365	326
7	Soft percentage	9.13	20	7.05
8	FCR	1.59	1.69	1.43
9	Production (kg/ha)	3720.0	2433.3	2173.3

Monitoring of pond microbial populations and soil and water parameters

Aquatic microbes play an important role in pond dynamics and nutrients recycling. Three tiger shrimp culture ponds (pond1, 2 and 3) were monitored at regular intervals for total heterotrophic, total presumptive *Vibrio*, ammonia oxidizing, nitrite oxidizing, sulfur oxidizing and reducing bacteria, and basic physico-chemical parameters in water and sediment samples. There was no definite trend in the bacterial population during the culture period and the interventions such as chaining and application of probiotics/prebiotics might have influenced all categories of microbial loads (Fig. 13). Similar trends were observed with nitrogen and sulphur recycling bacterial loads (Table 4). The pH and salinity of pond water during the culture period ranged from 7.1 to 8.9 and 13 to 36 ppt respectively. Carbonate alkalinity was nil to 10 ppm and total alkalinity ranged from 70 to 280 ppm indicating the major contribution of bicarbonate towards alkalinity. Nitrite-N and TAN concentration ranged from 0.02 to 0.34 and 0.07 to 0.69 ppm, respectively. The discharge water from the shrimp farms during harvest had all the parameters within the limits of prescribed standards except for nitrate nitrogen of 1.04 ppm. The discharge water was allowed through the drains to irrigate the *Salicornia* fields and the water coming out had optimum values. Soil pH and organic carbon content ranged from 7.8 to 9.2 and 0.11 to 0.44% respectively.

Table 4. Nutrients recycling bacterial load in water and sediment samples from *P. monodon* culture ponds [Mean ± SD (n=3)] (AOB: Ammonia oxidizing bacteria, NOB: Nitrite oxidizing bacteria, SOB: Sulfur oxidizing bacteria, SRB: Sulfur reducing bacteria)

DOC	Number of bacteria (10^3/ml)			
	AOB	NOB	SOB	SRB
Water				
39	6.0±1.73	22.0±6.56	19.0±3.46	15.33±11.15
54	12.67±6.67	8.67±5.69	25.67±4.04	88.0±105.65
84	14.0±6.56	15.67±10.21	23.33±4.04	190±34.64
100	16.67±11	16.67±2.89	27.33±12.01	151.67±101.04
114	8.67±5.69	9.67±4.62	16.67±2.89	18.0±8.89
129	15.67±1.15	12.0±13.86	23.0±13.86	35.0±12.12
Sediment				
39	7.67±6.35	14.0±6.56	90.0±104.40	42.67±43.66
54	13.0±8.18	13.0±8.18	176.67±57.73	131.67±88.93
84	9.67±4.62	14.67±5.51	68.67±70.44	200±45.83
100	12.33±4.62	11.33±6.35	96.0±62.20	190±34.64
114	11.33±6.35	11.0±4.0	19.33±7.50	220±17.32
129	14.0±6.56	22.67±4.62	61.67±76.54	90.67±103.93

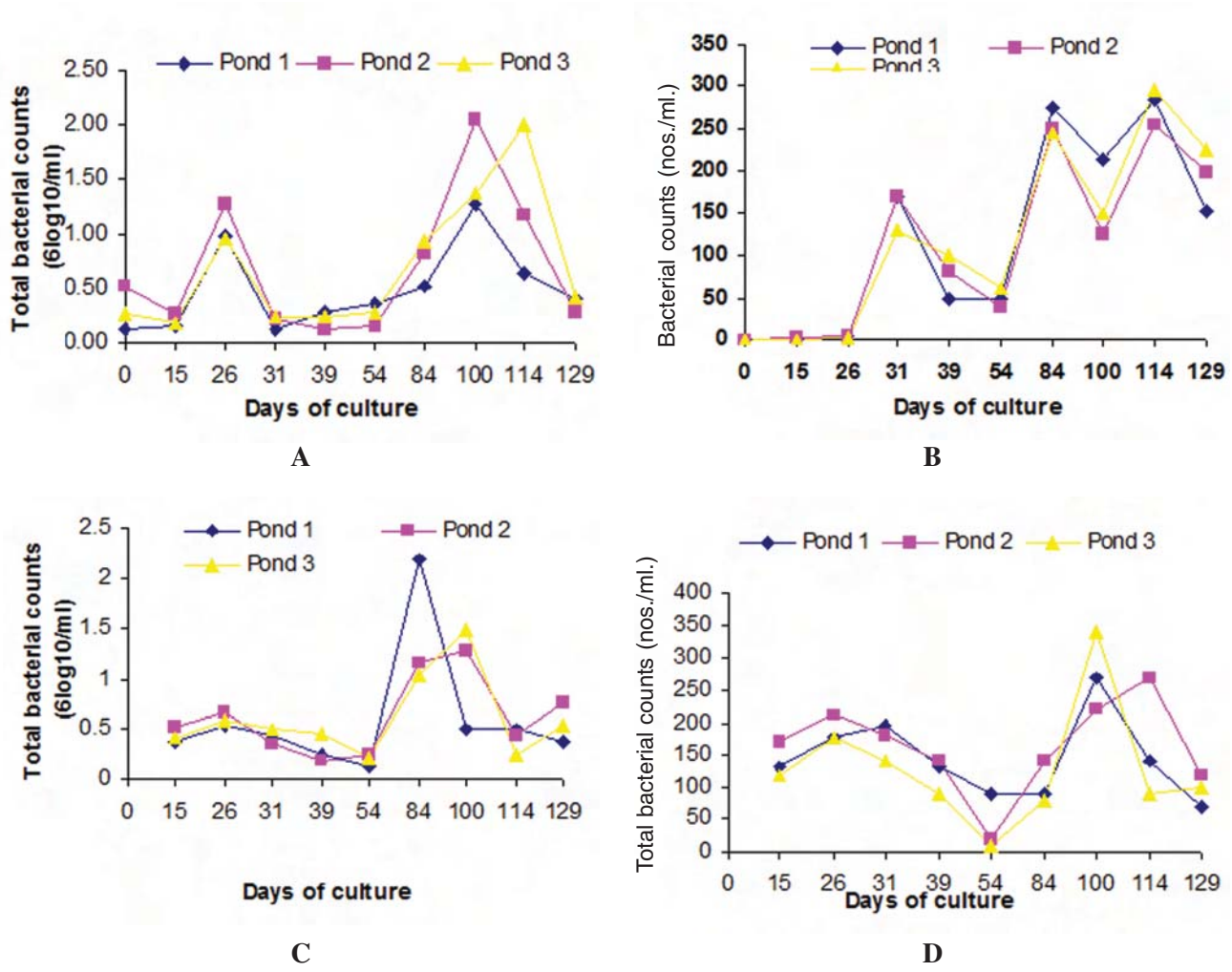


Fig. 13. Microbial loads in water and sediment samples in *P. monodon* culture ponds at Danti
A-Total bacterial counts in water samples B- Total presumptive vibrio counts in water samples C-Total bacterial counts in sediment samples D-Total presumptive vibrio counts in sediment samples

Banana shrimp culture in farmers' pond

The successful demonstration of winter crop of banana shrimp during 2010-2011 and the tolerance of this species to high salinity and low temperature at Danti farm of NAU, Navsari, have paved the way for farmers to take up banana shrimp farming in Navsari region. Mr. Vinodbhai D. Patel, a tiger shrimp farmer of Danti village of Umbharat, Navsari had volunteered for banana shrimp culture and the seed was supplied by the institute for this on-farm demonstration. The 0.6 ha pond was stocked@ 17.5 nos./m^2 on 17th December 2011with banana shrimp seed procured from a private hatchery in Chennai. The culture was carried out for 113 days and the shrimp were fed with vannamei feed. The shrimp registered average size of 9.9 g and survival of 70 % with 1.28 FCR. The production achieved was 1208 kg/ha/113 days.

Harvested banana shrimp from winter crop

Demonstration of Asian seabass culture

Asian seabass seeds (3000 nos. weight range 1-2 g) produced at CIBA were stocked in a 1500 m^2 area pond in the last week of July 2011. At the time of stocking the temperature of the water was 32°C and dropped to 14°C in January 2012. The fish survived in the low temperatures during winter season due to maintenance of 1.5 m water depth and the animals adjusted physiologically to the wide temperature variations. The average body weight (ABW) at different DOC is shown in Fig. 14 and at 206 DOC the ABW of fish was 237.3 g. The present trial has indicated the possibility of taking up culture of seabass in Gujarat even when the grow-out period includes winter season.

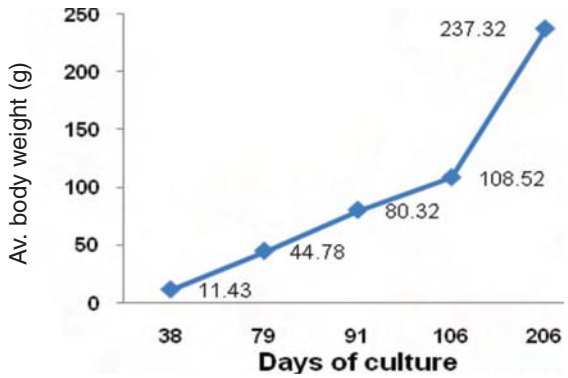


Fig. 14. Average body weight of *Lates calcarifer* at different days of culture

Demonstration of Pearlspot (*Etroplus suratensis*) cage culture in different salinity

Pearlspot *Etroplus suratensis* is an important fish in southern India. An experimental trial was conducted in Danti farm in floating, rigid PVC net cages (6 mm mesh) to assess the culture potential of this species in Gujarat. Pearlspot fry (1.95 g and 4.6 cm) produced and reared at CIBA hatchery were stocked @ 100 nos./cage (initial biomass - 195 g/m^3) in six (1 m^3) cages. Three floating cages were fixed in a brackishwater pond having 20 ppt salinity and during stocking the salinity dropped to 8 ppt following rain and then gradually increased to 16 ppt at harvest. The other three cages were fixed in a low-saline pond with 0 ppt salinity at stocking which slowly increased to 2 ppt at the time of harvest. The fishes in all the cages were fed twice a day using commercially available low-cost (' 12/ kg) feed (CP 18%) @ 5% of the body weight based on check tray observations. The fish growth was faster in brackishwater pond (15.28 ± 1.47 g) compared to low-saline pond (10.98 ± 0.12 g) in 125 days (Fig.3). Further trials are in progress to increase the growth rate by feeding an alternate feed.

Project Title (MoWR)	**Hydro geo chemical impacts of shrimp farming on coastal watershed**

Delineation of watershed and mapping of shrimp farm clusters

As a base line work to study the impact of shrimp farming on the quality of ground water, the shrimp farming area covering three adjacent mini watershed with two in Lower Vellar sub watershed and one Colleroon watershed at Cuddalore District of Tamil Nadu (about 400 ha) was digitized using the LISS III data. There were six clusters of farms in the study area ranging from 8.7 to 101.9 ha and the number of ponds in each cluster varied from 20 to 140.

Development of methodology (GIS based Analytical Hierarchical Process) for selection of groundwater sampling units for continuous monitoring

Representative selection of sampling unit is important for any monitoring study. A GIS-based multi-criteria evaluation using Analytical Hierarchy Method (AHP) was attempted. Thematic maps of eight base layers were prepared. The relative importance of evaluation criteria was defined by pair-wise

comparison method for the above eight factors. The eight criteria of distance, seven criteria of drainage, three criteria of lineament, seven criteria of soil, eight criteria of land use, three criteria of slope, seven criteria of geomorphology and five criteria of geology were calculated and combined to identify the monitoring locations and weightage were derived. The range of characteristics was divided into three classes: (i) high priority, (ii) moderate priority and (iii) low priority. As per the analysis, 10 wells came under high priority, 13 wells in moderate priority and 6 sample wells under low priority. In addition, 17 wells in the watershed have also been selected randomly.

No impact of shrimp farming on groundwater quality

Trend analysis was carried out to ascertain the groundwater quality in the study area before the initiation of aquaculture and the present status. The decadal changes in land use was captured using satellite data of 1991, 2000, 2011 and corresponding archive groundwater quality data were collected from PWD. Data from seven wells during 1991, 2000 and 2011 were used. Landuse analysis shows that there was no aquaculture activity in 1991. During 2000, it was observed that aquaculture activity was about 299 ha and during 2011, it was about 230 ha. The analysis showed that during 1991 itself the TDS and EC values in the wells at Porto Novat and T.S. Pettai were high. The ground water analysis has been depicted in Fig 15.

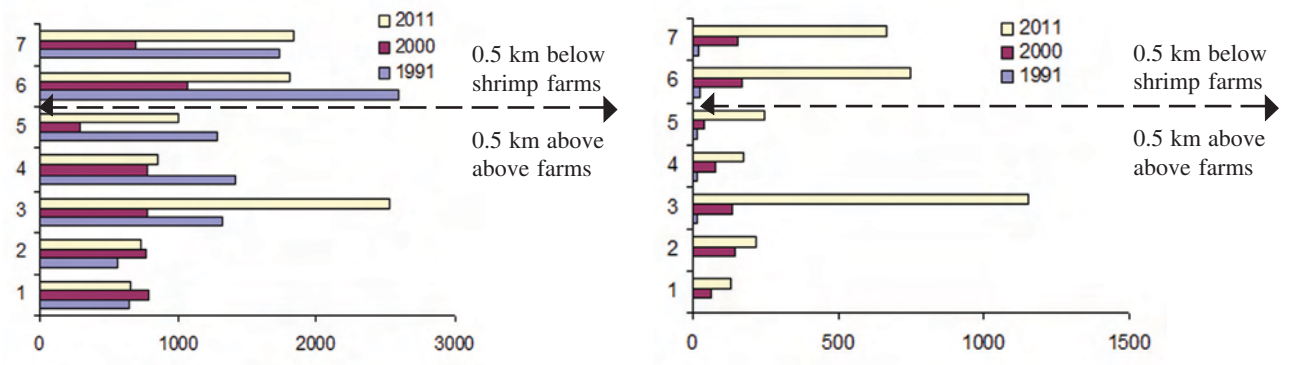


Fig. 15. Groundwater quality during pre- aquaculture (1991) and aquaculture (2000 and 2011) periods in coastal (< 0.5 km from shore) and other areas (beyond > 0.5 km from shore)

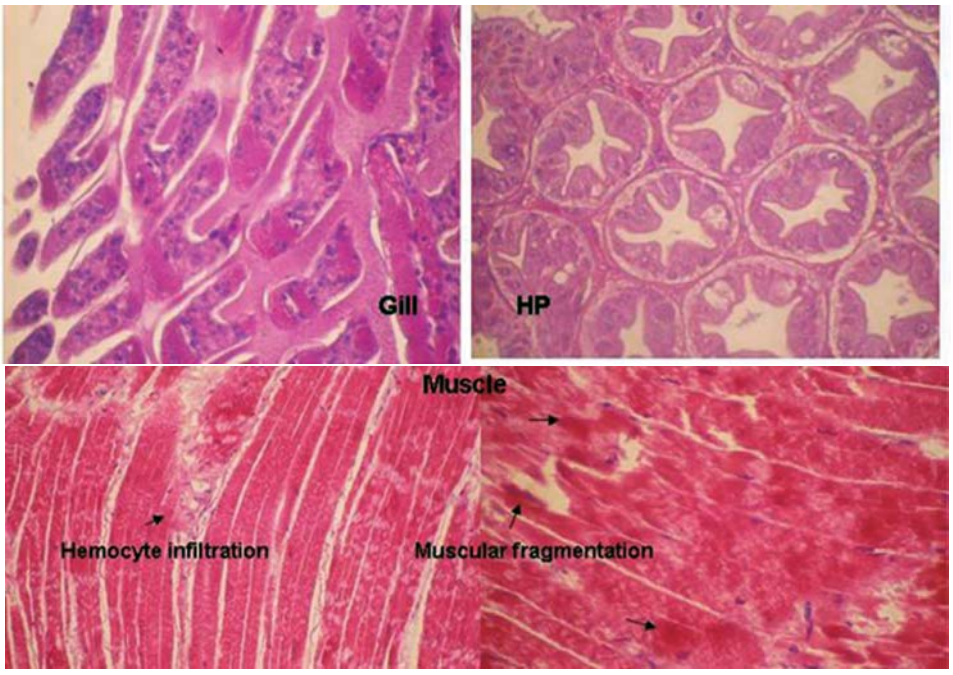
Project Title (NFDB)	Monitoring of disease occurrence and culture practices in *L. vannamei* in hatcheries and farms

The objective is to monitor the hatcheries and farms of *L. vannamei* for disease occurrence and culture practices followed. Ten samples were collected from different farms of Andhra Pradesh covering Nellore, Gudur and Bapatla. Similarly, samples were collected from different parts of Tamil Nadu covering Nagapatnam and Kattur with a total of 5 samplings. For cultured shrimp, samples were collected both from normal ponds and some of the affected ponds. All the samples were processed for the detection of WSSV, IHHNV, YHV, IMNV and TSV.

A normal shrimp (left) and a red discolored *L.vannamei* from the affected ponds.

The samples were negative for all the viruses tested indicating that morality was not due to these viruses. Hemolymph samples from normal shrimp were sterile for bacterial growth. Some of the affected shrimp had *Vibrio* sp.

Tissue sections of affected shrimp from hepatopancreas and gill had no viral inclusion or occlusion bodies. Muscle from the affected shrimp showed necrotic changes with fragmentation of muscle fiber.



Histopathology of affected shrimp of *L.vannamei* collected during the sampling

L.vannamei larval samples were collected from 2 hatcheries in Gudur (AP) consisting of 3 samplings and in Tamil Nadu from 5 hatcheries located at Muttukadu, Koovathur and Marakkanam covering 8 samplings. All the samples from hatcheries were collected during normal stage. There was no disease outbreak or abnormality during the time of sample collection. The samples were processed for the detection of WSSV, IHHNV, YHV, IMNV and TSV and found negative.

Monitoring of vannamei culture was done in two study areas of Tamil Nadu (Kattur) and Andhra Pradesh (Bapatla) each with three cluster of farms distributed across salinity (low) to evaluate the growth performance of SPF *L. vannamei* reared at different densities. Environmental parameters were monitored for salinity, pH, calcium, magnesium, total hardness, alkalinity, electrical conductivity (EC), total dissolved solids (TDS) and also for total bacterial count (TBC) and total vibrio count (TVC). The culture practices, the bio-security protocols, environment, feed and health management, economics and the innovations in this evolving culture practices were studied in depth. The water quality parameters observed (60 ponds) during the culture across different farms are given in Table 5.

Table 5. Water quality parameters during *L.vannamei* culture across different farms

Parameter	Range
Salinity (ppt)	2-8
EC (mS)	2.67-6.88
TDS (ppt)	1.88-3.09
pH	7.84-8.51
Alkalinity (ppm)	200-350
Calcium (ppm)	120-300
Magnesium (ppm)	80-451
Hardness (ppm)	920-2408
ADG (g)	0.13-0.34

Healthy *L. vannamei*

The Total Plate Count ranged from (0.63-1.64) X 10^3 CFU/ml and vibrio count of yellow colony was (0.52-1.53) X 10^3 CFU/ml and green colony was (0.1-8.3) X10^2 CFU/ml. In winter months, the average daily growth (ADG) range of 0.15 to 0.20g was observed compared to a higher ADG range of 0.22-0.34 g in summer months in this low saline environment. Production range of 3 to 9 tons/ha was obtained across a stocking density of 10 to 50 nos./m^2 in 60 to 140 days of culture. The cost of production of *L. vannamei* in the farms monitored was ₹110 to 130 depending on the intensification and level of management.

***L. vannamei* mortality due to mineral deficiency**

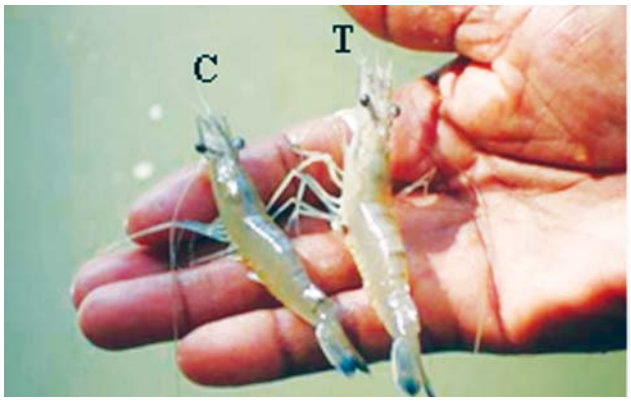
Despite the relative success of some farmers culturing it in inland low salinity waters, several problems still arise including that of the deficiencies in the ionic profiles of pond water as certain minerals like calcium and magnesium have been suspected to limit growth and survival of shrimp. The ability of *L.vannamei* to tolerate a wide range of salinities (0.5-40 ppt) has made it a popular species for low salinity culture. The impact of minerals under low saline culture is being investigated.

Project Title (NFDB)	Up-Scaling of production technology and large scale field demonstration of indigenously developed immunostimulant CIBASTIM for penaeid shrimps

This project objectives are to produce CIBASTIM, the immunostimulant on pilot scale, to carry out production cost analyses and trials in Gujarat, Tamil Nadu, Andhra Pradesh and West Bengal to demonstrate its efficacy during culture. The outcome of these trials would help to popularize and commercialize the product.

Six farmers in Kakinada (AP) and 3 farmers in Navsari (Gujarat) have been provided with CIBASTIM for application in 18 shrimp culture ponds of 0.4 to 0.8 ha in size. The water and soil parameters of the ponds are monitored on weekly basis and in 60 DOC, the shrimp from treated ponds appeared healthy with good lustre compared to control ponds.

CIBASTIM demonstration pond (Kakinada)



Tiger shrimp from control (C) and CIBASTIM demonstration (T) pond (DOC 60)

Project Title (DBT)	Molecular mechanisms and steroidal control of reproductive maturation in the commercially important shrimp *Penaeus monodon*

The objective of this study was to explore the effect of 17-α hydroxy progesterone on vitellogenesis and spawning of female *P.monodon*. To gain further insight into the mechanisms of progesterone action, it is necessary to characterize and study the expression patterns of progesterone receptor from the ovarian tissues. The ovarian tissues of shrimp at the pre vitellogenic stages were incubated for 24 h in medium 199 supplemented with 17-α hydroxy progesterone at different concentrations (10 µg, 50 µg and 100 µg). The diameter of the oocytes in all concentrations increased significantly in a dose dependant manner after 24 h incubation (Fig. 16). A corresponding rise in the vitellogenin mRNA transcript level was also observed in the hormone-treated ovarian tissues (Fig. 17). In order to confirm the *in vivo* effect of this hormone on ovarian maturation, experiments were conducted on wild tiger shrimp broodstock. Broodstock were grouped into three: the first group with intact eye stalk received hormonal injection @ 100 µg/g body weight of

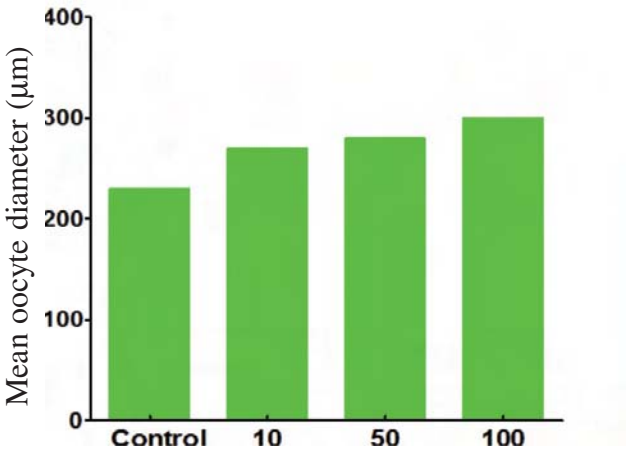


Fig. 16. Oocyte diameter after 24 h *in vivo* experiment with 17 α hydroxy progesterone. (All the treatment group showed increase in oocyte diameter - P<0.05)

the animal on first, 7th and 14th day of experimentation, the second group was unilaterally eyestalk ablated and injected with the same dose of hormone at the same time interval and the third group was unilaterally eyestalk ablated. While none of the shrimp in the first group reached final stage of maturation, a significantly higher proportion of the shrimp in the second group (hormonal treatment + eyestalk ablation) reached the final stage of ovarian development. The results suggested that 17 α hydroxy progesterone would not override the inhibitory control of the eyestalk hormone on ovarian maturation, and it would be effective only when the eyestalk hormones are removed at least partially. On PCR amplification using ovarian RNA and species specific primers, a 943 bp of the cDNA encoding progesterone receptor of tiger shrimp was identified from all the maturation stages (Fig. 18). Though preliminary, these results imply a role of 17 -α hydroxy progesterone in the reproductive cycle of penaeid shrimps.

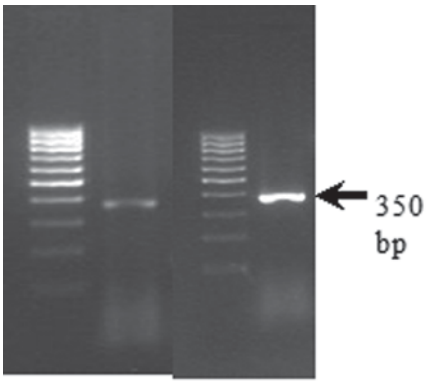


Fig. 17. Vg mRNA transcript levels in control and hormonal treated ovarian fragments after 24 h incubation.

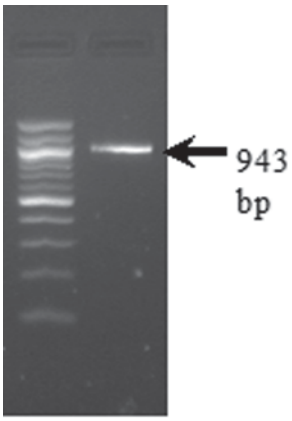


Fig.18. PCR product of female ovarian cDNA with primers for progestin membrane protein

FINFISH CULTURE DIVISION

Project Title (Institute)	Development of technology for quality seed production of commercially important brackishwater fishes under control conditions

Asian seabass (*Lates calcarifer*)

Broodstock of Asian seabass was strengthened with addition of 45 fishes (1-5 kg) from the wild. The F_3-F_4 generation domesticated stock of 75 fishes (2-4 kg) were also maintained in ponds and tanks following 70% daily water exchange and monitoring of water quality parameters. The salinity ranged from 21 ‰ in January to 32.2 ‰ in July; the temperature ranged from 25.8^{0}C in December to a high of 31.3^{0}C in April and all other water quality parameters were well within permissible limits. Forage fishes *viz.* tilapia and oil sardine @ 5% of body weight were fed to the fishes. Maturity of seabass was observed throughout the year peaking during July-October. Twelve breeding trials (8 using domesticated stock and 4 using wild stock) were carried out and successful spawning was observed in 9 cases (6 in domesticated and 3 in wild stock). The size of females used ranged from 3.5 to 8 kg while for males it was 2.0 to 3.0 kg. The number of eggs released per spawning, fertilization rate and hatching rate varied from 0.6 to1.0 million and 0.9 to 1.1 million, 43 to 84% and 61 to 75% and 85 to 91% and 61 to 88% in the domesticated stock and wild stock respectively. The larval survival rate for 25 days rearing ranged from 8 to 52% (average 38%) in domesticated stock and 6.8 to 35% (average 28%) in case of wild stock (Table 6). No significant differences were observed in the size or growth of the larvae among the stocks. The overall survival rate of the hatchlings up to fry stage (25 days) ranged from 6.8 to 52% with an average value of 34%.

Table 6. Details of breeding trials on Asian seabass

Trial No	Source of Spawner	Initial egg size (µm)	No of eggs spawned (in million)	Fertilized egg size (µm)	Fertilization (%)	Hatching (%)
1.	D	480	0.60	759	50	85
2.	D	455	0.80	750	43	56
3.	W	523	0.90	791	72	91
4.	D	426	0.70	736	68	71
5.	D	445	0.69	743	75	68
6.	W	473	1.10	820	72	88
7.	D	464	0.86	758	84	75
8.	D	460	0.83	800	68	43
9.	W	458	0.56	748	56	51

D-Domesticated W- Wild

The technology for seabass nursery rearing was further validated and the economic feasibility of rearing them in RCC tanks was studied. Fry were reared at a stocking density of 500 nos./m^3 for a period of 30 days and were fed with formulated feed under flow-through system. The maximum survival rate recorded was 90%, with an average value of 62%. The production cost was around ₹4.50/ per fingerling of 5-7 cm size which could be sold for ₹8-10. Nursery rearing of seabass in the culture site in hapa net cages was further refined and demonstrated in a farmer's pond where a survival rate of 90% could be obtained

A farmer at Machilipatnam stocked seabass fry obtained from CIBA hatchery in a nursery pond wherein zooplankton and small crustaceans collected from an adjoining canal were introduced. Over a rearing period of 15-30 days with 92% survival, the farmer could realize ₹7/- per seed against a production cost of ₹3/- indicating the techno-economic viability of seabass fry rearing which could be promoted as a livelihood option for small farmers.

Grey mullet

The existing grey mullet stock was strengthened with the addition of 70 fishes (0.25-1.2 kg) and stocked in RCC tanks and ponds. The fishes were maintained following routine water exchange (70% on alternative days) and fed with formulated feed @ 2-3%. Gonadal maturation was monitored during August-December and oozing males and maturing females with ova diameter of 320-560 µm could be observed. About 30% of captive female fishes were observed in maturing condition. Twelve breeding trials were carried out in the spawning tanks, using females with ova diameter above 450 µm and oozing males in 1:2 ratio. The protocol included administration of pituitary, HCG and LHRH-α hormones individually or in combination, for accelerating maturation and spawning. All fishes were maintained in the RAS with 30 ppt salinity and a temperature was 27±1°C. Though improvement was observed in ovulation and egg diameter increased to 600 µm, successful spawning could not be observed.

Milkfish

The broodstock fishes of 6+ years in age and in the size range of 4-5 kg were maintained in RCC tanks with formulated feed @ 2-3% of body weight following regular protocols. Thirty sub adult fishes were added to the broodstock in this year. The maturity conditions were monitored regularly and

oozing males could be observed during September and maturing females with ova diameter of 230 µm was observed indicating probability of controlled breeding in our facilities.

Captive stock of milkfish

Matured male

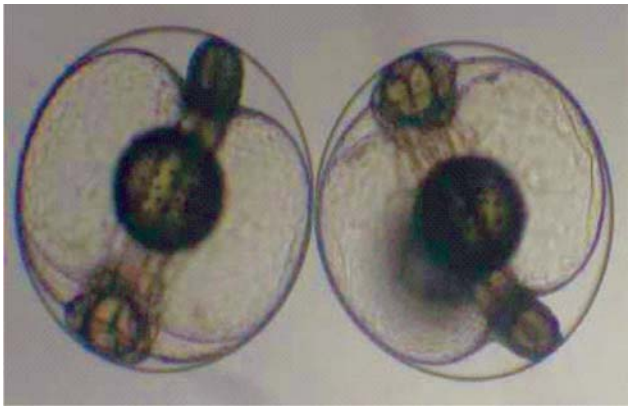
Maturing female

Pearlspot

Broodstock was maintained in the pond, RCC tanks and net cages. Feasibility of breeding the fish in small net cages was evaluated. A total of 10 cages were installed and different soil substrates were provided. For egg laying, tiles were also provided in cages. The fish could be bred even in cages as small as 0.7 m^3 provided with clay soil substrate. Hatchlings up to 1000-1200 nos. were collected from the nest pits made in the soil. These were further reared to fry on live feed like rotifer and *Artemia* nauplii with a survival of 90%. In the tanks, breeding throughout the year could be assessed and eggs could be isolated and hatched successfully in FRP tanks. The hatchlings were further fed live feed and reared up to fry stage. A total of 6,349 fry were supplied to entrepreneurs and farmers.

Developing embryo

Spotted scat



Developing embryo

About 250 captive broodstock were maintained in an earthen pond with formulated feed being given @ 3% of body weight. Regular monitoring of gonadal maturity was made. Significant achievement was made in the controlled breeding of Scat. Two trials were conducted using matured females of 160mm/150g–210mm/350g with oocyte diameter ranging from 424-522 µm and males in oozing condition. Fishes were treated with HCG @ 5000-6000 IU/kg body weight as prime dose twice at an interval of 24 hours. The LHRH-α was administered after 72 hours @ 100 µg/kg body weight. Both females and males were maintained in the ratio of 1:2. After ovulation (32-38 hours after LHRH-α administration) eggs were stripped and fertilization was effected using milt obtained from oozing males and the eggs were incubated @ 500 nos./litre.

Fertilization rate ranged from 15 to 40% while that of hatching ranged from 10 to 45%. The hatched larvae were 1.57-1.68 mm in size. After hatching, the larvae were stocked in rearing tanks and fed

with rotifer from 2 dph and *Artemia* nauplii from 10 dph. Formulated feed was provided from 21 dph. It could be inferred that scat females could be induced to spawn when the mean oocyte diameter is above 400 µm and large scale propagation of scat is possible under controlled conditions.

Scat early fry

Grading of scat fry

Moon fish

About 90 moon fish broodstock in the size range of 68-84 mm/8-12 g procured from commercial catches were stocked in an earthen pond and were fed with formulated feed @ 3% body weight. From the captive stock, oozing males could be observed from August and the females matured in January. Effort was also made to breed the fish in captive conditions during January-February by conducting three trials (Table 7). Females with ova diameter of 385-520 µm were selected and administered with HCG @ 100-300 IU/kg as prime dose and the LHRHá hormone was administered as resolving dose @ 50 µg/fish. Ovulation was successful and the oocyte diameter increased up to 880±20 µm. The mean diameter of the spawned eggs was 850±15 µm. However, fertilization was not successful.

Table 7. Breeding trials on moon fish (*Monodactylus argentius*)

Sl. No	Fish size (g/mm)		Initial oocyte diameter (µm) ± SD	Hormone administration		Response		
	Female	Male		Priming dose – HCG (IU/kg BW)	Resolving dose – LHRHα (µg/kg BW)	Spawning after resolving dose (hrs)	Total eggs	Mean diameter of spawned egg (µm) ± SD
1	75/147	75/145	520±18	100	50	18	6500	880±26
2	70/135	Nil	465±12	200	50	19	5800	850±20
3	74/142	Nil	385±23	300	50			

Reproductive physiology of grey mullet

The spawning period of grey mullet is very short both in wild and captive stocks. Under controlled conditions it has been observed that the maturation process does not progress beyond a stage and this might be due to the hormonal imbalance in the captive stock. Hence, a study was conducted to assay the reproductive hormonal profile of captive and wild stock. Hormonal assay showed the gradual reduction in 17β-estradiol (E2) in matured wild fish induces the secretion of GtH II through positive feedback and accelerate the final oocytes maturation through synthesis of MIH (17-α-20-β-DHP) (40.14). However, E2 level remain higher in captive stock compared to wild stock and this could have prevented the final oocyte maturation in controlled condition (Fig. 20).

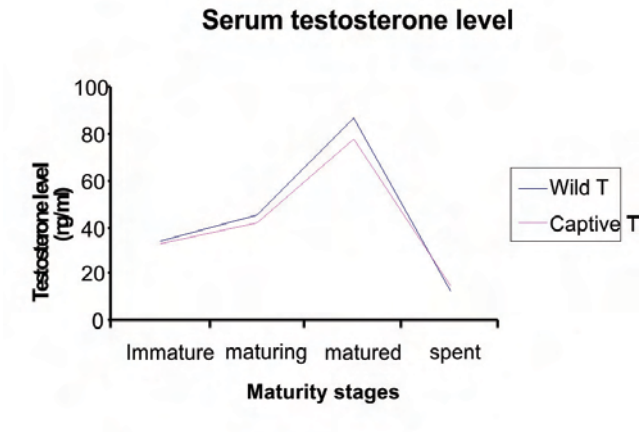


Fig. 19. Testosterone level in captive and wild stock of female mullet

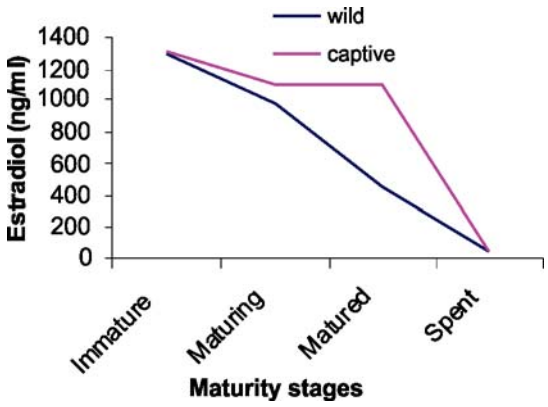


Fig. 20. Estradiol level in captive and wild stock of female mullet

Project Title (Institute)	Refinement of fish culture technologies in brackishwater eco-system

Cage culture of Asian seabass to juvenile size in net cages in brackishwater open system

Hatchery produced advanced fry of seabass of three size groups i.e. 1.23 g, 2.41 g and 3.39 g were stocked in net cages, the fry being fed formulated feed. The trial was conducted for 45 days to study the influence of size on heterogeneity during rearing. The Specific Growth Rate (SGR) was relatively better in small size compared to that in larger size groups. However, no significant effect was observed in the survival (77-90%) or cannibalism (8.7-18.5%). The final coefficient of variation for weight was 26±1.69 % and size heterogeneity (3.11±0.32) was significantly high in the smaller size group of fish in comparison to the larger size groups (final coefficient of variation for weight was 14.48± 0.8 to 16.8±1.47 %; size heterogeneity 1.5±0.38 to 1.72±0.39).

Nursery rearing of grey mullet and milkfish

At Kakdwip Research Centre, grey mullet (*Mugil cephalus*) of average size 0.5g were stocked in a pond and managed with three types of treatments i.e. with fertilizer only, feed only and a combination of feed and fertilizer. The growth and survival were monitored over a period of 5 months and it was observed that higher growth (98 cm) and survival (83%) were obtained in the treatment involving combination of feed and fertilizer than in those fish that were fed only formulated feed (52g/76%) or fertilization alone (41g/78%)

Milkfish fry were procured, acclimatized and transported to Kakdwip, the transportation period being 8 hours. After re-acclimatization, the seeds were stocked in an earthen pond (300 m^2 area) @1,60,000/ ha. The fishes were fed floating pellet @ 5-10% daily. After 40 days, the fish attained 20 g. average weigh.

Monoculture of grey mullet and milkfish

Grey mullet seed reared under nursery at KRC were stocked @ 10,000/ha in two farmers' ponds and reared for 350 days. From the average initial size was 42 g., the fishes attained size ranging from 390 to 420g and the survival ranged from 85 to 88%. The final production was 3.43-3.57 tonnes/ha.

Milk fish were stocked juveniles of 20g size in a 0.8ha nursery pond at KRC @ 10,000nos./ha and they were fed floating pellets. After 6 months, the fish attained average weight of 350g and the production being 2.5 tonnes/ha.

Polyculture of grey mullet and freshwater prawn

In two of the very low saline ponds located at Kamar Hat, Kakdwip, polyculture of carps, freshwater prawn and grey mullet was demonstrated. Fishes were fed farm made feed consisting of fish meal (30%), mustard oil cake (20%), rice (20%) and rice bran (30%). Grey mullets attained size of 320-350g with a survival of 55-60 %.

Culture of pearlspot in tanks and cages

To evaluate the desirable density for pearlspot with and without soil in the rearing system, fry of average size 0.39 g were stocked in FRP tanks at different stocking densities of 150, 300 and 450 nos./m^3. A stocking density of 150 nos./m^3 was found to be desirable for fry rearing. The presence or absence of soil substrate did not show any significant effect on growth but it influenced survival of fishes. In another trial, fry were reared and fed formulated feed and fish grew to 3.5-4.9g (5.25-6.2cm) after 90 days, the survival ranging from 29-80%.

Cage culture of pearlspot was attempted in two 3 m^3 net cages at stocking density of 40 nos./cage and the total biomass of the stock was 350 g/m^3. The fishes were reared for 45 days and they attained 50 size.

Cultivation of seaweed using hatchery discharge water

The suitability of using hatchery discharge water for secondary aquaculture like seaweed (*Kappaphycus alvarezi* and *Gracilaria* sp.) and green mussel was explored using floating and submerged rafts, bags and net enclosures. *K. alvarezi* showed better growth (from 50 g to 200-300 g/m^2 in 4 months) indicating that the seaweed can be cultured using hatchery discharge water. The salinity DO ranged from 22-29.5 ppt, the pH ranged from 7.6 to 8.4, the TDS ranged from 2.5 to 6.0 ppm, ranged from 14-27 ppt, nitrite-N, ammonia-N ranged form 0.05 to 1.2 ppm, ranged from 0.01 to 0.20 ppm, alkalinity ranged from 140-160 ppm and the electrical conductivity ranged from 31-46 ms/cm.

Kappaphycus cultured in hatchery discharge water

Project Title (NAIP)	**An export oriented marine value chain for farmed seafood production using Cobia (*Rachycentron canadum*) through rural entrepreneurship**

The specific objective is to develop a comprehensive package for seed production of cobia (*Rachycentron canadum*) using captive land based broodstock.

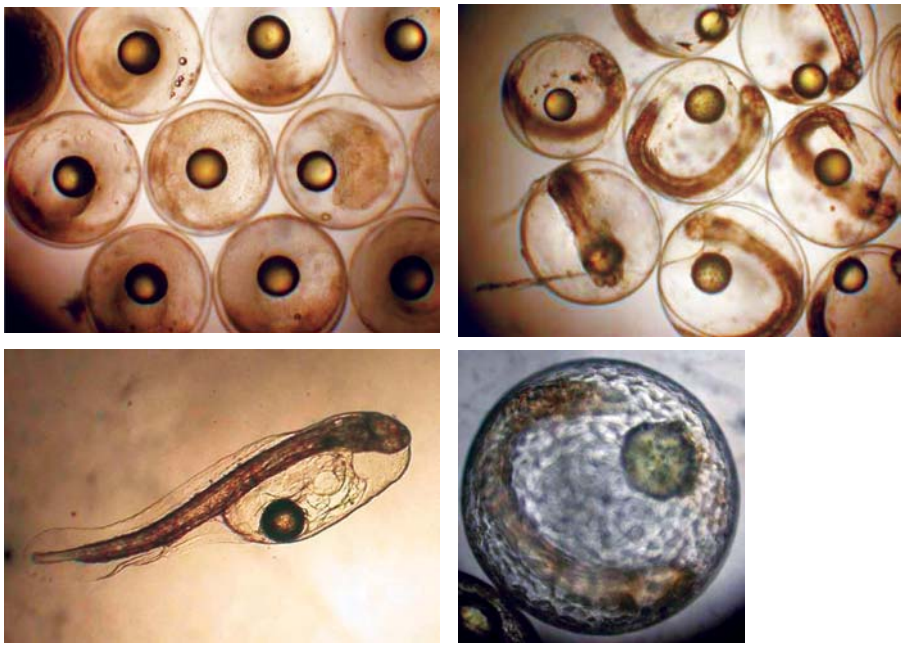
Broodstock management

A total of 36 fishes ranging from 3.0-25.0 kg were maintained in earthen ponds as well as in RCC tanks. During this year, 8 more fishes (3.0-18.0 kg) were added to the existing stock. In the earthen

pond, the stocking density was @ 0.5 kg/m^3 whereas in the RCC tanks it was 1.0 kg/m^3. The fishes were fed daily forage oil sardines/tilapia along with squid once in 3-4 days. In RCC tanks, water was exchanged @ 70% daily whereas in the ponds it was carried once in 3 days @ 60%. Water quality parameters were also regularly monitored. In the pond, the salinity was maximum (32.2 ppt) in July 2011 and minimum (21 ppt) in January 2012.The water temperature ranged from 28.4 to 31.3^{0}C; the pH ranged form 3.0 to 8.0 and the DO ranged from 3.0 to 6.0 ppm. The alkalinity ranged from 140 to 160 ppm; the NH_3-N ranged from 0.1 to 0.8 ppm; the $N0_2$-N ranged from 0.007 to 0.066 ppm and the TDS ranged from 24.0 to 32.3 ppt.

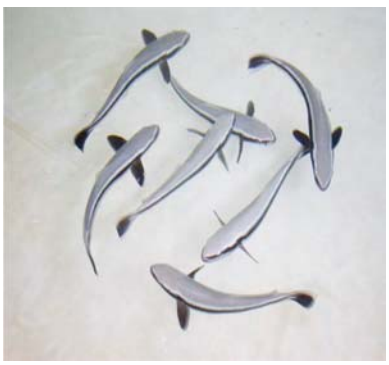
Assessment of maturation, breeding and larval rearing

The fishes were regularly monitored for maturation through sampling and found to be in maturing condition throughout the year. The maturity stages were assessed. Matured fishes with ova diameter of above 600 mμ were selected for breeding trials. A total of 10 breeding trials from April to November were carried out. The body weight of fishes ranged from 13.0 to 16.0 kg. The egg size ranged from 496.9 to 851.7 μ. Fishes were administered HCG as a prime dose ranging from 100-300 IU/kg body weight and in cases where ovulation was not noticed during subsequent days, a resolving dose of LHRHa @ 20μg/kg body weight was given. Successful spawning was observed in all the cases however, fertilization was seen only in two cases during May and August and successful hatching was observed only in one case. A significant achievement was the successful breeding and rearing of cobia larvae obtained from pond reared broodstock for the first time as compared with other reports where seed production is usually carried out using open sea cage reared broodstock.



