Annual Report 2012-13

Central Institute of Brackishwater Aquaculture

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Frontcover

A proud SHG beneficiary showcasing the crabs reared by her

SHG women preparing farm-made aqua feed

Backcover

SHG women displaying farm-made aqua feeds developed by them

SHG women cleaning hapas during seabass fish rearing

वार्षिक प्रतिवेदन
Annual Report

2012-13

केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान

(भाकृअनुप/ICAR)

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Preface

It goes to the credit of shrimp farmers that the culture of *Litopenaeus vannamei* has been impressive and sustained quite well. This could be attributed to the fact that Better Management Practices and measures aiding sustained production have been followed meticulously. We hope that production is sustained in a manner that shrimp farmers can get maximum profit from shrimp farming. The initial leap in vannamei shrimp production could be a reflection of their performance in an environment that was never tested before. CIBA has widened the horizon of research by including different aspects of vannamei culture. In addition to surveys of farms culturing vannamei carried out by our Scientists, a culture trial with two different stocking densities was experimented at our Kakdwip Research Centre and the results are encouraging. The entire culture was carried out as per the guidelines issued by the Coastal Aquaculture Authority. Vannamei culture needs to be sustained and this is possible only by the active participation of all the stakeholders. We are proud to inform that the stakeholders are in constant touch with us and we shall not be found wanting in this partnership. CIBA has increased the surveillance and monitoring of diseases and environment as we need to be extremely vigilant regarding the appearance of disease causing bacteria/viruses. It is with this aim that CIBA is already monitoring the efficiency of discharge water treatment system from farms culturing vannamei in particular. I take pride in the fact that banana shrimp culture introduced to our clientele in Gujarat has shaped up well. This has been possible due to the unstinting support of the Navsari Agricultural University, Gujarat. I hope this collaboration blossoms into long-term partnerships wherein the brackishwater aquaculture needs of Gujarat can be addressed very effectively. I congratulate the team of Scientists who have put in considerable efforts to ensure that brackishwater aquaculture in Gujarat gains momentum. I need not overemphasize the output given by the jewel in our crown: Kakdwip Research Centre. The Scientists under very trying circumstances have risen to the occasion and delivered exceedingly well. I am very happy to have such a research centre which we can always bank upon for our on-farm trials. There has been commendable progress on research related to Asian seabass, Cobia and pearlspot. Our Scientists have demonstrated the potential of Asian seabass culture in farmers' ponds. Similarly, work is being focussed on pearlspot culture which has a huge potential in Kerala. We have also initiated work on the Indian White shrimp *Fenneropenaeus indicus* by producing families, tagging juveniles and rearing them communally to comprehend genetic parameters. Our collaboration with the Norwegian Research Council has paid rich dividends and I am proud to inform that this international venture has resulted in the construction of a linkage map with Single Nucleotide Polymorphism (SNP) markers in tiger shrimp for the first time globally and a chip with 6000 SNPs has been fabricated which would prove very

useful for future genetic studies in tiger shrimp. Most of this would not have been possible but for the active support of NAIP, NFDB and DBT funded projects which have enabled us to recruit young researchers to pursue their doctoral programmes. There are several exciting results that have emerged this year and one could have a look at them by going through this Annual Report.

Our Institute is very fortunate to have the untiring support and continuous encouragement of our Secretary, DARE & Director General of ICAR, Dr. S Ayyappan who is a source of inspiration for all of us. We are very thankful to Dr. (Ms) B. Meenakumari, Deputy Director General (Fisheries), Dr. Madan Mohan, Assistant Director General and the Fisheries Division of ICAR for rendering all support. The sagacious advice and directions of Dr. S.D.Tripathi, Chairman of the Research Advisory Committee (RAC) alongwith the other RAC members have aided in honing the skills of CIBA to keep our aim focussed. We share a deep sense of gratitude to all our stakeholders who have been very frank and constructive in their opinion and these have helped us to address the issues in a very industry-friendly manner. Let me express my sincere thanks and great appreciation to the entire CIBA family which has risen to the occasion by their sincerity, dedication, long working hours and excellent team work of Scientists, Technicians, Administrative, Finance & Skilled Support Staff. The progress of this Institution has been made possible by this team work which I value the most and hope that it would further strengthen in the years to come.

A. G. Ponniah
Director

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कार्यकारी सारांश

पर्यावरणानुकूल और लागत–प्रभावी प्रौद्योगिकियाँ

- भारतीय सफेद झींगों पर जैव–लॉक ट्रायलों में कार्बोहाइड्रेट रहित 45: प्रोटीन योजकों की तुलना में कार्बोहाईड्रेट युक्त 35: प्रोटीन डायट योजकों (चावल और कॉर्न आटा) में बेहतरीन कार्य–निष्पादन दर्शाता है। टायगर झींगे के तीन स्तर नेट–आधारित पेरीफाइटन नर्सरी पालन में अधिक वृद्धि, जीवंतता, प्रतिरक्षा पाया गया है।

- लैक्टोबैसिलस रैम्नोसोनस, बैसिलस सबटिलिस, ऐन्टरोकॉकस फेसियम, सैकरोमईसस प्रोबयॉण्टों के कार्यों की प्रक्रिया की जांच–पड़तालों से किशोर टायगर झींगों में स्ट्रेन–विशिष्ट जैव–उपचारी और प्रतिरक्षा–अधिमिश्रण प्रतिक्रिया स्पष्ट हुआ है।

- गरमियों में बोयाना होनेवाले केंकड़ों की तुलना में शरद में तथा शरद मौसम पश्चात् बोयाना होनेवाले केंकड़ों ने अधिक शारीरिक वज़न दर्शाया है। बोयाना की बारंबारता शरद और शरद पश्चात् (दिसंबर से अप्रैल) में लगभग दुगुना था, जबकि गरमियों (जुलाई) में अव्यक्त अवधि न्यूनतम पाया गया। आगे, जोया की संख्या कारेपेस चौड़ाई (शारीरिक वज़न) के साथ सह–संबंध सकारात्मक पाया गया।

- सिल्ला सेर्रेटा के एकल–लिंग और मिश्रित लिंग पालन के अंतर्गत, एकल–लिंग नर और मादा संख्याओं में कायिक जननग्रंथि सूचिका बहुत अधिक पाई गई तथा मिश्रित संख्या पालन में पाले गए 1:1 तथा 2:1 नर अनुपात संख्या में बहुत कम पाया गया। एकल–लिंग नर संख्याओं में शारीरि वज़न के संदर्भ में किलेट लेग की प्रतिशतता बहुत अधिक थी और मिश्रित मादा संख्याओं में बहुत ही कम थी। एकल–लिंग मादा संख्याओं में बहुत अधिक और नर पालनों में बहुत कम जीवंतता पाई गई।

- मत्स्य/झींगा बहु–खेती के अंतर्गत इष्टतम स्तर की फीडिंग बारंबारता निर्धारित करने के लिए लीज़ा पारसिया, एल. टाडे, मुगिल सिफेलस, स्केटोफेगस अर्गस, मईस्टस गुलियो और पेनियस मॉनोडॉन प्रजातियों को विभिन्न बारंबारता स्तरों पर सीबा द्वारा विकसित कम लागत की फीड दी गई। दो सौ दस दिनों के पालन में यह पाया गया की तीन बार प्रतिदिन आहार खिलाने से शारीरिक वज़न में बहुत अधिक बढ़ोतरी देखाी जाती है।

- पश्चिमी बंगाल में काक्द्वीप अनुसंधान केन्द्र में किए गए लिटोपेयनस वान्नमेई के प्रथम वैज्ञानिक खेत–प्रयोग चलाए गए तथा किसी भी प्रकार के वाणिज्यिक प्रोबयॉटिक/धात्विक अनुपूरकों के प्रयोग के बिना एक ही फसल में 3.53 टन झींगों का उत्पादन प्राप्त हुआ है।

- प्रतिमाह स्तर पर वान्नमई खेती पर पर्यावरणीय अनुवीक्षण कार्यक्रम (ईएमपी) के अंतर्गत कुल N तथा कुल अमोनिया N अन्य जलकृषि तालाबों में कुल N अमोनिया मानक सीमा से अधिक था। तथापि, जलाशय में सभी नमूने स्थलों में उनकी सान्द्रता तटवर्तीय जलजीव पालन प्राधिकरण द्वारा निर्धारित मानक मूल्यों के अंदर पाया गया।

- वान्नमई की कम लवन स्तर जलकृषि में अपनाए जानेवाले सामान्य पद्धतियों का दस्तावेज़ीकरण किया गया है और उसमें तालाब तैयारी के दौरान जोताई नही की जाती है तथा 70 दिन पालन पर आंशिक फसल और अंत में 100–110 दिनों के सामान्य पद्धतियों में 4–5 t/ha औसत उत्पादन के साथ छोटे आकार (20 ग्राम) के झींगों का उत्पादन प्राप्त हुआ है।

2. बृहत् स्वास्थ्य प्रबंधन

- झींगा तालाब अवसादों में सफेद दाग लक्षण के वायरस (WSSV) की जीवंतता के मूल्यांकन से यह स्पष्ट हुआ कि ड्रेन किए जानेवाले तालाबों को घूप में सुखाने के बावजूद भी तालाब अवसादों में वायरस का भारी लोड 19 दिनों तक के लिए रोगजनक सिद्ध हुआ, जबकि ड्रेन नहीं किए जानेवाले तालाबों में 35 दिनों तक रोगजनक सिद्ध हुआ। इन प्रायोगिक अन्वेषणों के आधार पर यह सिद्ध होता है कि फसलों के बीच में तालाबों को सुखाने की बेहतरीन प्रबंधन पद्धतियों में परिवर्तन किया जाना आवश्यक है तथा WSSV की जांच–पड़ताल को एक अतिरिक्त जैव–सुरक्षा उपाय के रूप में शामिल किया जाना है।

- समुद्री बृहत् शैवाल काप्पाफईकस अल्वारेज़ि से बैसिल्लस मयोकोइडस और बी. मेगाट्राइकम जैसे दो बैसिल्लस स्ट्रेनों को जलकृषि व्यवस्थाओं में वि.हार्वेई जैव–दमन एजेन्टों के रूप में प्रयोग किया जा सकता है।

- वान्नमई जलकृषि में झींगों की जीवंतता में सामान्य वितरण की प्रवत्रत्ति तथा विभिन्न विब्रियोस की भूमिका से यह स्पष्ट होता है कि रोगजनक विब्रियो का वायरल दूषण की अनुपस्थिति में एक महत्त्वपूर्ण भूमिका है, जबकि वायरल दूषण अवधियों के दौरान वायरल रोगजनकों के साथ में कम रोगजनक प्रजातियां अत्यधिक मात्रा में थीं और इस मात्रा का झींगा जीवंतता की वृद्धि करने में एक महत्त्वपूर्ण भूमिका निभाई थी।

- बीस से बासठ दिन पालन के पश्चात एल. वान्नमइ की जीवंतता के छह मामलों का OIE प्रोटोकॉलों का प्रयोग करते हुए जांच–पड़ताल में WSSV, MBV, HPV और IHHNV का अनुवीक्षण करते समय यह पता चला कि पांच खेतों में WSSV दूषण (इन पांच तालाबों में से एक में IHHNV के साथ सह–दूषण था) मौजूद था जबकि इनमें अन्य असाधारण वायरस के लिए नकारात्मक परिणाम प्राप्त हुए।

- तमिलनाडु और आन्ध्र प्रदेश के वान्नमइ हैचरियों और तालाबों में सभी OIE (WSSV, IHHNV, YHV, TSV और IMNV) सूचित वायरल रोगजनकों से होनेवाले रोग की उपस्थिति का अनुवीक्षण किया गया। झींगों की निकटतम जीवंतता AHPNS की तुलना में WSSV को कारण माना गया तथा इस संबंध में कृषि मंत्रालय को रिपोर्ट के साथ किसानों का सलाह भी भेजी गई है।

- दो तापमानों में ऐशियाई सीबॉस किशोरों पर पूर्ण–कोशिका ताप–मृत नोडा वैक्सीन के टीका देने पर यह पता चला कि निम्न तापमानों में अधिक क्षमता है और दोनों तापमानों में जींवतता में काफी सुधार देखी जाती है। टीका प्रदत्त मत्स्यों के थईमस तथा किड्नी में प्रतिरक्षा जीनों की अभिव्यक्ति अधिक देखा जाता है। टीका प्रदत्त मत्स्यों में ऑक्सीकारक ऐन्ज़ाइम क्रियाकलापों में वृद्धि रक्षा व्यवस्था में सुधार को बताता है।

3 तेज़ गति की वृद्धि, रोग प्रतिरोध में बढ़ोतरी तथा सरल परिपक्वता

- निम्न और उच्च लवणता दबाव के अंतर्गत टायगर झींगों के एसएसएच निधियों में दोनों में Acyl-CoA बाइंण्डिंग प्रोटीन (ACBP) भिन्न रूप में अभिव्यक्त जीन में विभिन्न ऊतकों में उत्कर्षित अभिव्यक्ति स्तर दर्शाए गए, जिससे लवणता दबाव के प्रति सहन और रूपांतरण में प्रकार्यात्मक भूमिका के सुधार का सुझाव मिलता है।

- टायगर झींगों में वृद्धि की प्रवृत्तियों के लिए मार्करों का विकास करने हेतु SNP का लिपिड स्टोरेज ड्रॉपलेट प्रोटीन जीन में हिनसेल्ल ऐन्ज़ाइम तथा सैपोसिन आइसोफॉर्म में Bpu101 ऐन्ज़ाइम का प्रयोग करते हुए किसानों के झींगा नमूनों में जीनोटाइप किए जाने पर नमूनों ने मॉनोमॉर्फिज़म दर्शाया है।

- सीबा चेन्नई में तैयार किए गए पी. मॉनोडॉन जीन क्रमों के साथ NCBI EST और न्यूक्लियोटाइड डेटाबेस का प्रयोग करते हुए टायगर झींगा जीन अभिव्यक्ति अध्ययनों के लिए एक ऐजिलेन्ट माइक्रोअरे स्लाईड (8 x 60 k) की रीतिबद्ध डिज़ाइन बनाई गई थी। चिप में WSSV दूषण के विरोध में विभिन्न प्रकार से 42,013 अभिव्यक्त जीन का क्रम प्राप्त किया जा सकता है।

- मादा टायगर जीन के विभिन्न परिपक्वता स्तरों में ऑप्टिक लोब, मस्तिष्क और थोरेसिक गैंगोलियन में ट्रांसस्क्रिप्टों की अभिव्यक्ति का अध्ययन किया गया तथा इस अध्ययन में अन्य पेनेइडों के जैसे परिपक्वता पर नकारात्मक नियंत्रण निश्चित किया जाता है। तीन आण्विक ट्रांसस्क्रिप्टों (विटेल्लोजन रिसेप्टर, थ्रॉम्बोस्पोंडिन और हीट शॉक प्रोटीन) की अभिव्यक्ति प्रवृत्तियों से स्पष्ट होता है कि विटेल्लोजेनेसिस प्रभावित एफ.इंडीकस में सेरोटिनिन का सकारात्मक प्रभाव पड़ता है।

- मादा टायगर झींगों में हाईड्रॉक्सी प्रोजेस्टेरोन देने से अंतःपात्रीय और अंतर्जीवीय प्रायोगिक अध्ययनों से यह स्पष्ट होता है कि Vg संश्लेषण डिम्बाशयी परिपक्वन पर आधारित हैं और हॉर्मोन परिवर्तनों अप्रभावी होता है जबतक की जलजीव में निहित अंतः स्त्रावी पर्यावरण को सुधार नहीं लिया जाता है।

- विटामिन सी और बीटा ग्लूकन में युक्त स्वस्थ एवं कमज़ोर मादा (उनके प्रतिरक्षा प्राचलों के आधार पर) झींगों में प्रतिरक्षा–मॉड्यूलन से यह स्पष्ट होता है कि पूर्व उर्द्धृत झींगा प्रतिरक्षा को प्रभावित कर सकता है जिससे उन्हें विटामिन दिए जाने की तुलना में इसमें उनकी प्रजनन क्षमता बेहतर होते पाई जाती है। तथापि, उनके प्रस्फुटन और जीवंतता के संदर्भ में वे स्वस्थ ब्रूडस्टॉक के रूप में साबित हुए हैं।

- भारतीय सफेद नर झींगा के शुक्राणु लक्षणों पर तथा मादा झींगा परिपक्वन में संविरचित फीड और ताज़े (क्लैम और स्क्विड) फीड के प्रभाव के अध्ययन से स्पष्ट हुआ कि पुरुष को 100% संविरचित फीड दिए जाने पर उनके शुक्राणु लक्षणों पर प्रभाव पड़ा है और मादाओं को दोनों फीड दिए जाने पर उनके प्रजनन क्षमताओं पर कोई प्रतिकूल प्रभाव नहीं पड़ा।

4 प्रजातियों और व्यवस्थाओं का वैविध्यीकरण एवं प्रोत्साहन

- छोटे नेट घेरों में पर्लस्पॉट प्रजनन के सीड उत्पादन के दस ट्रायलों से 200–300 फिंगरलिंगों का प्रति घेरे उत्पादन देखा जाता है। नर –मादा मत्स्यों को अण्डों से निकालने से बोयाना के बीच की अवधि में कमी हुआ और 15 दिनों की अवधि में जोड़ा बोयाना केलिए सक्षम हो गया इससे बोयाना जोड़ा से अधिक शावकों को प्राप्त करने की संभाव्यता देखी जाती है।

- सूखा फीड पेलेट और अर्द्ध–नमी युक्त आटे, दोनों में बाइंडर शामिल किए जाने के प्रयोगों से पता चला कि पूर्व उद्धृत में अच्छी वृद्धि देखी जाती है और वह सबसे वरीय माना गया। पर्लस्पॉट की प्रजनन क्षमता में सुधार करने के लिए फीड में खाद्य पदार्थ लिपिड स्तर को अनुकूल बनाने के लिए यह प्रायोगिक स्तर से साबित किया गया कि 12 और 15% खाद्य पदार्थीय लिपिड स्तर त्वरित परिपक्वन पैदा करने के लिए सही सिद्ध हो सकता है।

- काक्द्वीप में 325 दिन के बाद ऐशियाई सीबॉस पालन में खेत–उत्पादित फीड का प्रयोग करते हुए 2768.34 Kg/ha की उत्पादकता के साथ 69% जीवंतता युक्त 799 ग्राम के औसत शारीरिक वज़न और 1.76 FCR प्राप्त हुआ है। फिंगरलिंगों के कार्य को प्रभावित किए बिना किण्वित सामग्रियों से मत्स्य मील में 30% भाग प्रतिस्थापित किया जा सकता है।

- टायगर झींगे में वसा अम्ल प्रोफाइलों के मूल्यांकन से यह पता चला कि जलकृषि झींगों के खाद्य भागों में 1.34–1.54% की श्रेणी में कुल लिपिड प्राप्त हुए, जबकि वान्नमेई में वह 1.11% था।

- कोबिया का उर्वरीकरण एकल केस में 75% सफलतापूर्वक पाला गया, जिसका प्रस्फुटन दर 60% था। पच्चीस दिनों की अवधि में इल्लियों की जीवंतता 25% पाई गई और फिंगरलिंग 72% जीवंतता के साथ किशोर स्तर तक पहुंच गए। आन्ध्र प्रदेश में एक किसान के तालाबों में पांच महीनों के ग्रो–आउट जलकृषि से 1.000 से 1.250 किलोग्राम वज़न के मत्स्य प्राप्त हुए।

- ग्रामीण जनजीवन में घरेलू उत्पादन व्यवस्था के प्रभाव, उसका योगदान और उत्पादकता स्रोत निर्धारित करने के लिए दक्षिणी 24 परगणा जिले के सागर, काक्द्वीप और नामखाना जैसे तीन तटवर्तीय ब्लॉकों में घरेलू उत्पादन व्यवस्था के घरेलू सर्वेक्षण से यह पता चला कि घरेलू भूमि का ज़्यादातर भाग तालाब जलकृषि के लिए आबंटित किया जाता है ओर उसमें उत्पादकता 1400 kg/ha है।

5 नीति एवं योजना को समर्थन देने के लिए सामाजिक–आर्थिकी एवं आर्थिकी विश्लेषण

- एक जनजाति गांव में चेनोस चेनोस, मुगिल सिफालस, एट्रोप्लस सुराटेन्सिस, लिज़ा पार्सिया एवं पेनेयिस मॉनोडॉन जैसे संयुक्त प्रजातियों का प्रशिक्षण–सह–जागरूकता कार्यक्रम एवं प्रायोगिक बहु–खेती आयोजित किया गया।

- सीबा जनजाति उप–योजना के अंतर्गत, जनजातीय महिला स्वयम सेवक संगठनों के लिए एक मश्रूम खेती यूनिट, खारापानी श्रृंगारिक मत्स्य (स्पोटेड स्केट) पालन, खेती–उत्पादित मत्स्य फीडों का निरूपण और हापास में ऐशियाई सीबॉस के नर्सरी रियरिंग के बारे में जानकारी दी गई।

- गुजरात के पाथरी गांव, नवसरी के जनजातीय किसानों की संपूर्ण आवश्यकताओं के निर्धारणों के आधार पर बनाना झींगा के अतुल्यात्मक ई–शिक्षण मॉड्यूल : निम्न ताप तटवर्ती प्रदेशों में एक सक्षम वैविध्यपूर्ण प्रजातियों की जलकृषि का विकास किया गया।

- झींगा वैविध्यीकरण में विस्तार पद्धतियों के लिए तमिलनाडु, केरल, गुजरात और आन्ध्र प्रदेश के मात्स्यकी विभागों के अधिकारियों से जानकारी प्राप्त की गई ताकि उनकी जानकारी आवश्यकताओं का निर्धारण किया जा सके।

- तमिलनाडु, आन्ध्र प्रदेश, उड़ीशा और पश्चिमी बंगाल के मास्यकी विभागों के अधिकारियों को वन्नमई जलकृषि से संबंधित एक अल्प संदेश सेवा (एसएमएस) प्रदान की गई।

- झींगा किसानों से दल पद्धति के अंतर्गत प्रभावी–मध्यम–कमज़ोर के विभिन्न स्तरों पर दल प्रकार्यों के तीन केस अध्ययन किए गए तथा सफल दलों द्वारा अपनाई गई पद्धतियां सामने आईं।

- पश्चिम बंगाल, आन्ध्र प्रदेश, तमिलनाडु और केरल, इन चार तटवर्ती प्रदेशों में एक जिले में पूर्व विकसित पद्धति तथा विस्तार किसानों के डेटा विश्लेषण किया गया और यह पाया गया कि मौसमी भिन्नताओं के कारण झींगा जलकृषि सामान्य रूप से प्रभावित होता है और बाढ़, भारी वर्षा तथा तूफानों जैसे गंभीर मौसमी परिस्थितियों से अत्यंत प्रभावित होता है।

- मौसमी प्रभाव के समाधान के रूप में किसानों को तकनीकी संस्तुतियां दी गईं और उनपर वैज्ञानिकों द्वारा अनुसंधान किया जाना है तथा आन्ध्र प्रदेश के कृष्णा जिले में किए गए अंतर्विषयी एवं बहु–पणधारी प्रतिभागिता अध्ययन, पेनल बैठकें और प्रचार कार्यशालाओं से प्राप्त जानकारी के आधार पर तीन दस्तावेज़ तैयार किए गए।

- वन्नमई और मॉनोडॉन के साथ की गई वैज्ञानिक झींगा पालन की तुलना में परंपरागत खेती में ग्रीन हाउस गेस (ग्राम./हे./दिन) का निस्सरण बहुत अधिक पाया गया। टायगर झींगा तालाबों में कि.ग्रा./CO_2 eq/ हे. प्रति मौसम वैश्विक स्तर पर गरमी की वृद्धि की क्षमता (GWR) मूल्य 91 था, वन्नमई तालाबों में 218 से 351 के बीच था और पोक्काली झींगा खेती में 405 था। स्टॉकिंग सघनता में बढ़ोतरी के साथ GWP में भी बढ़ोतरी हो रही है।

- पेदपट्टनम (मछलीपट्टनम जिला, आन्ध्र प्रदेश) में झींगा तालाबों के पुनर्जीवन के लिए प्रतिभागिता ग्रामीण मूल्यांकन (पीआरए) से पता चलता है कि 80–90 प्रतिशत तालाब, वर्ष 2000 से अप्रयुक्त हैं तथा भयंकर झींगा रोग के कारण से अप्रयुक्त हैं।

- आन्ध्र प्रदेश में कृष्णा जिले के जलकृषि विकास के लिए जिला स्तर पर योजना बनाने हेतु विभिन्न पहलुओं पर प्राथमिक सूचना इकत्रित की गई है तथा इसे माध्यमिक स्तर पर स्रोत, वित एवं सरंचनात्मक आवश्यकताओं की जानकारी से समकेत किया गया ताकि दीर्घकालिक स्तर पर जलकृषि का विकास किया जा सके।

- उपग्रह डेटा और जीआईएस का प्रयोग करते हुए उड़ीशा में महानदी, देवी और भिटरकणिका वन्य जीवन (बीडबल्यूएलएस) के मानग्रोव गीली भूमियों पर खारापानी जलकृषि के प्रभाव का अध्ययन किया गया। इस अध्ययन से यह स्पष्ट पता चलता है कि जलकृषि उड़ीशा के मानग्रोवों पर आधारित नहीं है, जैसे कि प्रायः ऐसा सोचा जाता था ।

- तमिलनाडु के वेल्लार तटवर्ती जलाशय के झींगा खेती पर जल–भू–रसायनिक प्रभावों के अध्ययन से पता चलता है कि तट (क्रीक के दक्षिणी पूर्वी तरफ के पास तथा तट के पास) के उत्तर–पूर्वी तरफ, समुद्री पानी प्रवेश सुभेद्य है।

Executive Summary

1. Environment-friendly and cost-effective technologies

- Bio-floc trials in Indian white shrimp revealed that 35% protein diet with carbohydrate addition (rice and corn flour) showed better performance than that of 45% protein without carbohydrate addition. Periphyton-based nursery rearing showed significantly higher growth, survival and immunity of tiger shrimp in three tier net-based substrate system.

- Investigations on the mechanism of action of different strains of probionts like *Lactobacillus rhamnosus, Bacillus subtilis, Enterococcous faecium* and *Saccharomyces* sp revealed strain-specific bioremedial and immunomodulatory response in tiger shrimp juveniles.

- The crabs that spawned in winter and post-winter had significantly higher body weight compared to those spawning in summer. The frequency of spawning was almost double in winter and post winter months (December to April), whereas latency period was minimum in summer (July). Further, the number of zoea was positively correlated with carapace width (body weight).

- Under mono sex and mixed sex culture of *Scylla serrata*, gonadosomatic index was highest in monosex male and female populations and lowest in male population grown in mixed sex culture for 1:1 and 2:1. Percentage of chelate leg to body weight was highest in mono sex male followed by mixed sex (2:1), male population and lowest in mixed sex female populations. Highest survival was noticed in mono sex female and lowest in mono sex male culture.

- To determine the optimum feeding frequency under fish/shrimp polyfarming, *Liza parsia , L. tade*, *Mugil cephalus*, *Scatophagus argus*, *Mystus gulio* and *Penaeus monodon* were fed at varying frequencies with low cost feed developed by CIBA. After a DOC of 210 days, it was observed that feeding three times a day resulted in highest weight gain.

- The first scientific on-farm trial of *Litopenaeus vannamei* in West Bengal was carried out at Kakdwip Research Centre and a production of 3.53 tonnes of shrimp in a single crop was recorded without the use of any commercial probiotics/mineral supplement.

- Environmental monitoring programme (EMP) of vannamei farming on a monthly basis, revealed that total ammonia N and total N from few culture farms were above the standard limit. However, their concentration in the water body at all the sampling places was within the standard values prescribed by the Coastal Aquaculture Authority.

- The general practices adopted in low saline farming of vannamei were documented and found to vary from normal practices like no ploughing during pond preparation and partial harvesting at 70 DOC and final harvest at 100-110 days producing small sized (20 g) shrimps with an average productivity of 4-5 t/ha.

2. Comprehensive health management

- Assessment of the longevity of the White Spot Syndrome Virus in shrimp pond sediments revealed that in ponds where WSSV was reported earlier, a heavy load of the virus remained infective in pond sediment despite sun-drying the drainable pond bottom for 19 days whereas in non-drainable ponds, the virus remained infective for 35 days. Based on these findings, better management practices of drying of pond between crops need to be modified and the checking of sediment for WSSV needs to be incorporated as an additional biosecurity measure.

- Two bacillus strains viz. *Bacillus mycoides* and *B. megaterium* extracts from the marine macro algae *Kappaphycus alvarezii* and the marine diatom *Skeletonema costatum* could be used as a bio-inhibitory agents to control luminescence caused by *V. harveyi* in aquaculture systems.

- In vannamei culture, the pattern of general distribution and role of different vibrios in shrimp mortality revealed that pathogenic vibrios played a major role in the absence of viral infection whereas less pathogenic species which were abundant during viral infection in conjunction with viral pathogens had an important role in accelerating shrimp mortality.

- Investigation into six cases of mortality in *L. vannamei* at 20-62 DOC while screening for WSSV, MBV, HPV and IHHNV using OIE protocols, revealed that samples from five farms exhibited WSSV infection (one of these five farms had co-infection with IHHNV), whereas they were negative for other exotic viruses.

- Monitoring of disease occurrence in vannamei hatcheries and farms in Tamil Nadu and Andhra Pradesh for all the OIE listed viral pathogens viz. WSSV, IHHNV, YHV, TSV and IMNV was carried out. The early mortality of shrimps was attributed to WSSV rather than AHPNS and a report sent to the Ministry of Agriculture along with an advisory for farmers.

- Vaccination of whole-cell heat-killed Noda virus vaccine on Asian seabass juveniles at two temperatures revealed higher efficiency at the lower temperature and improved survival at both the temperatures. The expression of immune genes in thymus and head kidney were elevated in vaccinated fish. Elevated enzyme activity in the vaccinated fish indicated improvement of antioxidant defence system.

3. Faster growth, increased disease resistance and easy maturation

- Acyl-CoA binding protein (ACBP), one of the differentially expressed genes in both the SSH libraries of tiger shrimp under low and high salinity stress showed significantly elevated expression levels in various tissues suggesting a functional role in salinity stress tolerance and adaptation.

- Association studies to unravel markers for growth traits in tiger shrimp revealed that one SNP in lipid storage droplet protein gene using HincII enzyme and another in saposin isoform I gene using Bpu 101 enzyme when genotyped in shrimp samples collected from farmers' ponds at harvest, exhibited monomorphism.

- An Agilent microarray slide (8 x 60k) was custom-designed for tiger shrimp gene expression studies using the NCBI EST and nucleotide database including *P. monodon* gene sequences generated at CIBA, Chennai. A total of 42,013 sequences find place in the chip for identification of differentially expressed genes against WSSV infection.

- Expression of GIH transcripts in optic lobes, brain and thoracic ganglion of female tiger shrimp at different stages of maturation was studied and it confirms the negative control on maturation as in other penaeids. Expression pattern of three molecular transcripts (vitellogenin receptor, thrombospondin and heat shock protein) revealed that serotonin positively influenced vitellogenesis in *F. indicus.*

- *In vivo* and *in vitro* experiments through administration of 17 α-hydroxy progesterone in female tiger shrimp revealed that Vg synthesis depends upon stage of ovarian maturation and hormonal manipulations are ineffective until the proper endocrine environment is established in the animal.

- Immunomodulation of healthy and weak mother shrimp (categorised by their immune parameters) with vitamin C and beta glucan indicated that the latter can influence shrimp immunity by improving the reproductive performance than when only vitamins are given. However, it could not improve the offspring quality of the weak mother shrimp in terms of their hatching and survival which was relatively better in the healthy broodstock.

- The effect of formulated feed and fresh (clam and squid) feed on spermatological characteristics of males and on maturation of female Indian white shrimp revealed that 100 % formulated feed did not adversely affect the spermatological characteristics of the males whereas the reproductive performance of the females was not affected when either of the feeds was provided.

4. Diversification & promotion of species and systems

- Pearlspot breeding in small net cages validated through ten trials of seed production revealed a per cage production of 200-300 fingerlings (5-7g) within 2 to 2.5 months. The removal of eggs from the parent fishes was found to reduce the intermittent spawning period and the pair spawned again within a period of 15 days indicating the possibility of obtaining more offspring from a potential spawning pair.

- An experiment on pearlspot fish with dry feed pellets and semi-moist dough with inclusion of binder in both, revealed that the latter was the preferred choice with good growth. To optimise the dietary lipid level in feed for improving the reproductive performance of pearlspot, it was experimentally proven that dietary lipid levels of 12 and 15 % could be optimal for inducing quick maturation.

- Using farm-made feed for Asian seabass culture in a farmer's pond near Kakdwip, an average body weight of 799 g with a survival of 69 % and FCR of 1.76 was obtained after 325 DOC with a productivity of 2768 kg/ha. Fermented ingredients could replace 30 % fish meal in farm-made feed without affecting the performance of the fingerlings.

- Evaluation of fatty acid profiles in tiger shrimp revealed that total lipid ranges from 1.35-1.54 % in the edible portions of cultured shrimp whereas in vannamei it was 1.11%.

- Cobia was successfully bred resulting in a single case of fertilisation (75%) with hatching rate of 60%. Over a period of 25 days, the larval survival was 25% and the fingerlings reached the juvenile stage with a survival of 72%. Five months of grow-out culture in a farmer's pond in Andhra Pradesh yielded fish weighing 1.000 to 1.250 kg.

- A household survey on Homestead Production system carried out in three coastal blocks of South 24 Parganas district viz. Sagar, Kakdwip and Namkhana to assess the contribution and impact of homestead production system in rural livelihood and also to comprehend the resource productivity revealed that a major portion of homestead land is allotted for pond aquaculture with a productivity of 1400 kg/ha.

5. Socio-economic & environment analysis for support to policy and planning

- A training-cum-awareness program and experimental polyfarming with species in combination such as *Chanos chanos, Mugil cephalus, Etroplus suratensis, Liza parsia* and *Penaeus monodon* was taken up in a tribal village.

- Under the CIBA Tribal Sub Plan, a mushroom farming unit, brackishwater ornamental fish (spotted scat) culture, demonstration of farm-made fish feeds and nursery rearing of Asian seabass in hapas were taken up with tribal women SHGs.

- Based on the assessment of the overall needs of the tribal farmers of Pathri village, Navsari, Gujarat, an asynchronous e-Learning module on banana shrimp viz. Banana shrimp: A potential diversified species for culture in low temperature coastal areas, was developed.

- For extension approaches in shrimp diversification, information from officials of the Department of Fisheries from Tamil Nadu, Kerala, Gujarat and Andhra Pradesh were collected to assess the information needs.

- A short message service (SMS) relating to *L.vannamei* culture was disseminated to the State Department of Fisheries officials of Tamil Nadu, Andhra Pradesh, Odisha and West Bengal.

- Under the group approach among shrimp farmers, three case studies of groups functioning at different levels i.e effective-moderate-poor revealed what the successful group adopted.

- Based on an earlier developed methodology and data analysis of extensive farmers' survey in one district each in four coastal states viz. West Bengal, Andhra Pradesh, Tamil Nadu and Kerala, shrimp aquaculture was found to be moderately vulnerable to seasonal variations and extremely vulnerable to severe climatic events like flood, heavy rains and cyclone.

- Technical recommendations for farmers to mitigate climate change impacts, researchable areas to be addressed by Scientists and policy recommendations have been brought out as three documents, based on the inputs from the interdisciplinary and multi-stakeholder participatory study conducted in Krishna District, panel meetings and dissemination workshops.

- Average emission of GHGs in g $ha^{-1}day^{-1}$ was high in traditional farming compared to scientific shrimp farming with vannamei and monodon. Global warming potential (GWP) values in kg CO_2 eq./ha/season were 91 in tiger shrimp farm, 218 to 351 in vannamei farms and 405 in Pokkali shrimp farm, the GWP being directly proportional to the stocking density.

- Participatory Rural Appraisal (PRA) for revival of shrimp ponds in disuse in Pedapattnam (Machilipatnam District, AP) revealed that 80-90 % ponds were left unused in the year 2000 and are still not in use due to severe attack of shrimp diseases.

- For District level planning of aquaculture development in Krishna district of Andhra Pradesh, primary information on various aspects was collected and integrated with secondary information on resources, financial and infrastructure requirement to develop aquaculture in a sustainable manner.

- The impact of brackishwater aquaculture development on three mangrove wetlands of Mahanadi, Devi mouth and Bhitarkanika Wild Life Sanctuary (BWLS) in Odisha were studied using satellite data and GIS. This study makes it clear that the development of aquaculture is not at the expense of mangroves in Odisha as is often perceived.

- Hydro-geochemical impacts of shrimp farming on coastal watershed of lower Vellar watershed in Tamil Nadu revealed that the North East side of coast (near to coast and near to the South East side of the creek) is highly vulnerable to seawater intrusion.

3

Introduction

Brackishwater aquaculture covers an approximate area of 1,25,000 ha, or 43% of the total aquaculture area and approximately equals 75% of the area under freshwater aquaculture. India is endowed with 1.2 million ha brackishwater area for development of aquaculture. About 91% of the shrimp farmers in our country have a holding of less than 2 ha, 6 % between 2 to 5 ha and only 3% have > 5 ha. If brackishwater aquaculture has to be sustained, environment friendly and cost-effective culture technologies by all strata of farmers have to be adopted. Development and adoption of bio-secure farm practices, access to institutional credit, development of necessary linkages, infrastructure and favourable legislations and policies are some of the major issues that need to be addressed to promote sustainable brackishwater aquaculture. Some of the important species for brackishwater aquaculture are shrimp, finfishes and crabs. In addition to Asian seabass, the other finfishes gaining popularity are pearlspot, cobia and grey mullet. The introduction of specific pathogen free Pacific White shrimp into India in a limited way has substantially changed the shrimp culture scenario in India.

With the introduction of *Litopenaeus vannamei*, there exists major issues regarding shrimp farm management and the environment especially with regard to stocking density, feed, water management and their role in determining the carrying capacity of the system. It is pertinent to note here that Better Management Practices (BMPs) are vital for effective farm management leading to sustainable production. The Central Institute of Brackishwater Aquaculture (CIBA) is sedulously working on these cardinal principles for sustained shrimp farming and systematic 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 and a Research Centre at Kakdwip in West Bengal. The Institute has a Director, 43 Scientists, 26 Technical, 25 Administrative and 37 Supporting staff as on 31.03.2013**.**

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 service

Organizational set-up

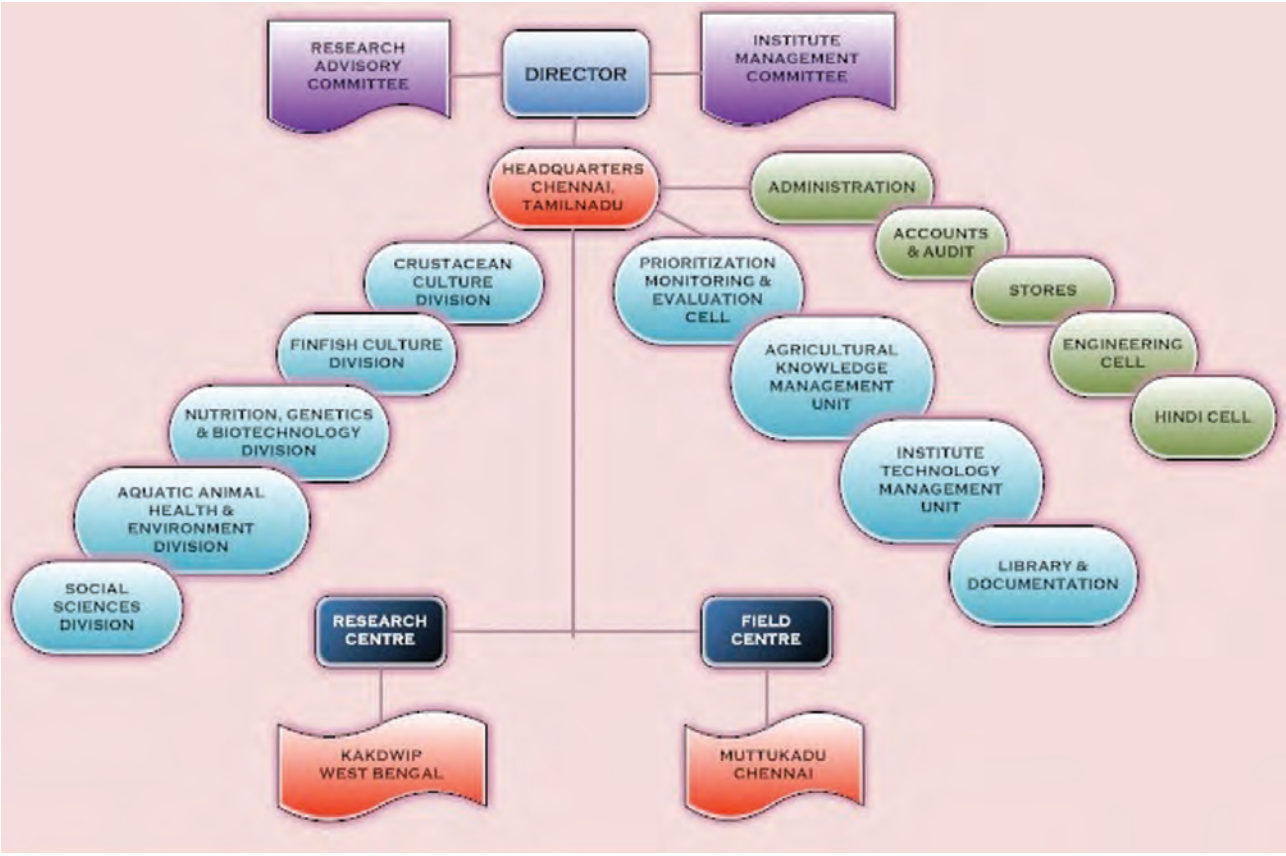
The research activities of the Institute are carried out under five Divisions, *viz*.,

- Crustacean Culture Division

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

The research activities of the Institute were diverse in nature, starting from basic research to applied and adoptive research which was carried out under 12 in-house and 32 externally funded projects during 2012-13.

ORGANISATION CHART



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Financial Statement 2012-13

(₹ in lakhs)

Sub-Head	BE	RE	Actual Expenditure
Plan			
Travelling Expenses	30.00	30.00	29.96
HRD	50.00	7.00	7.00
Contingency	470.00	310.00	309.98
Works	100.00	100.00	100.0
Equipments	150.00	100.00	99.97
Information Technology	50.00	50.00	50.00
Miscellaneous expenses	30.00	8.00	8.00
Library	30.00	30.00	30.00
Furniture & Fixtures	70.00	40.00	40.00
TSP	20.00	15.00	15.00
Total	**1000.00**	**690.00**	**689.90**
Non-Plan			
Establishment	952.00	981.81	981.81
O.T.A	0.20	0.20	0.14
Travelling Allowance	8.00	7.20	7.20
Research & Operational	20.00	18	18.00
Administrative Expenses	135.00	118.68	118.67
Miscellaneous	0.00	0	0
Sub Total	**1115.20**	**1125.89**	**1125.82**
Pension	220.00	568	401.73
Loans & Advances	7.00	7	2.28
Total	**1342.20**	**1700.89**	**1529.83**

Revenue generation

(₹ in lakhs)

Year	Target	Achievement
2012-13	**28.00**	**31.10**

Official Language Implementation Programme

Official Language Implementation Committee meetings were held quarterly during the year 2012-13. Usage of Hindi in official correspondences, bilingual use of Hindi and English in files and publications in Hindi were reviewed in these meetings. Hindi Pakhwada (Fortnight) was celebrated at the Headquarters, CIBA during the second fortnight of September 2012. As part of celebrations, various competitions in Hindi Kavita Path, Hindi Samachar, Hindi Prashnothari (Team and individual events) were held with Hindi Diwas being celebrated on 28.9.2012. Prizes were distributed to the winners by the Director, CIBA. A guest lecture on Official Language Implementation was delivered by a Hindi expert during the event. Hindi Diwas was held on 27.9.2012 at KRC of CIBA, Kakdwip. Hindi quiz, essay, recitation and singing competitions were held and the winners were awarded prizes by the OIC, KRC of CIBA, Kakdwip, a guest lecture being held during the event.

STAFF POSITION

The details of sanctioned, filled and vacant positions as on 31.03.2013 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	26	5
A.O.	1	1	-
F.A.O	1	1	-
DD(OL)	1	0	1
A.A.O	3	3	-
J.A.O.	1	1	-
Private Secretary	1	1	-
P.A.	2	2	-
Stenographer Gr. III	1	2	(-)1 (excess)
Assistant	7	6	1
U.D.C.	3	3	-
L.D.C.	5	5	-
Skilled Support Staff	55	42	13
TOTAL	**180**	**140**	**40**

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

Formulated and fresh feed ratio on male and female maturation in Indian white shrimp

Initial and final spermatological characteristics were evaluated in three ratios of formulated and fresh feed: 100 % fresh feed (clam+squid), 100 % formulated feed developed by CIBA and formulated feed with fresh feed (each 50 %) in a 21-day experiment. The spermatological characteristics of spermatophore weight (g), sperm count (x 10^6) and live sperm (%) were not significantly different among treatments ($P>0.05$). None of the animals showed melanization and there was no significant difference in molting frequencies. It could be inferred that provision of 100 % formulated feed did not adversely affect the spermatological characteristics.

A similar experiment was carried out to evaluate the effect of formulated diet on maturation and spawning of female *F. indicus* using two treatments: 100 % fresh feed (clam + squid) and fresh feed (clam) along with formulated feed (50 % each). Reproductive performance of unilaterally eyestalk ablated females in both treatments was similar with regard to the percentage of animals reaching final ovarian maturation and females exhibiting viable spawning (50 % vs 47 %). The results indicate that the nutritional status and physiological state of the broodstock determines the reproductive performance under captivity.

Effect of serotonin on reproductive performance of female Indian white shrimp

In an effort to study the effect of serotonin on reproductive performance of female Indian White shrimp, an experiment with four treatments: unablated (negative control), eyestalk ablated (ES, positive control), hormone administered (serotonin injection (50 µg/g BW) and ES + serotonin) was carried out. Vitellogenic activity of ovary was monitored for 4 weeks post treatment. Expression pattern of three molecular transcripts (vitellogenin receptor, thrombospondin and heat shock protein) were analyzed. The administration of serotonin was found to positively influence vitellogenesis in *F. indicus.*

Species description of post larvae of farmed penaeids in India

A key has been designed to serve as a guide for identification of post larvae of commercially farmed penaeid shrimp in India in view of the regulatory requirements for culture of *L. vannamei* and to confirm the species status when investigators have access only to early PL in hatcheries. Although presently, the shrimp sector in India is dominated by two species viz. tiger shrimp and Pacific White shrimp, other less preferred species such as *Fenneropenaeus indicus*, *F. merguiensis*, *M. japonicus*, *P. semisulcatus* and genus Metapenaeus were also included for the construction of the key since their culture is also being undertaken. As larval description of crustacea, particularly penaeid shrimps ends

with the description of first post larvae, PL 1 was used to design the key. Live samples were used to analyze *L. vannamei*, *F. indicus* and *P. monodon* in addition to the published descriptions whereas for other penaeids, existing information was used.

Evaluation of two seaweed species for their bioremediation potential

In order to identify suitable seaweeds that can be evaluated for their bioremediation potential under low salinity, a field survey of brackishwater environment system in and around Chennai viz. Muttukadu backwaters and Pulicat Lake was carried out. Fortnightly survey conducted during the low salinity period of November 2012 to January 2013 revealed that *Gracillaria* and *Ulva* were prominent. In order to study the adaptability and growth rate of seaweed in different salinity regimes, a 2x4x3 factorial experiment was conducted with *Enteromorpha compressa* and *Gracilaria corticata* with four treatments having four different salinities viz. 10, 20, 30 and 40 ppt each with three replications. Both the seaweeds were able to grow in all salinities and showed difference in their growth rate. The growth rate of *E. compressa* was higher than *G. corticata* when exposed to different salinities. Maximum growth was observed in 30 ppt for *G. corticata* while for *E. compressa,* it was at 40 ppt. The *G. corticata* had slower growth in 10 ppt, moderate growth in 40 ppt, moderately high in 20 ppt and the highest growth rate in 30 ppt reaching 4.19 g/day. In case of *E. compressa* the growth increased in proportion to salinity, the highest growth rate being observed at 40 ppt (4.62 g/day).

To understand the bioremediation capacity of the selected seaweeds, an experimental trial with a factorial design (2x3x3) was carried out with the above mentioned two seaweed species in hatchery discharge water at different dilutions. The experiments were carried out at the shrimp hatchery at Muttukadu in 40 L FRP tanks with 30 g seaweeds initially. Initial and final water quality parameters were monitored and analyzed. The data were analyzed using ANOVA to determine significant differences among treatment means. Analysis of variance revealed that the difference in ammonia concentration between the two seaweeds was significant ($P< 0.05$) for *G. corticata, E. compressa* and nitrite concentration between two weeds. The ammonia concentration in the treatments with *E. compressa* decreased to 78% compared to *G. corticata.* Nutrient assimilation was observed to be more effective in *E. compressa* compared to *G. corticata.*

Optimization of induced maturation in domesticated tiger shrimp

In continuation of earlier observations, maternal immune status of broodstock shrimp was closely monitored and reduced reproductive performance of immunocompromised or weak (low immune index, high vibrio, less hemocytes count and high lysozyme) individuals were observed compared to normal/healthy broodstock. In the present experiment, two major groups categorised as healthy or weak group of broodstock shrimp (based on their external features and immune parameters as indicated by the representative samples) were subjected to immunomodulation with bio-modulators like vitamin C and betaglucan to examine their definite role in improving reproductive performance in either group of broodstock.

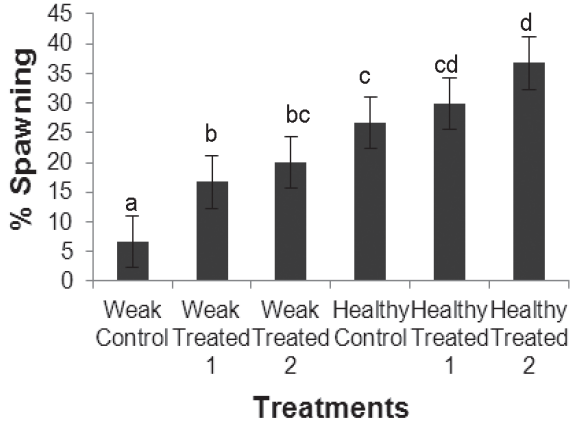


Fig. 1. Spawning rate (%) as observed in six groups

Immature broodstock were treated with vitamin and glucan following which eyestalk ablation was performed in each of the female shrimp. Advancement in maturation and spawning was observed in all the six weak (control and treatment 1 & treatment 2) and healthy groups (control and treatment 1 & treatment 2) (Fig.1).

Maturation rate improved significantly (177 %, P<0.01) in the weak individuals on glucan treatment followed by vitamin C treatment (103 %, P<0.01), the improvement being much less pronounced (25%) in healthy individuals than weak ones. The spawning rate was significantly (200 %, P < 0.01) improved in the weak group treated with glucan followed by that of vitamins (149 %, P<0.01), which is not observed in healthy groups (57.5 and 28.8 % respectively for the two groups). Fecundity of the healthy mother shrimp was significantly (P<0.05) higher than the weaker females irrespective of the treatment status, though treated females showed higher fecundity.

In conclusion, biomodulators such as beta glucan can influence shrimp immunity which in turn would improve the reproductive performance in a better manner than when vitamins are given. However, it could not improve the offspring quality in terms of their hatching and survival which was better only in the healthy group of broodstock shrimp. Further investigations are in progress.

