

Central Institute of Fisheries Education
M.F.Sc. (Fisheries Resource Management)
Course Structure (Total credits 32)

A	MAJOR COURSES			20 Credits
	A1	CORE COURSES		12 Credits
1	FRM 501	Principles in Fisheries Management	2+1	
2	FRM 502	Fisheries Resources	2+1	
3	FRM 503	Fish Stock Assessment	2+1	
4	FRM 504	Practices in Fisheries management	2+1	
	A2	OPTIONAL COURSES		8 Credits
1.	FRM 505	Bio Systematics of Aquatic Fauna	1+2	
2.	FRM 506	Aquatic Ecosystems, Biodiversity and Conservation	1+1	
8	FRM 507	Advances in Fish Capture Technology	2+1	
4	FRM 508	Coastal Zone Management	2+1	
5	FRM 509	Aquatic Flora and its Management	1+1	
6	FRM 510	Trophodynamics in Aquatic Systems	1+1	
7	FRM 511	Reproductive Biology of Finfish	1+1	
8	FRM 512	Remote Sensing and GIS for Fisheries Management	1+1	
9	FRM 513	Climate change: Aquatic Ecosystems and Fisheries	1+1	
B	MINOR COURSES (Courses outside major discipline / from other relevant disciplines)			9 Credits
C	SUPPORTING COURSES (Compulsory)			5 Credits
1	FST 501	Research Methodology	1+1	
2	FST 502	Statistical Methods	1+2	
	Total Course Work Credits			32 Credits
D	MASTERS' SEMINAR			1 Credits
1	FRM 591	Masters' Seminar I	0+1	
E	FIELD TRAINING			2 credits
1	FRM 551	Field Training Phase I	0+2	
F	MASTERS' RESEARCH			20 Credits
	FRM 599	Masters' Research (Semester III)	0+10	
	FRM 599	Masters' Research (Semester IV)	0+10	
	Total MFSc Program Credit Hours			57 Credits

FISHERIES RESOURCE MANAGEMENT

Course Contents

FRM 501 **PRINCIPLES OF FISHERIES MANAGEMENT**

2+1

Objective To acquaint the students with the principles of sustainable management of aquatic ecosystem and fisheries

Theory

Unit I **Fish production systems**

Definitions of - Capture fisheries and enhancement (stock enhancement) and other production systems ; species enhancement, culture-based fisheries, enhancement through new management practices, ranching

Unit II **Objectives of management**

Food and nutritional security & safety, sustainability; environmental, ecological, economic integrity, and social equitability

Unit III **Issues in fisheries**

Overexploitation, overcapacity, pollution, habitat degradation/ biodiversity loss, Environmental flows; Exotics; trans-boundary issues

Unit IV **Climate change**

Introduction to climate change - Vulnerability, adaptation and mitigation options

Unit V **Characteristics of fisheries**

Renewable, finite resource; historical property rights, common property, open and regulated access, multispecies, multi fleet, large dependent population, trade and markets drivers, sharing water-bodies with other users

Unit VI **Methods of management**

Input - fishing efforts, mesh regulations, fishing ban, licensing, capital investments, etc. and output - catch quotas, minimum legal size, etc., control measures ecosystem approach(introduction of exotics), Spatial Planning, community and participatory management, trade regulations, certification, incentives and disincentives, negotiations

Practical

Visit to lakes, reservoirs, river stretches, and marine landing centers to understand production system and interact with managers Co-operative societies and stake holders

Visit to mangrove to understand management

Suggested Readings

1. Aggarwal, P. K. 2008."Global climate change and Indian agriculture: impacts, adaptation and mitigation." *Indian Journal of Agricultural Sciences*, 78.11: 911.
2. Anderson, L.G., 1986. The economics of Fisheries management. John Hopkins University Press. Baltimore.
3. CMFRI, National Marine Fisheries Census, 2010 India.
4. Cochrane, K.L., 2002. A Fishery Manager's Guidebook Management measures and their application. FAO Fish. Tech. Pap. 424. Food and Agriculture Organisation of United Nations. Rome.
5. FAO. 2014. The State of World Fisheries and Aquaculture (SOFIA). Fisheries Department, Food and Agriculture Organization of the United Nations, Rome.
6. González-Laxe F., 2005. The precautionary principle in fisheries management. *Marine Policy*, pp 495–