Cobia embryonic developmental stages and hatched out larvae

Early larvae of Cobia (7 DPH)



Hatchery reared juveniles

The newly hatched larvae measured 3.2mm. Initial feeding was started from 3rd dph with rotifers. Larval rearing was done under green water system. Some of the larvae however succumbed to mortality on 6th day and the remaining larvae were fed *Artemia* nauplii from 8th day. Around 15 juvenile cobia were obtained after 40 days of rearing.

Rearing of Cobia juveniles

To evaluate the growth of the first generation cobia, juveniles were reared with forage fishes in triplicate with five fishes per tank. The growth performance of fishes is depicted in Table 8. There was not much difference in growth when fed with either squid or tilapia.

Table 8. Growth performance of cobia juveniles under captive conditions (mean ± SD)

Feed Type	Trait	Initial size	At 10 days	At 20 days	At 30 days
Squid	Length (cm)	7.05 ±0.22	11.23±0.14	13.83±0.17	21.04±0.22
	Weight (g)	4.35 ±0.29	5.87 ± 0.15	10.73±0.20	42.45±0.29
	Survival (%)	-	77.77	100.00	100.00
Tilapia	Length (cm)	8.20± 0.32	9.96 ± 0.23	13.63±0.19	20.30±0.32
	Weight (g)	3.30 ±0.34	4.98 ± 0.24	10.49±0.27	39.75±0.34
	Survival (%)	-	77.77	100.00	92.85

Project Title (DBT)	**Indo Norwegian platform on fish and shellfish vaccine development- Development of viral vaccine against nodavirus and infectious pancreatic necrosis virus**

Impact of temperature on pathogenic effect of nodavirus to Asian seabass juveniles

The specific objective for CIBA under the Indo-Norwegian platform is to evaluate the efficacy of the viral vaccine developed by the collaborating institute, during different stages of the fish against Noda Virus and IPNV. During rearing in the hatchery and in farm condition in low temperatures, fishes were found to be sluggish and often prone to viral/bacterial infection. To study the influence of temperature and the pathogenic effect of nodavirus, juveniles of 8.01 cm/8.0 g to 10.1 cm /10 g were challenged intramuscularly and intraperitoneally with nodavirus @ 0.1 ml/g of fish and maintained in two temperature regimes of 28 ºC and 24 ºC for 10 days. Mortality was observed 5-6 days post infection (p.i.) in fishes maintained at lower temperature. However, at higher temperature there was no mortality indicating that temperature had a role to play in the infection.

Hatchery reared juveniles (25-30 g) were administered heat killed vaccine by intramuscular and intraperitoneal injections @ 10 µl/g body weight and maintained for 30 days. The relative survival rate between the vaccinated and control group was monitored. In the vaccinated group, mortality started from 15th day p.i. whereas in the control, mortality started from 10th day p.i. The cumulative percentage of mortality over a period of 30 days was 80% in the control group whereas in immunisation through intramuscular route, it was 33. On vaccination through intraperitoneal injection, the cumulative mortality was 70 % in control group compared to 38 % in the vaccinated group (Table 9).

Table 9. Evaluation of efficacy in terms of cumulative mortality (%) of heat killed vaccine on Asian seabass juveniles during different days post vaccination (DPI)

DPI	Intramuscular		Intraperitoneal	
	Control	Vaccinated	Control	Vaccinated
10	10	0	0	0
18	0	0	20	0
22	30	0	0	0
23	0	0	30	0
24	0	0	0	25
27	40	17	50	0
28	0	33	60	0
29	60	0	70	0
30	80	0	0	38

Differences in mortality were tested for statistical signiûcance and the relative percentage survival (RPS) was calculated according to Amend (1981).

$$\text{RPS} = 1 - \left[\frac{\%\ \text{cumulative mortality of vaccinated group}}{\%\ \text{of cumulative mortality of control group}} \right] \times 100$$

The relative percentage survival was 58.33 and 46.43 by vaccination through intramuscular and intraperitoneal routes respectively.

Project Title (NFDB)	**Demonstration of Asian seabass *Lates calcarifer* farming in the pond culture system**

This NFDB funded project is to demonstrate the techno economic viability of the nursery, pre-grow out and grow out farming of Asian seabass to farmers in different agro-climatic conditions. In farmer's pond at Gilagaladindi near Machilipatnam, in nursery rearing trials, the survival rate ranged from 52 to 68% for a period of 45-50 days, the fry being fed formulated feed and reared in hapa net cages. In the pre-grow out trials, fishes were stocked at a density of 30,000 nos/ha. and reared for a period of 3 months. Fishes attained 60-80 g size from the initial size of 3-5 g and the recovery rate was 92%. In the grow-out culture from August to March (8 months), they attained the size of 400 g -1.2 kg. Final yield was 3.2 tonnes/ha.

Harvested seabass

In the farmer's pond at Harwada, near Karwar, Karnataka, after 50 days of nursery rearing in hapa net cages from fry stage (1 cm), the fish attained size of 3-4 g with survival rate of 62%. These fishes were then transferred to pre-grow out system and reared for 3 months till they reached 60-80 g with a survival of 83%. In the grow-out pond, after 6 months a size of 0.450 – 1.25kg could be obtained.

At Sahada, Balasore, Odisha, in Septemeber 2011, nursery rearing with two size groups (1 cm & 2cm) was demonstrated in hapa net cages. The survival was 42% for small size and 68% for the large size, indicating a fairly large size requirement for the low temperature season. Nursery phase at Madanganj, Namkhana, West Bengal was demonstrated following routine protocols. The survival was 42% and the size of the fingerlings was 3.0-3.5g. The poor survival could partly be attributed to low feed intake during winter.

A haul of grow out seabass at Harwada, Karwar

The hatchery seed supplied by CIBA was stocked by a farmer @ 40,000-50,000 nos./ha in Karwar and reared for 15-20 days. The farmer obtained 85% survival and the trial was repeated three times. The average final size of the seed was 6-8 cm. This has opened new avenues for nursery rearing and fry rearing could be thought of a livelihood option for farmers.

Aquatic Animal Health and Environment Division

Project Title (Institute)	Diseases of finfish and shellfish in brackishwater aquaculture: Diagnostics, prophylaxis and therapeutics

Use of viral metagenomics for screening emerging viruses

Viral metagenomics involving viral purification and shotgun sequencing was deployed to decipher the Laem Singh virus (LSNV) genome, associated with monodon slow growth syndrome (MSGS) in tiger shrimp. The MSGS affected shrimp samples were collected from Andhra Pradesh and initially screened to rule out the presence of DNA viruses (WSSV, MBV, HPV, IHHNV) and RNA viruses (TSV, *Pv*NV and IMNV). The samples showing typical symptoms that were positive only for LSNV by Real Time-PCR were subjected to viral purification by CsCl gradient ultracentrifugation. The whole transcriptome was amplified from the RNA of purified virus and the products were cloned in TA vector. Positive clones were amplified by PCR and sequenced.

Mortality investigation in tiger shrimp

Following reports of a disease outbreak in December 2011 in Nagapattinam area, mass mortality in a tiger shrimp farm (80 DOC with 10/m^2 stocking density) at Vettaikaranirupu near Velankanni was investigated. The shrimp exhibited reddish body discolouration and erratic swimming behaviour by coming to the edges of ponds, the mortality reaching 60-70% within 8-12 hr. A similar condition prevailed in about 200 ha of farming area which was reported earlier. Haemolymph samples from moribund shrimp had no vibrios, ruling out bacterial involvement. Samples of hepatopancreas, pleopods, gills, eye stalk and muscle of moribund shrimp were collected for molecular diagnostics and histopathology and were screened for DNA viruses (WSSV, IHHNV and HPV), RNA viruses (IMNV, TSV and *Pv*NV) and necrotizing hepatopancreatitis causing bacteria (NHPB) using IQ 2000 kit .The samples were found negative. However, the samples were found positive for WSSV and IHHNV by nested PCR with OIE protocols (Fig. 21) which clearly indicates that the mortality could be due to a mixed viral infection.

Tiger shrimp with reddish discoloration

Mortality investigation in milk fish

Slow progressive mortality of milk fish (1-1.5 kg size) cultured in a 2.2 acre pond and was in 530 DOC during October 2011 at Chamakuripalem, near Narasapuram (West Godavari dt Andhra Pradesh) was investigated. The pond had a salinity of 10 ppt and temperature of ~38°C .The affected fish were lethargic with haemorrhagic lesions around oral region, abdomen and gills. The pond suffered mortality with about 5-6 fish d^{-1}. Blood samples from moribund fish were found positive for vibrio infection.

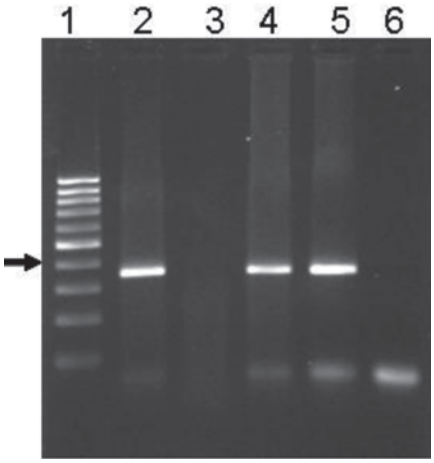
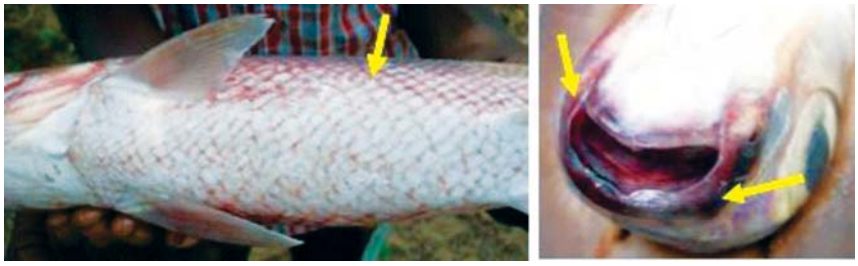


Fig. 21. Gel showing amplification of IHHNV using OIE protocol (Lane 1: molecular weight marker; lane 2: positive control; lane 3: negative control; lanes 4-6: samples - lanes 4 and 5 showing a 392 bp product are positive for IHHNV)

Though the *Vibrio* sp. isolated was sensitive to trimethoprim and chloramphenicol, use of antibiotics in aquaculture is not advocated. The disease condition could be associated with vibriosis hence better management practices were suggested.



Milk fish affected with vibriosis showing hemorrhagic lesions on lateral sides and around mouth

Mortality investigation in *L. vannamei*

Investigations on the mass mortality of *L. vannamei* in shrimp farms (45-80 DOC) near Gangapattinam of Nellore district, Andhra Pradesh during May 2011 was carried out. Samples from seven farms were collected and subjected to bacteriological, histopathological and molecular diagnostic analysis.

***L. vannamei* mortality in shrimp farms**

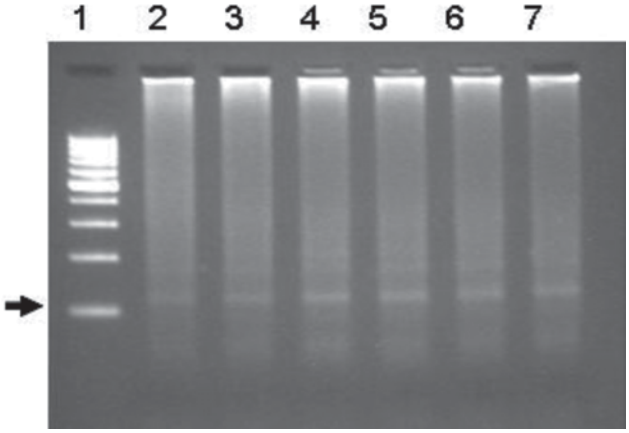


Fig. 22. Amplification of 135 bp product by RT-PCR protocol-1 of OIE (2010) for specific detection of YHV (Lane 1: molecular weight marker; lanes 2-7: samples from affected shrimp)

Two samples from each farm were screened for DNA viruses (MBV, HPV), RNA viruses (YHV, IMNV, TSV, *Pv*NV, and LSNV) and NHPB (necrotising hepatopancreatitis bacteria) using IQ 2000 kit. Samples were found to be positive for WSSV by nested PCR using OIE protocol. Screening for YHV with IQ 2000 kit amplified non-specific bands of about 200 bp, instead of the expected 277 bp amplicon. However, when re-examined with OIE Real Time PCR protocol-1 for specific detection of YHV, the samples were found positive for 135 bp product (Fig. 22).

Parasitic infestations in koi carp

A batch of koi carp (*Cyprinus carpio*) fingerlings (weight: 12-16.6 g; length: 8-11.5 cm) with loss of scales, emaciation and low feed intake was reported by an aquarium fish farmer from Kolathur

near Chennai. Five live fish samples were received and parasitological, bacteriological and virological investigations were carried out. Parasitic infestation with adult and various life cycle stages of crustaceans (*Lernaea* and *Argulus*) was observed. The parasites were identified as *Lernaea cyprinacea* and *Argulus japonicus*. No other microbial pathogens were involved.

a b c

a. *Lernaea cyprinacea* in Koi carp, *Cyprinus carpio (koi)* - anterior end (100x)
b. *Lernaea cyprinacea* in Koi carp, *Cyprinus carpio (koi)* - posterior end (100x)
c. *Argulus japonicus* in Koi carp (100x)

Vertical transmission of WSSV in mud crab *Scylla* spp.

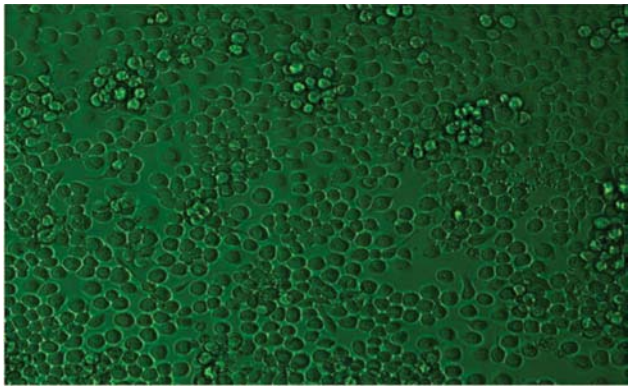
Broodstock are the main source of WSSV infection in shrimp farms due to vertical transmission of the virus. Presence of WSSV in various ovary tissue cells of the shrimp has been reported. In the present study, WSSV infection through possible vertical transmission in mud crab was investigated. Two experimental challenge studies were conducted with WSSV infection in wild caught female *Scylla olivacea* (n=31) and *S. serrata* (n=14). Wild caught *Scylla* spp. that tested negative for WSSV were challenged with the same virus (*per os*). Infection was confirmed both by nested and Real Time-PCR. The infected and control animals were ablated and observed for ovarian maturation. Spawning was not observed in both experimental trials. Later, the animals were sacrificed and tested for WSSV infection. WSSV was confirmed in 62.5% of ovarian tissue samples by nested PCR. The WSSV copy number quantified by qRT-PCR in ovarian tissue in both trials was found to be low ($8.7x10^1$- $5.63x10^2$ copy numbers g^{-1} tissue). The study clearly demonstrates that WSSV interferes with the ovarian development in mudcrab.

a. *Scylla sp*. Underdeveloped ovary infected with WSSV

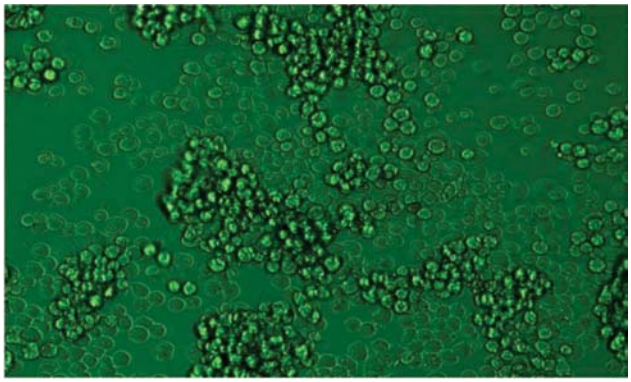
b. Normal ovary

Development of primary cell culture from shellfish and finfish

White spot viral disease has been recognized as an economically important viral disease of shrimp. Studies on WSSV replication, pathogenesis, quantification and control measures have been hampered



Sf9 insect cell line - control



Sf9 insect cell line infected with WSSV

by the lack of *in vitro* cell culture system. Adaptation studies in two different established cell lines namely Sf9 and C6/36 insect cell lines which were procured from NCCS, Pune were carried out. Initially, after two blind passages, CPE was observed from third to fifth passage in both the cell lines. Thereafter, no CPE was observed up to nine passages, indicating that Sf9 and C6/36 cell lines are not suitable in-*toto* for *in vitro* multiplication of WSSV.

Bioinformatics analysis relevant to microbial infection and disease resistance

Computational tools are used for the structural and functional prediction of proteins and also to identify biomolecules. Homology modelling predicts the 3D structure and function of proteins. The predictive capacity of *in silico* models reveals useful information from unknown genes and 3D molecular structures of target protein. An attempt was made to annotate unknown sequences using *in silico* models. The unknown functional genes of WSSV were retrieved from NCBI data bank (AF411634.1, AY048541.1 and AY048546.1). Functional site prediction and *in silico* analysis for these genes was carried out using online bioinformatic tools. The protein structure was carried out using homology modelling based on the template obtained from protein database (PDB). Protein structure checking tool PROCHECK was used for the validation of the Ramachandran plot quality (Fig. 23). For these proteins, secondary structure, disulphide linkages, motifs and profiles were predicted. Two motifs, gene envelope family and calcium-binding domain sites were predicted using motif finder.

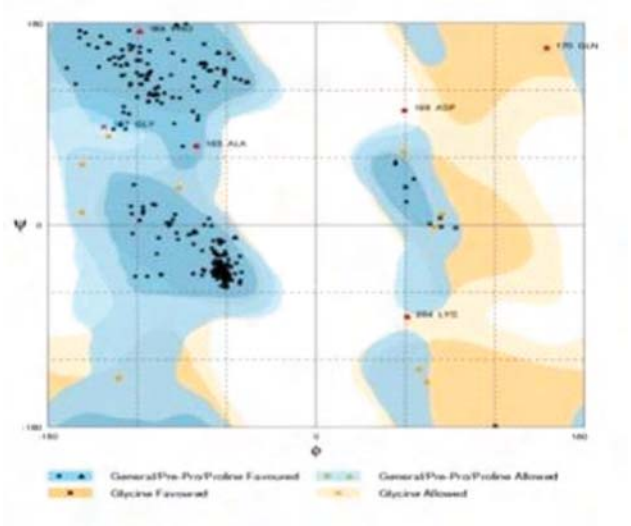


Fig. 23. Validation of Ramachandran plot of modelled protein obtained using PROCHECK

Incidence of diseases in shrimp zerowater exchange system and polyfarming

Zerowater exchange shrimp monoculture systems in West Bengal were surveyed to document the disease incidence and the results indicated that white spot disease (11.76 %), black spot (vibriosis)

(3.92 %) and difficulty in moulting (5.88 %) were the major disease problems. Polyfarming ponds showed copepod infestation and *Caligus epidemicus* in *Etroplus suratensis*. In addition, a rare case of spinal cord defect was observed in *Mugil cephalus*.

Effect of antibiotics application on shrimp seed transport and grow out culture

As part of the study on evaluating the antbiotic residues in shrimp, the survival rate of chloramphenicol, furazolidone and ciprofloxacin treated *P. monodon* seed during transport were studied and found to be significantly higher ($P<0.05$) than untreated seed. Average body weight (ABW) after 134 days of culture (DOC) was 17.40 g in control and 21.92 g in antibiotic treated seeds with FCR of 2.11 and 2.08 and survival rate of 40 % in the treated and control. Comparison of seasonal performance revealed that the ABW was 25.79 g in monsoon and 13.53 g in winter crop with FCR of 1.62 and 2.57 and survival rate of 56 and 25 % respectively, with significant difference in FCR ($P<0.01$) and survival rate ($P<0.05$). No significant differences were observed in hematological parameters, whereas significant differences ($P<0.01$) were observed in water and soil quality parameters between monsoon and winter crop but not with respect to antibiotic treated and control groups.

Transmission models for betanodavirus infection in finfish

Zebra fish (*Danio rerio*) as a potential laboratory model to study the transmission of betanodavirus in fish was studied. Challenge experiment by immersion method was carried out in triplicates of 20 fish (TL=2.80 cm, ABW=0.27 g) each and a control group of 20. The test fishes were maintained in 50 ml of filtered fresh water inoculated with 2 ml of the cell culture soup procured from C. Abdul Hakeem College, Melvisharam (Vellore). Fishes were maintained for 2 hours in the bath and were transferred to 5 L containers holding 2.5 L of water. The control group also was treated similarly but with 2 ml of cell culture media instead of cell culture soup. Challenge experiment by immersion did not elicit clinical manifestations or mortality in test groups or control groups up to a period of three weeks. Six samples from each group were pooled separately after the experiment to check the presence of virus by Real Time-PCR as per the optimized test system in the laboratory. All groups were devoid of any specific bands in the gel and so were declared betanodavirus negative. The virus could not invoke clinical manifestations in fish during the period of observation suggesting either the transient nature of the host for the viral strain or very low viral load beyond the detection level or even complete viral clearance from the host system.

In yet another study on an earlier field isolate of seabass from Andhra Pradesh, the molecular phylogenetic analysis revealed that the genotype of betanodavirus revealed complete homogeneity of the capsid protein gene to that of seven band grouper nervous necrosis virus strain SGWak97 (Acc. No. AY324870). This finding confirms the existence of RGNNV genotypes in Indian fishes known to infect warm water fin fishes.

Herbal drug *Withania somnifera* enhances immunity in *Penaeus monodon*

Among the herbal drugs, *Withania somnifera* has been reported to induce immune modulating effect in human and other domestic animals. An experiment was carried out to investigate the immune enhancing ability of powdered drug *W. somnifera* in shrimp. In an earlier experimental study, the beneficial effects of this drug on physicochemical parameters and microbial quality of water and immune response parameters of shrimp were observed. In continuation to this, different concentrations of the drug (0.25, 0.50, 0.75 and 1.0 g per kg feed) was coated onto the feed and fed for 45 days to two groups of shrimp with average weight of 1.73 g and 9.26 g respectively. The control was fed with out

incorporating the herbal drug. At the end of the experiment, the groups of larvae were challenged with *Vibrio harveyi*. The results revealed that larvae administered with the drug @ 0.75 g/kg recorded the highest survival of 36 % (Fig. 24). Based on the present study, *W. somnifera* powder appears to be a potential prophylactic agent against *V. harveyi* and WSSV infection of shrimp.

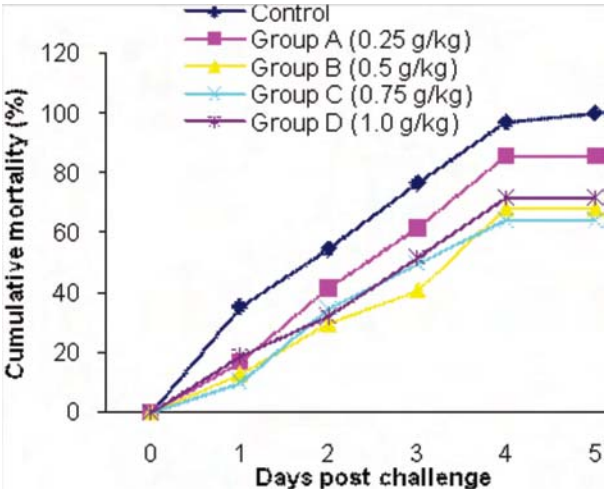


Fig. 24. Cumulative mortality in *P. monodon* larvae administered with varying doses of *W. somnifera* following challenged (Group A - 0.25, B- 0.50, C- 0.75 and D-1.0g per kg feed)

Protective effect of yeast expressed WSSV baits against the virus

The protective effect of two white spot virus (WSSV) proteins (VP28 and VP15), that were used as baits for yeast two-hybrid and transformed to yeast in a previous attempt, was verified. *P. monodon* postlarvae (PL8) were either fed directly or the yeast cells were initially fed to artemia and thereafter given to shrimp larvae. After 5 days of continuous feeding, the larvae were subjected to formalin and salinity stress tests and challenged with WSSV orally. Shrimp larvae fed with yeast cells, either with the bait or the empty vector, exhibited better survival and stress tolerance than the control larvae. When challenged with the virus, the survival significantly ($P<0.01$) varied between the treatments and also between the time points ($P<0.01$) and their interactions. In the control, there were no survivors after 72 hrs. After 72 hrs there were survivors in all the treated groups and at the end of 96 hours, larvae that were fed with yeast cells containing the WSSV proteins (either directly or through artemia) and showed significantly higher survival than the larvae fed with the vector only, clearly demonstrating the enhanced protective effect of WSSV proteins (Fig 25).

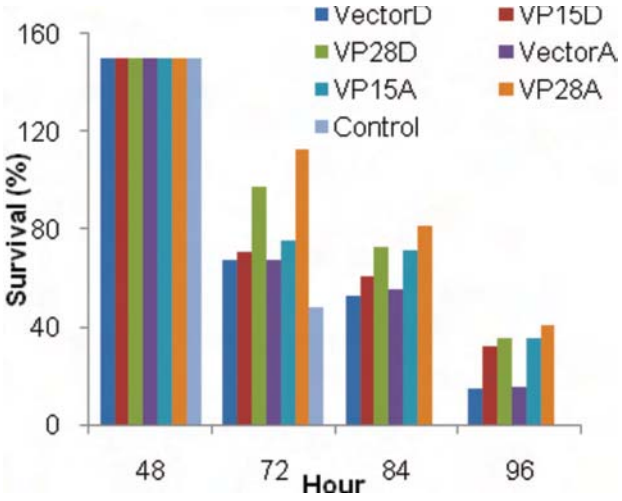


Fig. 25. Survival of shrimp larvae fed with yeast cells and challenged with WSSV (Fed yeast cell directly – Vector D, VP15D, VP28D; Yeast cell fed through artemia - Vector A, VP15A, VP28A)

Investigation of zoea syndrome in *Litopenaeus vannamei*

A survey was conducted in thirteen *L. vannamei* hatcheries (6 in Tamil Nadu and 7 in Andhra Pradesh) relating to the loss incurred by Zoea syndrome and to comprehend the etiology. It was reported that the hatcheries had encountered and experienced 80-90 % mortality in a cycle due to zoea syndrome during their initial stage of hatchery establishment when there was no proper biosecurity awareness. Information collected from the hatcheries revealed that the problem could be avoided following strict biosecurity measures. Water and zoea samples from hatcheries revealed normal bacterial load ranging from $2.4x10^2$ cfu/ml to $1.6x10^3$ cfu/ml. The histological examination of the zoea samples appeared normal. From feedback given by hatchery owners, it was felt that this is more of a management problem and does not warrant further investigation.

Investigation of white gut syndrome of *Penaeus monodon* in grow-out culture

Of late, many *P. monodon* grow out ponds were reported to have whitegut disease followed by mortality. Hence the economic importance and occurrence of whitegut disease in tiger shrimp farms was assessed by surveying 12 farms (3 farms in Andhra Pradesh and 9 farms in Tamil Nadu). The white gut affected shrimp exhibited stunted growth with reduced feed intake. The gut was empty and appeared opaque. Suspected shrimp samples were collected from various tiger shrimp farms for microbial examination. The hemolymph and gut samples were subjected to total plate count and it was observed that the samples collected from a farm at Saphale (Maharashtra) had $3.5x10^5$ cfu/ml and $5.2x10^6$ cfu/ml, respectively. The isolated bacteria from affected shrimps were identified as *V. harveyi* and *V. parahaemolyticus.*

Project Title (NBAIM/ICAR)	**Application of micro-organisms in agriculture and allied sectors - Microbial diversity and identification**

The objective of this study was to optimize the expression of the economically important genes of microbes using different vector systems. Pectinase comprises a group of enzymes such as pectolyase, pectozyme and polygalacturonase which break down pectin, a polysaccharide substrate found in the cell walls of plants. Optimum growth condition for pectinase production, such as pH and temperature were standardised. The optimum pH and temperature found to be between pH 6-8 and 30-37ºC depending upon the bacterial species. Another important activity involved cloning and expression of isopentyl transferase (ipt) gene from *Agrobacterium tumefaciens*. The *Agrobacterium ipt* gene encoding cytokinin isopentenyl transferase increases the levels of endogenous cytokinin and effectively enhances resistance of plants to hornworm infection. The *ipt* gene was amplified from *A. tumefaciens* and cloned in pET32A vector system and transformed in to *E. coli* DH5α and the expressed proteins confirmed by SDS PAGE (Fig 26)**.**

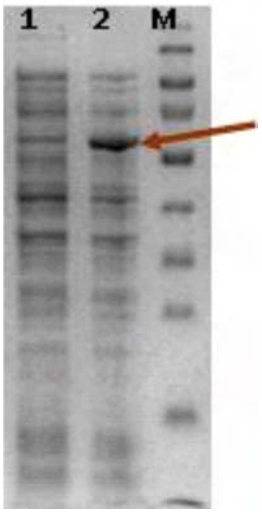


Fig.26. SDS PAGE showing expression of isopentyl transferase gene in *E.coli BL21* (Lane 2)

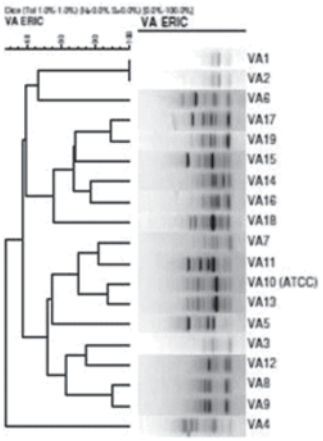


Fig. 27. Phylogenetic analysis of *V. alginolyticus* isolates from east coast based on ERIC-PCR

As part of the microbial diversity investigation, 18 isolates of *V. alginolyticus* from various brackishwater ecosystems were confirmed using 16s rRNA gene-specific primer. Molecular typing of these isolates was carried out using ERIC PCR which yielded products with the size range of 400bp to 2.5kb. Phylogenetic analysis was carried out using fingerprinting II software (BioRad, USA). The isolates could be separated into five clusters based on geographic location with three major clusters at 40 % hierarchical level (Fig 27). Another important activity was to establish a repository of these microbes with bioactive potential for *ex situ* conservation of microbial biodiversity and future biotechnological applications. In this context, recombinant plasmids carrying catalase, chitinase, azurin, lipase and betaine aldehyde dehydrogenase genes were deposited in the NBAIM genomic repository.

Project Title (NBAIM/ICAR)	Bioremediation of effluents from shrimp farms

The objective was to develop bioremediation tools for ammonia, nitrite and sulphide mitigation in shrimp hatcheries and grow-out ponds. For the period 2011-12, improvement of nitrifying-denitrifying biofilter for ammonia, nitrite and sulphide removal was undertaken using commercially available carrier materials such as bio-balls and ceramic rings prepared by enriching these media with chemolithotrophic AOB, NOB and denitrifying bacteria. Nitrite and ammonia levels could be maintained below detectable limits for over 18 days without water exchange using these biologically enriched media in laboratory scale aquaria and ammonia spiked experiments.

Bioballs prepared using filamentous sulfur oxidizing bacteria (*Beggiatoa* sp)

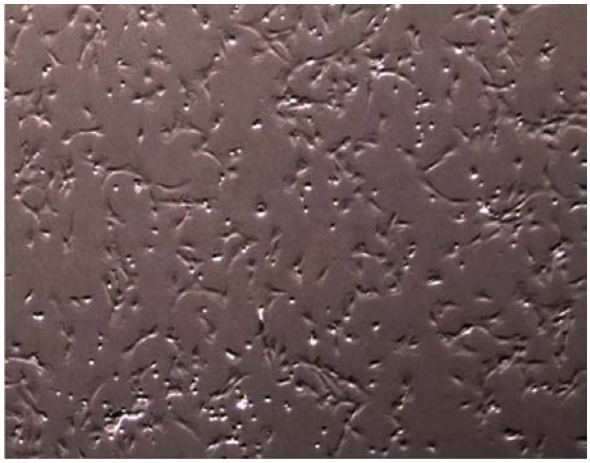
A similar biofilter using commercial media colonized with filamentous sulphur oxidizing bacteria, *Beggiatoa* spp was also examined for sulphide removal. The *Beggiatoa* spp were found to ameliorate sulphide levels efficiently *in vitro*. Lab-scale biofilters using bio-balls enriched with chemolithotrophic AOB, NOB and denitrifying bacteria, and filamentous sulphur oxidising bacteria were found to be successful in maintaining ammonia, nitrite, and sulphide levels.

Project Title (DBT)	Development of in vitro system from *Fenneropenaeus indicus* and freshwater crab *Paratelphusa hydrodomous* for WSSV replication, pathogenesis and quantification

The development of laboratory based systems for the investigation of viral disease of shrimp such as White Spot Disease is crucial to understand the infectious agent and the disease process. Adaptation of WSSV virus to grow in laboratory conditions as in cell culture, aid in developing a range of diagnostic tests and vaccines.

Attainment of maximum passages and possibility of establishment of permanent cell lines

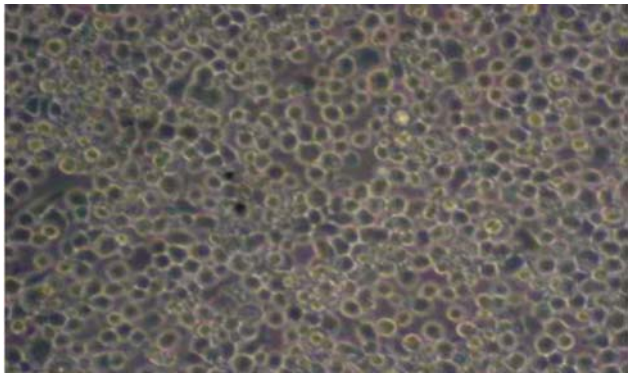
The growth factors IGF-II, bFGF and shrimp hemolymph serum (1 %) were deployed to stimulate the proliferation of hemocytes and ovarian cells from *Fenneropenaeus indicus*. A significant stimulation effect on cell proliferation with addition of growth factors was observed. The cells grew and proliferated rapidly, formed confluent hemocytes and ovarian monolayers in 3-5 days with predominantly fibroblast-like type of cells following 4 days incubation. These cells could be sub-cultured for 5-6 passages with supplementation of growth factors and regular replacement of the medium. Later, the fibroblast-like cells disappeared, and hence subcultures could not be maintained.



Fibroblastic nature of primary hemocyte culture with supplementation of growth factors

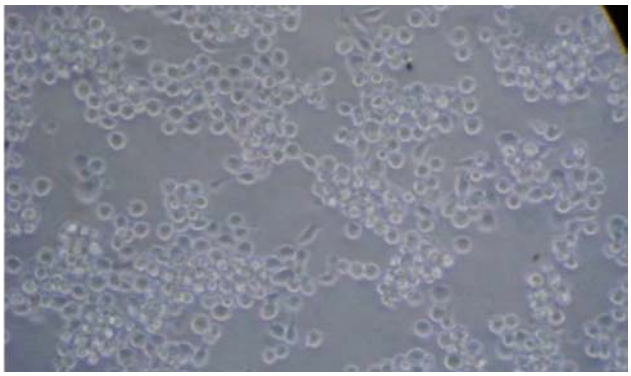
Susceptibility of primary cell culture of *F. indicus* to WSSV

Attempts were made to test the susceptibility of primary hemolymph and ovarian cell culture systems to white spot syndrome virus (WSSV). The WSSV were inoculated in primary hemocytes and ovarian cultures. Cytopathic effects (CPE) were observed after 2- 3 days post inoculation. CPE was characterised by highly refractile bodies, cell shrinkage, small clumps of cells and detachment of cells. Uninoculated cells remained without obvious change throughout the experimental period. CPE became more pronounced by third passage in hemocytes culture and by fifth passage in ovarian cultures. The study revealed the usefulness of primary hemolymph and ovarian cell cultures for *in vitro* replication of WSSV.



a

Control



b

Primary ovarian culture infected with WSSV showing CPE

Confirmation of the multiplication of WSSV in shrimp cell culture

The confirmation of WSSV replication in *in vitro* system tested by PCR was found positive. The WSSV copy number was quantified by qRT-PCR. This confirmed viral replication in the primary cultured cells. Using an anti-WSSV polyclonal antibody, VP28 capsid protein was detected by Western blot analysis. Further experimental pathogenicity studies were carried out on shrimp resulting in 90 - 95 % mortality by 8 -10 days p.i on trials with cell culture supernatants from hemocyte and ovarian cultures. The samples were screened for WSSV and found positive by PCR and qRT-PCR. High copy numbers ($2.98x10^9 – 7.8x10^9$ copy numbers g^{-1} tissue) were found in WSSV infected primary hemocyte and ovarian cultures respectively. The primary cell culture systems were found useful as *in vitro* models for studies on WSSV replication and gene expression.

Project Title (DBT)	**Horizontal transmission and infectivity of white spot syndrome virus in brackishwater aquaculture ecosystems**

The objectives of the project were to develop protocols for concentration and enumeration of WSSV in pond water and sediment, comprehend the horizontal transmission of WSSV in aquaculture ponds by studying occurrence, WSSV load in pond water and sediment and its prevalence in the farmed penaeids and passive hosts including benthic crustaceans and planktonic crustaceans and study the duration of infectivity of host-free WSSV virions. Protocols for concentration and enumeration of WSSV in pond water and sediment were standardized using 40-100 L of water. Viruses in culture ponds were concentrated by ultrafiltration and occurrence of WSSV examined in 18 samples from culture ponds, creeks and hatcheries. Efficacy of recovery of WSSV by tangential flow filtration (TFF) and poly ethylene glycol (PEG) precipitation methods were standardized for concentration of viruses from water. For comprehending the efficacy of recovery by TFF, the experiment was carried out nine

times by spiking 10 L virus free water with known counts of WSSV and recovering the viruses by TFF involving steps of purification of WSSV by density gradient ultra centrifugation (Fig 28), quantification of WSSV by Real-Time PCR (Fig 29), addition of known count of WSSV to virus free seawater and again concentration of WSSV by TFF, followed by DNA extraction from viral concentrate and quantification of WSSV by Real-Time PCR. Efficacy of recovery of WSSV from water by TFF was found to be 100 % (at all times WSSV could be recovered) and 7.5 to 51.6 % of WSSV was recovered by this method. Protocols for enumeration of viruses in brackishwater ponds were also standardized by epifluorescence microscopy. The viral counts in brackishwater samples ranged from 1.6-4.9 x 10^7 ml^{-1} in shrimp culture ponds, 1.3-1.5 x 10^5 ml^{-1} in shrimp hatcheries and 3.3-4.2 x 10^9 g^{-1} in sediments.

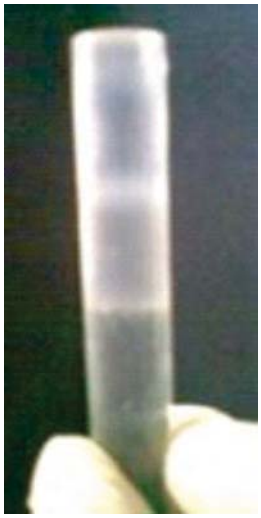


Fig. 28. Purification of WSSV by sucrose gradient

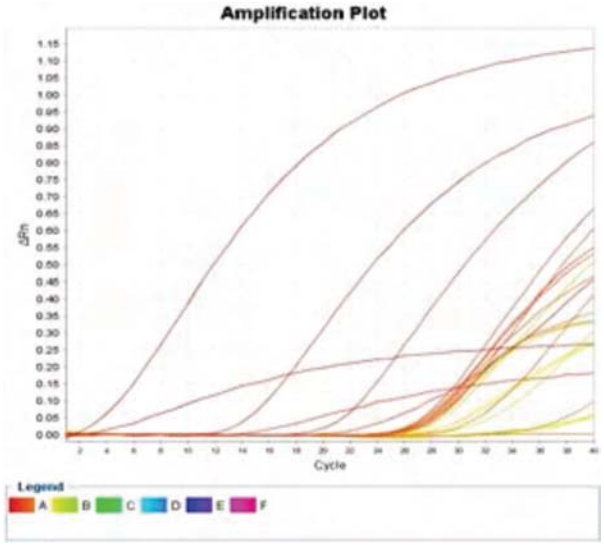


Fig. 29. Quantitative real-time PCR plot of WSSV

Role of bivalve molluscs in the removal of WSSV was examined. *Meretrix meretrix* were collected from Muttukadu lagoon and screened for WSSV by nested PCR. Animals devoid of the virus were maintained in WSSV-free sea water, fed with algae *Nannochloropsis* and *Chlorella*. After adaptation, the tanks were spiked with 100 WSSV ml^{-1} (final count in water). The presence of WSSV was examined by nested PCR periodically at 24 h, 48 h, and 72 h intervals. The virus could be detected up to 48 h by nested PCR and quantitative real time PCR. However, the clam faecal mater and tissue were devoid of the virus.

Filtration of WSSV by clams

Project Title (DBT-NORWEGIAN Project)	**Development of bacterial vaccines (*Vibrio anguillarum*) for sea bass**

V. anguillarum is an important causative agent of classical vibriosis in seabass. It is important to identify immunogenic antigens of *V. anguillarum* to develop suitable vaccines for controlling vibriosis. The work envisages cloning of gene(s) associated with immunogenic antigens for developing DNA based vaccine.

Standardization of experimental challenge protocols

Challenge experiments were carried out with heat-killed and formalin-inactivated vaccines by immersion and artemia enrichment. The survival with formalin inactivated and heat killed vaccines were 94.3, 87.7, 67.5, and 85 % respectively by immersion and artemia enrichment trials. Serum samples were collected and the immune response was assessed by ELISA and Western blotting.

Cloning and expression of *Vibrio anguillarum* OMP and immunoblotting

Cloning and expression of outer membrane protein genes revealed the epitope being present in the surface of the *V. anguillarum* pathogen. This could result in finding a better epitope and a good vaccine candidate against *V. anguillarum*. The OMP K is a major expressed protein on the surface of *V. anguillarum.* The OMP K was amplified from pathogenic *V. anguillarum,* cloned and expressed *in vitro* (Fig 30).

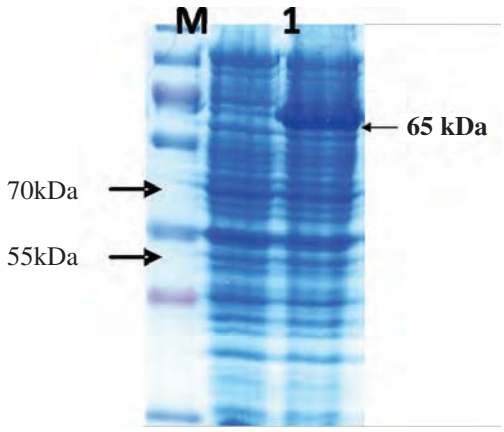


Fig 30. Expression of OMP K , surface immunogenic protein of *V. anguillarum* in BL21
(M : Protein marker; Lane 1 : Uninduced BL21 cells (Control); Lane 2 : Induced expression of OMPK in BL21 cells)

The 2D gel separation of outer membrane proteins (OMPs) from pathogenic *V.anguillarum* was carried out using 2D gel electrophoresis. Identification of immuno-responsive native proteins of *V. anguillarum* from whole cell lysate was carried out by immunoblotting**.** The efficacy of these vaccines developed will be tested using suitable bioassay systems.