Mode of action of probiotics in larval rearing

Mode of action of probiotics in larval rearing was evaluated through experiments on gut colonization and persistence of probiotics in water. Experiments carried out to investigate the mechanism of action of different strains of probionts like *Lactobacillus rhamnosus, Bacillus subtilis, Enterococcus faecium, Saccharomyces* sp revealed strain-specific bioremedial and immunomodulatory response in tiger shrimp juveniles. An experiment conducted by exposing protozoea of tiger shrimp with three antibiotics Chloramphenicol, Furazolidone and Ciprofloxacin (1-4 ppm) and three probiotics (two commercial- as per manufacturer's instructions or one known probiotic strain-*Lactobacillus rhamnosus* @ 10^6 CFU/ml of the rearing media), and a control group of larvae reared without any such exposure, revealed improved performance in terms of survivability, growth and metamorphosis pattern in the probiotics group followed by the antibiotics group.

The survivability was significantly (P<0.05) higher in three antibiotics (42 %) and three probiotic treated groups (49 %) of shrimp larvae compared to control (29.3 %) while rearing from nauplius to PL-20 stage. On challenge with pathogen *Vibrio anguillarum* after withdrawing the treatments, all the three probiotic groups showed significantly (P< 0.005) higher survival rate compared to that of the control and antibiotic treated groups. This study reconfirms the probiotic-induced beneficial effect in shrimp hatchery larval production system indicating that antibiotics could be totally replaced.

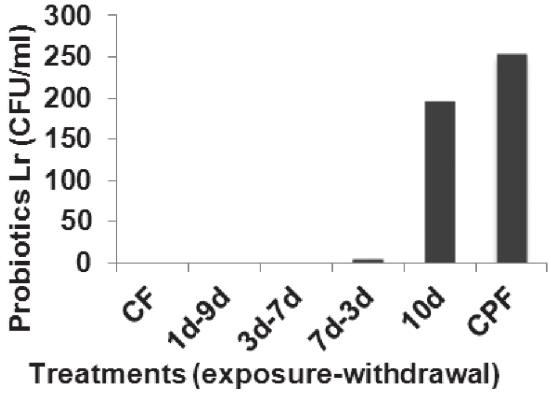


Fig. 2. Figure showing persistence of probionts in the rearing water after exposure to probiotics

Probiotics may modulate the functioning of immune system both at systemic and mucosal levels, thereby giving protective response to the animal whereas antibiotics are known to cause immunosuppression. A study was conducted to observe the colonization pattern of feeding lactic acid bacteria in shrimp post

larvae. The shrimp were fed probiotics for different durations followed by withdrawal for a fortnight while observing the probiont colonization in the gut. The rearing water was screened for the presence of the probiotics after withdrawal. The study reveals a 3-5 days persistence of the probiotics in the shrimp 3-15 days post-probiotic feeding (Fig. 2).

Evaluation of disinfection system in shrimp hatchery for healthy seed production

The microbial load in the source water before and after disinfection and in different units of hatchery viz. maturation, spawning, larval rearing, algal and artemia units were assessed during the production cycle of *F. indicus, P. monodon and F. merguiensis*. To assess the effect of disinfection methods for effective biosecurity, experiments were conducted. Water samples were collected in sterile bottles from rearing tanks of shrimp hatchery at MES and plated onto a selective medium for isolation and microbiological analysis. Quantitative analysis was carried out on ZMA for Total Plate Count (TPC) and on TCBS plates for Total Vibrio Count (TVC). For the identification of vibrio isolates, 15 to 20 colonies were selected from TCBS plates containing 20 – 200 colonies and streaked onto fresh TCBS plates individually. Thereafter, the isolates after purification, were stored in TCBS agar slants for further testing. Bacterial isolates were identified based on the colony, physiological and biochemical characteristics as well as molecular techniques. The vibrio which are constantly isolated by biochemical characterization were *V. mimicus, V. metschnikovii*, and *V. proteolyticus.* With 16S rRNA universal primers (fD1 and rP2) a product of ~1,500 bp was amplified from all the bacterial isolates. The purified products were sequenced and the data blasted in genbank sequence database. Isolated bacterial strains from different units during the production cycle were identified to be *Bacillus* sp., *Vibrio proteolyticus, V. metschnikovii, V. mimicus* and *V. alginolyticus*.

Evaluation of herbal antibacterial product for live feed

Polychaete worms, the best quality live feed for shrimp maturation, are found to have a very high bacterial load when collected from wild. To reduce the bacterial load from this live feed, an attempt was made to treat it with herbal antibacterial products like neem leaf, garlic and turmeric extracts while applying in four doses with four durations. Neem-based products were found to be more effective followed by garlic and turmeric extracts (Table 1). Neem extract disinfection level increased in proportion to the duration of treatment (1-4 hrs). The extracts of neem, garlic and turmeric could significantly reduce the bacterial load including the vibrio. Though this study established the disinfecting properties of these herbal products in polycheate worms, further standardisation is required and the edibility of these products as additives needs to be evaluated.

Table 1. Reduction in the total bacterial count and total vibrio count of the live polychaetes after treatment with natural and herbal disinfecting agents

	Total bacterial count (CFU/g)	Total vibrio count (CFU/g)	Edibility
Lactic acid	10^{3-4}	10^{3-4}	Edible
L-Ascorbic acid	10^{3-4}	10^{3-4}	Edible
Formic acid	10^{2}	10^{2}	-
Neem leaf extract	10^{4-5}	10^{4}	Edible
Garlic extract	10^{4-5}	10^{4}	Edible
Turmeric powder	10^{4}	10^{4}	Edible

High density rearing of Indian white shrimp using biofloc

A successful trial of bio-floc experiment involving Indian white shrimp by feeding different protein levels and two carbohydrate sources revealed that 35% protein diet with carbohydrate addition (rice and corn flour) showed better performance (1.91 g) than that of 45% protein (1.67 g) without carbohydrate addition (Fig. 3).

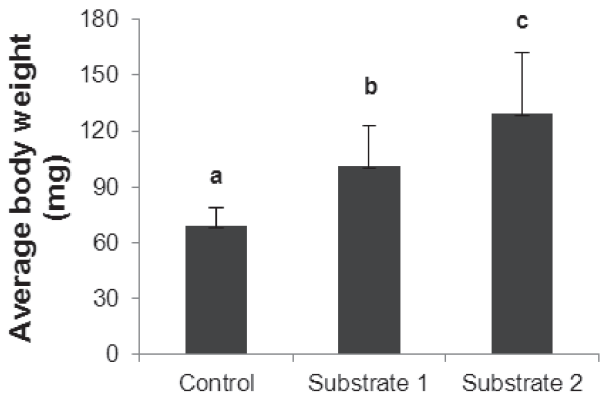


Fig. 3. Growth of *F. indicus* in different substrates

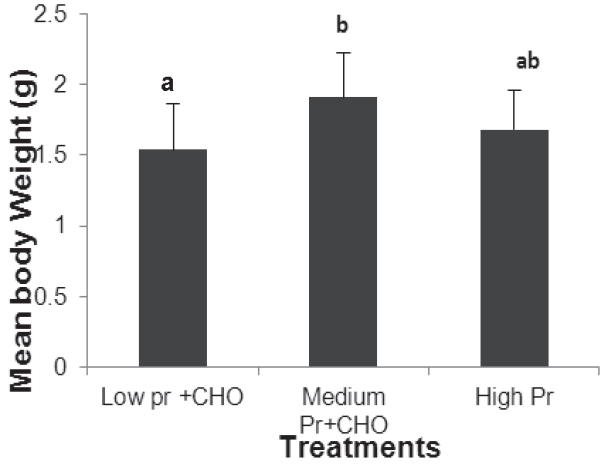


Fig. 4. *P. monodon* growth in different CHO interventions

Periphyton-based nursery rearing showed significantly ($P<0.05$) higher growth and survival of tiger shrimp in the bagasse-based substrate treatment with higher growth and immunity in three tier net-based substrate system (Fig. 4). Nursery tanks were prepared with all biosecurity arrangements and a high density nursery rearing experiment with and without substrates has been initiated with *L. vannamei*.

Survey of different feeding practices in vannamei culture

Management of feed and feeding practices alongwith stocking density and water quality is an important aspect of shrimp culture. Pacific White shrimp during culture require a continuous supply of feed. However, conventionally feed is given only 4-5 times a day to avoid excess labour cost. Therefore, with automatic feeder, the feeding could be done in such a way that daily, once in every 5-15 minutes, feed is broadcast for 3-5 seconds thereby ensuring an intermittent supply of feed. For *L.vannamei* culture, night time feeding is not practiced routinely and majority of the farms feed between 6.00 AM to 7.00 PM with feed distributed 4 or 5 times in a day. Night feeding is usually restricted to ensure continuous oxygen supplied by using paddle-wheel aerators. The feed distribution is less (18-26 %) during morning and evening whereas higher quantities (28-35%) are provided during the rest of the day. As followed for tiger shrimp, it starts with a blind feeding (2 kg/ lakh and with 400-600 g per day increment till 30 days) which is monitored by the check tray. Sampling for average body weight (ABW) and survival is carried out after 40-45 DOC to alternatively confirm the available stock. Feeding strategy is also regulated based on the temperature and molting period.

Pond culture of *Litopenaeus vannamei* at KRC

The first scientific on-farm trial of *Litopenaeus vannamei* was carried out at Kakdwip Research Centre (KRC) of CIBA. The experimental design included two stocking densities (20 and 40 nos./m^2) in six earthen ponds using pelleted feed (35% protein) under zero water exchange system with 4-9 hrs

of aeration. After 109 DOC, the final productivity was 2.34 ton/ha and 4.0 ton/ha from 20 and 40 no/m^2 stocking density respectively with a combined FCR of 1.5. The average body weight was 29.0 g and 24.7 g in 20 and 40 no./m^2 stocking density respectively. A total of 3.53 tonnes of shrimp was produced in a single crop without the use of any commercial probiotics or mineral supplement.

The effluent water was drained in layers from each pond after estimating various parameters following the guidelines of CAA. The lowest 40-50 cm water (bottom water) of each treatment pond was pooled in two separate discharge water treatment ponds (DWTP) and treated with locally available mollusks (oysters @ 5 kg/100 m^2) and green algae *Enteromorpha* species (500 g/100m^2) for 72 hours to remove excess suspended particles and dissolved nutrients. This treatment ensured reduction of NH_3-N up to 81% and PO_4-P up to 74%. The success of this trial reveals the possibilities of good economic returns when farming vannamei at low stocking densities. The reservoirs T20 and T40 recorded total microbial count of 11.78, 42.75 and 71.72 x 10^3 cfu/ml and vibrio count as 4.0, 26.35 and 22.18 x 10 cfu/ml respectively. The culture tested negative for 5 viruses *viz*. WSSV, IHHNV, TSV, YHV and IMNV.

Monitoring efficiency of discharge water treatment system from shrimp farms

Efficiency of discharge water treatment system from shrimp farms (SFDWTS) was evaluated in 5 crops of vannamei culture in Andhra Pradesh and Tamil Nadu. Water and soil parameters (monthly intervals) and environmental parameters (at regular intervals for duration of 60 to 76 h) were analysed. The culture details are given in Table 2. Water and soil parameters were in normal range except for total ammonia N (TAN) in few of the ponds. In DWTS, though high total suspended solids (TSS) and total settleable solids (TSettS) were observed at initial stage, a decrease in value (TSS < 100 mg/l and nil TSettS) was observed within a period of 60 to 72 hours and 48 to 60 hours, respectively (Fig. 5). There was no improvement with respect to TAN, NO_2-N, NO_3-N and total N either in summer or in winter crops of Farm 1 at Ongole. The phosphorous (phosphate and total P) values were low initially in a few crops and in crops with high values, the decrease was observed only in 2 DWTS ponds which could partly be attributed to adsorption of phosphate by the clay content of bottom soil. Chemical oxygen demand (COD) values were initially high after which they reached permissible levels within 60 to 72 hours. Based on the evaluation of the existing SFDWTS, it is concluded that the present DWTS is efficient in decreasing total suspended and settleable solids, but not the nutrients (N and P).

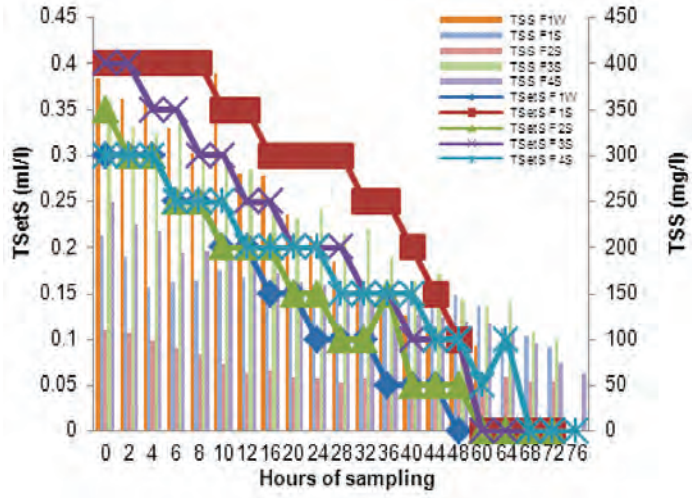


Fig. 5. Total settleable and suspended solids

Table 2. Culture details of vannamei farms

Parameter	Farm 1 - Ongole (AP)		Farm 2 - Tuni (AP)	Farm 3 - Sirkali (TN)	Farm 4 - Ongole (AP)
	Winter crop	Summer crop	Summer crop	Summer crop	Summer crop
Av. pond area (ha)	0.6	0.6	0.6	0.6	0.8
SD (nos./m^2)	45	38	48	33	31
Date of Stocking	12.11.2011	26.05.2012	15.02.2012	28.02.2012	06.04.2012
Date of Harvesting	05.04.2012	25.09.2012	25.06.2012	31.07.2012	28.08.2012
Days of culture (DOC)	147	122	126	154	145
Survival (%)	100 (20 % in excess of SD)	83	93	100 (20 % in excess of SD)	92
Count	32	34	30	25 count (50 % partial harvesting)	30
FCR	1.6	1.8	1.8	1.4	1.6
Production (tonnes/cultured area)	8.4	7.9	8.9	7.9	7.6
Production (tonnes/ha)	14.1	13.1	14.9	13.2	9.5

Survey on use of chemical and biological products in aquaculture

Out of 101 different chemical and biological products available in Chidambaram, Tamil Nadu, farmers were using 27 of them. Similarly, farmers from Nagapattinam were using all the 51 products available locally. On an average, 5-17 products were used by each farmer. Notably, none of the farmers used antibiotics. Farmers in the Allavaram and Sakhinetipalli villages of Andhra Pradesh used 5-7 different chemicals and biological products. The most commonly used were lime, bleaching powder, probiotics, sanitisers, oxidising agents like calcium peroxide, hydrogen peroxide and mineral mixture (Table 3).

Table 3. Usage of chemicals and biological products by farmers

S. No	Chemicals & biological products	Usage/acre	Expenditure (₹/acre)
1	Lime- ₹4/- per kg	200 kg	800-1000
2	Bleaching powder	100-150 kg	3000
3	Probiotics		12,000-20,000
4	Sanitisers		8000-10,000
5	Mineral mixture		10,000-12,000

Though expensive, farmers preferred to use these products for enhancing production.

Seed production of Banana shrimp *Fenneropenaeus merguiensis*

Seed production of banana shrimp was initiated for stocking in Danti, NAU, Navsari and also in farmer's ponds. The brooders were collected from Adirampattinam Coast in Pattukkotai district of Tamil Nadu. Adult female brooders weighing >45 g (100 nos) and males weighing >30 g (30 nos) were transported, in polyethylene bags to a makeshift hatchery. Some females spawned during transportation. About 8.5 lakhs nauplii were reared to PL 12-15 stage following the conventional hatchery protocol. About 0.70 lakh seed were stocked in Danti (3 ponds) and 1.40 lakh in a farmer's pond at Surat. One batch of tiger shrimp (30,000 nos) was stocked in the fourth pond at Danti for purposes of comparison. During the culture period, all abiotic and biotic parameters are being monitored.

Polychaete culture

The primary objective was to explore the possibility of culturing locally available species of polychaete. Uniformly, 27 adult worms (weight ranging from 3.12 to 5.16 g) were used for producing offspring in a raceway type system with a 500 L overhead tank for circulating water for 2 hrs through all the 6 tanks. Three substrata used in the breeding tank were loamy, sandy-loam and sand alone which were maintained in duplicates. Prior to the experiment, the substrata were sun-dried to ensure removal of unwanted organisms in the soil. The tanks were cleaned weekly to remove filamentous algae and water exchanged completely. The loamy and sandy-loam tanks produced 15 and 10 egg sacs respectively and sandy tanks produced 9 egg sacs during the culture period. The total juveniles produced from all the tanks (n=2225) were used for growth trials using different feeding combinations. The average body weight of the juveniles was 26.3 mg.

The total fat content of polychaetes was estimated by collecting the samples at 60, 150 and 240 DOC (Fig. 6). At 240 DOC, there was a significant reduction in oleic and linoleic acids. A small increase in eicosapentanoic (EPA) and docosahexanoic acids (DHA) with the progress in culture was observed. The results suggest that adult polycheate (2-3 g) have a higher concentration of EPA and DHA (suitable for shrimp broodstock development) and hence is a preferred choice.

District Level Planning for Brackishwater Aquaculture

This is aimed at integrating the present resources scenario with financial and infrastructure requirement to develop aquaculture in a sustainable manner. To achieve this, Krishna district of Andhra Pradesh was selected as it has the highest number of shrimp entrepreneurs with maximum area under shrimp culture. The primary information such as total land area, aquaculture farm area developed and under culture, available potential area, coastal length, ecologically important ecosystems if any and secondary information such as demographic details, general administrative arrangement, climate, rainfall, ground water quality, hydrogeological characteristics and infrastructure facilities were collected from different sources. The land and water resources were derived from the IRS P6 LISS III satellite data of the year 2012 (Fig. 7).

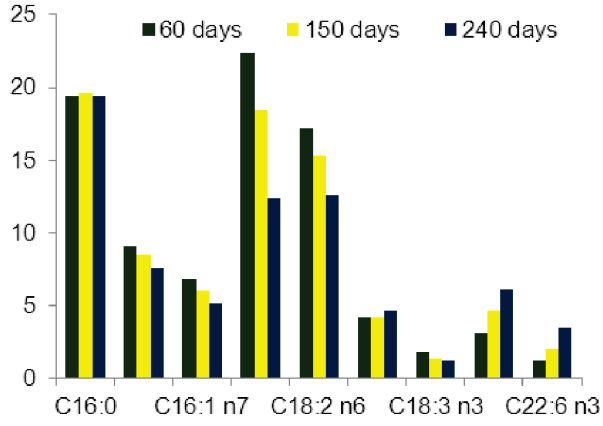


Fig. 6. Fatty acid profiles (% of total) of cultured polychaete collected at different DOC

The land resources of Krishna district is given in Table 4. The brackishwater and freshwater aquaculture occupied an area of 26547 ha and 27122 ha respectively.

Table 4. Land resources of Krishna district

Landuse	Area in ha
Agriculture	660334
Aquaculture Disuse	11967
Brackishwater Aquaculture	26547
Freshwater Aquaculture	27122
Hills	31583
Kolleru	7094
Mangrove	13756
Mudflat	22572
River	38510
Saltpans	143
Scrub land	2481
Settlement	30869
Tank	5845
Total	**878829**

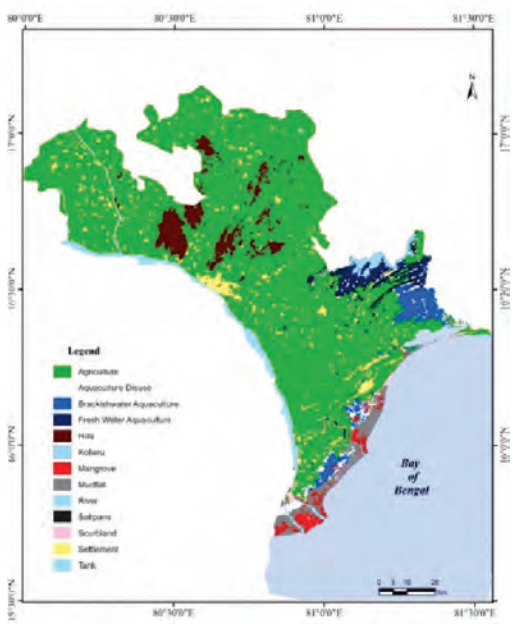


Fig. 7. Land resources map of Krishna district derived from IRS P6 LISS of year 2012

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

The objective is to develop a database on spawning characteristics of female mud crab *Scylla serrata* induced for spawning (unilaterally eyestalk ablated) and to determine the management practice that promotes the production of good quality larvae. The data collected were size of broodstock, latency period, incubation time, number of zoea produced per female, histological characteristics of ovaries of females not responding to eyestalk ablation and preliminary results on the post larval production trials. The mean carapace width of the females (200-800 g) used for the study was 526.1 mm (Table 5). There was a significant correlation (r = 0.88, P< 0.001) between carapace width and mass indicating that mass increases in proportion to carapace width. Table 4 summarizes the spawning characteristics of *S. serrata*. Of the 42 unilaterally eyestalk ablated crabs, 49 % spawned and produced viable zoea1. The variability in the reproductive performance of eye stalk ablated crabs was similar as described for other crustaceans. Although mud crabs were found to spawn throughout the year, a strong seasonal influence was noticed. It was observed that the body weight of crabs that spawned in winter and post winter had significantly (P<0.05) higher body weight when compared to those that spawned in summer. The frequency of spawning is almost double in the winter and post winter months (December to April), however the minimum latency period was observed in July (summer) (Table 6). The mean number of zoea produced by the female was 42,83,528 with 6314 zoea per gram female. The high variability in zoea production could be attributed to variability in the body size of the broodstock. The average weight of the animal spawned was 526 g. The number of zoea was positively correlated (r =

0.70) with carapace width (body weight) indicating that zoea number would increase in proportion to the body weight of the mother crab. Histological analysis of ovaries of females that did not respond to eyestalk ablation revealed that they were at the pre-vitellogenic stage. It was further observed that after mating, the females became vitellogenic indicating that mating is a pre-requisite for vitellogenesis. The information generated would facilitate in the establishment of commercial hatchery and also for domestication of this species.

Table 5. Spawning characteristics of female *Scylla serrata* in captivity

Variable	Minimum	Maximum	Mean
Carapace width of crab spawned (mm)	131	164	147.6 ± 12.1
Body weight of crab spawned (g)	200	810	526.1 ± 48.3
Latency period (days)	1	69	33
Fecundity (number of zoea)	0.67 X 10^6	9.78X 10^6	4.38 X 10^6
Incubation period (days)	8	14	9.5
Hatchability (%)	90	97	94

Table 6. Influence of season on spawning characteristics

Variable	Summer	Winter and post winter
Body weight (g)	448.2^a ± 52.1	594.3^b ± 28.4
Latency period (days)	36.3 ± 10.4	40.8 ± 6.6
Fecundity (no of zoea)	5.6 X 10^6	6.1 X 10^6
Successful spawning (%)	24.5	54.5

Means followed by different superscripts differ significantly (P<0.05)

High rate of spawning was observed under captivity, however the quality of the larvae was directly linked to the quality of the individual broodstock as larval performance varies with individual specimens. Out of a total of four cycles of larval rearing that was carried out,three were successful (Table 7). Slightly higher survival rate was obtained with lower stocking density and when more than 100 individuals per litre were stocked, survival came down drastically. The survival in different stages is as follows : zoea 1 (100 %), zoea 2 (66 %), zoea 3 (39%), zoea 4 (11.2 %), zoea 5 (8.2 %), megalopa (4.5 %) and crab stage (2.13 %).

Table 7. Characteristics of larviculture of *Scylla serrata*

Variable	Minimum	Maximum	Mean
1	672000	80000	2.13
2	6544500	150000	0.8
3	39542000	100000	1.7

Molting cycle: In order to optimize the larval rearing protocol of *S. serrata*, the molting cycle of larvae was studied. Three principal stages-post molt, inter molt and pre molt were noticed. During the initial 45 days of rearing, crab instar 2 grew from 0.31 g to 8.05 g with an estimated survival of 61%; sex ratio was 1:1 without any significant difference in the growth rate between the two sexes. However, from 45 days onwards, survival decreased even though the growth rate almost doubled. After 75 days of rearing, the crabs weighed on an average 39 g with a survival of 35%.

Mono sex and mixed sex culture of *Scylla serrata* at KRC, Kakdwip

Grow-out experimental culture was carried out in 12 earthen ponds (100 m^2) for 143 days from mid October 2012 till the end of February 2013. The experiment was divided into four treatments as given in Table 8. Hatchery-reared *S. serrata* with an initial weight of 60.87 g (male) and 54.57 g (female) were stocked. Locally available trash fish was used as feed. Highest survival was noticed in mono sex (females) and lowest in mono sex male culture (Table 8). Salinity during the culture period ranged from 8.1 to 13.3 ppt. The temperature ranged from 10° C to 27°C. Benthos analysis indicated a decreasing trend of benthic fauna over time. The important benthic fauna identified were polychaete worms, gammarids, tanids and molluscs. Total average benthic fauna varied from 4135 to 1136 numbers per m^2 at initial and the final period of grow-out culture respectively. Among the benthic fauna, polychaete worms formed the highest group followed by gammarids and tanids, molluscs being the least (Fig. 8.).

Gonadosomatic index analysis indicated highest values in mono sex male and female populations and lowest in male population grown in mixed sex culture for 1:1 and 2:1. Percentage of chelate leg to body weight was highest in mono sex male followed by mixed sex (2:1) male population and lowest in mixed sex female populations.

Table 8. Average body weight and survival of crabs during grow-out

Treatments	(Mean± SE) (g)	Range (g) Min	Max	Survival (%)
Mixed sex 1:1	237.70±20.98	60	520	25
Mixed sex 2:1	199.81±17.57	90	750	35
Mono sex (Females)	157.74±14.47	50	650	35
Mono sex (Males)	147.43±15.87	60	530	23

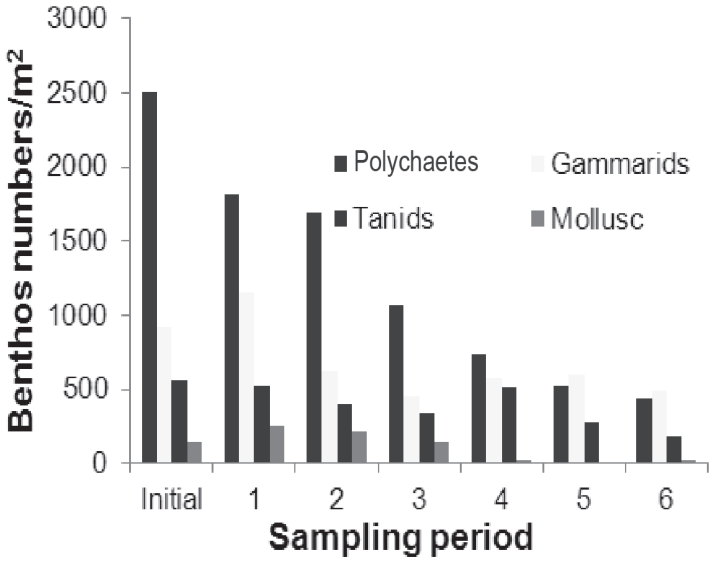


Fig. 8. Benthic fauna in crab grow-out culture

Project Title (Institute)	Development of techniques to quantify the impact 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 mangrove wetlands of Mahanadi, Devi mouth and Bhitarkanika Wild Life Sanctuary (BWLS) in Odisha were studied using multi temporal satellite data and GIS.

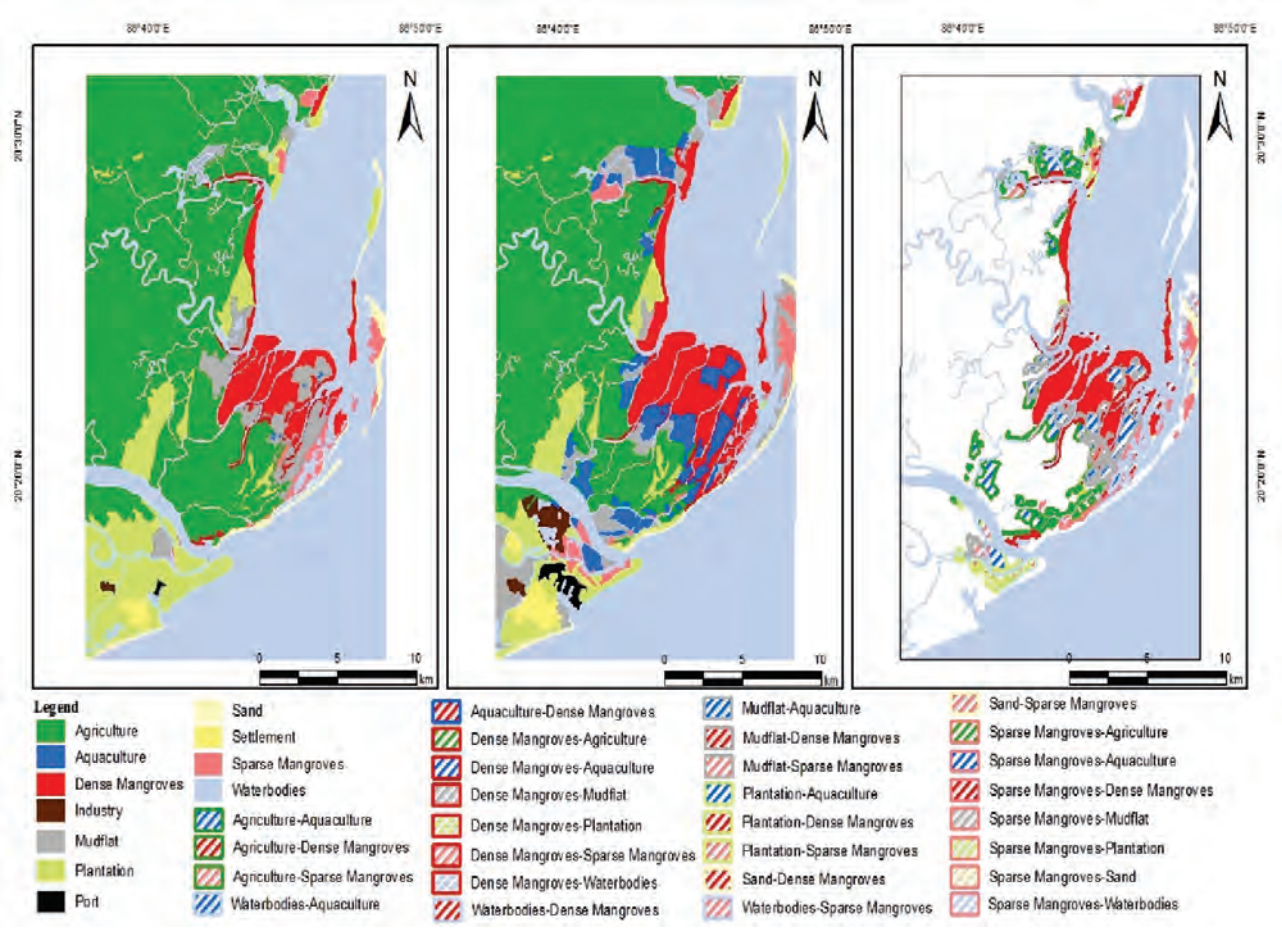


Fig. 9. Mangroves and other land classes farms in and around Mahanadi a) in 1990 b) 2008 c) changes in the wetland from 1990 -2008

The mapping of mangroves and its changes that occurred in Mahanadi between 1990-2008 is given in Fig. 9. The dense mangroves (DM) in Mahanadi delta have increased from 2931 ha in 1990 to 4409 ha in 2008. The sparse mangroves (SM) have also increased from 917 ha in 1990 to 1290 ha in 2008. The changes have occurred from mangroves to other classes and vice versa (Table 9). Overall, dense and sparse mangroves have increased by 1471.29 ha and 667.62 ha respectively. The aquaculture farms of 85.44 ha was developed from dense (64.26 ha) and sparse mangroves (21.18 ha) contributing to a reduction of 2.1 % and 2.3 % in dense and sparse mangroves respectively.

The Devi mouth mangrove wetland is characterized by the presence of 15 exclusive mangrove species and the satellite data shows their presence along the creeks of Boman Nadi of Bitikolia estuary. Based on the mapping of mangroves and its changes that occurred in Devi mouth between 1990-2008, the changes in areal extent in mangroves and its surroundings were calculated. The dense mangroves in Devi mouth mangroves have increased from 315 ha in 1990 to 570 ha in 2008. The sparse mangroves have also meagerly increased by 10 ha during the same period. The changes have occurred from mangroves to other classes and vice versa. Overall dense and sparse mangroves have increased by 643.45 ha and 15.19 ha respectively from mud flats, plantations and water bodies.

In BWLS delta, the dense and sparse mangroves increased from 15483.10 ha to 16142.22 ha and 1611.14 ha to 1975.48 ha respectively between 1990 -2008. The dense mangroves were regenerated (916.39 ha) from mud flats, water bodies, agriculture and sand classes. Simultaneously, conversion also

occurred from mangroves (257.26 ha) to mud flats, water bodies and sand due to natural changes in the environment. The sparse mangroves also have increased (773.02 ha) from agriculture, mud flats and water bodies between 1990-2008 and during the same period, it was changed to water bodies and mud flats. The analysis indicates that in BWLS mangroves, the changes that occurred between 1990-2008 were mainly due to natural changes such as erosion or accretion and not due to man-made activities.

Table 9. Land cover change dynamics in and near by major mangroves of Odisha

Land cover changes	Land cover changes		
	Mahanadi	Devi mouth	BWLS
Dense Mangroves (DM)	**Negative changes in mangroves**		
DM - Agriculture	7.26	242.94	
DM - Aquaculture	64.26	0	
DM - Plantation	5.6	2.02	
DM - Mudflat	33.72	26.98	25.47
DM - Sparse mangroves (SM)	86.86	5.76	
DM - Water bodies	43.06	36.42	133.38
DM - Sand	0	1.39	98.41
Total	**240.76**	**315.51**	**257.26**
SM - Agriculture	7.13	2.28	
SM - Aquaculture	21.18	0	
SM - Plantation	50.42	0	
SM - Mudflat	119.03	6.40	368.59
SM - Water bodies	53.67	18.37	40.09
SM - Sand	31.87		
Total	**283.3**	**27.05**	**408.68**
Dense Mangroves remained without change	2690.92	242.95	15225.8
Sparse mangroves remained without change	752.53	18.38	1202.47
Positive changes			
Agriculture - DM	61.09	2.0	29.92
Aquaculture - DM	5.30	0	
Plantation - DM	195.17	78.03	8.48
Mudflat - DM	479.74	76.39	304.16
Sand - DM	10.49	4.12	3.47
Sparse mangroves - DM	380.89	20.99	
Waterbodies - DM	579.37	146.41	570.36
Total	1712.05	327.94	916.39
Agriculture - SM	215.79	4.0	86.52
Mudflat - SM	119.15	4.37	35.80
Plantation - SM	334.24	2.30	
Sand - SM	115.26	1.88	
Waterbodies - SM	166.48	29.69	650.70
Total	**950.92**	**42.24**	**773.02**
Overall changes in Dense mangroves	+1471.29	+643.45	+659.13
Overall changes in Sparse mangroves	+667.62	+15.19	+364.34

The combination of satellite data analysis and field surveys has given a set of new data which helped to quantify the changes in mangroves and their causes. Our measurements of the extent of changes in three mangrove areas and their surroundings in Odisha show an increase of 14.61 % dense mangroves and 38.81 % sparse mangroves. The overall changes in sparse mangroves is due to the conservation and regeneration efforts of the state forest departments and NGOs between the pre aquaculture period and the present scenario. This study makes it clear that the development of aquaculture is not related to the availability of mangroves in Odisha as is often perceived.

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

Banana shrimp culture demonstration in Gujarat

Banana shrimp culture demonstration in a farmer's pond was carried out at a stocking density of 17 nos /m^2 for a period of 113 days and a production of 1.2 ton /ha was achieved as detailed below (Table 10).

Hauls of banana shrimp from farmer's pond

Broodstock development of ginger shrimp

For evaluating the culture potential of the endemic species *Metapenaeus kutchensis* in Gujarat, broodstock development was attempted. Since broodstock were not available during the peak season, juveniles of 2-5 g size were collected from Navsari and Veraval backwaters and stocked in ETP pond. After 154 DOC, the average body weight was about 18-20 g and when they are of 30 -35 g size, seed production would be initiated (Fig. 10).

Wild ginger shrimp *Metapenaeus kutchensis* cultured in ETP ponds at Danti

Table 10. Banana shrimp culture in Gujarat

S.No	Particulars	Details
1	WSA (ha)	0.6
2	Culture period (days)	113
3	Number stocked (nos.)	1,05,000
4	Stocking Density (nos./m^2)	17.5
5	ABW (g)	9.90
6	Size (nos./kg)	101
7	ADG	0.09
8	Biomass (harvested)	725
9	Total accumulated feed (kg)	722
10	Survival Rate (%)	70
11	FCR	1.28
12	Production (kg/ha)	1208.3

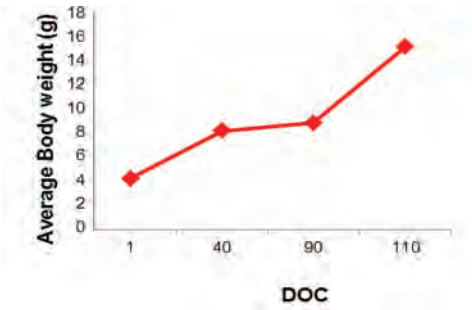


Fig.10. Growth rate of *M. kutchensis* cultured in ETP ponds at Danti, Gujarat

Characterization of soil profile in Danti farm ponds

Since information on soil profile of Gujarat shrimp ponds is lacking, the soil profiling of shrimp ponds was carried out in Danti farm at Navsari Agriculture University. Depth-wise samples (n=128) were collected with pond core soil sampler and analysed for basic physico-chemical parameters including mineral content. Analyses revealed a decrease in electrical conductivity (18.5-2.4 dS/m) and organic carbon (1.25-0.13%) and no definite trend in pH (8.42-9.04) with increasing depth. Total N content ranged from 76 to 355 mg/kg soil and there was a decrease in N upto 7.5 cm depth (3 cores) increasing thereafter. Total P content ranged from 321 to 712 mg/kg soil. Pond 1 had high EC values followed by ponds 2, 3 and 4. The OC content was high in ponds 1 and 2 compared to ponds 3 and 4. There was not much change in mineral content among the ponds.

Microbial dynamics of shrimp culture ponds.

Tiger shrimp and Pacific White shrimp culture was evaluated for the role of probiotics on microbial dynamics, environmental parameters and production. Preliminary analysis revealed that application of probiotics in large quantities does not influence the parameters positively. The ponds using probiotics at high dosage in intensive system revealed no significant improvement in terms of survival, growth and average daily gain compared to operations at low dosage. It was observed that ponds with lower dosage of probiotics had significantly higher production (Table 11). Hence, it is suggested that efficacy of the probiotics depends to a larger extent on the pond environment and there is a need for scientific intervention to recommend the required dosage of probiotics which could help in reducing the expenditure on probiotics leading to a lower production cost.

Table 11. Production details of low and high intensity culture of *L.vannamei*

Particulars	Intensity	
	low	High
ADG (g)	$0.19^{a} \pm 0.02$	$0.176^{a} \pm 001$
ABW (g)	$24.23^{a} \pm 2.32$	$23.39^{a} \pm 3.01$
Survival (%)	$84.84^{a} \pm 7.34$	$61.53^{b} \pm 5.94$
FCR	$1.43^{a} \pm 0.07$	$1.92^{b} \pm 0.25$
Production (kg/ha)	$7031.67^{a} \pm 365.73$	$7939.00^{a} \pm 765.82$
Cost of probiotics (₹)	13302.70	71726.00
Cost of probiotics/kg shrimp (₹)	2.33	9.03

Means followed by different superscripts differ significantly ($P<0.05$)

Assessment of ICT needs and development of e-Learning module

A total of 50 tribal farmers were randomly selected to assess the needs of tribal farmers from Pathri (Gandevi taluk), Navsari, Gujarat. The respondents were briefed about the Information and Communication Technology especially e-Learning module and its importance in aquaculture. Information was collected using a well-structured and pre-tested questionnaire from the targeted groups comprising of shrimp/fish culture practices and allied activities.

The parameters were included for identifying the needs in shrimp culture practices for tiger shrimp, banana shrimp and vannamei. The needs of fish culture practices and allied activities were identified in five areas - milkfish, pearlspot, seabass, value added products from shrimp & fish and mud crab fattening. A summary of the measuring system of all three categories of needs of e-Learning module is presented in Table 12.

The need of e-learning modules on banana shrimp, milkfish, seabass, coastal/ tribal developmental programs, pearlspot and seabass culture practices were ranked high. In addition, e-Learning on market information, details of addresses of fisheries/ aquaculture institutes and departments were sought by the users of KVK for development of aquaculture in coastal areas. Limited interest was evinced in e-Learning module on tiger shrimp, value added products from shrimp/fish, mud crab fattening and vannamei culture.

Table 12. Needs for the development of e-Learning modules in the study area

Categorization of aquaculture and its allied activities	Total assessment score	Rank
Shrimp culture practices		
Tiger shrimp	50	8
Pacific White Shrimp	30	10
Banana shrimp	80	1
Fish culture practices and allied activities		
Milkfish	77	2
Pearlspot	72	5
Seabass	74	4
Value added products from shrimp/fish	28	11
Mud crab fattening	12	12
Basic information		
Address of fisheries/aquaculture related institutes, departments etc.,	64	7
Coastal/tribal developmental programs	75	3
Market information	67	6
Educational/health oriented information	45	9

Based on the overall needs assessment of the tribal farmers of Pathri village and on the collaborative work of CIBA and NAU for the development of banana shrimp culture at Danti farm in Gujarat, an asynchronous e-Learning module-Banana shrimp: A potential diversified species for culture in low temperature coastal areas was developed. This module contains main topics on distribution, biology, seed production and culture practices of banana shrimp including economics of its culture. The e-Learning module highlights the potential and prospects for culture of this species as an alternative livelihood activity for farmers in Gujarat during winter.

Demonstration of cage farming of finfishes under Tribal Sub Plan

Fifty four cages were stocked with seabass, milk fish and pearlspot in 5 places located in tribal holdings of low saline water bodies in Kabilpore, Kurshad, and Pathri villages of Navsari and Surat Districts to assess the potential of culturing finfishes. The culture is in progress.

Cage culture of *Lates calcarifer* and *Etroplus suratensis* at Navsari

Fabricated cage given to beneficiaries in different tribal villages in Navsari and Surat districts under TSP for culture of seabass

Experimental pond culture of pearlspot

Experimental pond culture trial was initiated at Danti-Umbharat farm. The pond was filled using tidal waters and post bleaching, was fertilised. The depth of water was maintained at 1.2 m and two paddle wheel aerators placed for aeration. Initial soil and water samples were collected and analyzed for abiotic parameters. A total of 3560 nos. of fish seeds (@ 2.36 nos/m^2) were released into ponds. Mortality due to Caligus infestation on gill cavities was observed from 46th day of culture. A total of 411 dead fish were recovered from the pond periphery. After diagnosis of Caligus infection, the pond was treated with Butox® @ 300 ml/ha which controlled the mortality. As a preventive measure, a repeat dose was given. Temperature (32 - 17 ^{0}C), and salinity (25 – 51 ppt) showed wide variation, the highest temperature being recorded in May and the lowest in December. The maximum salinity was observed in July and minimum during September. After 251 DOC, an average body weight of 28.2 g was attained.

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

Effect of 17 α-hydroxy progesterone on ovarian maturation

To elucidate the effect of 17 α-hydroxy progesterone on vitellogenesis and reproductive maturation, *in vitro* and *in vivo* experiments were carried out. Further, the receptor for progesterone was characterized in the ovary of tiger shrimp. The lowest Vg mRNA relative level was found in vehicle treated intact animals (calibration group 1). All the treatment groups had significantly higher Vg mRNA levels compared to the control. Treatment group that received hormonal administration and eyestalk ablation had highest Vg mRNA levels compared to control. The shrimp treated with hormone alone had 4 times higher and the eye stalk ablated alone group had 9 times higher Vg mRNA level than the intact animals. Dose dependant effect of 17 α-hydroxy progesterone on Vg mRNA relative levels in the ovary explants incubated *in vitro* was observed. Significantly higher Vg mRNA relative levels were found in the pre vitellogenic ovaries than immature ovary. Western blot analysis with rabbit anti-hPR antibody detected the PR homolog (apparent molecular weight of ~ 70 kDa) of tiger shrimp. This study confirms the gonodotropic role of 17 α-hydroxyprogesterone on vitellogenesis. By *in vivo* administration, 8 days of post hormone treatment (100 µg/individual) could stimulate significantly higher levels of vitellogenin synthesis than the unilateral eyestalk ablation. Even the higher Vg synthesis was found in the hormonal treated shrimp only (Fig. 11) along with unilateral eyestalk ablation. This confirms that multi hormonal stimulation is essential for active Vg synthesis. *In vitro* experiment showed that Vg synthesis in response to 17 α-hydroxy progesterone, depends upon stage of ovarian maturation. It can therefore be concluded that hormonal manipulations are ineffective until the proper endocrine environment is established in the animal.

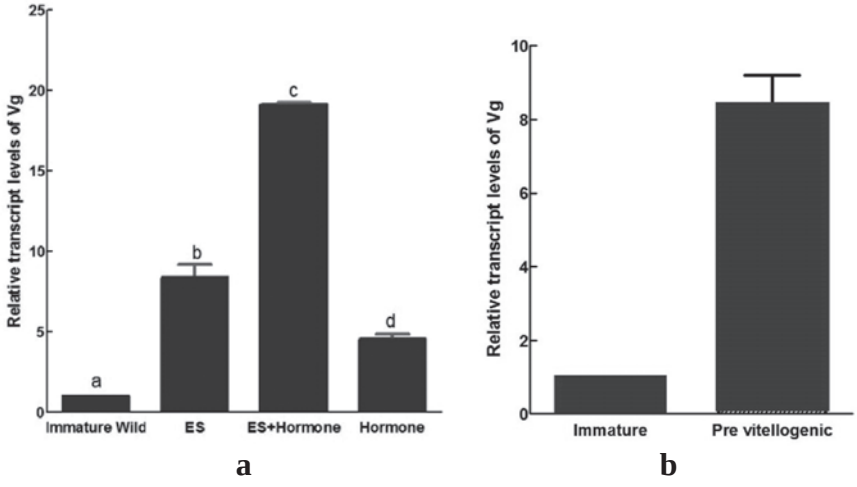


Fig. 11. Changes in the transcript levels of Vg in the ovary at (a) different treatment groups (b) different ovarian stage measured by quantitative RT-PCR (n =5 animals; bars indicate standard deviations; significant differences (P<0.05) between means indicated by different letters)

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

Temporal variation of groundwater quality of lower Vellar watershed with respect to pH, EC, TDS, cations and anions in the study area with four seasons viz. summer (March to May) South-West monsoon (June to September), North-East monsoon (October to December) and winter (January to February) showed that the average groundwater quality during different seasons fluctuated with a higher value during summer. Hydro-geochemical analysis by Chadha plot showed that 54% of the samples were influenced by reverse ion exchange, 28% of the samples by seawater intrusion and only 18% of samples due to recharging of surface water. The geophysical survey carried out using Vertical Electrical Sounding (VES) method at 18 locations both horizontally (1.5 to 6 m) and vertically (3 to 57 m depthwise) shows that discharge and recharge rate is high in Adivaranganallor area when compared to other areas (Fig. 12).

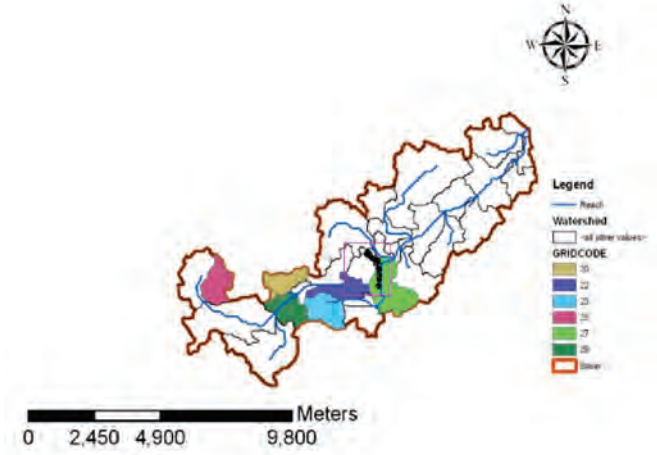


Fig. 12. Discharge and recharge rate in study area

The model SWAT was applied for lower Vellar watershed. The results show that six micro watersheds are influencing the nutrient loading into the Vellar river (Fig. 13). It was also shown that nutrient loading from the agricultural fields to the creek was not directly proportional to the amount of precipitation. Well-distributed and continuous rainfall led to low quantities of nutrient leaching. A heavy rainfall after a comparatively dry period and immediately after fertilizer application led to an increase in nutrient loading. The vulnerability of the aquifer for seawater intrusion was carried out using multicriteria method viz, GALDIT. The most important factors controlling seawater intrusion were: groundwater occurrence (aquifer type; unconfined, confined and leaky confined); aquifer hydraulic conductivity; depth to groundwater level; distance from the shore (distance inland perpendicular from shoreline); impact of existing status of sea water intrusion in the area and thickness of the aquifer. The map derived for this study area shows that the North East side of coast (near to coast and near to the South East side of the creek) is highly vulnerable to seawater intrusion.

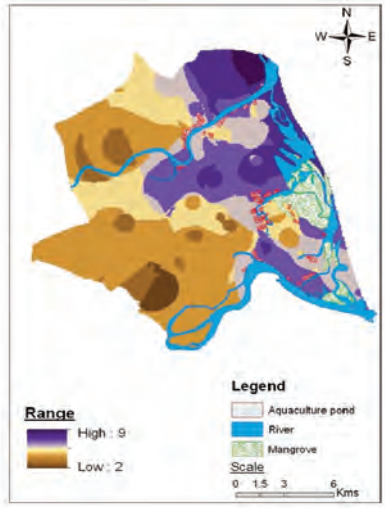


Fig. 13 . SWAT model output for nutrient loading

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

Efficacy of CIBASTIM in growth and production

Efficacy of CIBASTIM in growth and production was evaluated in the state of Andhra Pradesh (20.29 ha) and Gujarat (48.38 ha). The farms selected cultured tiger shrimp and represented average faming

Table 13. Effect of CIBASTIM administration on production and average body weight (Mean±SD) in *P.monodon* (2012-13)

Stocking density (nos./m^2)	Production (kg/ha)		Average Body Weight (g)	
	Treatment	Control	Treatment	Control
<7 (n=15)	2103.68^a±720.62	1136.22^b±477.18	33.06^a±10.12	26.09^a±8.76
8-12 (n=50)	3129.31^a±1229.07	2203.91^b±989.88	35.18^a±7.11	33.63^a±10.30
13-16 (n=11)	3892.38^a±449.25	1874.82^b±704.17	26.34^a±4.59	28.40^a±7.79
>16 (n=9)	3376.12^a±211.42	2550.53^b±461.21	25.80^a±2.26	25.39^a±2.17

Note: Means in the same row with different superscript are significantly different (P< 0.05).

conditions prevailing in the particular state. The stocking densities ranged from 5 to 24 nos./m^2, the salinity ranged from 6-41 ppt in Andhra Pradesh and 19-45 ppt in Gujarat. Significant (P<0.05) improvement (29.6-51.8 %) in the production (kg/ha) was observed in CIBASTIM treated ponds compared to controls in all the densities of stocking (Table 13). It was also observed that anatomical deformities like, antennae cut, tail rot and rostrum cut were significantly lower in CIBASTIM treated pond compared to controls (Table 14).

Table 14. Effect of CIBASTIM administration on appendage deformities (Mean±SD) in *P.monodon* cultures (2012-13)

Deformities	Shrimp from treatment ponds (n=290)	Shrimp from control ponds (n=228)
Antennae cut	5.06 ^{a}±3.95	12.38 ^{b}±1.92
Tail rot	4.57 ^{a}±0.58	9.18 ^{b}±0.88
Rostrum cut	4.80 ^{a}±0.45	10.67 ^{b}±1.03
Soft shell	7.13 ^{a}±2.39	16.58 ^{b}±0.87

Note: Means followed by different superscript differ significantly (P< 0.05).