7. Munro, G., Houtte, A.V. and Willmann, R., 2004. The conservation and management of shared fish stocks: legal and economic aspects. FAO Fish. Tech. Pap. 465. Food and Agriculture Organisation of United Nations. Rome.
8. Narayanakumar, R and Panikkar, K. K. P. and Sehara, D. B. S. and Sathiadhas, R., 2000. Socio-economic analysis of marine fishermen in India.
9. Narayanakumar, R and Panikkar, K K P and Sehara, D B S and Sathiadhas, R., 2000. *Socio-economic analysis of marine fishermen in India*. In: Marine Fisheries Research and Management. Pillai, V N and Menon, N G, (eds.) CMFRI; Kochi, Kochi, pp. 895-906.
10. Rao, K.R.M., Manikandan, M.S. and Leal, W., 2005. An Overview of the impacts of changes in common property resources management in the context of globalization: A case study of India. *International Journal of Sustainable Development and World Ecology*. 12(4): 471-477.
11. Sathiadhas, R., 2009. Inter-sectoral Disparity and Marginalization in Marine Fisheries in India. *Asian Fisheries Science*, 22 (2). pp. 773-786.
12. Sathiadhas, R., Khader, Vijaya, Hassan, Femeena, Kasim, H. M, Sudhakara, N S. Narayanakumar, R., Dhanapal, K and Lakshmi, J., 2003. Role of women in Fisheries: An Overview. In: Workshop on Empowerment of Fisher Women, 13-14 October 2003, Hyderabad.
13. Sathiadhas, R., Narayanakumar, R. and Aswathy, N., 2012. *Marine Fish Marketing in India*. CMFRI Kochi, Ernakulam. ISBN 978-81-901219-8-9.
14. Sathiadhas, R., 2008. "Economic concepts and applications with special reference to climate change. In: Winter School on Impact of Climate Change on Indian Marine Fisheries held at CMFRI, Cochin 18.1. 2008 to 7.2. 2008.
15. Shotton R., 2000. (Ed.) Use of Property Rights in Fisheries Management. FAO Fisheries Technical Paper 400/1 & 401/2. Food and Agriculture Organisation of United Nations. Rome.
16. Shyam S. Salim and R. Narayanakumar, 2012. Manual on World Trade Agreements and Indian Fisheries Paradigms: A Policy Outlook.
17. Singh, A. K. 2014 "Emerging Alien Species In Indian Aquaculture: Prospects And Threats." *Journal of Aquatic Biology and Fisheries* 2.1: 32-41.
18. Singh, A. K., and W. S. Lakra. 2006, "Alien fish species in India: Impact and emerging scenario." *Journal of Ecophysiology and Occupational Health* 6.3 and 4 : 165-174.
19. Smakhtin, V. U., and A. Markandu. 2006. "A Pilot Assessment of Environmental Flow Requirements of Indian River Basins." *Unpublished Research Paper, IWMI Strategic Assessment*.
20. Vivekanandan, E., 2008. "Adaptation and mitigation measures. In: Winter School on Impact of Climate Change on Indian Marine Fisheries held at CMFRI, Cochin 18.1. 2008 to 7.2. 2008."
21. Vivekanandan, E., 2011. "Marine Fisheries Policy Brief-3; Climate change and Indian Marine Fisheries." *CMFRI Special Publication* 105: 1-97.
22. Zacharia, P. U. and Najmudeen, T. M., 2012. Marine Finfish Resources of India: Distribution, Commercial Exploitation, Utilization Pattern and Trade. In: World Trade Agreement and Indian Fisheries Paradigms: A Policy Outlook, 17-26 September 2012, Kochi.

FRM 502 : FISHERIES RESOURCES

2+1

Objective: To acquaint the students with major fisheries resources and their present status and utilization

Theory

Unit I

Overview of the status of world inland fisheries resources:

Present status, potential and management of different inland waters

Unit II

Status of Inland fisheries Resources of India:

Lacustrine, Riverine, Estuarine, Upland and wetland and Reservoir fisheries

Unit III

Sustainable fish production from reservoir, floodplains and wetlands;
Conservation of riverine fishery resources

Unit IV	Overview of the status of world Marine fisheries resources Major fishing regions and nations of the world, present trend of marine capture fisheries – mechanized and small scale fishery. Important finfish and shellfish resources of world oceans, their conservation and management strategies.
Unit V	Status of major marine fisheries resources of India – Catch trends – pelagic, demersal, midwater, deep sea and oceanic fishery Trawl, gill net, lines, seine, bag net fishery Conservation and management strategies.
Unit VI	Methodologies followed in the collection of data for estimation of fish catch inland and marine systems
Practical	Visit to: Lakes, Reservoir, river Stretches, lagoon, mangroves, Marine landing centers, intertidal areas Data collection on – catch and efforts Case studies on present status of fishery resources in selected systems

Suggested Reading:

1. Belgrano, Andrea and Fowler, W. Charles, 2011. Ecosystem Based Management for Marine Fisheries, Cambridge University Press, 362pp.
2. Cushing, D.H., 1975. Marine ecology and fisheries. Cambridge University Press. Cambridge UK, 292pp.
3. De Silva, S.S. and Amarasinghe, U.S.(eds). Status of reservoir fisheries in five Asian countries. NACA Monograph No. 2. Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand, 113p.
4. Jennings, S. & Kaiser, M.J. 1998. The effects of fishing on marine ecosystems. Advances in Marine Biology, 34:201-352.
5. Misra, S.R. 2006. Inland Fisheries in India Issues and Concerns. Concept publishing company A/15/16, Commercial Block, Mohan Garden, New Delhi (India), 133 pp.
6. Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. Journal Du Conseil, 39: 175-192.
7. Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., Torres, F. Jr. 1998. Fishing down marine food webs, Sciences, 279: 860-863.
8. Pauly, D., Christensen, Villy., Guenette, Sylvie., Pitcher, Tony, J., Sumaila, U. Rshid., Walters, Carl J., Watson, R. & Zeller, Dirk 2002. Towards sustainability in World Fisheries, *Nature*, 418: 689-695.
9. Pillai, V.N. and Menon, N.G. (Eds.) 2000. Marine Fisheries Research and Development. Published by CMFRI 914 p.
10. Vass, K.K., Mitra, K., Suresh, V.R., Katiha, P.K. and Srivastav, N.P. 2006. River Fisheries in Indian Issues and Current Status. Inland Fisheries Society of India. Barrackpore, West Bengal, India. 321 p.
11. Walters, J.Carl and Martell, Steven, J.D., 2004. Fisheries Ecology and Management. 448 pp.
12. Zwieten, P.A.M. van., Bene C., Brummett, R. and Valbo-Jorgensen, J., 2011. Review of tropical reservoirs and their fisheries: The cases of Lake Nasser Lake Volta and Indo-Gangetic basin reservoir, FAO Technical paper-557.