Project Title (Institute)	Technology development for environmental management in brackishwater aquaculture

Bioremediation using agro-waste products – effect of carbohydrate addition

The efficiency of cassava waste biomass (CWB) and sugarcane bagasse (SB) substrates for bioremediation of metabolites in brackishwater was evaluated in a yard experiment in 100 L fibre reinforced plastic (FRP) tanks (in triplicate) for 42 days and it was tested with and without carbohydrate addition using tapioca starch (TS). The materials were analysed for proximate composition and fibre fractionation. Crude protein content was more in SB whereas crude fibre content was less in CWB (Table 10). The CWB appears to be a comparatively more bio-degradable substrate than SB with more cellulose and less lignin content compared to SB (Fig.31). Ammonia induction was carried out using ammonium sulphate. Analysis of water samples collected at periodic intervals revealed low mean values of total ammonia nitrogen (TAN), nitrite N, and total *Vibrio* count ($P < 0.01$) and high total

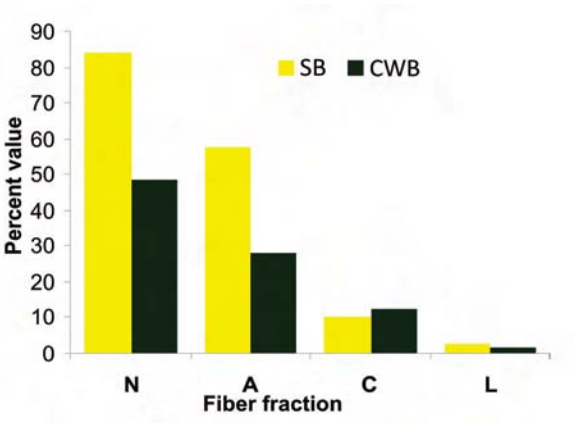


Fig. 31. Fibre fractionation in cassava waste biomass (CWB) and sugarcane bagasse (SB) used for bioremediation (N-Neutral detergent fibre, A - Acid detergent fibre , C –Cellulose, L -Lignin)

heterotrophic bacteria count ($P < 0.01$) in treatment groups. The TAN and nitrite N reduced between 19 to 41 % and 13 to 26 % respectively in treatment groups. The treatment groups with TS were observed to be more efficient for bioremediation of metabolites compared to the use of substrate alone. Among the substrates, CWB was able to reduce metabolites more efficiently than SB. Characterisation of the microbial flora on the biofilm of substrates revealed mostly gram negative organisms.

Table 10. Proximate composition of materials used for bioremediation

Material	Fresh material (%)			Dry matter basis (%)		
	Moisture	Crude protein	Crude fibre	Ether extract	Total ash	Nitrogen free extract
SB	10.6	3.4	41.7	0.44	1.2	53.3
CWB	7.6	5.1	13.0	0.53	5.8	75.5
TS	11.4	0.6	ND	0.23	0.2	98.9

CWB - Cassava waste biomass, SB - Sugarcane bagasse, TS- Tapioca starch, ND – Not detectable

Another experiment was conducted in 500 L FRP tanks with shrimp (ABW:1.76 g) for 87 days with effective treatments (CWB, CWB + TS, TS) and control in triplicate. Mean average body weight of shrimp was significantly ($P < 0.01$) higher in the treatment groups with CWB followed by TS and CWB + TS (Fig. 32) compared to control and was correlated with the reduction in TAN by 67, 60 and 51 % in treatment groups with CWB, TS and CWB + TS respectively. Cassava waste biomass appears to be a suitable substrate for bioremediation of metabolites and for augmenting shrimp growth. The actual mechanism of which the growth is enhanced needs to be validated.

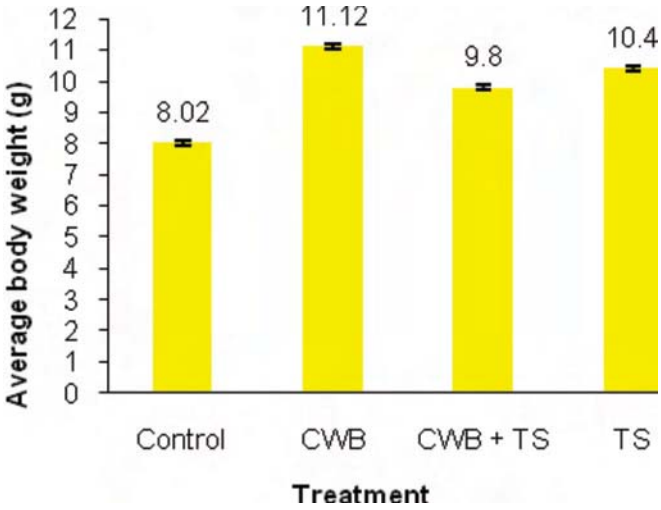


Fig.32. Effect of different treatments on shrimp growth

Microbial dynamic populations in different shrimp culture practices

In order to comprehend pond microbial dynamics, the bacteria involved in nitrogen and sulphur cycling, enumeration of ammonia oxidizing, nitrite oxidizing, sulphur oxidizing and sulphur reducing bacterial population, total vibrio load, total heterotrophic bacterial load, and composition of pathogenic *Vibrio* (*V. harveyi*, *V. anguillarum*, *V. alginolyticus*, *V. parahaemolyticus*), monitoring of soil and water quality parameters was carried out in different types of commercial shrimp culture systems in Nagapatnam district, Tamil Nadu. Based on the culture operations, shrimp culture farms were classified into four categories: Group I (Extensive *L. vannamei*), Group II (Semi-intensive *L. vannamei*), Group III (High input *P. monodon*) and Group IV (Low input *P. monodon*). Culture practices followed in different groups along with water quality parameters are depicted in Table 11. Probiotics were applied in all the groups. No definite trend could be observed in the population of all the microbial groups investigated. Soil and water parameters were in the optimum range in all the groups.

Table 11. Culture practices and water parameters (Mean ± SD) in varying culture

Parameter	*L. vannamei*		*P. monodon*	
	Extensive	Semi-intensive	High input	Low input
SD (nos./m^2)	10	28	9	7
DOC	90	80	143	130
Aeration	after 10th day 4h/day	after 5th day 8 h /day	after 40th day 2 h/day	After 60th day 2 h/day
FCR	1	1.2	1.6	1.3
SR (%)	94	89	67	84
ABW (g)	32.3	25.3	35.6	29.5
Production (t/ha)	3.03	6.1	2.14	1.73
Water parameters				
pH	8.1 ± 0.3	8.2±0.3	8.2±0.5	8.3±0.3
TAN (ppm)	0.46±0.28	0.45±0.43	0.43±0.71	0.35±0.28
Nitrite-N (ppm)	0.03±0.06	0.03±0.04	0.07±0.18	0.03±0.02
Nitrate-N (ppm)	0.17±0.38	0.12±0.13	0.35±0.84	0.16±0.32

The varying trend of microbial population in ponds during the culture period could partly be attributed to the application of probiotics and this needs further investigations to relate the different microbial levels observed.

Use of ^{15}N tracers to understand the nitrogen pathway in shrimp

Soya bean micro-plot cultivation

Feed is the major protein source for shrimp. Plant protein source is one of the ingredients for nitrogen content in shrimp feed beside fish meal and tagging this nitrogen source with ^{15}N stable isotope aids in comprehending the nitrogen pathway in shrimp. Soya bean CO-3 variety was sown in micro plots and ^{15}N enriched urea (30 % atom excess) was applied in split doses and harvested after 130 days to tag the N in the soya seeds. The ^{15}N enriched soya meal was prepared from ^{15}N enriched soya bean by hexane extraction method. It contained 43.73 % protein, 5.85 % fat and 9.19 % lipid. The ^{15}N content in soya meal analysed by mass spectrometer showed 3.14 % of ^{15}N out of 6.99 % of total nitrogen. The soya meal so prepared would be used in the preparation of shrimp feed to trace the nitrogen pathway in shrimp.

Effect of ZnO nano particles on aquatic animal health

Zinc oxide nanoparticles exhibited enhanced antibacterial property against *Vibrio harveyi*. An experiment was carried out for 12 days to evaluate the impact of zinc oxide (Zno) nanoparticles on *Etroplus suratensis* through oral administration of different sizes (50 nm and 100 nm) and concentrations (10, 50 and 100 ppm) of ZnO nanoparticles. They were fed standard fish diet with continuous aeration. Animals were sampled on the 6th and 12th day for various biochemical determinations, hematological and enzyme analysis. Preliminary results revealed that in treatment tanks, animals were healthy whereas there was no significant difference between treatments and control with respect to alkaline phosphatase enzyme concentration in muscle and gill tissues.

Monitoring of traditional shrimp farming systems

Two traditional Pokkali fields, 12.5 ha at Edavanakadu (Farm-1) and 5 ha at Adavankadu (Farm-2) located on Vembanadu canal in Kerala, and two small (0.05 and 0.2 ha) and two large (4 and 10 ha) bheris located on the banks of Moriganga river in South 24 Parganas District, West Bengal were selected for monitoring the traditional shrimp farming systems.

In Pokkali fields, both shrimp and fishes were allowed to enter through tidal water and additional stocking of hatchery seeds *(P. monodon)* was carried out @ 4.5 lakhs in Farm-1 and 2 lakhs in Farm-2. Harvesting was carried out during full moon and new moon days. The normal duration of Pokkali paddy is nearly 120 days from June to October. The monthly water and soil quality parameters from October 2011 indicated that these parameters were optimum for shrimp farming. The salinity ranged from 5 to 20 ppt and the average pH values were 7.3 and 7.2 in farms 1 and 2 respectively (Table 12). The soil pH was acidic, the organic carbon content being high. The selected bheris were stocked with multiple species of shrimp and fishes *viz*. *P. monodon*, *Macrobrachium rosenbergii*, tilapia sp, *Liza parsia* and also catla and rohu during the rainy season. *Lates calcarifer* is not a part of regular stocking practice and it enters the culture system by water inflow during the lunar cycle. The stocking pattern of tiger shrimp is 12-16 times in a year at regular intervals of 15-21 days and other species are stocked once during the culture. This repeated stocking pattern leads to co-existence of shrimp in different age groups and renders harvesting possible at every lunar cycle, starting by April and continuing upto November. The routine monitoring of bheris for water parameters from November onwards revealed that the salinity ranged from 8.5 ppt in December to 18 ppt in March. The pH tends to increase in summer compared to winter (7.5 to 8.5). The TAN, nitrite N and nitrate N ranged from 13.8 to 41.6 µg/L, 1.4 to 17.8 µg/L and 16.9 to 66.2 µg/L respectively. It has been planned to monitor the pokkali fields and bheris for a year to build up a database.

Table 12. Water and soil quality in Pokkali fields (Mean followed by range in parentheses)

Pond details	Farm-1	Farm-2
Water parameters		
pH	7.3 (6.8-7.6)	7.2 (6.9-7.6)
Salinity (ppt)	12 (5-20)	12 (5-20)
TAN (ppm)	0.11 (0.02- 0.42)	0.09 (0.03-0.18)
Nitrite N (ppm)	0.03 (0.003-0.10)	0.03 (0.004-0.09)
Nitrate N	0.61 (0.08 -1.23)	0.62 (0.3-1.04)
Phosphate (ppm)	0.18 (0.03-0.29)	0.06 (0.02-0.12)
Total alkalinity (ppm)	126 (109-148)	94 (74-107)
Total hardness (ppm)	1973 (754-3548)	2115 (612-3649)
Calcium (mg/l)	171 (85-388)	189 (85-432
Magnesium (mg/l)	314 (129-496)	376 (100-650)
Soil parameters		
pH	6.6 (6.1-8.0)	6.32±1.14 (5.1-7.9)
EC (dS/m)	1.38 (0.38-1.07)	1.48±0.88 (0.73-2.57)
Organic carbon (%)	0.8 (0.42-0.98)	0.75 (0.36-0.96)
Available P (ppm)	26.9 (16.6 - 33.3)	19.9 (13.3-27.7)

Impact of *L. vannamei* farm discharge water on the receiving water body

Water quality was monitored in the water body receiving discharge waters from *L. vannamei* culture

Table 13. Water quality in the water body receiving discharge water from *L. vannamei* farms

Parameter	Discharge water at outfall (OF) area	Receiving Water Body (away from OF area)				Prescribed standard suggested by CAA at final discharge point
		100 m	250 m	500 m	1 km	
pH	7.72	7.54	7.61	7.45	7.39	6.0-8.5
TSS (ppm)	84.3	74.9	81.2	76.2	75.2	100 (max)
TAN (ppm)	0.58	0.41	0.32	0.24	0.21	0.5 (as unionized ammonia max.)
Total N (ppm)	4.24	3.84	2.0	1.64	1.72	2 (as N max.)
Phosphate	0.378	0.289	0.194	0.134	0.121	0.2 (as dissolved phosphate max.)

farms at Tuni in East Godavari district, Andhra Pradesh. Except for total N and phosphate, all the parameters were well within the optimum range at outfall (OF) area. Though total N and phosphate values were high at OF area, it reverted to normal standard values prescribed for discharge waters at 500 m and 250 m away from OF area respectively (Table 13).

Project Title (NACA)	**Strengthening adaptive capacities to the impacts of climate change in resource- poor small scale aquaculture and aquatic resources dependent sector in the South and South-East Asian regions - Indian case study: Impact of climate change on shrimp farmers and small scale farmers in low-lying coastal lands on East Coast of India**

Technical efficiency of shrimp farmers in overcoming negative imapcts of climate change

The technical efficiencies of the farmers in the study area, Krishna district in Andhra Pradesh was explained through Stochastic Frontier Function using as inputs, socio-economic variables such as stocking density (SD), farming experience in years (FEXPYR), water spread area (WSA), education level (REPEDU), trainings undergone or not (TRNATTND) and member of Society or not (SOCNSOC), and climatic variables such as cyclone storm – level of success (CYCLS), flood from heavy rain – level of success (FLDLS), irregular season observation (IRSOBSV), observation of low temperature change (LTEMOBS) and drought observation (DRTOBS). A 100 % technically efficient farm produces maximum possible output using all the resources in an optimal way. The mean technical efficiency in the present study was estimated to be 87 % and about 54 % of the farmers are more than 90 % efficient. The high efficiency may be attributed to the use of better quality feed, seed and adoption of latest technology in farming. However, a majority of these constitute large farmers who were carrying out intensive and semi-intensive method of cultivation whereas, small scale farmers mostly practise extensive method of cultivation. The discrepancies in efficiencies are explained by regressing technical efficiency with different adaptation strategies to overcome the negative effects of climate change besides the socio-economic and demographic factors of the individual farmers.

Among socio-economic variables, stocking density, farming experience and society membership has significant influence on the efficiencies (Table 14). The coefficient of the SOCNSOC is significant and positive indicating that non-society members were more efficient than society members. This could be attributed to the fact that most of the non-society farmers in Krishna District were farmers with large holdings. Among the climatic variables, cyclone storm – level of success and flood from

heavy rain – were the only two variables which were significant. Further, the coefficient of these variables were positive indicating that those farmers who had successfully overcome the negative effect of cyclone storm and floods have increased their efficiency levels. All other climate variables were found to be non-significant.

Table 14. Efficiency differentials across shrimp farmers in the study area

	Coefficients	SE	t Stat
WSA	-0.00250	0.00316	-0.791
SD	0.00215	0.00110	1.958*
FEXPYR	0.00073	0.00041	1.771*
REPEDU	0.00050	0.00260	0.193
TRNATTND	0.00269	0.01534	0.175
SOCNSOC	0.27589	0.01467	18.805**
CYCLS	0.01641	0.00484	3.393**
FLDLS	0.01238	0.00475	2.607**
IRSOBSV	0.00575	0.00550	1.046
LTEMOBS	0.00073	0.00496	0.146
DRTOBS	-0.00180	0.00460	-0.391
R^2	0.895		
F-statistic	203.9		
Intercept	0.33707		

*Significant at 10 % level; ** Significant at 1 % level

Predictions on future sea level, rainfall and temperature

The predictions of climatic variables such as rainfall and temperature (maximum and minimum), and sea level rise (SLR) were calculated for 2020 and 2050 and compared with the present levels.

SLR is already occurring in the case study area in Nagapatnam and an increase of almost 10 cm has been measured between 1940 and 1995. Under the A2 scenario, it was predicted to rise by 8 cm by 2020 and 18 cm by 2050. However, sea level is rising more quickly than predicted and if the observed SLR continues at the present rate, then sea level could be 12 cm higher in 2020 and 30 cm higher in 2050. Increasing SLR will also result in increased saltwater intrusion into the river delta areas. This, in conjunction with stronger and more frequent storm surges may result in seawater flooding of farms close to the coast and in low lying areas.

Rainfall and temperature scenarios are based on simulated changes averaged over broad south-west and north-east monsoons. There is not much difference in average monthly rainfall from the present to the predicted scenarios during January to May, August, September, November and December months in 2020 and 2050. There will be a decrease in rainfall during July 2020 compared to the present value and increase in 2050, whereas increase in rainfall compared to the present value is predicted during June 2020 and 2050 (Fig. 33). Peak rainfall was observed (269 mm) in the month of October at present and the predictions showed a decreasing trend during 2020 and 2050. It is assumed that probability of rainfall distribution will be 13 % less in the month of October.

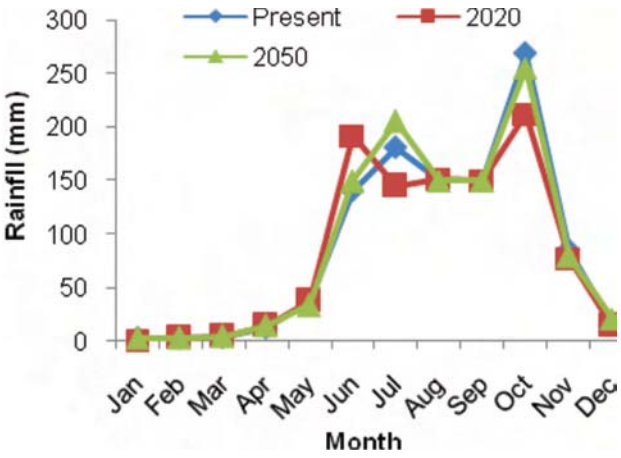


Fig. 33. Rainfall prediction scenario in 2020 and 2050

Average monthly maximum temperatures will increase by 0.65°C by 2020 and 1.84°C by 2050 and also hot weather spells would linger for longer periods. The present peak average temperature occurring in May to June would be the same or could be more in 2020 and 2050 posing significant risks. Since there will not be much change in rainfall, the increase in temperatures will have an adverse effect on

the water availability in source waters and changes in water quality parameters thereby affecting shrimp growth. The prediction showed that the lowest minimum temperature is expected to be warmer by more than 2°C in 2020 and 2050 compared to the present. The increase in temperature during winter months would have a beneficial effect on pond productivity and shrimp growth with better food conversion rate and reduced white spot disease outbreaks.

Project Title (NICRA)	**National Initiatives on Climate Resilient Agriculture (NICRA) – Impact of climate change on aquaculture and mitigation options for minimizing green house gases from aquaculture sector**

The major objectives of the project are documentation of the impact of climate variables on aquaculture, assessment of green house gases (GHGs) emission, pond management interventions to minimize the GHGs emission and mitigating the climate change (CC) impacts on aquaculture.

Documenting the impact of climate variables on aquaculture - development of methodology

Data related with CC events, perceived impacts, risk assessment, vulnerability, adaptations and mitigations were collected from four districts, one in each coastal state *viz.*, Nagapatnam in Tamil Nadu (TN), West Godavari in Andhra Pradesh (AP), Alappuzha in Kerala (KL) and South 24 Parganas in West Bengal (WB) using the developed three stage robust methodology, i) Focus group discussions with 20-30 farmers in two representative villages of each of the identified district to document farmers' exposure in relation with climatic variations and extreme climatic events, their impacts including economic impact (production/economic loss), risk assessment, adaptations/solutions and mapping of seasonal and cropping calendars, ii) Stakeholder workshop at the district level involving representatives of all key stakeholders to identify farmer, researcher and policy adaptations for the CC impacts identified in the FGDs and, prioritise them with a time line and responsible agencies, iii) In-depth farm survey with 120 practicing shrimp farmers in each identified district to collect data on CC impacts, exposure, sensitivity, farming practices, infrastructure, institutions, socio-economics, adaptations and mitigation measures.

Table 15. Risk matrix table of CC events* perceived by farmers in four coastal states

Consequences / Likelihood	Disastrous (5)	Extremely Negative (4)	Moderately Negative (3)	Minor Negative(2)	Little Negative(1)
Certain (5)		*Flood (KL) Heavy Rain (KL)*	*Seasonal variation (AP)*		
Regular (4)	*Flood (TN)*	*Seasonal changes (TN) Heavy Rain (TN) Cyclone (TN)*	*High temperatu re, (WB/TN/KL/AP)Less Rainfall (WB) Seasonal variation (WB/KL) Uneven Rain Fall (AP); Cyclone (AP)*	*Drought (KL)*	*Low temperature (KL)*
Likely (3)		*Cyclone (WB)*			
Possible (2)					
Rare (1)					

Catastrophic | High Risk | Moderate risk | Minor risk | Low risk

*Each cell indicates the risk matrix as shown in the legend for a particular climate change event with reference to shrimp aquaculture observed in four states. Empty cell indicates that no event was identified. **(TN-Tamil Nadu; KL-Kerala; WB-West Bengal; AP-Andhra Pradesh)**

Totally 1150 respondents from four states were part of the three stage study. The risk matrix based on the perceived risk assessment by the aquafarmers indicated that extreme events like flood, heavy rain and cyclone were perceived to be certain to regular likelihood and had disastrous to extremely negative consequences (loss of livelihood or more than 50 % loss) on aquaculture (Table 15). Further, seasonal changes, high temperature and uneven rainfall were perceived to occur regularly and had moderately negative (25 to 50 % loss) impact. Planned adaptive measures in the form of relief, insurance and institutional credit, dredging and strengthening of source water canals are necessary to enhance the adaptive capacity of the farming community.

Vulnerability of shrimp farmers to climate change

Vulnerability of shrimp farming to CC was operationalised as the susceptibility of shrimp farming to climate disturbances determined by its exposure and sensitivity to perturbations and the capacity of farmers to adapt. The vulnerability index for shrimp farming in Nagapatnam district revealed that shrimp aquaculture is moderately vulnerable to climatic variations but highly vulnerable to extreme events (Fig. 34). Participatory approach with a strategy of inter-departmental co-ordination is essential to deal with CC impacts and minimise the vulnerability of shrimp aquaculture sector.

Impact of sea level rise (SLR) on aquaculture

Remote sensing and GIS tools were used to estimate the aquaculture related vulnerability. Impact of sea level rise (1m) in Nagapattinam district indicated that an area of 521 km^2 and aquaculture area of 2786 ha will be inundated (Fig. 35). If the SLR of 1m is associated with storm surges, an area of 1001 km^2 will be inundated.

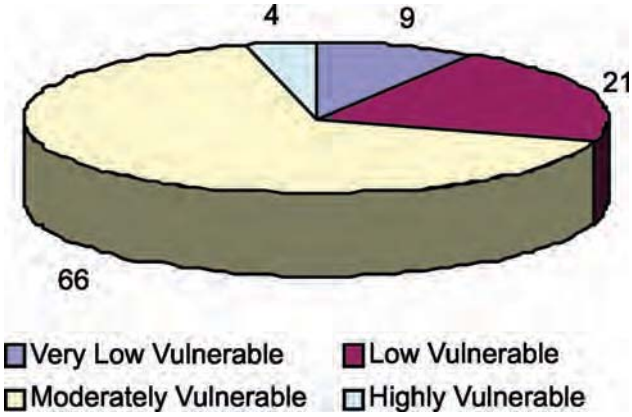


Fig. 34. Shrimp farmers vulnerability to climate change

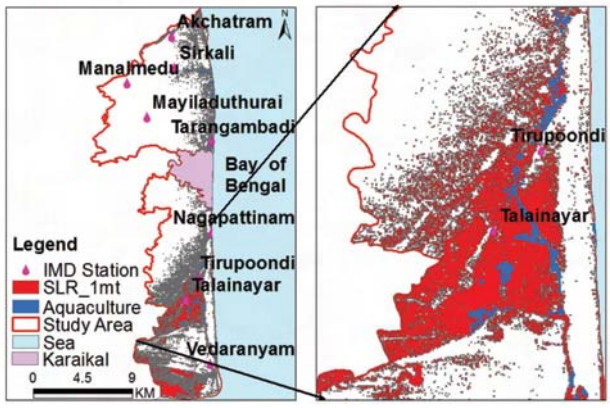


Fig. 35. Impact of sea level rise on aquaculture area

Assessment of damage to aquaculture due to Thane cyclone

Tropical storm Thane formed over the Indian Ocean on December 25, 2011 and by December 28, it had strengthened into a cyclone and hit the land on 30th December south of Chennai. The storm had maximum sustained wind of 120 kmph with gust of air upto 80-150 kmph. Cuddalore district of Tamil Nadu within 7 km coastal stretch was the most affected area due to Thane cyclone. As there was no culture, only the infrastructure was damaged due to the cyclone. In Cuddalore district, Government has estimated that 200 ha of aquaculture area was damaged and the loss due to this was ₹10 million (estimated @ ₹50,000/ha). In this study, interview was conducted with important stakeholders using

systematic methodology and it was estimated that the damage was ₹9.13 million, which is approximately equal to the Government estimate.

Infrastructure damage to shrimp farms - Uppalavadai

Infrastructure damage to shrimp farms - Nanamedu

Impact of climate change on shrimp hatcheries

A survey of 15 hatcheries in Tamil Nadu indicated that salinity and temperature are the most important factors that affected the availability and performance of broodstock. Broodstock were maintained at around 29-30°C. The spawner availability and reproductive performance of *P. monodon* across the seasons in relation to the changing climatic variables over the past 10 years revealed that healthy broodstock with higher captive maturation and effective spawning are a function of seasonal and geographic location. A changing pattern in the performance of broodstock in hatchery and grow-out production could be observed over the years. The broodstock source availability for hatcheries revealed that Palayar is the best source and the shift in the geographical location was due to either insufficient quantity or higher infection levels (Fig 36). This baseline data will help in long term monitoring of CC on broodstock availability.

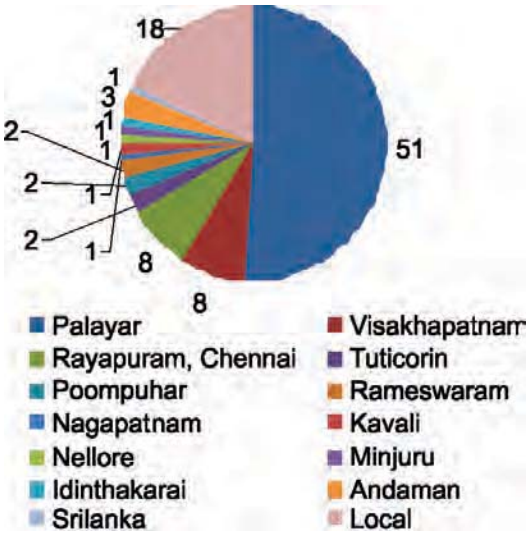


Fig. 36. Broodstock source for shrimp hatcheries (in term of % contribution)

Fabrication of green house gases sampler for aquaculture ponds

In order to estimate the GHGs from aquaculture ponds varying in intensification and practices, a prototype floating chamber was fabricated. The chamber, air sampling pump and tedlar bag were connected in series by silicon tubing with a three way valve, to control the circulation of flux and further flow into the tedlar bag. Thermometer was fixed in the chamber to measure the internal

GHG sampler for aquaculture ponds

temperature. The GHG fluxes (changes in concentration with time) diffusing across the water-air interface was collected at different time intervals in tedlar bags and taken to the laboratory for analysis. The simultaneous analysis and quantification of GHGs carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) from the above matrices was done with single injection using multi-valve, μECD, methanizer - FID combination detector. Pond water and slurry were taken directly into the headspace vials and analysed with the aid of headspace auto sampler in the GHG analyser. The CH_4, CO_2 and N_2O concentration in tested ponds ranged from 1.25-3.92 ppm, 49-294 ppm and 233-295 ppb in water and 2.06-6.02 ppm, 302-2533 ppm and 184-1012 ppb in slurry, respectively.

Life cycle assessment in shrimp production and hatchery systems

Structured Life Cycle Assessment (LCA) questionnaires were prepared and the details were collected from hatcheries and farms. Using the LCA software the data was analysed to estimate the contribution of aquaculture production to global warming potential and other impacts. Fish meal and its transportation (ocean freight) contribute to highest percent for all the impact categories except for eutrophication from wheat flour. Category-wise impact for every tonne of shrimp production revealed that except for eutrophication due to feed use, all the other impact categories are mainly due to feed preparation in feed mill and energy use by water pumps and aerators. The data from 15 shrimp hatcheries in Tamil Nadu revealed that energy use in terms of electricity, diesel, petrol and two stroke oil per one million PL production in shrimp hatchery was 236.08 Kwh, 4.4 l, 0.03 l and 0.4 l respectively.

Carbon sequestration in shrimp culture ponds

Estimation of different carbon fractions in aquaculture ponds help to understand the sequestration potential of shrimp culture systems. Soil and water samples were collected periodically from both *L. vannamei* and *P. monodon* culture ponds at different places in Tamil Nadu throughout the culture period. The total carbon concentration increased gradually from 18.65 to 50.29 ppm and 8.39 to 48.8 ppm in water and 0.19 to 3.44 % and 0.314 to 3.243 % in soil under *P. monodon* and *L. vannamei* culture ponds respectively. The results showed that organic carbon content was higher than inorganic carbon content in soil whereas a reverse trend was observed in water throughout the culture period. The organic carbon content that remained in the soil after the harvest of crop contributed to sequestration of carbon and out of the inorganic carbon content in the water, some portion was utilized by the microbes and the remaining was lost to atmosphere.

Estimation of actual aeration requirements to reduce energy cost

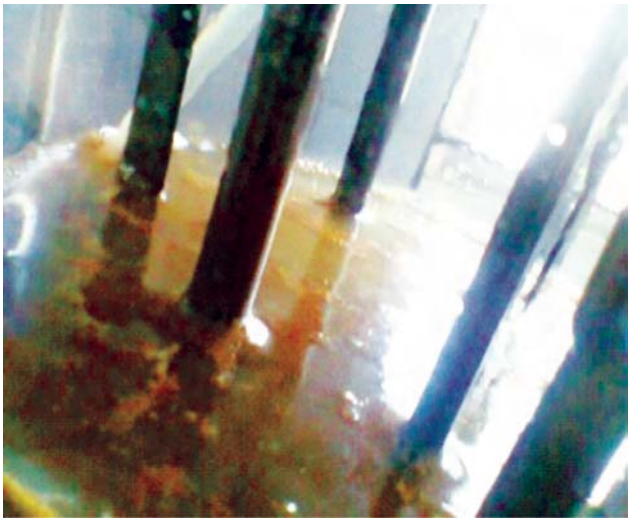
Aeration requirement and efficient use of aerators for minimising energy use in aquaculture ponds requires information on sediment respiration rate (SRR) and water respiration rate (WRR). In this study, one pair of black PVC columns were placed vertically 10 cm deep in the sediment and leaving 10 cm above the water at three different places *viz.* water pumping area, centre of the pond and sluice gate in *P. monodon* and *L. vannamei* culture ponds and incubated for 24 hours. Mechanical aeration requirements in shrimp culture ponds calculated based on SRR, WRR for the conditions of minimum, medium and maximum shrimp respiration rate was 2.39 HP for 28 DOC in *L.*

Soil and water respiration studies near sluice gate

vannamei and 2.31 HP for 74 DOC in *P. monodon* culture ponds which was less than the farmers' use of 4 HP.

Evaluation of anaerobic ammonia oxidation (Anammox) process

Evaluation of Anammox process, which emits nil or less nitrous oxide, the potent global warming gas is a potential area of CC mitigation in aquaculture ponds. Laboratory scale bioreactor and anaerobic chamber facility were established for the enrichment of anammox bacteria. Sediment samples collected from Pulicate lake at Pazhaverkadu, Tamil Nadu were subjected for enrichment of batch cultures of anammox bacteria with mineral medium in fermenter. The pH of the medium was maintained between 7.8 and 8.2. The initial ammonia level was 7 ppm and after 4 days the concentration decreased to 2 ppm. The flocs formed in the fermenter could be probably the biofilm of the bacterial community that could represent Anammox activity. The DNA from biofilm was subjected to PCR analysis using Pla46F, forward primer for Planctomycete group of bacteria and 1390R for universal bacterial reverse primer**.** The Anammox process and species of Planctomycetes group have to be confirmed with chemical analysis, cloning and sequencing techniques.



Bacterial flocs formed from enriched sediment sample

Changes in mineral composition of shrimp under salinity stress

Cultured shrimp are frequently exposed to climatic conditions such as high temperature, scarcity of water, extremely heavy rainfall and flood resulting in sudden decrease or increase of salinity in pond waters. In this context, the effect of salinity on whole shrimp mineral profiles was estimated in shrimp reared in salinity from 0 to 70 ppt for 45 days. The experimental animals (10-12 g) held at 20 ppt were acclimatized by changing 2 ppt per day using freshwater for reducing the ambient salinity and crude common salt for higher salinities. Among the macro minerals calcium was high at 20 ppt and lower at 0 ppt and 50 ppt by 14 and 22 %, respectively. Magnesium and sodium increased with increase in salinity, phosphorus level decreased by 26 % at high salinity and not much change was observed for potassium with increase or decrease in salinity (Fig. 37). Among the micro minerals, there was not much variation for Cu, Fe, Se & Zn and Mn increased beyond 30 ppt. All the grades of feed samples used in shrimp farming are being analysed and based on the mineral content in water, necessary supplementation will be done to balance the requirement under low or high salinity.

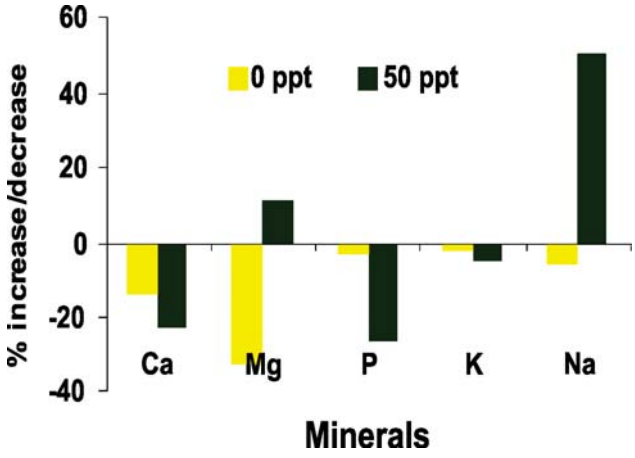


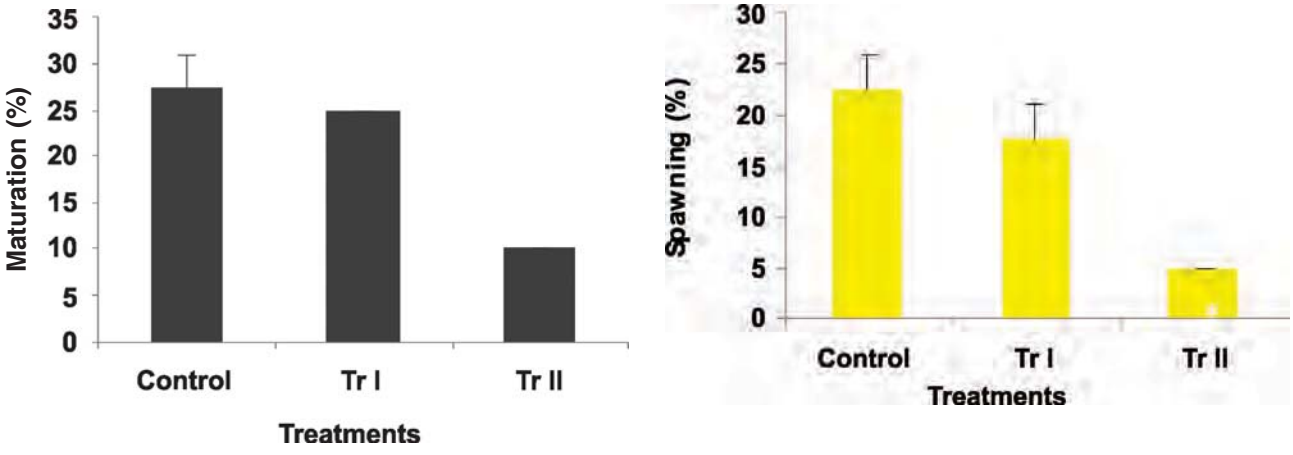
Fig. 37. Changes in macro mineral compositionin *P. monodon* from 20 ppt to 0 and 50 ppt

Addressing reduced availability of fish meal and fish oil under CC scenario

One of the projected effect of CC is the reduced availability of fish meal and fish oil for feed industry. Five experimental feeds were prepared by replacing fish oil with soy oil at 0, 25, 50, 75 and 100 % in the 40 % fish meal replaced diets. An experiment was conducted with the juveniles of tiger shrimp of initial weight of 0.54 g. The results of 45 day feeding trial indicated that fish oil can be replaced with soy oil up to 75 % in a 40 % fish meal replaced diet.

Effect of projected CC impact - elevated temperature on reproductive performance of tiger shrimp

The effect of three different temperature regimes (control-29°C; Tr I- 31°C and Tr II- 33°C) on maturation, spawning, egg size, fertilization and hatching rate of *P. monodon* was investigated under controlled hatchery conditions. Shrimp length and weight and water parameters such as pH, salinity, dissolved oxygen, temperature, ammonia, nitrate and nitrite were monitored during the study. The salinity, dissolved oxygen and pH were maintained at 30±1 ppt, 5 mg/l and 7.7±0.5 respectively. Higher ammonia and nitrite levels were observed at elevated temperature compared to control. The spawning success, fertilization rate and production of viable nauplii showed no significant variation ($P>0.05$) between the control (29°C) and Tr I (31°C), whereas hatching improved (Fig. 38). However, significantly low ovarian maturation and spawning was observed with high elevated temperature of 33°C (Tr II) which was significantly different from control ($P<0.05$). Temperature has a definite influence on reproductive performance and this experiment would be continued at different temperatures to quantify the impact in relation to smaller changes in temperature.



a b

Fig. 38. Effect of temperature on percentage maturing (a) and spawning (b) of *P. monodon*
(control-29°C; Tr I- 31°C and Tr II- 33°C)

Project Title (DBT)	**Development and evaluation of greenwater technology for aquatic bioremediation in coastal aquaculture**

Evaluation of green water technology for aquatic bioremediation

Green water culture system is a bioaugmentation technique, wherein economically important herbivorous finfishes such as grey mullet (*Mugil cephalus*) and milkfish (*Chanos chanos*) are used as bioaugmentors in fish cages in shrimp culture ponds. This technology was successfully demonstrated in two farmers' ponds at Sirkazhi with mullet and in Cuddalore with milkfish. In Sirkazhi, an earthen pond (0.9 ha) which was stocked with tiger shrimp seed @ 12 nos/m^2 was selected, wherein a net hapa

(100 m^2) was installed and 100 grey mullet (TL: 41± 3.4 mm & weight: 3.2 ± 0.28 g) were stocked. Similarly, a net hapa (64 m^2) was installed in 0.3 ha pond, where tiger shrimp seed was stocked @ 12 nos./m^2 in Cuddalore with 100 milkfish (TL: 75±6.2 mm & weight: 5± 0.46 g). In both locations, control ponds were also maintained without addition of finfish. The culture period was continued for 204 days in Sirkazhi and 148 days in Cuddalore. In both the places, farmers benefited with higher net income in the treatment ponds compared to the control ponds. Microbial analysis in water indicated high count of *Vibrio* sp. such as *V. harveyi, V. parahemolyticus, V. alginolyticus* and *V. anguilarum* in control, whereas these were low in treatment ponds.

Demonstration of greenwater technology

Harvested tiger shrimp and milk fish

NUTRITION, GENETICS AND BIOTECHNOLOGY DIVISION

Project Title (Institute)	Development of cost effective feeds for brackishwater fish and shrimp through specific dietary nutrient optimizations and alternative feed ingredients

Cost effective feeds for pearlspot through customized vitamin and mineral mixture

In the pursuit of development of cost effective feeds for pearlspot, *(Etroplus suratensis)*interventions through use of customized supplementation of vitamin and mineral mixture would lead to maximizing the production at a reduced cost. A customized vitamin mixture has been formulated and included in pearlspot fry feed (improved feed developed in the previous year having 35 % crude protein and 7 % lipid) formulation at 0, 0.5, 1.0, 1.5 and 2.0 %. These feeds were tested in wild pearlspot fry (average initial body weight of 3.27 g) in a 45 days feeding experiment. The effect of various levels of supplementation of customized vitamin mixture on growth parameters during the experimental period is given in Table 16. Results revealed that supplementation of vitamin mixture up to 1.0 % showed better performance compared to control and the optimal supplementation level was 0.5-1.0 %.

Table 16. Effect of customized vitamin mixture on the growth performance of pearlspot fry
(Mean± SE)

Diets / Parameters	Level of customized vitamin mixture supplementation (%)				
	0	0.5	1.0	1.5	2.0
Initial body weight (g)	3.23 ± 0.34	3.29 ± 0.02	3.26 ± 0.04	3.26 ± 0.04	3.33 ± 0.06
Final body weight (g)	4.69^{b}± 0.02	4.90^{a} ± 0.04	4.92^{a} ± 0.10	4.85^{ab} ± 0.05	4.96^{a}± 0.02
Weight gain (%)	45.27±1.31	48.99±1.44	50.82±2.63	48.84±0.90	49.11±3.17
Survival (%)	95.56±2.22	97.78±2.22	97.78±2.22	95.56±2.22	95.56±2.22
FCR	1.98^{b} ±0.016	1.89^{a} ±0.039	1.74^{a} ±0.015	1.75^{a} ±0.008	1.75^{a} ±0.005

Values bearing different superscripts in a row differ significantly (P<0.05)

Another experiment was carried out to study the effect of customized mineral mixture in pearlspot fry. Improved pearlspot fry feed has been formulated to contain 0, 0.5, 1.0, 1.5 and 2.0 % level of customized mineral mixture. These feeds were tested in wild collected pearlspot fry (average initial body weight of 2.18 g) in a 45 days feeding experiment. The effect of varying levels of supplementation of customized mineral mixture on various growth parameters during the experimental period is given in Table 17. A diet supplemented with customized mineral mixture was beneficial in improving growth and other parameters compared to control diet. Supplementation of mineral mixture at 0.5 % indicated improved performance compared to control and further increase in supplementation revealed no additional advantage.

Table. 17. Effect of customized mineral mixture on the growth performance of pearlspot fry (Mean± SE)

Diets / Parameters	Level of customized vitamin mixture supplementation (%)				
	0	0.5	1.0	1.5	2.0
Initial bodyWeight* (g)	2.17 ± 0.03	2.19 ± 0.01	2.14 ± 0.01	2.16 ± 0.04	2.18 ± 0.02
Final body weight (g)	3.69^{b} ± 0.03	3.94^{a} ± 0.09	4.05^{a} ± 0.05	4.06^{a} ± 0.02	4.01^{a} ± 0.03
Increase in weight (g)	1.52^{c} ± 0.01	1.75^{b} ± 0.09	1.91^{a} ± 0.05	1.90^{ab} ± 0.04	1.82^{ab} ± 0.03
Survival *(%)	88.89±2.22	88.89±2.22	84.44±	82.22±	84.44±
FCR	1.62^{d} ±0.002	1.63^{d} ±0.01	1.74^{c} ±0.03	1.82^{b} ±0.03	2.16^{a} ±0.01

Values bearing different superscripts in a row differ significantly (P<0.05)
* Not significant

Field testing of improved pearlspot feed

Improved pearlspot feed developed in the previous year was evaluated under cage culture. Wild collected 15,000 pearlspot fingerlings (2.10 g) were stocked in a 6 m diameter circular cage and fed improved feed, containing 38.0 % crude protein and 6.1 % lipid. The feeds were prepared in varying sizes from 400-800 µ, 900-1200 µ, 1.2 to 1.6 mm crumbles followed by1.8 and 2.0 mm pellets. Fishes were fed @5-8 % body weight in two divided doses. The required quantity of feed was placed in the feed trays and feeding was regulated by observing the left over feed in the feed trays. The results revealed that animals had attained 21.1± 3.6 g at the end of 58 days of rearing with an FCR of 1.6. This is an improvement over the growth observed under cage culture practised by farmers where it takes three to four months to reach a size of 20 g from 2 g.

Development of specific feed for low and high salinity farming of tiger shrimp

For developing specific feeds for high saline shrimp farming, optimal protein and lipid contents were evaluated in the preceding years. In the current year, the effect of vitamin C supplementation was evaluated. Vitamin C is known to play an important role in molting, wound healing, melanization of exoskeleton and enhancing resistance to stress. The enhanced resistance to stress could be attributed to its role as an antioxidant by inactivating damage-causing free radicals produced through normal cellular activity and from various stressors like hyper salinity stress. Keeping this in mind, four experimental feeds were prepared with 0, 0.2, 0.4 and 0.6 % ascorbyl poly phosphate. These experimental feeds were tested in tiger shrimp juveniles (initial body weight of 1.18 g) in hypersaline rearing conditions (45 ppt). The experimental animals were acclimatised by enhancing salinity @ 2 ppt per day using crude common salt. Significantly (P<0.05) higher weight gain was observed in shrimp fed with 0.4 and 0.6 % ascorbyl poly phosphate compared to 0 and 0.2 % supplementation. The FCR was also significantly lower (P<0.05) in shrimp fed with 0.4 and 0.6 % ascorbyl poly phosphate

and there was no significant difference in survival among the treatments (Table 18).