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

In this project, farms and hatcheries handling vannamei were regularly monitored for the occurrence of different diseases. All the OIE listed viral pathogens: WSSV, IHHNV, YHV, TSV and IMNV were diagnosed by PCR. Bacteriological analysis of hemolymph and water samples was carried out to evaluate pathogen status. Histopatholgical analysis was carried out to evaluate the overall pathological status as well as presence of specific pathogens. Sampling was carried out in different areas of Tamil Nadu and Andhra Pradesh and were collected from a total of 74 farms covering 106 ponds. The areas covered in Tamil Nadu were Kalpakkam, Marakkanam, Nagapattinam & Kattur; Nellore, Gudur, Ongole, Bapatla, Bhimavaram and Kakinada in Andhra Pradesh. Prevalence of WSSV and IHHNV was observed throughout the year (Fig. 14).

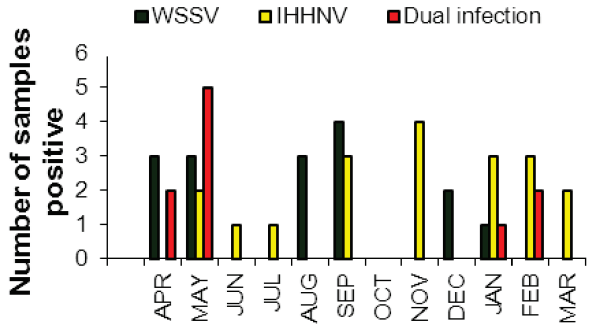


Fig. 14. Distribution pattern of WSSV and IHHNV

High prevalence of WSSV and mortality was reported during April-May in Tamil Nadu and during August-September in Andhra Pradesh. From September onwards, IHHNV prevalence was found to be high. Throughout the investigation, exotic viruses viz. HV, TSV and IMNV were not detected in any of the samples. During the sampling period, it was observed that some of the farms were having total mortality for DOC of 32 to 72 days. A total of 8 samples from Tamil Nadu and 7 from Andhra Pradesh were analysed. All the samples were infected with WSSV and some had dual infection with IHHNV. Histopathological analysis of the hepatopancreas did not match with the symptoms ascribed to AHPNS (EMS). Therefore, it could be concluded that the early mortality of shrimp in India was due to WSSV infection rather than AHPNS. Based on this, a report was presented to Ministry of Agriculture and advisory for farmers was prepared. For disease monitoring of hatcheries, a total of 11 visits were made to different hatcheries and 48 samples were collected. The sampling areas included Muttukadu and Marakkanam (Tamil Nadu) and Gudur (Andhra Pradesh). Only three samples exhibited the presence of virus-one for IHHNV and two for WSSV second step positive. All the samples tested negative for the 3 exotic viruses: YHV, TSV and IMNV.

Monitoring vannamei culture under different farming systems and developing BMPs

A total of 90 ponds distributed in nine locations both in Tamil Nadu (Kalpakkam, Sadras, Marakkanam, Pazhverkadu, Kattur, Anupampattu) and Andhra Pradesh (Suryalanka, Thummanapalli and Karlapalem) were monitored during *L. vannamei* culture. Each location included two to three clusters of farms distributed across salinity (low) and density to evaluate the growth performance of SPF vannamei. Variability was observed in these farms with regard to their biosecurity compliance, farm design and modifications, salinity regime, seed sourcing, culture duration and approach to crisis management. However, the culture practice evolving is more or less similar in both the states with respect to approach for water utilization, pond preparation, biosecurity measures, stocking, seed sourcing, aeration, other infrastructure, mineral supplementation, harvesting and marketing.

The number of ponds in each cluster varied from 3 to 15 and the average area of the ponds varied from 0.42 to 1.23 ha. (Table 15). The average stocking density in the farms monitored ranged between 16-50 nos./ m^2 and the production achieved was between 3030 and 6267 kg / ha (Fig. 15). However, a low average production of 6780 kg/ha was achieved in Kalpakkam area because of the disease outbreak due to WSSV and IHHNV infection. The farmers harvested the crop at an average body weight (ABW) ranging from 19-30 g during the normal situation. However, the ponds in Kalpakkam area were harvested prematurely at an ABW of 15 g due to disease. Few of the farmers had shorter duration of culture (50-70 days) and harvested shrimp at an ABW of 10-14 g as the price for this count was proportionately higher and moreover in a year, they can go in for 4-6 crops.

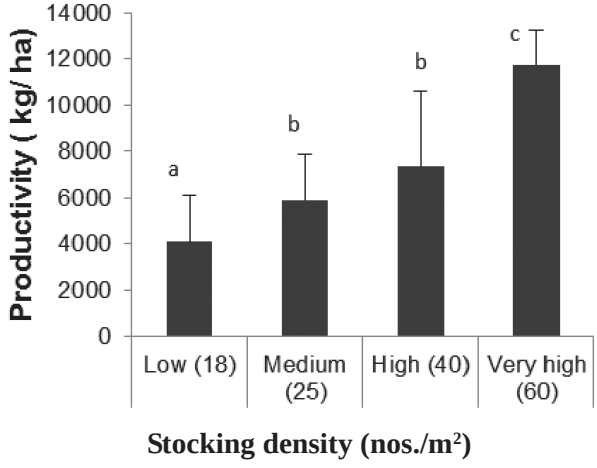


Fig. 15. Productivity across different stocking densities in *L. vannamei* culture

Table 15. Performance of the shrimp in ponds located in TN and AP

	Pond Area (ha)	Stocking /m^2	Harvested quantity (kg)	ABW (g) Mean*	ADG (g)
Tamil Nadu					
Kalpakkam	0.59	16	678	14.90	0.22
Sadras	0.42	24	3030	27.78	0.21
Pazhaverkadu	0.70	27	4737	28.55	0.23
Kattur	0.60	40	3987	19.55	0.22
Anupampattu	0.80	50	3602	24.40	0.20
Marakkanam	0.50	40	4862	28.00	0.20
Andhra Pradesh					
Suryalanka	1.00	43	6267	28.04	0.21
Thummanapalli	1.23	39	5542	30.33	0.24
Karlapalem	0.50	27	3155	29.20	0.21

*Means indicate averages pooled over 9 ponds per location

Environmental and microbiological parameters monitored included salinity, pH, calcium, magnesium, total hardness, alkalinity, EC, TDS, the ionic composition (Ca^+ & Mg^+), TPC and TVC. The duration of culture ranged from 70 to 140 days, the average stocking density ranged from 8 to 57 nos./m^2, the average harvest weight ranged from 19 to 30 g and the production ranged from 2.20 to 7.87 tonnes/ha. Higher microbial and vibrio load was recorded in ponds having higher stocking density and also during disease prevalence. Diurnal fluctuation of nitrogenous parameters and microbial load were found to follow a distinct pattern with bacterial load and metabolites increasing in the night. Failure in the crop was observed in 23.3 % of the total ponds, where premature harvest was done or survival rate declined thereby reducing the productivity by 70-90 %. In ponds where the stocking density was high, calcium and magnesium levels were lower compared to ponds with low stocking and often below the optimum level. Stocking density and culture duration greatly influenced the pond water quality parameters with ponds having higher biomass exhibiting higher level of nitrogenous metabolites like ammonia and nitrite and a relatively lower pH and dissolved oxygen. The production was influenced by use of probiotics leading to higher ABW as well as survival rate compared to conventional ponds that were not provided with probiotics during culture.

Biosecurity fence

Good plankton bloom in a vannamei pond

Biofloc-based farming system

Quantifying floc in a vannamei pond

Innovative vannamei culture practices

Due to high stocking in vannamei, some farmers minimize the duration of culture obtaining 80-100 count in two months benefitting monetarily. Most of the vannamei farms rely on minimal/zero water exchange thereby helping in maintaining biosecurity**.** Commercial probiotics of different bacterial strains comprising *Bacillus* sp., *Lactobacillus* sp. and *Pseudomonas* sp. are extensively used with various claims about its mode of action like disease prevention, immunomodulation, growth enhancement and bioremediation. There is a potential for application of biofloc technology in vannamei especially at high stocking density as it will not only decrease feed costs but also improve the water quality parameters. However, not many farmers follow the biofloc mode of production, though biofloc formation is natural at high stocking culture with or without carbohydrate addition. Some progressive farmers have started introducing a nursery phase to rear the PL10-12 for 2-4 weeks in an effort to bring down the culture duration.

FINFISH CULTURE DIVISION

Project Title (Institute)	**Dissemination of technology on the seed production of Asian seabass (*Lates calcarifer)* and development and refinement of seed production technology for other commercially important brackishwater fishes**

Improved breeding and seed production of Asian seabass

The captive broodstock was strengthened with addition of 35 fishes in the size range of 1.2-2.0 kg collected from wild. The existing larval rearing protocols were modified and larvae were stocked in tanks with water depth of 10 cm which was gradually increased to 90 cm @ 10 cm / day up to 9th day without water exchange and thereafter from 10th day onwards, 30% water exchange was carried out. The survival rate improved compared to the earlier protocol and the maximum was 70% with an average of 45% during a 25-day rearing period. A total of 9.3 lakh seed produced in the hatchery were supplied to farmers and R&D Institutes, the revenue earned being ₹ 7.06 lakhs.

Breeding of grey mullet and milkfish

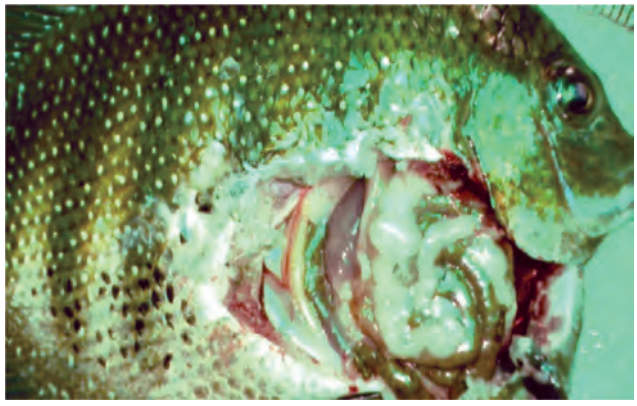
Land-based captive broodstock of Grey Mullet (*Mugil cephalus*) was strengthened with addition of 40 fishes in the size range of 0.20-1.21 kg collected from wild and stocked in ponds and holding tanks.

During the months of September-November, maturing females and oozing males were observed in this stock. In October, 6 trials were carried out using fishes with eggs having ova diameter of 340-502 µm. However, no successful breeding was observed since the fishes were not in the final stages of maturity and even with hormonal administration, ovulation was seen in only two cases. The feasibility of adopting *in vitro* fertilization techniques to accelerate ovulation was explored. The ova with a diameter of 340 µm was stripped, incubated with addition of E_2 and HCG in L15 medium @ 0.001 µg. Survival of the egg and improvement of egg size (from 350 to 450 µm) was observed, indicating the possibility of *in vitro* ovulation.

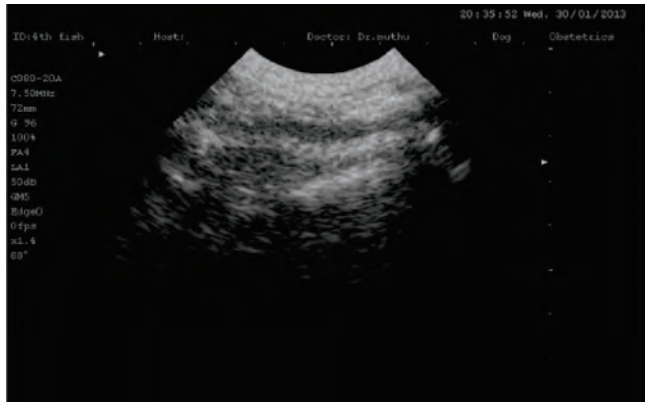
Captive land-based broodstock of milk fish *Chanos chanos* of age over 6 years in the size range of 3.5 to 5.0 kg were maintained in RCC tanks @1.0 kg/m^3 biomass. Thirty fishes in the size range of 0.5-1.5 kg were added to the existing broodstock and maintained in earthen ponds. Oozing males could be observed in the months of April-May. Maturing ova of 300 µm diameter was observed in a fish that died during the second week of May, indicating the possibility of female maturation under controlled conditions in the tank.

Non-invasive method to distinguish the sex of pearlspot

A feasibility study was carried out on the possibility of using ultra sonar probe with frequency of 7.5 Mz to assess the sex and maturity stages of pearlspot. The gonads of 12 fishes (> 80 g) were scanned to distinguish the sex and the result of ultrasound was confirmed with macroscopic observation of gonad through surgery. The preliminary observation confirmed the feasibility using the non-invasive technique for assessing sex and maturity stage when the fish are above 80 g.



Fish with immature ovary



Ultrasound scan image

Cage-based pearlspot seed production

Pearlspot breeding in small net cages (0.75m^3) was validated by conducting 10 seed production trials and the potential / cage was estimated to be between 200-300 fingerlings (5-7g) within 60 to 75 days. To understand the feasibility of incubation of eggs and larval rearing in absence of parental care, pearlspot eggs were removed from substrates and artificially incubated. The hatching rate ranged from 40 to 50% the lower rate being due to fungal infection. The hatching rate increased to 95-100 % against 45-60% in control when methylene blue was used. The survival of pearlspot larvae in the hatchery (0-30 dph) exceeded 90% when reared exclusively on rotifers (*Brachionus plicatilis*), *Artemia* nauplii or a combination of both. The removal of eggs from the parent fishes was found to reduce the intermittent spawning period and the pair spawned within 15 days' duration indicating the possibility of obtaining more offspring from a potential spawning pair.

Evaluation of different breeding systems for pearlspot seed production

The broodstock were maintained in healthy conditions in rigid PVC cages and RCC tanks. Five types of breeding systems were tested *viz*. RCC raceways (33 tonnes capacity); RCC tanks (18 tonnes) with flow-through; FRP tanks (1.2 t & 5 t) with flow-through; net cages; 1 tonne plastic tanks with recirculation and pond breeding system (at KRC). The RCC tanks and FRP tanks with water flow-through was found to be the most efficient in terms of seed production. In RCC tank breeding system, trials were conducted with and without soil at the bottom of the tanks. It was observed that more batches of seed could be collected from tanks with soil base (4 batches) than without soil base (2 batches). One day old (1 dph) larvae were collected from breeding nests (pits) and could be reared successfully without parental care. Batches of seed of age 1 dph to 40 dph were collected and fry rearing was carried out in indoor FRP tanks. Numbers ranged from 60 to 3500 per batch. During the larval rearing phases, rotifer and *Artemia* nauplii were fed followed by formulated particulate feed. To develop a recirculation system for seed production, a simple cost effective biofilter based system has been designed with four one tonne rectangular tanks and breeding trials have been initiated.

Recirculating tanks for breeding

Genetic studies in pearlspot

Genetic studies were initiated to evaluate growth and reproductive traits. Six full-sib families were reared separately in net hapas and cages fixed in a pond. Fishes were maintained in healthy condition with prophylactic treatments and feeding with pellets. Growth of the individual families was recorded at fortnightly intervals. The fish exhibiting higher growth would be selected for breeding.

Captive breeding of brackishwater ornamental fish - spotted scat

The broodstock of spotted scat *Scatophagus argus* was strengthened with the addition of 170 fishes in the size group of 72 to 320 g procured from commercial catches. Females and males were maintained in the ratio of 1:3 and about 45% spotted scat attained maturity. Twelve breeding trials were carried out through hormone administration initially with HCG as priming dose and LHRHa as resolving dose, out of which nine pairs successfully spawned through stripping and larval rearing performed for six sets. Scat larvae were fed with rotifers and *Artemia* nauplii and after 15th day, they were gradually weaned to artificial diet.

Fully mature spotted scat

Early fry

Effect of salinity on early fry of spotted scat

The effect of salinity on growth and survival of spotted scat fry was evaluated to ascertain the optimum salinity wherein maximum growth is exhibited. Thirty day old scat fry (16.1 mm/0.151 g) were stocked @ 4 nos/L in triplicate and reared in 5, 10, 15, 20, 25 and 30 ppt salinities for 30 days. Fishes were fed daily with artificial feed @ 5-8% body weight. At the end of the rearing period, better survival and growth in salinities between 5 and 20 ppt was observed in comparison to other salinities. Maximum survival rate of 98 % was recorded at 5 ppt followed by 10 ppt (97 %), 15 ppt (90 %), 20 ppt (88 %), 25 ppt (77 %) and 30 ppt (68 %) (Fig. 16). Scat fry attained maximum body weight of 0.550 g at 5 ppt and minimum of 0.415 g at 30 ppt. Similarly, total length of fry reached a maximum of 26 mm at 5 ppt and a minimum of 22.9 mm at 25 ppt. The results indicated that the optimum salinity for rearing of scat fry was 5 to 10 ppt .

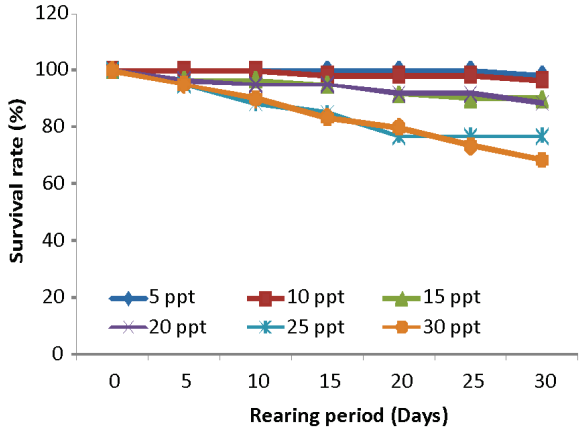


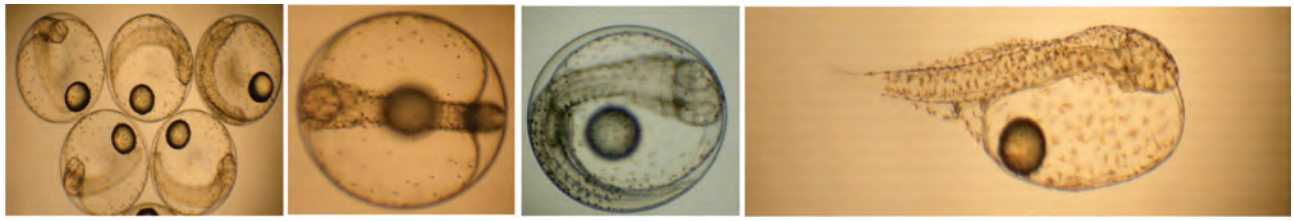
Fig. 16. Influence of salinity on survival (%) of spotted scat

Captive breeding of brackishwater ornamental fish - moonfish

Broodstock of moon fish *Monodactylus argenteus* (n=90; 45 to 110 g) maintained in an earthen pond, attained maturity. Females (75 g) with an oocyte diameter of above 400 µm and male (45 g-75 g) in oozing condition were selected for induced breeding. The HCG hormone @ 200 IU per fish for female was administered intramuscularly. After 24 hrs, LHRHa hormone @ 20 µg/per fish was administered. Two males were also administered only LHRHa of same dose and maintained along with the female for spawning. Between 16-20 hrs post LHRHa administration, female spawned spontaneously and fertilized eggs with a diameter

Broodstock of moon fish

of 830 µm were found floating on the surface of water. Fertilization was estimated to be between 50-77% with the hatching rate varying from 60-63%. This is the first report of pond-based captive breeding in *M. argenteus.* Larvae hatched 16 hrs after fertilization and the size was 1.66 mm. The fecundity estimated was 8-90 eggs/g. The newly hatched larvae were carefully transferred into larval rearing tanks and rotifer was introduced as an initial feed 36 hrs post hatching. However, larvae could be reared only up to 6 dph.



Embryonic and larval development of *Monodactylus argenteus*

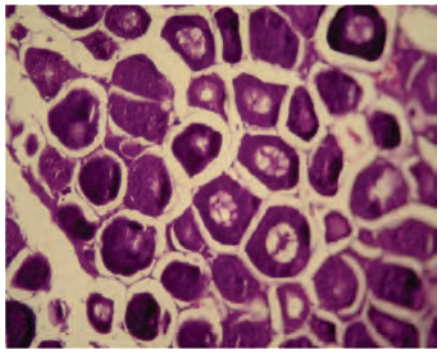
Reproductive physiology of grey mullet

Maturation and spawning of grey mullet has not been consistent under captive conditions. Hormonal profiling along with histological architecture of gonad would yield a clear picture of maturation. Hence, detailed investigations on the reproductive physiology of the wild population were undertaken as an initial step to have baseline information for comparison with the hormonal profile of captive populations.

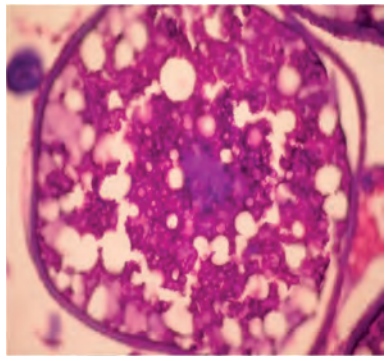
Different maturity stages of male grey mullet

Immature ovary of grey mullet

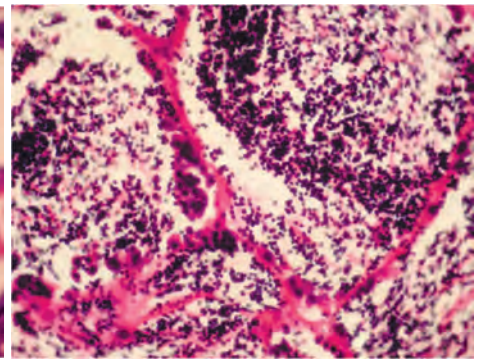
Histological features of the ovary



Immature ovary (Magnification 40X)



Maturing ovary (Magnification 40X)



Matured testis

Table 16. Hormonal profiling of wild male and female grey mullet

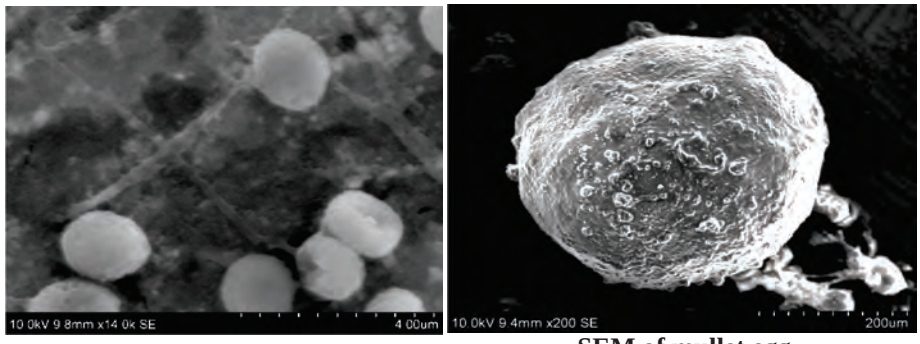
Maturity stages	Male			Female				
	Testosterone	Progesterone	Estradiol	Testosterone	Progesterone	Estradiol	vitellogenin	Oocyte dia. (mm)
Immature	$516^{d}\pm6.56$	$414^{a}\pm6.69$	$22.24^{a}\pm4.001$	$510^{c}\pm2.03$	$148^{c}\pm12.9$	$25.34^{c}\pm2.28$	$40.02^{d}\pm0.001$	-
Maturing	$750^{c}\pm0.001$	$130^{b}\pm4.67$	$14.16^{b}\pm1.53$	$628^{b}\pm12.12$	$483^{a}\pm4.93$	$186^{b}\pm4.17$	$106^{b}\pm5.13$	523
Mature	$914^{b}\pm40.25$	$8.5^{c}\pm1.33$	$2.24^{c}\pm0.23$	$938^{a}\pm30.37$	$309^{a}\pm6.36$	$323^{a}\pm13.02$	$286^{a}\pm3.87$	620
Ripe	$1820^{a}\pm40.25$	$1.8^{d}\pm0.14$	$0.9^{d}\pm1.4$	$312^{d}\pm12.20$	$488^{b}\pm4.9$	$310^{a}\pm13.0$	$181.67^{c}\pm0.08$	635
Spent	$412^{e}\pm13.20$	$2.7^{c}\pm0.25$	$1.20^{c}\pm0.001$	$300^{d}\pm41.37$	$78^{d}\pm10.97$	$10.6^{c}\pm0.65$	$40.22^{d}\pm0.08$	-

Values are expressed as mean ± SE, value in the column having different superscripts differ significantly (P<0.05)

Analysis shows that highest Vtg (Vitellogenin) and E2 (Estradiol) level in mature fish having oocyte diameter of 600 µm could pave the way for induced breeding in captivity through E2 administration or its precursor either through feed or by injection (Table 16).

Males and females in ratio of 2:1 have been maintained in a Recirculatory Aquaculture System (RAS) to assess maturity and year-round sex hormone profile of captive female broodstock. Monthly samples of blood for further studies are being collected through standardized non-invasive method by gently pressing the dorsal aorta.

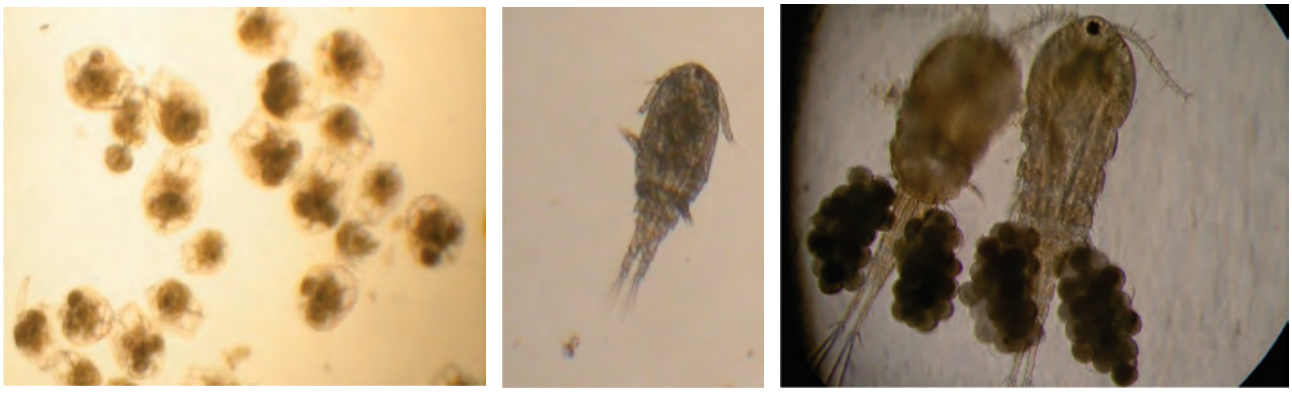
For understanding the structure of the spermatozoa, mature mullet were subjected to Scanning Electron Microscopic (SEM) study. Spermatozoa were 6.74 µm long with a head length of 1.72 µm and width of 2.0 µm. Mid piece length was 0.48 µm and the width was 0.72 µm. Flagellum length was 4.533 µm.



SEM of mullet egg

Mass culture of Copepod

The feasibility of using agro by-products for the mass culture of *Oithona brevicornis*, an important copepod used as live food for fish larval rearing, was evaluated. Fermented juice of groundnut oil cake (GNOC), gingelly oil cake (GLYOC), cotton seed oil cake (COC), rice bran (RB) and wheat bran (WB) were used in the experiment.



Nauplii (N) **Copepodite (CP)** **Adult (A) with egg sac**

Table 17. *Oithona brevicornis* fed with different agro by-products

Feed	N	CP	A	Total
RB	$2040^{c}\pm30.55$	$2040^{e}\pm23.33$	$1020^{c}\pm20$	$5010^{d}\pm53.64$
WB	$2030^{c}\pm33.33$	$1050^{b}\pm28.86$	$333^{b}\pm6.66$	$3420^{b}\pm50.44$
GOC	$1050^{b}\pm28.86$	$1530^{d}\pm26.66$	$1050^{c}\pm37.11$	$3620^{c}\pm64.89$
GLY OC	$1050^{b}\pm28.86$	$1250^{c}\pm17.63$	$1030^{c}\pm17.63$	$3330^{b}\pm58.59$
COC	$683^{a}\pm12.01$	$253^{a}\pm13.33$	$240^{a}\pm23.09$	$1176^{a}\pm38.44$

Values indicate density and are expressed as mean ± SE. Values in column with different superscripts differ significantly ($P<0.05$). (N-Nauplii; CP-Copepodite; A-Adult)

Adult copepods were introduced in the tanks @ 10 nos. and the maximum density was observed after 17 and 19th day of culture. Significantly ($P<0.05$) higher density of adult copepodites and nauplii were observed in RB juice fed tank than other groups indicating that fermented juice of RB could be used as feed for mass culture of *Oithona brevicornis* (Table 17).

Project Title (Institute)	**Improvement and validation of brackishwater fish culture technologies**

High-density rearing trials of seabass in cages

Rigid PVC wire mesh cages (2x1x1 m) were used for grow-out studies. Juveniles (20-25g) were stocked at 75 nos/m^3 and fed on formulated CIBA feed @ 5-7% body weight /day for 3 months at the end of which 80% of fish attained 150-170 g size. Further rearing is being done in a circular net cage. Presently, the size of fish ranges from 450 and 500 g after 105 days. Cage culture using advanced fingerlings stocked in rigid PVC net cages in open waters has also been initiated in Navsari. Trials are being carried out at Kollam in Kerala. On-farm pond culture trial is in progress at Danti farm in Navsari.

Milkfish larval rearing

Milkfish larvae (13 mm/8 mg) were reared in two densities (1000 & 2000 per 500 L) for 15 days, with *ad lib* algae, rotifer and artemia followed by micro-particulate feed. The fry attained 27 mm/144 mg, the overall survival being 74% (Table 18). Higher survival and growth were observed at lower densities.

Table 18. Milkfish larvae rearing at two densities

Stocking Density	1000 nos	2000 nos
Survival (%)	72-100	64-76
Final length (mm)	26.9-27.3	18.2-23.4
Final weight (mg)	144-135	54-91

Pond rearing of milkfish seed

In two ponds of area 875 m^2, milkfish of size 30 mm/0.3 g were stocked @ 1000 nos./pond in an effort to test the efficacy of providing periphyton substrate (bamboo poles) for enhancing growth. Fishes in the pond with periphyton substrate grew faster (final size after 120 days: 179 mm/40 g) compared to fishes in pond without periphyton substrate (174 mm/36 g). Nursery rearing trial of milkfish in a pond (already containing abundant *lab-lab)* at a density of 5000 nos./0.15 ha was undertaken at Danti Farm, during April-May 2012. From an average initial size of 23 mm/88 mg, the fishes attained 9.5-13.2 cm (8-10 g) in a month with a survival of > 60%.

Grow-out culture of milkfish

Monoculture of milkfish in a farmer's pond in Sahada (Odisha) at a stocking density of 2800 nos/ha yielded fishes with an average size of 350 g in a period of 4 months.

Milkfish grow-out cage culture

Rigid PVC net cages (13 nos) fixed in various aquatic environments (tribal villages of Kabilpore, Pathri and Kursad in Gujarat) were stocked with 11.5 g milkfish fingerlings at 50-60 nos /cage. The fishes have attained 74.6 g (Kabilpore) and 51.2 g (Pathri) in 3½ months, the demonstration being in progress.

Nursery rearing of *Mugil cephalus*

Nursery rearing trial of grey mullet fry in 11 ponds (460 to 963 m^2) was undertaken with a stocking density of 3 nos./m^2 and a culture duration of 60 days to test the effect of feed, periphyton and compost on growth. Results revealed that periphyton provided adequate nutrition comparable to supplementary feed (final weight 6.00-8.1g with periphyton and 6.00-8.25 g with feed) compared to compost alone (5.4-7.3g (Table 19).

At Sahada, nursery rearing of grey mullet at a density of 4 nos./m^2 yielded fishes of 30 g size in 60 days . Under monoculture at Madanganj, Namkhana over a period of 2 months, the fishes attained 100-120 g size whereas in Sahada, they attained 100-150 g in a similar duration.

Table 19. Growth of grey mullet using various feed combinations

Combination	Length (mm)	Wet weight (g)
Feed + Fertiliser	83	7.36
Periphyton + Fertiliser	84	6.96
Compost + Fertiliser	86	6.35
Control	85	6.32

Nursery rearing of pearlspot

Rearing trials conducted at MES to rear early fry of initial size 0.05g (14 mm) in net cages at a density of 50 nos./m^3 up to juvenile stages showed that the fishes attained 1.56 g in 40 days, 4.42 g in 77 days, 6.88 g in 108 days, 9.25 g in 143 days and 14.1 g in 204 days.

Grow-out culture of pearlspot

A trial was conducted in a farmer's pond (0.5 ha) at Balasore, Odisha where 125 nos. of 40-70 g to 100-110 g size fishes were cultured for six months' duration with formulated feed (35 % CP, @ 2% body weight). Majority of the fish attained 80-150 g size (larger fishes 200-220 g). Profuse breeding was also noticed. Monoculture trial was conducted at Danti farm in Navsari wherein 3500 nos (2.5-6.6 g size) of pearlspot juveniles were stocked in a 0.15 h pond. After 250 days of culture, the size ranged from 18 and 54 g with an overall survival of 40%.

Secondary Aquaculture of seaweeds

Cultivation of *Kappaphycus* sp. strung on nylon ropes was tried in broodstock holding pond. Bunches of *Kappaphycus* of 250 g grew to 900 g in 3 months. Harvest of over 1.5 tonnes of wet seaweed was obtained from 100 m^2 with 10 kg initial seeding. This trial indicated the potential of *Kappaphycus* cultivation within a brackishwater pond as a means of additional income.

Efficacy of seaweed for bioremediation of shrimp farm discharge water

About 100 to 500 g of *Kappaphycus* was suspended in 10 litres of shrimp pond discharge water (25 ppt) and the changes in nitrogen and phosphorus content in water was monitored. The level of 200 and 300 g seaweed was found effective in decreasing total ammonia nitrogen (TAN) by 71 and 88% in 48 hours. *Kappaphycus* was not effective in decreasing phosphate levels (the decrease being 26% only).

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

Development of viral vaccine against Noda virus for seabass

The whole-cell heat-killed Noda virus vaccine developed by the collaborating Institution was used for vaccination. Juveniles of Asian seabass of size 10.0 cm/14.0 g, 11.05 cm/18.2 g under two different temperatures (25°C and 28°C) were observed for 30 days post vaccination for evaluating the efficacy of the vaccine in terms of Relative Percentage of Survival (RPS) (Fig. 17). The results indicated that RPS was found to be 80% in the case of 25°C and 60.66 % at 28°C. The cumulative mortality due to the virus is relatively high at the lower temperature than at high, the vaccination being more efficient at the lower temperature than at high. However, vaccination helps in improving the survival at both the temperatures confirming the advantages of vaccine against Noda virus in the juveniles.

Challenge study in juveniles at 25±1⁰C **Challenge study in juveniles at 28±1⁰C**

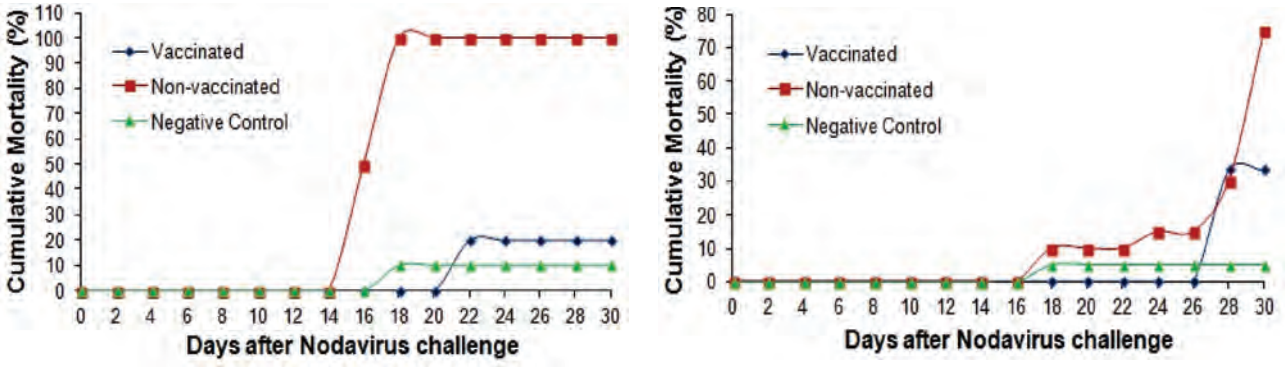


Fig. 17. Cumulative percent mortality and relative percent survival (RPS) in vaccinated and and non-vaccinated seabass

Immune related gene expression in vaccinated seabass

The immune genes expressed in thymus and head kidney of the vaccinated fish were quantified using Real Time PCR and the results indicated that the vaccine elevates the expression of immune-related genes (Fig. 18). An attempt was made to evaluate the efficiency of the vaccine by analyzing the immune related gene (CD8α & TNFα) from the thymus and head kidney of the vaccinated fish in different time intervals (Fig. 19).

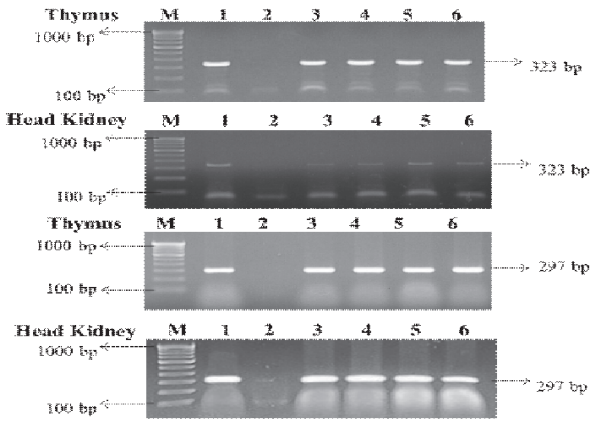


Fig. 18. RT-PCR analysis of immune-related genes (CD8 α and TNFα) expression in the thymus and head kidney of vaccinated fish at different time intervals
(Lane M – 100bp Marker,
1 – Normal Positive Control,
2 – Negative Control,
3 – 24hr,
4 – 3rd day,
5 – 5th day,
6 – 10th day)

Antioxidant enzyme activity and haematological parameters in juvenile fish

Some of the important antioxidant enzymes like GPX, GST, SOD, GRX, CAT and LPO and hematological parameters like Total Erythrocyte Count (TEC), haemoglobin, PCV, MCV, MCH and MCHC were assayed in the juveniles infected with Noda virus and also in fishes vaccinated and challenged with Noda virus. The results indicate that the activities of the enzymes were elevated in the vaccinated fishes compared to their non-vaccinated counterparts indicating the improvement of antioxidant defense system. In juveniles infected with Noda virus, there was a reduction in the hematological parameters count which are at normal levels under vaccination. It could therefore be inferred that whole-cell heat-killed vaccine is useful for protection against Noda virus infection in Asian seabass.

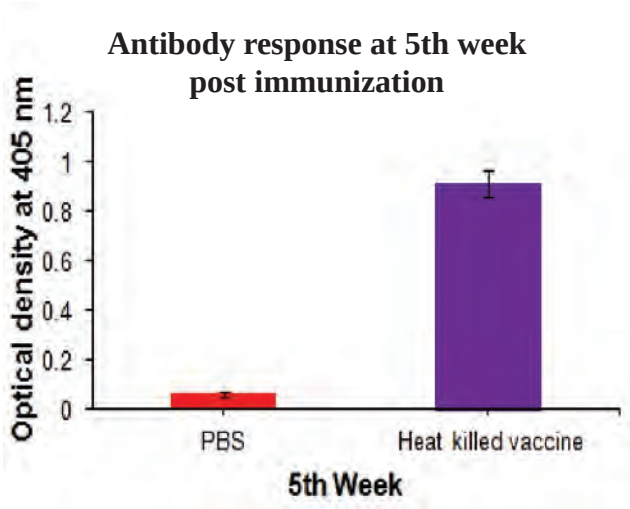


Fig 19. Sea bass anti-nodavirus ELISA titre (mean optical density ± SE for duplicates) for fish administered intramuscular injection of heat-killed nodavirus with adjuvant

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

Cobia broodstock development and breeding

The main objective was to develop a comprehensive technology for controlled breeding and seed production in hatchery using land based pond-reared broodstock of Cobia, standardizing the techniques for nursery rearing of fry and to evaluate the production potential and growth rate of this species in brackishwater pond culture system. A captive land-based broodstock was developed in a pond of 300 m^2. Fish from wild as also from culture ponds were transported to the hatchery site, quarantined for 7-10 days and thereafter stocked in the holding pond. The stocking density was maintained at about 1kg/m^3.

Cobia broodfish with *Argulus* sp. infestation

Fishes were fed with oil sardine and tilapia @ 5% of the biomass. Regular water exchange was carried out with the water quality parameters being monitored regularly. The broodstock succumbed to mortality during the last week of November 2012 mainly due to low concentration of Dissolved Oxygen (< 2 ppm). Later, the broodstock number was strengthened by procuring farm-reared stock from Tuticorin. Live fishes were stocked @ 6 kg/m^3 in a water tanker (40 fishes of average weight of 3 kg in a 20 tonne water tanker). The transportation involved a time of 17 hr wherein a distance of 700 km was traversed. This exercise brought out a good protocol for the successful transport of live Cobia fishes.

The fishes on regular monitoring revealed infestation with *Argulus* sp. The infection was severe on the forehead region, and base of the fins especially during the months of November-December when the temperature was low. The parasites were highly resistant to many treatment protocols and hence manual removal had to be resorted to regularly.

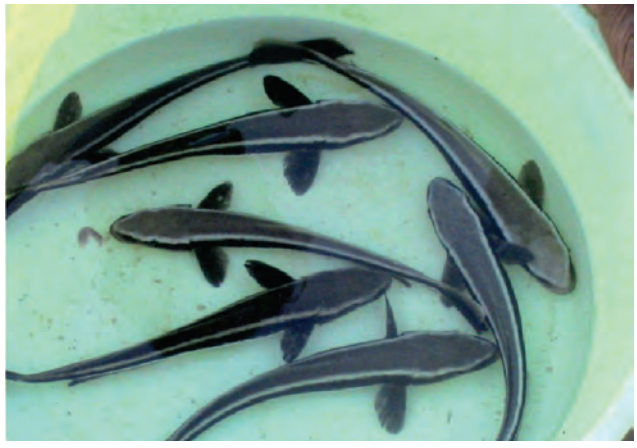
The pond-reared broodstock were monitored regularly for maturity. Fishes when mature, were transferred to RCC tanks for controlled breeding trials. Eight breeding attempts were made following routine protocols on females (ova diameter 590 to 693µm) in the range of 13 to 25 kg and males in the range of 3.5-12.0 kg . The fish responded and spawned four times, however, fertilization could be observed only in one case (75%), the hatching rate being 60%. The total number of eggs spawned was 15.0 lakhs.

Larval and nursery rearing

Larvae were stocked in indoor tanks and reared using green water technology. They were initially fed with rotifers upto 5th day after which artemia nauplii were introduced at a concentration of 100-150 nos./ltr up to 15th day. From 16th day they were gradually weaned to formulated feed. By 20th day, the fry were totally weaned to formulated commercial feed (INVE). However, over a period of 25 days, the survival rate was low (5%). The fingerlings were reared to juvenile size with INVE feed and thereafter with squid and fish meat. The fishes were maintained with a flow rate facilitating 100% water exchange. Hydrographical parameters were as follows: water temperature 28°C, salinity: 28.33 ppt, pH: 7.8, D.O.: 5.1, ammonia :0.032 ppm and nitrite: 0.018 ppm. Nursery rearing was carried out for 100 days the initial mean size being 7.63 cm and 3.82 g, attaining a mean size of 20.67 cm and 41.10 g. The overall survival rate was 72%.

Grow out Culture

The hatchery-produced seed were supplied to a private farmer from Gudivada, Krishna District, for stocking in grow-out pond at Peddapattinam. Fishes were fed with tilapia trash fish @ 20-50% of biomass and over a culture period of five months, they attained a weight of 1.0-1.25 kg. Salinity in the pond ranged from 27-29 ppt.



Nursery reared juvenile cobia

Cobia seed distribution to farmers by Dr. M. Sakthivel, President, AFI

A rearing trial under low-saline farming was carried out in a pond with an area of 1512 m^2 at Kakdwip Research Centre with hatchery-bred seed from CIBA, Chennai. Eighty two fingerlings (24 cm/70 g) were stocked @ 0.05 nos/m^2. Fishes were fed with chopped trash fish and formulated pellet feed in the ratio of 2: 1. After 150 days, fishes attained an average weight of 400.33 g with a length of 35.0 cm (Fig. 20). Mean exponential value of length-weight relationship (*b*) and condition factor (*K*) was found to be 3.567 and 0.81 respectively considering the whole culture period indicating good health condition. It could be inferred that growth would be higher in high-saline pond compared to that in low-saline.

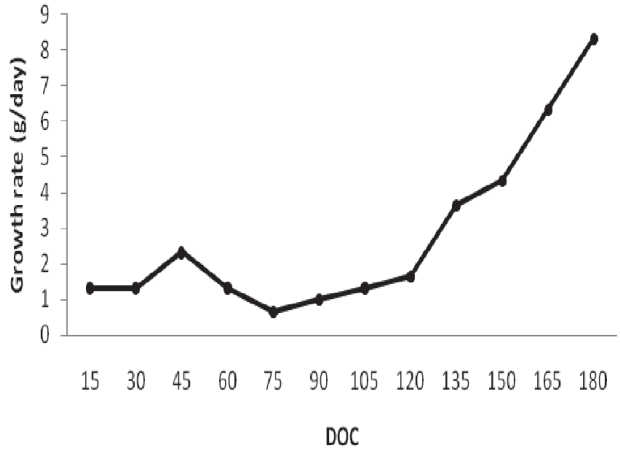


Fig. 20 Growth rate (g/day) of cobia reared in pond at KRC

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

The main objective was to demonstrate the techno-economic viability of Asian seabass in pond culture system. Various phases of seabass farming viz., nursery, pre-grow out and grow-out had been demonstrated earlier in the states of Andhra Pradesh, Tamil Nadu and Maharashtra. During this year, grow-out phase was continued at Harwada (Karwar) and Uttara Kannada (Karnataka) and all the three phases were demonstrated in farmers' ponds at Sahada (Balasore Dist., Odisha) and Madanganj (Namkhana, West Bengal). Hatchery-produced seabass fry were transported under oxygen packing in densities of 200-500/L water involving transportation period of 9-14 hours. At the destination points, the survival rate ranged from 94-98 %. The fry were acclimatized and reared to fingerlings size in small net cages (nursery phase) and to juveniles size in pond system (pre-grow out phase). The juveniles were cultured to marketable size by feeding formulated feed developed at CIBA or low cost fishes like oil sardine/tilapia.

Demonstration at Harwada

At Harwada, one pre-grow out trial was carried out. The juvenile fishes reared in small ponds (0.3 ha) during the previous year were transferred to 0.8 ha grow-out pond. The size of the fish at stocking was 23.5 cm/167.5 g (range-19 cm/85 g to 29 cm/250 g). After 34 days in the grow-out ponds, the fishes attained a size ranging from 36 cm/600 g to 51.0 cm/2.4 kg. The stocking density was 4000 nos./ha. The recovery rate was 91%. The production from 0.8 ha was 3057.6 kg @ 3.82 tonnes/ha.

Demonstration at Sahada

At Sahada, two nursery trials of rearing, two trials of pre grow-out and one grow-out trial were carried out. The first nursery trial lasted 45 days at a stocking density of 200 nos./m^3 in hapas. The survival rate ranged from 53.8 to 56.8%. Two pre grow-out demonstrations were carried out at Sahada. The nursery grown seed was further reared in earthen pond of 0.2-0.4 ha for obtaining juveniles. In the first trial, a 0.2 ha pond was stocked with 2,690 nos. @ 13,450 nos./ha with 3.8-5.0 cm to 0.9-2.0 g fish. The fish were reared for 60 days and at harvest, the size ranged from 16-18 cm (70-90 g) with a recovery rate of 63%. In the second trial which lasted 65 days, a pond of area 0.4 ha was stocked with 5700 nos. of fish @ 14,250 nos./ha (4.2-6.3 cm to 1.8-4.0 g). At harvest, the size of the fish ranged

from 14-22 cm (52 to 100 g) with a recovery rate of 58%. The fishes were fed with formulated feed @ 7-10% of the biomass in both the trials.

Farmers Interaction meet at Harwada, Karwar, Karnataka on 22.01.2013.

Two grow-out demonstrations were carried out at Sahada. In the first trial, the fish were stocked @ 3000 nos./ha (1200 nos./0.4 ha) with a size range of 18 -20 cm (90-110 g). After 354 days of culture, the fishes attained a size ranging from 35 cm/1.2 kg to 43 cm/3.5 kg using CIBA formulated feed initially for 200 days @ 3-4% of the biomass (total feed supplied was 980 kg) and thereafter with trash fish, the total trash fish supplied being 3.8 tonnes. The recovery rate was 76%. The second demonstration started in August 2012 wherein juvenile fishes (2,000 nos.@ 5,000 nos./ha) reared in the nursery from June 2012 in hapas for 41 days and later in the pre grow-out for 60 days, were stocked in the grow-out pond (0.4 ha). The size of the fishes at stocking was 16 cm/70 g to 18 cm/90 g. After 200 DOC, fishes attained a size ranging from 23 cm/245 g to 28 cm/700 g (estimated biomass was 0.9 tonnes @ 2.25 tonnes/ha/200 days) Fishes were fed with CIBA formulated feed @ 2-3% of the biomass. The total quantity of feed supplied was 1.83 tonnes and the FCR was 1.79. The third grow out culture demonstration was initiated in December 2012. Juvenile fishes in the size range of 14 cm/52 g to 22 cm/100 g were stocked in a 0.4 ha pond @ 5,000 nos./ha and were fed with CIBA formulated feed @ 2-3% of the biomass. After a culture period of 63 days, the size of fishes ranged from 20 cm/120 g to 28 cm/280 g. The estimated biomass was 720 kg (1.80 tonnes/ha), the total quantity of feed supplied was 1200 kg and the FCR was 2.1.

Demonstration at Madanganj

At Madanganj, two nursery rearing, two pre grow-out and one grow-out demonstrations were completed. In the first trial, fry (2.8 cm/0.4 g to 6 cm/1.2 g) were stocked @ 200 nos./m^3 in hapa net cages in the pond. Regular grading at an interval of 5-6 days interval was carried out. Particulate formulate feed @ 10% of the body weight was fed thrice daily. At harvest, the fish ranged from 4.8 cm/1.0 g to 9.8 cm/3.9 g with a survival of 61%. In the second trial, fry (2.5 cm/0.25 g to 4 cm/0.3 g) were stocked @ 100 nos./m^3. After 40 days, the size ranged from 3.5 cm/1.2 g to 9 cm/ 3.5 g with a survival of 71%. Particulate formulated feed @ 10% of the biomass was fed thrice daily. In the first pre grow-out trial, 6400 nos. nursery-reared seed were stocked in a 0.2 ha pond at a stocking density of 32,000 nos/ha and fed formulated feed and trash fish meat. The initial size of the stocked seed ranged from 4.8 cm/1.0 g to 9.8 cm/8.9 g. After 3 months, at harvest, the size of the fish ranged from 12.4 cm/42.3 g to 20.8 cm/75 g with a recovery rate of 68%. In the second trial, another 0.2 ha area pond was stocked with seed (4.5 cm/1.2 g-9.0 cm/3.5 g) @ 14,000 nos/ha (2800 nos/0.2 ha). Formulated feed @ 10% of body weight was fed initially which was reduced to 5% in the later phase. At harvest (81 days' culture) the fishes ranged from 18.5 cm/56.8 g-30.1 cm/90.0 g with

Harvested seabass at Sahada farm, Odisha

a recovery rate of 72%. The pre grow-out juveniles were stocked in two 0.4 ha ponds. In one pond, the stocking density was 10,750 nos/ha the initial stocking size being 12.4 cm/42.3 g-20.8 cm/75 g. After 108 days of rearing, the size of the fish ranged from 19.7 cm/92 g to 30 cm/418 g. In another pond, 2000 nos. of fishes in 0.4 ha (@ 5,000 nos/ha) with initial size of 18.5 cm/56.8 g-30.1 cm/90 g were stocked. After 96 days of rearing, the size range of the fish ranged from 20.8 cm/103 g and 40.3 cm/450 g. The fishes were fed with formulated feed @ 3% of body weight initially after which it was reduced to 2%.