FRM 503

FISH STOCK ASSESSMENT

2+1

Objective: To acquaint the students with the methods of stock assessment and their applications to fisheries management

Theory

- | | |
|----------|---|
| Unit I | Concept of stock, definition of growth parameters |
| Unit II | Estimation of growth parameters employing hard parts and size frequency; concept of mortality and mortality rates |
| Unit III | Sampling of commercial catches |
| Unit IV | Gear selectivity |
| Unit V | Holistic models - Schaefer's model, Fox model, Swept area method |

Unit IV	Yield per recruit model
Unit VII	Stock recruitment relationship, Stochastic model – estimation of technical reference point MSY and other yield base reference point
Unit VIII	Virtual population analysis, economic and social reference points, Eumetric fishing
Unit IX	Ecosystem based models
Unit X	Assessment of fishery under data poor conditions
Practical	Data collection at landing Centres and onboard research vessels, estimation of growth and mortality parameters (hard parts/length based/age based), Gear selectivity, Yield per recruit and relative yield per recruit model of Beverton and Holt and Schaefer and Fox models, Cohort analysis, Swept area method, MSY, Stock recruitment relationship, Use of FiSAT, CEDA, YIELD, Ecopath with Ecosim etc .

Suggested Readings

1. Beverton R.J.H. and Holt. S. J., 1957. On the dynamics of exploited fish population. *Fish. Invest. Ser. II, Vol. 19*: 533p. Min. of Agriculture and Fisheries, London.
2. Callucci, V.G., Saila, S.B., Gustafson D.J. and Rothschild, B.J., 1996. Stock Assessment. Quantitative methods and applications for small scale fisheries. Lewis publishers. Boca Raton, P. 527.
3. Devaraj M. 1983. Fish Population dynamics : a course manual, CIFE Bulletin 3 (10):98p
4. Gulland, J.A. 1977. fish population dynamics. John wiley and sons. Chichester. P. 422.
5. Gulland, J.A. 1992. A review of length based approaches to assessing fish stocks. FAO technical paper. 323. p.100.
6. Hilborn, R and C.J. Walters, 1992. Quantitative Fisheries Stock Assessment – Choice, Dynamics and Uncertainty. Pub. Chapman and Hall. 570p.
7. King, M., 1995. Fisheries Biology, Assessment and Management. Pub. Fishing News Books. 341p.
8. Manual. FAO. Fisheries Technical paper No: 301. FAO Rome. p407.
9. Nikolsky G.V., 1980. Theory of fish population dynamics. As the biological background for rational exploitation and management of fishery resources. Bishen singh Mahendra Paul singh and Otto Koeltz Science Publishers. P. 323.
10. Pauly, D. 1980. Selection of simple methods for the assessment of tropical fish stocks. *FAO Fish. Circ.*, (729): 54p.
11. Quinn, T.J and R.B. Deriso, 2003. Quantitative fish dynamics. Pub. Academic Press.
12. Ricker, W.E. 1971. Methods for the assessment of fish production in freshwaters. Blackwell Scientific publishers, Oxford and IBH, Edinburg., 348p.
13. Sparre, P., E. Ursin and S.C. Venema, 1998. Introduction to Tropical fish stock assessment. Part.I Published by FAO Tech Pap. 306/ Rev. 2 Rome, FAO, 407p

Objectives: To acquaint the students with the options available for fisheries management through legislations and regulations

Theory

Unit I	Fisheries regulatory, legal and enforcement regimes- responsibilities of the Centre and States of India
Unit II	Indian Fisheries Act 1897; Wild Life Protection Act 1972, EEZ, Maritimes Zones of India Act (MZI Act) 1976, 1981 (Regulation of fishing by Foreign vessels), Marine fisheries legislations in various States of India (MFRAs and Majumdar committee), Deep Sea Fishing Policy 1991, 2005, Comprehensive Marine Fisheries Policy 2004, other regulations (Chartered, leased, joint ventures LoP etc.) and guidelines on fisheries issued from time to time
Unit III	Policy and legislations on Environment, Biodiversity, water and pollution Control
Unit IV	Monitoring, Control and Surveillance (MCS) systems for capture fisheries: definition; components; role in fisheries management
Unit V	Inland Fisheries legislations, regulation and development: Inland fisheries governance, Inland Fisheries Acts, leasing policies for water-bodies. Issues of property right in Inland water bodies
Unit VI	Management needs associated with aquaculture development and relevant legislations; Coastal Aquaculture Authority Act; Coastal Regulation Zone (CRZ) notifications, Integrated Coastal Zone Management (ICZM)
Unit VII	FAO Code of Conduct for Responsible Fisheries
Unit VIII	International regulatory and developmental instruments: United Nations Law of the Sea Historical perspectives; international negotiations and settlements over open seas, conflict management ,UN fish stocks agreement, shared stocks), FAO Compliance Agreement (1993)
Practical	Preparation of management plans for specific fisheries, Inter sectoral conflict management, fisheries development plan for ICZM, Comparative studies on the Fisheries Acts of any two states of India and preparation of a report. Visit to appropriate Government organizations/ research institutions/NGO and preparation of working report. Mesh size studies for trawl, gillnets and purse seine.