Table 18. Effect of dietary vitamin C level on growth performance of tiger shrimp

Parameters	Dietary ascorbyl polyphosphate (%)			
	0	0.2	0.4	0.6
Weight gain* (%)	$287^{c} \pm 1.55$	$321^{b} \pm 2.83$	$341^{a} \pm 2.95$	$348^{a} \pm 9.63$
FCR*	$2.33^{a} \pm 0.015$	$2.23^{b} \pm 0.010$	$2.07^{c} \pm 0.020$	$2.06^{c} \pm 0.020$
Survival (%)	71.1 ± 2.2	77.78 ± 2.2	82.22 ± 5.9	82.22± 2.2

*Values bearing different superscript in a row differ significantly (P< 0.05)

The choline requirement varied with the type of lipid and amount of phospholipid in the diet. During the past year, lecithin requirement was studied in hyper osmotic conditions. In the present study at two different levels of lecithin, the choline requirements were evaluated in hyper osmotic stress condition. Five experimental feeds were prepared with varying choline chloride (750, 1000, 1250, 1500 and 1750 mg/kg diet) at each level of soy lecithin (1.5 and 2.0 %). These experimental feeds were tested in tiger shrimp juveniles in 60 day feeding trial at 45 ppt salinity. The experimental animals were acclimatised as described above. Significantly (P<0.05) higher weight gains were observed in shrimp fed with 1500 and 1000 mg/kg of choline chloride at 1.5 and 2.0 % dietary soy lecithin level (Table 19).

Table 19. Effect of dietary Choline chloride (mg/kg diet) at two soy lecithin levels in growth performance of tiger shrimp

Parameters	1.5 % soy lecithin					2.0 % soy lecithin				
	750	1000	1250	1500	1750	750	1000	1250	1500	1750
Weight Gain (%)	257^{a}±14.2	301^{b}±8.8	330^{c}±3.2	372^{d}±4.3	350^{cd}±3.9	255^{a} ±17.2	366^{d}±2.7	355^{d}±2.7	360^{d}±2.4	348^{d}±3.5
FCR	2.39±0.05	2.27±0.01	2.08±0.04	2.07±0.03	2.12±0.04	2.33±0.01	2.11±0.05	2.12±0.05	2.10±0.04	2.12±0.04
Survival(%)	80.0 ± 3.9	84.4 ± 5.9	82.2± 5.9	82.2 ± 2.2	86.6 ± 3.8	82.2 ± 2.2	82.2 ± 5.9	80.0 ± 3.4	84.4 ± 4.4	82.2 ± 2.2

*Values bearing different superscript in a row differ significantly (P< 0.05)

Effect of vitamin C supplementation on low saline conditions was studied using five feeds formulated with varying levels of vitamin-C (0, 0.05, 0.1, 0.2 and 0.4 %). This feed was provided to tiger shrimp juveniles (ABW: 3.07 g) ha for maintained in triplicate for each dietary treatment for 42 days at low salinity regime (10 ppt). No significant improvement was found in growth performance due to supplementation of vitamin C in low saline condition.

The effect of supplementation of choline chloride under low saline conditions was studied by supplementing choline chloride @ 600, 900, 1200, 1500 and 1800 mg/kg in the diet of tiger shrimp juveniles with an average body weight ranging from 5.05-5.18 g in low saline (10 ppt) regime. (Table 20). It was observed that supplementation of choline chloride @1200 mg/kg resulted in improved growth performance compared to those in other levels of choline.

Development of cost effective feeds for grey mullet fry

The effect of customized mineral mixture in the diet (crude protein 27 % and fat 9 %) of grey mullet (*M. cephalus*) fry was evaluated by including mineral mixture at 0, 1, 2, 3 and 4 % levels. Grey mullet fry with mean body weight of 0.36 g were randomly distributed in 15 tanks (500 l each) with 15 fry per

Table 20. Performance of tiger shrimp fed different levels of choline chloride

Parameters	Choline chloride supplementation (mg/kg)				
	600	900	1200	1500	1800
Initial body weight (g)	5.10 ± 0.03	5.10 ± 0.02	5.10 ± 0.05	5.10 ± 0.03	5.10 ± 0.03
Final body weight (g)	7.26 ± 0.06a	7.60 ± 0.10bc	8.43 ±0.02d	7.65 ± 0.02c	7.30 ± 0.01ab
Total weight gain (g)	2.16 ± 0.03	2.50 ± 0.07	3.34 ± 0.02	2.55 ± 0.04	2.17 ± 0.02
TWG(%)	42.41±0.42a	49.01±1.20ab	65.46±4.19c	50.08±1.04b	42.34±1.05a
FCR	2.49 ± 0.06bc	2.33 ± 0.06b	1.77 ± 0.11a	2.35 ± 0.09b	2.71 ± 0.07c
Survival %	80.00±5.77	83.33±3.33	93.33±3.33	80.00±5.77	80.00±5.77

Means followed by different superscript are significantly different P< 0.05

tank in triplicate for 42 days at low salinity regime (10 ppt). The results indicated that at 3 % level of supplementation of mineral mixture, there was significantly (P<0.01) higher weight gain, protein efficiency ratio (PER) and lower FCR in fishes of Group IV (Table 21). There was significant improvement in nutrient digestibility when fishes were supplemented with 3 % mineral mixture as compared to diet without mineral mixture. It could therefore be inferred that 3 % mineral mixture should be supplemented in the diet of *M. cephalus* fry in low saline condition.

Table 21. Growth performance and nutrient digestibility of grey mullet

Parameters	Mineral mixture levels (%)				
	0	1	2	3	4
Initial body weight (g)	0.362±0.001	0.363±0.001	0.363±0.001	0.361±0.001	0.362±0.001
Final body weight g)**	2.41 a ±0.01	2.45 ab ± 0.01	2.49 b ±0.03	2.63 c ±0.03	2.42 a ±0.01
Total weight gain (g)**	2.05 a ±0.01	2.09 ab ±0.01	2.13 b ±0.03	2.27 c ±0.03	2.06 a ±0.01
Average daily gain (mg) **	48.81 a ±0.09	49.79 ab ±0.16	50.81 b ±0.67	54.1 c ±0.75	49.03 a ±0.14
FCR**	2.32 b ±0.04	2.22 b ±0.05	2.30 b ± 0.01	1.97 a ±0.12	2.38± b 0.03

** Means bearing different superscripts in a row differ significantly (P<0.01)

Phospholipid plays an important role in the formation of membrane structure and hence their role in early life stages of fish assumes considerable importance**.** To study the effect of lecithin in the diet (crude protein 27 % and fat 9 %) of grey mullet (*M. cephalus*) fry, lecithin was incorporated at 0 0.5, 1, 2 and 4 % levels and fed to grey mullet fry (mean body weight of 1.65-1.69 g) which were randomly distributed in 15 tanks (500 l each) @ 15 fry per tank and the feeding trial was carried out in triplicate for 42 days at low salinity regime (10 ppt). Results indicated that FCR was significantly (P<0.01) lower in fishes fed diet supplemented with 2 % lecithin. There was no significant change in weight gain due to supplementation of lecithin but nutrient digestibility was significantly (P<0.01) higher when lecithin was supplemented with 0.5 to 2 % level. Therefore, it can be concluded that 2 % lecithin may be supplemented in diet of *M. cephalus* fry in low saline condition.

Project Title (Institute)	**Outreach activity on fish feed**

Optimal feeding frequency for seabass fingerlings

Optimization of feeding frequency would help in improving the growth and FCR in fish and shrimp. During the previous year, the effect of feeding frequency was evaluated in advanced seabass fingerlings

(30 g size). To estimate the optimal feeding frequency in the early fingerling stage (3-10 g) an experiment was conducted using wild seabass fingerlings (ABW: 3.15 g). One hundred and eighty animals were randomly distributed into twelve 500 L FRP tanks each containing 15 animals. CIBA seabass feed was provided @ 6-8 % at four levels of feeding frequency (one, two, three and four times/ day at 7, 11, 15 and 19 h).

It was observed that as the feeding frequency increased from one to four there was a progressive increase in various growth parameters. The highest weight gain, ADG, SGR and DGC were recorded in the group fed four times closely followed by three (Table 22). However the trend in FCR showed a progressive increase with increase in the feeding frequency (1.73 to 2.37). The FCR of groups fed two and three times did not show much variation. Considering the growth and FCR, it was observed that feeding seabass fingerlings (3-10 g size group) three times daily was found to be beneficial.

Table 22. Growth performance of seabass with different feeding frequencies

Feeding frequency	WG (%)	ADG (mg/day)	Survival* (%)	SGR	DGC	FCR
One	$148^{c}\pm4.80$	$102.6^{c}\pm2.79$	82.22±5.88	$2.02^{c}\pm0.043$	$1.15^{c}\pm0.026$	$1.73^{c}\pm0.036$
Two	$182^{b}\pm5.72$	$127.0^{b}\pm2.96$	86.67±3.85	$2.30^{b}\pm0.046$	$1.34^{b}\pm0.027$	$1.94^{b}\pm0.015$
Three	$235^{a}\pm12.24$	$162.2^{a}\pm4.16$	86.67±3.85	$2.68^{a}\pm0.083$	$1.60^{a}\pm0.045$	$2.02^{a}\pm0.026$
Four	$240^{a}\pm8.61$	$172.4^{a}\pm4.91$	88.89±2.22	$2.72^{a}\pm0.057$	$1.65^{a}\pm0.038$	$2.37^{a}\pm0.022$

Values bearing different superscripts in a row differ significantly ($P<0.05$)
* Not significant

Evaluation of feeding methods for seabass

Pelleted feeds are presently being used to feed carnivorous fish like seabass under Indian farming conditions. A major problem encountered while feeding the sinking type feeds is the uneaten feed which spoils the soil and water quality. In this context, an attempt was made to evaluate suitable feeding practices for seabass using sinking pelleted feeds. In order to control the uneaten feed and to prevent the blackening of pond bottom, feeding was carried out in feeding trays as well as by broadcasting. Forty fingerlings were randomly distributed into four 2 tonne circular FRP tanks and adapted for intake of CIBA 'BHETKIAHAR'. Two FRP tanks were kept as control and feed was broadcasted. Feed was provided in feeding trays in the other two tanks. The feeding trays (45X30 cm, enamel trays) were suspended in the water column and placed one foot above the bottom of the tank. Each tank had 10 fingerlings (ABW: 32.30 g) and the experiment lasted a month. Feeding was carried out twice a day @ 5.0 % of the body weight and the uneaten feed was collected one hour after feeding. The fish were observed to swim to the feed trays and the feed consumption appeared to be similar (feed consumption of 3.82 % in feeding trays vs 3.92 % in broadcasting) in both the methods of feeding. The growth and FCR also indicated a similar trend in the two methods. From this experiment, it could be inferred that seabass can be adapted to consume feed from feeding trays without affecting the growth and FCR. Through this method, feed wastage and its consequences on the pond bottom could be managed. However further experiments in pond culture are required to conclusively infer about the effect of feeding in check trays/platforms.

Alternate protein ingredients as a replacer of fishmeal in seabass feed

The effect of replacement of fishmeal with chicken waste meal (CWM) was evaluated in seabass fingerlings (ABW: 3.09 g). A total of 150 fingerlings were randomly distributed into 15 FRP tanks of

capacity 1000 l. Each treatment was in triplicate with 10 animals in each unit. The CWM was included at 0, 5, 10, 15, and 20 % level on w/w basis replacing fish meal and the effect of inclusion was studied for 60 days (Table 23).

Table 23. Growth performance of juvenile seabass fed chicken waste meal based diets

Parameters	Levels of chicken waste meal (%)				
	0	5	10	15	20
IBW (g)	3.07^{a} ± 0.09	3.08^{a} ±0.05	3.12^{a} ±0.11	3.04^{a} ±0.12	3.12^{a} 0.09
FBW (g)	12.59^{a} ±0.24	12.37^{a} ±0.49	11.78^{ab} ±0.34	10.79^{b} ±0.32	8.15^{c} ±0.12
Wt. gain (%	309.94^{a} ±3.70	300.97^{a} ±13	278.20^{ab} ±16.05	255.5^{b} ±5.50	162.1^{c} ±8.05
ADG (mg/d^{-})	158.64^{a} ± 2.56	154.71±^{a} 7.6	144.32^{ab} ±5.71	129.21^{b} ±3.71	84.01^{c} ±2.33
Survival (%)	93.33	90.0	90.0	80.0	83.3
FI (g/ fish)	15.85^{a} ±0.06	16.09^{a} ±0.53	15.30^{ab} ±0.62	14.20^{b} ±0.18	9.93^{c} ±0.44
FCR	1.67^{a} ±0.03	1.74^{ab} ±0.03	1.77^{ab} ±0.02	1.83^{b} ±0.03	1.97^{c} ±0.06
SGR (%d^{-1})	2.35±^{a} 0.02	2.31^{ab} ±0.05	2.21^{bc} ±0.07	2.11^{c} ±0.03	1.60^{d} ±0.05
DGC	1.45^{a} ±0.01	1.42^{ab} ±0.04	1.35^{bc} ±0.04	1.27^{c} ±0.01	0.92^{d} ±0.03

Figures followed by the same superscript in a row do not differ significantly from each other (P> 0.05)

There was no significant difference in final body weight, absolute weight gain, weight gain, feed intake, FCR and average daily gain in the fish fed with diets containing CWM upto 10 %. Inclusion of CWM at levels more than 10 % showed a significant reduction in growth parameters compared to control. There was no significant difference in survival among the fish fed different diets. The result from this study indicated that CWM is a potential ingredient in feed for seabass and it can be included upto 5-10 % in replacing fish meal.

The effect of replacing of fishmeal with corn protein concentrate (CPC) was evaluated in seabass fingerlings (ABW: 36.28 g). A total of 225 fingerlings were randomly distributed into 15 FRP tanks of capacity 1000 l. Each treatment was in triplicate with 15 fingerlings per unit. The CPC was included at 0, 5, 10, 15, 20 and 25 % level on w/w basis replacing fish meal and the effect of inclusion was studied for 60 days. The results indicated that CPC can be included upto 15 % in the diet of seabass without affecting growth.

Supplementation of amino acids in grow-out diets of seabass

Earlier studies indicated that fishmeal could be replaced upto 10 % with corn gluten meal (CGM) in diet of seabass fingerlings. To increase the incorporation of this alternate source in the grow-out diets, five experimental feeds were prepared *viz.*, CGM at 10 %, CGM at 15 %, CGM at 15 % & methionine, CGM at 15 % & lysine, CGM at 15 % &

Table 24. Effect of amino acid supplementation to corn gluten meal based seabass diets

Test diets	Parameters		
	Weight gain (%)	FCR	Survival (%)
CGM at 10%	415.37^{a}±1.76	2.14±0.02	93.3
CGM at 15%	323.87^{c}±2.43	2.37±0.02	88.9
CGM at 15% + Methionine	361.19^{b}±1.76	2.16±0.08	91.1
CGM at 15% + Lysine	353.59^{b}±4.45	2.18±0.12	88.9
CGM at 15% + Methionine + Lysine.	406.99^{a}±3.44	2.19±0.02	86.7

Figures followed by the same superscript in a column do not differ significantly from each other (P< 0.05)

methionine & lysine. The results indicated that individual amino acid supplementation was able to enhance the utilization of these alternate protein sources compared to the non-supplemented protein sources.(Table 24). The synergistic effect of amino acid supplementation was observed in weight gain when both the amino acids were supplemented.

Initial work on the effect of replacement of fishmeal with corn gluten meal (CGM) and meat & bone meal (MBM) indicated that both these ingredients could be included individually upto 10 %. To increase the incorporation of these alternate sources in the grow-out diets of seabass, both CGM and MBM were incorporated at 7.5 % each by replacing 15 % of fish meal in the control diet (AA_0). These diets were supplemented individually with lysine @ 0.3 % (AA_L) and methionine @ 0.15 % (AA_M) and also in combination (AA_{LM}). The results indicated that individual amino acid supplementation was able to increase the utilization of these alternate protein sources (Table 25). When both the amino acids were supplemented the synergistic effect of amino acid supplementation was observed in weight gain of the fish.

Table 25. Effect of amino acid supplementation to corn gluten and meat and bone meal based seabass diets

Test diets	Parameters		
	Weight gain (%)	FCR	Survival (%)
AA0	380.1c±2.24	2.29±0.08	88.9
AAL	410.9b±1.52	2.11±0.07	93.3
AAM	411.6b±1.47	2.13±0.10	91.1
AALM	442.9a±1.48	2.08±0.06	88.9

AA0 - control diet; AAL- lysine @ 0.3%; AAM - methionine @ 0.15%; AALM -in combination

Figures followed by the different superscript in a column indicate significant difference from each other (P> 0.05)

Development of farm made feed for seabass

Wild collected seabass fry (ABW: 0.30 g) were weaned with farm-made feed for 45 days in hapa and survival of 75.4 to 76.2 % was recorded. These seabass fry (ABW: 3.57g) were stocked in two grow out ponds (Pond I- 1400 m^2 and Pond II- 600 m^2) at Madanganj and Namkhana (West Bengal) respectively. Fishes were fed a semi moist form of feed initially @ 10 % body weight two to three times daily and gradually replaced by dry pellet feed (2 mm size) @ 2-8 % body weight. The fish were harvested after 360 days and they attained body weight of 890 and 820 g with an average daily weight gain of 2.46 and 2.27 g/day in Pond I and Pond II, respectively. Growth pattern of seabass in different trials is depicted in Fig. 39. The survival were 64 and 68 % in Pond I and Pond II respectively. Total production of 398.72 and 167.28 kg with total productivity of 2848 and 2788 kg/ha were recorded in Pond I and Pond II, respectively. The FCR of farm-made feed was 1.91 and 1.95 in Pond I and Pond II, respectively (Table 26).The economics of culturing seabass in these 2 ponds indicated that a net profit of ₹1,73,077/ha/year could be obtained in this venture.

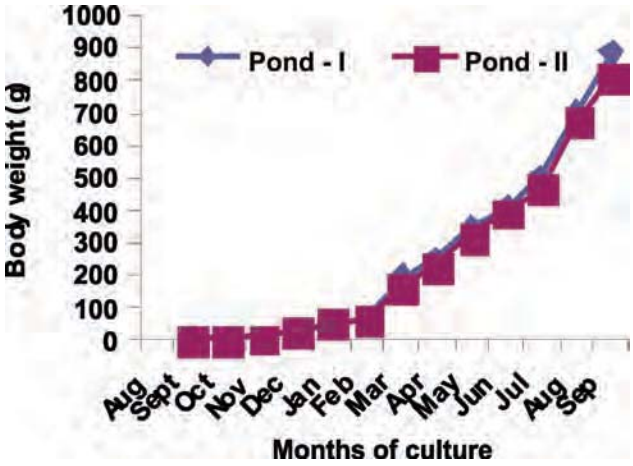


Fig. 39 Growth pattern of seabass with farm-made

Amelioration of anti nutritional factors

A study was conducted for the amelioration of glucosinolate level of mustard oil cake by applying various methods *viz.*, heat treatment, water soaking and water extraction for different durations. A maximum reduction of 46.92 to 46.95 % of total glucosinolate was observed by soaking the mustard oil cake for 8-10 h in water.

Table 26. Performance of seabass with farm-made feed

Parameters	Pond-I	Pond-II
Pond area (m^2)	1,400	600
Culture period (days)	360	360
Initial body weight (g)	3.57±0.52	3.57±0.52
Final body weight (g)	890 ± 95.57	820 ± 97.45
Production (kg)	398.72	167.28
Productivity (kg/h)	2848	2788
Survival (%)	64	68
FCR	1.91	1.95

An experiment was carried out to study the effect of two levels of treated and untreated mustard oil cake in seabass diet. For this study, 10 fingerlings (ABW: 5.62 g) were randomly stocked in 400 L FRP tank. Fishes of four groups I, II, III and control (diet having untreated mustard cake at 5 % level), test diet-I (TD-I) with untreated mustard cake at 10 % level, test diet-II (TD-II) having treated mustard cake at 5 % level and test diet III (TD-III) containing treated mustard oil cake at 10% level. In TD-II and TD-III, treatment of mustard oil cake was carried out by soaking the same in water for 8 h. The experiment was continued for 42 days. Diet with treated mustard oil cake at 5 % level (TD-II) showed highest body weight gain ($P<0.05$) and PER and lowest FCR among all the diets. The diet with treated mustard cake at 10 % level showed better performance than both diets with 5 % and 10 % untreated mustard cake (Table 27). The diet with treated mustard oil cake at 5 % level showed highest body weight gain ($P<0.05$) and PER, and lowest FCR. Hence, 8 h water soaking of mustard cake is recommended before inclusion in seabass diet and it can be included at 5 % level for better performance.

Table 27. Growth and feed utilization of seabass fed on the experimental diet

Parameters	Experimental diets			
	Control diet	Test diet I	Test diet II	Test diet III
Initial weight (g)	5.62±0.01	5.62±0.01	5.61±0.01	5.62±0.01
Final weight (g)	8.13^{b} ±0.08	$7.83\pm^{a}$ 0.02	8.81^{d} ±0.03	8.49^{c} ±0.04
Weight gain (g)	2.52^{b} ±0.08	2.21^{a} ±0.02	3.19^{d} ±0.02	2.87^{c} ±1.04
Weight gain (%)	44.76^{b} ±1.51	39.35^{a} ±0.40	56.89^{d} ±0.43	50.98^{c} ±0.67
Average daily gain (mg/d)	59.85^{b} ± 1.94	52.62^{a} ±0.49	76.03^{d} ±0.62	68.26^{c} ±0.91
SGR	0.88^{b} ±0.03	0.79^{a} ±0.01	1.07^{d} ±0.01	0.98^{c} ±0.01
TDMI (g)	9.43±0.09	9.32±0.06	9.69±0.11	9.76±0.49
PER	0.70^{b} ±0.03	0.62^{a} ±0.00	0.86^{d} ±0.01	0.77^{c} ±0.02
FCR	3.76^{c} ±0.15	4.21^{d} ±0.11	3.03^{a} ±0.04	3.40^{b} ±0.06

Figures followed by the same superscript in a row do not differ significantly from each other ($P< 0.05$)

Project Title (Institute)	Outreach activity on nutrient profiling and evaluation of fish as a dietary component

The geographical, cultural and seasonal variations in the nutrient profiles of brackishwater shrimp and finfishes were analysed for building a baseline database for brackishwater species. Samples of cultured seabass were collected from Andhra Pradesh from different environmental conditions. The fatty acid

profiles of muscle were analysed from two different salinity conditions of rearing *viz.* < 5 ppt and 20 ppt. The fatty acid profiles varied with the salinity in which fish were cultured. Fatty acids like oleic acid, linoleic acid, and linolenic acid were higher in low salinity rearing, whereas docosahexanoic acid, eicosapentanoic acid and myristic acid were higher at 20 ppt rearing (Fig. 50).

The nutrient composition in terms of proximate and mineral profiles of edible and non-edible portions of *P. monodon* and *F. indicus* were analysed. The results of proximate composition showed that the percentage of protein in the edible part was higher (20.6 % and 20.9 %) than that of non-edible portion (15.5 % and 16.2 %). The higher amounts of total lipid and cholesterol were found in non-edible portion (2 % and 230 mg %) than edible portion (0.8 % and 170 mg %) on wet basis indicating that the edible shrimp portion is a low fat non-vegetarian food item and also contains only moderate amounts of cholesterol. The total ash content was significantly higher in non-edible portions than that of edible portion due to the presence of exoskeleton. The calcium content of dry non-edible was 12-20 times higher than that of dry edible portions (Fig. 41). The other minerals like manganese, magnesium, iron

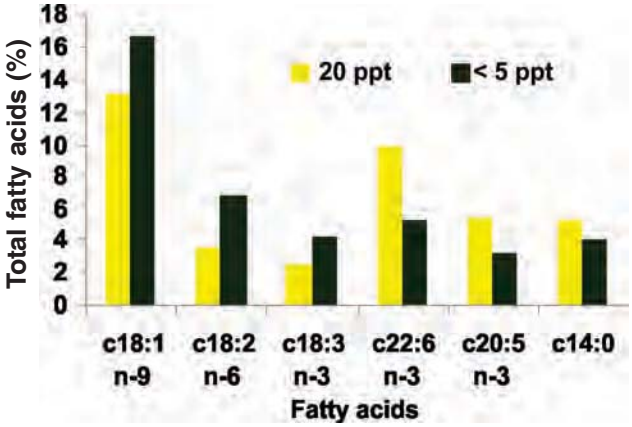


Fig. 40. Fatty acid profiles of seabass reared at <5 ppt and 20 ppt

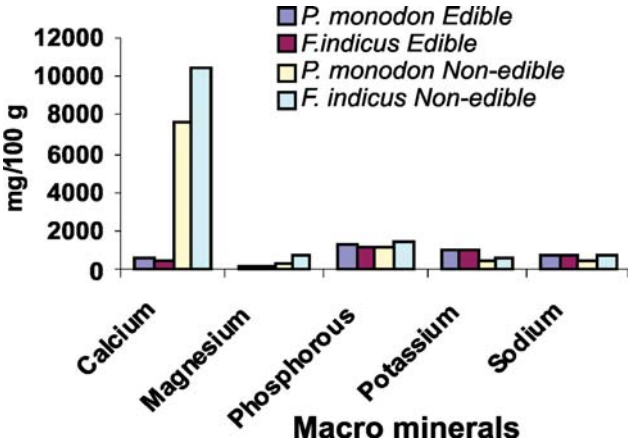


Fig. 41. Macro mineral composition of edible and non-edible portions of shrimp

and copper were 1.5-2 times higher in non-edible portions, whereas the edible portions contained higher amounts of sodium, potassium and phosphorous. The analytical results indicate that the byproducts of shrimp processing industry are a good source of nutrients especially the essential minerals.

In order to popularize the nutritional richness of shrimp, comparative analysis of shrimp lipids with other non-vegetarian food items was presented to different stakeholders through souvenirs, lecture notes and presentations.

Project Title (NABARD)	**Cost effective shrimp farming through adoption of indigenous innovative feed and better management practices by small scale farmers**

Five demonstrations were successfully carried out in farmers' ponds in Ramanathapuram district of Tamil Nadu using indigenous shrimp feed developed by CIBA (Table 28).

The CIBA feed is highly palatable and well accepted by the shrimp. There was not much difference in the final growth, production and FCR in shrimps fed with cost effective CIBA feed and existing commercial high cost shrimp feed. However the feed cost was considerably lower in CIBA feed consequent to which the cost of production of shrimp was comparatively lower. The CIBA feed cost

Table 28. Production performance of CIBA shrimp feed *vis a vis* control feed in tiger shrimp ponds of farmers

Parameters	Farm -1		Farm -2		Farm-3		Farm-4		Farm-5	
	CIBA feed	Control feed	CIBA feed	Control feed	CIBA feed	Control feed	CIBA feed	Control feed	CIBA feed	Control feed
Pond size (ha)	0.4	0.4	0.7	0.6	0.6	0.6	0.5	0.5	0.55	0.57
Stocking nos. (density - m2)	10	10	15	15	15	15	16	16	8	8
DOC	152	152	151	150	142	143	152	154	114	115
Surivival (%)	80.88	84.85	73.17	77.78	68.89	70.99	57.72	55.71	80.27	79.74
Size at harvest (g)	34	33	30	30	40	37	34	35	23.5	22
Production (kg)	1100	1120	2305	2100	2480	2364	1570	1560	830	800
Feed offered (kg)	1950	1960	3950	3500	4600	4270	2580	2650	1380	1350
FCR	1.77	1.75	1.71	1.67	1.85	1.81	1.64	1.70	1.66	1.69
Shrimp Production cost /kg ₹	159.3	168.3	132.1	142.0	141.1	152.1	140.1	154.2	205.3	224.9
Feed cost/kg of shrimp produced ₹	97.50	107.63	94.25	102.50	102.02	111.09	90.38	104.47	91.45	103.78

Shrimp produced using CIBA feed

₹55 / kg whereas the control feed cost ₹ 61.50 / kg. The feed cost per kg of shrimp produced was ₹ 8-14 lower than the control feed. Analysis of soil and water quality during the culture period indicated that all the water quality parameters were within acceptable levels in case of both feed types. Through these demonstrations the cost effectiveness of indigenous shrimp feed technology was reconfirmed in farmers' ponds.

Project Title (DBT)	**Enrichment of aquafeed with cellulolytic and amylolytic microbes isolated from digestive tract of brackishwater fishes**

A 42-day of experiment was conducted on six groups of grey mullet juveniles (ABW: 0.12 g) in triplicate with fifteen fish per replicate. Fishes of group I were fed with control diet (D1) made up of locally available ingredients. For preparation of other diets, locally available ingredients (rice bran, mustard oil cake, sunflower cake, sesame cake, leucaena leaf meal and azolla) were fermented with three potential gut bacteria i.e., *Bacillus sp. DDKRC1* (LC8), *Bacillus subtilis DDKRC5* (CCx) and *Geobacillus stearothermophilus DDKRC4* (CCan1). The diets (D2, D3, D4 & D5) were formulated with fermented ingredients replacing 25, 50, 75 and 100 % by weight of fish meal, respectively and

the diet (D6) was prepared by supplementing the control feed with mixture of bacteria i.e. *Bacillus subtilis DDKRC5* (CCx) (14.25 x 10^7 cfu/ml) and *Bacillus sp. DDKRC1* (LC8) (2.94 x 10^7 cfu/ml) @ 1 % (v/w) of feed in equal ratios (1:1) at feeding time. Group I, II, III, IV, V and VI were fed with diet D1, D2, D3, D4, D5 and D6 respectively.

Growth and feed utilization efficiency of mullet

It was observed that total weight gain, average daily gain and weight gain were significantly (P<0.01) higher in group VI whereas there were no significant differences in groups I, II, III & IV. The lowest weight gain was observed in group V. It could be inferred that fermented ingredients could replace 75 % of fish meal in diet of *M. cephalus* without affecting growth rate, FCR, PER and survival. Supplementation of live bacterial mixture *Bacillus subtilis DDKRC5* (14.25 x 10^7 cfu/ml) and *Bacillus sp. DDKRC1* (2.94 x 10^7 cfu/ml) @ 1 % (v/w)) with control diet could improve growth rate, FCR and PER (Table 29). Fish fed with feed supplemented with live bacterial mixture resulted in better growth and FCR as compared to fish fed with diet containing fermented ingredients. Though cost of feed prepared with fermented ingredients is low due to replacement of fish meal, but live bacterial supplementation seems to be economical.

Table 29. Growth and feed utilization efficiency of *Mugil cephalus* fed with different diets

Parameters	Treatment Groups					
	Group I	Group II	Group III	Group IV	Group V	Group VI
Initial body wt. (g)	0.122 ± 0.001	0.123 ± 0.001	0.123 ± 0.001	0.122 ± 0.001	0.122 ± 0.001	0.123 ± 0.001
Final body wt. (g)	0.61^{b} ± 0.01	0.60^{b} ± 0.02	0.61^{b} ± 0.01	0.61^{b} ± 0.01	0.40^{a} ± 0.01	0.71^{c} ± 0.01
Total wt. gain (g)	0.49^{b} ± 0.01	0.49^{b} ± 0.01	0.50^{b} ± 0.01	0.49^{b} ± 0.01	0.31^{a} ± 0.01	0.59^{c} ± 0.01
ADG (mg/d)	11.46^{b} ± 0.44	11.46^{b} ± 0.43	11.02^{b} ± 0.44	11.02^{b} ± 0.43	6.41^{a} ± 0.26	14.03^{c} ± 0.25
Weight gain (%)	415.51^{b} ± 0.83	415.21^{b} ± 2.62	416.18^{b} ± 0.48	414.25^{b} ± 2.02	235.79^{a} ± 3.40	484.55^{c} ± 4.35
FCR	2.41^{c} ± 0.08	2.42^{c} ± 0.12	2.47^{c} ± 0.06	2.49^{c} ± 0.07	4.29^{b} ± 0.04	1.90^{a} ± 0.01
SGR (%)	3.90^{b} ± 0.02	3.90^{b} ± 0.06	3.91^{b} ± 0.02	3.90^{b} ± 0.05	2.77^{a} ± 0.03	4.30^{c} ± 0.06
PER	1.43^{b} ± 0.01	1.43^{b} ± 0.01	1.42^{b} ± 0.01	1.42^{b} ± 0.02	0.73^{a} ± 0.02	1.83^{c} ± 0.01
Survival (%)	97.44	94.28	96.03	95.55	84.97	100

Values bearing different superscript in a row differ significantly (P<0.01)

Nutrient digestibility in mullet

From the experiment, it was observed that digestibilities dry matter (DM), organic matter (OM), crude fibre (CF), hemicellulose, cellulose, crude protein (CP), ether extract (EE) and nitrogen free extract (NFE) were significantly (P<0.01) higher in group VI fed with feed supplemented with live bacterial mixture (*Bacillus subtilis DDKRC5* and *Bacillus sp. DDKRC1*).

Crude fibre, cellulose, hemicellulose, NFE digestibilities in group II, III and IV were significantly (P<0.01) higher than that of group I fed with control feed but lower than that of group VI. Crude protein and ether extract digestibility were similar among groups I, II, III and IV (Table 30). Supplementation of live bacterial mixture resulted in significant improvement of nutrient digestibilities.

Gut micro-biota and gut enzyme activity in mullet

From the result of gut microbial population and gut enzyme activity it was observed that cellulolytic, amylolytic and proteolytic bacterial population and digestive enzyme activity were significantly higher (P<0.05) in fishes fed live microbial (mixture of *Bacillus subtilis DDKRC5* and *Bacillus sp.*

Table 30. Apparent nutrient digestibility in *M. cephalus* fed with different diets

Digestibility (%)	Treatment Groups					
	Group I	Group II	Group III	Group IV	Group V	Group VI
Dry matter	70.61^{b} ± 0.31	70.10^{b} ± 0.37	69.91^{b} ± 0.10	69.86^{b} ± 0.06	61.25^{a} ± 0.52	72.54^{c} ± 0.02
Organic matter**	72.02^{cd} ± 0.57	71.44^{bcd} ± 0.29	70.28^{bc} ± 0.30	69.77^{b} ± 0.87	65.14^{a} ± 0.49	73.35^{d} ± 0.36
Crude fiber	56.92^{a} ± 0.22	67.52^{b} ± 0.51	68.58^{b} ± 0.64	67.55^{b} ± 0.42	66.55^{b} ± 0.38	70.91^{c} ± 0.48
Hemicellulose	66.00^{b} ± 1.21	69.76^{c} ± 0.67	69.09^{c} ± 0.62	68.88^{c} ± 0.56	66.26^{b} ± 0.64	78.74^{d} ± 0.24
Cellulose	62.01^{a} ± 0.40	66.85^{b} ± 0.21	66.42^{b} ± 0.05	66.14^{b} ± 0.99^{b}	65.89^{b} ± 0.46	71.66^{c} ± 1.13
Crude protein	94.58^{b} ± 0.94	94.12^{bc} ± 0.13	94.97^{bc} ± 0.72	94.15^{b} ± 0.24	91.56^{a} ± 0.72	96.66^{c} ± 0.11
Crude lipid	96.10^{b} ± 0.11	95.41^{b} ± 0.60	95.75^{b} ± 0.53	94.97^{b} ± 0.53	91.07^{a} ± 0.31	97.80^{c} ± 0.20
NFE	84.33^{a} ± 0.14	90.91^{b} ± 0.39	90.13^{b} ± 0.07	90.03^{b} ± 0.41	89.98^{b} ± 0.29	92.34^{c} ± 0.12

Means bearing different superscripts in a row differ significantly. (P<0.01)

DDKRC1) supplemented feed (Figs. 42, 43). Gut microbial population (Total count, cellulolytic, amylolytic and proteolytic count) and gut enzyme activity were also higher (P<0.05) in fish fed with diet formulated with fermented ingredients than that of fish fed on control diet.

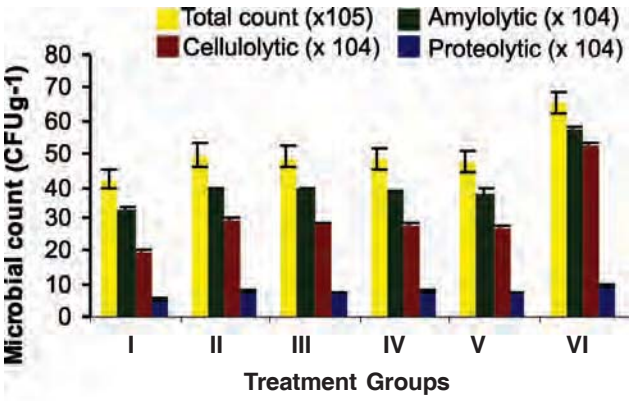


Fig. 42 Microbial count in gastrointestinal tract of *M. cephalus* fed with different diets

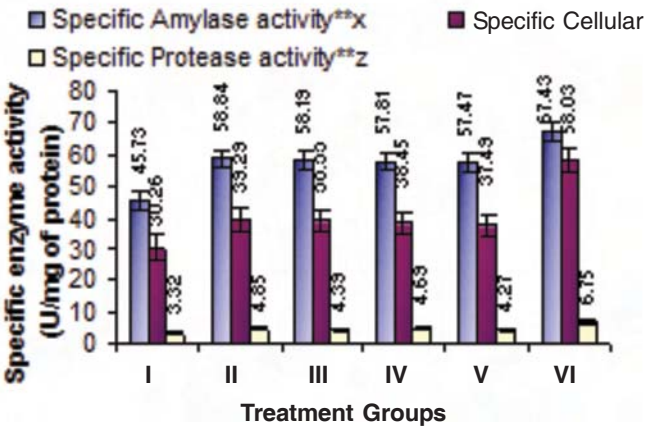


Fig. 43 Digestive enzyme activity in *M.cephalus* fed with different diets

(X = µg of maltose liberated / mg of protein / min, Y = µg of D-glucose liberated / mg of protein / min, Z= µg of L-tyrosine liberated / mg of protein / min).

Project Title (Institute)	Exploring candidate genes for economically important traits in brackishwater organisms using biotechnological and bio-informatic tools

Effect of eyestalk ablation on male specific reproduction associated genes in tiger shrimp

With the male specific genes identified last year, an experiment was carried out to comprehend the effect of eyestalk ablation on male specific reproductive genes *viz.* multiple inositol polyphosphate phosphatase 2 (*MIPP2*), testis specific transcript *(TST1)* and meiotic recombination protein DMC1/ LIM15 homolog isoform 1 (*Dmc1*) in tiger shrimp. While eyestalk ablation induces gonadal maturation in females and it has rarely been considered necessary in males. The experiment was to confirm if the the identified male specific genes would be upregulated with eyestalk ablation. Semi-quantitative PCR analyses revealed higher expression levels of these reproductive genes in the ablated shrimp compared to the controls (Fig. 44).

Protection against WSSV in tiger shrimp immunized with PAP

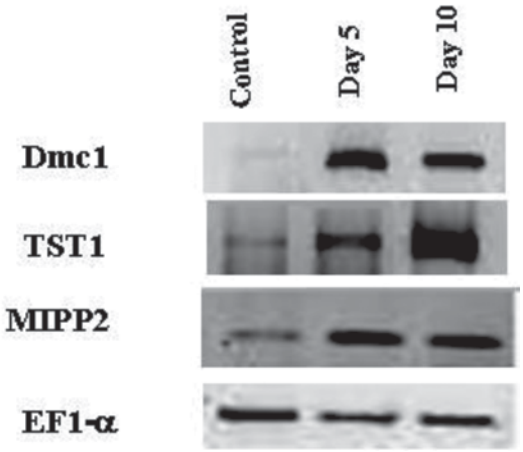


Fig. 44. Semi-quantitative PCR analysis of *Dmc1*, *TST1*, *MIPP2* and *EF1-á* expression in testis of *Penaeus monodon* following eyestalk ablation

The RT-PCR of tiger shrimp that survived a WSSV infection was carried out to analyse the host mediated expression of phagocytosis activating protein (*PAP*) gene. The *PAP* was cloned and expressed as recombinant protein for protection studies. Shrimp were injected with three doses (5, 15 and 20 μg g^{-1} body weight) of recombinant *PAP*. Relative survival of 10% was observed in shrimp immunized with a dose of 15μg g^{-1} body weight of recombinant *PAP*. Significant differences ($P<0.05$) were observed between shrimp immunized with recombinant *PAP* and the control groups on challenge with 10^{-7} dilution of WSSV virus stock estimated to contain 2.62 x 10^6 μL^{-1} viral copies. The expression of *PAP* in WSSV infected shrimp samples indicated its possible role in host response for resistance against WSSV infection. Low but significant protection offered by recombinant *PAP* exposes its role in delaying mortalities occurring due to WSSV challenge. Cox proportional hazard model revealed that body weight of shrimp did not influence the survival of *PAP* immunized shrimp after WSSV challenge.

Molecular markers to differentiate vannamei postlarvae from other shrimp species

Fifty four adult samples (11 tiger shrimp, 6 pacific white shrimp, 10 Indian white shrimp, 8 banana shrimp, 10 kuruma shrimp and 9 green tiger shrimp) of known identity based on morphological features were collected from Kasimedu landing centre, Chennai as also from farmers' ponds. Muscle tissue from all specimens was preserved and utilized for mtDNA extraction. The tested approach involved 3 sets of primers that amplify a fragment of 16S rRNA gene in specific shrimp species only. One set of primer pair is specific for tiger shrimp and Pacific white shrimp; another primer pair is specific for tiger shrimp; and the third primer pair is specific for Indian white shrimp. When PCR is carried out with mtDNA samples using species-specific primers of Indian white shrimp, amplification should be observed only in Indian white shrimp. However during laboratory testing, cross-amplification with same sized PCR product in other species also was observed. A similar cross-amplification was observed for all three sets of primers. In order to rule out possible error, a sub sample (coded without species name) was given to two different Scientists who repeated the testing with the same samples and reported cross-amplification. Therefore, the so called species-specific primers were found inadequate for the development of species-specific marker and identification of species. A plausible reason for failure of this approach could be the assumption of species-specificity of primers by the authors based on the analysis of sequences of mtDNA from a mere 2 or 3 shrimp only.

Feasibility of algal culture using coolant waters from Thermal Power Station

Effluent water samples from the Ennore Thermal Power Station were collected and physico-chemical parameters were analyzed with the objective of evaluating the feasibility of using thermal power water for culturing micro algae. The salinity was 30 ppt, the temperature was 30^0C and the pH ranged from 8.73 to 8.75. The water samples were filtered by plankton net. The settled sediments were observed for the presence of plankton and compared with the reference keys. *Pleurosigma* sp., *Cyclotella* sp.,

Planktoniella sp., *Cossinodiscus* sp., *Skeletonema* sp. and *Rhizosolenia* sp. were the plankton present. The water sample was inoculated into the common algal F2 medium. The growth of the plankton was very slow. This effluent water could be used for growing algae only after enrichment with various nutrients.

Project Title (Institute)	**Outreach activity on fish genetic stocks**

Tiger shrimp samples along with digitized images were collected from Tuticorin (TU), Chennai (CH), Visakhapatnam (VI), Paradip (PA), Kakdwip (KD), Ratnagiri (RI), Mangalore (MA), Kollam (KO) and Andamans (AN). The whole shrimp was digitised against a laminated graph paper background for ease in morphometric data generation and tissue sample was also collected from each shrimp and stored in 95% alcohol for extraction of DNA required for mtDNA gene sequencing and microsatellite genotyping.

For the final truss morphometric analyses, the digitised images of 1082 shrimp specimens were utilized to generate truss morphometric measurements. Fourteen landmarks were identified on the shrimp body that would generate 30 truss measurements. The software tpsUtil, tpsDig and PAST were used for generating truss measurements. Since the shrimp used for generating truss measurements belonged to different sizes, the data was first adjusted for the effect of size using the procedure given by Elliott *et al.* (1995). Analysis of covariance revealed significant sex effect consequent to which the data were analyzed sex-wise using Canonical Variate Analysis (CVA). Step-wise discriminant function analysis was carried out to detect important truss measurements that contribute to discrimination among stocks. The 'R' software was utilized for analysis and plotting UPGMA tree based on *Manhattan* distance measures between stocks whereas SPSS software was utilised for step-wise discriminant function analysis.

Mahalanobis D^2 statistic revealed significant differences between all pairs of stocks. Using CVA, canonical scores were extracted. These scores were used for estimating stock centroids which were then utilized for computing *Manhattan* distance measures for generating the UPGMA tree (Fig. 45 a,b). As far as the shape differences were concerned, Mangalore stock was found to be different from the other stocks for both male and female data sets. In both the data sets, Ratnagiri and Visakhapatnam clustered together so did Kakdwip and Paradip.