Dr. S. Ayyappan, Secretary, DARE & DG, ICAR at the NFDB Workshop held at CIBA, Chennai on 23.02.2013

Impact of the demonstrations

The demonstration has made a significant impact on the farmers/entrepreneurs and coastal folk to take up nursery rearing and pre grow-out as a livelihood option. A large number of farmers have taken up nursery rearing as an occupation for additional income generation in the ponds and hapas. The Women Self Help Groups also have taken it up as an activity for enhancing their livelihood. During the year, six Farmers' Interaction Meets were conducted at Harwada, Kakdwip and Sahada. A Final Workshop was held at CIBA, Chennai, on 23.2.2013 during which the achievements at various centres on the demonstration of Asian seabass in pond culture system were discussed. A compendium comprising various achievements made at CIBA on Asian seabass, was released. Brochures on Asian seabass culture were released in Bengali, Odiya, Marathi, Telugu, Kannada, Malayalam and Tamil.

AQUATIC ANIMAL HEALTH AND ENVIRONMENT DIVISION

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

Unknown viruses unearthed through metagenomics

Viral metagenomics protocols were standardized and a single water sample from Kandaleru creek (Nellore) was processed. A water sample consisting of 80L was subjected to viral concentration using tangential flow filtration (TFF). The viral DNA was isolated from this concentrate and subjected to shotgun cloning using TA vector. Forty-six clones were obtained and screened for the presence of viral genome inserts by M13 PCR. The PCR amplification products of clones containing inserts were sequenced and analysed using bioinformatics online tools. The metagenomic analysis of the viral preparation of the water sample from Kandaleru revealed presence of circoviruses, beak and feather disease virus, nanovirus-like particles and grapevine associated totivirus-1. This is for the first time that metagenomics has been utilised for detecting the viruses present in a brackishwater creek.

Mass mortality in vannamei – the cause

Six cases of mortality in *L. vannamei* at a DOC of 20-62 days were investigated. Shrimp samples were screened for WSSV (White Spot Syndrome Virus), MBV, HPV and IHHNV using OIE protocols. While samples from five farms had WSSV infection (one of these five farms had co-infection with

IHHNV), they were negative for other viruses. One farm sample was not positive either for WSSV or IHHNV. Therefore, WSSV was suspected to be the main cause of mortality during this low DOC period.

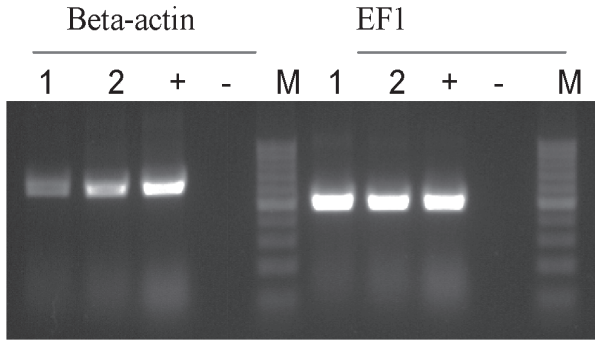


Fig. 21. Verification of cDNA synthesis from gills and haemocytes of tiger shrimp

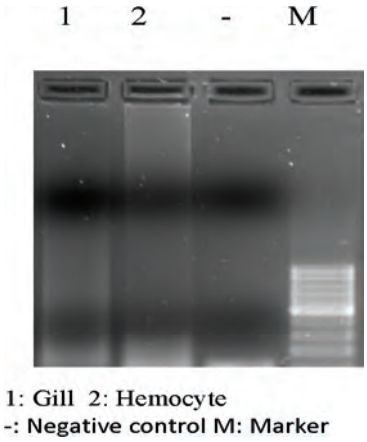


Fig. 22. Amplification of clones from gills and haemocytes of *P. monodon* by LD PCR

WSSV interacting proteins in tiger shrimp

Proteins interacting with WSSV were studied by Yeast Two-hybrid to understand the virulence mechanism and treatment strategy**.** Libraries were constructed from gills and haemocytes of wild tiger shrimp. The constructed cDNA was verified by amplifying two housekeeping genes beta-actin and elongation factor 1 (EF1) (Fig. 21). The cDNA was taken for LD PCR to amplify the clones and the amplified product was verified in agarose gel which were subsequently column purified. (Fig. 22). The amplified clones along with the library vector (pGB-GAD7) were transformed to yeast Y 187 by Lithium acetate method. This was plated onto synthetic deficient media devoid of leucine and the plates were incubated for 3 days. Colonies that developed were scraped and several frozen glycerol stocks were prepared. The libraries are being screened against already developed Vp15 and Vp28 baits of WSSV.

Role of IHHNV in vannamei size variation

The possibility of virus associated with size variation and growth reduction in different farms culturing vannamei was investigated. Nine samples from four different farms of Tamil Nadu and Andhra Pradesh were screened for IHHNV and seven suspected samples from four different farms were screened for LSNV. All the samples were negative for LSNV by RT PCR. Though six out of 9 samples were positive for IHHNV by PCR (Fig. 23), no gross abnormalities were observed. The PCR positivity for IHHNV was further verified by histopathology (Fig. 24).

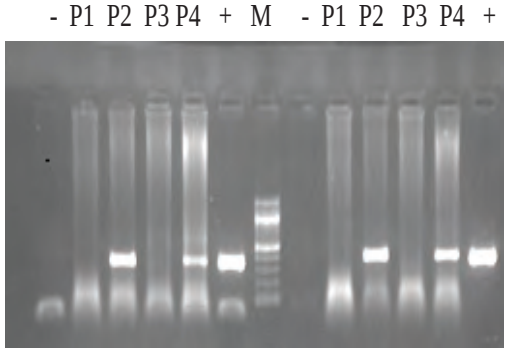


Fig. 23. PCR gel picture showing positive and negative signals for IHHNV infection by using OIE primers (356 bp & 392bp)

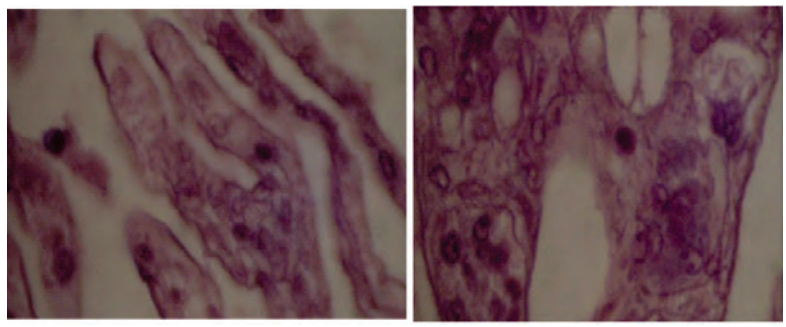


Fig. 24. Presence of prominent intranuclear, Cowdry type A inclusion bodies in the gill tissue of IHHNV infected shrimps (H&E 100X)

Vibrios associated with vannamei culture

The pattern of general distribution and role in shrimp mortality of different vibrios was investigated in farms culturing vannamei. Shrimp haemolymph samples from 16 farms (8 normal and 8 diseased farms located at Nellore, Gudur, Bhimavaram, Marakkanam, Kattur and Kalpakkam) were analysed both by biochemical and molecular characterization (Fig. 25). The shrimps from normal ponds were found negative for vibriosis. Shrimps from WSSV positive ponds were found to have higher composition of *V. campbellii* (60%) followed by others. Two ponds with mixed viral infection (WSSV and IHHNV) exhibited almost similar distribution of different nonpathogenic vibrios. However, two ponds negative for virus infection but exhibiting mortality, were dominated by pathogenic vibrios with *V. parahaemolyticus* (45%) being the predominant one.The study indicated that pathogenic vibrios played a major role in shrimp mortality during the absence of viral infection while less pathogenic species were abundant during the viral infection and probably played a role in accelerating shrimp mortality along with the viral pathogens.

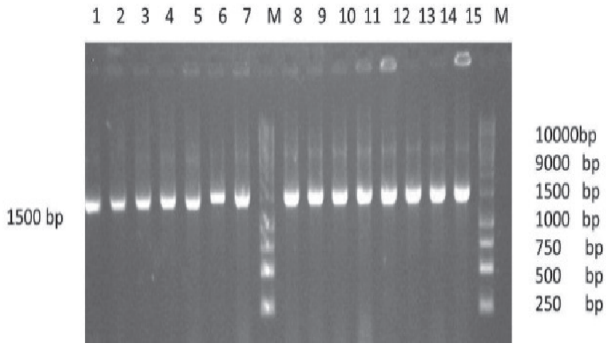


Fig. 25. 16S rRNA PCR amplification of bacterial isolates from haemolymph of diseased shrimp
(Lane M: 1kb DNA Ladder.
Lane 1-15: Amplified product from bacterial isolates)

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

Infectivity of WSSV in pond sediment and water

To comprehend the duration of infectivity of host free WSSV virions, viability or survival of WSSV in seawater and shrimp pond sediments under experimentally simulated drainable and non-drainable pond conditions was examined by shrimp infectivity experiments. The WSSV with an initial viral load of 1000 virions ml^{-1} was found to be viable for a period of 12 days in seawater of 27 ppt at 29-32°C as revealed by its ability to infect juvenile shrimp (Fig. 26), whereas in shrimp pond sediment (with initial viral load of 2,11,500 copies g^{-1}), the virus was viable and infective up to 19 days despite sun-drying (Fig. 27). In the case of non-drainable conditions, WSSV (7,53,600 copies g^{-1}) remained infective for a period of 35 days.

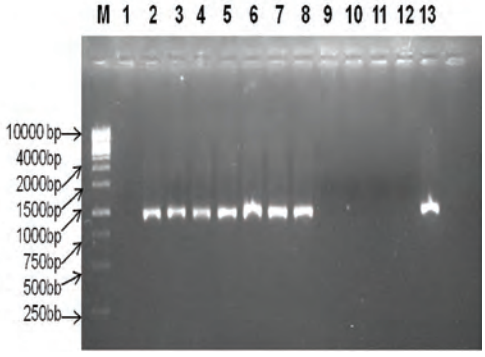


Fig. 26. Viability of WSSV in seawater as revealed by infectivity of shrimp (nested WSSV PCR): Lane M: Mol. wt. marker, Lane 1: control (shrimp in WSSV-free water)
(Lane 2: 0 day, Lane 3: 2 days, Lane 4: 4 days, Lane 5: 6 days, Lane 6: 8 days, Lane 7: 10 days, Lane 8: 12 days, Lane 9: 14 days, Lane 10: 16 days, Lane 11: 18 days, Lane 12: negative control, Lane13: positive control)

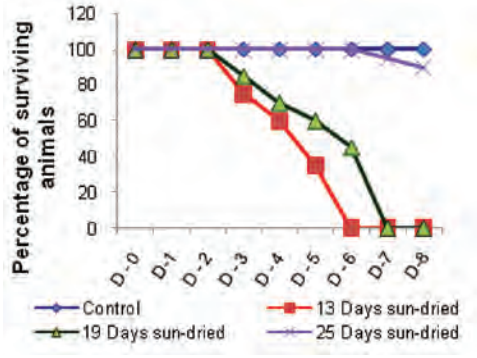


Fig. 27. Shrimp mortality pattern due to WSSV infection and WSD, an indicator of decline in WSSV viability in shrimp pond sediment during various days of sun-drying

Although the sediment samples tested nested-PCR positive after 19 days of sun-drying and 40 days under water-logged conditions, shrimp did not develop WSD, suggesting that the virus was not viable. Hence, PCR testing of shrimp farm sediment before starting culture as one of the BMPs may help in ensuring biosecurity for WSSV. The information generated here would help in the improvement of better management practices (BMPs) with regard to pond preparation protocols for shrimp aquaculture.

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

Nitrification-denitrification biofilter for ammonia and nitrite removal

Efforts were made to multiply the naturally occurring microbes by colonization on different substrates and use these to reduce the level of different toxic nitrogenous compounds. Commercially available filterfloss, aquamats, bioballs, aquaclay balls and ceramic rings were colonized with nitrifiers and denitrifiers. These colonized materials were tested for simultaneous removal of ammonia, nitrite and nitrate through nitrification-denitrification. Colonised materials were packed in an external biofilter (Fig. 28) and connected to a FRP tank containing 100 L of sea water spiked with 500 mg L^{-1} of NH_4Cl_2 and monitored regularly for nitrite levels using standard methods. The salinity of seawater was 15 ppt and the water flow rate was 1000 L^{-h}. After addition of bio-balls colonised with ammonia oxidising bacteria (AOB), nitrite levels were monitored for ammonia oxidation until 90 hrs. Thereafter, bio-balls colonised with nitrite oxidising bactera (NOB) was added and monitored for nitrite oxidation until 137 hrs. Aqua-clay balls colonised with denitrifying bacteria (DNB) were added and monitored for reduction in the levels of nitrite. Nitrite levels were found dropping from 0.56 µg/ml to 0.51 µg/ml. at 169 hrs, nitrite levels reached the peak, hence C source was added to induce DNB biomass for active denitrification. The C source was added twice during 167 and 187 hrs to manipulate C/N ratio. After addition of carbon source, the nitrite levels reduced from 0.74 µg/ml to 0.36 µg/ml. The experiments have indicated that combination of these microbes *viz.*,AOB, NOB and DNB could effectively be used in mitigating ammonia levels in aquatic systems.

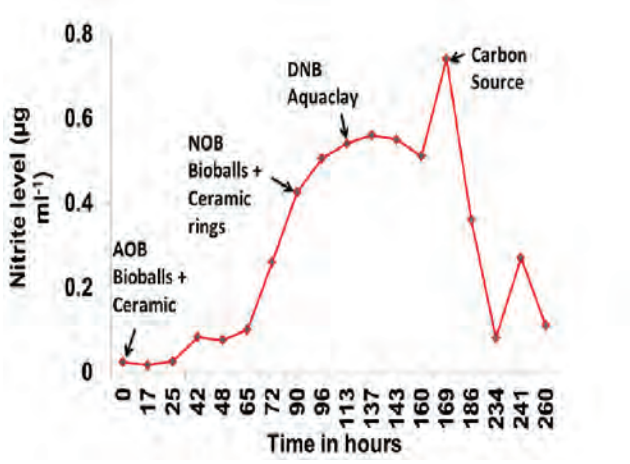


Fig. 28. Nitrite levels in ammonia spiked seawater using nitrification-denitrification biofilter

Evaluation of Biorings colonized with CSOB for sulphide removal

Biorings colonized with three different strains of Halomonas sp. were tested for sulphide removal in aquarium tanks. Aquarium tanks were daily spiked with 0.02 ppm of sulphide. After a week, the bottom of the control aquarium tank turned black indicating a high sulphide content while the experimental tank bottom remained unchanged. Difference in the bacterial community structure of the experimental tank sediment was observed using PCR-DGGE.This higher count of bacteria could be due to the migration of bacteria from the biorings to the sediments.

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

Microbial Diversity of aquaculture ponds

Metagenomic library was constructed from WSD affected shrimp pond sediment. The 16S rDNA was amplified using bacterial fD1 and rP2 universal primers and the amplified PCR products were purified and cloned into pTZ57R/T vector in *E. coli* DH5α. The clones were screened using M13F and M13R primers for inserts. Over 200 clones with 16S rDNA inserts were detected, out of which 61 clones were sequenced. The sequences were subjected to BLAST analysis to decipher the microbial diversity (Fig.29). A large number of bacteria hitherto un-reported in aquaculture ponds such as planctomycetes, chloroflexi, firmicutes, actinobacteria and verrucomicrobia have been detected.

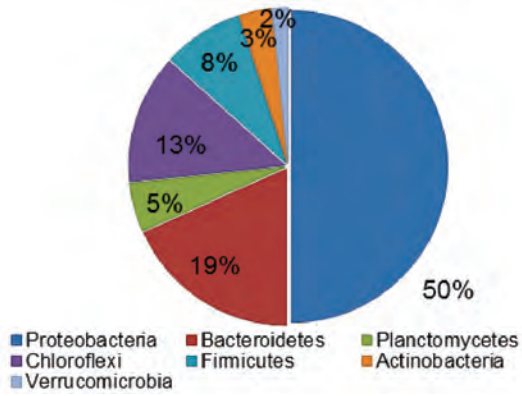


Fig. 29. Microbial flora of shrimp pond sediment affected by WSD

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

Cloning and expression of *Vibrio anguillarum* Outer Membrane Proteins

Outer membrane proteins of bacteria are considered ideal candidates for vaccine development. Three OMPs viz. OMP26La, K and U genes from pathogenic *V. anguillarum* were cloned into PET32a transformed to DH5α and expressed in BL21. The immunogenic potential of these proteins are being investigated.

To identify immuno-responsive proteins of *V. anguillarum*fromwhole cell lysate,2Dgel electrophoresis and Isoelectric focusing was carried out. The specificity IEF gels made for whole cell bacterial preparation was cross checked by western blotting. MALDI-TOF LC- MS/MS of 2D gel protein spots revealed eight immune responsive proteins from which OMPK was identified (Fig. 30). Bioassay studies with these three OMPs as potential immunogens are in progress.

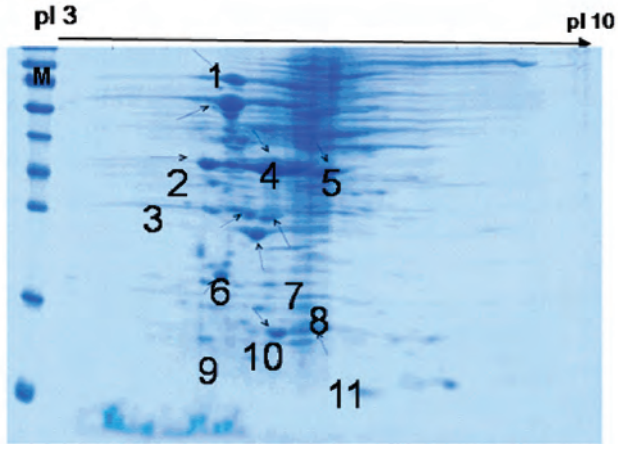


Fig. 30. 2D gel protein profile of *Vibrio anguillarum* strain HI 11326 whole cell preparation, M: Protein marker (Genei)

Project Title (NFBSFARA)	Defense genes of tiger shrimp *(Penaeus monodon)* with respect to bacteria *(Vibrio harveyi)* and white spot virus (WSSV) infection

Genotypes of a particular strain of WSSV in different penaeid shrimp hosts (*Penaeus monodon*, *Fenneropenaeus indicus* and *Litopenaeus vannamei*) were verified. Initially different genotypes of WSSV in different host systems from nature were verified. Genotyping was compared with three different ORFs: ORF 94, ORF 125 and ORF 175. There was no correlation in WSSV genotyping specific to any host or specific to any geographical location (Fig. 31).

Sequencing of ORF 75 fragment showed variable repeat units with 45 and 57 base pairs. An attempt was made to experimentally infect the WSSV strain from one host and passage it through different hosts. Initially, a strain of WSSV from tiger shrimp was passaged in *F. indicus*. Samples were collected till 4 passages. Thereafter, genotyping for all the above ORFs was carried out in all the 4 passage samples.PCR was carried out initially to test positivity for WSSV infection.The genotyping with respect to any of the ORFs tested did not change even up to 4 passages indicating that genotypes of WSSV do not vary with respect to different shrimp host (Fig. 32).

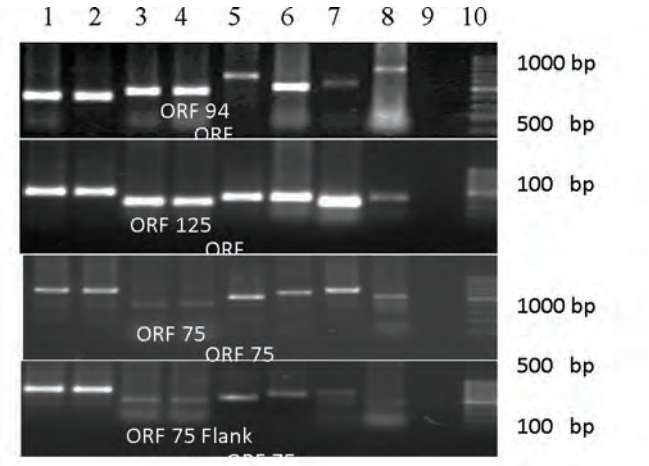


Fig. 31. Genotypes of different WSSV strains from different hosts and geographical locations obtained from culture ponds

1: monodon (Nagapattinam), 2: monodon (Marakkanam), 3: monodon (Bhimavaram 1), 4: monodon (Bhimavaram 2), 5: vannamei (Kalpakkam), 6: vannamei (Nagapattinam), 7: vannamei (Gudur), 8: vannamei (Nellore), 9: Negative control 10: Marker

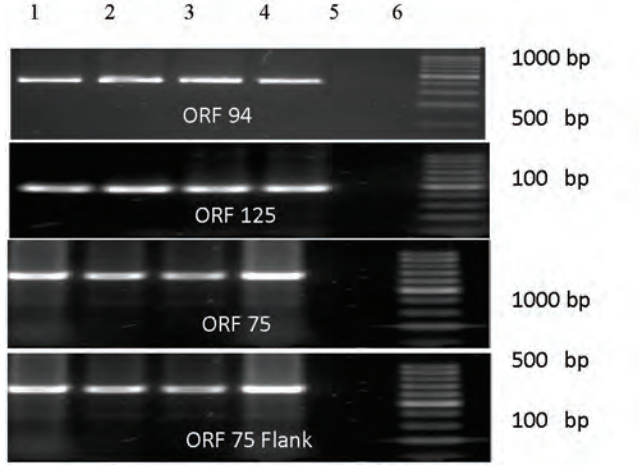


Fig. 32. Genotyping of WSSV after passage in *F. indicus* (Passage 1, 2: Passage 2, 3: Passage 3, 4: Passage 4, 5: Negative control, 6: Marker)

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

Cassava waste biomass enhances bioremediation and shrimp growth

A yard experiment was conducted in 500 L FRP tanks in triplicate for 92 days with two different stocking rates (8 and 16/m^2) with tiger shrimp (ABW: 0.25 g) with and without aeration (A, NA) at a salinity of 34-36 ppt. Cassava waste biomass (CWB) was added on the first day in the treatment tanks except in control and the animals were stocked on the 19th day of the experiment. Water samples were collected at periodic intervals for analysis of physico-chemical and microbial parameters. In treatment tanks with CWB and no aeration (CWBNA8, CWBNA16) all animals died on 12th day post stocking due to the reduced dissolved oxygen value of 3.1 mg /l, whereas in treatments with aeration, the value was 6.12 mg/l. Although total ammonia nitrogen (TAN) (Fig. 33) and nitrite nitrogen (NO_2-N) concentrations were within the normal range in experimental tanks, CWBA8 and CWBA16 showed comparatively low level of metabolites compared to control. The total heterotrophic bacteria (CFU/ml) was in the range of 7-16 X 10^5 to 1.9-3 X 10^5 in CWBA8 and CWBA16 respectively compared to other treatments (10^2 to 10^4) whereas a reverse trend was observed for total vibrio count (TVC).The shrimp in CWBA8 treatment showed higher growth compared to those in CWBA16 followed by control with aeration (CA8 and CA16) and controls without aeration (CNA8 and CNA16) (Fig. 34). The results confirmed previous results of increased shrimp growth with CWB and also indicated that CWB should not be added without aeration.

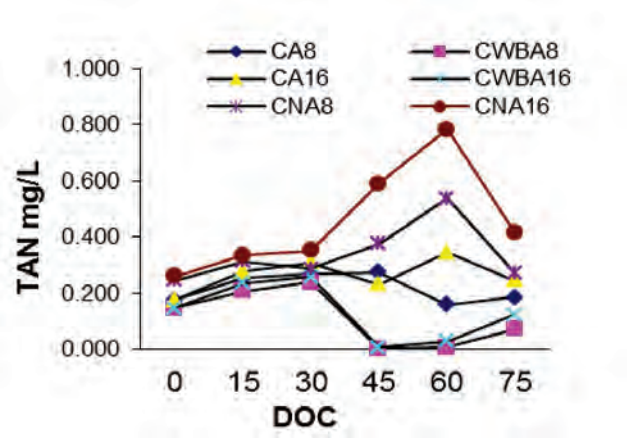


Fig. 33. Total Ammonia Nitrogen levels in control (A & NA) and CWB (A) treatment tanks

C – Control; CWB – Cassava waste biomass; A – Aeration; NA - No aeration; 8 and 16 are stocking densities

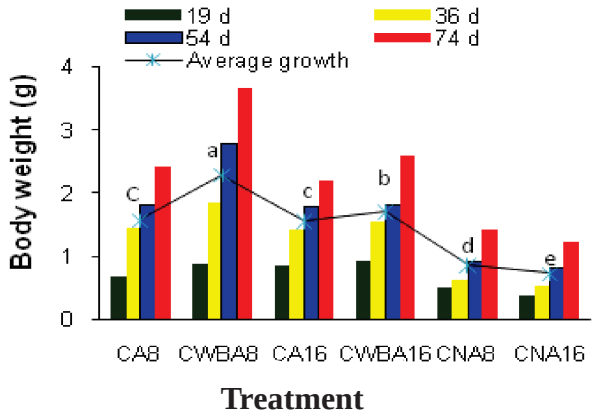


Fig. 34. Shrimp growth in control (A & NA) and CWB (A) treatment tanks

(values with different superscripts are statistically significant (P<0.05)

Ascertaining if toxic hydrocyanic acid leach from cassava byproducts

To ascertain whether the toxic hydrocyanic acid (HCN) would leach into water when used for bioremediation, cassava byproducts (viz:CWB, cassava powder and cassava tippi) were soaked in 100 L FRP tanks containing seawater (34 ppt). Analysis of water and substrate samples from the experimental tanks for toxicity of hydrocyanic acid (HCN) at different time intervals (24, 48, 72 and 96 h) revealed that HCN was not detected (detection limit of 0.02 mg/L) in any of the samples.

Comparison of inert and non-inert materials for bioremediation efficiency

To evaluate if non-inert materials like CWB and sugarcane bagasse (SB) were superior in bioremediation to inert materials like nylon mat and polyvinyl chloride (PVC) pipe, the efficiency of bioremediation of metabolites was compared in 100 L FRP tanks for 22 days. Ammonia and nitrite induction was carried out using ammonium sulphate and potassium nitrite, respectively. The treatment groups with non-inert materials showed high reduction of TAN (63-71%) and nitrite-N (10-14%) in 72 h after induction compared to inert materials and control with reduction of TAN (55-58%) and nitrite-N (2-8%.) The treatment groups with non-inert materials showed high total heterotrophic bacterial population in CFU/ml [44 (SB) to 10400 (CWB) x 10^3] compared to those with inert materials and control (6-34 x10^3) (Table 20).

Table 20. Per cent reduction of metabolites and total heterotrophic bacterial count

Treatment	% reduction of metabolites in 72 h		THB(X 10^3 CFU/ml)
	TAN	NO_2- N	
Control	58.4	7.7	10-14
Nylon mat	55.0	6.5	13-34
PVC pipe	56.8	2.3	6-16
CWB	71.1	14.4	84-10400
SB	62.6	9.7	44-850

Comparison of environmental parameters in traditional and monoculture farms

To study the dynamics of traditional farming systems: Pokkali (PS) and Bheri systems (BS), monitoring of environmental parameters (pH, alkalinity, ammonia, nitrite and nitrate) was carried out in two

traditional pokkali fields in Kerala, two small and two large bheries in West Bengal and two tiger shrimp monoculture farms (SM) near to PS and BS. Pokkali rice is cultivated from June to early November when the salinity level of the water in the fields is low whereas shrimp farming is practiced during high saline phase. The environmental parameters were evaluated in summer, monsoon and winter. There was no appreciable difference in the parameters measured, between traditional and SM farming systems. It could be inferred that in spite of higher stocking density and biomass, monoculture farms had similar water quality parameters as that of bheries which might be due to better management practices and application of probiotics.

Environmental parameters in vannamei farms

Environmental monitoring programme (EMP) of vannamei farming was initiated from August 2012 on Paleru River (study area – 8.1 km), the source and receiving water body for vannamei farming in 870 ha of Prakasam District, Andhra Pradesh. Twelve sampling stations on the water body (Fig. 35) and sampling points for shrimp farms discharge water samples were fixed randomly to assess the impact of discharge water from the culture farms on the receiving water body and three places were selected at different villages for the collection of soil samples at various distances away from the farms (0, 50, 100, 200, 300, 400 and 500 m) for soil salinization. Analysis of monthly samples revealed that though parameters like total ammonia N and total N from few cultured farms were above the standard limit, their concentration in the water body at all the sampling places were within the standard values prescribed by the Coastal Aquaculture Authority. Total plate count (TPC) and vibrio count (TVC) in source water and soil were within the optimum range (x10^3 cfu/ml), and varied from 0.3 to 10.1 and 0.01 to 0.71 in water, and 0.9 to 18.9 and 0.06 to 0.99 in soil, respectively (Fig. 36). The water body had a good dilution rate

Fig. 35. Sampling stations on Paleru water body

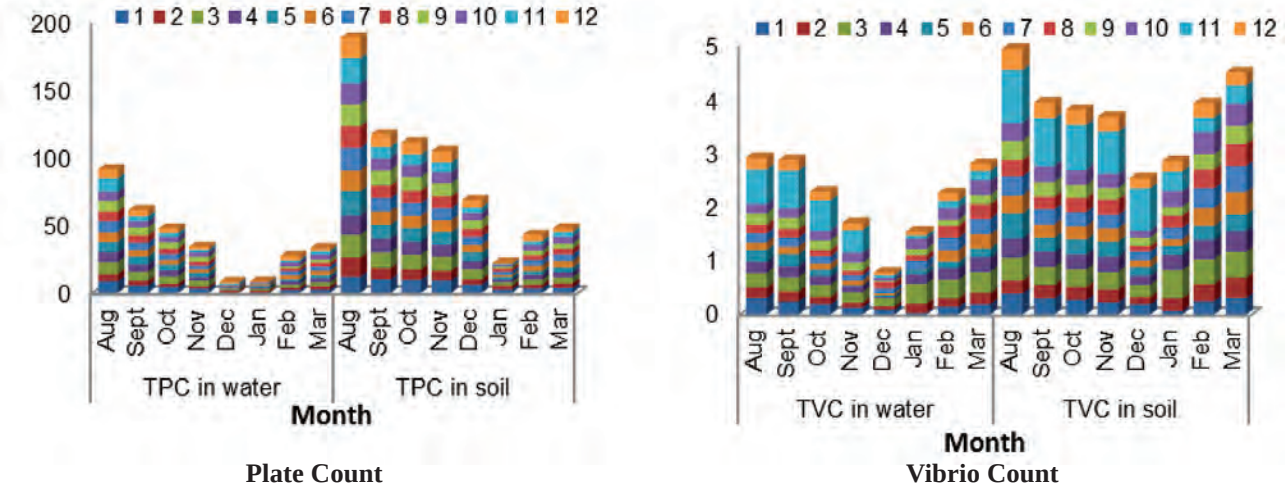
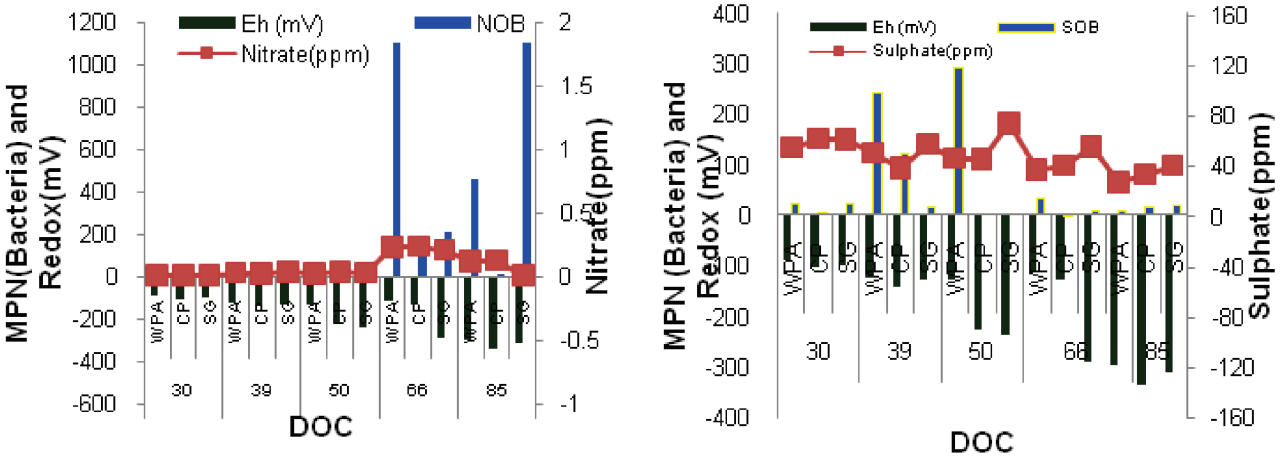


Fig. 36. Total plate and Vibrio count in water and soil from Paleru River (Each column represents the count (TPC and TVC) of all the 12 sampling stations. Each block from the bottom of the column proportionately indicates the bacterial count (x10^3 cfu/ml) for the sampling sites 1 to 12 independently).

and flushing time to assimilate the nutrient concentration from the shrimp farms and other activities. There was no soil salinisation as evidenced by the electrical conductivity values of less than 4 dS/m.

Optimization of sampling protocols for redox potential in shrimp culture ponds

The value of redox potential value at different sampling places within a pond and during different DOC is dissimilar and hence it is difficult to draw any valid conclusions based on these values. In order to get an idea of pond bottom condition based on the measurement of redox potential, temporal (at different DOC) and spatial sampling from three places, water pumping area (WPA), pond centre (PC) and sluice gate (SG) was carried out in three vannamei culture ponds. In addition to the redox potential (E_h), soil OC, water (TAN, NO_2, SO_4, S^{-2}) and microbial parameters (AOB, NOB, SOB and SRB) were also analysed. Although large variation exists in E_h values, as a whole, the values were high at SG followed by PC and WPA. The AOB population trend was not uniform during culture period and could not be correlated with TAN and nitrite concentration. The NOB population increased after 60 DOC and was correlated with increased nitrate concentration (Fig. 37a). The SOB population decreased towards the later stage of culture (Fig. 37b), whereas SRB population increased with DOC and remained more or less same during culture period. High negative E_h values were positively correlated with organic carbon (OC) in soil and SRB and negatively correlated with AOB, NOB and had weak correlation with SOB. To monitor the condition of the bottom of the pond, it is recommended that the E_h near to the sluice gate needs to be measured.



a) b)

Fig. 37. Variation in E_h, a) NOB and nitrate b) SOB and sulphate at different sampling places during *L.vannamei* culture

Classification and categorization of aquaculture chemicals available in market

In view of the large number of aquaculture chemicals available in the market, there exists a need to categorize them so that inputs on their control can be rendered for policy decisions. With this objective, a survey of aquaculture chemicals available in the market for shrimp farming was carried out in Prakasam and Nellore Districts. Details of 182 chemicals were collected with a structured questionnaire categorised at three levels. At the first level, based on the purpose for which the chemicals are used, they were categorised into feed supplements, disinfectants, prophylactics and therapeutants and soil & water conditioners. The second level included probiotics, growth promoters, vitamins, enzymes and amino acids, immunostimulant (feed supplements), inorganic and organic chemicals (disinfectants),

antibacterial and antifungal (prophylactic and therapeutants) and herbal conditioners for soil & water. The third level included dissolved oxygen enhancers, plankton stimulators and ammonia and nitrite removal products under probiotics group of soil and water conditioners.

Nitrogen pathway in shrimp culture using tracer techniques

For tracing the nitrogen pathway in shrimp culture, a yard experiment was conducted in triplicate with 10 animals (ABW: 4.2 g) in 100 L FRP tanks for 17 days with different combinations of ^{15}N enriched shrimp feed. Soya bean meal (^{15}N enriched) was prepared by incorporating soya cake at various levels (0, 15, 20, 30 and 45%) by altering the fishmeal and other marine protein sources in the feed. Water was exchanged once in 4 days. Survival rate was around 99% and the shrimps attained a size of 6.7 g. The ^{15}N content was measured in ^{15}N enriched feeds and shrimps at the end of the experiment using mass spectrometer. The results revealed an increase in ^{15}N concentration in the feeds and shrimps with increasing ^{15}N soya cake content (Table 21). The nitrogen pathway will be assessed after the completion of ^{15}N analysis in the water and soil samples.

Table 21. ^{15}N content in feeds and shrimps for tracing the nitrogen pathway

Treatments	Feed		Shrimp	
	Total N (%)	^{15}N (%)	Total N (%)	^{15}N (%)
Control 20% SBM	6.406	0	10.49	0
15% ^{15}N SBM	6.6499	0.5194	10.1389	0.1912
20% ^{15}N SBM	6.4752	0.7497	10.4514	0.3545
30 % ^{15}N SBM	6.3635	0.8887	10.7590	0.6596
45% ^{15}N SBM	6.2473	1.0867	10.7478	0.7591

Nano-sensor for detection of metabolites

The work on sensors using nano materials had been initiated for the early detection of metabolites in the aquaculture pond environment. Single walled carbon nanotubes (SWCNT) of 4 nm diameter were used for the fabrication of nano sensor. Different solvents viz., acetone, chloroform and N, N- Dimethyl formamide (DMF), were screened for the dispersion of SWCNT and it was observed that DMF is the best solvent as it gave good dispersion. In order to coat the SWCNT suspension, two methods were evaluated i) 250 µl was drop casted and ii) spin coated at 900 rpm on glass slides pre-treated with 3-aminopropyl triethoxy silane (APTES) and dried in hot air oven at 100°C for 10 min. It was observed that spin coating resulted in 80% of the sample getting wasted whereas drop casting ensured stability in coating. Characterisation of coated glass slides using scanning electron microscopy (SEM) revealed SWCNT network. Platinum electrode was fixed on CNT slide and its response was tested against ammonia and nitrite using multi meter. The results revealed that the resistance of CNT with metabolites in comparison with air, increased with ammonia concentration and decreased with nitrite concentration (Table 22).

Table 22. Change in resistance of SWCNT under metabolites

Metabolite concentration	R_a	R_t
NH_3 1.0 ppm	3.12	280
NO_2 1.0 ppm	3.40	0.5

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

Quantification of greenhouse gases from aquaculture ponds

The method of Greenhouse gases (GHGs) analysis was validated by carrying out analysis of the same samples at two Institutes with different instruments. Comparison of the values showed per cent variation of -1.3 to 2.4, -9.6 to 9.8 and -5.7 to 5.8 for N_2O, CH_4 and CO_2 values, respectively confirming the validity of the method.

The GHGs N_2O, CH_4 and CO_2 emission were quantified from four *Litopenaeus vannamei* farms (at different stocking densities) and one tiger shrimp farm in Andhra Pradesh and Tamil Nadu for a period of four months. In addition, traditional farming system (Pokkali fields) of Kerala was also studied. Average emission of GHGs in g $ha^{-1}day^{-1}$ was high in traditional farming compared to scientific shrimp farming with vannamei and monodon. Global warming potential (GWP) values in kg CO_2 eq./ha/season were 91 in tiger shrimp farm, 218 to 351 in vannamei farms and 405 in Pokkali shrimp farm. The GWP values increased with the increase in stocking density (Table 23). These values were much lower compared to GWP values from paddy fields of Orissa (4180) and livestock in Tamil Nadu (646), where GHG, CO_2 was not estimated in both the cases. Continuous measurement of these gases would provide useful information to track gas emission trends and help to combat climate change.

Floating chamber for the collection of GHGs in Pokkali shrimp pond

Table 23. GHGs emission from shrimp aquaculture ponds

Shrimp farming system/Species (Study area)	Stocking density (No./m^2)	Avg. GHG emission (g/ha/d)			GWP (kg CO_2 eq./ ha/ season)*
		N_2O	CH_4	CO_2	
L.vannamei (Mammalapuram, TN)	20	-1.43	6.67	2083	218
L.vannamei (Kattur, TN)	25	1.57	7.67	1600	271
L.vannamei (Marakkanam, TN)	44	0.90	8.70	2004	299
L.vannamei (Ongole, AP)	50	-0.06	1.83	2923	351
P.monodon (Marakkanam, TN)	18	0.28	1.17	644	91
Traditional farming (Pokkali, Kerala)	-	2.02	4.34	2663	405

*GWP was calculated per season of 4 months culture/crop (120 days)

Quantification of microbial biomass carbon (MBC) in aquaculture systems

The MBC, an indicator for increased atmospheric carbon dioxide (CO_2), accelerates global warming. The changes in soil MBC was studied in scientific farms in Tamil Nadu, Andhra Pradesh and traditional farms in Kerala. In scientific shrimp ponds, MBC in soil ranged from 50 to 938 µg C /g and 70 to 721 µg C / g in vannamei and monodon culture ponds, respectively whereas in traditional shrimp farming ponds, the MBC in soil ranged from 584 to 2114 µg C /g. Organic matter content in pond soils ranged

from 0.36 to 1.24% and 0.62 to 2.2% in the scientific and traditional shrimp ponds, respectively. The values of MBC and total organic carbon (TOC) were significantly correlated with days of culture (DOC) and were very high during summer crop compared to winter crop of vannamei (Fig. 38). The traditional shrimp farming system with high MBC and organic matter compared to the scientific shrimp farming system, may contribute more to the increased atmospheric CO_2.

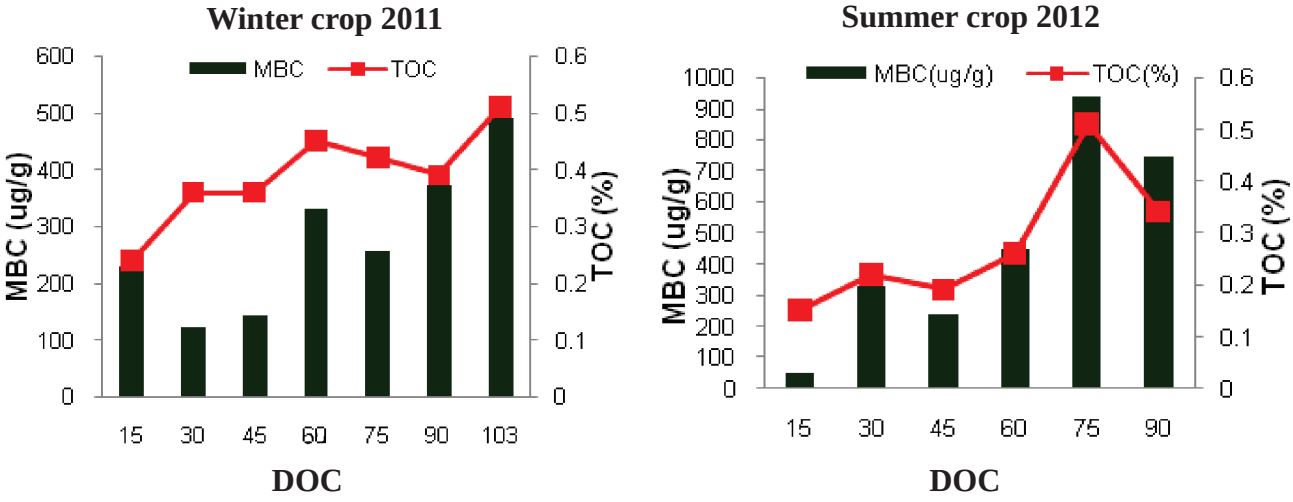


Fig. 38. MBC and TOC variation in soil during summer and winter crops of *L.vannamei*

Climate change impacts and vulnerability assessment of aquaculture

Based on the earlier developed methodology and data analysis of extensive farmers' survey (n=120) in one district each in four coastal states viz., West Bengal, Andhra Pradesh, Tamil Nadu and Kerala, shrimp aquaculture was found to be moderately vulnerable to seasonal variations (20-40 % loss) and extremely vulnerable to severe climatic events (50-100 % loss) like flood, heavy rains and cyclone. Vulnerability assessment of aquaculture to climate change based on exposure, sensitivity and adaptive capacity indicators indicated that 4-19 %, 37-66 %, 1-34 % and 9-43 % of the aqua farmers in all the four states were under high, moderate, low and very low categories respectively.

Perceived climate change impacts and adaptation measures in Gujarat

The major climate change (CC) events - perceived through the standard methodology of focus group discussions, stakeholder workshop and extensive farmers' survey were :diurnal temperature fluctuations, irregular rainfall, high and low temperatures with per cent production loss up to 10, 20, 30 and 50 respectively.The stakeholders identified the following measures to increase the adaptation capacity of farmers: to set up an institute with one station for each coastal district with all laboratory testing facilities for feed, seed, soil and water; training for farmers on better management practices and create exposure on CC effects; low premium for aquaculture insurance for the benefit of farmers; research on the candidate species which can tolerate low temperature during winter; standardisation of culture technologies for shrimp species like *F. merguensis* and *M. kutchensis* and finfish species like seabream, mullet and pearlspot by multi-location trials in different crop calendar periods; preparation of region wise cropping calendar; and to popularize the 'aquaculture plan' adopted by Gujarat with master mapping of the total brackishwater area for proper planning and regulation to prevent the damages caused by the extreme climatic events.

Impact of sea level rise on aquaculture in West Godavari District

Out of 14,827 ha of aquaculture area, about 11 ha would be submerged with 0.5 m SS/SLR and 14,816 ha would be submerged with 1 m SS/SLR (Table 24).

Table 24. Potential inundation in land resources at 0.5 m and 1 m SS / SLR in West Godavari District, Andhra Pradesh

Class	Existing Resource (ha)	Inundated area (ha)	
		0.5 m SLR	1 m SLR
Agriculture	22229.35	262.56	21966.79
Aquaculture	14826.86	11.03	14815.83
Mudflat	2049.30	32.83	2016.47
Settlements	2059.86	-	2059.86
Water bodies	639.05	-	639.05
Total	41804.42	306.41	41497.99

Table 25. Sen's slope estimator of slope for seasonal and annual weather parameters (Bold values indicate statistical significance at 95% confidence level, + for increasing and - for decreasing)

Variable	Summer	Rainy	Winter	Annual
T_{Max}	**0.015**	**0.027**	**0.035**	**0.025**
T_{Min}	-0.011	0.005	-0.015	-0.007
T_{Mean}	0.001	**0.016**	0.009	**0.008**
T_{HMax}	0.000	0.020	0.016	0.000
T_{LMin}	**-0.047**	0.007	**-0.029**	**-0.027**
RF	0.866	1.467	-1.240	-1.903
RD	0.348	0.345	0.477	**0.837**

Month, season (winter, summer and rainy) and year-wise trends were computed through Mann–Kendall (MK) test for weather parameters viz., maximum, minimum, highest maximum (T_{HMax}), lowest minimum (T_{LMin}) and mean temperatures, rainfall (RF) and number of rainy days (RD) of Nagapattinam District, a major shrimp farming area in Tamil Nadu using data of 40 years (1961-2000) obtained from Indian Meteorological Department, Pune. Statistical significance of the trends was decided by MK 'Z' statistic and magnitude of the trend was assessed by computing Sen's slope estimator (Table 25). The analysis revealed a significant trend for maximum temperature in all cases of experimentation, whereas the trend was significant for a few months or seasons for minimum, mean, H_{Max},L_{Min} and number of rainy days. There was however no trend for rainfall of the region. Autoregressive and moving average model (ARIMA) was fitted for forecasting the maximum temperatures of the study area and lag 12 (ARIMA (2,0,1)(1,1,1)s) was found to be suitable model with R^2 value of 0.94. Model predictions were reassessed with Willmott's index and was found to be reasonably good (0.95). Availability of quality water for shrimp farming in the study area may get affected as there is an increase in maximum temperatures. The forecasting model for temperature in the study area could be used for shrimp farming crop calendar planning.

Aeration requirements to minimise energy use

Estimation of actual aeration requirements is essential particularly in the context of high energy expenditure due to excessive use of aerators by the farmers. Sediment and water respiration rates (SRR and WRR respectively) were determined fortnightly using column method in two farms culturing tiger shrimp and Pacific White shrimp. There was a significant difference in aeration requirements with increasing DOC. The aeration requirement for tiger shrimp culture even after 100 DOC was less than that for vannamei culture at 74 DOC. Total aeration used in the farmers' ponds was similar to the calculated value during the first fortnight of the study and later the number of aerators used exceeded the calculated values (less than the farmers' use of aeration 4 HP ha^{-1}) indicating the scope for minimising energy use for aeration as well as to reduce the cost of production.

Identification of Anammox bacteria to mitigate nitrous oxide emission

Amplification of extracted microbial DNA from aquatic sediments with Planctomycetes and anammox specific primers showed specific band size positivity on gel electrophoresis. The DGGE analysis of the positive band and further sequencing of eluted DNA and BLAST analysis of sequence showed 95% homology with anammox bacteria, *Kuenenia stuttgartiensis*.The presence of anammox bacteria

was also confirmed through chemical analysis (hydrazine) test through anammox reaction that produces very little or no nitrous oxide. The laboratory enrichment methodology has proved successful in identification of anammox bacteria by molecular techniques which will be useful to develop products to mitigate nitrous oxide emission from aquaculture ponds.

Replacement of fish oil and fish meal in the diets

The replacement of fish oil and fish meal in the diets due to their decreasing availability under CC scenario is an important area to be addressed as a response to climate change. Six experimental feeds were prepared by replacing fish oil with sunflower oil at 0, 25, 50, 75 and 100% in the 50% fish meal replaced diets and a control without replacement. The efficacy of the feed was evaluated for survival and weight gain in tiger shrimp juveniles (0.72 g) for 45 days. The growth indicated that fish oil can be replaced with sunflower oil up to 50% in a 50% fish meal replaced diet. The fatty acid profile of shrimp followed a similar trend for experimental feeds.

Reproductive performances of tiger shrimp under elevated temperature

Increase in temperature that is forecast under climate change impact, would affect the reproductive performance of tiger shrimp. To understand the impact of temperature, a total of 180 gravid females and 90 males were subjected to two elevated temperatures [(TE1: 30 °C ±1; TE2: 32 °C ±1) and control (27 °C ±1)] through titanium heaters maintained in black circular tanks (6 mt) stocked with 30 shrimp in the ratio of 1 male: 2 females. Shrimp were assessed for maturation, spawning and hatching performance. At a highly elevated temperature of 32 °C spawning and fertilization rates reduced whereas hatching rate was improved in moderately higher temperature of 30°C . The treatments indicated higher range of ammonia and nitrite when compared to control because of increased temperature and metabolic activity of the shrimps and can affect maturation. The microbial population which might influence hatching performance in a tank is a function of temperature. A significant correlation was noticed between spawning tank water vibriocount and egg vibriocount ($r = 0.61$; $P < 0.01$). The egg vibrio count showed a negative correlation with hatching rate ($r = -0.56$; $P < 0.01$). The cellular parameters like total haemocyte count and phenoloxidase activity (Fig. 39) reduced significantly at an elevated temperature of 32°C.

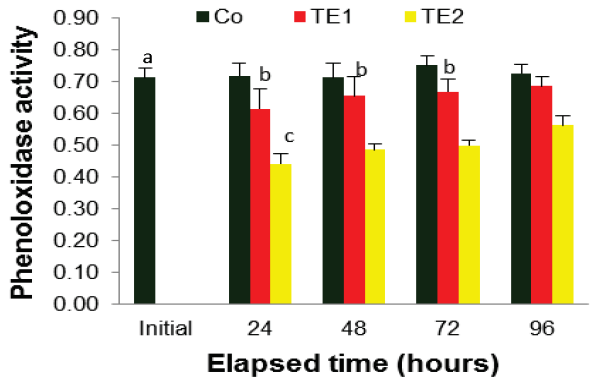


Fig. 39. Phenoloxidase (PO) Mean values (± S.D) of tiger shrimp in three temperature regimes against time (Values at the same exposure time with different superscripts differ significantly).