Suggested Reading:

1. Badapanda, K.C.2014. Fisheries Legislation. Narendra Publishing House, 400pp.
2. Badapanda, K.C.2014.Handbook of Fisheries Management. Narendra Publishing House, 392pp.
3. Brahtz, J.F.P., 1972. Coastal Zone Management. U.N. International Economic and Social Affairs, New York.
4. FAO, 1995. Code of Conduct for Responsible Fisheries, 41p.
5. FAO, 2009.International Guidelines for the Management of Deep-sea fisheries in the High seas.Rome, FAO, 73p.
6. Flewelling, P.1995. An introduction to monitoring, control and surveillance for capture fisheries, FAO Fisheries Technical Paper No. 338. Rome, FAO, 217 p.
7. Kathleen,I. Matics and Ted,L. McDorman (eds) 1992.Proceedings:Select papers presented at SEAPOL International Workshop on Challenges to Fishery Policy and Diplomacy in South-east Asia, published by SEAPOL,Bangkok,175pp.
8. Pandey, D.K. and De H.K.2014.Fisheries Governance and Legislation in India. Narendra Publishing House, 200pp.
9. Shenoy, Latha and Biradar, R.S.2005.Marine Fishing Regulation Acts of Coastal States of India- A Compendium. CIFE, 73pp.
10. Shenoy,Latha and Lakra,W.S(eds.)2012.Proceedings of National Workshop on Code of Conduct for

Responsible Fisheries, Feb 1-2, 2012, Mumbai, India, CIFE, pp. 102.

11. Sinha, R.K. (Eds), 1996. Marine resources and applicable laws (world environmental series Commonwealth publishers. 317 p.
12. Somvanshi, V.S. (ed.) 2001. Technical papers presented at National Workshop on Fisheries Monitoring, Control and Surveillance. FAO/Norway Cooperative Program GCP/INT/648/NOR, FSI, 200pp.
13. Verghese C.P. 1989. Fishing regulation in India's territorial waters. World Fishing. 1989. 2:7.
14. World Bank Report, 2010. Indian Marine Fisheries: Issues, Opportunities and Transitions for sustainable development, August 2010, Agriculture and Rural Development Sector Unit, South Asia Region, Report No. 54259-IN, pp. 101.
15. Yadava, Y.S. (ed.) 2000. Report of the National Workshop on the Code of Conduct for Responsible Fisheries, 29-30 Sep, 2000, Chennai, India, BOBP Report No. 90, pp. 166. Shenoy, L and R. S. Biradar, 2005. Marine Fishing Regulation Acts of Coastal States of India. Compendium, CIFE publication, 73P

FRM: 505: BIO-SYSTEMATICS OF AQUATIC FAUNA

(1+2)

Objective: To train students in identification of major taxa in aquatic ecosystem.

Theory:

- Unit I Principles of taxonomy :** Systematics, Taxonomy and Classification; Importance of taxonomy, International Code of Zoological Nomenclature, and its amendments and rules of Binomial Nomenclature; Morphology, morphometric, meristic, osteology and soft anatomical characters, Different taxonomical and other terms used in Fish taxonomy; Describing and naming of a new species; Cataloguing
- Unit II Classification of Commercially important aquatic fauna:** Classification of modern fishes up to order and family levels - Elasmobranchii (Cartilaginous fishes) and Actinopterygii (bony fishes). Classification of commercially important invertebrate up to family level: Arthropoda (Prawns, Shrimps, Lobsters and Crabs); Mollusca (Gastropods, Bivalves, Cephalopods and Scaphopods); Echinodermata (Sea Cucumbers), Preparations of dichotomous key
- Unit III Modern tools of taxonomy:** Cytotaxonomy, Basics of biochemical taxonomy (Electrophoretic studies of muscle myogen, eye-lens protein, enzyme pattern and serology), PCR based methods and DNA finger printing, mitogene in fish identification

PRACTICALS:

- Unit I** Collections and preparation of field data; preservation techniques of specimens: Identification of commercially important aquatic fauna. ;Morphology, Graphical representation and statistical analysis of meristic, morphometric, osteological and soft anatomical characters; Key Pattern – dichotomous key – type of keys –dichotomous, bracket, indented, branching, pictorial, and computer keys; Protocols followed for describing of a new species
- Unit II Species level identification of major commercial fishes (diagnostic characters of the orders, families and species)**
Elasmobranchii– sharks, rays and skates
Teleostei: Cypriniformes: Cyprinidae; *Labeo*, *Cirrhinus*, *Tor*
Siluriformes: Plotosidae, Silluridae, Ariidae, Clariidae and Heteropneustidae
Beloniformes: Exocoetidae, Hemiramphidae and Belonidae
Clupeiformes: Clupeidae, Pristigasteridae, Engraulidae and Chirocentridae
Mugiliformes: Mugilidae
Aulopiformes: Synodontidae
Perciformes: Carangidae, Coryphaenidae, Gerreidae, Haemulidae, Latidae, Lethrinidae, Lutjanidae, Mullidae, Mugilidae, Nemipteridae, Polynemidae, Priacanthidae, Sciaenidae, Scombridae, Serranidae, Sillaginidae, Sphyraenidae, Stromateidae, Trichiuridae, Teraponidae, Leiognathidae, Channidae, Pomocanthidae ,

Pomocentridae,
Pleuronectiformes: Cynoglossidae, Solidae, Bothidae, Pluronectidae
Mollusca: Gastropoda, Pelecypoda and Cephalopoda
Crustacea: Prawns, Shrimps, Crabs and Lobsters
Echinodermata: Sea cucumber

Unit III Modern taxonomical tools

Cytotaxonomy: Karyotyping – preparation and identification of chromosomes.