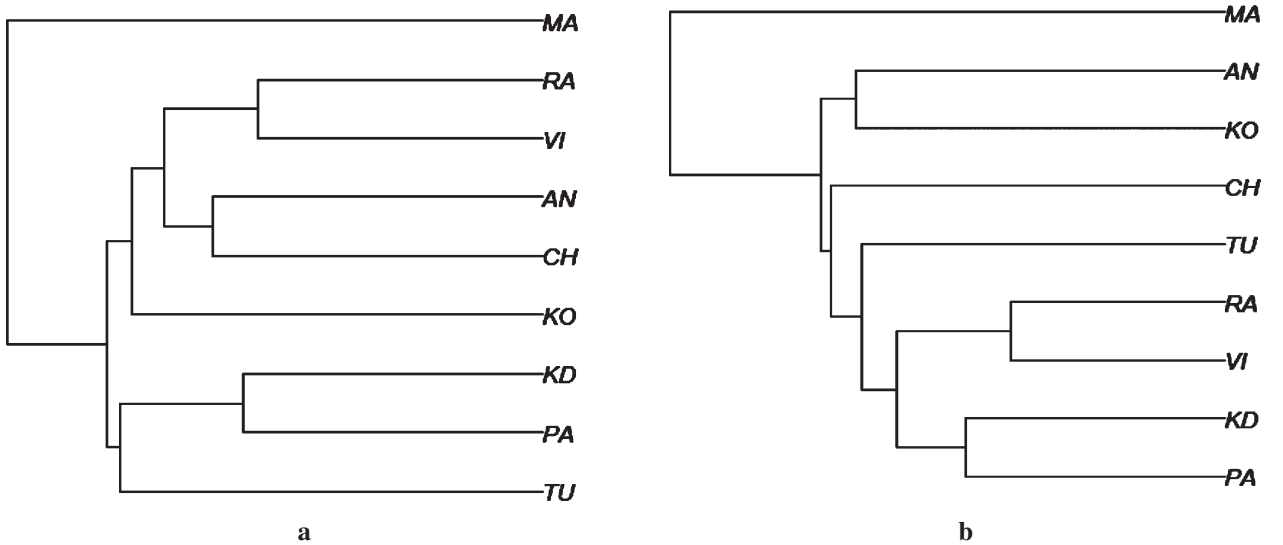


Fig. 45. UPGMA tree for a)males b)females based on Manhattan distance measures between tiger shrimp stocks

Step-wise discriminant function analysis correctly assigned 63.3 % of specimens in male data set and 56.9 % of specimens in female data set to stocks during cross-validation. Eighteen and 16 truss measurements respectively in male and female data sets significantly contributed to between-stock variability. At least 4 truss measurements in male data set and 5 truss measurements in female data set were essential to get significant discrimination (P<0.01) between all pairs of stocks. The centroids representing stock means were estimated by Discriminant Function Analysis wherein all morphometric measurements were utilized for explaining the between stock variability and function 1 was plotted against function 2 (Fig.46, 47). Based on morphometric analysis, it can be concluded that there are distinct stocks of tiger shrimp, however the sex seems to influence the discriminatory power of the analystical tools employed.

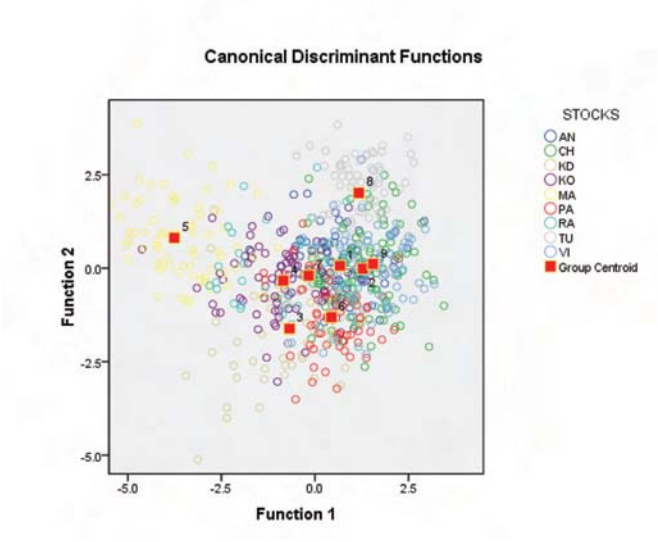


Fig. 46. Group centroids plot of male tiger shrimp stocks based on discriminant functions

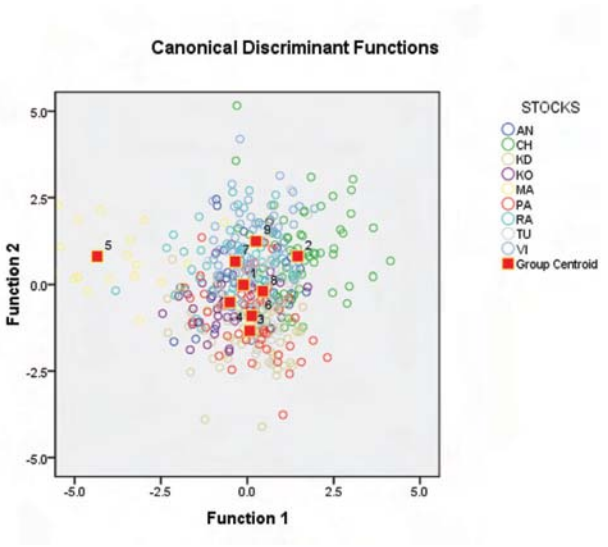


Fig. 47. Group centroids plot of female tiger shrimp stocks based on discriminant functions

The tail to head ratio was computed for males and females from all locations except Tuticorin and the results are tabulated in Table 31. The maximum tail to head ratio of 1.67 was observed in the Visakhapatnam stock and the minimum of 1.32 in the Chennai stock. The results indicate that at some locations there are significant differences between the sexes and between geographic locations. Further anlaysis is being carried out to determine if these differences are due to stock or any other factor.

Table 31. Tail to head ratio (T/H) (mean ± SE) of different stocks of tiger shrimp

Stock	Male	Female	Total
Andaman	1.54 ± 0.04 (26)	1.53 ± 0.03 (25)	1.54 ± 0.02 (51)
Chennai	1.36 ± 0.01 (40)	1.27 ± 0.02 (34)	1.32± 0.01 (74)
Kakdwip	1.57 ± 0.03 (24)	1.50 ± 0.03 (49)	1.52 ± 0.02 (73)
Kollam	1.37 ± 0.03 (38)	1.27 ± 0.05 (19)	1.34 ± 0.03 (57)
Mangalore	1.58 ± 0.02 (76)	1.41 ± 0.04 (23)	1.54 ± 0.02 (99)
Paradip	1.50 ± 0.04 (29)	1.34 ± 0.02 (27)	1.42 ± 0.03 (56)
Ratnagiri	1.34 ± 0.02 (28)	1.33 ± 0.03 (22)	1.34 ±0.02 (50)
Visakhapatnam	1.60 0.08 (22)	1.71 ± 0.22 (39)	1.67 ± 0.14 (61)

Figures in parentheses indicate the number of observations

Project Title (DBT)	Improved disease resistance of rohu carp and tiger shrimp farmed in India : Developing and implementing advanced molecular methods and streamlining access to and use of genetic resources

Nineteen males and 39 female adult tiger shrimp from wild were collected from Palayar and Uvari in Tamil Nadu and kept in the ratio of 1 M : 2 F. Five full-sib families were produced. The larviculture of these 5 families in separate hapas was carried out. One hundred and sixty juveniles from each of these 5 full-sib families were challenge tested with WSSV in April, July and November 2011, the shrimp being infected with a quantified amount of White Spot Syndrome Virus injected intramuscularly. During the course of the experiment, the temperature and pH of seawater ranged from 26.4 to 32.2^{0}C and 7.80 to 8.02. After challenge test, the shrimp were stored at -80^{0}C for extraction of DNA. Some of the parameters recorded are depicted in Table 32.

Table 32. Survival data and other parameters in 5 full-sib families of tiger shrimp

Parameters	Family 5	Family 6	Family 7	Family 8	Family 9
Initial mortality (h)	37.0	35.5	34.0	36.5	38.5
Median survival time (h)	55.0	53.0	50.0	62.0	70.0
100% mortality (h)	75.0	75.5	66.0	79.5	84.0
Temperature range oC	29.1-30.6	29.3-31.3	26.5-32.2	27.3-28.1	26.4-27.3
Average wet weight (g ± SD)	4.56 ±1.03	5.27±0.84	3.65±0.83	3.82 ±0.79	4.00 ±1.05

The Mantel-Cox test on data from all the 9 families revealed significant differences in survival between all of them (Fig.48. Kaplan-Meier curves). The Cox regression revealed that body weight of shrimp in the range of 3.65 to 5.27 g influenced survival whereas sex of the shrimp did not.

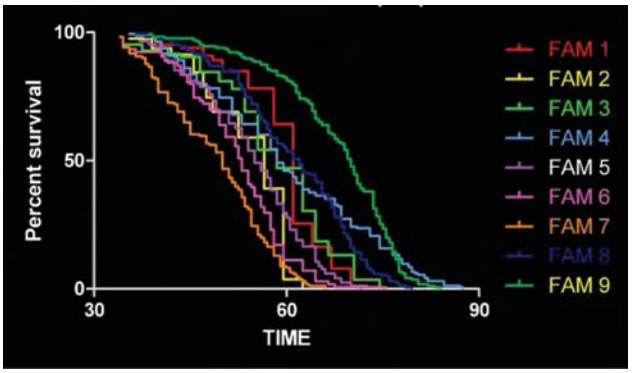


Fig. 48. Kaplan Meier Curves (survival proportions) in 9 families of tiger shrimp

The transcriptome sequence analyses of tiger shrimp revealed a total of 6,492 microsatellites that contained contigs as follows: 3 % (mono); 65 % (di); 24 % (tri); 5 % (tetra); 1 % (penta) and 2 % (hexanucleotide). Primers could be designed for 1,506 loci. The transcriptome sequence analyses also revealed that about 16 % annotated with available blast hit information. Many top blast hits were observed with the flour beetle *Tribolium castaneum* sequence (>2000 contigs). The longest sequence of 23976 bp had an identity of 77 % to projectin (insect muscle protein) from freshwater crayfish. In September 2011 and March 2012, the DNA samples of challenged shrimp were shipped in dry ice to Norway for genotyping on the SNP chip.

Project Title (NAIP)	Bioprospecting of genes and allele mining for abiotic stress tolerance

Expression of COMT gene from tiger shrimp in relation to salinity stress

Suppression subtractive hybridization (SSH) performed using gill tissues of low (3 ppt) and high (55 ppt) salinity stressed tiger shrimp *P. Monodon* revealed identification of differentially expressed

genes involved in signal transduction pathways, metabolism, defense proteins, DNA repair and synthesis, apoptosis, cell cycle regulation along with unknown and hypothetical proteins. Catechol-*O*-methyltransferase (COMT) a type of OMT was identified by SSH as one of the differentially expressed genes of tiger shrimp subjected to low and high salinity stress. The full length cDNA of COMT was cloned from the gills of tiger shrimp which consisted of an open reading frame of 666 bp, encoding 221 amino acids. Real time PCR analysis of the shrimp samples exposed to low salinity conditions at 3 ppt revealed significant increase in expression of COMT transcripts in the guts at 24 h, 48 h, 1 week and 2 weeks, gills at 24 h and in the muscle tissues at 48 h, with maximum expression of the COMT levels by 5 fold in guts (1 week), 1 fold in gills (24 h) and 1.5 fold in muscle (48 h) respectively (Fig. 49). The increased expression level of COMT at different time intervals in different tissues suggests a possible role of this gene in salinity stress tolerance in shrimps under low salinity conditions.

Differentially expressed genes from the gut tissues of tiger shrimp under low and high salinity

Construction of suppression subtractive hybridization (SSH) library from the gut tissues of tiger shrimp *P. monodon* under high (55 ppt) salinity stress generated 27 contigs and 41 singletons. The differentially expressed genes could be represented under different functional category involved in energy and metabolism,

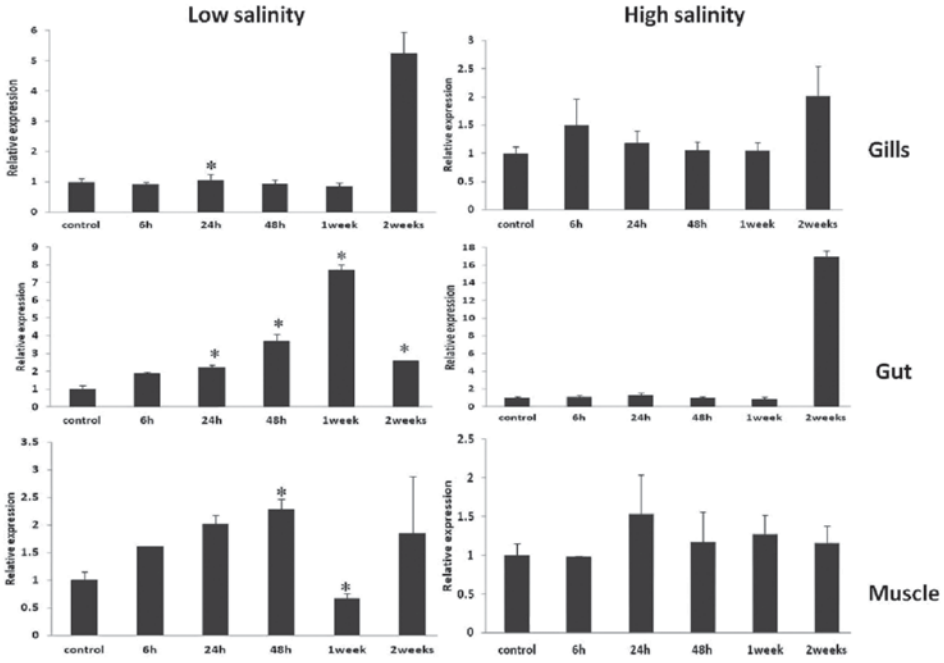


Fig. 49. Real time PCR analysis of putative *P. monodon* COMT transcripts
(in gills, guts and muscle under low and high salinity stress by real-time PCR at 6hrs, 24hrs, 48hrs, 1 week and 2 weeks time intervals. The significant difference (P<0.05) in OMT expression levels are indicated with asterisks).

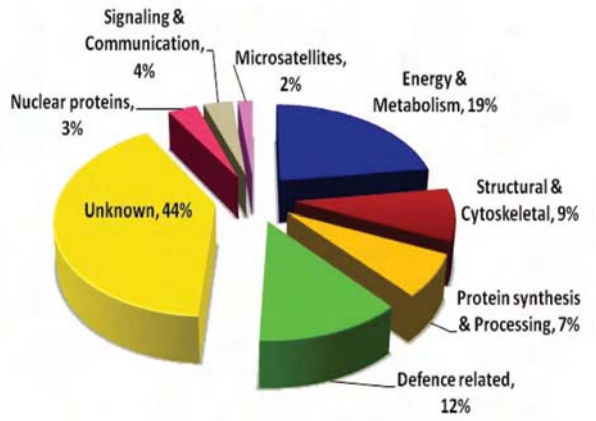


Fig. 50. Pie chart representing the percentage of differentially regulated genes in guts of shrimp *P. monodon* exposed to high salinity stress (55ppt)

structural and cytoskeletal, protein synthesis, defense proteins, nuclear proteins, signal transduction pathways along with unknown and hypothetical proteins etc (Fig. 50). Construction of SSH cDNA library from the gut tissues of low (3ppt) salinity stressed tiger shrimp is under progress.

Project Title (DBT)	Immunomodulation studies in freshwater prawn *Macrobrachium rosenbergii* using recombinant proteins of *Macrobrachium rosenbergii* nodavirus

Differentially expressed genes in immunomodulated freshwater prawn

Suppression subtractive hybridization (SSH) cDNA library was constructed from the hepatopancreas of 2 weeks post-immunomodulated prawns injected with 10 µg g^{-1} body weight *Mr*NV recombinant capsid protein. The EST sequences obtained from the SSH cDNA library were submitted to GenBank. Sequence homology revealed that 79% of the total ESTs had homology to known sequences in the GenBank database, while 21% had no similarity with any known protein sequences in the database (Fig. 51). The differentially expressed *M. rosenbergii* ferritin (516 bp) and cytochrome oxidase III (795 bp) genes were PCR amplified (Fig. 52). Ferritin, cytochrome oxidase III and α- amylase genes subjected to real time PCR for gene expression analysis

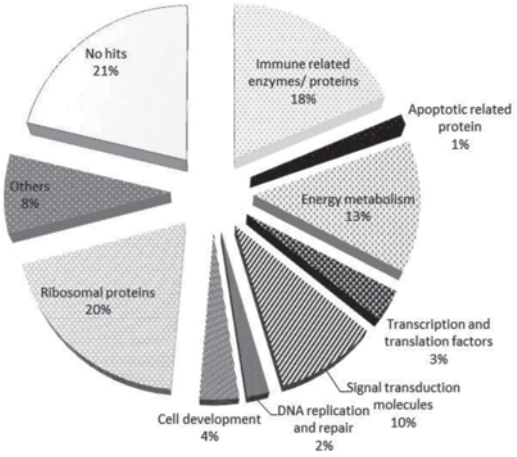


Fig. 51. Identification of differentially expressed genes identified from SSH library prepared from immunomodulated *Macrobrachium rosenbergii* using *Mr*NV capsid protein.

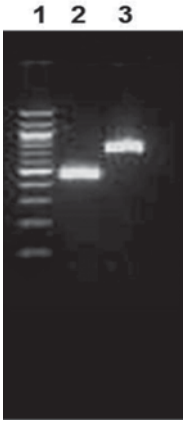


Fig. 52. Amplification of full length ferritin and cytochrome oxidase III subunit from *Macrobrachium rosenbergii* . (Lane 1. 100bp DNA molecular weight marker. Lane 2. Ferritin -516bp. Lane 3. Cytochrome oxidase III subunit -795bp).

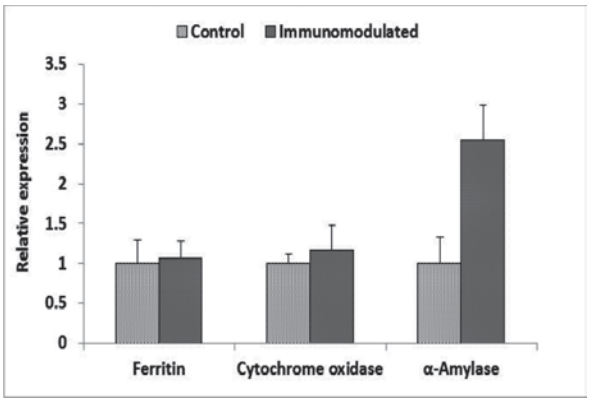


Fig. 53. Relative expression ratios of ferritin, cytochrome oxidase III subunit and á- amylase genes, expressed in the hepatopancreas of immunomodulated *Macrobrachium rosenbergii.*

were found to be up-regulated 1.06 fold, 1.16 fold and 2.54 fold respectively (Fig. 53). The phylogenetic analysis of the ferritin gene isolated from *M. rosenbergii* in the present study revealed that it belonged to similar clade of ferritin gene previously reported from *M. rosenbergii*. The cytochrome oxidase III phylogenetic analysis demonstrated that this gene from *M. rosenbergii* is closely related to *M. lanchesteri.*

Project Title (DBT)	Development of inhibitors for controlling quorum sensing luminescence causing *Vibrio harveyi* in shrimp larviculture system

The N-acyl homoserine lactone compounds were extracted from *Vibrio harveyi,* purified and detected using LCMS. Five strains of marine antagonistic *Streptomyces* and *Bacillus* bacteria were isolated and found inhibitory against *V. harveyi*. Aqueous extract of terrestrial plant *Phyllanthus niruri* was found inhibitory (8 mm zone) against *V. harveyi*. The FTIR analysis of this plant showed the presence of major group compounds such as primary and secondary amines, alkanes, amides, aliphatic amines, alkynes etc. Organic solvent-treated marine micro algae such as *Skeletonema costatum* and *Ulva fasciata*

showed inhibition against *V. harveyi*. The ethyl acetate extract of *S. costatum* reduced the luminescence to 10-25 counts per second (CPS) when compared to control. Methanol and chloroform treated extract of *U. fasciata* showed lower luminescence production (10 to 15 CPS). The challenge experiment in shrimp postlarvae using aqueous garlic extract against *V. harveyi* showed ten-fold reduction in the mortality compared to control.

SOCIAL SCIENCES DIVISION

Project Title (Institute)	**Growth, marketing and extension synergies in brackishwater aquaculture**

Extension in diversification of brackishwater aquaculture

The study was carried out to evaluate the extension approaches required by the stakeholders for the farming of diversified shrimp species other than the tiger shrimp (*Penaeus monodon*), *viz*., Indian white shrimp (*Fenneropenaeus indicus*), banana shrimp (*Fenneropenaeus merguiensis*), kuruma shrimp (*Marsupenaeus japonicus*) and western white legged shrimp (*Litopenaeus vannamei*). As a second phase of study, the data/information was collected from 94 aquafarmers *viz*., Tamil Nadu (8), Andhra Pradesh (25), Gujarat (south -36 and North -10) and Kerala (8). Farmers' opinion on (i) extension needs and (ii) requirement of extension material (such as booklets, etc.) for commercial culture of the above species was collected using open and close ended questionnaires.

The extension requirements of the aquafarmers were found to be more for *L. vannamei* than the other alternative species, except in south Gujarat region (Surat and Bharuch), where tiger shrimp culture is still followed successfully, and as per the opinion of farmers, any extension strategies for other shrimp species were not required at present (Table 33). Some of the aquafarmers from north Gujarat (Saurashtra area) have expressed their interest for *F. merguiensis* culture and wanted help in the form of training and demonstration. In Andhra Pradesh, one of the farmers expressed interest in *M. japonicus* and three in *F. indicus* farming with a request for extension support.

Table 33. Extension needs and requirement of extension material of aquafarmers

Opinion of the Aquafarmers	Andhra Pradesh	Tamil Nadu	Gujarat		Kerala
			South	North	
1 Training course in *L. vannamei* farming (general and technical knowledge)	✓	✓			✓
2 Farmers meet regarding *L. vannamei* farming	✓	✓			
3 Group discussion regarding *L. vannamei* farming	✓				
4 Demonstration of *L. vannamei* farming	✓	✓		✓	✓
5 Seminar on *L.vannamei* farming	✓				
6 Training in *L. vannamei* farming and Marketing	✓				
7 Training in *L. vannamei* farming and biosecurity	✓	✓			
8 Field visits to *L. vannamei* farming areas	✓	✓		✓	✓
9 Training / Seminar in *F. indicus* farming technology	✓				
10 Information on the *F. indicus* farming	✓				
11 Training in *F. merguiensis* farming technology				✓	
12 Training in *M. japonicus* farming technology					
13 Tiger only; no need of any other species			✓		
14 Training in both tiger and *L.vannamei*	✓				
15 Information material	✓	✓		✓	✓

Domestic markets for aquaculture produces

To estimate the demand for fish in Chennai urban region, prices and volume of sale were collected from bill registers of Tamil Nadu Fisheries Development Corporation (TNFDC). Daily average sales and weekly average prices were worked out for top ten marine and brackishwater species which varied from ₹ 180 to ₹ 350 per kg. Shrimp, seabass, pearlspot, mullets and milkfish were the preferred brackishwater fishes in Chennai according to order and commanded prices. Though there is an actual demand of 300 tonnes per day (per capita consumption of 8 kg per caput), only less than 200 tonnes is available indicating one third gap of the supply. A marked demand for small and low value fish from poor (65.17%) and repeat purchases of same fish varieties (78.23%) were also observed. There was positive perception (82.43%) about fish for medicinal values. For better domestic prices, aqua-crop calendar suggested for seabass was from mid September to April / May and for shrimp it was from August to November and January / February to April. This study was done at the request of TNFDC and report was submitted for its use.

A market case study on *L. vannamei* was undertaken in Chennai urban region. A domestic price of ₹ 250-320 band was paid for white shrimp (40-50 counts) in Chennai urban region, while farmers reported ₹ 220-250 as the price offered by exporters. If mini cold storage facilities are created for supporting slow release of harvest, domestic demand could be tapped by *L. vannamei* producers.

International markets for aquaculture produces

The major cobia producing countries are China and Taiwan. The total production of cobia was 0.42 MMT(Million Metric Tonnes) by capture and only 25 MT by culture in 2009 (FAO, 2011). China, Japan and Taiwan are the major importers in the world. Production costs were reported at equivalent of INR 110 in China and consumer prices at retail market were about INR 275 as reported in FAO datasheets. TNFDC reported sale values of cobia in India as ₹ 200 for more than 1 kg size fish and was about ₹150 -180 for less than 1 kg size fishes.

Egypt, Italy and Hawaii are major producers in the world for grey mullet. The total production of grey mullet globally was 1.13 MMT by capture and 2.17 MMT by culture in 2010. It has a very limited export potential. As per FAO (2011), though the production costs were kept to a minimum (< 1USD/ kg), accordingly market prices were also 'low' (<2USD/kg). TNFDC sale values ranged from ₹120-180 for approximately 1 kg fish.

Domestic fish marketing by women

The '*Thenkumari* Fisher-women Self Help Group (FWSHG)" in Tamil Nadu developed a partnership with corporate firm by adhering to the standards prescribed. The institutional credit support is a critical factor and the women repayment discipline is a lesson to be learned and emulated by others. In Kerala, MATSYAFED, the State owned Co-operative Federation for Fisheries Development had experimental trial with FWSHGs in three modes viz., Fresh Fish Express, Fresh Fish Point and Fish booths. All of these were established for special reasons but with the exclusive objective of enhancing the income status and livelihood improvement of fisher women. In West Bengal, the focal point is the women fish vendors in 'Benfish kiosks'. While the womenfolk accounted for the major labour force and work hours, their ownership of the assets were negligible. Nevertheless, their fiscal discipline, perseverance and group cohesiveness have proved their worth. Lack of awareness on technical and business management aspects of entrepreneurship opportunities and inadequate capacity building were the major constraints. Awareness and capacity building programmes need to be conducted to enhance

their skills not only in fish handling and value addition but in food safety too. Development and management of market linkages would contribute for their socio-economic development and help them to bring to the business mainstream.

Assessment of women empowerment through exposure (ICT) in coastal areas in Odisha

An assessment of women empowerment through information and communication technology (ICT) in coastal areas in Odisha was conducted. The opinions of 70 users of Communication Information Centres in Badhinuapalli and Kanheipur, Ganjam district were investigated using structured questionnaire. The findings show that the women in the study area gained a significant level of empowerment through exposure to ICT. Stepwise multiple regression analysis revealed that 84.7 % of the variation in a women empowerment can be accounted by the combined effect of five independent variables such as knowledge in ICT (62.5 %), education (13.3 %), participation in ICT project activates (6.0 %), extension media contact (1.7 %) and training exposure (1.2 %).

Communication Information Centre at Badhinuapalli Ganjam district

Crab fattening (in pens) by Irula tribal WSHGs

Livelihoods of Irula tribal women WSGHs had been severely affected due to tsunami disaster at Killai coastal villages, Cuddalore District, Tamil Nadu. Alternate livelihood through crab fattening technology was disseminated to these WSHGs by CIBA through Aquaculture Foundation of India. This programme was financially supported by Tsunami Emergency Assistance Project (TEAP) of the Asian Development Bank (ADB). Seven WSHGs consisting of 87 women members belonging to fisher women, Dalit and Irrula tribes practice crab fattening in 17 pens at Killai coastal villages. Market tie-up was made with crab market agents at Chintadripet, Pulicat and Nagapatnam. Market linkages were also created with GMR / CDM, Sea Food agency at Chidambaram. Crab fattening SHGs federation (CFF) with proactive committee members have taken up the control of functioning of the groups as a production and business enterprise.

Mobile telephony model - Teleaqua

The objective of the study was to understand and utilize the better existing models available in mobile

telephony. Teleaqua is the modified version of e-Sagu Aqua of IIIT, Hyderabad and V-Aqua of Byrraju Foundation that are already in operation in West Godavari district of Andhra Pradesh. The primary centre of Teleaqua was housed at Akkivedu, Bhimavaram (West Godavari) and manned by a fishery expert. It contained four components *viz.,* farmers, coordinator, fishery expert and database. The database contains information (Telugu) of farm parameters, details of soil & water, farmer's profile, fact sheets, disease history and photo gallery. A field co-coordinator selected by the farmers was allotted a fixed number of farms to be visited on a single day. He collected the details of the farms with photographic evidence. The fishery expert prepared and transmitted the farm specific advice to the field coordinator with the help of knowledge of database. Then it has to be delivered to the concerned farmer. Sometimes the fishery expert directly conveys the advice to the farmer via mobile phone.

Mobile telephony model - IFFCO Kisan Sanchar Limited

The IFFCO Kisan Sanchar Limited (IKSL) model is a tri-lateral joint venture between the Indian Farmers Fertilizer Cooperative Ltd (IFFCO), Airtel and Star Global Resources Limited in Thiruvallur district of Tamil Nadu. This service provided five free voice messages everyday for the fishing community and agricultural and allied sector farmers. Each voice message is of one minute duration and covered subjects like crop management, dairy, animal husbandry, market rates, weather forecast, human health, employment opportunities and information on Government schemes. IKSL distributed Airtel SIM cards branded 'Green SIM' to the farmers. It functions as a normal SIM besides providing the agricultural value added services (Agri VAS). Helpline support was being provided to the subscribers. Information as disseminated by Fisher Friend Mobile Application was also provided by this model.

Based on the understanding gained from the models studied, CIBA disseminated information related to coastal aquaculture through VMS to aqua/fish farmers. The focus area was Tamil Nadu, and about 300 farmers were covered under this service. Eighteen messages have been delivered through this free service. Weather forecasts, technologies/news, training programmes and market information were provided through this platform. This exercise was evaluated based on the feedback from 79 farmers with an open ended questionnaire. The same was depicted in the form of radar diagram (Fig. 54).

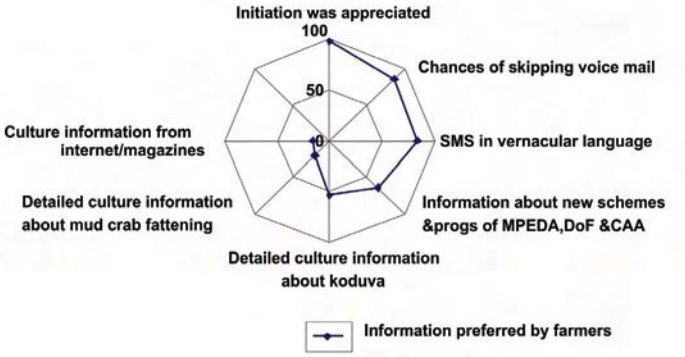


Fig. 54. Feedback of shrimp farmers about CIBA's voice mail service

Entrepreneurship motivation of the fisheries graduates

Brackishwater aquaculture in India is in the 'reviving phase' and inadequate skilled manpower is one of the serious constraints for the responsible development of the sector. Fisheries graduates need to be motivated to take up aquaculture and related avocations to contribute for the sustainable development of brackishwater aquaculture. An assessment of entrepreneurship motivation among the outgoing B.FSc graduates in Kerala (n=24) using a weighted entrepreneurship motivation index has shown that 63 and 33 % of the fisheries students respectively exhibited moderate and high entrepreneurial motivation (Fig. 55). The correlation coefficients showed that rural/urban nativity, family type, family annual income, parental education, parental occupation and community were not significantly related

to the entrepreneurial motivation levels of fisheries graduates. Further, a comparative assessment among the professional (n=24) and allied fisheries graduates (n=35) indicated that the professional graduates had relatively higher entrepreneurship motivation. Nevertheless, the risk taking ability was found to be low among the fisheries graduates in general ; however, the differences were not significant (P>0.05). Capacity building on entrepreneurship development and a government sponsored self-employment funding scheme in the model of 'agri-clinics' are essential to motivate the fisheries graduates towards aquaculture and allied activities.

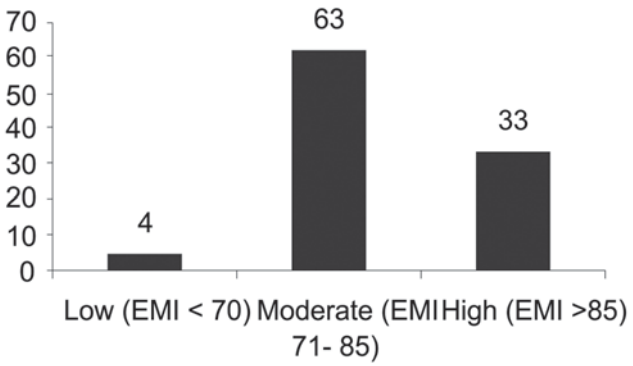


Fig. 55. Entrepreneurship motivation among fisheries graduates

Group cohesiveness management and supply chain linkage of shrimp farmer group

Effectiveness of farmer groups is a function of group cohesiveness by managing potential internal conflicts and threats. The Pamini river shrimp farmers association which is a successful shrimp farmers group has identified prospective conflicts and developed appropriate solutions to eliminate those conflicts (Table 34). The association had strong linkage with hatcheries, input dealers, consultants, local community, government agencies and processors. The identified solutions helped in addressing these conflicts adequately and strengthening the group cohesiveness which ultimately provided superior performance. The Pamini cluster had a successful shrimp harvest for a record ninth time in 2011 with 600 tonnes of quality shrimp with a premium price of ₹350/kg for 30 count. The association has established the supply chain linkage from brooder source to market to avail quality inputs and premium price. Identification of potential risks and implementation of appropriate risk management strategies at every level has ensured its group cohesiveness.

Farmer innovations in shrimp aquaculture

Aquaculture farmers try to apply some innovative practices and try to develop or modify culture practices. The farmer innovations documented this year include: (i) use of curd + neem leaves + curry leaves paste mixed with feed to improve the vigour and growth of shrimp(ii) ginger + garlic + turmeric paste mixed supplied through feed to enhance the digestibility and growth (iii) tamarind / turmeric paste mixed with feed to enhance the digestibility and growth, (iv) preparation and application of panchakavya (fermented and filtered solution made of cow dung, cattle urine, curd, jaggery etc.) to enhance natural productivity and water quality management, (v) banana flower extract to improve the immunity and disease resistance (vi) banana stem juice/banana leaves/banana straw to control the dinoflagellates and improve the water quality, (vii) charcoal to minimise/control the ammonia level in the pond, (viii) river sand to improve the water quality and facilitate better molting, (ix) sub-surface reservoir for recirculation of the water for effective water management and bio-security, (x) 90 days *L. vannamei* culture in freshwater for domestic market and low count shrimp a *niche* for tiger shrimp farming.

Utilization of ICT based dissemination system among users of coastal KVKs

A study was conducted (a) to assess the extent of utilization of ICT based dissemination system by the users of coastal KVK for aquaculture and allied activities and (b) to determine the effects of selected

Table 34. Potential conflict points and hygiene solutions for their management by a farmer group

Potential conflict points	Identifed solutions
Initial pumping for water culture Seed selection at hatchery& stocking	• Lot system & batch wise • Lot system for larval tanks • 50% Water Spread Area alone to be stocked in a batch by an individual
Adoption of BMPs & prevention of vertical entry of pathogens Bio-security	• No independent seed procurement • Member should not have farms anywhere • Consultants do consultancy only here • Net sampling by fishermen not allowed
Disease reporting and management	• Association to decide the course of action
Accountability & transparency	• Joint bank A/C; Audited balance sheet • GB minutes-practices-copy to all –binding • Uniform market price as per count size • Decision making only by executive committee
Social responsibility	• Association fixed wages; no child labour • Association decision is final in case disputes between farmers, input suppliers, payments etc
Membership	• Compulsory membership • Membership fee and association fee collection during marketing & agreement
Democratic functioning	• Membership fee equal • Annual association fee as per WSA • Decision making by consensus • Common meeting place • Members are equal irrespective of age, farm size, community etc.
Supply Chain linkage	• Contact with fishermen for brooder sourcing • Collective seed procurement from a single hatchery • Plan to use single brand of feed and buy directly from the producer company • Interact with govt.agencies as a group • Association fixed technical consultancy • Association fixed wages for labourers • Negotiation with the buyers for premium price

socio-economic variables of the users of KVK on their extent of utilization of ICT based dissemination system. The extent of utilization for ICT based dissemination system of 60 users of KVK, Kattupakkam, for their aquaculture and allied activities indicated 'full' extent of utilization for some of the ICT dissemination system such as mobile phones (66.67 %), video film (58.33 %), and television and audio CD (50 %). In the case of touch screen kiosks (33.33 %) the extent of utilization by the users was significantly 'low' and 'nil' . Out of eight ICT dissemination systems, mobile phone is highly recognized and utilized by the users for aquaculture and allied activities. Further the results revealed that the socio-economic variables namely education, extension media contact, training exposure, knowledge in ICT, and participation in ICT project activities had positive relationship with level of utilization of ICT based system. Stepwise regression analysis revealed that 82.5 % of the variation in

utilization level can be obtained by the combined effect of knowledge in ICT (60.1%), education (14.1%), participation in ICT project activities (5.9%), extension media contact (1.3%), and training exposure (1.1%).

Needs assessment for the development of e-Learning modules

Needs assessment of 60 users of coastal KVK, Kattupakkam, on e-Learning modules in aquaculture and allied activities such as *P.monodon/L. vannamei* culture practices, diversified species and allied activities, and base information have been investigated by means of a survey questionnaire. The need of e-Learning modules on soil and water management in shrimp *P.monodon/L. vannamei* culture, value added products from shrimp/fish and addresses and information on fisheries/aquaculture related institutes, departments, universities and coastal KVKs etc. were ranked first (Table 35). In addition e-Learning on preparation of quality and hygienic dry fish, educational and health oriented information, mud crab fattening, and dynamic market information were sought by the users of KVK for adoption of aquaculture in coastal areas.

Table 35. Needs of e-Learning module of users of KVK, Kattupakkam

Categorization of aquaculture and its allied activities	Overall	
	Score	Rank
***P. monodon* / *L. vannamei* culture practices**		
Soil and water management	33	1
Feed management	23	3
Disease management	31	2
Diversified and allied Information		
Mud crab fattening	58	3
Seaweed	19	5
Ornamental fishing	50	4
Seabass	4	6
Value added products from shrimp/fish	73	1
Hygienic dry fish preparation	60	2
Basic information		
Address and information on fisheries/aquaculture related institutes, departments, universities, Women Self Help Groups etc.,	85	1
Coastal development programme and subsidies	68	4
Dynamic market information (shrimp, fish, dry fish, etc)	76	3
Educational and health oriented information	81	2

User perceptions on commercialised technologies in brackishwater aquaculture

The objective was to understand the user perceptions on pH-DO (Dissolved oxygen) kit developed and commercialized by CIBA in 2009 for aquaculture use. The kit was distributed to the freshwater aquaculture farmers of Madhya Pradesh, Gujarat, Chhattisgarh and Punjab. Survey was conducted to understand the user perceptions on the different parameters like cost, ease of handling, ease of interpretation, availability, accuracy and constraints in using the kit. As per the survey, the CIBA pH-DO kit was found to be cost effective compared to other commercially available kits without compromise on the accuracy. The kit costs 62-65% lesser than the other commercially available kits. With regard to users' satisfaction levels on the kit, they are very much satisfied with the price and skill required, moderately satisfied with the package and speed of interpretation and neutral about availability. However, users expressed some qualitative suggestions with regard to the CIBA pH-DO kit which have been documented for further modification of the kit.

Project Title (NABARD)	E-extension strategy for ensuring knowledge led rural growth

Around 300 farmers were interviewed from Thalainayur aqua hub of Vedaranyam Taluk in Nagapatnam district of Tamil Nadu with a structured interview schedule on the information requirements of shrimp farmers with reference to Best Management Practices (BMPs). Shrimp culture is a major livelihood for more than three fourths of the population in this area. About 62 % of persons approached private input dealers (feed and probiotics suppliers) for information. Among the total, 86 % expressed interest to have awareness programmes in the farming community to motivate cooperation amongst farmers during the culture period. They also expressed an interest in training on BMPs.

They felt that simple publications and information on culture, BMPs and crisis management in Kiosks in the vernacular language will help to educate them. A sizeable percentage of farmers (51.3 %) reported that they desired to receive information from government agencies, which they ranked as highly reliable. About 82.3% were in need of information on the recommended dose of lime and fertilizer application. All the farmers expressed a need for training in soil pH (93.3 %) followed by water quality. Mostly all wanted to get a list of probiotics/chemicals that are to be avoided during culture. All farmers desired training on disease detection and their preventive measures. Farmers preferred CIBA to disseminate information through mobile phones regarding shrimp culture which was confirmed with the Friedman test. About 62 % of the farmers desired that the Short Message Service to be sent in the forenoon, once a week (88 %) in the vernacular language (100 %).

The successful approaches of four different ICT models used by 283 users pertaining to mobile telephone technologies were studied. The strengths of the models depicted as determined by rank based quotient (Table 36) are being used in building the content for kiosks and mobile phones. Quick delivery of services, accountability of advices and exchange of information among the major stakeholders were specified as high priority areas.

Table 36 . Successful approaches of ICT models

Sl. No.	Successful approaches/Strengths	Dynamic Market Information N=78	e-Velanmai N=90	Fisher Friend Mobile Application N=56	Mobiaqua N=59
1	Quick delivery of services.	1.00	1.00	0.99	1.00
2	Accountable advices are provided.	-	0.73	0.84	0.72
3	Exchange of information among the major stakeholders.	0.62		0.70	
4	ICT enables access to update information.		0.03	0.57	
5	Provides a strong database to support decision making.			0.35	
6	ICT can reach even the non-reachable remote areas.		0.31	0.16	0.31
7	It is a cost effective method of interactive system.	0.34	0.49	0.05	0.51
8	It enables farmers to cultivate like experts.		0.14	-	
9	Production cost is reduced by avoiding unnecessary applications.		0.89	-	
10	Reduces the lag period between research efforts to farm practice.		0.62	-	

KAKDWIP RESEARCH CENTRE

Project Title (Institute)	Enhancement of brackishwater aquaculture production of shrimp and fishes through economically viable and sustainable approach

Use of periphyton in improvement of tiger shrimp productivity

This trial was carried out and fed on pellet diet in zero water exchange system at Kakdwip Research Centre for 140 days in 2 earthen ponds (1000m^2) with *P.monodon* stocked @ 11 no. /m^2. For periphyton growth, a vertical substratum of white velon net (1 m width and 60/60 mesh size) erected in ponds provided an enhanced surface area of 4.5 %. During culture, it was observed that shrimp concentrated towards the net. The chlorophyll content of periphyton on the velon net substrate increased over the culture period. Gut content analysis revealed variation depending on the size of shrimp during the grow-out period. At harvest, the ABW of shrimp in treatment and control ponds were 31.64 g and 31.0 g respectively. The average production achieved from control and treatment ponds were 2.50 and 2.615 tonnes/ha/crop respectively indicating an increase of 0.115t/ha/crop in treatment ponds. The feed conversion ratio (FCR) was 1:1.57 and 1:1.44 in control and treatments ponds respectively. The 13% reduction in FCR would result in significant economic gain (Table 37). Hence, velon net as a substrate to grow periphyton in shrimp farming is a promising option for low input eco-friendly shrimp culture.

Table. 37 Natural productivity in zero water exchange shrimp farming systems

Natural Productivity System	Survival (%)	ABW(g)	FCR	Production tonnes/ha
Periphyton	74.22	31.64	1.44	2.61
Green water	79.60	29.99	1.45	2.70
Control	72.70	31.00	1.57	2.50

The highest productivity of 2.70 tonnes/ha was from green water system with the highest survival of 79.60 %. The lowest FCR of 1:1.44 was recorded from periphyton based system.

Microbial analysis of substrate based periphyton and green water systems

The total microbial and *Vibrio* count in velon substrate based periphyton and green water were monitored at regular intervals. The total microbial load was in the range of 10^6 and 10^4 and *Vibrio* count in the range of 10^3 and 10^1 in the sediment and water column respectively. The periphyton was effective in reducing total microbial load as well as *Vibrio* load in the water column while green water was found effective in controlling total microbial load. However, similar effects were not discernible in both systems for total microbial load and *Vibrio* count in sediment.