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**

Adaptation measures for small scale shrimp farmers to mitigate climate change impacts

Based on the results from the interdisciplinary and multi-stakeholder participatory study conducted in Krishna District, the impacts of CC on shrimp farming sector and the outcome of Stakeholder panel

meeting and Results dissemination workshop, the guidelines for adaptation measures to be undertaken by the farmers, institutional, policy, science and technology solutions to be undertaken for improving farmers' adaptive capacity to CC were developed. These have been brought out as policy documents and are given in brief below.

Technical recommendations for farmers:

- Strengthen and increase the height of pond dykes and farm bunds for protection against flood water
- Follow better management practices (BMPs) for climate smart shrimp aquaculture
- Use of electricity for water pumping and for aeration so that farmers contribute to reduced carbon foot print of aquaculture
- Maintenance of buffer zone between the farms and water source to protect farms against cyclones and storm surges
- Collective planning by the farmers group to mitigate the impacts of climate change

Researchable areas:

- Increase accuracy in predictions of changes in weather parameters and extreme climatic events and developing guidelines for the assessment of likely damage
- Develop forecasts on water availability in both fresh and brackishwater bodies and changes in salinity regimes
- Identify vulnerable coastlines and design defense structures
- Identify alternative species that can tolerate expected abiotic stresses such as salinity and temperature variation
- Investigate animal behaviour, pond dynamics and ecosystem in relation to climate change and extreme climatic events for developing seasonal crop calendar and management measures
- Investigate weather anomalies that may trigger disease outbreaks and the impact of changing seasonal patterns on emergence of new diseases
- Modifications of better management practices in the context of expected environment changes
- Estimate actual aeration requirements and improve the efficiency of pumping and aeration: develop low fish meal feed technology using plant protein sources
- Develop awareness materials on climate change impacts and adaptation measures

Policy recommendations:

- In case of extreme climatic events, equate aquaculture on par with agriculture so that shrimp farmers could access institutional credit support and crop insurance
- Secure national calamity contingency fund assistance for shrimp farmers to compensate for losses due to extreme climatic events
- Improve early warning systems on cyclones and floods
- Develop contingency plans to overcome losses from extreme climatic events or climate change affecting the normal crop calendar
- Improve the quality and availability of source waters through dredging and deepening of water bodies
- Build capacity of farmers through training
- Encourage women's participation in future climate change adaptation measures

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

Development of cost effective feeds for pearlspot

Etroplus suratensis is currently cultured by farmers using low cost cattle feed available in the market. The main problem with this feed is the poor water stability accompanied by poor growth. An attempt was therefore made to improve the water stability and presentation for maximizing growth. In the first experiment, cattle feed used by the farmer was powdered and made into smaller pellets with inclusion of synthetic binder. The prepared pellet was very hard with good water stability. This improved feed was evaluated for its suitability in a 45 days feeding experiment in juvenile pearlspot with an ABW of 3.2 g. At the end of the experiment, the weight gain was 2.31 g and 1.98 g respectively in the control and the improved feed with synthetic binder. This is possibly due to poor feed intake in the dry pelleted form because of its hardness compared to control. Keeping this in mind, another experiment was carried out for 45 days using feed in the form of semi-moist dough with addition of binder. The acceptability of the feed improved. The growth (2.32 vs 3.02 g) and FCR (2.41 vs 2.03) were significantly improved along with enhanced water stability.

Dietary lipid levels and reproductive performance of pearlspot

In pursuit of development of nutritionally balanced feed for pearlspot broodstock, an attempt was made to optimize the dietary lipid level for improving reproductive performance. A set of isoproteic feeds (40% protein) were formulated with varied lipid levels viz. 6,9,12 and 15%. The ingredient and chemical composition of experimental feeds are given in Table 26. Adult pearlspot (about 100 g) were obtained from Muttukkadu lagoon and Pulicat lake and acclimatized to laboratory conditions. A three month feeding trial was conducted to test the effect of dietary lipid level on maturation by randomly stocking groups of 6 fishes in 1000 L tanks. Monthly sampling was carried out to monitor the weight gain and health. On termination of the trial, the fishes were dissected for observing gonad condition and tissue samples collected for proximate analysis to ascertain the diet mediated changes in the biochemical composition (Table 27).

Table 26. Feed ingredient and chemical composition

Ingredients	Diets with different lipid levels (%)			
	6	9	12	15
Corn	15	15	10.9	7.28
Fish meal, Local	26.2	27	27.5	28
Fish meal, whole fish dried	10	10	10	10
Rice, Broken	5	5	5	5
Soybean meal, 46%	10	10	10	10
Squid meal	2	2	2	2
Wheat gluten	10	10	10	10
Wheat grain	13.4	9.65	10	10
Soy lecithin	1.2	2.7	4.3	5.85
Fish oil	1.2	2.7	4.3	5.9
Premix*	4.6	4.6	4.6	4.6
Spirulina	1.4	1.4	1.4	1.4
Proximate composition analyses				
Moisture	10.3	10.6	9.7	8.4
Protein	40.7	40.8	40.1	41.0
Lipid	5.1	7.5	11.2	14.5
Fibre	1.4	1.7	1.6	1.4
Ash	11.3	11.4	11.5	12.4
NFE	31.2	27.9	25.9	22.4

*Premix contained BHT – 0.35%, Vitamin mineral premix – 68%, sodium alginate – 21.70%, vitamin E – 3.3% and vitamin C – 6.6%.

A similar experiment was repeated in outdoor tanks

containing natural micro algae and biofloc. Feed intake was good and the fishes were active and grew well. On termination of the trial, the conditions of the gonads showed a marked difference in its appearance. The ovary of the fishes fed with the diet of 12 and 15% lipid level were fully ripe, tightly packed with eggs and brown in colour. However, the ovaries of lower dietary levels were not ripe, probably in an early maturing stage, having deep yellowish shrunken ovary. Gonad conditions indicated that dietary lipid levels of 12 and 15 % could be optimal for inducing quick maturation. This observation is further corroborated by the onset of two repeated spawnings in each of the dietary treatments.

In one of the spawnings, 3560 eggs were laid by a female weighing 288 g. In total, there were four spawnings, two each from diet with 12 and 15% lipid respectively. The first spawning occurred in a common tank where there were six fishes whereas anothe occurred in a tank where only a single pair was maintained. Average hatching and survival rate was 95% and 90% respectively. After 10 days, there was a significant loss in survival; probably due to lack of suitable larval feeds in the tanks. The eggs were found attached mostly on the tank wall. After 96 hours, eggs hatched out as wrigglers in tank conditions. In one of the spawnings, a day after hatching, the wrigglers were separated and grown in green water tanks in floating strainers. Under these conditions, after five days, the wrigglers metamorphosed successfully into free swimming larvae.

Table 27. Final carcass composition (mean±SD) of the fishes fed experimental diets varying in lipid levels

Diets	Moisture	Ash	Lipid	Protein
6	72.1 ± 0.3	20.0 ± 0.9	11.2 ± 0.1	60.7 ± 0.2
9	72.5 ± 1.0	22.1 ± 0.5	15.0 ± 0.6	53.80 ± 0.01
12	71.7 ± 1.1	21.1 ± 2.0	19.3 ± 0.3	52.9 ± 0.1
15	71.2 ± 0.9	19.4 ± 0.1	20.5 ± 1.2	54.4 ± 0.4

Comparison of Females from 12 and 15% DL- with gravid ovary (upper row) and 6 and 9% DL with maturing ovary (lower row)

Eggs (3560) deposited by female weighing 288 g

Newly hatched wrigglers

23 day old fry

56 day old fingerlings

Development of specific feed for low and high saline shrimp farming

During the preceding years, various stress busters were evaluated individually for their efficacy in the low and high saline conditions. During the current period, their combined effect was evaluated. For high saline feed, based on previous results, two diets were formulated with 38.07 & 35.53% crude protein and 5.65 & 6.45% ether extract in control and test feeds respectively. In addition, the test feed had a higher level of lecithin (2%), choline (0.1%) and acorbyl poly phosphate (0.4%) compared to the control (1, 0.05 & 0.1%) respectively. These feeds were tested in juvenile tiger shrimp having an initial weight of 2.8 g, for 45 days after acclimatization to higher salinity. The juveniles were acclimatized by enhancing 2 ppt salinity per day using crude common salt to reach the required salinity of 45 ppt. The results indicated that dietary combinations have a significantly ($P<0.05$) positive effect on growth (298.43 g) and protein efficiency ratio (1.64) compared to control (267.3 g and 1.43). In another experiment, these combinations of modified dietary nutrients were evaluated under high salinity stressed tiger shrimp in bigger size group (23.70 g). The results indicated higher average weekly gain (2.11 g) in treatment compared to control (1.86 g). In low saline regime,a 42 days experiment was carried out to evaluate the effect of combination of stress busters (choline and lecithin) on tiger shrimp with an initial ABW of 6.62 g and the results are given in Table 28.

Table 28.Performance of tiger shrimp with combination of stress busters in low salinity

Parameters	Treatments						
	Control	1.5% lecithin, 600 mg choline	1.5% lecithin, 900 mg choline	1.5% lecithin, 1200 mg choline	2% lecithin, 600 mg choline	2% lecithin, 900 mg choline	2% lecithin, 1200 mg choline
Initial body wt. (g)	6.61±0.01	6.63±0.01	6.63±0.02	6.63±0.01	6.62±0.01	6.62±0.01	6.62±0.02
Final body wt. (g)	8.24 ^{b} ±0.04	9.53 ^{cd}±0.18	9.83 ^{d}±0.05	8.87 ^{ab}±0.06	9.14 ^{bc}±0.01	8.72 ^{ab}±0.25	8.33 ^{a}±0.03
ADG (mg/day)	55.47 ^{b}±5.71	69.09 ^{cd}±4.03	76.22 ^{d}±0.76	53.41 ^{ab}±6.10	59.99 ^{bc}±0.06	49.95 ^{ab}±5.77	40.82 ^{a}±1.30
TWG (g)	2.33 ^{b}±0.24	2.90 ^{cd}±0.17	3.20 ^{d}±0.03	2.24 ^{ab}±0.26	2.52 ^{bc}±0.01	2.10 ^{ab}±0.04	1.71 ^{a}±0.05
FCR	2.74 ^{bc}±0.02	2.56 ^{b}±0.01	2.23 ^{a}±0.01	2.81 ^{c}±0.01	2.73 ^{bc}±0.01	2.81 ^{c}±0.01	3.27 ^{d}±0.19

The results indicated that shrimp fed diet containing 1.5% lecithin coupled with 900 mg choline showed significantly ($P<0.05$) higher performance compared to that in other diets.

Acyl-CoA binding protein expression in hyperosmotic stressed tiger shrimp fed with varying protein levels

Nutrigenomic studies were initiated to comprehend the molecular mechanisms involved in nutrient modifications. The effect of protein level on the expression of Acyl-CoA binding protein (ACBP) in hyperosmotic stressed shrimp was studied since the main challenge for the aquatic animal is to regulate its osmotic pressure through osmoregulation which is an energy dependent process wherein there would be a change in gene expression. The ACBP is an important enzyme in the metabolism of shrimp and is also known to exhibit altered expression during salinity stress. The feeding trial was conducted using animals of average size 5.5 g at 45 ppt salinity with four dietary crude protein levels viz., 40.64 (control), 38.85 (protein 1), 37.06 (protein 2) and 35.87% (protein 3). The ACBP transcript levels were analysed by real time PCR. The ACBP transcripts in hepatopancreas of shrimp fed with low level of protein (35.87%) exhibited an up-regulated level (7.89 folds) compared to higher level of protein (40.64%) fed shrimp. The results indicate that ACBP could be involved in the energy metabolism aspects of osmoregulation during high salinity stress in tiger shrimp.

Standardization of suitable form of feed for grey mullet fry

To standardize the suitable form of feed for *Mugil cephalus*, an experiment with three forms (mash, dough and pellet) was conducted on grey mullet fry. The fry (ABW 1.13 g) were randomly distributed in nine tanks (500 L each) at the rate of 15 per tank and the feeding trial was carried out in triplicate for nine weeks. Results indicated significant ($P<0.01$) higher weight gain, higher protein efficiency ratio (PER) and lower FCR in fishes (Table 29) fed with pellet feed compared to other forms. There was significant improvement in nutrient digestibility when fed pellets as compared to that of other groups. It can therefore be concluded that pellet feed is most suitable for grey mullet fry.

Table 29. Effect of different forms of feed on performance of *Mugil cephalus* fry

Parameters	Mash feed	Dough feed	Pellet feed
Initial body wt. (g)	1.127±0.01	1.127±0.01	1.130±0.01
Final body wt. (g)	3.340 [a]±0.012	3.533 [b]±0.06	3.76 [c]±0.07
Total wt. gain (g)	2.21 [a]±0.07	2.32 [a]±0.09	2.63 [b]±0.08
Av. daily gain (mg)	35.13 [a]±0.11	38.20 [b]±0.85	41.75 [c]±1.19
PER	1.12 [a]±0.001	1.17 [b]±0.05	1.36 [b]±0.03
SGR (%)	1.73 [a]±0.01	1.81 [b]±0.02	1.91 [c]±0.04

Optimization of feeding frequency in grey mullet fry

For optimizing feeding frequency for grey mullet fry rearing, an experiment with four feeding frequencies (1, 2, 3 & 4) was conducted in a yard experiment for nine weeks. The fry (ABW 2.91 g) were randomly distributed in 12 tanks (500 L each) at the rate of 15 per tank and the feeding trial was carried out in triplicate for nine weeks. Significantly higher weight gain, and lower FCR was observed when fishes were fed three times a day (Table 30). It can be concluded that grey mullet fry need to be fed three times daily.

Table 30. Performance of *M. cephalus* fry fed under varying feeding frequency

Parameters	Feeding frequencies			
	1	2	3	4
Initial Body Wt. (g)	2.91±002	2.91±001	2.91±002	2.91±003
Final Body Wt. (g)	5.70 [a]±0.06	6.16 [bc]±0.06	6.29 [c]±0.07	6.03 [b]±0.03
ADG (mg/day)	44.32 [a]±1.07	51.73 [bc]±0.93	53.80 [c]±1.14	49.51 [b]±0.49
SGR	1.07 [a]±0.02	1.10 [bc]±0.04	1.23 [c]±0.02	1.15 [b]±0.01

Project Title (Institute)	Outreach activity on fish feed

Extruded feed for shrimp

Extruded shrimp feed is a new concept in vannamei farming in India. The advantage of slow sinking property of extruded feeds with lower bulk density makes the extruded feed advantageous for high stocking density culture of this species. Three trials were carried out to optimize the operating conditions of the extruder for production of extruded shrimp feed. In the first trial, the effect of varying levels of moisture (15,20,25,30 and 35 %) on the extrusion property of feed was assessed. It was found that a moisture content of 25 to 30 % is ideal for production of slow sinking extruded feeds with good finish and water stability. In the second trial, the effect of temperature was studied at 100,110,120,130 and 140°C and the results revealed that a temperature of 120-130°C was found to be optimal. In the third trial, the effect of speed of extruder was studied at 2500, 3000, 3500 and 4000 RPM and the results revealed that 3000 RPM is ideal for production of slow sinking extruded feeds for the standard shrimp feed mix formulated containing 35 % protein.

Assessment of marine raw materials and exploring new feed resources

Assessment of raw materials at Tuticorin revealed that there are 28 small fish drying yard owners in and around Tuticorin. They produce around 80 tons of dry fish daily and sell the produce directly to the poultry feed industries in Tamil Nadu.There are two dry fish meal producers with a daily average production of 7.1 and 18.6 tons respectively. The dried fish comprise oil sardines and silver bellies. While 80 % of the good quality coarse ground fish meal has been sold to poultry feed companies, rest (20 %) of the dried biomass with scales and bones is sold as fertilizer. The current price of dry fish is as follows: ₹20 to 24/ kg; dry fish meal ₹23 to 27/ kg with assurance of 48 % crude protein (Fig.40).

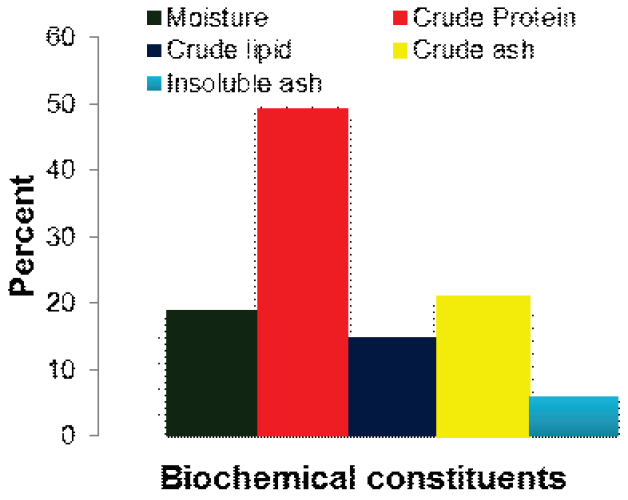


Fig. 40.Chemical composition of the dried coarse ground fish meal from Tuticorin

There are two sterilised fishmeal plants with installed production capacities of 300 tonnes/day. About 25 tonnes of shrimp shell meal is produced weekly from the wastes obtained from shrimp processing plants and sent to Chennai. Clam shell meals are sourced from sea and sold to poultry feed manufactures as a source of calcium to layer hens @ ₹3/ kg. There are also a number of crab processing plants in and around Tuticorin which yield crab shells as a by-product. Daily availability of marine bycatch is about 50 tonnes in Rameswaram, 15 tonnes in Pulicat and 10 tonnes in Kasimedu.

Participation of women in dry fish processing at Pulicat

Four case studies of women having 10 to15 years of experience in fish feed processing were followed to understand the role of women in dry fish processing at Pulicat. Women actively participate in trash fish processing and marketing at Tiruvalur District. Trash fish is marketed mainly to Namakkal and Cuddalore Districts in Tamil Nadu and also Andhra Pradesh. It is mainly used for poultry and fish feed. Of the four cases, one of them is a graduate and owns a poultry feed mill at Thiruthani, Tamil Nadu. Dry fish is sold at ₹18/- to ₹20/ kg. The wages paid for men is about ₹500/- and for women it is about ₹250 per day/-. Men are involved in transporting the dried fish from the storehouse to the

Trash fish drying

Sorting the trash fish

drying yard and back. They are also engaged in loading the dry fish into lorry. The women labourers are involved in sorting the dry fish, drying, transporting the feeds to the dry yard (head load) and packing. From May to September, dry fish season sets in. Problems encountered include lack of proper area for drying, non-availability of raw material throughout the year and high rate of transport to distant places, market remaining dull during rainy season and drying the fish during rains. Daily about 10 tonnes of dry fish is marketed by her.

Assessment of raw material in Mangalore region revealed that Malpe, Ullal and Udupi are the important places where there is abundance in availability of marine raw material. In Malpe, about 40 tons of dry fish is processed per day and about 20 tons in Ullal and Udupi.

Standardization of feed management strategies

In seabass culture using sinking pelleted feed, the main problem encountered is the left-over fed and its effect on soil and water quality. To address this, an experiment was carried out at KRC to study the effect of feeding seabass using platforms (check trays). Seabass with an ABW of 7 g and 10 g were stocked and fed in check trays. After 117 days, the ABW was 94 and 117 g indicating that check trays could be used efficiently for feeding.

Amelioration of anti-nutritional factors

A 6-week feeding trial was conducted to evaluate the effect of soaking and soaking with autoclaving of sunflower oil cake on growth and feed utilization in Asian seabass. Raw, soaked and soaked with autoclaving sunflower oil cake were included at two dietary levels of 5 and 10 %. Total weight gain was 4.11 g, 3.62 g, 4.14 g, 3.83 g, 4.07 g and 3.79 g with FCR of 3.75, 4.08, 3.72, 3.92, 3.78 and 3.95 in fish fed diets containing 5 % raw SFC, 10 % raw SFC, 5 % water soaked SFC, 10 % water soaked SFC, 5 % water soaked & autoclaved SFC and 10 % water soaked & autoclaved SFC respectively. The result of the study indicated that interventions like soaking and autoclaving have no significant effect when sunflower oil cake is included at 5 % level but at 10 % , both soaking and autoclaving the cakes significantly improves the performance of seabass.

Farm-made feed for Asian seabass farming in West Bengal

After two consecutive years of trial in farmers' pond, a third trial was conducted in a farmer's pond of 600 m^2 at Kamarhat, Kakdwip Block, South 24 Parganas, West Bengal. Before grow out culture, wild

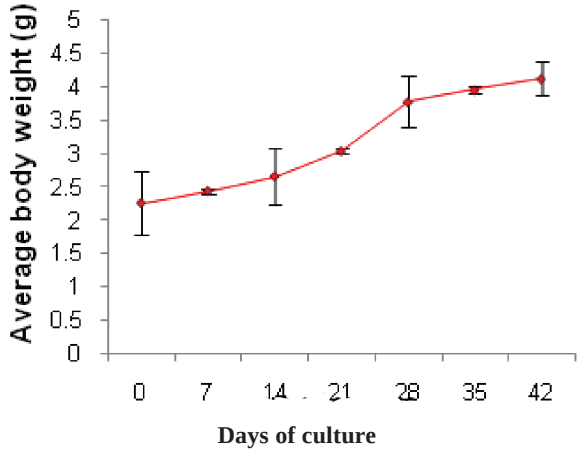


Fig. 41. Average body weight of seabass fry during weaning period

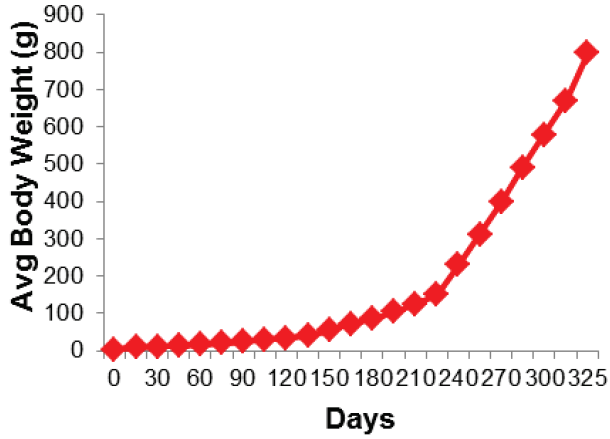


Fig. 42. Growth of seabass in culture pond with farm-made feed

seabass fry having an initial body weight of 2.25 g were collected and stocked in hapa (2×1×1 m) fixed in a brackishwater pond for weaning. Weaning was practiced for a period of six weeks. During weaning, farm made feed was provided to fry twice daily at 10 a.m. and 4 p.m. at the rate of 20 % of body weight / day. The fry grew gradually and attained a final weight of 4.12 g. A survival of 79.40 % was noticed during the weaning period. Highest mortality was observed between 0 to 7 days (Fig. 41).

After weaning, fry with an initial body weight of 4.12 g were stocked @ 0.5 nos /m^2 in the pond. Initially, fishes were fed with semi-moist form of the farm-made feed @ 15 % of body weight two to three times daily and gradually replaced by dry pellet feed (2 mm size) @ 2-8 % of body weight. Routine sampling was carried out once a month for assessing the growth of fish. After 325 days of culture, the fish were harvested. The average body weight of 798.56 g with a survival of 69.33% and FCR of 1.76 was obtained. A production of 166.1 kg with productivity of 2768.34 kg/ha was achieved (Fig. 42).

Increasing quality of ingredients used in farm-made feed through fermentation

Eleven locally available low-cost feed ingredients, viz. rice bran (RB), sunflower cake (SFC), sesame cake (SMC), mustard oil cake (MOC), azolla (AZ), leucaena leaf meal (LLM), sugarcane bagasse (SB), groundnut cake (GNC), soybean meal (SBM), moong husk (MH) and algae meal (AM) were fermented with two potential fibres and starch degrading microbes i.e., *Bacillus sp. DDKRC1* and *Bacillus subtilis DDKRC5* to enrich the nutrient status of feed ingredients. From an *in vitro* study, it was found that there was improvement in protein content and reduction in cellulose content in all feed ingredients (Table 31). There was reduction in tannin content (44.64 to 54.62 %) in SFC, AZ, MOC and AM and reduction in glucosinolate content (17.55 %) in MOC when these ingredients were fermented with mixture of Bacillus sp. and *Bacillus subtilis* which indicated that these microbes could degrade the cellulose, tannin, glucosinolate and thereby improve the nutrient quality of feed ingredients when they encounter optimum moisture level.(Table 27).

Table 31. Change of nutrient composition of different ingredients after fermentation with *Bacillus* sp. and *Bacillus subtilis*

Feed ingredient	Nutrient composition						
	DM%	CP%	EE%	CF %	OM%	Ash%	NFE
Rice bran	-0.45	7.99	9.39	-4.25	-0.08	0.60	6.44
Sunflower cake	-0.31	2.04	6.52	-3.08	-0.05	0.51	-0.50
Sesame cake	0.15	2.16	6.01	-0.48	-0.03	0.34	-3.39
Leucaena leaf meal	-0.62	2.08	18.57	-5.70	0.05	-0.72	-1.22
Sugarcane bagasse	-0.38	14.29	11.57	-1.06	-0.02	1.51	-0.77
Azolla	-1.06	2.82	12.62	-2.83	-0.06	0.44	-1.18
MOC	-0.03	0.42	2.07	-5.58	0.10	-0.95	0.96
Groundnut cake	-0.42	0.74	4.33	-5.79	0.09	-0.94	0.97
Soyabean meal	-0.75	2.06	18.09	-2.89	0.06	-0.51	-2.25
Moong husk	-1.41	2.57	18.30	-3.00	-0.18	1.40	-0.86
Enteromorpha algae meal	-2.04	7.35	6.57	-10.70	0.15	-0.81	-0.65

Fish meal replacement with fermented ingredient in farm-made Asian seabass feed

An experiment was conducted with five groups of seabass fingerlings (average body wt. 6.70-6.71 g) in triplicate with 10 fishes per replicate over a period of 90 days. Fishes of group I were fed with control diet (T1) made up of locally available ingredients. Diets T2, T3, T4 and T5 were prepared by

replacing fish meal at10, 20, 30 and 40 % by weight with fermented ingredients (mustard oil cake, ground nut oil cake and soybean meal) and fed to groups II, III, IV and V respectively.The results indicated that fermented ingredients could replace 30 % fish meal in farm made feed without affecting the performance of the fingerlings (Table 32).

Table 32. Performance of Asian seabass on diet formulated with fermented ingredients replacing different levels of fishmeal

Parameters	T_1	T_2	T_3	T_4	T_5
Initial Body Wt. (g)	6.70±0.01	6.71±0.01	6.70±0.01	6.71±0.01	6.71±0.01
Final Body Wt. (g)	19.60^{b}±0.031	19.84^{c}±0.015	20.14^{d}±0.05	19.54^{b}±0.05	19.17^{a}±0.05
ADG (mg/day)	143.30^{b}±0.29	145.89^{c}±0.22	149.33^{d}±0.61	142.52^{b}±0.58	138.44^{a}±0.51
TWG%	192.49^{b}±0.22	195.68^{c}±0.48	200.78^{d}±1.08	191.16^{b}±0.70	185.69^{a}±0.62
PER	1.22^{ab}±0.02	1.23^{ab}±0.04	1.28^{b}±0.03	1.26^{ab}±0.04	1.17^{a}±0.03
SGR	1.19^{b}±0.001	1.20^{c}±0.003	1.22^{d}±0.003	1.19^{b}±0.003	1.17^{a}±0.003

Means followed by different superscripts differ significantly (P<0.05)

Design and performance evaluation of a prototype feeder

A prototype of a simple automatic feeder using electricity was developed containing only standard, easily available parts. Initially, the feeder was designed such that dispensing of feed was done by electromagnetic valve powered by a solenoid, coupled with timer switches. The unit was fabricated and tested for dispensing using the timer for different time periods. Based on the results, the distribution system was re-designed with alternate pipes of different length and diameter powered by the motor of 0.25 hp and tested for its distribution efficiency. The feed hopper bottom tapers down such that the angle of repose is 45° for easy and efficient dispensing of the shrimp feed. This was fabricated after a detailed study of the engineering properties of different sizes of shrimp feed viz., bulk density, moisture content, coefficient of friction etc.

Prototype feed dispenser

The evaluation study of the modified distribution mechanism revealed that the radius of influence ranged between 0.2 m to 5.45 m. The maximum radius of distribution of 5.5 m was observed for the feed size of 2.5 mm at 1400 rpm at a height of installation of 2.5 m. Even for a height of installation of 1.5 m at 1400 rpm for a feed size of 3 mm, the distribution was observed to be at 5.45 m. It could therefore be inferred that motor speed is more important than the height of installation. Invariably, at higher motor speeds the distribution is wider for all sizes of feed tested.

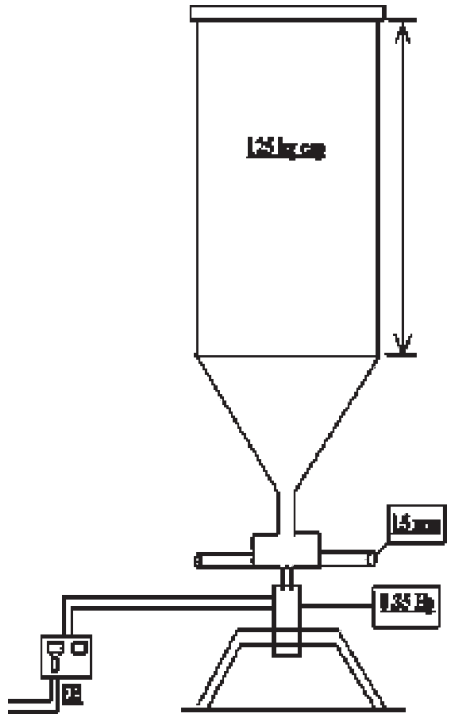
The scaled-up version of the automatic feeder for a capacity of 125 kg was fabricated. The automation was effected through two timers with digital display so that the dispensing of the feed and the duration of feeding could be adjusted easily by the farmers. The distribution system had alternate pipes of different length (100 mm,150 mm) and diameter (15, 20, 25 mm) powered by a 0.35 hp motor. Performance evaluation of the automatic feeder was done exhaustively viz., quantity of feed dispersed and the dispersion efficiency for different spreaders at variable speeds. It was observed that the maximum

dispersion distance was about 21.7 m with 15 mm diameter spread for 3 sec of operation at 1300 rpm. The maximum quantity of feed dispersed was about 2.37 kg of feed of size 2.5 mm through 25 mm dia spreader at 1300 rpm.

The approximate cost for fabricating of feeder is given below:

Cost of the hopper	₹ 1000/-
Timer unit with digital display	₹ 9000/-
0.35 hp series motor with regulator	₹ 2000/-
Installation accessories	₹ 3000/-
The approximate cost works out to be	₹ 15,000/-.

Up scaled Version of feed dispenser



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

Fatty acid profiles of farmed tiger shrimp

The present study quantified the proximate and fatty acid profiles of farmed tiger shrimp (samples from 20 ponds) along with the respective feeds (five commercial feeds, each one in four ponds) used for culture. The crude protein and ether extract values (%) of five feeds ranged between 38.02 to 39.62 and 5.02 to 7.06 respectively. The eicosapentanoic acid (EPA) and docosahexanoic acid (DHA) values (%) were in the range of 3.5 to 7.7 and 4 to 6.5 respectively in the feeds. The crude protein (19.3-20.5) and total lipid (1.35-1.54) values were non-significant in the edible portions of cultured shrimp. Even though wide variations were observed in the fatty acid profiles of feeds, except for EPA the others were almost similar in the shrimp edible portions (Fig. 43).

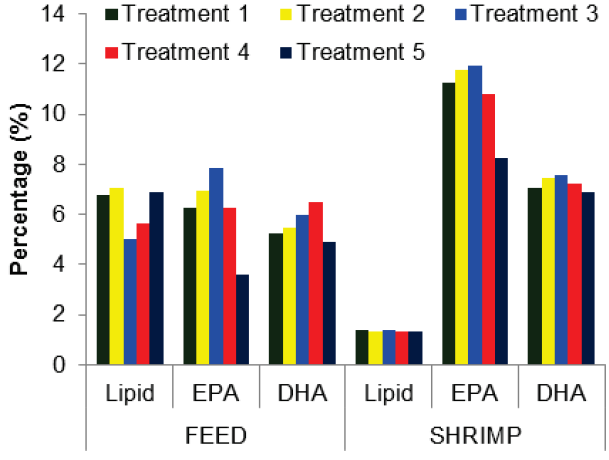


Fig. 43. Lipid and n-3 HUFA (%) in feeds and cultured tiger shrimp

Nutrient profile analysis of mudcrab from different geographical regions

Mud crabs were collected from different geographical regions like Kakdwip (West Bengal), Nagayalanka (Andhra Pradesh), Pulicat and Chintadripet (Tamil Nadu) for nutrient profiling. The protein, lipid and ash values of mud crab edible portions were 17.45, 0.4 and 2.31%, respectively (Fig. 43 a). Palmitic, linoleic and arachidonic acids were 12.01, 3.44, 9.52% respectively in the mud crabs from Chintadripet market. The fatty acid profiles indicated significantly higher (P<0.05) linoleic acid in Kakdwip samples (6.5%) indicating the cultured nature of sample. Crab is also a low fat food with rich ω-3 highly unsaturated fatty acids like eicosapentanoic (15.8 %) and docosahexanoic acids (9.40 %).

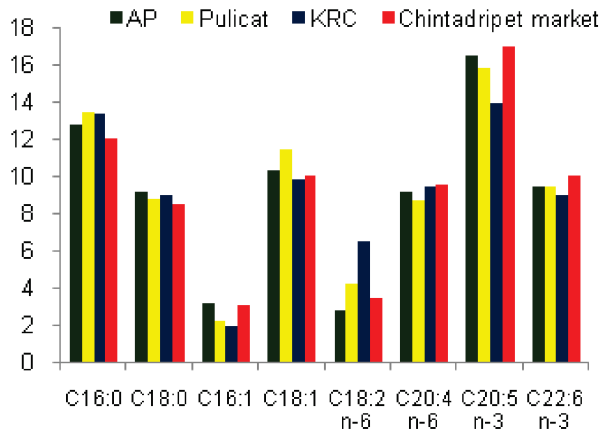


Fig. 43 a. Fatty acid profile of mud crabs

Fatty acid profiles of vannamei shrimp

The proximate and fatty acid composition of the edible and inedible portions of vannamei shrimp were analysed (Fig. 43 b). The moisture and protein content were significantly (P<0.05) high in edible portion (78.89 % and 19.63 %) than in inedible portion (70.51 % and 15.87 %) respectively. The ash content was low (P<0.05) in edible portion (1.35 %) compare to that in inedible portion (7.10 %) due to the presence of exoskeleton. The amount of lipid in inedible portion and edible portion was found to be 1.94 % and 1.11 % respectively indicating no significant differences (P>0.05) in total saturated fatty acids in both edible and inedible portions. Among the saturated fatty acids, palmitic (C16:0) and stearic (C18:0) were the predominant fatty acids in both portions. Oleic acid (C18:1ω-9) is the predominant monounsaturated fatty acid in both the portions and it was significantly (P<0.05) higher in inedible portions (16.64 %) compared to edible portion (12.44 %). Linoleic acid (C18:2ω-6) was higher in inedible portions whereas eicosapentanoic acid (C20:5ω-3) and docosahexanoic acid (C20:6ω-3) were higher in edible portions among the polyunsaturated fatty acids. The ω-3/ω-6 fatty acid ratio was also significantly (P<0.05) higher in edible portion.

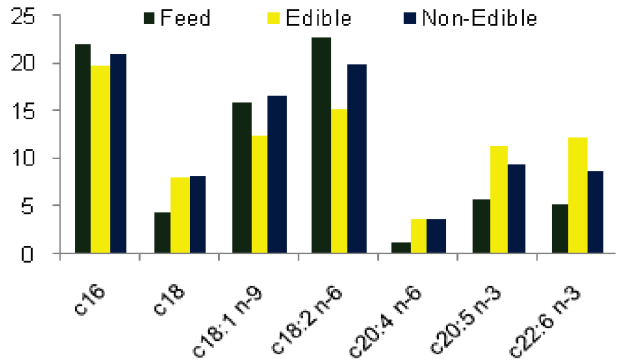


Fig. 43 b. Fatty acid profile of vannamei

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

Demonstrations using indigenous shrimp feed developed at CIBA

Seven demonstrations were successfully completed using shrimp feed developed at CIBA. The results revealed the cost effectiveness of CIBA shrimp feed technology. The 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 shrimp feed and existing commercial high-cost feed in all the seven demonstrations. However, the feed cost was considerably lower in CIBA shrimp feed and

hence the cost of production of shrimp was comparatively lower. The feed cost per kg of shrimp produced was ₹ 6-15/ lower than that of the control feed. Further, the soil and water quality parameters analysis during the culture indicated that there was no significant difference between the control and test ponds fed with CIBA shrimp feed. Through the demonstrations, the cost effectiveness of indigenous shrimp feed technology was reconfirmed in farmers ponds. After the completion of demonstration, an impact study was undertaken which revealed that demonstrations under this project had significant visible impact and the adjoining farmers started using CIBA shrimp feed. Currently, CIBA shrimp feed is very popular in Ramanathapuram district for its cost effectiveness coupled with good growth and FCR. A final workshop was also conducted on 10.04.2012 at CIBA with participation of all the stakeholders including farmers who undertook demonstration, other input dealers, consultants and NABARD officials.

Impact of demonstration leading to continuous use of CIBA shrimp feed by farmers in Ramnad District

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

Association studies to unravel markers for growth traits in tiger shrimp

The *Penaeus monodon* EST database at Genbank (http://www.ncbi.nlm.gov) was accessed and the available 39, 397 sequences downloaded. The gene identities of these SNP-containing contigs were obtained using blast2go software. Based on the gene identities of top blast sequence accessions and their probable functions, various growth-related genes in shrimp were short-listed for further study. To genotype these SNPs by Restriction Fragment Length Polymorphism (RFLP), restriction enzymes that cut one of the alleles at polymorphic loci were identified using NCB cutter tool. Wherever restriction enzymes are available, RFLP markers could be deployed to genotype shrimp samples for polymorphic SNPs. Heavier and lighter shrimp samples (n=892) were collected from farmers' pond at harvest in a commercial culture. One SNP in lipid storage droplet protein gene using HincII enzyme and another in saposin isoform I gene using Bpu10I enzyme that were genotyped in harvested shrimp samples revealed that all genotyped samples were monomorphic.

The EST database of tiger shrimp at GenBank was screened to find microsatellite markers in growth candidate genes Cyclophilin, Fibrillarin, PC2 and SPARC. The EST reads of tiger shrimp pertaining to Cyclophilin gene does not contain any microsatellite markers. No reads were observed for Fibrillarin, PC2 and SPARC genes in EST database of GenBank for tiger shrimp.

Mourilyan virus detected in tiger shrimp

Tiger shrimp from culture ponds located in the East coast of India were found positive for Mourilyan virus (MoV) using gene specific primers by RT-PCR. The sequence analysis of the 610 bp PCR product of MoV showed close similarity to MoV of Australian isolate. This confirmed for the first time the natural prevalence of MoV in India. A specific nested RT- PCR was developed based on the sequence

information obtained for MoV G2 envelope glycoprotein gene of Indian isolate. Based on the nested PCR, 580 bp (Ist step) and 372 bp (2nd step) PCR products were amplified from G2 virion envelope glycoprotein gene from *P. monodon* infected tissues. The MoV could be detected with increased sensitivity in infected shrimp tissues such as gills, gut, hepatopancreas, muscle and haemolymph. The real time analysis revealed highest MoV copy numbers ($22.5x10^5$) μl^{-1} cDNA in gill tissue of shrimp (Fig. 44).

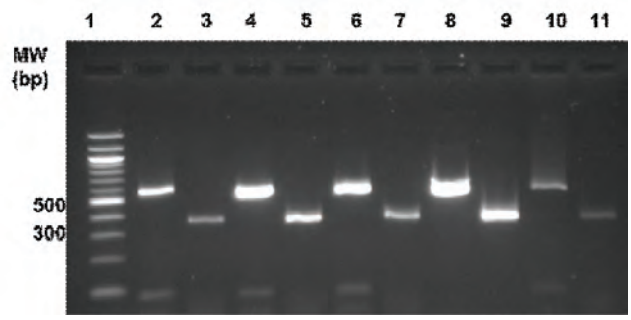


Fig. 44. Nested PCR developed for detection of Indian isolate of MoV.(Lane 1: 100 bp marker. Lane 2 and 3: Gills. Lane 4 and 5: Guts. Lane 6 and 7: Muscles. Lane 8 and 9: Hepatopancreas. Lane 10 and 11. Haemolymph)

Testicular gene expression in *Fenneropenaeus indicus*

Efforts to induce maturation in captive penaeid shrimp are focused mainly on females in spite of the fact that males also vary in their reproductive potential. To develop a baseline information on testicular development in *F. indicus*, specific primers for genes functionally related to testicular development *viz.* Multiple inositol polyphosphate phosphatase 2 (*MIPP2*), Meiotic recombination protein DMC1/LIM15 homolog isoform 1 (*Dmc1*), Testis specific transcript (*TST1*), insulin-like androgenic gland factor (*IAG)* and heat shock protein-90 (*HSP90*) were examined by semi-quantitative RT-PCR using *EF1*-α as the internal control.Among the genes analysed, *MIPP2, Dmc1, TST1* and *IAG* exhibited male specific expression while *HSP90* exhibited higher expression levels in females compared to males.

Adult male *F. indicus* shrimp collected from wild were divided into two groups, control (n=5) and test (n=10) to analyze the effect of eyestalk ablation on the expression of male reproductive genes. Following an acclimation period of one week, the test animals were eyestalk ablated and sampling was done on day 5 (n=5) and day 10 (n=5) post-ablation. Semi-quantitative RT-PCR analysis revealed weak expressions of male specific reproductive genes (*TST1, MIPP2* and *Dmc1*) in the test group compared to control (Fig. 45).

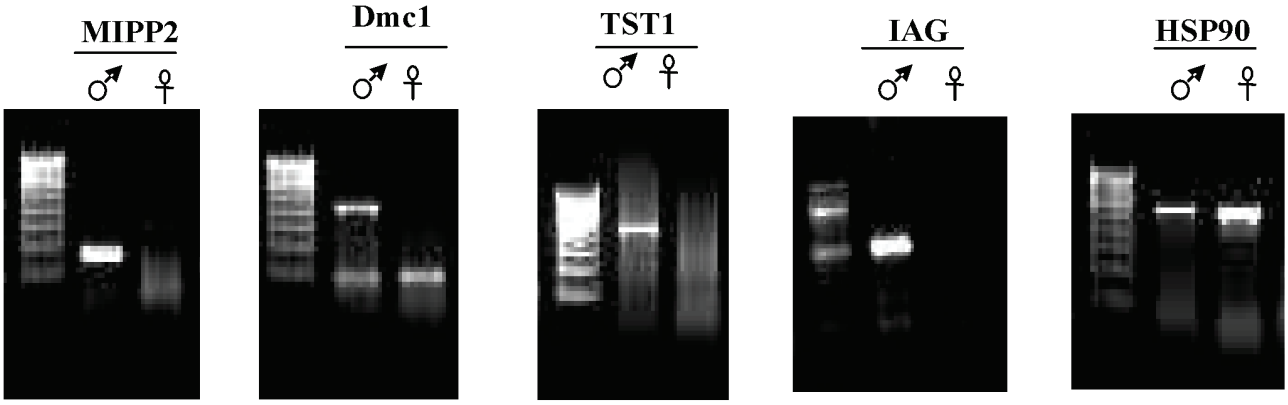


Fig. 45. Semi-quantitative PCR analysis of testicular gene expression in *Fenneropenaeus indicus* (Lane 1: Molecular marker; Lane 2: testis; Lane 3: ovary)

Evaluating the potential for selection of economically important traits in rotifers

As a first step to evaluate the potential for selection of economically important traits in rotifers, efforts were made to standardise the sexual reproduction protocol. *Brachionus plicatilis* collected from Krishna district of Andhra Pradesh (Krishna strain) and Adyar estuary of Tamil Nadu (Adyar

strain) were cultured separately in an incubator at 25°C in 30 ppt, and fed with green algae *Nannochloropsis oculata*. The lorica length was measured. The mean lorica length of Adyar rotifer measured was 172.4 µm in females and 131 µm in males. In the Krishna strain it was 145.2 µm in females and 122 µm in males. For mating between these strains, adequate mictic females and male rotifers were produced through sexual reproduction by adopting calorie restriction method. Rotifers of selected strains were cultured in 500 L capacity FRP tanks @ 500 nos./ml. On the first day of culture, calorie level (green algae *Nannochloropsis oculata*) was restricted to 50% which was reduced to 0% on the third day. The culture was continued for 12 days. It was observed that about 60% of the population transformed to mictic (females) with resting eggs and male rotifers were also observed.

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

Truss morphometric analyses to determine stock structure

The digitized images of 1,184 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. The truss data of male and female shrimp were analyzed separately as sex influences morphometric measurements. Few samples from each location were used to partially sequence cytochrome c oxidase I (CO I) mitochondrial gene. Partial CO I gene sequence containing 569 bp was utilized to estimate population specific (stock specific) and inter-population (between stocks) parameters in Arlequin version 3.5.1.3.

Approximately 70 % of shrimp specimens' data was used for estimation of discriminant functions and the remaining were used for validation of developed functions. The discriminant function could correctly classify about 68 % and 69 % of shrimp to the respective stocks for male and female data respectively. The validation step assigned about 64 % of male shrimp and 53 % of female shrimp correctly to their stocks. Overall, discriminant function 1 clearly separates Mangalore stock from rest of the stocks. For both the sexes, the truss measurements spanning across first five tail segments were more important than other measurements to discriminate the stocks. The head-to-tail ratio was also estimated for few samples of these stocks (as a ratio of tail weight divided by head weight). The tail proportion was observed to be high compared to head proportion for Vishakhapatnam stock in both male and female shrimp.

Mitochondrial gene sequence analyses to determine stock structure

Two hundred and thirty five samples from all ten locations along Indian coast have been used for phylogenetic analysis based on partial CO I gene. The numbers of sequences used were 25 each for Andamans, Chennai and Kakdwip, Gujarat (30), Kollam (28), Mangalore (27), Paradip (20), Ratnagiri (12), Tuticorin (20) and Vishakhapatnam (23). The number of polymorphic sites varied from 5 in Kakdwip samples to 44 in Gujarat samples. Highest number of haplotypes was observed in Gujarat samples whereas lowest number of haplotypes was found in Ratnagiri samples. However, the sample size of Ratnagiri is low compared to all other stocks. The h1 is common and the most frequent haplotype. Two haplotypes h1 and h2 are shared by all the stocks. The nucleotide diversity was highest for Andaman stock and low for Kakdwip and Tuticorin stocks. This indicates that the degree of polymorphism is high in Andaman stock and low in Kakdwip and Tuticorin stocks. Most of the observed substitutions in all the stocks were transitions rather than transversions. Transversion substitutions

were not observed for Kakdwip stock. The analysis of molecular variance (AMOVA) indicated that most of the variation existing in the stocks of tiger shrimp was due to within-stock rather than between-stock differences. None of the F_{ST} values were found significant which implies that not a single stock is significantly differentiated from other stocks. The exact test for non-differentiation gave significant result for Andaman and Kakdwip stocks but after Bonferroni correction, the P-value was found to be non-significant. The Tajima's D values for neutrality test were observed to be significant ($P<0.01$) for Chennai, Gujarat, and Paradip stocks after standard Bonferroni correction. The Fu's FS value was negative for Gujarat, Kakdwip and Tuticorin stocks. From the results, it could be concluded that none of the stocks of tiger shrimp studied are significantly differentiated from others.

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

Genotyping WSSV-challenged tiger shrimp

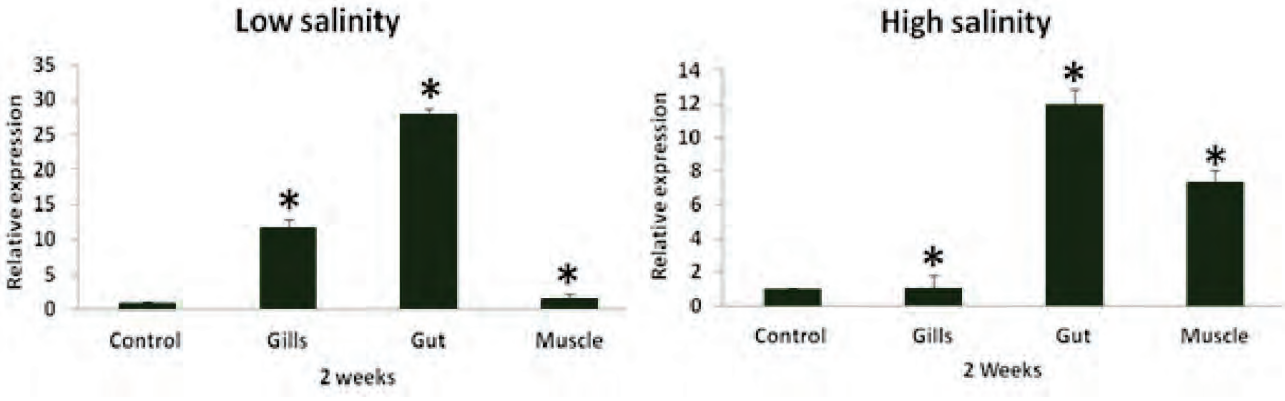
The transcriptome sequencing and assembly of Andaman, East Coast and WSSV-survivor shrimp using *Illumina* RNA-seq Next Generation Sequencing technology resulted in identification of about 20,372 Single Nucleotide Polymorphisms (SNPs) satisfying the assumptions of minor allele frequency ≥ 0.3 and coverage ≥100X. From these, 6,000 SNPs were selected for the creation of the *Illumina* SNP-chip for genotyping. Sixty-two percent of these selected SNPs could be annotated with known genes. Shrimp belonging to one full-sib family were genotyped for 6,000 SNPs using SNP-chip and genotype data so obtained was used to generate linkage map for tiger shrimp based on recombination principle. Overall, 3,961 informative SNP markers were mapped to 44 linkage groups indicating the haploid chromosome number of tiger shrimp. The male and female maps contained 3,598 and 3,487 SNP markers respectively and 3,124 SNP markers were informative for both sexes. A higher recombination rate was observed in male compared to female parents. The transcriptome data also identified 7,207 microsatellites in 6,492 contigs (3% were mono-, 65% di-, 24% tri-, 5% tetra-, 1% penta- and 2% hexa-nucleotide repeats). The same SNP-chip was used to genotype WSSV-challenged shrimp to record genotypes for 6K SNPs. About 4,237 SNP genotypes along with survival data is being analysed to find suggestive associated markers to WSSV-resistance.

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

Acyl-CoA binding protein gene expression under low and high salinity

Two suppression subtractive hybridization (SSH) cDNA libraries were performed using gut tissues of *Penaeus monodon* exposed to low (3 ppt) and high (55 ppt) salinity stress conditions. The SSH library could identify differentially expressed genes that belonged to various functional classes such as the nucleic acid regulation and replication, defence proteins, allergen protein, signal transduction pathways, apoptosis, energy and metabolism, cell cycle regulation and hypothetical proteins. Acyl-CoA binding protein (ACBP) was identified as one of the differentially expressed genes in both the SSH libraries of tiger shrimp subjected to low and high salinity stress. The full-length cDNA of tiger shrimp ACBP gene (273 bp) was isolated and sequenced. Real time PCR analysis of shrimps subjected to 3 ppt salinity conditions after 2 weeks revealed an increase in expression of ACBP transcripts, in the gut (28.08-fold), gills (11.71-fold) and in the muscle tissues (1.70-fold) whereas at 55 ppt salinity conditions after 2 weeks shrimp exhibited increased ACBP transcript levels in the gut (11.95-fold), gills (1.052-

fold) and muscle tissues (7.35-fold) (Fig. 46). The significant increase in expression levels of ACBP in various tissues of shrimps suggests a functional role of this gene in salinity stress tolerance and adaptation.