Electrophoresis studies (muscle myogen, eye-lens protein, enzyme pattern and serology), Molecular markers–PCR, RAPD, RFLP, Microsatellites, mini satellites and Mitochondrial DNA and their application in fish phylogenetic studies; Barcoding

SUGGESTED READING:

1. Apte, D., (1998). **The book of Indian shells**. Oxford University Press. Calcutta, Chennai, Delhi, Mumbai. p 115.
2. Barman, R. P. and S. S. Mishra. 2012, **Nemipteridae, Polynemidae, Mullidae** (Separate compilation for each family).
3. Barman, R. P., S. S. Mishra, S. Kar, P. Mukherjee and S. C. Saren. 2012. **Marine and estuarine fishes of Maharashtra**. *Zool. Surv. India, Fauna of Maharashtra, state fauna series*, 20(part 1): 369-480, 2012.
4. Cooksey, K., 1997. **Molecular Approaches to the study of the oceans**. Chapman and Hall, London. ICZN: International code for Zoological Nomenclature Publ: International Commission 1999.
5. Day, F., 1878. **The fishes of India**. Published by William Dawson and sons Ltd.
6. FAO, 2000. **DNA based molecular diagnostic techniques**.
7. Fischer, W. and Biachi, G., 1984. **FAO-identification sheets for fishery purposes**. Vol I-VI pages variable.
8. Hamilton F., 1822. **Fishes of the River Ganges and its branches**. Publ. Edinberg
9. Holden, M. J. and Raitt, F. S., 1974. **Manual of Fisheries Science**, Part II - Methods of Resource, Investigation and their Application. FAO Fish Technical Paper 115 Review Page 1-224.
10. **International Commission for Zoological Nomenclature**. 2012.
11. Jayaram, K.C., 2010. **The freshwater fishes of the Indian Region** II edition. Narendra Publishing house New Delhi.
12. Jayaraman, K. C., 2002. **Fundamentals of fish taxonomy**. Publ.
13. Lagler, Karl F., John E. Bardach, Robert R. Miller and Dora R. May Passino, 1977. **Ichthyology** II edition. John Wiley & Sons.
14. Le Gal, Y. and Halvorson. H.O., 1998. **New development in Marine biotechnology**, Plenum.
15. **Marine species identification portal** for crustaceans (crabs and prawns etc).
16. Mayr, E., 1977. **Principles of systematic zoology**. Tata Mc Graw Hill Publishing Co. Ltd. New Delhi, p. 428.
17. Michael M. Cox and David L. Nelson. 2010. **Principles of Biochemistry**, Fifth Edition. W.H. Freeman and company, New York.
18. Moyle, P. B. and J. R., Cech., 1996. **Fishes – An Introduction to Ichthyology**. Prentice Hall Inc. N. Jersey, 594p.
19. Munro, I.S.R., 2000. **The marine and freshwater fishes of Ceylon**. Narendra Publishing house, New Delhi. 351 p.
20. Nelson J.S., 2006. **Fishes of the world**, IVth edition, John Wiley & sons.
21. Ponniah A.G. and George John, 1998. **Fish Chromosome Atlas**. National Bureau of Fish Genetic Resources (NBFGR), Lucknow publication.
22. Poutiers, J. E. 1998. **Bivalves; Gastropods**. In: K. E. Carpenter, V H. Niem (eds.), FAO species identification guide for fisheries purposes. The living marine Resources of the Western Central Pacific. Volume I. Seaweeds, corals, bivalves And gastropods. Pp.123-686.FAO, Rome, ISBN 92-5-104051-6.
23. Raje, S.G. S. Sivakami, G. Mohanraj, P.P. Manojkumar, A.Raju and K.K. Joshi. 2007. An atlas of the elasmobranch fishery resources of India. CMFRI special Publication no.95.
24. Subramaniam, T. V., K.R. Karandikar and N.N. Murthy . 1952. Marine Gastropods of Bombay Part II. *J. Bombay University*. Vol 21. 26-73.
25. Subramaniam T. V., K.R. Karandikar and N.N. Murthy . 1949. Marine Pelecypods of Bombay Part I. *J. Bombay University*. Vol 17. 50-81.
26. Subramaniam, T. V., K.R. Karandikar and N.N. Murthy . 1951. Marine Gastropods of Bombay Part I. *J. Bombay University*. Vol 3. 21-34.
27. Talwar P. K. and Jhingran A.G., 1991. Inland fishes of India and adjacent countries, Delhi Oxford & IBH Publishing Co.Pvt. Ltd. 1158 p. Vol. I & II

28. Talwar, P.K. and Kacker, R.K., 1984. *Commercial sea fishes of India*. Published by ZSI, Kolkata. 997 p.
29. Thomas D., Kocher and Carol A. Stepien (Ed.). 1997. ***Molecular systematics of Fishes***. Academic Press. New York .314p.
30. Whitmore, D.H., 1990. **Electrophoretic and Isoelectric focusing techniques in fisheries management**. 350pp.