Demonstration of finfish and shellfish polyfarming

As part of the efforts at refining the polyfarming technology, the practices adopted in three ponds (each of 1.18 ha) was followed. In these ponds *Mugil cephalus* (4.5 g), *Etroplus suratensis* (4 g) and *Penaeus monodon* (0.1 g) were stocked @ 10,000, 1000 and 10,000 numbers/ha, respectively. Prior to stocking, essential pond preparation steps, *viz.* bottom tilling, liming and application of mahua oil cake as manure were followed. Fertilization and liming was carried out at regular intervals and water

exchanged during high tides for maintaining proper pond environment. Farm-made fish feed (₹10/kg) using boiled potato (when the price fell to ₹3-4/kg) and commercial carp floating feed (₹30/kg) were applied in feeding zones encircled with nylon net with an open bottom. After 150 days, tiger shrimp was harvested (ABW= 42 g) and grey mullet (570 g) and pearlspot (100 g) were harvested after 300 DOC. The farmer could realize a production of 2520 kg/ha with a net income of ₹1.69 lakh/ha.

Refinement of low cost polyculture feed

Low cost polyculture feed (CP-29.77%) formulated with locally available unconventional feed ingredients, has been refined and a demonstration trial was conducted in a farmer's pond (4666 m^2) at Madanganj, Namkhana, South 24 Parganas list. Six brackishwater species *viz. Liza parsia* (21431 nos./ha), *Liza tade* (4286 nos./ha), *Mystus gulio* (15000 nos./ha), *Mugil cephalus* (2357 nos./ha), *Scatophagus argus*(2143 nos./ha) and *Penaeus monodon* (2143 nos./ha) with initial average body weight of 0.5 , 0.5, 5 , 50, 10 and 0.02 g respectively, were stocked. Low cost feed @ 4 to 10 % of estimated biomass was fed twice daily. Lime was applied monthly @ 140 kg /ha. Monthly routine sampling was carried out to assess the growth and water quality parameters. After 325 DOC, production of 3.14 tonnes/ha could be realized with a FCR of 0.88 and net profit of more than ₹ 2.0 lakhs/ha. The survival and growth of the different species are known in Fig. 56 and 57.

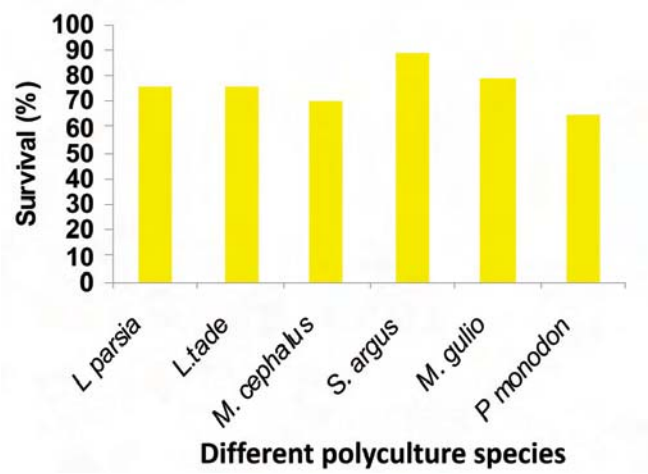


Fig.56. Survival of the species under polyfarming with farm-made feed

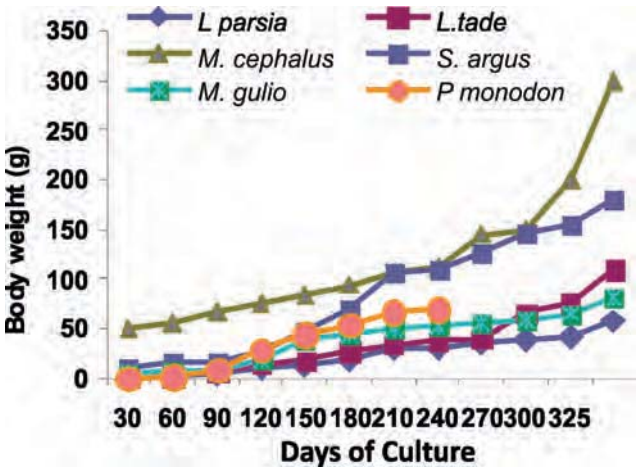


Fig.57. Growth of the different species under polyfarming

Evaluation of biofloc technology and associated microbes

Biofloc-based shrimp and fish culture system converts toxic nitrogen metabolites to useful microbial proteins ultimately reducing the production cost. These biofloc are made up of heterotrophic microbes, various algal communities, protozoans and food particles. Supplementation of carbohydrate and manipulation of carbon nitrogen ratios provide the basic nutritional input to the available microbes which ultimately dominate and start floc formation. An experiment was carried out to evaluate the amount of bacteria which would remain suspended as floc over a time period at different CN ratios. Bacteria were grown at four CN ratios CN5, CN10, CN15 and CN20 using molasses and ammonium sulphate in 1 lit flask with constant shaking in rotary shaker at 100 rpm. At 0 h, 24 h and 72 h, biofloc suspension was passed through 10µ filter paper and bacterial quantity on the filter and filtrate was estimated. It was observed that the bacterial quantity increased from the initial range of 10^4 and reached

10^6 at 24 h and 10^8 at 72 h. The experiment further revealed that increased microbial load at 24 h was due to individual bacteria that passed through the filter, but by 72 h, the floc dominated the system (Fig. 58).

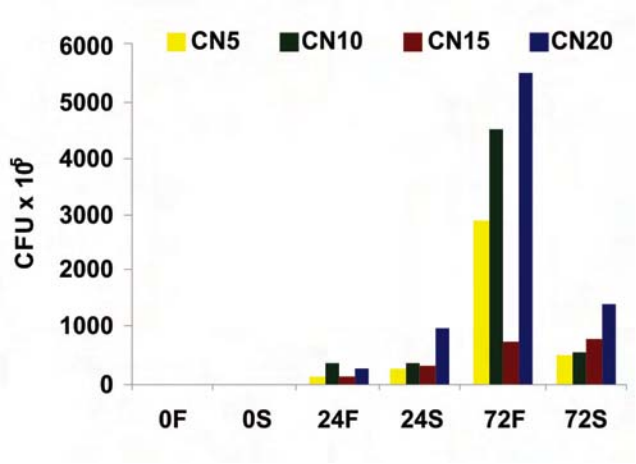


Fig. 58. Microbial dynamics in biofloc system at different time intervals. (*S – Microbes in suspension; F-microbes as floc)

Documentation of evolving brackishwater aquaculture systems in West Bengal

A cross-sectional interview-based survey was carried out in four tribal villages (Manmathapur, Harintangi, Alipore and Mrinalnagar) of Kakdwip block to assess the present status of the tribals with special reference to aquaculture. Respondents for the study comprised 68 households and their main profession is agriculture and sometimes as casual labourers. Considering all the villages, about 32% of the households are very small and have a pond of <0.1 ha area. Traditional farming is practiced in all the ponds and the fishes produced are consumed domestically and the production level is very low (< 0.1 ton/ha). Most of them are fresh water ponds (67%). The farmers release carp seeds in these ponds. There is no application of fertilizer and lime and fishes are not fed. In brackishwater impoundments, water is exchanged every lunar cycle. The farmers solely depend on autostocking. Fishes, shrimps and crabs are harvested during water exchange. Productivity from brackish water impoundments is less than 500 kg/ha. The inhabitants of the tribal villages of Kakdwip block dwell in very poor conditions. A considerable percentage of families are landless (44.5%) in all the villages. Those having little land are not able to sustain their yearly requirements. Hence, they need to opt for other vocations like crab collection, piggery and working as daily labourers near or far from their homes. Piggery and poultry are the most preferred secondary profession possibly due to their specific ancestral culture. An integration of aquaculture with these professions may improve their economic condition.

Homestead farming system in West Bengal

A survey was carried out in four villages *viz.* Pukurberia, Akshynagar, Shibpur and Kalinagar of Kakdwip block, South 24 Parganas district where numerous homestead brackishwater ponds are available. The uniqueness of these ponds is that both fresh water and brackishwater species are cultured together. Respondents for the study comprised 82 households having at least one homestead brackishwater pond. Considering all the villages, most of the households comprised of smaller families (<5 members) and ratios of males are more. Most of the households have more than 20 years of aquaculture experience and invest their personal savings as source of finance. Major occupation is casual labour and most of them are engaged in fishing, however a moderate number of households have agricultural land. Most of the house holds in all the villages practiced traditional polyculture in their own pond which are less than 0.1 ha and the ponds are aged between 11 to 20 years. Most of the ponds are fertilized with organic fertilizer in the form of cow dung. Dough feed (mustard oil cake, rice bran etc.) is also applied. Production from these ponds is less than 1000 kg/ha and it is used for domestic consumption. Major problem encountered is low production. Majority of the households earn less than ₹3000/ month. Homestead brackishwater ponds if managed properly can help to improve the economic condition of the households.

Project Title (NAIP)	Strategies for sustainable management of degraded coastal land and water for enhancing livelihood security of farming communities

The objectives of the project are enhancement of the productivity of degraded land and water resources through integrated approaches, livelihood security and employment generation for the poor farming communities, empowerment through capacity building and skill development of stakeholders including men and women farmers of the coastal region.

Development and implementation of land shaping technology

This is being implemented in the low lying coastal areas of Sunderban, West Bengal round the year (crop cultivation in raised land and integrated aquaculture in the pond) to increase the income of the farmer. A total of 5.47 ha has been developed under this programme. Thirty-four rain water harvesting ponds were excavated with 15262.94 CUM area for irrigation and fish culture. Inputs (paddy, brinjal, okra, bottle gourd, bitter gourd, snake gourd, cucumber, pumpkin, yam seeds, organic fertilizer and neem pesticide) were distributed to 36 beneficiaries whose land (7.638 ha) was cultivated during kharif and rabi seasons. The farmers achieved an average production of 3.19 t/ha paddy, 11.37 t/ha vegetables, 0.57 t/ha pulse crop (chickling pea) and 1.64 t/ha fish (Fig 59). Rain water harvested was 20486.24 CUM. It was found that there was a significant increase in income of farmers through this technology as they were successful in integrating aquaculture and crop cultivation throughout the year with irrigation facility being made available from the harvested rain water.

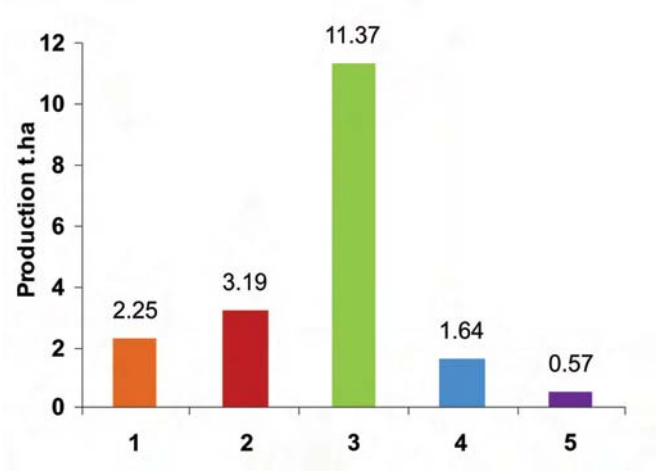


Fig. 59 Production status before and after land shaping

1- Paddy (local variety), kg/h before land shaping, 2- Paddy (HYV), t/ ha after land shaping, 3-Vegetable, t/ha after land shaping, 4-Fish, t/ha after land shaping, 5-Pulses crop, t/ha after land shaping

Water harvesting pond of land shaping unit at Uttarchandanpiri village

Vegetable & fish cultivation in land shaping unit at Akshaynagar

Implementation of brackishwater aquaculture

A total of 2.53 ha has been developed by excavating 13 brackishwater ponds. Tiger shrimp @ 3ps/ m^2 and mullet seed (*Mugil cephalus* and *Liza tade* in 1: 3 ratio) @ 0.6 nos/ m^2 were stocked in excavated ponds. After 4 months of culture, an average production of 450 kg/ha tiger shrimp and 745 kg/ha fish were achieved (Fig. 60). The farmers earned ₹1,34,383 / ha /year from the sale of shrimp and fish. It would be pertinent to note here that before implementation of this project, the land was fallow and not being utilized for any agricultural activity on account of high soil salinity.

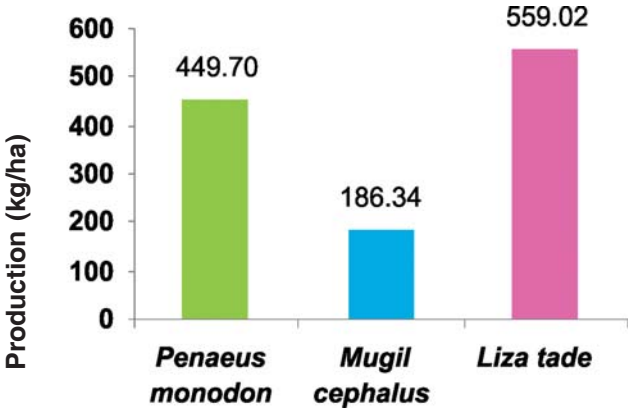


Fig. 60. Production status of brackishwater polyfarming under NAIP

Brackishwater pond excavated at Gangadharpur village

Shrimp harvesting at Ganeshnagar Village, Namkhana Cluster

Paddy cum fish cultivation

A total of 0.67 ha has been developed which includes four freshwater ponds for paddy-cum-fish cultivation. Scampi @ 0.44 no./m^2 were stocked 15 days after paddy transplantation and Indian Major Carp fingerlings (*Catla catla, Labeo rohita & Cirrhinus mrigala* in 4:3:3 ratio) were stocked @ 0.68 no./m^2 in farmers' land where trenches/ponds were excavated. After 4 months of culture, farmers obtained a production of 149 kg/ha scampi, 525 kg/ha fish and 1719 kg/ha paddy earning an extra income of ₹56000 /ha/year when they practiced paddy-cum-fish culture as compared to paddy cultivation alone (Fig.61).

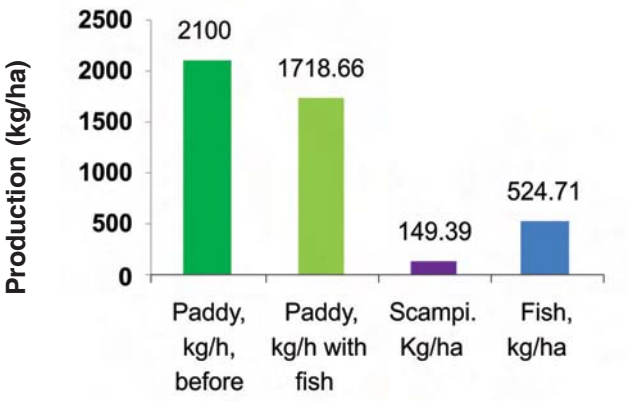


Fig. 61. Production status of paddy as sole crop and paddy-cum-fish cultivation

Introduction of diversified crops

The suitability of different potential crops in coastal degraded area of Sunderban was studied and it was observed that amongst the three rabi crops *viz.* sunflower, sesame and green gram, appear to be

Land developed for paddy-cum-fish cultivation at Jumainaskar

Fish harvesting in paddy plot at Ganeshnagar

the most profitable crop yielding 1650 kg/ha and an income of ₹ 22,033/ha. Sunflower, mustard and spinach seed along with manure, fertilizers and pesticides required for cultivation have been distributed to 250 farmers for cultivation of sunflower (11.9 ha) mustard (4.24 ha) and spinach (1.2ha) in six villages adopted by NAIP (Fig.62). Sunflower cultivation has been adopted by a large section of farmers on their own.

Sunflower harvest at Gangadharpur village, Kakdwip cluster

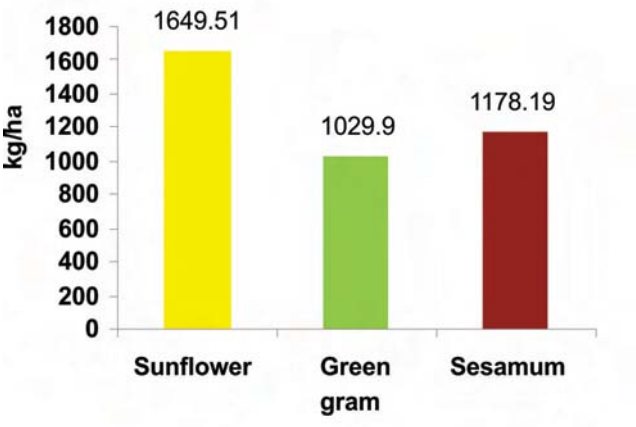


Fig. 62. Production status of alternative crops at coastal degraded land of Sunderban

Mushroom cultivation

Mushroom cultivation was introduced in the salinity affected village of Gangadharpur, Kakdwip to improve the livelihood and nutritional security of poor farmers especially women. Preetilata Self-Help Group within the village was selected based on the interest evinced by them, suitability of land, and proximity to the local market and railway station. A model mushroom shed was constructed with 16 rows rack system and a capacity for keeping 500 cylinders. Spawn of *Pleurotuss ajorcaju* popularly called as "oyster mushroom" was supplied on a regular basis. It was

Mushroom cultivation at Gangadharpur

observed that on an average, each packet of spawn (200 g) produced 0.76 kg of mushroom but in the last 5 months of culture, the average production rose to 1.54 kg/ pkt. spawn. Average production cost was ₹ 16.9/kg which reduced to ₹ 8.7/kg in the last five months. The huge jump in productivity in the latter period could probably be attributed to a combination of skill gained, establishment of market channel from local market, presence of a Kolkata based exporter and favourable season. The actual monetary benefit during 13 months was ₹ 7400/-. Apart from this monetary gain, farmers consumed mushroom as vegetables (worth ₹ 4000/-). By establishing a strong market channel, mushroom cultivation could be a viable option in improving the livelihood and nutritional security of farmers in Sunderban. As the soil of this area is saline and nutritionally degraded, the spent mushroom by-product could serve as a substrate for amelioration of soil and could render an additional advantage through reduction of cost of fertilizer.

Vermicomposting : A total of 16 vermicomposting units (10 during 2010 -11 and 6 during 2011-12) were constructed in 4 villages. The average production of vermicompost from 10 units was 601 kg/yr. Farmers could reduce chemical fertilizers by using vermicompost without affecting total production.

Vermicomposting unit at Dwariknagar

Livestock/poultry health management

Six livestock health camps and trainings were conducted. A total of 511 families were benefited and 366 farmers were trained in livestock and poultry health management. During the camp, vaccination against Foot and Mouth Disease for 500 cattle, hemorrhagic septicemia and black quarter for 1000 cattle, goat pox for 600 goats and Ranikhet disease for 600 poultry were carried out. In addition, deworming was carried out in 570 cattle and 600 goats. Other camp activities such as pregnancy verification in 98 cattle, infertility treatment in 167 cattle and treatments in 75 animals were also carried out.

Artificial insemination at Ganeshnagar village

Livestock health management training at Gangadharpur village

5

Ongoing Research Projects

Crustacean Culture Division

Project Title 1	**Improvement of shrimp production and productivity through quality seed production and diversification into other shrimp species**
Project Leader	**Dr. P.Ravichandran**
Project Location	**Chennai**

Sub-Project Title	Sub-Project Leader
Optimization of induced maturation of domesticated tiger shrimp *P. monodon*	Dr.C.P.Balasubramanian
Environmental manipulation for improved maturation under captivity	Dr.P.Nila Rekha
Microbial monitoring in shrimp hatchery and development of probiotic based seed production techniques	Dr.A.Panigrahi
Culture of *Litopenaeus vannamei*	Dr.P.Ravichandran
Evaluation of shrimp farm waste water treatment system	Dr.M. Muralidhar
To enhance the efficacy of the CIBASTIM through incorporating the adjuvants and to improve the delivery system by addition of specific encapsulating agents	Dr.C. Gopal
Culture of polychaetes	Dr.C.Gopal
District level planning for brackishwater aquaculture	Dr.M.Jayanthi
Domestication of tiger shrimp	Dr.G.Gopikrishna

Project Title 2	**Scaling up of production system of mud crabs**
Project Leader	**Dr.C.P.Balasubramanian**
Project Location	**Chennai**

Sub-Project Title	Sub-Project Leader
Optimisation of seed production of *Scylla* spp.	Dr.C.P.Balasubramanian
Refinement of nursery rearing of *Scylla* spp	Dr. J. Syama Dayal
Identification of potential farmers and demonstration of nursery rearing technique	Dr.C.P.Balasubramanian

Project Title 3	**Development of techniques to quantify the impacts scenario between environment and aquaculture using remote sensing and GIS**
Project Leader	**Dr.M.Jayanthi**
Project Location	**Chennai**

Sub-Project Title	Sub-Project Leader
Assessment of impact of aquaculture on Sunderban mangroves	Dr.M.Jayanthi
Development of methodologies for aquaculture development management using RS and GIS	Dr.M.Jayanthi

Project Title 4	**Collaborative project on brackishwater aquaculture development in Gujarat**
Project Leader	**Dr.S.M.Pillai**
Project Location	**Navsari Agricultural University, Navsari, Gujarat**

Sub-Project Title	Sub-Project Leader
Development of cuture technology package for banana shrimp and Asian seabass	Dr.S.M.Pillai
Evaluation of current shrimp farming practices and to assess the potential of brackishwater finfish culture in Gujarat	Dr.V.S.Chandrasekaran
Addressing the extension requirements of aqua farmers in Gujarat	Dr.V.S.Chandrasekaran
Assessment of farming practices followed in *L.vannamei* culture in Gujarat	Dr.C.Gopal
Study on the role of innovative water management methods on pond microbiology and productivity in shrimp culture systems	Dr. P.K. Patil

Project Title 5	**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.S.M.Pillai and Dr.M.Jayanthi**

Project Title 6	**Monitoring of disease occurrence and culture practices in L. vannamei in hatcheries and farms**
Project Location	**Chennai**
Funding Agency	**Department of Biotechnology**
Principal Investigator	**Dr. P.Ravichandran**
Co-Investigators	**Dr. A. Panigrahi, Dr. C.Gopal, Dr. M. Kumaran, Dr. S.K. Otta, Dr. Ezhil Praveena, Dr. T. Bhuvaneswari and Shri D.Rajababu**

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. S.M. Pillai, 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, Dr. J. Syama Dayal and Dr. Sherly Tomy**

Finfish Culture Division

Project Title 9	**Development of technology for quality seed production of commercially important brackishwater fishes under control conditions**
Project Leader	**Dr.A.R.Thirunavukkarasu**
Project Location	**Chennai & Kakdwip**

Sub-Project Title	**Sub-Project Leader**
Controlled breeding and quality seed production of Asian seabass *L. calcarifer,* grey mullet *Mugil* cephalus and milk fish *Chanos chanos*	Dr.A.R.Thirunavukkarasu
Technology improvement for breeding and seed production of pearlspot *Etroplus suratensis*	Dr.M.Natarajan
Development of breeding technology for ornamental fishes	Dr.M.Kailasam
Development of technologies for controlled breeding of Threadfin bream *Polynemus sp.*	Dr. J.K. Sundaray
Reproductive physiology of commercially important brackishwater finfishes	Dr.Prem Kumar

Project Title 10	**Refinement of fish culture technologies in brackishwater eco-system**
Project Leader	**Dr.M.Natarajan,**
Project Location	**Chennai & Kakdwip**

Sub-Project Title	**Sub-Project Leader**
Cage culture of Asian seabass in brackishwater open system	Dr.A.R.Thirunavukkarasu
Standardisation of nursery rearing technology for grey mullet and demonstration of culture technologies for mullet and milkfish in farmer's ponds	Shri G.Biswas
Cage culture of pearlspot	Dr.M.Natarajan
Evaluation of aquatic species for cultivation in effluent treatment pond	Dr.Shiranee Pereira

Project Title 11	**An export oriented marine value chain for farmed seafood production using Cobia *(Rachycentron canadum)* through rural entrepreneurship**
Funding Agency	**National Agricultural Innovation Project**
Co-Principal Investigator	**Dr.A.R.Thirunavukkarasu**
Co-Investigators	**Dr.M.Kailasam and Dr.Prem Kumar**

Project Title 12	**Demonstration of Asian seabass Lates calcarifer farming in the pond culture system**
Project Location	**Chennai**
Funding Agency	**National Fisheries Development Board**
Principal Investigator	**Dr.A.R.Thirunavukkarasu**
Co-Investigators	**Dr.M.Kailasam, Dr.J.K Sundaray, Dr.Prem Kumar, Dr.K.Ambasankar and Dr.J.Syama Dayal**

Project Title 13	**Indo Norwegian platform on fish and shellfish vaccine development- Development of viral vaccine against nodavirus and infectious pancreatic necrosis virus**
Project Location	**Chennai**
Funding Agency	**Department of Biotechnology**
Principal Investigator	**Dr.A.R.Thirunavukkarasu**
Co-Investigator	**Dr.Prem Kumar**

Aquatic Animal Health and Environment Division

Project Title 14	**Diseases of finfish and shellfish in brackishwater aquaculture: Diagnostics, prophylaxis and therapeutics**
Project Leader	**Dr.T.C.Santiago (upto July 2011), Dr. N. Kalaimani (August 2011 to February 2012) and Dr. K. P. Jithendran (March 2012 onwards)**
Project Location	**Chennai and Kakdwip**

Sub-Project Title	Sub-Project Leader
Screening emerging viral diseases in finfish *(Etroplus suratensis* and *Mugil cephalus*) and shellfish (*L. vannamei* and mudcrab) and development of suitable diagnostic techniques	Dr.S.V.Alavandi
Epizootiology, diagnostics and prophylactics of viral diseases of cultivable finfish	Dr.K.P.Jithendran
Characterisation of finfish and shellfish viruses and virus virulence studies	Dr.M.Poornima
Prophylactics and therapeutics of diseases in responsible shrimp aquaculture	Dr.N.Kalaimani
Studies on plant based immunomodulators in shrimp for enhanced disease resistance	Dr.P.K.Patil
Search for WSSV interacting proteins in *Penaeus monodon* by yeast two-hybrid to study the virulence mechanism and treatment strategy	Dr.S.K.Otta
Investigation of zoea syndrome in *L. vannamei*	Dr. Ezhil Praveena
Investigation of white gut syndrome of *P. monodon* in grow-out culture	Dr. T. Bhuvaneswari

Project Title 15	**Technology development for environmental management in brackishwater aquaculture**
Project Leader	**Dr. M. Muralidhar**
Project Location	**Chennai**

Sub-Project Title	Sub-Project Leader
Bioremediation of water and soil environment in brackishwater aquaculture	Dr. N. Lalitha
Environmental parameters monitoring and impact assessment in different farming systems and rendering services	Dr.M.Muralidhar
Nitrogen pathway determination and nano-remediation in aquaculture	Dr.R.Saraswathy

Project Title 16	**Bioremediation of effluents from shrimp farms**
Project Location	**Chennai**
Funding Agency	**National Bureau of Agriculturally Important Microorganisms**
Principal Investigator	**Dr.S.V. Alavandi**
Co-Investigators	**Dr.T.C.Santiago and Dr.N.Kalaimani**

Project Title 17	**Application of micro-organisms in agriculture and allied sectors - Microbial diversity and identification**
Project Location	**Chennai**
Funding Agency	**National Bureau of Agriculturally Important Microorganisms**
Principal Investigator	**Dr.T.C.Santiago (up to July 2011), Dr. N. Kalaimani (August 2011 to February 2012), Dr. K. P. Jithendran (March 2012 onwards)**
Co-Investigators	**Dr.N.Kalaimani and Dr.S.V.Alavandi**

Project Title 18	**Development of bacterial vaccines *(Vibrio anguillarum)* for sea bass**
Project Location	**Chennai**
Funding Agency	**Department of Biotechnology- Norwegian**
Principal Investigator	**Dr.T.C.Santiago (up to July 2011), Dr. M. Poornima (August 2011 onwards)**
Co-Investigators	**Dr.N.Kalaimani and Dr.M. Poornima**

Project Title 19	**Development of in vitro system from *Penaeus indicus* and freshwater crab *Paratelphusa hydrodomous* for WSSV replication, pathogenesis and quantification**
Project Location	**Chennai**
Funding Agency	**Department of Biotechnology**
Principal Investigator	**Dr.M.Poornima**

Project Title 20	**Horizontal transmission and infectivity of white spot syndrome virus in brackishwater aquaculture ecosystems**
Project Location	**Chennai**
Funding Agency	**Department of Biotechnology**
Principal Investigator	**Dr.S.V.Alavandi**
Co- Investigator	**Dr. M. Poornima**

Project Title 21	**Development and evaluation of greenwater technology for aquatic bioremediation in coastal aquaculture**
Project Location	**Chennai**
Funding Agency	**Department of Biotechnology**
Principal Investigator	**Dr. M. Kailasam**

Project Title 22	**Strengthening adaptive capacities to the impacts of climate change in resource-poor small scale aquaculture and aquatic resources dependent sector in the South and South-East Asian regions** **Indian case study: Impact of climate change on shrimp farmers and small scale farmers in low-lying coastal lands on east coast of India**
Project Location	**Chennai**
Funding Agency	**Network of Aquaculture Centres in Asia-Pacific**
Lead Centre	**NACA**
Principal Investigator	**Dr.M.Muralidhar**
Co-Investigators	**Dr.M.Kumaran and Dr.M.Jayanthi**

Project Title 23	**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**
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 and Dr.A.Nagavel**

Nutrition, Genetics and Biotechnology Division

Project Title 24	**Development of cost effective feeds for brackishwater fish and shrimp through specific dietary nutrient optimizations and alternative feed ingredients**
Project Leader	**Dr. S.A. Ali, (upto May 2011), Dr.K. Ambasankar (June 2011 onwards)**
Project Location	**Chennai and Kakdwip**

Sub-Project Title	Sub-Project Leader
Optimization of nutrients and ingredients for development of cost effective feeds for pearlspot fry rearing	Dr.K.Ambasankar
Optimization of dietary nutrients for high saline shrimp culture	Dr.J.Syama Dayal
Optimization of dietary nutrients for low saline shrimp culture	Dr.T.K.Ghoshal
Optimization of nutrients and ingredients for development of cost effective feeds for grey mullet *(Mugil cephalus)* fry rearing	Dr.Debasis De
Field testing of shrimp feed with fibrolytic enzyme mixture	Dr.K.Ambasankar

Project Title 25	**Outreach activity on fish feed**
Project Leader	**Dr.K. Ambasankar**
Project Location	**Chennai & Kakdwip**

Sub-Project Title	Sub-Project Leader
Use of alternate protein ingredients as a replacer of fishmeal in seabass feed	Dr.J.Syama Dayal
Development of feed management strategies for grow-out culture of seabass	Dr.K.Ambasankar
Interventions to improve feed digestibility efficiency and growth performance in seabass	Dr.T.K.Ghoshal
Formulation and testing of farm-made feeds for the culture of seabass in West Bengal	Dr.Debasis De

Project Title 26	**Outreach activity on nutrient profiling and evaluation of fish as a dietary component**
Project Leader	**Dr.J.Syama Dayal**
Project Location	**Chennai**

Sub-Project Title	Sub-Project Leader
Assessment and structured surveys on fish consumption profile and clinico-epidemiological studies on general health profiles of population *vis-a-vis* fish intake	Dr.J.Syama Dayal
Nutrient profiling of candidate species	Dr.J.Syama Dayal
Quality evaluation of Asian seabass	Dr.S.Kannappan

Project Title 27	**Exploring candidate genes for economically important traits in brackishwater organisms using biotechnological and bio-informatic tools**
Project Leader	**Dr.G.Gopikrishna**
Project Location	**Chennai**

Sub-Project Title	Sub-Project Leader
Association studies to unravel markers for growth traits	Dr.G.Gopikrishna
Larviculture, grow-out and harvest of tiger shrimp	Dr.S.Kannappan
Screening for reproduction associated genes in male *Penaeus monodon*	Dr.Sherly Tomy
Molecular studies on immune genes for disease resistance in *P. monodon*	Dr.M.S.Shekhar
Evaluating the potential for selection of economically important traits in rotifer *Brachionus plicatilis*	Dr.M.Kailasam

Project Title 28	**Outreach activity on fish genetic stocks**
Project Leader	**Dr.G.Gopikrishna**
Co-PI	**Dr.K.Vinaya Kumar**
Project Location	**Chennai**

Project Title 29	**Enrichment of aquafeed with cellulolytic and amylolytic microbes isolated from digestive tract of brackishwater fishes**
Project Location	**Kakdwip**
Funding Agency	**Department of Biotechnology**
Principal Investigator	**Dr.Debasis De**
Co-Investigator	**Dr.R. Ananda Raja**

Project Title 30	**Cost effective shrimp farming through adoption of indigenous innovative feed and better management practices by small scale farmers**
Project Location	**Chennai**
Funding Agency	**National Bank for Agriculture and Rural Development**
Principal Investigator	**Dr.K.Ambasankar**
Co-Investigators	**Dr.V.S. Chandrasekaran**

Project Title 31	**Bioprospecting of genes and allele mining for abiotic stress tolerance**
Project Location	**Chennai**
Funding Agency	**National Agricultural Innovation Project**
Consortium	**Dr. M.S.Shekhar**
Co-Investigators	**Dr.C.Gopal, Dr.Sherly Tomy and Dr.K.Vinaya Kumar**

Project Title 32	**Immunomodulation studies in freshwater prawn Macrobrachium rosenbergii using recombinant proteins of Macrobrachium rosenbergii nodavirus**
Project Location	**Chennai**
Funding Agency	**Department of Biotechnology**
Co-Investigator	**Dr.M.S.Shekhar**

Project Title 33	**Improved disease resistance of rohu carp and tiger shrimp farmed in India : Developing and implementing advanced molecular methods and streamlining access to and use of genetic resources**
Project Location	**Chennai**
Funding Agency	**Department of Biotechnology**
Project Co-ordinator	**Dr.A.G.Ponniah**
Principal Investigator	**Dr.G.Gopikrishna**
Co-Investigators	**Dr.P.Ravichandran, Dr.C.Gopal, Dr.M.S.Shekhar and Dr.K.Vinaya Kumar**

Project Title 34	**Development of inhibitors for controlling quorum sensing luminescence causing *Vibrio harveyi* in shrimp larviculture system**
Project Location	**Chennai**
Funding Agency	**Department of Biotechnology**
Principal Investigator	**Dr. S.Kannappan**
Co-Investigator	**Dr.P.K.Patil**

Project Title 35	**Molecular studies on sequential pathogensis 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**

Social Sciences Division

Project Title 36	**Growth, marketing and extension synergies in brackishwater aquaculture**
Project Leader	**Dr.V.S.Chandrasekaran**
Project Location	**Chennai**

Sub-Project Title	Sub-Project Leader
Extension in diversification of brackishwater aquaculture	Dr.V.S.Chandrasekaran
Marketing of aquaculture produce	Dr.T.Ravisankar
An assessment of gender participation and women entrepreneurs in aquaculture in Tamil Nadu and Orissa	Dr.B.Shanthi
Transfer of technology through ICT and capacity building	Dr.D.Deboral Vimala
Alternative strategies for aquaculture extension service	Dr.M.Kumaran
Applications of information and communication technology for aquaculture development and planning	Dr. P.Mahalakshmi
User perceptions of commercialized technologies in brackishwater aquaculture	Shri J. Ashok Kumar
Organisation and conduct of extension and outreach activities of the Institute	Dr.V.S.Chandrasekaran

Project Title 37	**E-extension strategy for ensuring knowledge led rural growth**
Project Location	**Chennai**
Funding Agency	**National Bank for Agriculture and Rural Development**
Principal Investigator	**Dr.D.Deboral Vimala**
Co-Investigators	**Dr.T.Ravisankar, Dr.M. Kumaran and Dr.P.Mahalakshmi**

Project Title 38	**Economics of shrimp ponds in disuse and participatory appraisal of productive use options and policy needs**
Project Location	**Chennai**
Principal Investigator	**T. Ravisankar**
Funding Agency	**National Bank for Agriculture and Rural Development**
Co-investigators	**P. Ravichandran, D. Deboral vimala, M. Jayanthi and R. Saraswathy**

Kakdwip Research Centre

Project Title 39	**Enhancement of brackishwater aquaculture production of shrimp and fishes through economically viable and sustainable approach**
Project Leader	**Dr.J.K. Sundaray**
Project Location	**Kakdwip**

Sub-Project Title	Sub-Project Leader
Improvement of shrimp farming by natural productivity	Dr. J.K. Sundaray
Polyfarming of finfish and shellfish	Dr. J.K. Sundaray
Refinement of low cost feed for polyculture	Dr.Debasis De
Evaluation of biofloc technology and associated microbes based intervention in sustainable shrimp and fish culture	Dr.Sujeet Kumar
Epizootics of white spot disease outbreak in brackishwater aquaculture system of West Bengal	Dr.R.Ananda Raja
Evaluation of scientific mechanism of sugarcane bagasse as bioremediation material	Dr.N. Lalitha
Documentation of evolving brackishwater aquaculture systems in West Bengal	Dr. J.K. Sundaray

Project Title 40	**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.R.Ananda Raja, Dr.Sujeet Kumar, Dr.A.Panigrahi and Dr.M.Kumaran**

6

Technology Assessed and Transferred

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.

At Headquarters

Sl. No.	Training Programmes	Duration	No. of participants
1.	Brackishwater cage culture	5 March, 2011	16
2.	Water and soil quality related to fish nutrition and bacteriology	6-14 April 2011	1
3.	Use of "Anuvadak" English-Hindi Translation software	13-14 September 2011	16
4.	Empowerment of Women stakeholders (Scheduled Tribes and Poor) on aquaculture and allied Technologies	26 September - 3 October 2011	30
5.	CAA guidelines and regulations for coastal aquaculture and Better Management Practices (BMPs) for sustainable shrimp aquaculture	13-15 October, 2011	7
6.	CAA guidelines and regulations for coastal aquaculture and Better Management Practices (BMPs) for sustainable shrimp aquaculture	3-5 November,2011	28
7.	CAA guidelines and regulations for coastal aquaculture and Better Management Practices (BMPs) for sustainable shrimp aquaculture	15-17 November, 2011	27
8.	CAA guidelines and regulations for coastal aquaculture and Better Management Practices (BMPs) for sustainable shrimp aquaculture	28-30 November, 2011	3
9.	Nutrient use efficiency in aquaculture	8-21 December 2011	16
10.	Development of gene chip for microbial identification using DNA probes	8 February 2012	1
At Kakdwip Research Centre			
1.	Hands-on training on disease management and diagnostic in brackishwater aquaculture	9-13 May 2011	08
2.	On-farm training on fisheries work experience program	16-24 May 2011	19
3.	Brackishwater aquaculture	25 June 2011	48
4.	Recent trends in finfish and crustacean grow-out practices	27 June-02 July 2011	08
5.	Paddy cum fish cultivation	22 July 2011	33

Sl. No.	Training Programmes	Duration	No. of participants
6.	Nursery rearing of crabs	27 August 2011	15
7.	Diversification of crops	11-12 January 2012	250
8.	Livestock health management	01-07 February 2012	366
9.	Livestock health camp	01-07 February 2012	511
10.	Hands on training on disease management and diagnostic in brackishwater aquaculture	13-17 February 2012	20
At CIBA-NAU collaborative centre, Navsari, Gujarat			
1.	Brackishwater aquaculture for scheduled Tribe farmers in Navsari region of Gujarat	26-27 August 2011	64

Dr. C. Balaraman, Former VC, TANUVAS inaugurating the NAIP sponsored national training on nutrient use efficiency in Aquaculture

Participants of the NAIP sponsored national training on nutrient use efficiency in aquaculture

Empowerment of women stakeholders (Scheduled Tribes and Poor) on aquaculture and allied technologies

Brackishwater aquaculture for tribal farmers in Navsari region of Gujarat

Recent trends in finfish and crustacean grow-out practices

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Training and Education

HUMAN RESOURCE DEVELOPMENT

International

Name and designation	Training programme	Duration	Organisation
Dr.Akshaya Panigrahi, Senior Scientist	Molecular diagnostics and immunology (Fisheries)	25.1.2011-24.4.2011	Scottish Fish Immunology Research Centre, School of Biology Sciences, University of Aberdeen, Scotland, U.K
Dr.K.Ambasankar, Senior Scientist	Nutraceuticals (Fisheries)	21.3.2011 – 14.6.2011	CSIRO Marine and Atmospheric Research, Cleveland Laboratories, Cleveland, Queensland, Australia
Dr.M.Muralidhar, Senior Scientist	Life cycle analysis of aquaculture systems under Carbon sequestration/Carbon trading/ Climate change (Fisheries)	1.5.2011-31.7.2011	University of Stirling, Scotland, UK
Shri J. Ashok Kumar, Scientist	Bioinformatics	1.5.2011–31.7.2011	University of Nebraska Medical Center, Omaha, Nebraska, USA
Dr.P.Ezhil Praveena Scientist	Molecular Breeding (Fisheries)	8.8.2011 – 5.11.2011	Aquaculture Research Institute, University of Idaho, USA
Dr.R.Ananda Raja Scientist	Gene Knock-Down Technology (Fisheries Science)	18.8.2011 – 17.11.2011	Friedrich –Schiller-University of Jena, Germany
Dr.M.Poornima, Senior Scientist	Molecular Diagnostics (Fisheries)	24.10.2011–23.1.2012	Centre of Excellence for Shrimp Molecular Biology & Biotech, National Center for Genetic Engineering and Biotechnology, Mahidol University, Bangkok, Thailand
Dr. Prasanna Kumar Patil Senior Scientist	Stem Cell Research (Fisheries)	1.11.2011 – 29.1.2012	Stem Cell Research Center, Rutgers University, New Jersey, USA

National

Name and designation	Training programme	Duration	Organisation and venue
Dr.J. K. Sundaray Principal Scientist	Good Aquaculture Practices	28-29 April, 2011	MPEDA, United States Food and Drug Administration (USFDA) & Centre for Food Safety and Applied Nutrition (CFSAN), Bhubaneswar
Dr. A. G. Ponniah Director	Training Programme on Labour Laws	10-12 May, 2011	National Academy for Agricultural Research and Management, Hyderabad
Dr.V.S. Chandra-sekaran Principal Scientist	16th Management Development programme in Agricultural Research	20-25 October, 2011	National Academy of Agricultural Research Management, Hyderabad
Dr.S.K.Otta and Dr.Ashutosh D. Deo Senior Scientists	Refresher course on Agricultural Research Management for Senior / Principal Scientists	3-23 November, 2011	National Academy of Agricultural Research Management, Hyderabad
Dr.J.K.Sundaray Principal Scientist	Financial Management in Scientific Institution	21-26 November, 2011	Department of Science and Technology, New Delhi held at Xavier Institute of Management, Bhubaneswar
Dr.S.Kannappan Senior Scientist	Metagenomics: A practical approach to molecular taxonomic profiling	22 November - 1 December, 2011	National Bureau of Agriculturally Important Microorganisms, Mau, Uttar Pradesh.
Dr.P.Mahalakshmi Scientist	Project Management : Methodology, Implementation, Monitoring & Evaluation for Women Scientists	2-6 January, 2012	Administrative Staff college of India, Hyderabad
Dr.R.Saraswathy Senior Scientist	Application of Nanotechnology in Agriculture	2-12 January, 2012	Central Institute for Research on Cotton Technology, Mumbai
Dr.Sujeet Kumar Scientist	Development of Gene chip for microbial Identification using DNA probes	28 January – 10 February, 2012	National Bureau of Agriculturally Important Microorganisms Mau, Uttar Pradesh
Dr.M.Kumaran and Dr.A.Panigrahi Senior Scientists	JIFSAN-Training programme on " Train –the Trainers Good Aquaculture Practices"	17-21 January, 2012	Tamil Nadu Veterinary & Animal Sciences University, Chennai

Technical staff

Name and designation	Training programme	Duration	Organisation
Shri N.Ramesh Technical Assistant (T-3)	Maintenance service, application and constructional features of pumps	6-10 February 2012	M/s.Kirloskar Brothers Limited, Kirloskarwadi, Maharashtra

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Awards and Recognitions

- Dr Ashutosh D. Deo was conferred with Best Teacher Award for 2007-2010 from Professional Fisheries Graduates Forum, Mumbai for service rendered as Assistant Professor at College of Fisheries (CAU), Lembucherra, Tripura.

- The paper "Studies on the reproductive biology of black king fish Cobia (*Rachycentron canadum*) in the coastal waters around Chennai" by S.Elangeshwaran, A.R.T.Arasu, S.Venu, M.Kailasam, Prem Kumar, R.Subburaj and G.Thiagarajan was adjudged as the Best Paper in the National conference on New Vistas in Indian Aquaculture organised by CIBA during 23-24 February 2012 at Chennai.

- Ms. J. Kiruthika, S. Rajesh, A.G. Ponniah and M.S. Shekhar, received the Best Paper award for "Suppression subtractive hybridization reveals differential gene expression in shrimp *Penaeus monodon* induced to low salinity stress" in the National conference on New Vistas in Indian Aquaculture organised by CIBA during 23-24 February 2012 at Chennai.