(a) (b)

Fig. 46. Acyl-CoA binding protein(ACBP) gene expression in tissues under (A) low salinity stress (B) high salinity stress (Asterisks indicate significant difference (P< 0.05) in ACBP expression levels)

Project Title (DBT)	**Molecular studies on sequential pathogenesis of WSSV and defence mechanism in *Penaeus monodon***

Microarray chip to identify differentially expressed genes against WSSV infection

A challenge experiment was carried out using virus dilution (10^{-7}) estimated to contain 2.62 x 10^6/µl viral copies by real time analysis. Gills, gut, eye stalk, haemolymph, pleopod, muscle, hepatopancreas were collected from the WSSV infected and control group of shrimp at 6 h, 24 h, 48 h and thereafter up to 72 h post infection period for sequential pathogenesis and gene expression analysis. Real time PCR has been standardized to estimate WSSV copies from infected shrimp tissues using IQ REAL™ WSSV TaqMan assay. Maximum WSSV copies were observed in gill tissue of the infected shrimp at all time points post infection (Fig. 47). The WSSV (VP28) DIG labelled probe has been prepared having 0.01 pg/µl labelling efficiency. The DNA extracted from gills, gut, eye stalk, haemolymph, pleopod, muscle, hepatopancreas collected from the infected shrimp were used for the DNA dot blot experiment. The DIG labelled WSSV probe was able to detect the virus in all the infected shrimp tissues. This probe will be used for WSSV pathogenesis studies by *in situ* hybridization. Agilent microarray slide (8 x 60k) was custom designed for tiger shrimp gene expression studies using the NCBI EST and nucleotide database. In addition, the microarray chip contained *P. monodon* gene sequences generated at CIBA, Chennai. A total of 42,013 sequences have been used in the microarray chip to identify differentially expressed genes against WSSV infection.

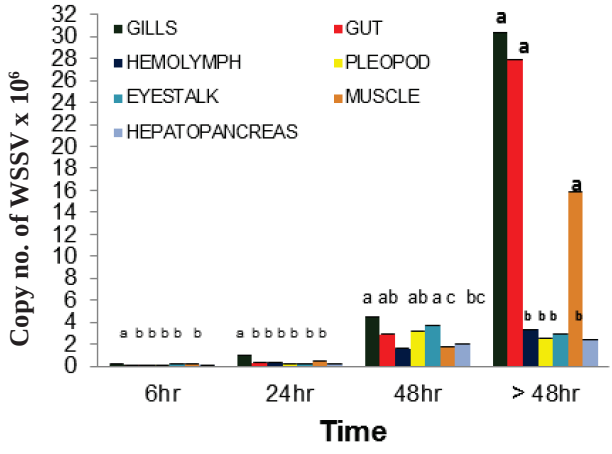


Fig.47. Comparative Real time PCR analysis of WSSV viral load in infected shrimp tissues

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

Development of inhibitors for controlling *Vibrio harveyi*

In order to develop inhibitors for controlling Quorum sensing luminescence disease causing marine *Vibrio harveyi* during shrimp larviculture, marine bacteria which harbour the *AiiA* gene (AHL-lactonase (AiiA), metallo-beta-lactamase gene) were screened which ultimately breaks down the lactone ring of AHL compounds produced by *V. harveyi* through amide bond disruption. Out of 100 marine bacillus strains screened, only two strains viz. *Bacillus mycoides* and *B. megaterium* were reported positive for the presence of *AiiA* gene using PCR. These two bacillus strains could be used as bio-agents to control *V. harveyi* in aquaculture. When *V. harveyi* grew in LB broth with crude marine plant extract (*Hexagonia acaloza* at 250 mg/ml), the growth was controlled and virulence processes like proteolysis, lipolysis, phospholipase, thermonuclease and bio-luminescence became weak. Challenge experiments in tiger shrimp post-larvae showed 12% reduction in cumulative percentage mortality.

Another challenge experiment of marine macro algae (*Kappaphycus alvarezii*) extract (200 mg/ml) in tiger shrimp post-larvae against *V. harveyi* showed 12% reduction in cumulative percentage mortality. Cell surface hydrophobicity using SAT and BATH test revealed strong to moderate level in treatment. The growth of *V. harveyi* was also reduced to 10.24%. The FTIR analysis of *K. alvarezii* was found to have various functional groups of compounds like alcohols, phenols, alkenes, primary amines, nitro compounds, esters, ethers, aromatics and carboxylic acids which may be responsible for the antagonism against *V. harveyi* and the changes of virulence factors.

Ethyl acetate extract of marine diatom *Skeletonema costatum* was found to weaken phospholipase and proteolysis activity of *V. harveyi*. Challenge experiments in tiger shrimp post-larvae showed 17% reduction in cumulative mortality. Further characterisation by FTIR and GC-MS revealed various functional compounds like alcohols, phenols, unsaturated aldehyde, ketones, alkenes, primary amines, aromatics and carboxylic acids etc. On GC-MS analysis, the crude extract *S. costatum* was found to contain fatty acid, 16-Octadecanoic acid, (48.05%) followed by pentadecanoic acid (18.94%). This study confirmed that marine diatom, plant and macro algae extracts could be used as a bio-inhibitory agents to control luminescence caused by *V. harveyi* in aquaculture systems.

Project Title (DBT)	Molecular mechanisms of Gonad-Inhibiting Hormone action on the control of egg maturation in the penaeid shrimp *Penaeus monodon*

Differential expression of GIH transcripts at different stages of maturation in tiger shrimp

Deciphering the molecular signalling pathway of GIH-mediated regulation of vitellogenesis has great relevance in penaeid shrimp broodstock development. The study envisages comprehending GIH-protein interactions and how these interaction networks form the functional circuitry regulating reproduction and to identify and characterize the individual proteins or groups that interact with GIH ultimately regulating the reproduction in shrimps. The differential expression of GIH transcripts in optic lobes, brain and thoracic ganglion of female tiger shrimp at different stages of maturation were determined by semi-quantitative RT-PCR using *EF1*-α as the internal control. GIH transcript levels exhibited a strong expression at Stage I and weak expression at Stage IV. The high level of GIH at immature stages indirectly confirms the negative control on maturation as reported in other penaeid shrimps.

SOCIAL SCIENCES DIVISION

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

Extension approaches for shrimp diversification

To evaluate the extension approaches required by the stakeholders for farming of diversified shrimp species other than the tiger shrimp, Indian white shrimp, banana shrimp, kuruma shrimp and Pacific white shrimp data was collected from the Department of Fisheries officials (DoF) of Tamil Nadu, Andhra Pradesh, Gujarat and Kerala through interviews. An informative proforma was designed for the interview to elicit information on the status of shrimp aquaculture and among the diversified species which had a higher appeal among stakeholders. The officials with field experience ranging from 1 to 33 years were surveyed and 60 % of the officials spend more than 25 % of their time in field related works. About 75 % of the officials dealt with tiger shrimp. The other prominent species are *Fenneropenaeus indicus*, *L. vannamei*,*Macrobrachium rosenbergii* and carps. From their interactions with farmers, they concluded that contact through mobile phones was ranked first as the best mode of communication followed by personal contacts. Only 22 % had undergone training courses and 83 % respondents evinced interest to attend training programmes on different aspects of shrimp culture. Forty eight percent of respondents opined that there should be shrimp diversification while 51 % of respondents were in favour of continuing with tiger shrimp. The next best alternative species suggested was Pacific White shrimp followed by *F. indicus* (35 %), *F. merguiensis* (6 %) and *M. japonicus* (6 %). The requirements of the shrimp farmers in general as observed by the officials are technical guidance on site selection, mass awareness programmes on diversification, assured supply of SPF seed, low cost feed, and remedy for size differences for growth in tiger shrimp.

Shrimp price dynamics in the domestic and international market

In order to comprehend shrimp price dynamics in the domestic and international market, an analysis of secondary market information on weekly average shrimp prices from domestic markets viz., Howrah, Visakhapatnam, Bhimavaram and Cochin along with export markets viz., New York and Tokyo wholesale markets was carried out. Additionally, a survey of 116 value chain respondents in eight states was conducted for collecting information on reported shrimp price crash during May to September 2012. Salient findings of the above study are: export market prices for Indian shrimps have a normal dip in April – June every year due to large quantum of arrivals from Kerala, West Bengal and Andhra Pradesh (Fig. 48). Due to unprecedented national shrimp output of 2.17 lakh tonnes, the prices plummeted. Japan's import restriction placed on Indian shrimps based on residual levels of Ethoxyquin, an anti-oxidant, resulted in the farm-gate prices in West Bengal slumping to 190 to 220/kg for 25-30 count and spillover effect was seen in other regions also reducing the price by 25 to 35 % of the normal.

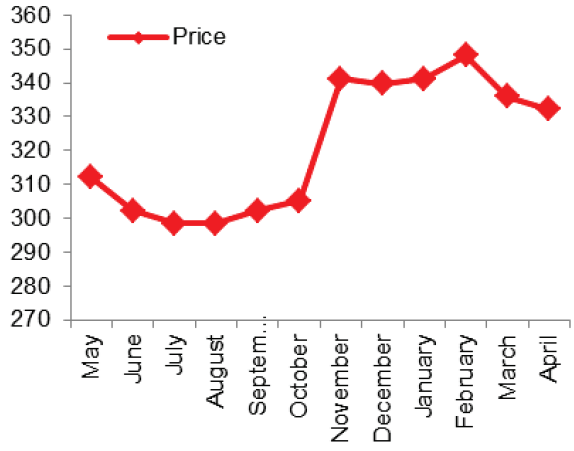


Fig. 48. Average export price of Indian shrimp May 2012-April 2013 (₹ per kg of 25 to 30 count)

It was also found that farm-gate prices have recovered to ₹ 260 and above for 30c, after September 2012. The value chain analysis indicated that the exporters have reduced procurement also to one-third of previous years due to poor international prices during the price crash period. Domestic prices remained higher than ₹ 230 to 250 in reference markets for similar size and hence more efforts need to be taken to tap domestic market potential to sustain shrimp farming in India.

Women participation in brackishwater aquaculture

To understand the role of women in aquaculture and allied aquaculture-based livelihoods, coastal women self-help groups in Tamil Nadu and Andhra Pradesh were studied. A coastal village Pedavasala (East Godavari, Andhra Pradesh), with 300 men and women were involved in crab trading. About 30 coastal women SHGs members were involved in dry fish sales at Ramanapallam, Thallarevu Mandal, (E. Godavari District). In 14 coastal villages of Ramnad District of Tamil Nadu, 29 coastal men and 34 women SHGs members were involved in seaweed farming. Four coastal women and men were involved in dry fish processing and trading in Tiruvalur and 50 coastal women and men were involved in dry fish processing for Feeds at Royapuram. About 407 Matsya Mithra Group (MMG) members were involved in fish marketing in Jalapushpa Bhavan (Fish market) developed by NFDB at Nellore. Women were involved in fish sales, fish cutting and cleaning, auctioning, transportation and maintenance of the market. Institutional support (from CIBA, TNWDC, DOF, SIFT, IFAD, NGO's & Banks) was strongly found in livelihood development programmes for coastal women Self Help Groups.

Eel processed for crab collection at Pedavasala, AP

Dry fish processing in smoking bins by coastal women at Ramanapallam (AP)

Under the CIBA Tribal Sub Plan, a mushroom farming unit, release of brackishwater ornamental fish (spotted scat) culture, demonstration of farm-made fish feeds and nursery rearing of Asian seabass in hapaswere taken up with tribal women SHGs.

Ornamental fish culture by WSHGs

Grading of seabass seeds by WSHGs

Mushroom farming by WSHGs

Transfer of Technology through ICT and capacity building

To develop a system for dissemination of brackishwater aquaculture information through mobile phone, the Krishi Vigyan Kendra (KVK), Kattupakkam Mobile phone model in agriculture and allied sectors was studied. The information was sent through Way2SMS to the farmers in English language. Daily SMS alerts were issued on agriculture, horticulture, dairy, poultry and fishery technologies and developments and call for events. The service was also being used as a medium to send information on important trainings and other programmes like field days, seminars, workshops, Frontline demonstrations, exposure visits etc., to the members of the Farmers Clubs, Commodity groups, individual farmers and Self Help Group networks under the KVK.

A sensitization programme on *L.vannamei* culture for the Department of Fisheries officials of the maritime states through Short Message Service (SMS) in Mobile phones was planned. The information to be shared included guidelines, reproductive biology, culture aspects including bio-security requirements, farm design and management aspects. In this connection, 68 technical messages was disseminated via SMS for DoFs in TN (60), AP (89) Odisha (45) and WB (51).Out of the total 252 officials, 88 % wanted CIBA to send information on seabass via SMS through mobile telephony. About 18 messages via VMS were disseminated to 289 farmers in Tamil Nadu in vernacular. A preliminary feedback collected from 92 farmers in Tamil Nadu revealed that they require culture information about seabass (84 %), *L.vannamei* (72 %), ornamental fish farming (69 %), details about shrimp diseases (70 %) and information on soil and water details (36 %).

Guidelines for successful group approach among shrimp farmers

Collective planning and compliance of BMPs is the major objective of shrimp farmer groups. In order to be successful, the shrimp farmer groups need to have common standard operating procedures which are to be collectively evolved and enforced. Based on analysis of the working of farmer groups, the following guidelines which could ensure success of group approach have been prepared: (i) It should be an obligation for a farm which operates in the cluster to be part of the group irrespective of its size, location and infrastructure. (ii) The group should prepare a common crop calendar in the general body meeting (GB) which should indicate when to begin and close the farming operations in the cluster. (iii) The group should finalize better management practices to be followed in the ensuing culture period and all the members should agree and record in the guidebook for the culture period. (iv) The farmer group based on its experience should identify one or two reputed hatcheries to procure the seeds collectively. The team may insist on disease screening at various stages which may include PCR screening of mother brooder after spawning, nauplii, initial postlarvae and later PL stages (during purchase). (v) If an outbreak of the disease occurs, it should immediately be informed and the group should handle it collectively through either premature harvest or bleaching the entire stock (if DOC is less than 60 days). During such occasions, the group should compensate the individual farmer for the loss. (vi) The group as a collective body needs to undertake the development, repair and maintenance of common infrastructure by having a common fund contributed by all. (vii) The farmer group executive committee should invite quotations from the available buyers and negotiate for a premium price for the shrimp produced in the cluster. The group should deduct an agreed amount from the farmer's sale proceeds and deposit the same into the farmer group account to be used for paying compensation and taking up common works. (viii) The farmer group shall ensure that banned drugs/chemicals are not used in the cluster thereby ensuring food safety and reducing the cost of cultivation. The group can procure other inputs also collectively to reduce the cost and ensure quality. (ix) The group should ensure cordial relations with local community by preferring local people for farm level employment

and help in societal infrastructure development. It should ensure minimum labour standards, minimum wage and harmony with local people. (x) The group should enforce record keeping of all the operations followed in the farm by printing a common record book and periodically verifying the same. Three case studies of farmer groups functioning at different levels i.e effective- moderate - poor were conducted. The group functioning well followed all the guidelines and the moderate group tried some guidelines other than complete membership, collective disease management and marketing intervention. The group categorized as poor, though had the potential to be an effective group, could not even succeed in collective seed procurement.

Entrepreneurship Development

In order to understand what drives entrepreneurship in brackishwater aquaculture, two case studies were documented. The first case study was of Mr. Sivagnanam of Kattur village in Thiruvallur district of Tamil Nadu who can serve as a role model for other potential entrepreneurs. He started with aquaculture of freshwater prawn and gradually moved to Indian major carps. His initiative enabled him to link with Oceanic edibles, a domestic live fish marketing company operating through contract-farming mode to supply live fish for domestic marketing in Chennai. He approached financial institutions for credit and because of his capacity and prompt repayments, the banks helped him continuously in all his ventures. Through his constant interactions with fellow fish farmers in the State, he became the Secretary of fish farmers association. Observing his growth, potential farmers have approached him and he has introduced 15 new farmers to aquaculture. With the advent of *L.vannamei*, he ventured into low saline farming based on 70:70:70 model of *L.vannamei* culture (70/m^2;70 days; 70 counts,) which he has been operating. He was awarded the Best Shrimp Farmer Award- 2011 from Fisheries Technocrats Forum, Chennai and best *L.vannamei* shrimp farmer Award from the MPEDA in 2013. The second case study is that of Shri. Pradeep Bhai of Olpad village in Surat district of Gujarat. He started as a fisherman who based on his own enquiry, concluded that shrimp aquaculture would be an ideal enterprise to build his career. He, along with a few potential entrepreneurs, approached government officials and policy makers and convinced them that unused lands could be utilised for shrimp farming. They prepared a district-wise aquaculture plan scientifically and obtained lands on lease from the government for shrimp aquaculture. He mobilized his farmer colleagues to form the Zeal aquaculture Pvt. Ltd. He has initiated culture with *L.vannamei* using *HDPL* lined ponds and the firm's total production has crossed 1000 tonnes. These two case studies clearly indicate that the initiative exhibited by interested farmers coupled with the active support provided by bank and government officials led to successful aquaculture operations by other farmers who were associated with them.

Farmer innovations in shrimp aquaculture

In order to document and evaluate innovations of shrimp farmers, details of the following ten innovations were collected: i) using agriculture shade net as substrate for development of periphyton, ii) disinfection of pond water by connecting a pipe with a bleaching power drum, iii) comfortable feeding floats made of indigenous PVC material, iv) tub made feed check tray, v) pond sludge depth indicator, vi) wooden stand with scale, vii) bottom soil sampler and central drainage system, viii) self-designed sludge pump-cum-aerator, ix) automatic flow through-water quality management and x) an indigenous automatic feeder. All these innovations could increase the efficiency of shrimp farming and there is potential for translating these into either small commercial products or as practices that other farmers could adopt.

Decision Support System for evaluating land suitability for aquaculture

Fuzzy decision support system (FDSS) was developed for classification of aqua sites with regard to their suitability for aquaculture development. For designing the FDSS, five input variables such as water (containing 9 sub-variables), soil (7), support (4), infrastructure (5) and risk factor (2), and one output variable : land suitability, was categorised into sub-regions called linguistic variables such as unsuitable, moderate and suitable. After splitting the variables, Gaussian and triangular membership functions were used for designing the input and output variables respectively. Totally 243 i.e. (3^5) fuzzy rules with logical AND operator, truncation implication and centroid method for defuzzification were employed to develop an efficient fuzzy model for decision making about classification of aqua sites. Case study was conducted in Krishna district (Andhra Pradesh) to validate the performance of the developed FDSS. The water, soil, support, infrastructure and risk factors related data used in this study were collected from 14 randomly selected aqua farms from Peddapalem, Peddakammavarupalem, Edurumondi, Chinnakammavarupalem and Nagayalanka in the case study area. After collecting the required information, the aqua farms were initially classified by FDSS and thereafter, the same aqua farms were classified according to the existing fuzzy logic based classification model (Mahalakshmi and Ganesan, 2012). Based on the results, out of 14 aqua farms, 12 aqua farms were classified correctly by the developed FDSS (Table 33). This shows that classification results obtained from the developed FDSS showed 86 % agreement with the results from the existing fuzzy logic based classification model.

Table 33. Comparison of developed FDSS and existing fuzzy classification model

	Developed FDSS				Total predicted	%
	Classification	Suitable	Moderate	Unsuitable		
Existing fuzzy model	Suitable	4	0	0	4	100
	Moderate	1	6	1	8	75
	Unsuitable	0	0	2	2	100
Total observed		5	6	3	12/14	
%		80	100	67		86

Development of content for Kiosk application

Kiosk application was developed for disseminating aquaculture related information along with the activities of CIBA, for stakeholders such as students, farmers, teachers, aquaculture professionals, extension personnel etc. It was developed in Python programming language by click event driven format. The kiosk application covers the following topics: information about CIBA, brackishwater aquaculture statistics, aquaculture (candidate) species, video films, technologies developed by the institute and services. Brackishwater aquaculture statistics are displayed in map format. Candidate species contains basic information such as scientific name, size, habitat and distribution etc. of crustacean and finfish brackishwater species. Video films on Institute profiles, mud crab fattening, value added products, farm-made fish feeds, shrimp farming and animation movie for women self-help groups in various languages such as Tamil, Telugu, Hindi and English with in-built audio are included in the application. Details of technologies such as CIBA Bhetkiahar, CIBA shrimp feed technology for commercialization, molecular kits, greenwater technology, NOVA RT- PCR kit for the diagnosis etc. developed by the institute are highlighted in the application. In this application, candidate species, brackishwater aquaculture statistics and technologies were designed using flash movies and thereafter embedded in Python.

Estimation of production and export based on Time series forecasting models

There is ample scope for using modeling and statistical tools to predict at the national level as to what would be the shrimp production in future, estimate the production of shrimp from a specific geographic area as well and give an idea of the production economics.

Monthly exports data on quantity and value of shrimp exports were collected from MPEDA Cochin and subjected to time series data analysis. The data used for building the models were from January 1995 to March 2010. The SAS 9.2 Time Series Forecasting System used for building the forecasting models and predicting the trends upto March 2015. ARIMA (Autoregressive integrated moving average) models were found appropriate for forecasting the marine products exports with RMSE (Root mean square error) values 1539 and 56.13 for marine exports quantity and value respectively. The models chosen were not only based on lowest RMSE values among the alternative models but also by looking at white noise and stationary assumptions. The model chosen for quantity of shrimp exports was Logistic ARIMA (0,0,1)(0,1,1)s and for total value of shrimp exports was ARIMA (2,0,2)(1,1,0)s. Training errors ranged from 0.68 to 12.68 % and 1.42 to 10.29% for quantity and value of the exports respectively. The year-wise actual and predicted figures are shown in Table 34 which shows that there is a close agreement between these two values confirming that the model is suitable for predicting shrimp production.

Table 34. Year-wise actual and predicted values using time series model for quantity and value of exports

Year	Quantity (M. Tons)		Value (₹in crores)	
	Actual	Predicted	Actual	Predicted
1996	103470	.	2631.91	0
1997	106297	103879.7	3109.52	2845.84
1998	101112	103343.6	3378.42	3295.28
1999	103069	102362.1	3362.38	3314.59
2000	117507	108178.3	4535.03	4068.37
2001	121134	112916.0	4100.37	4298.48
2002	140831	122965.5	4678.38	4456.26
2003	123923	127819.9	3936.24	4245.81
2004	137814	129609.7	4202.43	4122.09
2005	143503	135599.0	4255.48	4168.4
2006	142439	140078.0	4578.78	4462.68
2007	136060	139323.1	4051.35	4328.97
2008	126055	135028.3	3667.76	3796.25
2009	132487	131605	4228.84	3977.50
2010		132094.9	.	4168.40
2011		132090.4	.	4258.15
2012		132090.4	.	4234.80
2013		132090.4	.	4251.59
2014		132090.4	.	4245.48

An attempt was made to assess the shrimp production from Nellore district (Andhra Pradesh) Various stakeholders like feed suppliers, seed suppliers, processing plants and traders were interviewed to get an idea on cultured area both under tiger shrimp and vannamei, along with inputs from Fisheries Department at Nellore. The production estimation through back calculation of quantity of feed sold in an area provided reasonable estimates. There are around 27 feed companies selling shrimp feed. The feed sales in Nellore district along with the estimated production figures are givenin Table 35.

Table 35. Estimated shrimp production (tonnes) from Nellore district

Year	Feed sold (Mt)		Estimated production (with FCR 1.7)		% in total production		Total production (Mt)	% change
	PM	LV	PM	LV	PM	LV		
2010	9400	12170	5529	7158	43.57	56.42	12,688	0
2011	12750	44900	7500	26411	22.11	77.88	33,911	167
2012	10250	71200	6029	41882	12.58	87.41	47,911	41

PM= monodon, LV = vannamei

A web-based tool was developed for computing the project costs and economic appraisal parameters using PHP scripting language. This tool requires input on project life in terms of number of years, area under culture, bank interest rates, year-wise fixed and variable costs for entire project and outputs per ha culture costs, profitability indicators like gross returns, net returns, profit and economic appraisals like internal rate of returns, net present value and payback period.

Project Title (NABARD)	**Economics of shrimp ponds in disuse and participatory appraisal of productive use options and policy needs**

Participatory Rural Appraisal for revival of shrimp ponds in disuse

In order to understand the reasons behind the abandonment of shrimp ponds and the expectation of farmers for reviving them**,** a Participatory Rural Appraisal (PRA) with 70 respondents in Pedapattnam (Machilipatnam District, AP) was conducted on 23rd and 24th January 2013. The tools used were transect walk, time trend, social mapping, resource mapping, seasonal calendar, wealth ranking, problem tree analysis, Venn diagram, technology matrix and focus group discussion. Most of the households (99 %) were of homogenous social structure viz. Roman Catholic Christians from SC & ST communities. Out of the total, 80-90 % who left shrimp farming were small farmers. Due to severe attacks of shrimp diseases, 80-90 % ponds were left unused in the year 2000 and still are not in use. Majority of economically active persons were agricultural labourers and since Mahatma Gandhi National Rural Employment Guarantee Programme provided 100 days assured employment, small farmers have not taken the initiative to revive the shrimp ponds. Enterprising farmers have obtained Asian seabass fingerlings from CIBA, and after nursery-rearing, supplied 10-15 g fingerlings to about 15 farmers in Gudiwada, West Godavari & East Godavari districts. The problems noted among the villagers were low income, health problems and alcoholism. The community showed interest to revive the aqua ponds and they expected government support for seed and feed so that they could take up culture of seabass obtain financial assistance from government for repairing bunds, sluices and other farm structures and technical support from CIBA including one or two days' field training programme regarding seabass culture and management. The PRA has clearly indicated that unless there is specific support to these farmers, they would not be in a position to revive the abandoned shrimp ponds

Geospatial case analysis to determine the extent of shrimp ponds in disuse

An assessment of development of aquaculture farm area in different periods of through times series data was completed to evaluate the rate and extent of shrimp ponds in disuse in Krishna district. Ground truth verification and accuracy assessment was also done. Geo-spatial analysis to quantify the earlier land use and the extent of disuse from different lands was carried out and salient points are given below. From disused ponds, 143.47 ha were converted to mangroves due to the mangrove regeneration activities in the forest lands encroached for aquaculture. The sparse mangrove areas of 40.18 ha outside the forest land and mudflats of 121.89 ha were converted to shrimp farms. The shrimp farms of 11967.89 ha were delineated as disused ponds in 2012. Agriculture land of 1749.59 (1 %) and 218.91 ha (0.08 %) were converted to freshwater aquaculture farms and settlements. The disused farms were not revived due to the poor financial conditions of farmers, fear of disease problems, steep increase in production cost and also due to the volatility and loss of market prices. The farmers opined that they were not able to recover even the working capital amount spent and the profit margin is greatly reduced. This study has indicated that shrimp ponds in Krishna district have still not revived and the introduction of *L. vannamei* had minimum influence on the revival.

Project Title (ICSSR)	Assessment on the impact of Environmental Changes on the livelihoods of coastal Women in Tamil Nadu

Baseline survey on climate change impact on coastal Women livelihoods

The selection of sites and beneficiaries was initiated at Tiruvallur and Kancheepuram Districts. Social mobilization among the villagers and identifying the institutions for secondary data collection was also initiated. Baseline survey was conducted at 6 villages in Tiruvallur District and 7 villages in Kancheepuram District. Data has been collected on environmental threats and other threats faced by men and women, environmental changes and its impact on livelihoods and diversification of livelihoods, environmental changes and its impact on resources, factors like age, caste, health, ethnic groups, tourism, fish marketing practices and knowledge on environmental changes, access to livelihood assets, domestic workload and drudgery , environmental threats, challenges faced, vulnerabilities, management during lean season, decision making practices, adaptation measures, participation in the meetings, awareness programme, welfare measures, policies and institutional support.

Project Title (NFDB)	Appraisal of *Litopenaeus vannamei* culture systems and associated production risks for the development of Better Management Practices (BMPs)

Efficiency of evolving culture systems of vannamei farming

Under this project implemented from October 2012, the efficiency of evolving culture systems of *L.vannamei* farming and assessment of the production specific risks were carried out to develop suitable better management practices. To collect primary data from the vannamei farms, a comprehensive questionnaire was developed and validated for its reliability and validity. Subsequently, farm surveys were conducted in about 108 vannamei shrimp farms. Vannamei shrimp was cultured in different stocking densities ranging from 15 to 60 m^2. Two systems of production using brackishwater and low saline water were commonly observed. In addition, HDPL-lined high density culture has been adopted by corporate farms with a stocking density of 80 per m^2. The survey conducted on 68 brackishwater and 40 low saline culture farms revealed that 74 % of the farmers had two years of experience in farming vannamei but had not attended any training related to this. About 52 % of the farms surveyed had adequate biosecurity in all aspects. A salient observation was that the low saline culture systems adopted low stocking density, produced small sized (20 g) shrimps in 90 to 110 days with an average productivity of 4-5 t/ha.

Evolving vannamei farming practices in low saline water culture

Evolving vannamei farming practices in low saline water culture (n=40) was compared with brackishwater (n=68) farming to understand how the farming practices were evolving. The important differences in the practices adopted in low saline systems were: i) in pond preparation, ploughing was mostly not done; ii) with regard to water inletting, it was direct with no reservoirs and one filtration at pond entry; iii) in the pre-stocking water in ponds, organic manure/compost @ 100-200 kg/ha or fertilizer @ 25:25:15 NPK kg/ha and a higher dose of minerals organic manure/compost @ 100-200 kg/ha or fertlizer @25:25:15 NPK kg/ha was applied in addition to the fermented juice/ molasses (20 L/ha) and one dose water probiotic applied in brackishwater aquaculture; iv) in seed stocking, the protocol followed was similar except that generally stocking density was relatively low (20-30/m^2); v) in feeding and water quality management, it was similar except for higher dose of mineral mixture @ 60-100 kg/ha compared to 10-20 kg/ha/ 10 days in brackishwater aquaculture, v) while aeration followed was more or less similar, the harvesting periods were earlier-partial harvesting at 70 DOC and final harvest-at 100-110 days compared to 80 and 120-130 DOC in brackishwater.

Farmers' technical information requirement of vannamei farming:

The initial observations about the perceptions of farmers on the critical risk factors associated with vannamei farming have indicated that emerging diseases and market price were perceived as major

threats to shrimp farming. Seasonal variations and extreme events and soil and water quality were perceived as medium risks while food safety issues and social risks like labour issues and harmony with other stakeholders were considered as minimum risks.

Regarding technical information requirement at the field level, information on mineral requirement (kind of mineral, their optimum levels), disease prevention and pond management, water quality, aeration and feeding were the needs of shrimp farmers. It was expressed that group meetings with scientists and technical personnel at monthly intervals in the shrimp farming clusters to discuss and exchange information on these aspects would facilitate adoption of better management practices. Farmers felt that critical advise can be sent through mobile phones to a wider geographical area.

Project Title (NABARD) **e -Extension strategy for ensuring knowledge led rural growth**

e -Extension strategy for shrimp aquaculture

Under this project, content building, designing, installing and evaluating a farmer-friendly touch screen information kiosk on BMPs in shrimp culture were taken up. The contents of the kiosk were prepared based on identified demands for information on BMPs in shrimp culture arrived through on-farm meetings, awareness programmes and information need assessment survey. Information on BMPs in shrimp culture was provided in the information kiosk through text, pictures and audio back-up in vernacular keeping in mind the needs of small aqua farmers (Fig. 49).

Fig.49. Home screen of the software

The information has been developed in consultation with the subject matter specialists. This information would enable the Avarikadu farmers access to scientific practices on BMPs in simple language with regard to - site selection, biosecurity, seed selection, stocking, soil and water management, feeds and feed management, health management, harvest, subsidy details and also information on CIBA and NABARD.

A structured interview schedule was developed for evaluation based on the feedback obtained from kiosk facilitator (SRF) and individual users. The formative evaluation revealed that an information kiosk installed by a government institution is a freely accessible source of information to all farmers irrespective of their class and helps in transfer of technical information among small aqua farmers. All the farmers opined that it was very innovative and aimed at improving the access of aquaculture to information and knowledge. About 98 % of the farmers felt that the existing content on BMPs in shrimp culture was sufficient. They expected CIBA to update the content based on the needs of the farmer and their feedback. About 97 % of farmers considered it as user-friendly since it educated them effectively with digital information in local language for literates and digital information as audio for the semi-literate. Half of the total population had the intention to use whenever necessary since it was accessible to farm advices at their doorstep (Fig. 50).

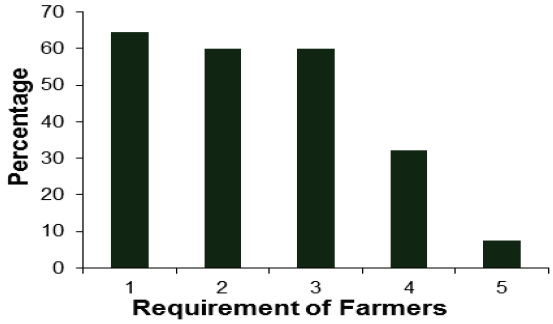


Fig. 50. Information requirements of farmer respondents (n=281)

1-Culture Information about *L.vannamei*, 2-Low budget culture, 3-Culture Information about koduva, 4-Internet Connection, 5-Culture information about mud crab

Project Title (NFDB)	Study on marketing and value chain improvement strategies for promoting white leg shrimp *(L. vannamei)* farming in India

This project was carried out to identify the marketing and value chain improvement strategies for promoting white leg shrimp *Litopenaeus vannamei* farming in India. The proposed research strategy tried to solve the exploratory and prospective analyses of production economics and marketing prospect for *L.vannamei* shrimp in domestic markets with a rapid survey and 'first benchmark farm dataset' on *L.vannamei* farming in the states like Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, Gujarat and Orissa. A report on *L.vannamei* production/culture for different farm categories & infrastructure development, domestic marketing requirements on size classes, price band preferences, seasonal demand patterns, sequential stocking, feed conversion ratio, harvesting, cost and returns and economic strategies was prepared. An analysis on marketing aspects of cost and returns and its impact on requirement of production of *L.vannamei* farming in the current situation as needed to this sector was carried out. The informative production data and prospects were calculated and validated to explore the marketing aspects for this study. From the results obtained, the specific technical and policy suggestions on marketing and value chain improvement strategies for promoting white leg shrimp, *Litopenaeus vannamei* farming in the sector was documented

KAKDWIP RESEARCH CENTRE

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

Optimum feeding frequency under shrimp/fish polyfarming

To determine the optimum feeding frequency of a low cost feed developed for shrimp/fish polyfarming, a trial was carried out in six farmers' ponds at Ganeshnagar and Namkhana. The species stocked were *Liza parsia* (5000/ha), *L. tade* (5000/ha), *Mugil cephalus* (2500/ha), *Scatophagus argus* (2500/ha), *Mystus gulio* (30000/ha) and *Penaeus monodon* (2500/ha). Feed @ 2-10 % bodyweight was given in three feeding frequencies (once, twice and thrice a day) in two ponds for each treatment. After 210 DOC, in the group fed three times a day the weight gain of all the species (Table 36) was highest indicating that this is the optimum feeding frequency.

Table 36. Final body weight in polyfarming at different feeding frequencies (210 DOC)

Species	Initial body weight* (g)	Final body weight (g) at feeding frequencies		
		1 time	2 times	3 times
Liza parsia	0.18±0.001	23.30 ^{a} ±0.33	24.63 ^{a} ±0.97	34.12 ^{b} ±1.53
L. tade	0.17±0.005	51.71 ^{a} ±3.99	67.56 ^{ab} ±7.25	78.70 ^{b} ±5.15
Mugil cephalus	11.28±0.10	250.62 ^{a} ±5.17	263.98 ^{ab} ±3.89	282.78 ^{b} ±7.78
Scatophagus argus	0.42±0.03	83.02±5.64	91.22±5.62	96.81±6.24
Mystus gulio	0.53±0.04	26.05 ^{a} ±0.21	26.55 ^{a} ±0.33	35.28 ^{b} ±3.27
Penaeus monodon	0.54±0.04	23.38 ^{a} ±0.56	25.51 ^{ab} ±0.17	35.82 ^{b} ±4.20

* Since the initial bodyweight between treatments were more or less uniform an average of all six ponds is given for final body weight, values with different superscripts differ significantly ($P< 0.05$)

Realizing the performance of polyculture feed developed by CIBA, many farmers evinced interest and 1.2 tonnes of low cost (₹19/ per kg) polyculture feed was distributed to farmers.

Improvement in tiger shrimp growth using periphyton

To determine the interaction of stocking density and provision of substrate on periphyton utilization and growth by *P. monodon*, a yard experiment was carried out for 75 days with split bamboos (5 × 2 × 1 cm) with 27 numbers per treatment at two different stocking densities of 10 and 20 nos./m^2 with aeration. At the end of the growth trial, in low density systems, a final body weight of 4.85 g and 75 % survival was recorded in bamboo based treatments compared with control (4.63 g and 58 % survival). In high density systems, a final body weight of 3.54 g with a 14 % higher survival was recorded in substrate-based treatment compared with control (2.96 g and 49% survival) (Fig.51 a,b). The provision of substrate in high stocking density system, significantly ($P<0.05$) reduced the level of nitrite–N, nitrate-N and non-significant reduced total ammonia–N compared to without substrate control group. Microscopic analysis of periphyton indicated that bacillariophyceae, blue green algae, green algae and dinoflagellates form the major groups of algal communities and this composition did not change between densities. The periphyton biomass in terms of dry matter showed significant ($P<0.05$) difference among the substrate based treatments, with a mean value 12.77 and 8.73 mg cm^{-2} in low and high density substrate based treatments respectively. Lower amount of periphyton biomass in high density substrate based system indicates an interaction between density and periphyton utilization. Based on the experiment, pond-based trial in farmers' ponds is being planned.

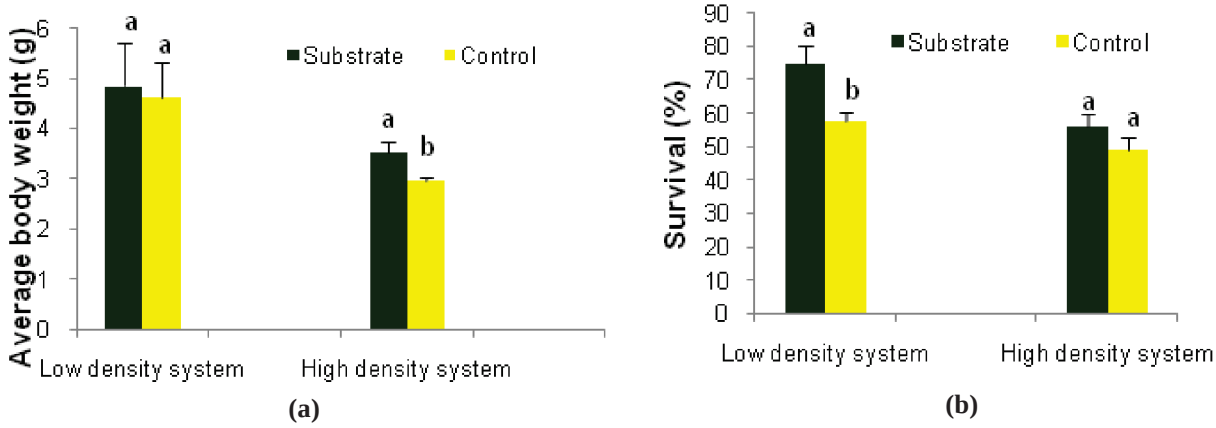


Fig. 51.(a) Mean body weight and (b) survival (± SD)in control and substrate based treatment at different stocking densities Values bearing different superscripts in a row differ significantly ($P<0.05$)

Biology of *Fenneropenaeus penicillatus* a potential species for diversification

A study on the biology of *Fenneropenaeus penicillatus*, a potential species for diversification, was carried out. Wild seed are available mainly during April-May and up to some extent in October-November in Sunderban region of West Bengal. A total of 102 specimens were collected from wild comprising three size range 80-90 mm (ABW 4.5 g), 90-100 mm (ABW 7.0 g) and 120-13 mm (ABW 9.5 g). Availability of size range 120-130 mm was dominant in sampling with standard length, rostrum length and carapace length of 108 mm, 33 mm and 20 mm respectively.

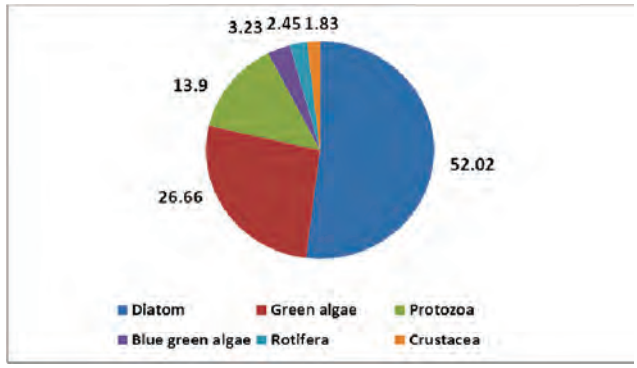


Fig. 52. Percentage occurrence of different groups in the gut content of juvenile *F. penicillatus*

Detailed analysis of food and feeding revealed that there exists a great amount of variation amongst the groups in gut content (Fig. 52, 53) with the size of shrimp.

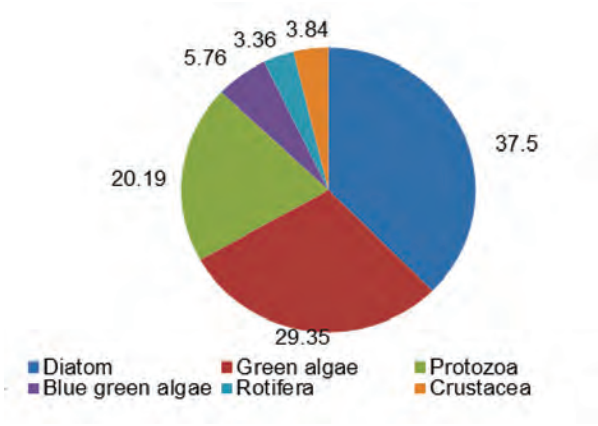


Fig. 53. Percentage occurrence of different groups in the gut content of adult *F. penicillatus*

Improvement in tiger shrimp growth and immune response using biofloc

Reports of biofloc utilization by tiger shrimp are scanty and a yard trial was carried out to determine the interaction between protein levels and the type of carbohydrate used. A 2 × 3 factorial experiment was carried out for 75 days with two protein levels (32 and 40), and three carbohydrates: molasses (M), rice flour (R) and no carbohydrate (N) while maintaining the C:N ratio at 10:1 with aeration. Tiger shrimp (3.3 g) was stocked at 100 no. m^{-3}. To simulate the natural conditions, all the treatments were exposed to natural light for 4-6 hrs/day. Limited water exchange was carried out twice when floc volume crossed 15 ml L^{-1}. Growth, water quality and microbial parameters were monitored at fortnightly intervals and immune response at the end of the experiment. The highest dissolved oxygen (7.75 ppm) was observed in 40+N followed by 32+N. Carbohydrate supplementation tends to reduce the total DO level with lowest value recorded in 32+M (6.95 ppm). The highest rate of DO reduction/hr (measured 60 and 120 min after aeration was stopped) was observed in molasses (0.60-1.20 ppm) followed by rice flour (0.45-0.91 ppm) and control (0.27-0.35 ppm). This rate of DO reduction/hr was negatively correlated with the floc volume which was highest in molasses (7.14-7.68 mL L^{-1}) followed by rice flour (5.85-6.57 mL L^{-1}) and control (2.97 -3.02 mL L^{-1}).

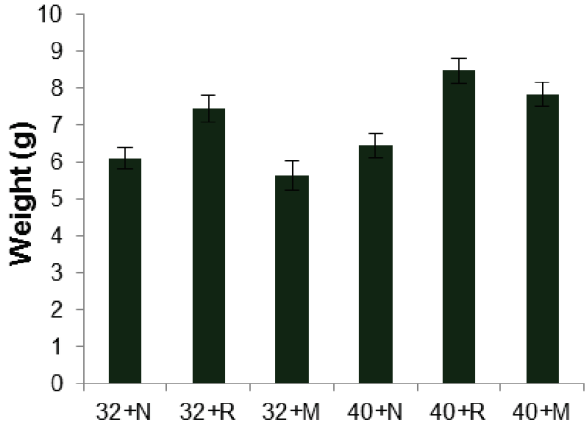


Fig.54. Effect of different carbohydrate and protein levels on growth performance of tiger shrimp

The highest body weight was observed in 40+R followed by 40+M, 32+R, 40+N, 32+N and the lowest in 32+M (Fig 54). The immune response study revealed that the highest haemocyte count and serum prophenol oxidase activity (OD 490 nm) was highest in 32+R (45.6 x 10^6 cell/ml and 0.28) and lowest in 40+N (25.8 x 10^6 cell/ml and 0.19) (Fig. 55). Total microbial count, vibrio and bacillus were higher in molasses supplemented groups, followed by rice flour and control. The highest Lactobacillus population and the lowest vibrio/total bacteria were observed in the 32+R group. In terms of growth and immune response, rice flour was a better substrate for biofloc compared to molasses. Further, the combination of rice flour and 32 % feed performed better compared to 40% protein feed. Based on growth and immune response, one could conclude that protein level of 40 % could be replaced with 32 % if rice flour is added while maintaining C:N ratio at 10:1.

Project Title (NFBSFARA)	Stock characterization, captive breeding, seed production and culture of hilsa *(Tenualosa ilisha)*

Biology of hilsa-a potential species for diversification

A multi-institutional project on Stock characterization, captive breeding, seed production and culture of hilsa (*Tenualosa ilisha*) was initiated in November 2012 with CIBA entrusted with the component on developing feed and brackishwater grow-out technology. In order to get baseline information on food and feeding, 37 specimens ranging from 5 to 900 g collected from Fresergunj, Namkhana, Kakdwip and Godakhali landing centers were analysed. The samples were dissected and gut taken out for content analysis by two methods i) qualitative which relates to the identification of organisms present in the gut and ii) quantitative which includes identification of gut contents into specific items and then quantifying each item. Gut content analysis of two size groups, 600-800 g and 200-400 g, indicated that frequency of occurrence (%) of diatom (42.71 to 66.23 %) was maximum followed by copepod (25 to 29.87 %) in both the size groups (Fig. 56 & 57). Among the diatom *Coscinodiscus* sp.and *Biddulphia* sp.were dominant in 200-400 g size group and *Coscinodiscus* sp. , *Thalassiothrix* sp. were dominant in 600-800 g size group. Volumetric index analysis revealed that copepods occupied maximum volume of gut in 200-400 g size group whereas diatom occupied maximum volume in 600-800gm size group.

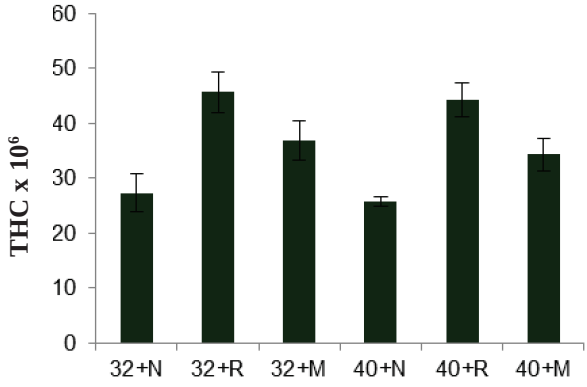


Fig.55. Effect of different carbohydrate and protein levels on total haemocyte count in tiger shrimp

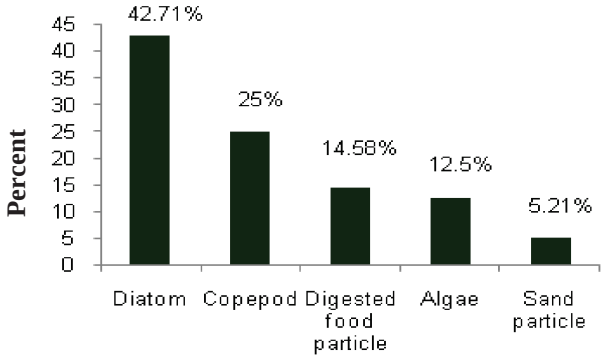


Fig. 56. Major food profile in gut of 200-400 g hilsa

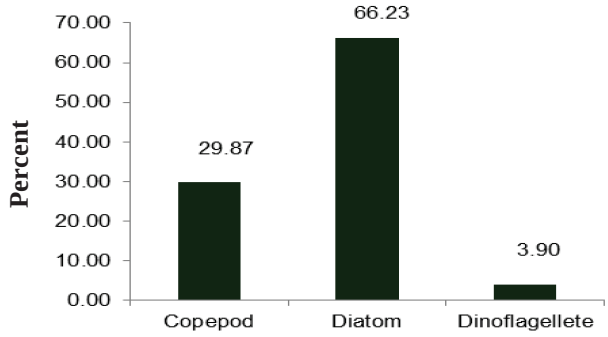


Fig. 57.Major food profile in gut of 600-800 g hilsa

Project Title (WorldFish Center)	Productive, profitable and resilient agriculture and aquaculture systems

Paddy variety for brackishwater rizipisciculture

To identify the paddy variety suitable for brackishwater rizipisciculture in kharif season, two experimental trials were conducted in Bhubannagar and Shibkalinagar of Kakdwip block in South 24 Paraganas district. In these, salt tolerant paddy variety Sabita and SR-26-B were evaluated in Bhubannagar and Amalmana and Gitanjali varieties in Shibkalinagar during August 2012. About 3600 sq.ft land was selected for each variety The saplings of the paddy were provided by Central Soil Salinity Research Institute, Canning. The production details of the four paddy varieties is given in Table 37 and based on the performance, Gitanjali and Amalmana variety were shortlisted for inclusion under paddy cum fish culture experimental trial for future.

Table 37. Production details of paddy variety

Variety	Yield/ha (kg)	Straw weight (kg)	Weight of 1000 grains (g)
Sabita	3000	168	38.35
SR26B	3450	176	30.50
Amalmana	3600	175	31.20
Gitanjali	4200	182	28.65

Paddy variety trial in Shibkalinagar

Improved homestead production system

A household survey on Homestead Production system was carried out in three coastal blocks of South 24 Parganas district viz. Sagar, Kakdwip and Namkhana to assess the contribution and impact of homestead production system in rural livelihood and also to understand the resource productivity. From this survey, socio-economic status of this area revealed that more than 90 % of households possess less than 1ha of land. Farmers are indigent and are engaged as labour (farm & non-farm) which is followed by betel vine cultivation. People involved in non-farm activities earn almost ₹ 40,000/year and those who are involved in farm activities earn less than ₹30,000 in a year. For this low income group, people spend 48 % of their earnings in food which is followed by agricultural input (12 %), clothing (11 %), health (8 %) and due to lack of awareness, investment in education (6 %) is extremely low.

About 94 % households possessing homestead ponds share maximum (41 %) land where more than 25 different types of species are cultured in which carps like *Labeo rohita* (Rohu), *Catla catla* (Catla), *Cirrhinus mrigala* (Mrigal), *Hypophthalmichthys molitrix* (Silver Carp), *Ctenopharyngodon idella* (Grass Carp) are the most commonly cultured species followed by *Puntius japonicus* (Japani Punti).

Homestead vegetable farming

In horticulture, almost 40 varieties of vegetables were cultivated which included turmeric, brinjal, arum, chilli, bitter gourd, pumpkin, ladies finger, potato, onion etc. but among these, betel vine is the most dominant variety. Pond dyke is used for fruit and timber tree cultivation and also for vegetable cultivation. All the crops grown are irrigated by homestead pond water but the pond is generally used for domestic purposes and betel vine cultivation. Due to a high demand in both national and international markets, 22 % households cultivate betel vine consequent to which the economic status of households gets improved. In animal husbandry, cows, goats, chicken and duck are reared. Though many farmers

Homestead pond

rear livestock, space is a major constraint. Gender inequity in participation of homestead activities was visible. The adult male-female ratio in agriculture is 1:0.77 and in aquaculture it is 1: 0.80.