FRM 506 AQUATIC ECOSYSTEMS, BIODIVERSITY AND CONSERVATION 1+1

Objective To acquaint the students with aquatic ecosystems, biodiversity and conservation

Theory

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|----------|---|
| Unit I | Inland Aquatic Ecosystem: lacustrine, riverine, reservoir, upland and flood plains, Overview: physico - chemical environment; productivity and ecological notions. |
| Unit II | overview of coastal wetlands and marine ecosystems: Brackish water lakes, lagoons, creeks, estuaries and coral reefs, backwater ecosystems, Seagrass ecosystem, deep sea ecosystem, physico- chemical environment; productivity and ecological notions. |
| Unit III | IUCN criteria - Red List, Wild life protection act, International treaties and conventions, Marine Protected Areas, Sanctuaries and Biosphere reserves. Establishment of National marine parks, in situ and ex situ conservation, Conservation value index – criteria – medicinal value and biological, IBI |
| Unit IV | Impacts of anthropogenic intervention on aquatic biodiversity: Damming of rivers, construction of shore protection walls, micro hydel power stations, oil rigs. |
| Unit V | Aquatic biodiversity: threats, planning and management, tools for conservation, participatory approach |
| Unit VI | Impact of climate change on the ecosystem biodiversity, health and productivity Concept of hotspots, Indian efforts on conservation of biodiversity |

Practical Identification of scheduled aquatic organisms - Predators of endangered animals. Observation of stranded aquatic mammals, corals, seafans and other endangered aquatic Organisms, Visit to various aquatic ecosystem for recording the biodiversity and richness indices, Conservation strategies (case studies). Biodiversity indices

Suggested Readings:

1. Gross, G., 1993. *Oceanography: A View of the Earth*. Sixth Edition Prentice – Hall Inc., New Jersey.
2. Castro, P. and M.E. Huber, 1997. *Marine Biology* Second Edition. Mc-Graw Hill Company.
3. Nybakken, J.W., 1997. *Marine Biology – An Ecological Approach*. Fourth Edition. Addison Wesley Edu. Pub. Inc.
4. Sverdrup, H.V., M.W. Johnson and R.H. Fleming, 1959. *The Oceans. Their Physics, Chemistry and General Biology*. Prentice – Hall Inc., New Jersey.
5. McCormick, J.M. and J.V. Thiruvathaakal, 1976. *Elements of Oceanography*. Saunders Company, Philadelphia.
6. Balakrishnan Nair, N. and D.M. Thamby, 1980. *A Text Book of Marine Ecology*. The Macmillan Co. India Ltd., New Delhi.
7. Odum H. T. 1983 *Ecosystem Ecology*

8. Odum H. T. And Odum E. P. 1953, *Fundamentals of Ecology*, with Eugene P. Odum, (first edition).
9. Duxbury, A.C., A.B. Duxbury and K.A. Sverdrup, 2000. An Introduction to the World's Oceans. 6th Edition. McGraw Hill Companies Inc.
10. Raymont, J.E.G., 1973. Plankton and Productivity in the Oceans. Pergamon Press, London.
11. Iversen, E.S., 1996. Living Marine Resources. Chapman and Hall, New York

FRM 507	ADVANCES IN FISH CAPTURE TECHNOLOGY	2+1
Objective	To impart knowledge on responsible fishing practices for sustainable fishery	
Theory		
Unit I	Design of fishing gears Factors affecting fishing gear design, types, general structure of gear, characteristics of fishing vessel and accessories of trawl (bottom and mid water), purse seine, gill net, bag nets, lines and traps.	
Unit II	Destructive and prohibited fishing practices	
Unit III	Fishing and Environment Equipments GPS - Components of GPS, working, functions, important applications of GPS in fisheries. Echo Sounder, SONAR, Net sonde Radio devices, GMDSS BRDs - Definition of bycatch, types of bycatch reduction devices and the principles of operation. Types of TEDs: soft and hard types, materials used for their construction and maintenance.	
Unit IV	Safety at sea Safety devices, Types of accidents at sea, Mitigation measures, Search and Rescue (SAR).	
Unit V	Applications of Remote Sensing(RS) and GIS to fisheries: identification of Potential Fishing Zones (PFZ), Participatory GIS in fishing systems, Theme Maps, applications of RS and GIS in fisheries.	
Unit VI	Fishing harbours: Classification, facilities, layout of a typical fishing harbour, stages in the planning of fishing harbours.	
Unit VII	Responsible fishing operations Contents of Article 8 of CCRF (fishing operations), Selective fishing gear and practices, environment-friendly fishing gears, enhancement of resources (FADs / ARs).	
Practical	Drawing and reading gear designs – Calculation of trawl net size based on engine power-Field visits to fishing harbour and preparation of drawing of its lay out - Training onboard fishing vessels in fishing techniques, familiarization with navigation and communication equipments - Study of layout and operation of a fish landing centre; Study of fish aggregating devices - Familiarization with various safety devices-Demonstration of fishing material testing equipments.	
Suggested Readings	1. Bjordal A & Lokkeborg S, 1996. Longlining, Fishing News Books Ltd. London, 156p. 2. FAO, 1972. Catalogue of fishing gear designs. Fishing News Books, Ltd, London. 3. FAO, 1995. Code of Conduct for Responsible Fisheries, 41p. 4. ICAR Winter School Manual 2002. Advances in Harvest Technology, CIFT, 468p. 5. Janardhanan Sundaresan, K.M. Santosh, Andrea Deri, Rob Roggema and Ramesh Singh, eds. 2013. Geospatial Technologies and Climate Change. 299p.	