- S. Rajesh, Ms. J. Kiruthika and M.S. Shekhar received the Best poster award for their poster "Isolation, identification and expression analysis of fatty acid binding protein (FABP) gene in *Penaeus monodon* shrimp in response to high salinity stress" in the National conference on New Vistas in Indian Aquaculture organised by CIBA during 23-24 February 2012 at Chennai.

- P.K.Patil, C.Gopal, H.Solanki, M.Muralidhar, J.Bhatt and S.M.Pillai were awarded the Best Poster Award for their poster "Effect of formalin killed *Vibrio anguillarum* administration on immunity and resistance to *Vibrio harveyi* in pond reared banana shrimp *Fenneropenaeus merguiensis*" in the National conference on New Vistas in Indian Aquaculture organised by CIBA during 23-24 February 2012 at Chennai.

Honours

- Dr.(Mrs) Shiranee Pereira was invited as a speaker at the Plenary session on "Animal alternatives in teaching, toxicity testing and medicine" at the 99th Indian Science Congress from 3-7 January 2012 at Bhubaneswar, Odisha and also nominated as a member of the National Committee of the CPCSEA, MoEF, Govt. of India.

Ph. D. Programme

Scientists

Mrs. P.Mahalakshmi, Scientist (SS) was awarded Ph.D degree on July 26 2011 for her thesis entitled "Decision making models for identification and classification of optimal location for aquaculture farming development" by the VIT University under the guidance of Dr.K.Ganesan, Director, TIFAC-CORE in Automotive Infotronics, VIT University, Vellore.

Research Scholars

Mr. P.Stalin was awarded Ph.D. degree on 4th May 2011 for his thesis entitled "Studies on the development of digestive system in larval stages of Asian seabass *Lates calcarifer* (Bloch 1790)" by the University of Madras under the guidance of Dr.M.Kailasam, Senior Scientist, Fish Culture Division.

Mr. K.Aravindan was awarded Ph.D. degree on 7th June 2011 for his thesis entitled "Molecular cloning, expression and immunological characterization of *Penaeus monodon* allergenic proteins" by the University of Madras under the guidance of Dr.T.C.Santiago, Principal Scientist (Retd.) CIBA.

Mr. N.Chakravarthy received Ph.D. degree on 27th June 2011 for his thesis entitled "Identification, cloning, expression and characterization of CuZnSOD from Asian seabass *Lates calcarifer* (Bloch 1790) and its effect on *Vibrio anguillarum* infection" by the University of Madras under the guidance of Dr.N.Kalaimani, Principal Scientist (Retd.) CIBA.

Mr. T.D.Babu was awarded Ph.D. degree on 14th July 2011 for his thesis entitled "Investigations on loose shell syndrome in black tiger shrimp, *Penaeus monodon* (Fabricius, 1798) in India : Putative aetiological agent" by the University of Madras under the guidance of Dr. S.V.Alavandi, Senior Scientist, Aquatic Animal Health & Environment Division.

Mr. S. Raja received Ph.D. degree on 9th August 2011 for his thesis entitled "Studies on adoption and efficiency of standard operating procedures in seed production of tiger shrimp *Penaeus monodon* (Fabricius, 1798)" by the University of Madras under the guidance of Dr. M. Kumaran, Senior Scientist, Social Sciences Division.

Mr. V. Rajaram was awarded Ph.D. degree on 8th September 2011 for his thesis entitled "Studies on the utilization of plant protein sources in the diet of black tiger shrimp *Penaeus monodon* with emphasis on protein metabolism" by the University of Madras under the guidance of Dr. S. A. Ali, Principal Scientist (Retd.) CIBA.

Mr. Gusheinzed Waikhom was awarded Ph.D. degree on 5th January 2012 for his thesis entitled "Reproductive performance and genetic diversity of different stocks of wild and captive reared banana shrimp *Fenneropenaeus merguiensis* (De Man 1888)" by the University of Madras under the guidance of Dr. S. M. Pillai, Principal Scientist, Crustacean Culture Division.

Mr. Abey Varampath Abraham received Ph.D. degree on 5th March 2012 for his thesis entitled "Studies on heavy metal ingress and removal in shrimp farming environment" by the University of Madras under the guidance of Dr. M. Muralidhar, Senior Scientist, Aquatic Animal Health & Environment Division.

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Linkages and Collaboration

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

NOFIMA (Norwegian Institute of Food, Fisheries and Aquaculture Research) Norway.

A project entitled "Strengthening adaptive capacities to the impacts of climate change in resource-poor small-scale aquaculture and aquatic resources-dependent sector in the South and South-east Asian Region" (Aqua Climate project), coordinated by Network of Aquaculture Centres in Asia-Pacific (NACA), Bangkok.

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List of Publications

CIBA Annual Report (2010-2011)

Training programme calendar (2012-2013)

CIBA Special Publication

1. Training manual on Water harvesting and land development (In Bengali)
2. Training manual on Recent Trends in finfish and crustacean grow-out practices
3. Proceedings of the Hindi Workshop : Recent Advance in aquaculture (both CD & Print) [Hindi]
4. Advances in Aquaculture nutrition and feed processing technology
5. Empowerment of women stakeholders (ST & poor on aquaculture and allied technologies)
6. CAA regulatory guidelines and BMPs for sustainable aquaculture
7. Nutrient use efficiency in aquaculture
8. Aquaculture database system for culture practices (ADS) Ver 1.0 (Catalogue)

Technology Series

1. Seabass feed technology – CIBA Bhetkiahar

Referred Journals

1. Ali S.A., Dayal J.S., Ambasankar K., 2011. Presentation and evaluation of formulated feed for mud crab *Scylla serrata*. Indian J. Fish., 58 (2), 67-73
2. Biswas G., Raja R. A., De D., Sundaray J. K., Ghoshal T. K., Anand S., Kumar S., Panigrahi A., Thirunavukkarasu A. R., Ponniah A. G., 2012. Evaluation of productions and economic returns from two brackishwater polyculture systems in tide-fed ponds. J. Appl. Ichthyol., 28, 116–122.
3. Biswas G., De, D., Thirunavukkarasu A.R., Natarajan M., Sundaray J.K., Kailasam M., Kumar Prem, Ghoshal T.K., Ponniah A.G., Sarkar A., 2011. Effects of stocking density, feeding, fertilization and combined fertilization-feeding on the performances of striped grey mullet (*Mugil cephalus* L.) fingerlings in brackishwater pond rearing systems. Aquaculture, 338–341, 284–292.
4. Biswas G., Ghoshal T.K., Natarajan M., Thirunavukkarasu A.R., Sundaray J.K., Kailasam M., De D., Sukumaran K., Kumar P., Ponniah A.G., 2011. Effects of stocking density and presence or absence of soil base on growth, weight variation, survival and body composition of pearlspot, *Etroplus suratensis* (Bloch) fingerlings. Aquacult. Res., 10.1111/j.1365-2109.2012.03132.x.
5. Biswas G., Sundaray J.K., Thirunavukkarssu A.R., Kailsam M., 2011. Length weight relationship and variation in condition of *Chanos chanos* (Forsskål, 1775) from tide-fed brackishwater ponds of the Sundarabans-India. Ind. J. GeoMarine Sci., 40 (3), 386-390
6. Biswas G., Thirunavukkarasu A.R., Sundaray J.K., Kailasam M., 2011. Culture of Asian seabass *Lates calcarifer* (Bloch) in brackishwater tide-fed ponds:growth and condition factor based on length and weight under two feeding systems. Indian J. Fish., 58(2), 53-57.
7. Chakravarthy N., Aravindan K., Kalaimani N., Alavandi S. V., Poornima M., Santiago T. C., 2012. Intracellular Copper Zinc Superoxide dismutase (icCuZnSOD) from Asian seabass *Lates calcarifer*: Molecular cloning, characterization and gene expression with reference to *Vibrio anguillarum* infection. Dev. Comp. Immunol., 36, 751-755.

8. Chatterjee A., De D., Sheikh I.U., 2011. Macro and micro elemental concentrations in some locally available tree fodder of Sikkim. Indian J. Anim. Sci. 81(9), 984-987.

9. Das A., De D., Katole S., 2011. Seasonal variation in eating behavior and nutritive value of mixed jungle grass for goats. Anim. Feed Sci. Tech. 11, 195-202.

10. Dayal J. S., Rajaram V., Ambasankar K., Ali S.A., 2011. Sunflower oil cake as a replacement for fish meal in feeds of Tiger shrimp, *Penaeus monodon* reared in tanks and net cages**.** Ind. J. GeoMarine Sci., 40 (3), 460-470.

11. Gopikrishna G., Gopal C., Krishna G., Jahageerdar Shrinivas S., Rye Morten, Lozano C., Gitterle T., Venugopal G., Paulpandi S., Ravichandran P., Pillai S. M., Ponniah A. G., Hayes B. J., 2011. Effect of stocking density, water exchange rate and tank substrate on growth and survival of post-larvae of *Penaeus monodon* (Fabricius, 1798)**.** Indian J. Fish., 58(3), 57-61.

12. Gopikrishna G., Gopal C. Shekhar M.S., Kumar K. V., Kannappan S. and Ponniah A.G. 2012. Growth performance and white spot syndrome virus resistance in families of kuruma shrimp (*Marsupenaeus japonicus)*, Ind. J. GeoMarine Sci., 41(1), 56-60.

13. Gusheinzed W., Pillai S. M., 2011. Comparative reproductive performance of captive reared Indian Stocks of *Fenneropenaeus merguiensis* (De Man) with wild-caught broodstock**.** J. Inland Fish. Soc. India, 43(2), 73-78.

14. Jithendran K. P., Shekar M. S., Kannappan S., Azad I.S., 2011. Nodavirus Infection in Freshwater Ornamental Fishes in India: Diagnostic histopathology and Nested RT-PCR**.** Asian Fish. Sci., 24 (1), 12-19.

15. Jithendran K. P., Natarajan M., Sahoo, P. K., Thiagarajan G., 2011. Squamous cell carcinoma in Grey mullet, *Mugil cephalus* L. (Perciformes: Mugilidae). Comp. Clin. Path., 20, 673-675.

16. Jithendran K. P., Vijayan K. K., Kailasam M., 2011. Microsporidian (*Glugea* sp.) infection in Greasy grouper *Epinephelus tauvina* (Forsskal, 1775). Indian J. Fish., 58, 125-127.

17. Kiron V., Puangkaew J., Panigrahi A., Scharsack J. P., Satoh S., 2011. Antioxidant and immune defenses of rainbow trout (*Oncorhynchus mykiss*) offered plant oils differing in fatty acid profiles from early stages**.** Aquacult. Nutr., 17(2), 130-140.

18. Krishna G., Gopikrishna G., Gopal C., Jahageerdar S., Ravichandran P., Kannappan S., Pillai S. M., Paulpandi S., Kiran R.P., Saraswathy R., Venugopal G., Kumar D, Gitterle T., Lozano C., Rye M and Hayes B. J, 2011. Genetic parameters for growth and survival in *Penaeus monodon* cultured in India**.** Aquaculture, 318, 74–78.

19. Krishnani K. K., Gupta B.P., Muralidhar M., Saraswathy R., Pillai S. M., Ponnusamy K., Nagavel A., 2011. Soil and water characteristics of traditional paddy and shrimp fields of Kerala**.** Indian J. Fish., 58(4), 71-77.

20. Kumar B., Chaturvedi V.K., Somarajan S.R., Kumar P., Sridevi R., Kumar S, Kaushik P., 2011. Comparative immune response of purified native OmpH protein derived from *Pasteurella multocida* P52 and oil adjuvant vaccine against hemorrhagic septicemia in mice**.** Indian J. Anim. Sci., 81 (12), 1193-96.

21. Kumar S, Chaturvedi V.K., Kumar B., Kumar P., 2011. Immune response and viscosity of haemorrhagic septicaemia oil adjuvant vaccine at different water-oil proportion**.** Indian J. Anim. Sci., 81 (10), 1000-04.

22. Kumaran M., Vimala D. D., Nagarajan S., 2011. Perceived Skill Gaps of Fisheries Extension Officers**.** Indian J. Fish., 58(4), 147-153.

23. Kumaran M., Vimala D. D., Raja S., Alagappan M., 2012. Information seeking behaviour of extension personnel in aquaculture sector**.** Fish. Tech., 49, 87-91.

24. Mahalakshmi P., Ganesan K., Venkatasubramanian V., 2012. DMTIOLA: decision making tool for identification of optimal location for aquaculture farming development**.** Aquacult. Int., DOI: 10.1007/s10499-012-9516-6.

25. Muneer P. M. Abdul, Gopalakrishnan A., Musammilu K. K., Basheer V. S., Mohindra V., Lal K. K., Padmakumar K. G. and Ponniah A. G., 2012. Comparative Assessment of Genetic Variability in the Populations of Endemic and Endangered Yellow Catfish, *Horabagrus brachysoma* (Teleostei: Horabagridae), based on Allozyme, RAPD, and Microsatellite Markers**.** Biochem. Genet., DOI 10.1007/s10528-011-9462-4.

26. Panigrahi A., Zhang N., Otta Subhendu K., Pati D., 2012. A cohesin-RAD21 interactome**.** Biochem. J., 442(3), 661-70.

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GenBank Sequences Submitted

Sl. No.	Species	Year of submission	No. of gene sequences	Gene	GenBank accession no.	Authors
1.	*Macrobrachium rosenbergii*	2012	1	Ferritin	JQ670927	Shekhar, M.S DilliKumar,M., Abhilipsa, D., Sahoo, P.K.
2.	*Macrobrachium rosenbergii*	2012	1	RPL26	JQ670928	Shekhar,M.S DilliKumar,M., Abhilipsa, D., Sahoo,P.K.
3.	*Macrobrachium rosenbergii*	2011	96	EST's	JK649863-JK649958	DilliKumar,M., Abhilipsa,D., Sahoo,P.K. and Shekhar,M.S.
4.	*Penaeus monodon*	2011	1	Carbonic anhydrase mRNA	JN900478	Shekhar,M.S., Rajesh,S., Kiruthika,J. and Ponniah,A.G.
5.	*Macrobrachium rosenbergii*	2011	1	Anti-lipopoly saccharide factor (ALF)	JN572544	DilliKumar,M., Abhilipsa,D., Sahoo,P.K. and Shekhar,M.S.
6.	*Macrobrachium rosenbergii*	2011	1	Peroxinectin mRNA	JN572543	DilliKumar,M., Abhilipsa,D., Sahoo,P.K. and Shekhar,M.S.
7.	*Penaeus monodon*	2011	1	Intracellular fatty acid binding protein mRNA	JN572542	Shekhar,M.S., Rajesh,S., Kiruthika,J. and Ponniah,A.G.
8.	*Penaeus monodon*	2011	1	Acyl-CoA-binding protein m RNA	JN572541	Shekhar,M.S., Rajesh,S., Kiruthika,J. and Ponniah,A.G.
9.	*Penaeus monodon*	2011	1	O-methyl transferase (OMT) mRNA	JN572540	Shekhar,M.S., Rajesh,S., Kiruthika,J. and Ponniah,A.G.
10.	*Danio rerio*	2011	1	Follistatin from muscle	JN662961	Ananda Raja, R., Ravinder, K. and Muzumder, K. C.
11.	*Bacillus sp. DDKRC1*	2011	1	16SrDNA	JN641289	De, D., Ananda Raja, R. and Ghoshal, T. K.
12.	*Bacillus subtilis subsp. Subtilis DDKRC2*	2011	1	16SrDNA	JN641290	De, D., Ananda Raja, R. and Ghoshal, T. K.
13.	*Bacillus sp. DDKRC3*	2011	1	16SrDNA	JN641291	De, D., Ananda Raja, R. and Ghoshal, T. K.
14.	*Geobacillus stearothermophilus DDKRC4*	2011	1	16SrDNA	JN641292	De, D., Ananda Raja, R. and Ghoshal, T. K.
15.	*Bacillus subtilis DDKRC5*	2011	1	16SrDNA	JN641293	De, D., Ananda Raja, R. and Ghoshal, T. K.
16.	*Bacillus tequilensis DDKRC6*	2011	1	16SrDNA	JN641294	De, D., Ananda Raja, R. and Ghoshal, T. K.

11

Consultancy and Commercialization of Technology

Technologies developed

- Development of *L.vannamei* feed
- Development of probiotics and health enhancers

Patents

- First examination reports for the patents viz. “Immobilizing matrix from bagasse for bacterial biomass and a process for preparation thereof” & “Product from lignocellulosic waste for the remediation of water contaminated with heavy metals” are being processed for obtaining patents.

12

RAC, IMC, IRC and IJSC Meetings

RESEARCH ADVISORY COMMITTEE (RAC)

The Research Advisory Committee of CIBA was constituted by ICAR (Council's order F.No.18-6/2007-ASR-I dated 24 November 2009) for a period of three years with effect from 25 July 2010:

Chairman	Dr. S. D. Tripathi
Members	Dr. Y. Basavaraju Dr. S. Paul Raj Dr. T. Subramoniam Dr. M. Chandramohan Shri. M. S. Santhanakrishnan Dr. Madan Mohan Dr. A. G. Ponniah
Member Secretary	Dr. S. M. Pillai

The 17th meeting of the Research Advisory Committee (RAC) of CIBA was held from 28 to 29 February 2012 and the major recommendations are:

Finfish Culture Division

- Develop collaborative programmes for breeding of mullet and ornamental fishes with the Centre of Advanced Studies in Marine Biology, Annamalai University.
- Feasibility studies on the breeding and culture of *Polynemus paradiseus* may be taken up to develop a package of practices.
- Studies on *in vitro* maturation of grey mullet eggs and studies on reproductive biology, especially gamete biology may be taken up.

Crustacean Culture Division

- Collaborative research programme carried out by CIBA with Navsari Agricultural University on farming of banana shrimp during the winter season has yielded excellent results and has been well accepted by the farmers as an alternate to tiger shrimp. As there is tremendous scope for expansion of this technology on the Kutch coast which offers a vast potential for farming of *Fenneropenaeus penicillatus* and *Metapenaeus kutchensis*, it is strongly recommended to continue this work and also to establish a Research Centre of CIBA in Gujarat in the XII Plan which will act as a nodal point for the development of brackishwater aquaculture in the entire North-West coastal region.

Nutrition Group

- To approach DBT to establish a small feed mill for dissemination of feed technology as a livelihood measure for the SHGs.
- Studies on HDL and LDL cholesterol levels should be included in shrimp nutrition profiling as dietary cholesterol, role of fish and prawns in human nutrition and highlighting the richness of some of these nutrients.
- Up-scaling of the fermented feed mixtures is to be taken up since it has shown promising results at experimental level.

Genetics and Biotechnology Group

- To initiate selective breeding programme on *F. indicus* to achieve SPF broodstock.

Environment Group

- The methodology for having re-circulation system for shrimp farm to reduce the effluent load in discharge water and thereby to ensure environment protection is to be studied and automation for monitoring the ecological conditions of pond water need to be initiated by using sensors.
- Greenwater technology demonstration has to be continued and to be re-oriented by culturing mullets together with shrimp in a polyculture system as a single unit.

Health Group

- Research is required to determine as to where to fix the control points since food safety and product safety certification is very important and to implement HACCP in the hatchery, farms and feed mill.
- The work on cell culture of shrimp/fish has to be given priority to develop remedial measures for diseases confronting the brackishwater aquaculture sector and monetary losses suffered by shrimp farmers.

Social Sciences Division

- Impact of the CIBA technologies on the farmers and industry needs to be studied so that researchable issues could be identified for development of new technologies.
- Success stories are to be brought out as pamphlets in a well illustrated manner, like the STREAM handouts in local languages.

INSTITUTE RESEARCH COUNCIL

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

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

The half yearly IRC Meeting was conducted on 23rd November 2011 for the mid-term review of research progress work. The 25th Annual IRC meeting was held during 28-29 March 2011. The salient recommendations are:

Major IRC recommendations

- The flagship programme on '*Domestication and Selective breeding of Fenneropenaeus indicus*', is to be taken up in XII plan.
- Culture of *L. vannamei* with two stocking densities will be taken up at KRC
- In paddy cum brackishwater aquaculture the details of income from paddy before implementation of the interventions or when the fields remained fallow is to be included to rate the scale of success.
- Genetic improvement of pearlspot with growth as the focal point has to be incorporated.
- The experiments carried out to develop specific feeds for low and high saline shrimp farming needs to be consolidated with studies on two size (2-5g and 15 g size) groups of shrimp.
- Infectivity studies can be taken up with vannamei instead of *P. monodon* since SPF seed of vannamei can be easily obtained. The role of copepods in WSSV transmission is to be studied since there is likelihood that in the pond substratum could be carriers of the virus.

INSTITUTE MANAGEMENT COMMITTEE (IMC)

The Institute Management Committee has been constituted as follows.

Chairman	Dr. A. G. Ponniah
Members	The Director (Fisheries), Government of Tamil Nadu
	The Director (Fisheries), Government of Andhra Pradesh
	Dr. M. C. Nandeesha
	Shri. Ali Hussain
	Shri. Ajitsinha Bajirao Patil
	Dr. T. V. Sankar
	Dr. A. K. Pal
	Dr. G. Maheswarudu
	Dr. K. K. Pal
	Dr. Madan Mohan
	Shri. Balabrahmaiah
Co-opted Members	Shri. B. Sathish, A.O, CIBA
	Shri. V.R. Senthilkumar
	Finance & Accounts Officer, CIBA
	Shri. R. G. Ramesh, AAO, CIBA

During the year, 38th and 39th meetings of IMC of CIBA were conducted on 28.06.2011 and 18.11.2011 respectively. The major recommendations of the meetings are;

- Approval for new major works amounting ₹ 109.470 lakhs for 2011-12
- Special allocation fund of ₹ 30 lakhs from ICAR towards Silver Jubilee Celebration of CIBA
- Clearance for procurement of equipments worth ₹ 41.00 lakhs, ₹ 39.00 lakhs and ₹ 16 lakhs towards purchase of computers.
- Approval of ₹ 20 lakhs for new major/minor works and ₹7.61 lakhs for purchase of minor equipments.

INSTITUTE JOINT STAFF COUNCIL (IJSC)

The composition of the Institute Joint Staff Council (reconstituted by CIBA for a period of three years upto 23.11.2012 vide Office Order No.13-1/2011-Admn. dated 12.10.2011) is as follows.

Official side

Chairman	Dr. A. G. Ponniah, Director
Members	Dr. A. R. Thirunavukkarasu, Head, FCD Dr. P. Ravichandran, Head, CCD Dr. N. Kalaimani, Principal Scientist Dr. G. Gopikrishna, Principal Scientist Finance & Accounts Officer
Member-Secretary	Administrative Officer

Staff side

Secretary	Shri. A. Manoharan, Assistant
Members	Shri. R. Subburaj, Technical Officer (T-5) (also member of CJSC of ICAR)
	Shri. R. Balakumaran, Tech. Asst. (T-3)
	Shri. B. Palanivelmurugan, LDC
	Shri. M. Pichandi, Skilled Support Staff
	Shri. C. Saravanan, Skilled Support Staff

A meeting was held on 25.10.2011 at the Headquarters, CIBA, Chennai.

GRIEVANCE COMMITTEE

The composition of the Institute Grievance Committee (reconstituted by CIBA for a period of two years with effect from 01.02.2010, vide Office Order F.No.6 (2)/2007-Admn. dated 28 January 2010) is as follows.

Chairman	Dr. A. G. Ponniah, Director, CIBA

Official side

Members	Dr. P. Ravichandran, Head, CCD Finance & Accounts Officer Administrative Officer
Member Secretary	Shri. R. G. Ramesh, AAO

Elected members

Dr. A. R. Thirunavukkarasu, HoD, FCD	Scientific Member
Shri. K. Paranthaman, T-2	Technical Member
Shri. K. Nandhini, JAO	Administrative Member
Shri. K. Nithyanandan, SSS	Staff Member

13

Participation in Conferences, Meetings, Workshops and Symposia

International

Particulars	Organizers	Duration	Participants
Successful Women Entrepreneurs in Brackishwater Aquaculture Sector-case Studies in Tamil Nadu, India	9th Asian Fisheries and Aquaculture Forum, Shanghai, China	21-25 April 2011	Dr. B. Shanthi
Workshop on Challenge Program on Water and Food	WorldFish Center and Bangladesh Agricultural Research Council, Dhaka, Bangladesh	1-2 June 2011	Dr. J.K. Sundaray
Review Meeting of Joint International Research Project under Indo-Norweign collaboration on Fish and Shellfish Vaccine Development	Tromso, Norway	7-9 June 2011	Dr. T.C. Santiago Dr. A.R.Thirunavukkarasu
International Conference – 2011 on Diseases of fish and shellfish	European Association of Fish Pathologist, Split, Croatia	11-16 September 2011	Dr. A.Panigrahi
Regional Workshop on Strengthening Assessment of Fisheries and Aquaculture in the Asia-Pacific Regional for Policy Development and Management	Yangon, Myanmar	4-6 October 2011	Dr. S.M.Pillai
3rd International Forum on "Water and Food" under the CPWF of the Consultative Group on International Agricultural Research (CGIAR)	Tshwane, Pretoria, South Africa	14 – 17 November 2011	Dr. J.K.Sundaray
Expert Group on Transboundary Aquatic Animal Health Issues in Bay of Bengal held at Bangkok, Thailand	Bay of Bengal Large Marine Ecosystem (BOBLME) & Network of Aquaculture Centres in Asia-Pacific (NACA)	12-13 January 2012	Dr. A.G.Ponniah
Workshop on "Empowering Vulnerable Stakeholder Groups in Aquaculture" under the ASEM Aquaculture Platform WP7	Universiti Putra, Kuala Lumpur, Malaysia	5–10 February 2012	Dr. B.Shanthi
Field visit and workshop of the project ''Increasing the resilience of agriculture and aquaculture systems in coastal areas of Ganges Delta''	WorldFish Center, Dhaka, Bangladesh	24 March - 3 April 2012	Dr. J.K.Sundaray

National

Participation by Dr.A.G.Ponniah, Director

Particulars	Organizers	Duration
18th Technical Committee Meeting for Organic Products under the Chairmanship of Dr.Gorakh Singh, Horticulture Commissioner, Ministry of Agriculture held at the Ministry of Agriculture, Krishi Bhavan, New Delhi	APEDA, New Delhi	5 April, 2011
1st Meeting of the Committee to evaluate the proposals received in response to invitation of Expressions of Interest (EOI) for setting up specific pathogen free (SPF) Multiplication centres for *L. vannamei* and *P. monodon* and to formulate guidelines for setting up of the Multiplication centres	DAHD&F, New Delhi	19 April 2011
Meeting of the Coastal Aquaculture Authority 32nd Meeting 36th Meeting	CAA, Chennai	 28 April 2011 3 January 2012
Thematic Meeting of National Initiative on Climate Resilient Agriculture (NICRA)	Central Marine Fisheries Research Institute, Kochi	6 May 2011
First Meeting of the Working Group on Biotechnology for formulation of 12th Plan Proposal of Department of Biotechnology, held at National Institute of Immunology, New Delhi	DBT, New Delhi	24 May 2011
First Meeting of the Niche Area Committee (NAC) on Biotechnology for Animal Health and Productivity and Quality held at INSA, New Delhi.	DBT, New Delhi	31 May 2011
Golden Jubilee and Foundation Day Function of Central Institute of Fisheries Education and National Consultation on Prioritization of Fisheries Research and Development, through Collaborations and Networking	CIFE, Mumbai	6 June 2011
Meeting of the Board of Directors of Tamil Nadu Fisheries Development Corporation Limited 188th Meeting 189th Meeting 190th Meeting 191st Meeting 192nd Meeting	TNFDC Ltd., Chennai	 30 June 2011 30 August 2011 29 Sept. 2011 13 March 2012 30 March 2012
Directors' Conference at National Bureau of Plant Genetic Resources, New Delhi.	ICAR, New Delhi	15-16 July 2011
Second Meeting of the Working Group on the Development and Management of Fisheries and Aquaculture for the 12th Five Year Plan (2012-17), at Central Inland Fisheries Research Institute, Barrackpore.	DAHD &F, Ministry of Agriculture, New Delhi	22 July 2011
EOI Committee Meeting to finalize the proposals for setting up Multiplication Centre for SPF *L. vannamei* and *P. monodon*	DAHD&F, Ministry of Agriculture, New Delhi	2 August 2011

Particulars	Organizers	Duration
35th Meeting of the Finance Committee and 75th Meeting of the Board of Directors of Tamil Nadu Veterinary and Animal Sciences University	TANUVAS, Chennai	29 September 2011
Meeting of the Evaluation Committee constituted for screening proposals for setting up of Multiplication Centres for SPF shrimp broodstock (*P. monodon* and *L. vannamei*)	CAA, Chennai	12 October 2011
Participated in the Art Exhibition on the theme "Lives and livelihoods of fisherfolk"	BOBP, Chennai	15 October 2011
Meeting for presentation of the proposal on "Platform for diagnostics and vaccines"	IVRI, Izatnagar	28–29 October 2011
DBT Task Force on Aquaculture and Marine Biotechnology	DBT, New Delhi	2-3 November 2011
Meeting of State Planning Commission Working Group on Fisheries to discuss on 12th Plan held at Coastal Aquaculture Authority, Chennai.	Department of Fisheries, Govt. of Tamil Nadu	15 November 2011
Chennai Aquaculture Technology Meet – 2011 (CATEET'11)	TANUVAS, Chennai	16-17 November 2011
5th Meeting of the Evaluation Committee constituted for screening proposals for setting up of Multiplication Centres for SPF shrimp broodstock (*P. monodon* & *L. vannamei*)	CAA, Chennai	22 November 2011
Meeting convened to discuss the final TDA output – BOBLME Project for submission to RCU	Bay of Bengal Programme, Chennai	24 November 2011
As a Member of Special Investigation Team constituted by Coastal Aquaculture Authority, visited the hatcheries of M/s.Nugen Bioshrimp Technologies (P) Ltd., Visakhapatnam,.	CAA, Chennai	15-16 December 2011
9th Indian Fisheries Forum held at IMAGE Auditorium, Chennai	Asian Fisheries Society	19-23 December 2011
BOBLME Meeting	BOBLME at Chennai	29 December 2011
Consultation Meet to finalize the documentation of the policy framework on agriculture, research and education	ICAR, New Delhi	9 January 2012
National Consultation on Prioritization of research programmes of Central Inland Fisheries Research Institute (CIFRI) for 12th Five Year Plan	CIFRI, Barrackpore	18 January 2012
36th Meeting of the Board of Management of Sree Venkateswara Veterinary University, Tirupathi held at A.P.Secretariat, Hyderabad	Sri Venkateswara Veterinary University, Tirupathi	10 February 2012
TANSA 2011 Expert Advisory Committee Meeting for the selection of Awardee in Biological Sciences	TNSCST, Chennai	13 February 2012

Participation in Workshop/Seminar by Scientists

Particulars	Organizers	Duration	Participants
National Seminar on Nano technology for Enhancing Food Security	Tamil Nadu Agricultural University, Coimbatore	7-8 April 2011	Dr.R.Saraswathy
One day International Workshop on Cobia and other marine finfish farming	Fisheries College and Research Institute, TANUVAS, Thoothukudi	11 April 2011	Dr.Prem kumar
Seminar on Good Aquaculture Practices	MPEDA, United States Food and Drug Administration (USFDA) and Centre for Food Safety and Allied Nutrition (CFSAN) USA, held at Chennai	19-20 April 2011	Dr.N.Kalaimani
Workshop-cum-Training Programme on Intellectual Property and Technology Management in Agriculture- AgrIP 2011	ZTM-BPD Unit, South Zone and ITMU, CIFT, Cochin	26-27 April 2011	Dr.P.K.Patil Dr.S.K.Otta
Workshop on Expert Consultation on Revitalizing Indian Fisheries Education to meet 21st Century Aspirations	Fisheries College and Research Institute, Thoothukudi	8-10 May 2011	Dr.M.Natarajan
CMFRI - NACA Seminar on Prospects of Aquaculture in Asia	CMFRI, Cochin	12 May 2011	Dr.A.R.Thirunavukkarasu
Workshop on Diversification of Species in Aquaculture - Status & Potential	CIFE, Mumbai	19 May 2012	Dr.A.R.Thirunavukkarasu
Transboundary Diagnostic Analysis Consultation Workshop (TDA-CWS)	Indismart Hotel, Kolkata, West Bengal	9 June 2011	Dr.T.K.Ghoshal
Meeting-cum-workshop of the Heads of Divisions and Regional Stations / Centres of ICAR Institutes	Central Institute of Agricultural Engineering, Bhopal	14-15 June 2011	Dr. A.R.Thirunavukkarasu Dr. P. Ravichandran Dr. J .K.Sundaray
CMU, CIC and CAC meeting of NAIP-2101/204 project	CSSRI, RRS, Canning Town, W.B	5 August 2011	Dr.T.K.Ghoshal
International Conference on Mangroves for Coastal Area Management	M.S.Swaminathan Research Foundation, Chennai	7-10 August 2011	Dr.V.S.Chandrasekaran Dr.M.Jayanthi
Information and Communication Technology in Agriculture (ICT-A) through virtual extension platform	Tamil Nadu Agricultural University, Coimbatore	9-10 August 2011	Dr.P.Mahalakshmi
9th International Symposium on Reproductive Physiology of Fish	Madras Christian College, Chennai	9-14 August 2011	Dr.A.R.Thirunavukkarasu Dr.J.K.Sundaray Dr.Prem Kumar Shri R.Subburaj

Particulars	Organizers	Duration	Participants
5th International Conference on Anti-counterfeiting and anti-piracy-building respect for Intellectual property (IP): Finding a sustainable solution to a global problem	Confederation of Indian Industry (CII)	25-26 August 2011	Dr.N.Kalaimani
Workshop on Biofloc Technology : Intelligent planning, effective implementation and productive utility of results to augment aquaculture production	Fisheries College and Research Institute, Thoothukkudi	2-3 September 2011	Dr.M.Muralidhar Dr.M.Jayanthi Dr.P.K.Patil
Workshop on Biofloc Technology: An eco-friendly technology for intensive production of fish and prawn	Aqua Research Lab, Department of Zoology, University of Delhi	13-16 September 2011	Dr.Sujeet Kumar
National Mega Meet on Technology Commercialization	Agribusiness knowledge centre (An initiative of NAARM and Gyantech Information systems (P) Limited under PPP agreement) Hyderabad	29 September to 1 October 2011	Dr.N.Kalaimani Dr.S.V.Alavandi
Sixth National symposium- Noni - A panacea for wellness	World Noni Research Foundation and International society for Noni science, Chennai Trade Centre, Chennai	1-2 October 2011	Dr.V.S.Chandrasekaran
National Workshop and Stake holders Meet on Fish Feeds	CIFA, Bhubaneswar	1-2 November 2011	Dr. T.K. Ghoshal
6th Nanotechnology Conclave-2011	Confederation of Indian Industry (CII), Department of Science & Technology, Government of India and Korea Institute of Science & Technology , Chennai	3-4 November 2011	Dr.R.Saraswathy
UGC's Innovative programme	Bharathidasan University, Tiruchirapalli	4 November 2011	Dr.A.R.Thirunavukkarasu
International Conference on Innovative approaches for Agricultural Knowledge Management : Global Extension Experiences	International Society of Extension Education, New Delhi	9-12 November 2011	Dr.P.Mahalakshmi
NAIP Stakeholders Workshop on Up-scaling of Technologies for Enhancing the Productivity of Degraded Coastal Land and Water	CSSRI, RRS, Canning Town, W.B	11 November 2011	Dr. T.K. Ghoshal

Particulars	Organizers	Duration	Participants
National Seminar on Promotion of Fisheries and Alternative Livelihood in Fisheries Sector	Tamil Nadu Veterinary and Animal Sciences University, Fisheries College and Research Institute,Thoothukudi	10-11 November 2011	Dr.A.R.Thirunavukkarasu Dr.B. Shanthi
Workshop on Vannamei Farming and Biofloc Systems	Devee Biologicals Pvt. Ltd, Hyderabad & Blue Aqua International Pvt, Ltd, Singapore	15 November 2011	Dr.M.Muralidhar Dr.N.Lalitha
Chennai Aquaculture Technology Meet 2011	Fisheries Research and Extension centre, Tamil Nadu Veterinary and Animal Sciences University, Chennai	16-17 November 2011	Dr.A.R.T.Arasu Dr.P. Ravichandran Dr.S.M.Pillai Dr.V.S.Chandrasekaran Dr.B.Shanthi Dr.M.Jayanthi Dr.D.Deboral Vimala Dr.P.Nila Rekha Dr.M. Kailasam Dr.Prem Kumar Shri Rajamanickam Shri R.Subburaj Dr. A.Nagavel
Workshop on Advanced Shrimp Pathology	Rajiv Gandhi Centre for Aquaculture, Sirkali, Tamil Nadu	14-19 November 2011	Dr.T.Bhuvaneswari
VIII Symposium on Diseases in Asian Aquaculture (DAA-VIII)	College of Fisheries, Mangalore	21-25 November 2011	Dr.M.Natarajan Dr.K.P.Jithendran Dr.S.Kannappan Dr.Akshaya Panigrahi Dr.T. Bhuvaneswari
Meeting of AOs & FAOs of ICAR Institutes	ICAR, New Delhi	22 November 2011	Shri A.Muthuraman Shri V.L.Jacob
National Seminar on Farming System Research and Extension for Inclusive Development	Madras Veterinary College, Chennai	24-25 November 2011	Dr.M.Kumaran
Review Meeting of NAIP Project at KAB-II Pusa Campus, New Delhi	NAIP, New Delhi	2 December 2011	Dr. T.K. Ghoshal
National Conference on Marine Biodiversity for New Biotechnological Applications	The Hindustan College of Arts & Science, Chennai	9 December 2011	Dr.G.Gopikrishna
9th Indian Fisheries Forum	Asian Fisheries Society (Indian Branch) at Chennai	19-23 December 2011	Dr.A.R.T.Arasu Dr.P.Ravichandran Dr.S.M.Pillai Dr.N.Kalaimani Dr.M.Natarajan Dr.G.Gopikrishna

Particulars	Organizers	Duration	Participants
			Dr.K.P.Jithendran Dr.C.Gopal Dr.V.S.Chandrasekaran Dr.J.K.Sundaray Dr.T.Ravisankar Dr.M.Muralidhar Dr.M.Jayanthi Dr.B.Shanthi Dr.S.V.Alavandi Dr.C.P.Balasubramanian Dr.M.Kailasam Dr.D.Deboral Vimala Dr.S.Kannappan Dr.Akshaya Panigrahi Dr.P.Nila Rekha Dr.K.Ambasankar Dr.Syama Dayal Dr.M.Kumaran Dr.R.Saraswathy Dr.T.K.Ghoshal Dr.Debasis De Dr.S.K.Otta Dr.Sherly Tomy Dr.P.Mahalakshmi Dr.Krishna Sukumaran Dr.Prem Kumar Dr.R.Ananda Raja Dr.Sujeet Kumar Miss. Shyne Anand P.S Dr.S.Sivagnanam Shri R.Subburaj
Regional Workshop on CeRA	S.V.Veterinary University, Tirupati	24 January 2012	Shri S.Nagarajan
National Conference on Biotechnological Approaches in Aquaculture (Live Aqua 2012)	Unit of Aquatic Biotechnology and Culture, Department of Zoology, Bharathiar University, Coimbatore	1-3 February 2012	Dr.R.Saraswathy Dr.S.Sivagnanam
Sensitisation cum training workshops for the PME Cell in Charge (Nodal Officer) of HYPM	National Academy of Agricultural Research Management, Hyderabad	13 February 2012	Dr.P.Mahalakshmi
Aquaindia 2012 : Indian Aquaculture - Changing era	Society of Aquaculture Professionals, Chennai	9-10 March 2012	Dr.A.R.Thirunavukkarasu Dr.P.Ravichandran Dr.S.M.Pillai Dr.M.Natarajan Dr.G.Gopikrishna Dr.C.Gopal Dr.V.S.Chandrasekaran Dr.C.P.Balasubramanian Dr.M.Kailasam

Particulars	Organizers	Duration	Participants
			Dr.M.Shashi Shekhar Dr.A.Panigrahi Dr.P.Nila Rekha Dr.K.Ambasankar Dr.J.Syama Dayal Dr.M.Kumaran Dr.P.K.Patil Mr.J.Ashok Kumar Dr.Prem Kumar Dr.N.Lalitha Dr.S.Sivagnanam Mr.S.Rajamanickam
Annual Workshop of Component-3 of NAIP project	BCKVV, Kalyani, West Bengal	15-16 March, 2012	Dr. T.K. Ghoshal
National Workshop on Frugal Innovations for Sustainable Solutions in Fisheries and Agricultural Sectors	National Bureau of Fish Genetic Resources, Lucknow	24 March 2012	Dr.M.Kumaran
Mid Term Review meeting of NAIP project with World Bank team members	CSSRI, RRS, Canning Town, West Bengal	27-28 March, 2012	Dr. T.K. Ghoshal
Women's Day celebration	Women SHGs of Kattur Village, Ponneri	31 March 2012	Dr.B.Shanthi Dr.P.Mahalakshmi

Meetings attended

Particulars	Organizers	Duration	Participants
Fisheries Group Coordination, Consortium Implementation Committee and Consortium Advisory Committee meeting of NAIP project-Bioprospecting of genes and allele mining for abiotic stress tolerance	NAIP	3-4 May 2011 14 September 2011 1-3 November 2011 19-20 March 2012	Dr. M.S.Shekhar
Inter-Departmental Meeting	Central Public Works Department, Chennai	9 June 2011	Dr.S.M.Pillai
Meeting of Research Framework for Nodal Officers	ICAR, New Delhi	1 September 2011	Dr.T.Ravisankar
CAC Review meeting of NAIP project	TANUVAS, Thoothukudi	2 September 3 October 2011	Dr.A.R.Thirunavukkarasu
Review meeting of ICAR Seed Project- Seed Production in Agricultural Crops and Fisheries	New Delhi	19-20 September 2011	Dr.S.M.Pillai Dr.A.R.Thirunavukkarasu

Particulars	Organizers	Duration	Participants
33rd Institute management Committee meeting of Central Institute of Freshwater Aquaculture, Bhubaneswar	Central Institute of Freshwater Aquaculture, Bhubaneswar	23 September 2011	Dr.S.M.Pillai
2nd Meeting of Planning Commission Sub-group	CIFE, Mumbai	24 September 2011	Dr.A.R.Thirunavukkarasu
Mid term evaluation meeting of ICAR Regional Committee II	CIFRI, Barrackpore	24 September 2011	Dr.J.K.Sundaray
Deliberations of the Genomic Platform for Fisheries for 12th Plan	NBFGR, Lucknow NBPGR, New Delhi	26 September 2011 16 November 2011	Dr.G.Gopikrishna Dr.K.Vinaya Kumar
Meeting on "Platform on Diagnostics and Vaccines"	IVRI, Izatnagar	29 October 2011	Dr.K.P.Jithendran Dr.S.V. Alavandi Dr.S.K.Otta
First National Dialogue on Application of Nanotechnology in Agriculture	CIFE, Mumbai	8-9 October 2011	Dr.R.Saraswathy
Brain-storming meet on Water Platform	Fisheries Division (ICAR) & NBFGR at Lucknow	18 October, 2011	Dr.M.Muralidhar Dr.M.Jayanthi Dr.A.Panigrahi
Second National Dialogue on Application of nanotechnology in agriculture	TNAU, Coimbatore	11-12 November 2011	Dr.R.Saraswathy
Impact Assessment of International Trainings in Frontier Areas of Agricultural Sciences	NAIP at New Delhi	28-30 November 2011	Dr.M.Muralidhar Dr.M.S. Shekhar Dr.M.Kumaran Shri J.Ashok Kumar
Expert Consultation & Farmers Meet on "Sustainable development and prospective in inland saline aquaculture"	Rohtak Centre of CIFE	10-11 February 2012	Dr.A.R.Thirunavukkarasu
National Conference on Biotechnological Approaches in Aquaculture (Live Aqua 2012)	Bharathidasan University, Tiruchirapalli	20 February 2012	Dr.A.R.Thirunavukkarasu
ICAR institute-SAU-State Department Interface	CIFRI, Barrackpore	13 March 2012	Dr.J.K.Sundaray
National Conference on Aquaculture: Fish for Billion in commemoration of Silver Jubilee of CIFA	CIFA	16-17 March 2012	Dr.A.R.Thirunavukkarasu

Participation in invited functions, workshops etc.