Due to poor economic status, poor water and seed quality, soil salinity and disease infection, both quality and quantity of production is insufficient. Hence, almost 23 % of household are unable to get proper nutrition. The survey results indicate that the major portion of homestead land is allotted for pond aquaculture however production from homestead aquaculture (1400 kg/ha) is below the national average (2700 kg/ha/ year).The details of production from homestead system is given in Table 38.

Table 38. Production of homestead systems

Components of Homestead Systems	Production/year/ household
Aquaculture	68.2 kg (1400 kg/ha)
Horticultural crop	100 kg
Poultry egg	257 (no.)
Poultry meat	84 kg
Livestock milk	147 litre
Livestock meat	53 kg

The gross income from homestead production system is higher from aquaculture activities in all the three blocks (Kakdwip, Namkhana and Sagar) than the non-aquaculture activities (horticulture and animal husbandry) keeping betel vine cultivation outside the non-aquaculture activity as it is carried out by only 22 % households. Betel vine alone fetches highest gross income of more than ₹60,000/ per year (Fig. 58).

Livelihood improvement of tribal communities

In order to have baseline information on socio-economic status of tribal villagers prior to interventions and to select the village, a survey was carried out in four tribal villages namely Manmathapur (Village 1), Harintangi (2), Alipore (3) and Mrinalnagar (4). The farmers of Manmathapur have small families comprising less than 5 family members (83 %) and are mostly illiterate (74 %) (Table 39). The villagers have experience in agriculture and aquaculture. Among the four villages, only one person in village 1 has undergone training in aquaculture. Harintangi has larger families (72 %) having 5 or more family members and literacy is very low compared to other villages but the literate have studied up to higher classes compared to those in other villages. Alipore is the least literate among the surveyed villages and have smaller families (62 %). In all the villages, very few people have taken bank loans. The state government has distributed vested agricultural land to the tribal families. Most of the families have no pond in all the villages. Farmers having small ponds produce fishes which are consumed at home, the production level being very low. Agriculture is a main profession in all the villages except Alipore. Some families maintain a piggery which appears to be a highly preferred activity in Alipore. In Alipore, the main profession is casual labour as most of the families are landless. In all the villages, most of the ponds are 11-20 years old. In village 1, all are freshwater ponds except a 26 bigha bhery which is shared by 14 families. In other three villages, a few families do hold small brackishwater impoundments.

All the families are engaged in traditional farming. Auto-stocking of some weed fishes viz. Puntia spp., *A. mola* and snakeheads etc. occur during rainy season. Some farmers release carp seeds procured from hawkers into freshwater ponds. Since no feed, fertilizer and lime are applied in these ponds, the productivity is low. Fishes produced through natural productivity is used for home consumption.

In brackishwater impoundments, water is exchanged every lunar cycle. They solely depend upon auto- stocking. Fishes, shrimps and crabs are harvested during water exchange. There is no marketing as production is low. About 46 % of the families in village 1 have brackishwater impoundment

Table 39. Socio-economic condition of four tribal villages of Kakdwip block (N= 70)

Variables	Descriptions	Manmathapur (Mundapara) (n = 30)% (village 1)	Harintangi (n = 14)% (village 2)	Alipore (n = 8) %(village 3)	Mrinalnagar (Mundapara) (n = 16)% (village 4)
Family size	< 5 members	83	28	62	52
	≥ 5 members	17	72	38	48
Sex ratio	Male: Female	49 :51	46 :54	47 :53	47 :53
Education	Illiterate	74	64	75	72
	Primary	10	21	12.5	18
	8th standard	8	15	12.5	8
	10th standard	8	0	0	2
	graduate	0	0	0	0
Experience in aquaculture / agriculture	< 5 years	23	28	12.5	26
	6-10 years	31	35	12.5	19
	10-20 years	25	21	25	38
	> 20 years	21	16	50	29
Training in aquaculture	Yes	3	0	0	0
	No	97	100	100	100
Finance	Bank loan	7	14	12.5	12.5
	Private loan	33	35	50	62.5
	Personal savings	60	51	37.5	25
Main activity	Agriculture	57	71	25	50
	Business	0	0	0	0
	Service	10	0	0	0
	Casual labour	27	11	75	40
	Others (Piggery and crab collection)	26	38	75	55
Ownership of land or pond	Own	62	64	27	57
	Leased	8	0	0	5.5
Land holdings	Landless	30	36	75	37.5
	< 0.1 ha	53	56	12.5	55.5
	0.1-1 ha	17	8	12.5	7
	> 1 ha	0	0	0	0
Perception	Risky	27	22	25	31
	Profitable	73	78	75	69
No. of ponds	0	73	71	63	65
	1	24	29	37	21
	2-5	3	0	0	14
	> 5	0	0	0	0
Area of ponds	< 0.1	100	100	100	100
	0.1-1.0	0	0	0	0
	> 1.0	0	0	0	0
Age of ponds	< 5	7	0	0	19
	6-10	17	7	12.5	25
	11-20	57	71	50	63
	> 20	19	22	37.5	7

(a 26 bigha bhery shared by 14 families) where production is fully dependent on auto-stocking and nutrients available in natural water. A similar trend is followed in other villages where 14, 25 and 19 percent families have brackishwater impoundments in villages 2, 3 and 4 respectively. Considering the whole water area available, the share of brackishwater is 67, 42, 26 and 48 percent in villages 1, 2, 3 and 4 respectively where productivity is very low (less than 500 kg/ha).

On the basis of the pilot survey in the tribal villages of Sundarbans, one of the villages namely Manmathapur (Mundapara), was selected for intervention. A training-cum-awareness program on Methodology in Brackishwater Aquaculture was organized in January 2013 in this village. About 70 farmers of both genders attended and interacted with the Scientists. About 13 ponds covering a waterspread area of 3885 m^2 has been selected for experimental farming. Polyfarming has been initiated in all the selected pond with species combination of *Chanos chanos*, *Mugil cephalus*, *Etroplus suratensis*, *Liza parsia* and *Penaeus monodan* the culture of which is in progress.

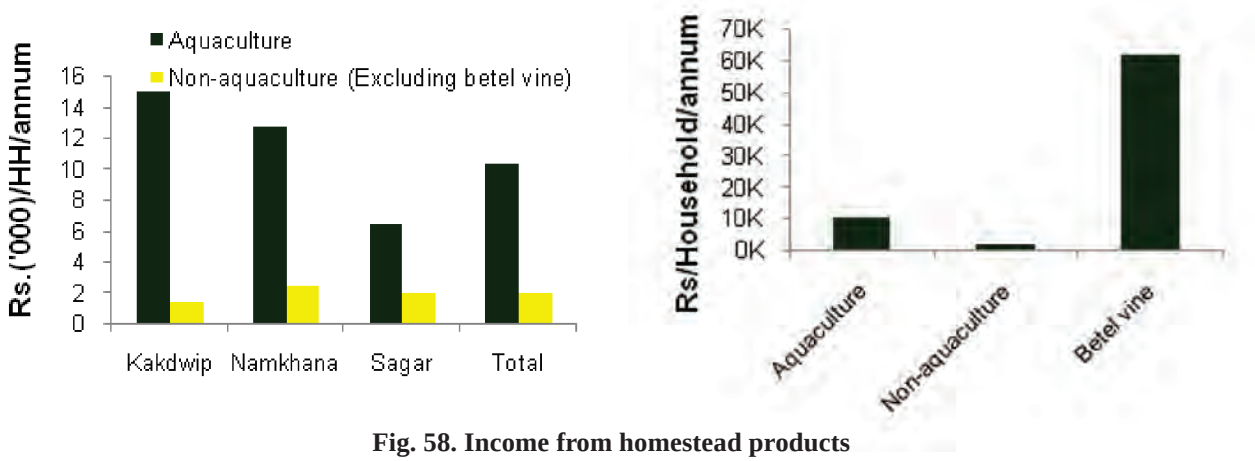


Fig. 58. Income from homestead products

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

Development and implementation of land shaping technology

Under the NAIP at Kakdwip Research Centre, land shaping technology was used as a model for harvesting rain water in kharif. This water was used for crop/vegetable cultivation in rabi and summer and fresh water fish culture could be carried out in the excavated ponds thereby converting monocropping land to multicropping diversified land with enhanced productivity and reduced risk of failure of monocrop due to the vagaries of nature. Thirty four rain water harvesting ponds were excavated for irrigation and fish cultivation. Inputs (paddy, vegetable, fish, scampi, organic fertilizer and neem pesticide) were distributed to 34 beneficiaries. The farmers achieved an average production of 3.08 t/ha paddy, 11.51 t/ha vegetables, 2.33t/ha fish and 0.30 t/ha scampi. A total of 10.93 ha was developed with 66 rain water harvesting ponds for irrigation and fish culture. After land shaping, farmers obtained a substantial income from the developed area and water scarcity for irrigation and fish farming has been substantially reduced.

Implementation of brackishwater aquaculture

Production of tiger shrimp was 574.54 kg/ha, *Mugil cephalus* 218.47 kg/ha and *Liza tade* 446.61 kg/ha following polyculture system. Before implementation of this project, the land was fallow and not

being utilized for any agricultural activity on account of high soil salinity. During 2012-13, 7.73 ha area has been developed with 42 brackishwater ponds.

Paddy-cum-fish cultivation

A total of 0.67 ha area has been developed. Scampi was stocked after 15 days of paddy transplantation @ 0.44 no./sq m and Indian Major Carp fingerlings (*Catla catla, Labeo rohita* and *Cirrhinus mrigala* in 4:3:3 ratio) were stocked @ 0.68 no/m^2 farmers land where trenches/ponds were excavated during 2011-12. After 4 months of culture, farmers achieved production of 158.45 kg/ha scampi, 627.42 kg/ha fish and 2538.46 kg/ha paddy. During 2012-13, 2.4 ha area was developed with 14 freshwater ponds for paddy-cum-fish cultivation. Compared to normal paddy cultivation alone, overall productivity was higher in the integrated system. The integration of horticultural crops and rizipisciculture can be adopted to improve the socioeconomic status of weaker rural communities.

Paddy cum fish cultivation unit at Jumainaskar

Fish harvesting in paddy fish unit at Jumainaskar

Environmental monitoring

Six creeks, 51 ponds and 21 agricultural plots were regularly monitored for salinity and nutrients to assess the environmental impact due to adaption of brackishwater aquaculture (BW), land shaping (LS) and paddy-cum-fish (PCF) interventions in villages. The LS and PCF had a positive impact on reclamation of saline degraded soil as lower salinity was recorded in treatment field (0-25 m from pond) compared to control (25-100 m from pond), after four months post excavation. The excavation work temporarily increased the salinity as evident from the values recorded in the treatment field during March compared to control but thereafter reduced. The brackishwater did not enhance the salinity of surrounding agricultural fields. The highest level of total ammonia-N was recorded in PCF (1.1 mg/L) and the lowest in BW ponds (0.35 mg/L).

TrainingProgramme

Six training programmes on vermicomposting, brackishwater aquaculture, rizipisciculture, land shaping with rain water harvesting and diversification of crops were conducted with 282 farmers being trained in these activities.

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, endocrine and nutritional control of female maturation, immune status of broodstock shrimp and its modulation in shrimp *(P. monodon, F. indicus)*	Dr.C.P.Balasubramanian
Standardisation of breeding and seed production technique of diversified shrimp species *(F. penicillatus, F. indicus)*	Dr.A.Panigrahi
Environmental manipulation using RAS and seaweed integration	Dr.P.Nila Rekha
Development of probiotic based shrimp production techniques-mechanism of action studies	Dr.A.Panigrahi
Culture of *Litopenaeus vannamei*, standardisation of high density nursery rearing of *L. vannamei*	Dr.P.Ravichandran
Evaluation of shrimp farm waste water treatment system	Dr.M. Muralidhar
Culture of polychaetes	Dr.C.Gopal
District level planning for brackishwater aquaculture	Dr.M.Jayanthi
Genetic studies for growth and reproduction traits in *F. indicus*	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
Development of larval rearing protocol for mud crab *Scylla serrata*	Dr.C.P.Balasubramanian
Demonstration of mud crab culture in farmers pond	Dr. A. Panigrahi

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 mangroves	Dr.M.Jayanthi
Assessment of impact of aquaculture on coastal lakes 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
Demonstration of culture technologies of banana shrimp *F. merguiensis* in Danti farm and farmer's pond	Dr.S.M.Pillai
Broodstock development, seed production and culture of *M. kutchensis*	Dr.C.Gopal
Characterization of soil profile in Danti farm and farmer's ponds	Dr. M.Muralidhar
Grow out cage culture of pearlspot in brackish and low saline waters at Danti farm	Dr.M.Natarajan
To address the extension needs of aquafarmers and organizing focus group discussions and preparation of extension materials	Dr. V.S.Chandrasekaran
Demonstration of milkfish culture in brackish and low saline waters at Danti farm	Dr. M.Kailasam
Study on the role of innovative water management methods on pond microbiology and productivity in shrimp culture systems	Dr. P.K.Patil
Assessment of ICT needs in aquaculture and development of e-learning modules	Dr. P.Mahalakshmi
Nursery rearing and grow-out culture of seabass in ponds and cages at Danti farm	Dr. Prem Kumar
Demonstration of cage farming of finfishes under tribal sub plan (TSP)	Dr.S.M.Pillai

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-Investigator	**Dr. S. M. Pillai**

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

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	**Dissemination of technology on the seed production of Asian Seabass *(Lates calcarifer)* and development, standardization and refinement of seed production technology for other commercially important brackishwater fishes**
Project Leader	**Dr. A. R. Thirunavukkarasu**

Project Location	**Chennai & Kakdwip**

Sub-Project Title	Sub-Project Leader
Transfer of Seabass seed production technology	Dr.A.R.Thirunavukkarasu
Technology development for controlled breeding of Grey Mullet *(Mugil cephalus)* and Milk Fish *(Chanos chanos)*	Dr.A.R.Thirunavukkarasu
Technology development for controlled breeding of pearlspot	Dr M. Natarajan
Improved broodstock management and initiation of selective breeding on pearlspot *Etroplus suratensis* in different farming systems	Dr. G. Gopikrishna
Establishing a captive broodstock development of technology for controlled breeding of threadfin bream *(Polynemus sparidius)* and golden spot mullet *(Liza parsia),* nursery rearing of fry of asian seabass, grey mullet, milkfish, pearlspot	Dr. J.K.Sundaray
Refinement of captive breeding technology for important brackishwater ornamental fishes	Dr. M. Kailasam
Reproductive physiology of grey mullets	Dr. Prem Kumar
Breeding of pearlspot in small net cages and RAS	Dr. Krishna Sukumaran

Project Title 10	**Improvement and validation of brackishwater fish culture technologies**
Project Leader	**Dr. M. Natarajan,**
Project Location	**Chennai & Kakdwip**

Sub-Project Title	Sub-Project Leader
Cage culture of Asian seabass in open brackishwater system	Dr.A.R.Thirunavukkarasu
Nursery rearing and growout culture of seabass, milkfish and mullets.	Dr J. K. Sundaray
Pond and cage culture of pearlspot	Dr.M.Natarajan
Secondary aquaculture in culture ponds	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**
Lead Centre	**Fisheries College and Research Institute (TANUVAS), Tuticorin**
Co-Principal Investigator	**Dr. A. R. Thirunavukkarasu**
Co-Investigators	**Dr. J. K. Sundaray, 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. J. K. Sundaray, Dr. M. Kailasam, Dr. K. Ambasankar and Dr. Prem Kumar**

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. K. P. Jithendran**
Project Location	**Chennai and Kakdwip**

Sub-Project Title	Sub-Project Leader
Epizootiology, diagnostics and prophylactics of viral diseases of cultivable finfish	Dr.K.P.Jithendran
Screening emerging viral diseases in finfish and shellfish and development of suitable diagnostic techniques	Dr.S.V.Alavandi
Characterisation of finfish and shellfish viruses and virus virulence	Dr.M.Poornima
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
Prophylactics and therapeutics of diseases in responsible shrimp aquaculture	Dr. R. Ananda Raja
Transmission studies on cryptic viral infections in *Litopenaeus vannamei*	Dr. Ezhil Praveena
Understanding the Vibrios associated with *Litopenaeus vannamei* shrimp aquaculture environment	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
Studies on role of probiotics in pond microbial dynamics in penaeid shrimp culture ponds	Dr.P.K.Patil

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**

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. S.V. Alavandi**

Project Title 18	**Development of bacterial vaccines *(Vibrio angullarum)* for seabass (Indo-Norwegian Platform)**
Project Location	**Chennai**
Funding Agency	**Department of Biotechnology**
Principal Investigator	**Dr. M. Poornima**
Co-Investigator	**Dr. A. R. Thirunavukkarasu**

Project Title 19	**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 20	**Defense genes of tiger shrimp *(Penaeus monodon)* with respect to bacteria *(Vibrio harveyi)* and white spot syndrome virus (WSSV) infection**
Project Location	**Chennai**
Funding Agency	**National Fund for Basic, Strategic and Frontier Application Research in Agriculture (NFBSFARA), ICAR**
Principal Investigator	**Dr. Subhendu Kumar Otta**
Co-Investigators	**Dr. K. P. Jithendran and Dr. T. Bhuvaneswari**

Project Title 21	**Identification of etiology of monodon slow growth syndrome (MSGS) of black tiger shrimp in India and development of rapid growth tools**
Project Location	**Chennai**
Funding Agency	**Department of Biotechnology**
Principal Investigator	**Dr. M. Poornima**
Co- Investigators	**Dr. S. V. Alavandi and Dr. P. Mahalakshmi**

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**
Collaborating Centre	**NaCSA**

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**
Lead Centre	**Central Research Institute for Dryland Agriculture**
Principal Investigator	**Dr. M. Muralidhar**
Co-Investigators	**Dr. M. Jayanthi, Dr. J. Syama Dayal, Dr. A. Panigrahi, Dr. M. Kumaran, Dr. R. Saraswathy, Shri J. Ashok Kumar, Dr. N. Lalitha 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. K. Ambasankar**
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

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

Sub-Project Title	**Sub-Project Leader**
Demonstration for shrimp and fish feed technology developed by CIBA and popularization of farm-made feeds	Dr.K.Ambasankar

Updating of aqua feed raw material data base and exploring novel and unconventional ingredients for use in aqua feeds	Dr.K.Ambasankar
Interventions to improve feed digestibility efficiency and growth performance using plant protein sources	Dr.T.K.Ghoshal
Formulation and testing of farm-made feeds in West Bengal	Dr.Debasis De
Functional genomic studies for effective replacement of fish oil and fish meal in shrimp and fish	Dr. J. Syama Dayal
Development of indigenous feeder for efficient nutrient delivery	Dr. P. Nila Rekha

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

Sub-Project Title	**Sub-Project Leader**
Popularization of fish/shrimp as health food	Dr.J.Syama Dayal
Nutrient profiling of candidate species	Dr.J.Syama Dayal

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.K. Vinaya Kumar
Molecular studies on immune genes for disease resistance in *P.monodon*	Dr.M.S.Shekhar
Documentation of polymorphic DNA markers in candidate genes of growth in tiger shrimp	Dr.S.Kannappan
Screening for reproduction associated genes in male Indian white shrimp, *Fenneropenaeus indicus*	Dr.Sherly Tomy
Evaluating the potential for selection of economically important traits in rotifers	Dr.M.Kailasam

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

Project Title 29	**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 (NABARD)**
Principal Investigator	**Dr. K. Ambasankar**
Co-Investigator	**Dr. V. S. Chandrasekaran**

Project Title 30	**Bioprospecting of genes and allele mining for abiotic stress tolerance**
Project Location	**Chennai**
Funding Agency	**National Agricultural Innovation Project (NAIP)**
CCPI	**Dr. M. S. Shekhar**
Co-Investigators	**Dr.Sherly Tomy and Dr.K.Vinaya Kumar**

Project Title 31	**Improved disease resistance of tiger shrimp and rohu carp farmed in India : Developing and implementing advanced molecular methods and streamlining access to and use of genetic resources (Indo-Norwegian Platform)**
Project Location	**Chennai**
Funding Agency	**Department of Biotechnology**
Project Co-ordinator	**Dr. A. G. Ponniah (CIBA)**
Project Investigator	**Dr. G. Gopikrishna**
Co-Investigators	**Dr. P. Ravichandran, Dr. C. Gopal, Dr. M. S. Shekhar and Dr. K. Vinaya Kumar**
Collaborating Centre	**CIFA, NOFIMA (Norway)**

Project Title 32	**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 33	**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**

Project Title 34	**Molecular mechanisms of gonad inhibiting hormone action on the control of egg maturation in the penaeid shrimp**
Project Location	**Chennai**
Funding Agency	**Department of Biotechnology**
Principal Investigator	**Dr. Sherly Tomy**
Co-Investigator	**Dr. S. K. Otta, Dr. C.P. Balasubramanian and Prof. T. Subramoniam**

Social Sciences Division

Project Title 35	**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
Gender assessment in aquaculture, allied aquaculture and agro based sectors in Tamil Nadu and Andhra Pradesh and empowerment of WSHGs in Tamil Nadu to adopt aquaculture integrated with agro based technologies	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
Application of computational methods in brackishwater aquaculture research	Shri J. Ashok Kumar
Organisation and conduct of extension and outreach activities of the Institute	Dr.V.S.Chandrasekaran

Project Title 36	**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, Dr. P. Mahalakshmi**

Project Title 37	**Economics of shrimp ponds in disuse and participatory appraisal of productive use options and policy needs**
Project Location	**Chennai**
Funding Agency	**National Bank for Agriculture and Rural Development**
Principal Investigator	**Dr. T. Ravisankar**
Co-Investigators	**Dr. P. Ravichandran, Dr. D. Deboral Vimala, Dr. M. Jayanthi and Dr. R. Saraswathy**

Project Title 38	**Assessment on the impact of environmental changes on the livelihoods of coastal women in Tamil Nadu**
Project Location	**Chennai**
Funding Agency	**Indian Council of Social Science Research**
Principal Investigator	**Dr. B. Shanthi**
Co-Investigators	**Dr. P. Mahalakshmi, Dr. V. S. Chandrasekaran and Dr. T. Ravisankar**

Project Title 39	**Study on marketing and value chain improvement strategies for promoting white leg shrimp *(L. vannamei)* farming in India**
Project Location	**Chennai**
Funding Agency	**National Fisheries Development Board**
Principal Investigator	**Dr. T. Ravisankar**

Project Title 40	**Appraisal of evolving *Litopenaeus vannamei* culture systems and associated production risks for development of better management practices**
Project Location	**Chennai**
Funding Agency	**National Fisheries Development Board**
Principal Investigator	**Dr. M. Kumaran**
Co-Investigators	**Dr. T. Ravisankar, Dr. D. Deboral Vimala and Shri J. Ashok Kumar**

Kakdwip Research Centre

Project Title 41	**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	Smt. P. S. Shyne Anand
Polyfarming of finfish and shellfish	Dr. J.K. Sundaray
Standardization of feed management practices of polyfarming with low cost feed	Dr.Debasis De
Evaluation of biofloc technology and associated microbes based intervention in sustainable shrimp and fish culture	Dr.Sujeet Kumar
Study of the biology of shrimp *Fenneropenaeus penicillatus* available in Sundarban region of West Bengal	Dr. Ashutosh D. Deo
Low saline aquaculture	Dr. J.K. Sundaray
Documentation of evolving brackishwater aquaculture systems in West Bengal	Dr. T.K. Ghoshal

Project Title 42	**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. Ashutosh D. Deo, Dr. R. Ananda Raja, Dr. Sujeet Kumar, Smt. P. S. Shyne Anand and Dr. M. Kumaran**

Project Title 43	**Productive, profitable and resilient agriculture and aquaculture systems**
Project Location	**Kakdwip**
Funding Agency	**WorldFish Center**
Principal Investigator	**Dr. J. K. Sundaray**
Co-Investigator	**Dr. Ashutosh D. Deo**

Project Title 44	**Stock characterization, captive breeding, seed production and culture of hilsa *(Tenualosa ilisha)***
Project Location	**Kakdwip**
Funding Agency	**National Fund for Basic, Strategic and Frontier Application Research in Agriculture (NFBSFARA), ICAR**
Principal Investigator	**Dr. Debasis De**
Co-Investigator	**Smt. P. S. Shyne Anand**

6

Technology Assessed and Transferred

The technologies/knowledge-base developed by the Institute were extended 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.	Methods of sample collection techniques to study mass mortality in *L. vannamei*	1 June, 2012	7
2.	Phone-in-programme on Better Management Practices in shrimp culture	17 July, 2012	36
3.	Seed production and larval rearing of Asian seabass *(Lates calcarifer)*	15-19 October, 2012	20
4.	Live feed production for larviculture of brackishwater finfishes	29 October-2 November, 2012	20
5.	Usage of kiosk & BMPs in shrimp farming	30 October, 2012	227
6.	Management of emerging diseases of shrimp with special reference to Pacific white shrimp *Litopenaeus vannamei*	10-14 December, 2012	25
7.	Capacity building of tribal women self-help groups on brackishwater aquaculture integrated with agro-based technologies	26-28 December, 2012	25
8.	Aqua feed processing and quality control	5-8 March, 2013	3
Kakdwip Research Centre			
9.	Fisheries work experience program	20-30 April, 2012	28
10.	Vermicomposting	23 May, 2012	15
11	Prospects of brackishwater finfish farming with special reference to raising of fish seed bank towards diversification	24 May-7 June, 2012	300
12.	Brackishwater aquaculture and paddy-cum-fish culture	29 May, 2012	22
13.	Technology initiative for sustainable brackishwater aquaculture	2-7 July, 2012	9
14.	Implementation of land shaping (NAIP)	18 July, 2012	34
15.	Implementation of land shaping (NAIP)	19 July, 2012	36
16.	Prospects of seabass farming in West Bengal and propagation of the nursery rearing technology	25 July, 2012	100

Sl. No.	Training Programmes	Duration	No. of participants
17.	BMPs in shrimp farming with special reference to West Bengal	27-31 August, 2012	8
18.	Nutrition, feed preparation & management for sustainable brackishwater aquaculture	17-21 September, 2012	10
19.	Fisheries work experience programme	18-26 December, 2012	25
20.	Methodology in brackishwater aquaculture (TSP Project)	18 January, 2013	66
21.	Crop diversification in Sunderban area of West Bengal	22 January, 2013	46
22.	Farmer interaction meet and seabass fish harvest mela at Madanganj, Namkhana, under NFDB Project.	15 February, 2013	260
CIBA-NAU Collaborative Centre, Navsari, Gujarat			
1.	Farming of banana shrimp and brackishwater finfishes in Gujarat state	15-19 January, 2013	20

7

Training and Education

HUMAN RESOURCE DEVELOPMENT

International

Participant	Particulars	Organiser	Period
Dr.J.K.Sundaray Principal Scientist	CPWF G2 Field Visit, Review and Planning Meeting and Ganges BDC Reflection Workshop	WorldFish Center, Dhaka, Bangladesh	25.3.2012- 2.4.2012
Dr.T.K.Ghoshal Senior Scientist	Training on Aquaculture Development	Purdue University, West Lafayette, Indiana, USA	1.4.2012- 28.4.2012
Dr.A.G.Ponniah Director Dr.M.Muralidhar Senior Scientist	Aqua-Climate Project Final Workshop and Regional Workshop on Impacts of Climate Change on Fisheries and Aquaculture	Bangkok, Thailand	14.5.2012- 16.5.2012
Dr.A.G.Ponniah Director	FAO/NACA/APFIC Regional Workshop on Application of Aquaculture Assessment Tools in Asia-Pacific	Bangkok, Thailand	3.7.2012- 5.7.2012
Dr.K.P.Jithendran Principal Scientist	Workshop on Regional Proficiency Testing Programme for Aquatic Disease Laboratories in Asia-Pacific	Bangkok, Thailand	25.7.2012- 26.7.2012
Dr.K.Vinaya Kumar, Scientist	Training on Genomic Prediction	Iowa State University of Science and Technology, USA	7.8.2012- 6.11.2012
Dr.S.V.Alavandi Principal Scientist	Workshop on DAFF/NACA Emergency Asia Pacific Regional Consultation on EMS/AHPNS	Bangkok, Thailand	9.8.2012- 10.8.2012
Dr.J.K.Sundaray Principal Scientist	CPWF Meeting on Aquaculture and Homestead	Dhaka, Bangladesh	7.11.2012- 12 .11.2012

National

Participant	Particulars	Organiser	Period
Shri D.Raja Babu Technical Officer (T 7-8)	Competency Enhancement Programme for Technical Officer (T-5 and above)	National Academy of Agricultural Research Management (NAARM), Hyderabad	7.5.2012-16.5.2012
Dr.Debasis De Senior Scientist	Assessment of Microbial Diversity by Next Generation Sequencing (NGS) for Taxonomic and Metabolic Reconstruction of the Gut Microbes	National Institute of Animal Nutrition and Physiology (NIANP), Bangalore	22.8.2012 - 4.9.2012
Dr.G.Gopikrishna Principal Scientist	MDP Workshop on Policy and Prioritization, Monitoring and Evaluation (PME) Support to Consortia-based Research in Agriculture	NAARM, Hyderabad	11.9.2012-17.9.2012
Shri S.Rajamanickam Technical Officer (T-5)	1st Capacity Building Programme for Technical Assistants sponsored by the Department of Science and Technology (DST)	Indian Institute of Public Administration (IIPA), New Delhi	24.9.2012-5.10.2012
Dr.V.S.Chandrasekaran Principal Scientist	National Training Policy	Institute of Secretariat Training and Management (ISTM), New Delhi	26.12.2012-27.12.2012
Dr.R.Ananda Raja Scientist	Bioinformatics Tools and Techniques for Gene and Protein Analysis	Tamil Nadu Veterinary and Animal Sciences University, Chennai	7.1.2013-11.1.2013
Dr.P.Nila Rekha Senior Scientist	Solar Engineer Installation Skill Development Programme	Indian Institute of Energy Management, Chennai	22.2.2013-23.2.2013

8

Awards and Recognitions

- Best paper award for "Seed production of pearlspot *(Etroplus suratensis)* in small net cages" was presented to Krishna Sukumaran**,** A. R. Thirunavukkarasu, M. Natarajan, M.Kailasam, J.K.Sundaray, Prem Kumar, R.Subburaj, G.Thiagarajan and S. Venu in the National Seminar on Emerging trends in Indian Aquaculture during 30-31st August, 2012.

- Dr. K. Ambasankar was awarded the Best paper award for "CIBA's initiative in small-scale feed production technology for production of farm-made feeds" presented in the National Seminar in Hindi at Kakdwip Research Centre on "Traditional Aqua farming System: Prospects and Challenges" during 11-12th December, 2012.

- Dr. Debasis De received the Best paper award for "Effect of lecithin on *Mugil cephalus* under low saline regime" in the National seminar in Hindi on "Traditional Aqua farming system: Prospects and Challenges" at KRC during 11-12th December, 2012.

- Dr. T.K. Ghoshal received the Best poster award in the National seminar in Hindi on "Traditional Aqua farming system: Prospects and Challenges" at KRC during 11-12th December, 2012.

- Best Oral presentation award was presented to Prem Kumar, A. R. Thirunavukkarasu, M.Kailasam, J.K.Sundaray, R.Subburaj and G.Thiagarajan for "Importance of nursery rearing in seabass farming" in the National seminar in Hindi on "Traditional Aqua Farming System: Prospect and Challenges" at KRC during 11-12th December, 2012.

- Best paper award was presented to K. Sivakumar, S. Kannappan and P K Patil for "Challenging of crude marine algae extract against bio-luminescence disease causing *V. harveyi* during *Penaeus monodon* larviculture" in the National seminar on Emerging Trends in Indian Aquaculture (ETIA-DHMOP-2013) organised by Dept. of Aquatic Biology & Fisheries, University of Kerala, Thiruvananthapuram from March 21-23, 2013.

Ph. D Programme

- Shri. E.C.Abhilash was awarded Ph.D by the University of Madras with effect from 18th June 2012 for his thesis entitled "Bacteria of public health importance in farmed shrimp and marketed seafood with special reference to *Vibrio vulnificus*" under the guidance of Dr.S.V. Alavandi, Principal Scientist, Aquatic Animal Health and Environment Division.

- Shri. M.Alagappan was awarded Ph.D. by the University of Madras with effect from 19th June 2012 for his thesis entitled "Studies on designing and evaluation of an expert system on shrimp aquaculture and its effectiveness in knowledge dissemination" under the guidance of Dr.M.Kumaran, Senior Scientist, Social Sciences Division.

9

Linkages and Collaboration

National

ICAR Institutes

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

Other Institutes / SAUs / State Agriculture Department

- College of Fisheries, University of Agricultural Sciences, Mangalore
- College of Fisheries, Sri Venkateswara Veterinary University, Muthukur
- Fisheries College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Thoothukudi
- West Bengal University of Animal and Fisheries Sciences, Kolkata
- Navsari Agricultural University, Navsari, Gujarat
- Tamil Nadu Veterinary and Animal Sciences University, Chennai
- Department of Horticulture, Govt. of Tamil Nadu, Chennai.
- Department of Animal Husbandry, Govt. of Tamil Nadu, Chennai.
- Tamil Nadu Agricultural University, Coimbatore
- University of Madras, Chennai
- Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai
- National Fisheries Development Board, Hyderabad

- Department of Animal Husbandry, Dairying and Fisheries, New Delhi
- Coastal Aquaculture Authority, Chennai
- Ministry of Science and Technology, New Delhi
- Ministry of Water Resources, New Delhi
- Agricultural & Processed Food Products Export Development Authority, New Delhi
- Marine Products Export Development Authority, Kochi
- Department of Biotechnology, New Delhi
- National Institute of Ocean Technology, Chennai

State Fisheries Departments/BFDAs

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

International

Nofima, the Norwegian Institute of Food, Fisheries and Aquaculture Research, Norway: a DBT-NRC collaborative project "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".

NACA, BANGKOK, Thailand

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.

WorldFish Center, Malaysia

A project entitled "Productive, profitable and resilient agriculture and aquaculture systems" has been undertaken under CGIAR – CPWF at Kakdwip Research Centre.

Temasek Life Sciences Laboratory (TLL), Singapore

A Collaborative project entitled **"**Genetic analyses of Seabass populations in Indian peninsular waters using microsatellite markers" between CIBA, NBFGR and TLL.

10

List of Publications

Special Publications

- Sustainable shrimp farming through adoption of BMP and biosecurtiy
- Manual on Seed production and larval rearing of Asian seabass *Lates calcarifer*
- Management of emerging diseases of shrimp with special reference to Pacific white shrimp *Litopenaeus vannamei*.
- Capacity building of tribal women Self Help Groups on brackishwater aquaculture and allied agro-based technologies
- Farming of banana shrimp and brackishwater finfishes in Gujarat State

Technology Series

- Biosecure shrimp farming technology

Pamphlet

- Shrimp as health food

e-Publication

- Banana shrimp
- An appraisal of Better Management Practices in Penaeid shrimp hatcheries
- Fact sheet on Ethoxyquin Residues

Refereed Journals

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11

Consultancy and Commercialization of Technology

❖ **MoU with The Waterbase Limited for a collaborative project on "Development and improvement of *L.vannamei* feed" in a Public Private Partnership mode**.

The Waterbase Limited, a corporate group and an important player in the field of shrimp feed industry has expressed its interest for a collaborative research project on improvement of vannamei feed. The core areas of the collaborative research plan include improvement of attractability, palatability and use of plant protein sources *vis-à-vis* fishmeal in shrimp feed formulations and to develop a cost-effective eco-friendly feed. The MoU has been signed between CIBA and The Waterbase Limited on 07.06.2012 for a period of two years from 7th June 2012 to 6th June 2014. CIBA received the intellectual fee of ₹5,61,800/ for this collaborative project from The Waterbase Limited.

❖ **MoU with M/S Jass Ventures-Demonstration of organic shrimp feed cum technology transfer**

CIBA entered into a MoU with M/S Jass Ventures Pvt. Limited, Anamika, S-17, Shanthi Nagar, Thiruppunithura, Ernakulam, Kerala for a collaborative R & D project on demonstration of organic feed using CIBA shrimp feed technology and organic farming technology for *Penaeus monodon*. The project will be covered in two phases: organic feed production and monitoring of demonstration farms in Phase-I followed by Organic feed and farming technology transfer in Phase-II.

❖ The consultancy service on indigenous shrimp feed technology to M/S Bismi feeds, Mayiladuthurai, Tamil Nadu has been extended upto December 2012.

Patents

❖ Replies to First Examination Reports for the patent applications 633/CHE/2006 and 368/CHE/2006 were submitted to the Patent Office, Chennai.

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 18th meeting of the Research Advisory Committee (RAC) of CIBA was held during 13-14th February, 2013 at Kakdwip Research Centre of CIBA, Kakdwip, West Bengal.

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 the projects
Member Secretary	Dr. S. M. Pillai

The half yearly IRC Meeting was held on 20th November 2012 and the 28th Annual IRC meeting during 25th and 26th March 2013 wherein the progress of research work was reviewed.

INSTITUTE MANAGEMENT COMMITTEE (IMC)

The Institute Management Committee has been constituted as follows:

Chairman **Dr. A. G. Ponniah**

Members

Dr. Madan Mohan
Director (Fisheries), Government of Tamil Nadu
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
Shri. Balabrahmaiah

Co-opted Members

Shri. B. Sathish, A.O., CIBA
Shri. V. R. Senthilkumar, OIC Engg. Cell, CIBA
Finance & Accounts Officer, CIBA
Shri. R.G. Ramesh, A.A.O., CIBA

The 40th IMC meeting was held on 20 June 2012 and 41st meeting on 14th December 2012.

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)
	Shri. R. Balakumaran, Tech. Asst. (T-3)
	Shri. B. Palanivelmurugan, LDC
	Shri. M. Pichandi, Skilled Support Staff
	Shri. C. Saravanan, Skilled Support Staff

(Shri. R. Subburaj, Member, IJSC is also a member of CJSC of ICAR)

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

Official Side

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

Elected Members

Scientific Member	Dr. A. R. Thirunavukkarasu, Head, FCD
Technical Member	Shri. K. Paranthaman, T-2
Administrative Member	Smt. K. Nandhini, J.A.O .
Staff Member	Shri. K. Nithyanandan, Skilled Support Staff

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Participation in Conferences, Meetings, Workshops and Symposia

International

- Aqua Climate Project Partners Meeting & Asia-Pacific Regional Workshop on the Impacts of Climate Change on Fisheries and Aquaculture organized by NACA at Bangkok, Thailand during 14-16th May, 2012 - Dr. A. G. Ponniah, Dr. M. Muralidhar
- Regional Workshop on Application of Aquaculture Assessment Tools in Asia Pacific in Bangkok, Thailand organized by FAO/NACA/APFIC during 3-5th July 2012 - Dr. A. G. Ponniah
- Workshop on Regional Proficiency Testing Programme for Aquatic Disease Laboratories in Asia-Pacific organized by FAO/NACA/APFIC at Bangkok, Thailand from 25-26th July, 2012 - Dr. K.P.Jithendran
- Workshop on DAFF/NACA Emergency Asia Pacific Regional Consultation on EMS/AHPNS at Bangkok, Thailand during 9-10th August 2012 - Dr. S.V. Alavandi
- Annual meeting of NCERA 225: Implementation and Strategies for National Beef Cattle Genetic Evaluation, organized at Des Moines, Iowa from October 17 - 19th, 2012- Comparison of actual 50K and imputed 770K marker panels for GWAS in Hereford cattle presented by -Dr. K. Vinaya Kumar
- CPWF Meeting on Aquaculture and Homestead for the project-Increasing the resilience of Agricultural and Aquaculture Systems in Coastal Areas of the Ganges Delta at Dhaka, Bangladesh from 7-12th November 2012 - Dr. J. K. Sundaray

National

Participation by Dr. A.G. Ponniah

- Inauguration of the Office Complex of NFDB at Hyderabad on 20th April 2012
- Meeting of the Fisheries Division of ICAR to discuss on the XII Plan document, convened by Director General, ICAR, at NASC Complex, New Delhi on 30th April 2012
- Aquaclimate Project Final Workshop and Regional Workshop on Impacts of Climate Change on Fisheries and Aquaculture organized by NACA, at Thailand during 14-16th May 2012
- Meeting of the XII Plan Platform on Diagnostics & Vaccines convened by the Director General, ICAR at NASC Complex, New Delhi on 4th May 2012

- Meeting between National Fisheries Development Board (NFDB) and the new management of M/s. Moana in order to update on the situation/evaluation of M/s. Moana and the proposed approach to bring the SPF *P.monodon* shrimp seed in India at NFDB, Hyderabad on 1st June 2012.
- Meeting convened by Deputy Director General (Fy.), ICAR to discuss on the Regional Proficiency Testing Programme of NACA, at Fisheries Division, ICAR, KAB-II, New Delhi on 12th June 2012
- Meeting of Standing Committee on Fixing responsibility in case of Project Time and Cost over run, to consider the construction of Trainees Hostel of CIBA, in the Chamber of DDG (Hort.), ICAR, KAB-II, New Delhi on 13th June 2012
- XXIII Meeting of the Regional Committee No.VIII, at Coimbatore organized by SBI, Coimbatore from 15-16th June 2012
- Meeting (19th) of the Expert Committee on Access & Benefit Sharing for processing the applications received by NBA, at NBA, Chennai from 18 to 19th June 2012
- Meeting (40th) of the Institute Management Committee, at CIBA, Chennai on 20th June 2012
- DBT Task Force Meeting on Aquaculture and Marine Biotechnology organized by DBT at New Delhi on 28th June 2012
- Selection Committee Meeting for considering the assessment proposals of Senior Scientist for promotion to Principal Scientist, under the Revised Career Advancement Scheme organized by ASRB at New Delhi on 23rd July 2012
- National Consultation on Setting National Biodiversity Targets organized by National Biodiversity Authority, at NASC Complex, New Delhi on 31st July 2012
- Brainstorming Session to Develop a Perspective Plan and Strategies for the development of Fisheries in the Country organized by DAHD & Fishery, Ministry of Agriculture, Govt. of India at NASC Complex, Pusa, New Delhi on 3rd August 2012
- Consultative Meetings with Collaborating partners for the Platform on Diagnostics & Vaccines at CIBA, Chennai on 7th August 2012
- Consultative Meeting on Network Project on Fish Health at CIBA, Chennai on 8th August 2012
- National Consultation on Integrated development of Uttara Kannada District of Karnataka organized by CMFRI, Kochi at Karwar on 1st September 2012
- Selection Committee Meeting for considering the assessment proposals of Senior Scientist for promotion to Principal Scientist, under the Revised Career Advancement Scheme, at ASRB, New Delhi from 3-5th September 2012
- Meeting (194th) of the Board of Directors of Tamil Nadu Fisheries Development Corporation Limited, at Secretariat, Chennai organized by TNFDC Ltd., Chennai on 7th September 2012

- Selection Committee Meeting for considering the assessment proposals of Senior Scientist for promotion to Principal Scientist, under the Revised Career Advancement Scheme, at ASRB, New Delhi on 12th, 19th & 27th September 2012
- Golden Jubilee celebrations of the Faculty of Marine Sciences, Annamalai University, Annamalai Nagar, Chidambaram organized by Annamalai University, Annamalai Nagar on 3rd October 2012
- The 23rd All India Congress of Zoology & National Conference on Conservation and Management of Faunal Resources for sustainability, organized by Guru Nanak College, Chennai on 4th October 2012
- Inauguration-cum-Interaction Meet on Mushroom farming unit and release of new variety of brackishwater ornamental fish (spotted scat) for rearing in tanks, at New Perungalathur, Kancheepuram Dist. under the TSP organized by CIBA, Chennai on 5th October 2012
- Selection Committee Meeting for considering the assessment proposals of Senior Scientist for promotion to Principal Scientist, under the Revised Career Advancement Scheme, at ASRB, New Delhi on 8th October 2012
- Meeting on Skills and Technologies for promotion of scientific and profitable fish production, at NASC Complex, New Delhi on 8th October 2012
- Expert Consultation on Managing Transboundary diseases of Agricultural Importance in Asia-Pacific held at NASC Complex, New Delhi on 10-11th October 2012
- Selection Committee Meeting for considering the assessment proposals of Senior Scientist for promotion to Principal Scientist, under the Revised Career Advancement Scheme organized by ASRB at New Delhi on15th October 2012
- Meeting (39th) of the Board of Sri Venkateswara Veterinary University (SVVU), Tirupati, at A.P.Secretariat, Hyderabad organized by SVVU, Tirupati on 20th October 2012
- Visit to Hitide Farm, Sirkali and Inauguration of the Kiosk & Hands-on-Training on usage of Kiosk and BMPs in shrimp farming under NABARD Funded Project, at Averikadu Village, Nagapattinam District on 30th October 2012
- National Conference on Fisheries Biotechnology held at CIFE, Mumbai on 2nd November 2012
- Institute Joint Staff Council Meeting at Kakdwip Research Centre, Kakdwip on 17th November 2012
- First Meeting of the Working Group on Aquaculture Crop Insurance organized by NFDB, at CIBA, Chennai on 19th November 2012
- Half-yearly Institute Research Council Meeting at CIBA, Chennai on 20th November 2012
- Meeting organized by MSSRF at Taramani, Chennai on 21st November 2012

- Selection Committee Meeting of TANUVAS for the selection of University Officers, held at Madras Veterinary College, Vepery, Chennai TANUVAS, on 21st November 2012
- DBT Task Force Meeting at Department of Biotechnology at New Delhi from 3-4th December 2012
- Meeting with the Project Coordinators of AICRPs and Network Project, organized by the Director General, ICAR at NBPGR Auditorium, New Delhi from 5-6th December 2012
- National Seminar in Hindi on Traditional Aquafarming System: Prospects and Challenges organized at Kakdwip by KRC of CIBA from 11-12th December 2012
- Institute Management Council Meeting at CIBA, Chennai on 14th December 2012
- Meeting (21st) of the Expert Committee on Access and Benefit sharing for processing the applications received by NBA at Regenta One, Hyderabad on 21st December 2012
- International Conference on Increasing Agriculture Productivity and Sustainability in India: The Future we want at National Institute of Advanced Studies, Bangalore on 8th January 2013
- RFD Meeting of the Fisheries Division of ICAR organized by ICAR, New Delhi on 9th January 2013
- Inauguration of the NFDB Sponsored Training Programme on Farming of banana shrimp and brackishwater finfishes in Gujarat State, organized by CIBA& NAU, Gujarat on 15th January 2013
- Valedictory function of the National Conference on Biodiversity – Green Strategies for sustainable development, organized by the Department of Advanced Zoology & Biotechnology, Women's Christian College, Chennai on 23rd January 2013
- Meeting (40th) of the Board of Management of Sri Venkateswara Veterinary University, Tirupati at A.P.Secretariat, Hyderabad on 31st January 2013
- Pillay Aquaculture Foundation Congress on Public-Private Partnership in Aquaculture and culture-based fisheries, held at Central Inland Fisheries Research Institute, Barrackpore on 9th February 2013
- Research Advisory Committee Meeting at Kakdwip Research Centre from 14-15th February 2013
- Farmers Interaction Meet cum Harvest Mela under NFDB Project at Madanganj, Namkhana, West Bengal on 15th February 2013
- Valedictory Session of the Zoological Society at New College, Chennai on 20th February 2013
- Brainstorming workshop on Methodologies to access impact of capacity building program under NAIP held at NASC complex, New Delhi on 21st February 2013

- Final Workshop of the NFDB Project on Demonstration of Asian seabass farming in pond culture system at CIBA, Chennai on 23rd February 2013
- National Workshop on Foresight and future pathways of Agricultural Research through Youth in India held at NASC Complex, New Delhi from 1-2nd March 2013
- Delhi Round Table Conclave 2013 on Vulnerable India: Ocean Acidification, Sea level rise and Extreme events, held at India International Centre, Maxmueller Marg, New Delhi from 11-12th March 2013
- Consultation Meeting with regard to the setting up of quarantine and biosecurity facility at A&N Islands, held at Krishi Anusandhan Bhavan – II, Pusa, New Delhi on 13th March 2013
- Meeting of the Head of Divisions and Directors of Fisheries Institutes with Secretary, DARE & Director General, ICAR, at NASC Complex, New Delhi on 15th March 2013
- Directors' Conference held at A.P.Shinde Symposium Hall, NASC Complex, New Delhi from 19-20th March 2013
- Meeting of the NFDB Project on Digital Knowledge Management Platform for Fisheries, held at KAB-II, Pusa, New Delhi on 21st March 2013

Participation in Workshops/Seminar/Meeting by Scientists

- Cobia Fish Harvest Mela, organized by RGCA, MPEDA held at Muttom on 9th April 2012 - Dr. A. R. Thirunavukkarasu
- Workshop on Emerging statistical tools in life sciences held at Fisheries University of Kerala from 11-13th April 2012 - Dr. Krishna Sukumaran
- Development of Surveillance Programme for Aquatic Animal Diseases held at NBFGR Lucknow during 17-18th April 2012 - Dr. Sujeet Kumar
- Inaugural Function of NFDB Headquarters building held at Hyderabad on 20th April 2012 - Dr. Dr.A. R. Thirunavukkarasu
- Project Review Board Meeting of NIOT on 23rd April 2012 - Dr.A. R. Thirunavukkarasu
- International training on Stock assessment of Hilsa sponsored by Bay of Bengal large marine ecosystem (FAO) at CIFRI, Barackpore during 30th April- 1st May 2012 - Dr. J.K. Sundaray and Dr. Ashutosh D Deo
- QRT meeting of ICAR Research Complex for Eastern Region held at Salt Lake, Kolkata on 4th May 2012 - Dr. T. K. Ghoshal
- CMU meeting with the NAIP Component-3 partner on 11th May 2012 - Dr. T.K. Ghoshal and Dr. Debasis De
- NFBSFARA Project proposal review meeting with DG, ICAR held at Krishi Bhavan, New Delhi on 14th May 2012 - Dr. Debasis De

- Farmers-Scientists Interaction meet under Tribal sub project on Brackishwater aquaculture technologies at Patri organized by CIBA, Chennai on 20th May 2012 - Dr. C. Gopal and Dr. M. Muralidhar
- Farmers-Scientists Interaction meet on Management of shrimp health and pond environment at Navsari organized by CIBA, Chennai on 21st May 2012 - Dr. C. Gopal and Dr. M. Muralidhar
- Seminar on Security & Convenience – Water and Waste Water Analysis held in Chennai on 29th May 2012 - Dr. M. Muralidhar and Dr. R. Saraswathy
- Workshop on preparation of project on Stock characterization, captive breeding, seed production and culture of hilsa (*Tenualosa ilisha*) under NFBSFARA at CIFRI, Barrackpore from 28th May - 6th June 2012 - Dr. Debasis De
- First Annual Review Workshop of NICRA project at Hyderabad from 12-14th June 2012 - Dr. M. Muralidhar
- Sensitization Programme on Prevention of Sexual Harassment at work place organized by National Institute of Public Cooperation and Child Development, Southern Regional Centre, Bengaluru from 14-15th June 2012 - Dr. R. Saraswathy
- National Seminar on Food Safety - Role of Standards organized by Bureau of Indian Standards (BIS) held in Chennai on 20th June 2012 - Dr. K. Ambasankar
- Brainstorming Workshop on Outreach program on harvest & post harvest losses in Fisheries Sector held at CIFT Cochin on 22nd June, 2013- Dr. T. Bhuvaneswari
- NFBSFARA Project proposal review meeting with DG, ICAR held at CIFRI, Barrackpore from 26-27th June 2012 - Dr. Debasis De
- Farmers-Scientists Interaction Meets to sensitize field level extension officials and farmers on Better Management Practices (BMPs) of shrimp farming, finfish breeding and culture and aquaculture guidelines at Alappuzha, Ernakulam and Kannur from 25-27th June 2012 - Dr. C. P.Balasubramanian
- DBT Project Review Meeting at New Delhi, on 27th June 2012 - Dr.A. R. Thirunavukkarasu, Dr. G. Gopikrishna
- Feed and Feed ingredients conclave 2012 at Hotel Vivanta Taj, Bangalore organized by The Solvent Extractor's Association of India (SEA) and the Compounded Livestock Feed Manufacturers Association of India (CLFMA) on 21st July 2012 - Dr. K. Ambasankar
- Board of Studies Meeting of CAS in Marine Biology, Annamalai University on 28th July 2012 - Dr.A. R. Thirunavukkarasu
- Workshop on Biofloc Technology organized by Society of Aquaculture Professionals, Chennai from 28-29th July 2012 – Dr. P. Ravichandran, Dr. M. Muralidhar, Dr. J. Syama Dayal, Dr. K. Ambasankar, Dr. Akshaya Panigrahi, Dr. P. Nila Rekha, Dr. P.K.Patil, Dr. K.P. Kumaraguru Vasagam and Dr. Sujeet Kumar