6. J.Prado, 1990. Fisherman's Workbook, FAO, Fishing News Books, 180p.
7. Josey Jacob and Latha Shenoy, 2012.Fisheries Engineering, Vol 1.On-board Machinery, CIFE, 148p.
8. Josey Jacob and Latha Shenoy, 2014 .Fisheries Engineering, Vol 2.Fishing Vessels, CIFE, 202p.
9. Larry Nielsen & David Johnson(eds),1983.Fisheries Techniques, American Fisheries Society,Maryland,468p.
10. Latha Shenoy, Y.Sreekrishna &S.Kamat, 2001. Practical Course Manual in Fishing Craft and gear Technology, CIFE, 110p.
11. Latha Shenoy & B.B.Nayak(eds)2013.Responsible Harvest & Quality standards for seafood export, CAFT Training Manual, CIFE, 113p.
12. Meenakumari B.,Boopendranath,M.R.,Pravin,P.,Thomas,S.N. Edwin,L.(eds)2009.Handbook of Fishing Technology,380p.
13. Meaden,G.J.& Aguilar-Manjarrez,J,eds.2013.Advances in geographic information systems and remote sensing for fisheries and aquaculture.FAO Fisheries and Aquaculture Technical Paper No.552,FAO,Rome.
14. Nambudiri D.D.&K.V.Peter(eds)2012.Advances in Harvest & Post harvest technology of fish,372p.
15. Sainsbury John, 1996. Commercial Fishing Methods-an introduction to vessels & gear, Fishing News books, Ltd, London.
16. Selvamani,B.R.&R.K.Mahadevan,2008.Fish Harvesting & Processing,279p.
17. Shahul Hameed,M.A. and Bhoopendranath,M.R 2000. Modern fishing gear Technology, 186p.
18. Sreekrishna,Y. and Latha Shenoy, 2001.Fishing Gear and Craft Technology, ICAR, 342 p.
19. Wileman,D.A.,1996.Manual of methods of measuring the selectivity of towed fishing gears.No.215,International Council for the exploration of the sea.126p.

FRM 508

COASTAL ZONE MANAGEMENT

2+1

Objective

The course would provide an insight into the various coastal resources, multi user issues and anthropogenic effects on the resources. The students will be enabled to devise coastal resource management plans

Theory

- Unit I Coastal zone, type, waves tides and currents
Coastal Resources: Non renewable resources - minerals, sand mining; Renewable resources – Tidal energy, salt, exploitable and potential biological resources (finfish and shellfish, seaweeds, mangroves, sea grasses)
- Unit II Exploitation of coral reef resources and their impact; potential and present production of living resources and their sustainability and conservation
- Unit III Mangrove Ecosystems: Importance, their role as coastal buffer zone and as breeding habitats for shellfish and finfish; conservation and management
- Unit IV Coastal zone fisheries: Small-scale fisheries (pelagics, demersal and shrimps) by traditional/ marginal fishing communities
- Unit V Coastal tourism: Beach resorts, restaurants and parks within the coastal zone. Impact of pollution on coastal resources
- Unit VI ICZM: Definition, case studies CRZ, Plans drawn for coastal zone – agencies, state government plans
Importance of EIA studies; Methodologies used; importance of fragile ecosystems and their rehabilitation programmes; CETP
Soft and hard wall, gyrons shore protection wall MARPOL reclamation

Practical	Study of floral, faunal diversity of mangroves and coral reefs, field visits and case studies.
Unit I	Type of coasts, Ecosystems; Field visits of atleast 3 ecosystems viz. Mangrove, sandy and rocky intertidal areas; documentation of biodiversity and assess the importance
Unit II	Observe the developments along the coastline and submit an ideal beach resort document based on the observations and internet information
Unit III	Study the shoreline changes and CZMP maps of different locations

Suggested Readings	<ol style="list-style-type: none"> 1. Borgese, E.M. and N. Ginsburg, 1979 – 1986. Ocean Year Book 1 – 6. The University of Chicago Press, Chicago. 2. Clark, John R 1996 Coastal Zone Management. Handbook by Boca Raton Lewis Publishers . 694p. 3. Brahtz, J.F.P., 1972. Coastal Zone Management. U.N. Interntional Economic and Social Affairs, New York. 4. Coastal Area Management and Development, 1982. U.N. Department of International Economic and Social Affairs. 5. Rajagopalan, R., 1996. Voices for the Oceans – A report to the Independent World Commission on the Oceans. International Ocean Institute, Operation Center, Madras, India. 6. David Symes and Jeremy phillipjan 2001. Inshore fisheries management. Reviews methods and Technologies in Fish biology and fisheries (vol.2). Kluwer Academic publishers, London. 7. ICZM notification Swaminathan's report 8. Ministry of Environment and Forests, Gazette CRZ 1991 and 2011 Notification 9. Jingran A. G. (1990)An Approach to Coastal Zone Management and Planning in West Bengal CICFRI Barrackpore Publication 10. Integrated Coastal Zone Management 2009 Publication:Chichester, U.K. ; Ames, Iowa : Wiley-Blackwell, 2009 . xvii, 342 p., 11. CRZ regulations of India, 2011
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FRM 509 **AQUATIC FLORA AND ITS MANAGEMENT** **1+1**

Objective The course will give an in-depth knowledge on the categorization, utilization, conservation and the management of aquatic floral resources.