Particulars	Organizers	Duration	Participants
Delivered Lecture on "livelihood development options of coastal farmers of Sunderban" to the students of CIFE, Kolkata Centre under Entrepreneurship Development Programme	Central Institute of Fisheries Education, Kolkata Centre	19 April 2011	Dr. T.K. Ghoshal
Delivered lecture to the group of lady members of Farmers' Club of Nischintapur Janakalyan Mahila Samity on Composite Fish Farming	Nischintapur village, South 24 Parganas, West Bengal	20 April 2011	Dr. T.K. Ghoshal
Delivered talk on Innovative ICT based extension approaches for aquaculture knowledge management, Model-based tools and techniques for aquaculture development in the PhD-FEX course Advances in Information and Communication Technology	Central Institute of Fisheries Education, Mumbai	5-6 August 2011	Dr.P.Mahalakshmi
As Chief Guest at the Valedictory Function of the National Conference on Marine Biodiversity for New Biotechnological Applications, delivered a presentation on Aquaculture Genetics and Biotechnology vis-à-vis shrimp disease management.	Hindustan College of Arts & Science, Kelambakkam, Chennai	9 December 2011	Dr.G.Gopikrishna
Participated in the Indian Science Congress and presented a paper on Testing times in toxicology- In vitro vs In vivo testing	Bhubaneswar, Odisha	3 -7 January 2012	Dr.Shiranee Periera
Talk on Promotion of Entrepreneurship in Coastal Areas	Sathyabama University	30 January 2012	Dr.B.Shanthi
Workshop on Advances in Aquaculture Technology (WAAT-2012)	Dept. of Marine Science, Bharathidasan University, Trichy	20-24 February 2012	Dr.R.Saraswathy

Participation in invited functions, workshops etc.

Particulars	Organizers	Duration	Participants
Resource person for the NAIP National training programme on Development of gene chip for microbial identification using DNA probes	National Bureau of Agriculturally Important Microorganisms, Mau, Uttar Pradesh	8 February 2012	Dr.M.S.Shekhar
Delivered a lecture on Anti-nutritional factors in feed ingredients and their amelioration in the Model Training Course on Fish Nutrition and Feed Formulation	CIFE, Kolkata Centre	28 February 2012	Dr. T.K. Ghoshal
Technical Session	INVE Aquaculture, Chennai	8 March 2012	Dr.P.Nila Rekha Dr.A.Panigrahi
Dr.P.J.Sanjeevaraj Endowment Lecture organized by Madras Christian College, Chennai and delivered lecture on "Sustainable use of aquatic resources" on the occasion.	Madras Christian College, Tambaram	13 March 2012	Dr.A.G.Ponniah
Delivered lecture on "Commercially important Perch fishes"	Government Arts College, Kumbakonam	22 March 2012	Dr.A.R.Thirunavukkarasu

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Services in Committees

Dr. A.G.Ponniah, Director

- Member, Executive Committee and Governing Body, Rajiv Gandhi Centre for Aquaculture (MPEDA), Mayiladuthurai
- Member, National Committee to Oversee and Regulate Introduction of Exotic Aquatic Species, Ministry of Agriculture, Govt. of India
- Member, Coastal Aquaculture Authority, Ministry of Agriculture, Govt. of India
- Member, General Body of Orissa Shrimp Seed Production Supply and Research Centre (OSSPARC), Odisha
- Member, ICAR Regional Committee No.VIII
- Member, Task Force Committee on Fisheries Development Mission – Tamil Nadu State Fisheries Department, Govt. of Tamil Nadu
- Member, Scientific Advisory Committee for Dr.Perumal Krishi Vigyan Kendra, Krishnagiri Taluk, Dharmapuri District, Tamil Nadu
- Director - Board of Directors of Tamil Nadu Fisheries Development Corporation Limited, Chennai
- Expert Member – Tamil Nadu Fisheries Research Council, Govt. of Tamil Nadu
- Member, Task Force Committee on Aquaculture & Marine Biotechnology of Department of Biotechnology, New Delhi
- Member, Working group on Fisheries for the Eleventh Five Year Plan (2007-2012)
- Member, National Centre for Sustainable Aquaculture (NaCSA)
- Member, Committee for protection of fish germplasm through registration and documentation, constituted by ICAR
- Member, Sub-Committee for studying the potential and viability of culturing endemic and exotic species, constituted by DAHD&F, Ministry of Agriculture
- Member, Scientific Advisory Committee, Krishi Vigyan Kendra, Tiruvallur
- Member, Committee to study various aquaculture standards for inclusion in National Programme for Organic Production (NPOP), constituted by National Steering Committee for Organic Products, MPEDA
- Member, Sub-Committee to formulate guidelines for farming of *L.vannamei* and norms for setting up of multiplication centres for production and supply of *L.vannamei*
- Member, Fisheries Institute of Technology and Training (FITT), Chennai
- Member, Sub-committee to finalize the guidelines for import of Ornamental fishes, constituted by Ministry of Agriculture, DAHD&F, New Delhi
- Member, Board of Management of Tamil Nadu Veterinary and Animal Sciences University, Chennai

- Member, Expert Committee to prepare Rules for Management and Conservation of Biodiversity Heritage sites constituted by National Biodiversity Authority, Chennai
- Member, Expert Committee to evaluate the access, patent, transfer of research results and material transfer applications, constituted by National Biodiversity Authority, Chennai
- Member, Expert Committee on preparing guidelines on ameliorative measures for Biodiversity rich areas threatened by overuse, abuse or neglect, constituted by National Biodiversity Authority, Chennai
- Member, Expert Committee on Access and Benefit sharing for processing the applications received by NBA, constituted by National Biodiversity Authority, Chennai
- Member, Selection Committee for selection of Deans and Directors of various faculties of TANUVAS (As ICAR representative)
- Member, Selection Committee constituted for the selection of an Awardee in the discipline of Biological Sciences, constituted by Tamil Nadu State Council for Science & Technology, Govt of Tamil Nadu
- Member, State Level Committee on Animal Genetic Resources (SLCAnGR), constituted by Animal Husbandry & Veterinary Services, Chennai
- Committee to review ARS disciplines and eligibility qualifications for various scientific positions in ICAR, under the Chairmanship of Dr.R.S.Paroda, Former Director-General, ICAR
- Task Force to finalize comments on Draft standards for Responsible Shrimp Aquaculture (SHAD) constituted by the Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, New Delhi
- Finance Committee of TANUVAS
- Selection Committee constituted for the selection of an Awardee in the discipline of Biological Sciences, constituted by Tamil Nadu State Council for Science & Technology, Govt of Tamil Nadu
- Academic Committee of MSSRF-IGNOU Community College in Fisheries, at Poompuhar
- Advisory Council of 8th Symposium on Diseases in Asian Aquaculture (8th DAA) of the Fish Health Section (FHS), Asian Fishery Society in Mangalore, organized by Karnataka Veterinary, Animal and Fisheries Sciences University College of Fisheries, Mangalore during 21-25 November 2011
- Expert Committee constituted by the Secretary to Govt., AHD&F Department, Chennai, for inspection of CARD Marine Finfish Hatchery of TNFDC Ltd. at Neelankarai and to evaluate the risks of CARD hatchery to the Aquatic Quarantine facility of RGCA and RGCA establishment to CARD
- Expert Group to work out possible arrangements and to formulate guidelines for *Litopenaeus vannamei* farming in freshwater aquaculture, constituted by the DAHD&F, Ministry of Agriculture, New Delhi
- Expert Group to suggest both short-term and long-term measures for creating an appropriate and effective legal and institutional frame-work for management and control of aquatic animal diseases, under the chairmanship of Deputy Director General (Fy.), ICAR, constituted by DAHD&F, Ministry of Agriculture, New Delhi

Dr.A.R.Thirunavukkarasu, Head, Fish Culture Division

- Project Review Board Member for NIOT, Chennai
- Advisory Board Member for Fisheries Institute of Technology (FIIT), Department of Fisheries, Govt. of Tamil Nadu
- Advisory Board Member Centre for Aquaculture Research and Development (CARD), Dept. of Fisheries, Govt. of Tamil Nadu
- Member, Board of Studies, Dept. of Zoology, Bharathidasan University, Trichy
- Invited Member for 12th Five Year Plan Sub-Group Meeting of Govt. of Tamil Nadu
- Member, Veterinary Research Advisory Committee, TANUVAS

Dr.P.Ravichandran, Head, Crustacean Culture Division

- Member of the Institute Management Committee of Central Marine Fisheries Research Institute, Cochin

Dr.S.M.Pillai, Principal Scientist & OIC, PME Cell

- Member of the Institute Management Committee of Central Institute of Freshwater Aquaculture, Bhubaneswar

Dr. G. Gopikrishna, Principal Scientist & SIC, Nutrition, Genetics & Biotechnology Division

- Provided technical inputs to Coastal Aquaculture Authority (CAA) for establishment of *L. vannamei* and *P. monodon* multiplication centres

Dr.V.S.Chandrasekaran, Principal Scientist & SIC, Social Sciences Division

- Served as a member of the Scientific Advisory Committee meeting of Dr. Perumal Krishi Vigyan Kendra, Krishnagiri Taluk, Dharmapuri District

Dr. S.V.Alavandi, Principal Scientist

- Served as a member of the Project Monitoring and Evaluation Committee (PMC), Small Business Innovative Research Initiative (SBIRI).Visited M/s Aristogene Biosciences, Bangalore on 16th February 2012 for PMC Meeting
- Services were provided in terms of inputs to Commissioner of Fisheries, Ministry of Agriculture and Animal Husbandry for import of Liptocitro larvae by M/s Biostadt India Ltd, Mumbai, from M/s Liptosa (Lipidos Toledo SA), Madrid, Spain
- Provided technical inputs to Coastal Aquaculture Authority (CAA) for establishment of *L. vannamei* and *P. monodon* multiplication centres

Dr.Shiranee Periera

- Nominated member of the National Committee of the CPCSEA, MoEF, Govt. of India

Dr.M.Poornima, Senior Scientist

- Provided technical inputs to Coastal Aquaculture Authority (CAA) for establishment of *L. vannamei* and *P. monodon* multiplication centres

Dr.B.Shanthi, Senior Scientist

- Member of the 14th IMC meeting of DRWA, Bhubaneswar

Dr. K. Vinaya Kumar, Scientist

- Provided technical inputs to Coastal Aquaculture Authority (CAA) for establishment of *L. vannamei* and *P. monodon* multiplication centres

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Workshops, Seminars, Meetings etc. organized by the Institute

WORKSHOPS

Scaling up of shrimp BMP programme

A 3-day National Workshop on Scaling up of shrimp BMP programme at National Level was organized by CIBA, Chennai during 16-18th May, 2011.

Climate Change and Coastal Aquaculture: Impacts, Adaptations and Mitigations for Resilience

A Stakeholders' Workshop on Climate Change and Coastal Aquaculture: Impacts, Adaptations and Mitigations for Resilience was organized by CIBA, Chennai under the project- National Initiative on Climate Resilient Agriculture (NICRA) on 24th October, 2011 at Krishi Vigyan Kendra, Undi, West Godavari District, Andhra Pradesh. About 100 people representing all the stakeholders of aquaculture attended the workshop. The chief guest Dr.B.Venkateswarlu, Director, CRIDA, Hyderabad & National Coordinator NICRA described the origin of NICRA project, implementation and execution of the project all over India, funds allotted for long term research as well as for providing immediate solutions to the farmers in view of climate change, and also the present status and future directions of the NICRA project. The Guest of Honour Shri M.V.S. Nagireddy, Governing Body Member, ICAR, New Delhi highlighted the needs and aspirations of the farmers in Godavari District and the need of indepth research on effect of climate change on aquaculture.

Data Analyses

A Data Analyses Workshop of the ICAR-DBT-NRC Indo-Norwegian Collaborative Project was

organized at CIBA from 28th November to 1st December 2011. Project Personnel from CIFA, CIBA and Norwegian Institute of Food Fisheries and Aquaculture, Norway, attended.

Developing adaptations for climate change impacts on coastal aquaculture

Four Stakeholder Workshops were organized under the NICRA project at the district level in four maritime states Tamil Nadu, Andhra Pradesh, Kerala & West Bengal on 9th August, 2011, 24th October, 2011, 9th February, 2012 & 23rd March, 2012 respectively, involving representatives of all the key

Farmers group discussion during Stakeholder workshop at Alapuzha, Kerala

Stakeholder workshop at Nagapattinam, Tamil Nadu

stakeholders to discuss the climate change impacts and to identify adaptations, prioritize with a time line and responsible agencies.The discussion with the aid of colour cards was participatory and the moderators of the group consolidated the discussions and presented the results.

Science & Technology group discussion during Stakeholder workshop at Diamond Harbour, West Bengal

STAKEHOLDERS MEETINGS

Stake holder's Interaction Meet on Vision 2030

Stake holder's interaction meet on Vision 2030 was held on June 21, 2011 and current scenario of aquaculture and strategies for future research was discussed. Dr. (Mrs) B. Meenakumari, DDG (Fy.), ICAR attended the meeting and handed over the first batch of hatchery produced juveniles of brackishwater ornamental fish Spotted Scat *Scatophagus argus* to a farmer.

Meeting on 'Policy brief discussion of Indian case study on shrimp farming under Aquaclimate Project'

A stakeholder panel consultation meet was organized at Hotel Ilapuram, Vijayawada on 8th December, 2011 under Aquaclimate project- *Strengthening adaptive capacities to the impacts of climate change in resource-poor small-scale aquaculture and aquatic resources-dependent sectors in the South and South East Asian region.*

Dr. M. Muralidhar, Coordinator and Dr.M.Jayanthi, Co-coordinator of the project presented the salient findings of the project. The meeting discussed the draft reports and policy brief based on the study findings. About 30 participants representing key departments, research institutions, promotional agencies, extension organizations, farmers, input companies, professionals, NGOs and development departments actively participated and provided their valuable inputs.

SUMMER SCHOOL

A summer school on "Advances in Aquaculture Nutrition and Feed Processing Technology" was conducted from 15th September 2011 to 5th October 2011, at CIBA, Chennai. Twenty five participants from the states of Jammu and Kashmir, Punjab, Gujarat, Maharashtra, Uttar Pradesh, Uttarakhand, West Bengal, Andhra Pradesh and Tamil Nadu participated in this programme. Faculties were invited from CIFA, CIFE, CMFRI, TANUVAS and Godrej Agrovet Ltd. A special class for a day was organized at Madras Veterinary College and TANUVAS Pharmacovigilance laboratory. A field trip was also arranged for the participants for exposure to shrimp farming, feed mill and fish meal production factory.

Release of summer school manual by Dr. C. Balachandran, Registrar, TANUVAS

Focus group discussion (FGD) meetings on 'Climate change impacts on coastal aquaculture: Farmer perceptions and adaptations'

Eight FGD meetings were conducted under National Initiative on Climate Resilient Agriculture (NICRA) project with a group of aqua farmers (20-30 nos.) at a rural informal/farm setting in two representative villages in one district each in four maritime states from 28th July 2011 to 21st March, 2012. The FGDs documented the farmers' exposure to climatic variations and extreme climatic events, their impacts and risk assessment. The methodology was completely participatory and respondent

FGD at Akivedu, Andhra Pradesh

FGD at Thirukarugavur, Tamil Nadu

driven, aided by colour cards. The group discussions yielded a consensus opinion in a specified colour card on every aspect of discussion.

Focused Group Discussion Meetings

Three FGD meetings were conducted at Rajoula, Diu and Veraval in the Saurashtra coastal region of Gujarat. At Rajoula, three farmers culturing tiger shrimp attended the meet, at Diu 10 farmers attended the meet and informed that only one crop of tiger shrimp is possible as the winter crop results either in breakeven or loss due to poor growth of shrimp. At Veraval though brackishwater aquafarming is well developed, five persons showed their interest in shrimp/any other brackishwater aquafarming, including the Fishermen Society Office bearers who attended the meet.

MEETINGS

Farmers' Meet

A brackishwater aqua farmers' meet was organized on 8th April, 2011 at Danti farm in Gujarat to commemorate the successful harvest of banana shrimp culture demonstration for the third time under the collaborative project of CIBA and NAU on the development of brackishwater aquaculture. The programme was attended by Dr. S.D.Tripathi, Former Director, CIFA, Dr.(Mrs). Meenakumari, DDG (Fy.), ICAR, Dr.A.R.Pathak, Vice Chancellor, NAU, Dr.A.G.Ponniah, Director, CIBA and Dr.R.C. Pathak, Director Research, NAU. Dr.R.C.Pathak welcomed the gathering and Dr.S.M.Pillai, Principal Scientist, CIBA and Principal Investigator of the Collaborative Project explained the background of the project and achievements made so far. About 80 farmers in and around Navsari and Officials from Department of Fisheries, Govt. of Gujarat and Scientists from NAU and CIBA participated in the meeting. All the participants visited the standing Banana shrimp cultured ponds. The objectives of the meet were to popularise CIBA technologies to the local brackishwater aqua farmers, to review the trends in brackishwater aquaculture development in Gujarat and to exchange the views between farmers and scientific communities.

Polyfarming Harvest Mela and Interaction Meet at Uttar Chandan Piri, West Bengal

To popularize polyfarming technology and to have an interaction among the stakeholders in Sunderban

area, a meet was organized on 11th April 2011 by KRC of CIBA in the farm site at Uttar Chandanpiri. A total of 76 farmers from Akshaya Nagar, Uttar Chandan Piri, Dwarik Nagar, Ganesh Nagar and Jumani Naskar regions participated in the meet. Mr Subhrangsu Jana shared his experience with all other farmers of 24 Parganas (South) district. He emphasized the importance of carrying out brackishwater aquaculture in Sunderban without harming the natural environment. He explained in detail about how he developed the farm with an integrated approach along with mangrove forest development and a variety of fish and shrimp species with the technical input, support and encouragement from KRC of CIBA. He explained the economic gain of polyfarming in Sunderban area with an amount of ₹.1.5 lakhs/ha/crop from the polyfarming of the fishes grey mullet, stripped mullet, pearlspot and tiger shrimp.Dr.A.G.Ponniah, Director, CIBA, complimented the farmer for his success in polyfarming venture. Dr. A. R. Thirunavukkarasu, Principal Scientist & Head, Fish Culture Division, CIBA, appreciated the integrated approach of mangrove, fish and shrimp farming and also emphasized the success of farmers club and how they can facilitate the development of brackishwater aquaculture in Sunderban area by co-operative approach.

Farmers' Interaction Meet

As a part of the NFDB funded programme on Demonstration of Asian seabass farming in pond culture system, an Awareness cum Interaction Meet was held at Karwar, Uttara Kanara District of Karnataka on 28th May 2011. The meeting was presided over by Dr.A.G.Ponniah, Director, CIBA and Dr.V.N.Naik, Chairman & Administrator, Marine Biology Centre was the Chief Guest. Shri P.M.Tandel, Member, Coastal Aquaculture Authority of India inaugurated the Meet. Dr.K.K.Philipose, Principal Scientist & SIC of Karwar Research Centre of CMFRI and Smt.Anjana Devi, Assistant Director of Fisheries and Executive Officer, BFDA, Karwar rendered a felicitation address. Sixty progressive farmers from the region participated in the meeting. Dr.A.R. Thirunavukkarasu, Principal Investigator of the Project welcomed the gathering and gave a brief about the objectives of the meeting, the background of the project, existing practices on seabass farming and the initiatives taken by CIBA & NFDB in promoting it as an alternative/ complementary species for sustainable aquaculture. Dr.A.G.Ponniah, in his

presidential remarks, gave an account of the achievements made in seabass breeding and seed production and feed development at CIBA.

Brackishwater Aqua Farmers Meet-2011

Brackishwater Aquafarmers meeting was conducted at Puri & Bhadrak, Odisha on 8th June 2011 with 100 participants and 10th June with 150 participants respectively.

Dr. A G. Ponniah Director CIBA releasing the juveniles in the pre-growout pond at a farmer's farm

MPEDA and field personnel of NAcSA participated in the programme. Shri.M.K.Sethuraman, President, Paminiriver shrimp farmers association, Thambikottai, Keelakkadu of Thiruvarur district of Tamil Nadu shared their continued success of shrimp farming by adopting a cluster approach.

An Innovative Initiative by CIBA for the Large Scale Farming of Pearlspot

Awareness Programme & Farmers - Scientists interaction on Best Management Practices in Shrimp culture

CIBA with the financial support from NABARD conducted under its Rural Innovation Fund (RIF), an awareness cum interaction meet on Best Management Practices in shrimp culture on 23 June 2011 at Avarikadu shrimp cluster village in Nagapattinam district of Tamil Nadu. About 188 farmers, Assistant General Manager NABARD, 7 Scientists from CIBA, district level officers of the Department of Fisheries (DoF), Officials from

The Matsya Kerala Scheme has taken up a massive programme for the farming of brackishwater fishes on a large scale consequent to which the demand for pearlspot fish juveniles has increased. The expertise of CIBA scientists and technicians under the leadership of Dr. M. Natarajan on the production of pearlspot seed can complement in meeting the demand. As a beginning, on 2nd July 2011, the hatchery produced seed of pearlspot were supplied to Women Self Help Group fish farmers from Kerala. The seed were handed over to a farmer by Shri Basudeb Acharia, Hon'ble Chairman of Parliamentary Committee on Agriculture in the presence of other Members of the Parliamentary Committee at Muttukkadu Experimental Station of CIBA. The Kerala State Fisheries Department officials Shri K.J. Prasanna Kumar, Dr. Neetha, Dr. Sophia, Dr. Rachael and Smt. Priya were also present. The WSHG representatives from Thodiyoor, Kaikulangara, Karichira, Parinadu, Kalluvathukal, Kottiyam, Sakthikulangara and Punalur in Kerala also received the seed.

Winter Culture of Banana Shrimp in Gujarat

An awareness meet was held at Danti farm of Navsari Agricultural University, Gujarat on 28th July 2011 on the winter culture of banana shrimp *Fenneropenaeus merguiensis*. Altogether 16 aquafarmers

from Danti and Chijgam in Navsari District and Olpad in Surat District participated in this meet. Each farmer intends to go for banana shrimp culture in the forth coming winter season stocking minimum of 2 ponds in each of their farms as it would be economically remunerative. It is expected that at least 22 ha will be under winter culture and the seed requirement would be about 33 lakhs. The technical details and the management measures to be followed during the crop were explained to the farmers. CIBA considers this development as a successful example of its outreach activity taken up in collaboration with Navsari Agricultural University. Further, this also opens up a new avenue for the shrimp farmers of Gujarat to diversify into banana shrimp culture during winter to obtain a reasonable crop when tiger shrimp growth slows down in low temperatures.

Brackishwater Aquaculture for Scheduled Tribe Farmers of Gujarat

CIBA kick-started its research activities under the Tribal Sub Plan (TSP) by organizing a two day Awareness Meet cum Training Programme on Brackishwater Aquaculture for Scheduled Tribe farmers in Navsari region of Gujarat during 26-27 August 2011 at the Krishi Vigyan Kendra of Navsari Agricultural University, Navsari co-ordinated by the Soil and Water Management Research Unit. The programme was conducted for familiarizing and subsequently empowering the participants with brackishwater aquaculture technologies, such as shrimp farming, fish culture, crab culture and related aspects, in order to offer them additional avocation for their livelihood development and income generation. This is the first ever event conducted by CIBA exclusively for the benefit of Scheduled Tribes under the TSP funding of ICAR. There were 64 participants, 24 men from Pathri village of Gandevi Taluka and 40 women from Mahuvas village of Vansda Taluka of Navsari District. In the inaugural session on 26th August 2011, Dr. C.K.Timbadia, Programme Co-ordinator of Krishi Vigyan Kendra (KVK), Navsari, welcomed the participants and briefed about the activities of the KVK. Dr.S.M.Pillai, Principal Scientist spoke on the scope of development of brackishwater aquaculture as a suitable livelihood option for the coastal communities, particularly the scheduled tribes and briefed about the small scale aquaculture practices like mud crab fattening and farming as a suitable technology for women. Dr.M.S.Purohit, Director of Extension Education, NAU, Navsari, highlighted the importance of aquaculture as an income generating activity and outlined the avenues available to farm women to improve their livelihood by adopting brackishwater aquaculture practices.

Aqua Farmers Meet at KRC

The Kakdwip Research Centre of CIBA organised the Brackishwater Aqua Farmers' Meet 2011 funded by the National Fisheries Development Board, Hyderabad on 21st October 2011. The prime objectives

of the meet were to provide technological solutions to farmers on issues relating to different aspects of brackishwater aquaculture. Dr.Amlesh Choudharay, Retired Emeritus Professor, Calcutta University, Mr. D. K. Biswas, Deputy Director, MPEDA, Kolkata, Prof. T. Abraham, Dean, Faculty of Fishery Science, WBUA & F.Sc, Mr M. Farooqui, Block Development Officer, Namakhana Block and Mr. Dilip Naskar, Assistant Director (Brackishwater) Department of Fisheries, Govt of West Bengal participated in the meet and interacted with the farmers. Dr.A.G.Ponniah, Director, CIBA elaborated on the new techniques evolved from the NAIP project operated at KRC, demonstrating how brackishwater aquaculture activities along with agricultural activities would be helpful for farmers for their socio economic upliftment. He also suggested that *L. vannamei* culture could be taken up in West Bengal in lower stocking densities. The seed of seabass were distributed to the project beneficiaries, under NFDB funded project on "Demonstration of Asian seabass, *Lates calcarifer* farming in pond culture system" by Prof. Amlesh Choudharay.

CIBA Science Forum

CIBA invited eminent persons from various disciplines to deliver lectures on science & technology. During this year, Ms.Meenakshi Bajaj, Dietitian, Institute of Diabetology, Madras Medical College, Chennai delivered a talk on Medical nutrition therapy in non-communicable disease on 5th May 2011. Dr. P. Iyanperumal spoke on Truth behind Beliefs on 29th July 2011 and a talk on An integrated approach of Indian Jyothisasthra in Indigenous/daily healing practices was delivered by Dr. Suvarna Nalapat, Retired Professor and HoD of Medical College Services of Kerala on 27th January 2012.

Women's Day Celebrations

Women staff members of CIBA celebrated the Women Day - 2012 on 8th March 2012 at CIBA headquarters. To mark this occasion, various competitions like rangoli, cooking competition, sports and cultural programmes were organized for the staff members. All women staff members and research scholars actively participated in the above competitions and won various prizes. Prizes were distributed to the winners by the Director, CIBA.

Launching of new website of CIBA

Dr. S.Ayyappan, Hon'ble Secretary, DARE and Director General, ICAR, launched the new-look website (http://www.ciba.res.in) of CIBA during his visit to Chennai on 16th August 2011. CIBA is one among the nine consortia partners of the NAIP sub-project of "Agroweb – Digital Dissemination System for Indian Agricultural Research (ADDSIAR)" being carried out under the leadership of National Bureau of Plant Genetic Resources (NBPGR) New Delhi. The Agroweb project team of CIBA has designed and developed the model website using in-house expertise and conforming with Uniformity Guidelines

Dr. S. Ayyappan, Secretary, DARE & DG, ICAR launches new look website of CIBA
(http://www.ciba.res.in)

for Websites as issued by ICAR. The meeting was attended by 200 staff members of CIBA and Madras Research Centre of CMFRI. Dr.A.G.Ponniah, Director, CIBA welcomed the gathering and thanked Dr. S.Ayyappan for accepting the invitation to visit the Institute in spite of his hectic schedule in the city. Dr.T. Ravisankar, Senior Scientist and Consortium Co Principal Investigator of the Agroweb sub project under NAIP explained the facilities added in the new look website of CIBA that has been dynamically updated with JOOMLA content management system and Web 2.0 technologies.

Inauguration of Silver Jubilee Trainees' Hostel of CIBA

CIBA in commemoration of its Silver Jubilee year, constructed a Trainees' Hostel. This Hostel was inaugurated by Dr.S.Ayyappan, Secretary DARE and Director General, ICAR on 3rd March 2012, in the presence of Dr.(Mrs) B. Meenakumari, DDG (Fisheries), Dr.A.G.Ponniah, Director, CIBA, Dr.G.Syda Rao, Director, CMFRI, the CPWD engineers, Scientists and staff members of CIBA &

CMFRI and officers from various state fisheries organizations. The Hostel has been constructed on an area of 507 sq. m with 2 VIP/Guest suites in the ground floor, 4-double bedded rooms in first floor and a dining facility.

A Talk on ZTM BPD Unit

A talk on ZTM BPD Unit (South Zone): Role in Technology Management and IP protection was presented by Dr. Leela Edwin, Head, Division of Fishing Technology & Member Secretary, ZITMC

(South Zone), CIFT on 11th July, 2011 in the CIBA Conference Hall. Forty participants attended the programme.

Brain storming session on researchable issues in aquaculture nutrition was conducted at CIBA on 14th December, 2011 under the chairmanship of Dr. S.J. Kaushik, Director of Research, INRA, France. The Researchers/Scientists working in the area of aquaculture/ fish nutrition from various National and State Research Institutes and Universities participated in the brainstorming session. The main objective was to deliberate the researchable issues in the field of aquaculture nutrition for developing and prioritizing the research needs in the XII plan

Demonstration programme

A demonstration programme on Development of herbal based pellet feed for ornamental fishes was conducted on 15th July, 2011 at New Perungalathur, Kancheepuram District among the 'Pournami' Irrular Tribal WSHGs by TANUVAS –KVK. This feed was processed in the farm model fish feed unit installed by CIBA under the DBT project. Feed ingredients were provided by KVK-Kattupakkam. This herbal based pellet feed is useful for immune enhancement and colour improvement in ornamental fishes. This technology was developed by FC&RI, Tuticorin.

Mass media programme

- ❖ Polyfarming success story was telecast in Annadata program of ETV BANGLA on 15th August 2011.
- ❖ TV program on (LONA JALARE CHINGDI CHAS Part-1) brackishwater shrimp farming was telecast in Doordarshan (DD BANGLA-1) on 4th November 2011 and Part 2 was telecast on 13th January 2012.
- ❖ Programme broadcasted in **Makkal TV** under the **Chapter 'Malarum Boomi of Pannai Shaithee' Farm News. This** programme was on Irrular tribal community practicing crab fattening in tide fed ponds at Kulathumedu Village, Pulicat and Women Self Help Groups practicing crab fattening (in pens) at Thonirevu village, Pulicat , Tiruvallur District. Tamil Nadu was telecast on 27th, 28th & 31st October 2011.

❖ Programme broadcast in **Doordarshan TV channel on 9th January 2012 on the topic- Empowering coastal women self groups through adoption of brackishwater aquaculture technologies of CIBA.**

EXHIBITIONS

The Institute participated in the following exhibitions

Sl. No	Event	Date
1.	Revitalizing Indian Fisheries education, TANUVAS, Fisheries College and Research Institute, Tuticorin	8-10 May 2011
2.	NACA-CMFRI-CIFT Meeting, CIFT, Kochi	8-9 May 2011
3.	"Chennai Coastal Carnival for Children" at Bharat Scout and Guide Campus, Wenlock Park, Triplicane, Chennai organized by the Centre for Environment education, Chennai supported by the South Asian Association for Regional Cooperation (SAARC) - Coastal Zone Management Centre (SCZMC), Maldives.	5-6 August 2011
4.	Diseases in Aquaculture – DAA-8, Mangalore	21-25 November 2011
5.	9th Indian Fisheries Forum, IMAGE Auditorium, Chennai	19-23 December 2011
6.	25th National Convention of Agriculture Engineers and National Seminar on Advances in Uses of Non Conventional Energy Resources for Agriculture, Fisheries and Rural development, Kolkata	19 January 2012
7.	Chennai Science Festival, Anna University, Chennai	27-30 January 2012
8.	FISH FESTIVAL Raipur 2012 at Raipur, Chhattisgarh	27-29 January 2012
9.	New Vistas in Indian Aquaculture, CIBA Silver Jubilee Celeration, CIBA, Chennai	23-24 February
10.	India International Seafood Show 2012, (IISS) organized at Chennai Trade Centre, Nandambakkam, Chennai	29 February - 3 March 2011.

Agricultural Research (ARS) service/NET examinations

Preliminary ARS/NET Examination, 2011 of Agricultural Recruitment Board (ASRB) was conducted at Chennai Centre by the Institute on 19th February 2012.

ICAR Examinations Coordinated by CIBA

- All India Entrance Examination for admission to UG/PG Degree Programmes in Agriculture and Allied Science - 2011 held on 16-17 April 2011
- IARI Ph.D. Entrance Examination 2011 held on 5th June 2011
- Competitive Examination for Assistant held on 8th October, 2011
- All India Competitive Examination ICAR-SRF Examination 2011 held on 4th December, 2011

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Visitors

Headquarters

Dr. Leela Edwin, Member Secretary, Zonal Institute Technology Management Centre (ZITMC), CIFT, Kochi	11 July 2011
Dr. P. Iyamperumal, Executive Director, Birla Planetarium, Chennai	29 July 2011
Dr.V.Sadamate, Member, Planning Commission, New Delhi, Dr.Dilip Kumar, Ex-Director, CIFE, Mumbai	18 August, 2011
Mr. Ashok Nanjappa, Mr.Ravi and Dr. Alexander Van Halderew, Water Base Ltd. Chennai	19 August, 2011
Dr. T. Subramoniam, Retd. Professor and Head, Dept. of Zoology,University of Madras, Chennai	7 September, 2011
Mr. Prasad Rao Katneni, Chief Executive & Mr. A. Saran, Head, Business Development, MAP Systems, Bangalore	13 September, 2011
Dr. Mohan Joseph Modayil, Chairman, ASRB, New Delhi	22 September, 2011
Dr. M. Michael Aruldass, Professor & Head, Department of Endocrinology, Dr. S.T.Santhiya, Professor & Head, Department of Genetics, University of Madras, Chennai	23 September, 2011
Dr. (Mrs.) B. Meenakumari, Deputy Director General (Fy.), ICAR, Dr. S.D.Tripathi, Chairman, RAC of CIBA, Dr. I. Karunasagar, Professor & Head (Micro.), College of Fisheries, Mangalore	12 December, 2011
Mr. Melanie Chapman, Education Counsellor, New Zealand High Commission, New Delhi	5 January, 2012
Mr. Michael Carter, Trade Commissioner & Consul Commercial, and Mr. Gitesh Agarwal, Business Development Manager, Australian Trade Commission, Australian Consulate General, Chennai	24 January, 2012
Dr. S.Syda Rao, Director, CMFRI	3 March, 2012

Kakdwip Research Centre

Dr. T.J.Abraham, Dean, Faculty of Fishery Science, West Bengal University of Animal and Fishery Science	13 May, 2011
Dr. D.Chandramohan, Member, RAC, CIBA, Dr. R.A.Selvakumar, Former ADG (M.Fy.) and Dr.P.Chandramohan , Managing Director, Indomer Coastal Hydraulics (P) Ltd. Chennai	25 June, 2011
Mr. S.Mani, Assistant Director, MPEDA	29 June, 2011
Dr. P.K.Mukhopadhyay, Principal Scientist and OIC, CIFA, Rahara Center and Dr. B K Mohapatra, Principal Scientist and OIC, Kolkata Centre, CIFE	2 July, 2011
Dr. A.K.Bandyopadhyay, CAC Chairman, NAIP and Dr. B.K.Bandypadhyay, PI, NAIP	19 August, 2011
Prof. Amalesh Choudhury, Emeritus Prof. (Retd), Kolkata University	9 May, 2011 21 October, 2011
Mr. Anjan Dandapat along with ATMA beneficiary farmers (11 Nos.) from Sahada, Balasore, Odisha	4 December, 2011
Dr. T.S.Nagesh, students and faculty from Faculty of Fishery Science, West Bengal University of Animal and Fishery Sciences, Kolkata	8 December, 2011
Dr. G.H.Pailan and Scientists from CIFE, Kolkata Centre	24 January, 2012
Dr. Lita Sunder,Assistant Professor along with students from Madras Christian College, Chennai	4 February, 2012
Dr. Liz Humphreys Sr. Scientist (IRRI) and Dr. Manoranjan Kumar Mondal, Collaborative Research Scientist, IRRI, Dhaka, Bangladesh	17 February, 2012
Dr. S.D.Tripathi, Chairman, RAC, CIBA and Prof. Rintu Banerjee, Microbial Biotechnology and Downstreaming Processing Laboratory, Agriculture and Food Engineering Department, Indian Institute of Technology, Kharagpur	25 March, 2012

17 Personnel

Managerial Personnel
Director: Dr. A. G. Ponniah

Headquarters

Scientific Personnel

Head of Division

Dr. A.R.Thirunavukkarasu, Finfish Culture Division
Dr. P.Ravichandran, Crustacean Culture Division

Principal Scientist

Dr. S.M.Pillai
Dr. T.C.Santiago (Superannuation on 31.7.2011)
Dr. Syed Ahmed Ali (Superannuation on 31.5.2011)
Dr. N.Kalaimani (Superannuation on 29.2.2012)
Dr. M.Natarajan
Dr. G.Gopikrishna
Dr. C.Gopal
Dr. K.P.Jithendran
Dr. V.S.Chandrasekaran

Senior Scientist

Dr. T.Ravisankar
Dr. (Mrs.) Shiranee Pereira
Dr. M.Muralidhar
Dr. (Mrs.) M.Jayanthi
Dr. (Mrs.) B.Shanthi
Dr. S.V.Alavandi
Dr. C.P.Balasubramanian
Dr. M.Kailasam
Dr. (Mrs.) D.Deboral Vimala
Dr. M.Shashi Shekhar
Dr. S.Kannappan
Dr. Akshaya Panigrahi
Dr. (Mrs.) P.Nila Rekha
Dr. K.Ambasankar
Dr. J.Syama Dayal
Dr. M.Kumaran
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 (Joined on 26.3.2012)

Scientist (Senior Scale)

Dr. (Mrs.) P.Mahalakshmi
Shri Ashok Kumar Jangam

Scientist

Dr. K.Vinaya Kumar
Dr. (Mrs.) Krishna Sukumaran
Dr. (Mrs.) Ezhil Praveena
Dr. Prem Kumar
Dr. (Mrs.) T.Bhuvaneswari
Dr. (Mrs.) N.Lalitha

Technical Officer

T (7 – 8)

Shri R.Elankovan
Dr. S.Sivagnanam (Promoted w.e.f. 14.2.2010)
Shri D.Raja Babu (Promoted w.e.f. 13.3.2010)

(T – 6)

Shri M.Shenbagakumar
Shri V.R.Senthil Kumar
Shri R.Puthiyavan
Mrs. K.Jacquline (Joined on 27.5.2011 on transfer from CIFRI, Barrackpore)
Shri Joseph Sahayarajan (Promoted w.e.f. 8.12.2010)

(T – 5)

Shri M.Gopinathan Nair (Driver)
Shri S.Rajamanickam
Shri S.Rajukumar
Shri S.Nagarajan
Shri S.Stanline
Dr. A.Nagavel
Shri R.Subburaj
Shri R.Rajashekaran

Technical Assistant

(T – 4)

Shri N.Ramesh (Promoted w.e.f. 6.8.2010)
Shri S.Saminathan (Promoted w.e.f. 18.1.2011)
Shri N.Jagan Mohan Raj (Promoted w.e.f. 15.2.2011)
Shri R.Balakumaran (Driver) (Promoted w.e.f. 29.6.2011)

(T – II – 3)

Shri D.M.Ramesh Babu
Shri G.Thiagarajan

(T - 3)

Shri K.Paranthaman (Driver) (Promoted w.e.f. 1.1.2011)

(T - 2)

Shri K.Karaian

(T – 1)

Shri K.V.Delli Rao

Administration and Finance

Administrative Officer

Shri A.Muthuraman
(Superannuation on 30.11.2011)
Shri B.Sathish (Joined on 7.12.2011)

Finance & Accounts Officer

Shri V.L.Jacob (Joined on 8.4.2011)

Assistant Administrative Officer

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

Junior Accounts Officer

Mrs. K.Nandhini

Personal Assistant

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

Stenographer Gr. III

Mrs. K.Hemalatha
Mrs. K.Subhashini

Assistant

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

Upper Division Clerk

Mrs. E.Mary Desouza
Shri P.Srikanth

Lower Division Clerk

Mrs. R.Vetrichelvi
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.Mariyappan
Shri K.Nithyanandam
Shri V.M.Dhanapal
Shri M.Subramani
Shri V.Kumar
Shri C.Saravanan

Shri S.Kuppan
Shri M.Pichandi
Shri S.Selvababu
Shri D.Senthilkumaran
Shri C.Raghu
Shri P.G.Samuvel
Shri M.Sakthivel
Shri R.Mathivanan
Shri R.Indra Kumar
Shri G.Dayalan
Shri Kanaka Prasad
Mrs. S.Premavathi
Shri M.Sampath Kumar
Shri J.Murugan

Supporting Staff

S.S. Gr. I

Shri E.Manoharan

Kakdwip Research Centre

Scientific Personnel
Principal Scientist & Officer-in-Charge

Dr. Jithendra Kumar Sundaray

Senior Scientist

Dr. T.K.Ghoshal
Dr. Debasis De
Dr. Ashuthosh Deo

Scientist

Dr. R.Ananda Raja
Shri Gouranga Biswas (on study leave)
Dr. Sujeet Kumar
Mrs. P.S.Shyne Anand

Technical Personnel

(T – 3)

Shri P.S.Samanta (Promoted w.e.f. 21.11.2005)
Mrs.Chanda Mazumder
(Promoted w.e.f. 28.11.2010)

Administrative Staff

Personal Secretary

Shri S.K.Halder (Promoted w.e.f. 29.9.2010)

Assistant

Shri S.K.Bindu
Shri P.K.Roy (Redeployed to CIFA, Bhubaneswar on 31.5.2010)

Upper Division Clerk

Mrs.Arati Rani Panigrahi

Skilled Support Staff

Shri N.C.Samanta
Shri Rash Behari Das
Shri Sasadhar Betal
Shri Patit Paban Halder
Shri Abhimanyu Naskar
Shri R.K.Ray
Shri Narendra Nath Jana
Shri Amar Gharami
Shri Krishna Pada Naskar
Mrs. Lakshmi Rani Bhuiya
Shri Uttam Kumar Santra
Shri Nayantara Dalui
Shri Purna Chandra Das

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Infrastructure Development

Headquarters, Chennai

- Aquatic health testing and wet lab independent modules constructed
- Trainee's hostel constructed
- Additional facilities such as bio security system, FRP tanks, and pipe line connections for the proposed aquatic health testing and wet lab.

Muttukadu Experimental Station, Muttukadu

- Providing of additional power supply to feed mill with necessary panel boards, cabling, change over switch including charges payable to TNEB etc.
- Work of strengthening of approach road (concrete road) with stone pitching from main gate to fish hatchery and renovation of various laboratories viz, plastering, replacement of door, windows and flooring.
- Providing temporary shed for yard experiments in the rear side of LRT section in shrimp hatchery, repair of existing wall and flooring on the eastern side of mud crab hatchery, construction of earthen pond for fish brood stock of FCD, adjoining the fish hatchery and between the Cobia and ETP pond, work on false ceiling and epoxy paint to spawning tanks of FCD and construction of semi-permanent shed for yard experiments of environment unit.

Kakdwip Research Centre of CIBA, Kakdwip

- Construction work of Type-IV qtrs-3 Nos., boundary wall/PVC coated chain link fencing and security cabin for sector-C and renovation/painting of boundary walls & replacement of old barbed wire fencing in sector A & B.
- Construction of wet lab and other laboratories and renovation of Type - I quarters (12 Nos), Type -II quarters (4 Nos), Type-III quarters (8 Nos) and Type- IV quarters (1 no).

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Library, Information and Documentation

Library Holdings

The CIBA Library procured 40 new books during the period. Subscriptions to 22 Foreign Journals and 33 Indian Journals for the Headquarters and 29 Indian Journals for KRC of CIBA library were also renewed. The Library presently holds 2340 books, 1580 bound journals, 700 reprints and photocopies, 2250 Reports/Bulletins and 4550 miscellaneous publications.

Exchange services

The Library maintained exchange relationship with National and International Organizations working on fisheries and aquaculture on mutual interest. It also maintains the free mailing of Institute's Annual Report and other institute publications to various research organizations, universities and other agencies.

Information services

The CIBA Library provided access to the reference books and journals to the scientific personnel of other research organizations, academicians, university/ college students, research scholars, stakeholders and other related visitors.

On line access to CeRA journals

Library has established online connectivity for the Consortium for electronic Resources in Agriculture (CeRA) journals subscribed by the National Agricultural Innovation project (NAIP) at headquarters and KRC**.**

Document Delivery Service

The library section supplied the photocopies of journal articles requested from various ICAR institutes, scientists and research scholars under CeRA - Document Delivery Request (DDR).

Other services

The library provides reprographic service to users.The reports, special publications and newsletters of international fisheries and aquaculture coordination agencies like NACA, FAO etc. are available in electronic form for reference.

Utilization of funds

During this year a total of ₹20.00 lakhs under plan funds and ₹1.00 lakh under Institute Technology Management Unit (ITMU) budget were utilized towards the renewal of subscription to journals and procurement of new books for Head quarters and KRC library of CIBA.