- Seminar on Advances in Fisheries Research (in Hindi) held at CIFT, Cochin during 17 - 18th August, 2012-Dr. Prem Kumar
- ICAR Knowledge Meet held at New Delhi on 22nd August 2012 - Dr.A. R. Thirunavukkarasu
- National Seminar on Emerging Trends in Aquaculture: Challenges and Opportunities- 2012, organized by SVV University, Tirupati during 30-31st August 2012 – Dr.A. R. Thirunavukkarasu, Dr.M.Natarajan, Dr.M.Kailasam, Dr. J.K.Sundaray, Dr. Prem Kumar, Dr. K. Ambasankar and Dr. Krishna Sukumaran
- National Consultation on Integrated development of Uttara Kannada District of Karnataka at Karwar on 1st September 2012 - Dr. A. R. Thirunavukkarasu and Dr. Prem Kumar
- National consultation on Alien Fish Species in Aquaculture and Aquarium trade: Issues and Perspectives, held at NBFGR, Lucknow from 6-7th September 2012 - Dr. M. Kailasam
- International Seminar on Future of Livestock Health: A Paradigm Change To Maximize Productivity for Economic Gains organized by TANUVAS Chennai on 6-8th September 2012 - Dr. J. Syama Dayal, Dr. P.K. Patil and Dr. R. Ananda Raja
- NAIP Project Review Meeting at Fisheries College & Research Institute, Thoothukudi on 20th September 2012 - Dr. A. R. Thirunavukkarasu
- MDP Workshop on Policy and Prioritization, Monitoring and Evaluation (PME) Support to Consortia-based Research in Agriculture held at NAARM, Hyderabad from 11-17th September 2012 - Dr. G. Gopikrishna
- National Conference on Aquatic Animal Health Management 2012 held at Annamalai University, Parangipettai from 14-15th September, 2012 – Dr. Prasanna Kumar Patil and Dr. K. Ananda Raja
- International Conference on Biotechnology Emerging trends at Sirsa organized by Chaudhary Devi Lal University, Haryana from 18-20th September 2012 - Dr. J. Syama Dayal, Dr. K. Ambasankar and Dr. R. Saraswathy
- Global Symposium on RTE foods Addressing Challenges In The Food Processing Industry at Cochin from 24-25th September 2012 - Dr. A. R. Thirunavukkarasu, Dr. T.K. Ghoshal, Dr. J. Syama Dayal and Dr. Prem Kumar
- Expert consultation on Managing Trans-Boundary Diseases of Agricultural Importance in Asia-Pacific from 10-12th October 2012 at NASC Complex, Pusa, New Delhi, India - Dr. M. Poornima
- Millennium Alliance, An India – U.S. Innovation Partnership for Global Development at Chennai organized by US-AID, Technology Development Board (Government of India) and FICCI on 16th October 2012 - Dr. M. Muralidhar
- Fourth International Conference on Advanced Nano Materials at Chennai from 17-19th October 2012 - Dr. A. Panigrahi, Dr. K. Ambasankar, Dr. J. Syama Dayal and Dr. R. Saraswathy

- Brainstorming Discussion on Information Materials on the Impact of Climate Change in Various Areas of Concern at Chennai organized by MSSRF in partnership with Gene Campaign on 19th October 2012 - Dr. M. Muralidhar
- The 8th Convocation of Jamsetji Tata National Virtual Academy (NVA) Fellowship for grassroots Academicians & 8th Convention of Grameen Gyan Abhiyan: Rural Knowledge Movement at Chennai organized by MSSRF on 28th October 2012 - Dr. M. Muralidhar
- Project Review Board Meeting at NIOT, on 29th October 2012 - Dr. A. R. Thirunavukkarasu
- International Conference on Agriculture, Food Sciences and Environmental Technology (AFSET) held at Jawaharlal Nehru University, New Delhi from 28-29th October 2012 - Dr. K. Ambasankar
- International Conference on Next generation sequencing and bioinformatics for genomics and healthcare organized by SciGenome Labs Private Ltd., Cochin held during 1-3rd November 2012 at IIT, Chennai – Dr. G. Gopikrishna, Dr. M.S. Shekhar, Dr. S.K.Otta, Dr. Sherly Tomy, Dr. P. Ezhil Praveena
- The 2nd National Conference on Fisheries Biotechnology at CIFE, Mumbai, from 2-3rd November 2012 - Dr. A. R. Thirunavukkarasu
- National Seminar on Science for Shaping the Future of India organized by Indian Science Congress Association (Bhopal Chapter), Bhopal from 2-3rd November 2012 - Dr. T.K. Ghoshal, Dr. K. Ambasankar and Dr. Debasis De
- Seminar on Mountain Fisheries: Challenges and Opportunity For Livelihood Security at Uttarkhand organized by DCFR, Bhimtal, Uttarkhand from 5-6th November 2012 - Dr. J. Syama Dayal
- DBT Project Review Meeting, at New Delhi, on 6th November 2012 - Dr. A. R. Thirunavukkarasu, Dr. G. Gopikrishna, Dr. M. Poornima
- National Conference on Immunobiology and Management of Viral Diseases in 21st Century at Mukteshwar from 8-10th November 2012 - Dr. M.S. Shekhar
- Challenge for Water and Food Reflection workshop organized by WorldFish Center at Dhaka, Bangladesh from 6-11th November 2012 - Dr. J.K. Sundaray
- National Conference on Current Trends in Food Security to Meet National Nutritional Challenges organized by Nutrition Society of India, Tirupati Chapter, Dept. of Home Science, Sri Venkateswara University, Tirupati from 16-17th November 2012 - Dr. J. Syama Dayal
- The 8th Biennial Animal Nutrition Association Conference at Rajasthan University of Veterinary and Animal Sciences, Bikaner from 28th-30th November 2012 - Dr. T. K. Ghoshal, Dr. Debasis De, Dr. K. Ambasankar and Dr. J. Syama Dayal

- Global Symposium on Aquatic resources for eradicating hunger and malnutrition-opportunities and challenges organized by Asian Fisheries Society Indian Branch(AFSIB), Mangalore from 4-6th December 2012 - Dr. A. R. Thirunavukkarasu, Dr. T.K. Ghoshal, Dr. Debasis De, Dr. K. Ambasankar, Dr. Sujeet Kumar, Dr. Sherly Tomy, Dr. P.S. Shyne Anand, Dr. K. P. Kumaraguru Vasagam and Dr. N. Lalitha

- International Conference on Nanotechnology creating better tomorrow for India and for the world from 5-7th December 2012 - Dr. R. Saraswathy

- National Hindi Seminar on Traditional Aquafarming system: Prospects and Challenges Kakdwip, West Bengal at KRC of CIBA from 11-12th December 2012 – Dr.A. R. Thirunavukkarasu, Dr.M.Kailasam, Dr.J.K.Sundaray, Dr. K. Ambasankar, Dr. J. Syama Dayal and Dr.Prem Kumar

- The 2nd International Conference on Stochastic Modeling and Simulation at Chennai organized by Vel Tech Dr. RR & Dr. SR Technical University, Chennai from 17-19th December 2012 - Dr. R. Saraswathy

- International Conference on Optimization, computing and business analytics at Techno India University, Saltlake, Kolkata organized by Operational Research Society of India from 20-22nd December 2012 - Dr. Debasis De

- The 100th Indian Science Congress organized by Kolkata University, Kolkata from 3-7th January 2013 - Dr. J.K. Sundaray and Dr. Ashutosh D Deo

- Focus Group Discussion with Officers of Department of Fisheries, Govt.of Gujarat regarding the extension needs on *L.vannamei* culture in the state at NAU, Navsari on 19th January 2013 - Dr. C. Gopal

- National Symposium on Climate Change and Indian Agriculture: Slicing down the uncertainities at Hyderabad organized by CRIDA, Hyderabad from 22-23rd January 2013 - Dr. M. Muralidhar and Shri. Ashok Kumar Jangam

- International Symposium on Genomics in Aquaculture organized by CIFA, Bhubaneshwar from 22-23rd January 2013 - Dr. G. Gopikrishna and Dr. J. Syama Dayal

- 2nd International Workshop on Advanced Functional Nanomaterials at Chennai organized by Centre for Nanoscience and Technology & Centre for International affairs, Anna University, Chennai on 28-30th January 2013 - Dr. R. Saraswathy

- Board of Studies Meeting at Kanchi Mamunivar Centre for PG Studies, Pondicherry University, on 4th February 2013 - Dr. Dr.A. R. Thirunavukkarasu

- International Conference on Bio-resources and stress management organized by Science City, Kolkata, West Bengal from 6-9th February 2013 - Dr. T K Ghoshal, Dr. J. Syama Dayal, Dr. K. Ambasankar, Dr. R. Saraswathy and Dr. Sujeet Kumar

- The 11th Agricultural Science Congress organized by Odisha University of Agricultural & Technology, Bhubaneswar from 7-9th February 2013 - Dr. Ashutosh D Deo

- Pillay Aquaculture Foundation Congress on Public private partnership in aquaculture and culture based fisheries organized by CIFRI, Barrackpore from 9-11th February 2013 - Dr. P. S. Shyne Anand
- Advisory committee meeting of NFBSFARA project organized by ICAR at Krishi Bhavan, New Delhi on 14th February 2013 - Dr. Debasis De
- International Workshop on Veterinary Pharma-covigilance For Global Food Security organized by Pharmaco-vigilance Laboratory for Animal Feed and Food Safety, Directorate of Centre for Animal Health Studies, TANUVAS, Chennai from 21-22nd February 2013 - Dr. J. Syama Dayal
- Workshop on Aquaculture at Govt. Arts College, Kumbakonam, on 24th February 2013 - Dr. A. R. Thirunavukkarasu
- Management Development Workshop on Technology Management for Researchers held organized by NAARM, Hyderabad from 28th February-6th March 2013 - Dr. S.V. Alavandi
- NAIP Workshop organized by the Fisheries College & Research Institute, Thoothukudi, from 1-2nd March 2013 - Dr. A. R. Thirunavukkarasu and Dr. Prem Kumar
- National Workshop on Foresight and Future Pathways of Agricultural Research through Youth in India at New Delhi organized by ICAR during 1-2nd March 2013 - Dr. Sherly Tomy
- International Level Seminar on Problems and prospects of coastal aquaculture and application of biotechnological tools for rural development organized by Vidyasagar University at Midnapore, West Bengal from 1-3rd March 2013 - Dr. J.K. Sundaray
- Directors and Head of Divisions Meeting convened by the DG, at New Delhi, on 15th March 2013 - Dr. A. R. Thirunavukkarasu, Dr. P. Ravichandran, Dr. G. Gopikrishna, Dr. K.P. Jithendran, Dr. V.S. Chandrasekaran
- ASEAN – INDIA Workshop on Marine Biotechnology, organized by NIO, Goa, from 19-20th March 2013 - Dr. A. R. Thirunavukkarasu
- National Seminar on Emerging Trends in Indian Aquaculture – ETIA 2013, organized by Department of Aquatic Biology, University of Kerala, on 21st March 2013 - 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, Coastal Aquaculture Authority, Ministry of Agriculture, Govt. of India. (till 25.6.2012)
- Member, ICAR Regional Committee No.VIII
- Member, Task Force Committee on Fisheries Development Mission – T.N. State Fisheries , Department
- Member, Scientific Advisory Committee for Dr.Perumal, Krishi Vigyan Kendra, Krishnagiri Taluk, Dharmapuri District, TN
- 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 and Marine Biotechnology, Department of Biotechnology, New Delhi
- Member, Executive Committee - National Centre for Sustainable Aquaculture (NaCSA)
- Member, Committee for protection of fish germplasm through registration and documentation, constituted by ICAR
- Member, Scientific Advisory Committee, Krishi Vigyan Kendra, Tiruvallur.
- Member, Executive Committee - Fisheries Institute of Technology and Training (FITT), Chennai.
- Member, Expert Committee on Access and Benefit sharing for processing the applications received by NBA, constituted by NBA, Chennai (Till 24 February 2013)
- Member, State Level Committee on Animal Genetic Resources (SLCAnGR), constituted by Animal Husbandry & Veterinary Services, Chennai.
- Member, Expert Group to work out possible arrangements and to formulate guidelines for *Litopenaeus vannamei* farming in freshwater aquaculture, constituted by the DAHD&Fy., Ministry of Agriculture, New Delhi.
- Member, 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.

- Member, Evaluation Committee constituted for screening proposals for setting up of Multiplication Centres for SPF shrimp broodstock (*P.monodon* and *L.vannamei*)
- Member, Board of Management of S.V.Venkateswara University, Tirupathi, as ICAR representative.
- Member, Selection Committee for the selection of Registrar, Controller of Examination and Director of Research of TANUVAS (as ICAR representative).
- Working Group on Fisheries and Aquaculture for the preparation of Twelfth Five Year Plan (2012-17), constituted by the State Planning Commission, Govt. of Tamil Nadu.
- Member, NACA Task Force to develop the NACA Regional Program on Impacts & Response to Climate Change in Aquaculture – 2012-16.
- Member, Board of Management of Tamil Nadu Fisheries University
- Member, Committee for examining the issues related to establishment of SPF *Penaeus monodon* Multiplication centre at Srikakulam, Andhra Pradesh, under the Chairmanship of Joint Secretary (Fy.), DAHD&F with DDG (Fy.), ICAR.
- Member, Expert Committee to develop standards for the process to be adopted for claiming SPF status for shrimp species (*Penaeus monodon* and *Litopenaeus vannamei*) along with identification of viruses to be screened for the purpose, constituted by Ministry of Agriculture, DAHD&F, New Delhi.
- Member, Committee to evaluate the proposals received in response to invitation of Expression of Interest (EoI) for setting up of Specific Pathogen Free (SPF) Multiplication Centres (MCs) for *Litopenaeus vannamei* and *Penaeus monodon* and to formulate guidelines for setting up of the MCs, constituted by DAHD&F, Ministry of Agriculture, Govt. of India.
- Chairman - Committee for drafting guidelines and better management practices in hatcheries and nurseries for quality seed production, constituted by the DAHD&F, Ministry of Agriculture, Govt. of India.
- Member, National Advisory Committee of the International Symposium on 'Greening Fisheries – Towards Green Technologies in Fisheries' organized by Society of Fisheries Technologists (India), Cochin and Central Institute of Fisheries Technology, Cochin, during 21-23 May 2013.
- Member, Committee for formulating guidelines for open access policy in ICAR, constituted by the Secretary, DARE & Director General, ICAR.
- Member, Committee for preparing the guidelines for hiring the technical manpower, constituted by the Secretary, DARE & Director General, ICAR.
- Member, Coordination Committee for the NFBSFARA funded project: Stock characterization, captive breeding, seed production and culture of hilsa (*Tenualosa ilisha*), constituted by the Secretary, DARE & Director General, ICAR.
- Member, Scientific Panel for Fish and Fisheries Products, constituted by the Food Safety and Standards Authority of India, Ministry of Health and Family Welfare, New Delhi.

Dr. A. R. Thirunavukkarasu, Principal Scientist & Head, Fish Culture Division

- ❖ Member, Project Review Board, NIOT, Ministry of Earth Sciences, Chennai
- ❖ Member, Board of Studies in Zoology, Bharathidasan University
- ❖ Member, Board of Studies in Marine Biology, Annamalai University
- ❖ Member, Board of Studies in Zoology, Pondicherry University
- ❖ Member, Board of Directors, Centre for Aquaculture Research & Development (CARD), Government of Tamil Nadu

Dr. P. Ravichandran, Principal Scientist & Head, Crustacean Culture Division

- ❖ Member, Coastal Aquaculture Authority, Ministry of Agriculture, Government of India (from June 2012)
- ❖ Member, Technical Committee for Aquatic Quarantine, Coastal Aquaculture Authority, Ministry of Agriculture, Government of India

Dr. G. Gopikrishna, Principal Scientist

- ❖ Expert Member, Screening-cum-Evaluation committee under Career Advancement Scheme-2011 at Sree Venkateswara Veterinary University, Tirupati.
- ❖ Member, Expert Committee meeting in Department of Biotechnology for evaluation of Twinning R&D proposals
- ❖ Guest Faculty, Central Institute of Fisheries Education, Mumbai
- ❖ Member, Expert Committee to develop standards for declaring SPF status for shrimp species breeding and farming constituted by the Coastal Aquaculture Authority, Ministry of Agriculture, Government of India

Dr. V.S. Chandrasekaran, Principal Scientist

- ❖ Member, Selection Committee for the recruitment of staff in KVKs of the Tamil Nadu Board of Rural Development, Thiruvannamalai
- ❖ ICAR nominee in the sixth Scientific Advisory Committee meeting of the KVK, Tirur
- ❖ Member, Committee for preparing set of guidelines and criteria for selection of Best Fish Farmer Award at NFDB, Hyderabad

Dr. M. Natarajan, Principal Scientist

- ❖ Chairman, Best Thesis Award Committee of Professional Fisheries Graduate Forum, Mumbai

Dr. S. V. Alavandi, Principal Scientist, AAH& E Division

- ❖ Member, Bio-Safety Committee of Entomology Research Institute, Loyola College, Chennai.

Dr M.Muralidhar, Principal Scientist, OIC, Environment Division

- ❖ Member, Committe for evaluation of tenders relating to purchase of gas chromatography for Coastal Aquaculture Authority.

Dr. K.P.Jithendran, Principal Scientist

- ❖ Member, Expert Committee for CAS in Aquatic Animal Health Management Division, SVVU, Tirupati

Dr. J.K. Sundaray, Principal Scientist

- ❖ Member, Board of Research Studies in Zoology, University of Madras.

Dr. T. Ravisankar, Senior Scientist

- ❖ Member, Working Group for formulation of a scheme on Aquaculture Crop Insurance for National Fisheries Development Board, Hyderabad.

Dr. M. Kailasam, Senior Scientist

- ❖ Member, Expert Committe constituted by Coastal Aquaculture Authority for seabass hatchery inspection

Dr. Subhendu Otta, Senior Scientist

- ❖ Alternate member in Aquaculture Subcommittee of Fish, Fisheries and Aquaculture Sectional Committee, FAD-12 under Bureau of Indian Standards.

- ❖ Member, Committe constituted by the Coastal Aquaculture Authority, Ministry of Agriculture, for surveying presence of EMS in *L.vannamei* farms of Bhimavaram, Andhra Pradesh

Dr. K. Ambasankar, Senior Scientist

- ❖ Principal Member, Fish and Fisheries and Aquaculture Sectional committee FAD 12 of Bureau of Indian Standards (BIS)

- ❖ Expert member, Board of studies of Fisheries Science Faculty, TANUVAS with effect from 28.06.2012

Dr.K.P. Kumaraguru Vasagam, Senior Scientist

- ❖ Member, Expert Committee of BCIL (DBT), New Delhi

Dr. Sherly Tomy, Senior Scientist

- ❖ Member, Institute Management Committee of National Bureau of Fish Genetic Resources, Lucknow

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Workshops, Seminars, Meetings etc. organized by the Institute

WORKSHOPS

Result Dissemination Workshop of CIBA-NACA Collaborative Aquaclimate Project

Central Institute of Brackishwater Aquaculture (CIBA), the Indian partner of an International Project on 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 (Aquaclimate) organized a *Results Dissemination Workshop* on 18th July 2012 at CIBA, Chennai for dissemination of project results and technical and policy briefs developed to prepare the shrimp aquaculture as climate resilient. The workshop was attended by 90 stakeholders representing farmers, consultants, State Fisheries Department, ICAR Research Institutes, Fisheries Colleges and Universities, Coastal Aquaculture Authority, Forest Department, Indian Meteorological Department, Central Water Commission, Marine Products Export Development Authority, National Centre for Sustainable Aquaculture, Society of Aquaculture Professionals, Non-Governmental Organisations, Banks, Insurance companies, and Institute's National Initiative on Climate Resilient Agriculture Project (NICRA) staff. The major recommendations of the workshop are the fine-tuning of farmers technical, science & technology and policy recommendations.

DG, NACA addressing the gathering

Deliberations during the workshop

Stakeholder workshop on Climate Change Impacts on Coastal Aquaculture in Gujarat: Adaptations and Mitigations for Resilience

A stakeholder Workshop on Climate Change Impacts on Coastal Aquaculture in Gujarat: Adaptations and Mitigations for Resilience was organised at Surat, Gujarat on 5th January 2013 by CIBA in collaboration with Navsari Agricultural University (NAU) under the NICRA project. About 120 people representing all the stakeholders of aquaculture including aquafarmers, feed and input suppliers, aqua consultants, researchers (KVK at Surat, CIFA Regional Station, Junagadh, NAU, Junagadh

Agricultural University, College of Fisheries, Veraval, IRMA), Govt. officials (Department of Fisheries, Department of Agriculture, MPEDA, NABARD) and non-governmental organisations attended the Workshop. The Workshop participants were divided the into three groups viz., farmers, researchers or technical and policy or institutional comprising mixed stakeholders in each group and after discussions, each group delivered the adaptation measures to reduce the impact of CC events and the responsible departments to act on the problem and the time limit.

Workshop on Asian seabass farming in pond culture system

A concluding Workshop of the project was organized at CIBA Headquarters on 23rd February 2013 which was attended by more than 250 stakeholders including farmers from West Bengal, Odisha, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and many entrepreneurs, experts and academicians.

Dr. S. Ayyappan, Secretary, DARE & DG, ICAR inaugurated the workshop and addressed the gathering. In his inaugural address, he appreciated the achievements made in Asian seabass farming through this NFDB project using artificial feed, under the leadership of Dr. A. R. Thirunavukkarasu, Head, Finfish Culture Division and Principal Investigator of the project. While releasing the brochures on seabass farming in 9 different regional languages, he appreciated the efforts of the Institute for creating awareness among the public in the maritime states of the country through the extension material in vernacular medium. Dr R. Prabakaran, Vice Chancellor of the Tamil Nadu Veterinary and Animal Sciences University (TANUVAS), briefly mentioned the status of fisheries and expressed that the future fisheries development is possible only through aquaculture. Dr.M.Sakthivel, President of the Aquaculture Foundation of India, in his felicitation address, complemented the scientists of CIBA for developing a comprehensive technology for Asian seabass farming. Dr. R. A. Selvakumar, Former ADG (M. Fy), ICAR congratulated the team of scientists associated with the seabass farming demonstration and urged NFDB and CIBA to take up further demonstrations and make it more popular in all parts of India. Dr Paul Pandian, the Executive Director (Technical), NFDB complemented CIBA for taking up a difficult task of conducting demonstrations in 7 locations of 6 coastal states successfully

and expressed his happiness over the encouraging results drawn from this project. Dr. A. G. Ponniah, Director, CIBA welcomed the delegates for the workshop and expressed his gratitude to NFDB for the funding support. He also opined that the results obtained out of the research trials and field demonstrations could be further expanded to farmers for commercial scale operations and encouraged frequent interactions with farmers to share their experiences for further refinement of the technologies.

SEMINARS

National Seminar in Hindi on Traditional Aquafarming Systems at Kakdwip Research Centre of CIBA, West Bengal

A two day National Seminar in Hindi on *Traditional Aquafarming System: Prospects and Challenges* was organised by Kakdwip Research Centre of CIBA, from 11-12 December 2012. The major thrust behind this was to give further impetus to Rajbhasha and disseminate information to the stakeholders across the country. The Chief Guest Dr A P Sharma, Director, CIFRI, Barrackpore while inaugurating the National Seminar appreciated the efforts of CIBA for conducting the National Seminar in Hindi at Kakdwip and he explained in detail about the role of traditional aquafarming and how it has helped the livelihood of coastal farming communities in West Bengal, Kerala and other states. Dr P Das, Former Director, NBFGR, Lucknow addressed the seminar as a guest of honour and explained in detail about the genesis of traditional farming in West Bengal and stressed upon the research focus on farming system in traditional farming practices. Dr A G Ponniah, Director, CIBA and Chairman, National Hindi Seminar informed the gathering about the research output from CIBA with reference to traditional farming system and how the ecosystem services have improved the farm productivity.

MEETINGS

Brackishwater Aqua Farmers' Meets

Three Brackishwater Aqua Farmers' Meets were conducted at Alappuzha, Ernakulum and Kannur on 25th, 26th and 27th June 2012 respectively to sensitize the fishery extension officers and farmers on Better Management Practices (BMPs) in shrimp farming, aquaculture guidelines for *L.vannamei* culture and seed production and culture of brackishwater fin fishes. About 180 farmers and

60 fishery extension officers participated and interacted with the scientists. An extension publication on "Orujalakrishi*: Krishireethiyum Margga Nirdhesangalum*" covering the BMPs and guidelines was also prepared in Malayalam and distributed to the officials and farmers as reference book.

Interaction Meet on Asian seabass farming and nursery rearing in West Bengal

As part of the awareness programme on Asian seabass farming, an Interaction Meet was organized to discuss the prospects of seabass farming in West Bengal and propagation of the nursery rearing technology at Kakdwip Research Centre of CIBA, on 25th July 2012. The meeting was attended by 86 farmers and 14 women entrepreneurs belonging to Self Help Groups engaged in fish farming. Dr. A. R. Thirunavukkarasu, Principal Scientist & Head, Fish Culture Division of CIBA and Principal Investigator of the Project, in his inaugural address, while appreciating the efforts of Bengal farmers in the traditional Asian seabass farming, emphasized on the adoption of improved farming technology of seabass on a large scale, which would be a sustainable activity in the years to come. Dr.J.K.Sundaray, Co-Principal Investigator of the project and Officer-in-Charge, KRC of CIBA shared the experience of nursery rearing in Odisha and West Bengal and the earlier experiences in Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra.

Farmers Interaction Meet on Asian Seabass (*Lates calcarifer*) farming in pond culture system in Odisha

To propagate and motivate farmers to take up Asian seabass farming, a Farmers' Interaction Meet was organized under the NFDB funded project Demonstration of Asian seabass (*Lates calcarifer*) culture in the pond culture system, at Sahada, Balasore, Odisha, on 5th September 2012, as a part of the awareness programme. The meeting was attended by more than 300 farmers, scientists of other Institutes and administrators and executives from various line departments. The objective of the meet was to propagate various technological options available on the nursery rearing, pre-grow out and grow out culture of seabass using formulated feed.

Farmers' Interaction Meet on Demonstration of Asian seabass (*Lates calcarifer*) in pond culture system at West Bengal

CIBA, Chennai has been demonstrating the techno economic viability of culturing Asian seabass known in Bangla as "*Bhetki*", in pond culture system many parts of India. As a part of the demonstration

Haul of seabass harvest

Interaction Meet & release of brochure on seabass farming in Bangla

to motivate the farmers for taking up seabass farming as a diversified species for the sustainability of aquaculture, demonstration is being carried out in farmer's pond at Madanganj, Namkhana, 24 Parganas (South), West Bengal. An Interaction Meet was held on 15th February 2013 at the farm site which was attended by about 250 farmers. Dr.A.G.Ponniah, Director, CIBA, presided over the meeting. The special Guests of Honour were Dr.S.D.Tripathi, former Vice Chancellor, CIFE, Mumbai and the Chairman of the RAC of CIBA, Dr.D.Chandramohan, former Deputy Director, NIO and Member of RAC, Dr. Madan Mohan, ADG (M.Fy), ICAR and Dr. Paul Pandian, Executive Director, NFDB. The Principal Investigator of the project Dr. A. R. Thirunavukkarasu gave a briefing on the background of the project and the salient achievements of the demonstration.

Asian Seabass Farming Demonstration Interaction Meet

As part of the transfer technology program on seabass (*Bhetki)* farming technology funded by NFDB, the institute has been demonstrating sustainable farming of seabass phase-wise in the states of Karnataka, Odisha and West Bengal. The fish farming demonstration interaction meet was conducted on 22nd January 2013 at Harwada, Karwar, Uttar Kannada District of Karnataka in order to motivate farmers to take up farming in their pond culture systems. The Honorable Minister of Fisheries and Science & Technology, Govt of Karnataka, Shri Anand Asnotikar inaugurated the meet and addressed various welfare schemes and development programs implemented for the fisheries and fisher community development in Karnataka. He complimented CIBA, Chennai for the innovative enterprising activity taken up at Harwada farmers' pond demonstrating the techno economic viability of "*kurudi*" (seabass). Dr. A. R. Thirunavukkarasu, briefly mentioned the technology options available on seabass seed rearing, pre grow-out farming and grow-out culture. He requested the farming communities to make use of the technologies available with the institutes and adopt for improved farming of seabass. Dr J K Sundaray, Principal Scientist, Dr K Ambasankar, Senior Scientist and Dr Prem Kumar, Scientist from CIBA also participated in the deliberations. The meeting was attended by more than 300 fish farmers from Uttar Kannada district. The officials from MPEDA, CMFRI, Department of Fisheries, Government of Karnataka, BFDA, Aquafarmers Society and faculty members from the Karnataka University of Animal and Fisheries Sciences also participated.

Adoption of aquaculture, allied aquaculture and agro based technologies by coastal Women Self Help Groups

The inauguration meeting of mushroom farming unit, release of brackishwater ornamental fish (spotted scat), demonstration of farm-made fish feeds along with interaction meeting was organized on 5th October 2012 among the *Irular* tribal women SHGs of New Perungalathur, Kancheepuram district under TSP project.

Inauguration of mushroom farming unit, release of brackishwater ornamental fish

The inauguration and demonstration programmes on nursery rearing of Asian seabass in hapas and interaction meeting with the *Irular* tribal women SHGs of Kulathumedu village, Tiruvallur district was organized on 10th October 2012 under TSP project.

Distribution of seabass seeds and stocking in hapas by the tribal WSHGs at Kulathumedu village, Tiruvallur District

Focus group discussion (FGD) meetings on perceived climate change impacts

Two FGD meetings were organized under the NICRA project at Olpad and Bhimpore villages in Gujarat on 3rd and 4th January 2013, respectively, which were attended by 25 farmers representing the neighbouring shrimp farming villages at each place. The meetings were organized in a farmer-friendly manner to document the perceived climate change events and impacts, risk assessment, mapping of crop calendar being followed in line with the seasonal variations and adaptation measures being implemented by them to mitigate the CC impacts.

Awareness Programme and Demonstration on Cage Farming of Finfishes for Tribal Farmers

An awareness programme along with a demonstration on cage farming of finfishes for tribal farmers was jointly organized by CIBA and NAU at Pathri (Gandevi taluk), Navsari, Gujarat on 20th May 2012. About 50 tribal farmers including 20 women participated in the programme. Dr. S. M. Pillai, Principal Scientist, CIBA in his inaugural address, reviewed the research and extension activities carried out under CIBA-NAU collaborative project with special reference to tribal farmers and emphasized on the importance of cage farming in and around Navsari. Mr. Chimanbhai, leader of the tribal group, stressed the need of practical knowledge on the finfish cage farming and its benefit towards the livelihood support for tribal farming community.

Information Kiosk for sustainable shrimp farming

Better Management Practices (BMPs) are highly essential for sustained aquaculture, particularly in shrimp farming. The CIBA with financial support from NABARD, under its Rural Innovation Fund has implemented a project on e-Extension strategy for ensuring knowledge led rural growth in which an information Kiosk has been installed in Avarikadu village of Nagapattinam district of Tamil Nadu on 30th October 2012. The touch screen kiosk is an effective way to disseminate BMPs on shrimp culture effectively in Tamil. The contents include site selection, bio-security, seed selection, stocking, soil and water management, feeds and feed management, health management, harvest, subsidy details and information on CIBA and NABARD. Dr. A.G. Ponniah, Director, CIBA inaugurated the Kiosk and expressed his happiness in his inaugural address on the installation of the kiosk in Avarikadu village, which is a major shrimp farming hub in Tamil Nadu and requested the farmers to make full use of it and also to give a regular feedback for further modifications in the content time-to-time. A pictorial book on BMPs in shrimp farming was released by Shri. D. Ganesh, District Development Manager (DMM), NABARD, Nagapattinam and he appreciated the efforts put in by CIBA for practically helping the shrimp farmers by guiding them with the BMP strategies in shrimp culture. A memorandum of understanding (MoU) was signed between CIBA and Avarikadu Panchayat for the effective use of the kiosk.

Visit of Honorable Minister of Fisheries, Government of West Bengal to KRC of CIBA, Kakdwip.

The Honourable Minister of Shri. Subrata Saha, visited KRC on 5th November, 2012. The minister after visiting the farm and laboratory facilities of the Research Centre, appreciated the work being carried out and the technologies developed by CIBA that are of great help to the brackishwater aqua-farmers to achieve better production and improve their economic status. He complimented CIBA scientists for taking up project work under NFDB, NAIP and CPWF for the betterment of farming communities in West Bengal. Dr. S. N. Biswas, Mr. R. F. Lepcha, Joint Director, Department of Fisheries, Mr. Uttam Kumar Panja, Deputy Director, Mr. Byomkesh Halder, Assistant Director Fisheries and other Officials also visited the facilities and appreciated the efforts of CIBA for the development of brackishwater aquaculture in West Bengal.

Participatory Rural Appraisal was exercised for two days on 23rd and 24th January, 2013 in Pedapattnam village of Machilipattnam district, Andhra Pradesh with the objective of reviving shrimp ponds which are in disuse. In total there were 40 people in the PRA team. In addition, Mr. Madhu Moorthy, Assistant General Manager, NABARD, Vijayawada and Mr. Nirikshina Rao, Director, SNEHA foundation (NGO) of Gudivada participated in this discussion and expressed their eagerness to extend support through CIBA to the Pedapatnam village. The PRA team was a well composed multi-disciplinary team consisting of a scientist and scholars from CIBA, a representative of World Vision NGO, MPEDA, DoF and was a perfect blend of staff and scholars from different departments and faculties. The tools used by the research team were transect walk, time trend, social mapping, resource mapping, seasonal calendar, wealth ranking, problem tree analysis, Venn diagram, technology matrix and focus group discussion.

PRA participants in group discussion

PRA Social Mapping Exercise

CIBA Foundation Day

The CIBA Foundation Day with the theme on Climate Change was celebrated on 2nd April 2012 at CIBA, Chennai. Dr.A.G.Ponniah, Director, CIBA, in his presidential address reviewed the achievements made by the institute in the past 25 years and future challenges in the brackishwater aquaculture sector. He emphasized the importance of climate change research and the paucity of research information on climate change in relation to aquaculture.

Dr. A. Ramachandran, Director, Centre for Climate Change & Adaptation Research, Anna University, Chennai, the Chief Guest of the function, delivered a talk on the Climate change scenario in Tamil Nadu with special focus on aquaculture. He highlighted the importance of aquaculture as the fastest

growing food production sector focusing on the overall global fisheries and aquaculture production in the past 3 decades and the demand for aquaculture production up to 2020.While correlating the fisheries and aquaculture production with climate change, he pointed out the threats to the sectors due to the increase in temperature, changes in monsoon and occurrence of extreme climatic events, Sea Level Rise (SLR), increase in salinity, water stress and changes in hydrological regimes.

ICAR Industry Day

ICAR Industry Day was celebrated at CIBA on 16th July 2012. The meeting started with the opening remarks made by Dr.A.R.Thirunavukkarasu, Director Incharge. A presentation on Intellectual Property Rights Regime in ICAR and CIBA was made by Dr. T. Ravisankar, Officer-in-Charge, Institute Technology Management Unit. The experience of Nutrition group of CIBA in technology transfer in Public Private Partnership mode under Intellectual Property Rights regime was shared by Dr. K. Ambasankar, SIC, Nutrition group. A brainstorming session on CIBA technologies - retrospect and prospects was conducted by Dr.P.Ravichandran, Principal Scientist & Head, Crustacean Culture Division, The focus theme was to identify constraints faced by CIBA Scientists in technology commercialization. The need for development of a system for cross verification of claims on technologies and creation of proper technology repository at Institute level were underlined.

Agricultural Education Day

The Agricultural Education Day was celebrated on 8th June, 2012 at CIBA, Chennai. The day was observed in recognition of the date of start of the Ph.D programme in CIBA. Dr. S. M. Pillai, Principal Scientist and Officer-in-Charge, PME Cell delivered the introductory remarks followed by an address by Dr. A.G. Ponniah,Director, CIBA. He emphasized the necessity of education and its importance in the fast developing sectors, particularly in agriculture, fisheries and aquaculture in the country. On this occasion, a debate was conducted on Privatization of Education and the research students actively participated in the debate. The pros and cons in both private and public educational systems were discussed in depth.

Brackishwater Aquaculture Farm Innovators Day

CIBA organised a brackishwater aquaculture farm innovators meet as part of the World Food Day Celebrations on 16th October, 2012. Shri.B.Suryakumar and Shri.M.Kalyanaraman of Hi-Tide Sea farms in Nagapattinam district of Tamil Nadu were invited to present their farm innovations in shrimp aquaculture. The innovators used 'shade nets' for covering green houses in agriculture as a substrate

for development of periphyton and bio-flocs for nitrogen assimilation in shrimp culture ponds to control total ammonia nitrogen which is a pollutant in shrimp culture ponds. Use of aquatic microbial community that gobble up the nitrogen waste and turn it into nutrients thus stabilising the water quality and support shrimp growth, is the principle behind this approach. This innovation gives enhanced water quality (zero water exchange) and pond carrying capacity which facilitate higher stocking density and ultimately higher productivity per unit area. Quality seed and electricity are two critical factors which determine the efficiency of this innovation.

CIBA Science Forum

CIBA invited eminent persons from various disciplines to deliver lectures on science & technology for the Science Forum. During the year Mr. Badri Narayan, Scientist, BD Biosciences delivered a talk on "The art & science of flow cytometry" on 26th May 2012. A talk on "Scholarly communication and open access publication" was delivered by Prof. Subbiah Arunachalam, Distinguished Fellow, Centre for Internet Society, Bangalore on 20th April, 2013.

Women's Day Celebrations

Women staff members of CIBA celebrated the Women's Day - 2013 on 8th March, 2013. To mark this occasion various competitions like rangoli, sports and cultural programmes were organized for the staff members of the Institute. All women staff members and research scholars actively participated in the above competitions and won various prizes, which were distributed by the Director, CIBA.

EXHIBITIONS

The Institute participated in the following exhibitions

Sl. No	Event	Date
1	International Day for Biological Diversity at GRT, Chennai.	22 May, 2012
2	Fish Festival at Rohtak, Haryana	22 September, 2012
3	Expert Consultation on Managing Transboundary Diseases of Agricultural Importance in Asia & Pacific jointly organized by the ICAR and APAARI at NASC Complex, New Delhi	10-12 October, 2012
4	National Conference on Conservation and Management of Faunal Resources for Sustainability at Guru Nanak College, Chennai	3-5 October, 2012
5	National Symposium on Mountain Fisheries: Challenges and Opportunity for Livelihood Security organized by Directorate of Coldwater Fisheries Research, Bhimtal	5-6 November, 2012
6	Global Symposium on Aquatic resources for eradicating the hunger and Malnutrition-opportunities and challenges organized by the Asian Fisheries Society India Branch (AFSIB) at Mangalore	4-6 December, 2012
7	Chennai Science Festival 2013 organized by the Anna University	30 January - 3 February 2013
8	National Conference on Public Private Partnership in Aquaculture and Culture Based Fisheries-2012 by CIFRI at Barrackpore, West Bengal	9-10 February 2013

Agricultural Research (ARS) service/NET examinations

Preliminary ARS/NET Preliminary Examination, 2013 of ASRB was conducted at Chennai Centre by the Institute on 24th February, 2013

ICAR Examinations Coordinated by CIBA

- The 17th All India Entrance Examination for Admission to UG and PG Degree Programmes in Agriculture and Allied Sciences for the Academic Session 2012-13 held on 14th April 2012 for UG and 15th April 2012 for PG
- IARI – Ph.D. Entrance Examination 2012-13 held on 10th June 2012
- All India Entrance Examination for admission to UG (AIEEA) – UG 2013 on 20th April 2013
- AIEEA – PG 2013 held on 21st April 2013
- ICAR'S SRF (PGS) in Agriculture and Allied Sciences – 2013 held on 21st April 2013

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Visitors

Headquarters

Sl.No.	Details of visitors	Date of visit
1	Dr. A. Ramachandran, Director, Centre for Climate Change and Adaptation Research, Anna University	2 April, 2012
2	Shri Inbasagaran, Subiksha Seafood, Coimbatore	2 May, 2012
3	Dr. Madan Mohan, ADG (Fishery), ICAR	20 June, 2012
4	Mrs. Rekha Gupta, Market Advisor, Innovation Norway, Royal Norwegian Embassy, New Delhi.	4 August, 2012
5	Dr. R.Paul Raj, Member Secretary, Coastal Aquaculture Authority	22 August, 2012
6	Shri Sandhip Ahirrao, Technical Sales Manager - Aquaculture, South & South East Asia, Lallemand Animal Nutrition, Chennai	30 August, 2012
7	Dr.(Mrs) B.Meenakumari, Deputy Director General (Fy.), ICAR, New Delhi.	10 September, 2012
8	Smt. Bibharani, Senior Manager (OL), Indian Oil Corporation Limited	30 September, 2012
9	Dr.R.Paul Raj, Member Secretary, Costal Aquaculture Authority	15 October, 2012
10	Dr. R. A. Selvakumar, Former ADG (M.Fy), ICAR & Mr. B.Surya Kumar, Hitide Farm, Sirkazhi	16 October, 2012
11	Dr.S. Murugan, IPS, DIG of Police, Special Crime Branch, CBI, Chennai	29 October, 2012
12	Dr. Altaff, Principal, New College, Chennai	29 October, 2012
13	Dr. B. Manimaran (CAA) and Dr. Paul Pandian (NFDB)	2 November, 2012
14	Dr.(Mrs.) Indrani Karunasagar, Professor, Mangalore Fisheries College	14 December, 2012
15	Dr.M.Sakthivel, President, Aquaculture Foundation of India	28 December, 2012
16	Dr. S. Ayyappan, Secretary DARE & DG, ICAR	23 February, 2013

Kakdwip Research Centre

Sl.No.	Details of visitors	Date of visit
1	Dr. Susmita Ekka, Scientist, Central Pollution Control Board, Eastern Zone, Kolkata	28 April, 2012
2	Dr. Raman Kumar Trivedi, Professor, Dept. of Fisheries Environment, Faculty of Fishery Science, WBUAFS	27 June, 2012
3	Dr. K. C. Dora, Dean of Faculty Fishery Science	13 September, 2012
4	Dr. Uttam Kumar Panja, DDF, Government of West Bengal	13 September, 2012
5	Dr. P.K. Mukhopadhyay, P.S. & OIC, Rahara Research Centre of CIFA	22 September, 2012
6	Mr. Subrata Saha, Hon'ble Minister of Fisheries, Government of West Bengal	5 November, 2012
7	Dr. Craig A Meisner, Country Director of WorldFish Center, South Asia and Bangladesh	8 January, 2013
8	Dr. Liz Humphreys, Sr. Scientist, IRRI, Philippines	27 February, 2013
9	Dr. Manoranjan Mondal, Sr. Scientist, IRRI, Bangladesh	27 February, 2013
10	Dr. (Mrs.) Rita Jayasankar, Principal Scientist & OIC, Puri Centre of CMFRI, Odisha	1 March, 2013
11	Dr. R. P. Misra, National Co-Ordinator, Component-3, NAIP Project	25 March, 2013

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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 (Superannuation on 28.2.2013)
Dr.M.Natarajan
Dr.G.Gopikrishna
Dr.C.Gopal
Dr.K.P.Jithendran
Dr.V.S.Chandrasekaran
Dr.T.Ravisankar (Promoted w.e.f.1.1.2009)
Dr.M.Muralidhar (Promoted w.e.f.1.1.2009)
Dr.(Mrs.) M.Jayanthi (Promoted w.e.f.1.1.2009)
Dr.(Mrs.) B.Shanthi (Promoted w.e.f.1.1.2009)
Dr.S.V.Alavandi (Promoted w.e.f.1.1.2009)
Dr.C.P.Balasubramanian (Promoted w.e.f.1.1.2009)
Dr.M.Kailasam (Promoted w.e.f.1.1.2009)
Dr.(Mrs.) D.Deboral Vimala (Promoted w.e.f.1.1.2009)
Dr.M.Shashi Shekhar (Promoted w.e.f. 1.2.2011)

Senior Scientist

Dr.(Mrs.) Shiranee Pereira (VRS on 21.12.2012)
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

Scientist (Senior Scale)

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

Scientist

Dr.R.Ananda Raja (transferred from KRC on 1.5.2012)
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
Shri D.Raja Babu
Shri M.Shenbagakumar (Promoted w.e.f. 1.7.2011)
Shri V.R.Senthil Kumar (Promoted w.e.f. 30.3.2012)

(T – 6)

Shri R.Puthiyavan
Mrs.K.Jacquline
Shri Joseph Sahayarajan
Shri S.Nagarajan (Promoted w.e.f. 3.1.2012)
Shri S.Stanline (Promoted w.e.f. 17.2.2012)
Dr.A.Nagavel (Promoted w.e.f. 21.8.2012)
Shri R.Subburaj (Promoted w.e.f. 27.8.2012)

(T – 5)

Shri M.Gopinathan Nair (Driver) (Superannuation on 31.8.2012)
Shri S.Rajamanickam
Shri S.Rajukumar (Transferred to NAARM, Hyderabad on 12.6.2012)
Shri R.Rajashekaran

Technical Assistant

(T – 4)

Shri N.Ramesh
Shri S.Saminathan
Shri N.Jagan Mohan Raj
Shri R.Balakumaran (Driver)
Shri D.M.Ramesh Babu (Promoted w.e.f. 24.7.2012)
Shri G.Thiagarajan (Promoted w.e.f. 4.8.2012)

(T - 3)

Shri K.Paranthaman (Driver)

(T - 2)

Shri K.Karaian
Shri K.V.Delli Rao (Promoted w.e.f. 3.5.2012)

Administration and Finance

Administrative Officer

Shri B.Sathish

Finance & Accounts Officer

Shri V.L.Jacob (Transferred to IISR, Calicut on 08.04.2012)
Shri Kunal Kalia (Joined on 16.7.2012)

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
Mrs.R.Vetrichelvi (Promoted on 15.6.2012)

Lower Division Clerk
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 (Superannuation on 31.3.2013)
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. Jitendra Kumar Sundaray

Senior Scientist

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

Scientist

Shri Gouranga Biswas
Dr.Sujeet Kumar
Mrs.P.S.Shyne Anand

Technical Personnel

(T – 3)

Shri P.S.Samanta
Mrs.Chanda Mazumder

Administrative Staff

Private Secretary

Shri S.K.Halder

Assistant

Shri S.K.Bindu
Shri P.K.Roy (Superannuation on 31.1.2013)

Upper Division Clerk

Mrs.Arati Rani Panigrahi (VRS on 1.6.2012)

Skilled Support Staff

Shri N.C.Samanta
Shri Rash Behari Das
Shri Sasadhar Betal
Shri Patit Paban Halder
Shri Abhimanyu Naskar (Superannuation on 31.10.2012)
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

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

Technical

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

Skilled Support Staff

Shri K.C.Samal (Superannuation on 31.3.2013)
Shri Sudharsan Naik
Shri Bijoi Bhoi
Shri Maharaga Majhi
Shri Premananda Bisoi

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Infrastructure Development

Muttukadu Experimental Station

- The approach road from the main gate to the fish hatchery near the seaside was strengthened with stone pitching and concrete. The work is in progress.

Kakdwip Research Centre of CIBA, Kakdwip

- **Rural Technology Centre**

  A Rural Technology Centre to promote the technical know-how and skills of farmers has been developed which would act as a liason between the Kakdwip Research Centre and the farming communities of Sundarban.

Rural Technology Centre at KRC

- **Model Integrated Farm:** This has been developed at 'C' sector of KRC for demonstration of integrated aquaculture activities to farmers of Sunderban area of West Bengal. The whole farm has two reservoir ponds and nine fish culture ponds with sluice gate, pump room, poultry shed and water pipe line.

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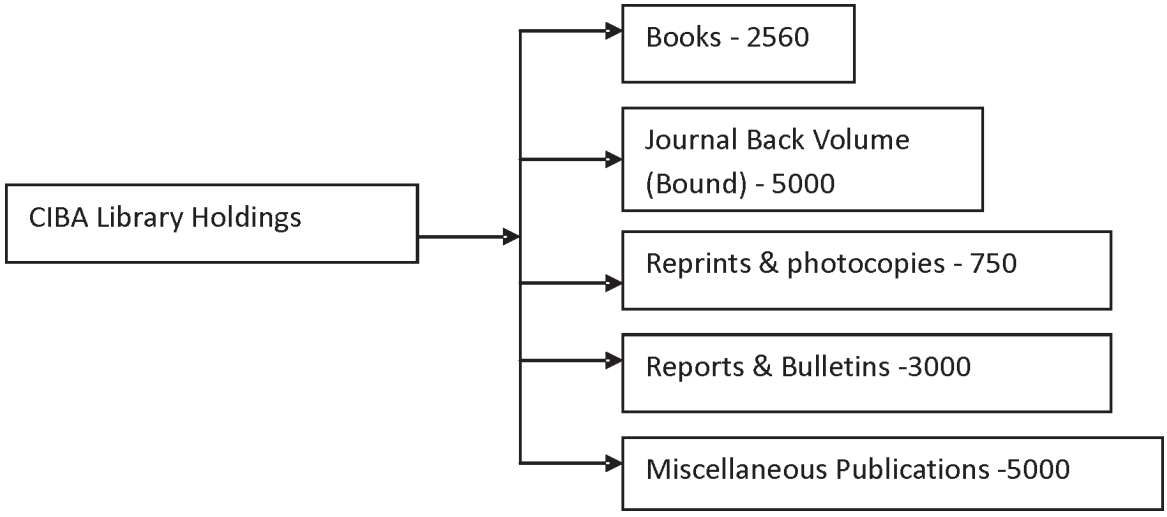
Library, Information and Documentation

Library holdings

CIBA Library procured 100 new books including official language books during the period. About 26 international and 32 national journals including vernacular language journals for the headquarters and 30 national journals for Kakdwip Research Centre of CIBA Library were subscribed. The library holdings as on 31.03.2013 are as under:



Online access to CeRA journals and document delivery service

Library has established online connectivity with the Consortium for Electronic Resources in Agriculture (CeRA) journals subscribed by the National Agricultural Innovation project (NAIP) at headquarters and KRC for the year 2012-13. This section supplied photocopies of journal articles requested from various ICAR institutes, scientists and research scholars under CeRA - Document Delivery Request (DDR).

Exchange services

CIBA library maintained exchange relationship with national and international organizations working on fisheries and aquaculture on mutual interest. The library maintained the free mailing of the Annual Report and other institute publications to research organizations, universities and other agencies to give wide coverage to the research and development programmes of the institute.

Information services to the stakeholders

CIBA library provided access of reference books and journals to scientific personnel of other research organizations, academicians, university/college students, research scholars, stakeholders and other related visitors. The library provided reprographic service (photocopying) to the users on a nominal payment basis. The reports, special publications and newsletters of international fisheries and aquaculture coordination agencies like NACA, FAO etc. available in electronic form were downloaded regularly and sent online to the scientists. The pdf files have been archived for future use.

Utilization of funds

A total of ₹30.00 lakh under plan funds were utilized towards the renewal of subscription to journals and procurement of new books for Headquarters and KRC library.


CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE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