Theory

Unit I	Freshwater and marine flora Taxonomy - their importance in resource management. Seagrass resources: Taxonomy, biodiversity, life history, ecological and economical importance and conservation techniques
Unit II	Mangrove - distribution, taxonomy, phenology; ecological importance and conservation practices
Unit III	Marine macro-algal resources: Taxonomy, biodiversity, life history, ecological and economical importance and conservation techniques
Unit IV	Commercially important products from aquatic flora.- Agar-algin-phytocolloids- food grade algal resources - other uses like pigment extraction pollution treatment, fodder, fertilizer production, nitrogen fixation
Unit V	Culture and modern cultivation practices for phytoplankton, seaweed, mangrove and <i>Azolla</i> (Strain isolation, tissue culture and protoplast isolation, cryopreservation)

Practical Collection, identification of freshwater, brackishwater and marine phytoplankton and seaweeds. Collection and preparation of herbaria and higher aquatic plant including freshwater angiosperms, mangrove, and seagrass, culture of important phytoplankton, *Azolla*

Suggested 1. Chapman, V.J. and D.J. Chapmen, 1980. Seaweeds and Their Uses. Chapman & Hall, London.

- Readings**
2. Chapman, V.J., 1976. Mangrove Vegetation. J. Grammer, Berling.
 3. Iversen, E.S., 1996. Living Marine Resources Chapman & Hall, New York.
 4. Sundaralingam, V.S. 1990. Marine Algae (Morphology Reproduction and Biology). Bisen Singh Mahendra Pal Singh, Dehra Dun : 258 p.
 5. Chaudhuri, A. B, 2007. Biodiversity of Mangroves
 6. Amos Richmond, Ed. 2004. Handbook of Microalgal Culture, Blackwell Publishing
 7. Petr, T. 2000. Interactions between fish and aquatic macrophytes in inland waters. A review. FAO Fisheries Technical Paper. No. 396. Rome, FAO. 185p.
 8. Kathiresan K. 2005 Biodiversity of Mangrove Ecosystem Hindustan Publishing Corporation, New Delhi, 251 p.

FRM 510 TROPHODYNAMICS IN AQUATIC SYSTEMS (1+1)

Objective The students will be apprised of application of biological inferences from trophodynamics for management of fisheries resources

Theory

- Unit I Food and feeding habits of different types of fin and shell fishes
- Unit II Morphological and anatomical adaptation for feeding; feeding behaviour
- Unit III Energy flow and trophic indices and modeling;
- Unit IV Application of information on trophodynamics in fisheries management

Practical Morphological and anatomical adaptations in fin fishes and shellfishes with different feeding habits. Analysis of gut contents. Use of indices in feeding, digestion and food consumption rates of fishes. Case studies using available data sets

- Suggested Readings**
1. Adiyodi K.G , Reproductive Biology of Invertebrates: Vol-X P.B Prog in Developmental Endocrinology, Narendra Publishing House Publishers & Distributors
 2. Adiyodi K.G. Reproductive Biology of Invertebrates: Vol-X P-A Prog in Dev. Endocrinology Narendra Publishing House Publishers & Distributors.
 3. Agarwal, N.K. 1996. Fish reproduction APH publishing corporation, New Delhi. 155p.
 4. Barrington, E.J.W.1981. Invertebrate structure and Function (2nd Edition). The English Language Book society and Nelson, Great Britain. 765p.
 5. Bone, Q. N.B.Marshall and J.H.S.Blaxter, 1995. Biology of Fishes (2nd edition) Black ie Academic and professional, New york. 332 p.
 6. Carl E. Bond. 1979. Biology of Fishes (2nd edition). Saunders college publishing Harcourt Brace college publishers, New york. 750 p.
 7. Hoar, W.S. and D.J Randall (Ed.) 1969. Fish physiology vol.III Academic press, New york. 415p.
 8. Khanna, S.S.1993. An introduction to fishes. Central Book of Depo, Allahabad, 530 p.
 9. Malcolm Jobling 1995. Environmental Biology of Fishes, Chapman and Hall London. 455 p.
 10. Maria J. Rocha, Augustine Arukwe and B.G. Kapoor, 2006. Fish Reproduction Pb.Science Publishers, Enfield, NH
 11. Saxena, A.B.1996. Life of crustaceans. Recent advance in entomology series –10.Onmol publications pvt. Ltd. New Delhi. 380 p.
 12. Venkataramanujam, K. and N. Ramanathan 1994. Manual of Finfish Biology. Oxford and IBH publishing Co. pvt. Ltd 1108.

FRM 511 REPRODUCTIVE BIOLOGY OF FINFISH (1+1)

Objective: Application of inferences from reproductive biology for management of fisheries resources

Unit I Mode of reproduction: asexual, hermaphrodism, protoandric, protogynic, sexual

Unit II Reproductive cycles- Semelparity and iteroparity-maturation and spawning periodicity and maturity stages

Unit III Fish eggs and larvae

Unit IV Factors influencing reproduction-Biotic & abiotic

Unit V Spawning aggregation and migration

Unit VI Reproductive potential and recruitment strength

Unit VII Application of information on reproductive biology in fisheries management

Practical: Identification of maturity stages, spawning season, spawning periodicity and estimation of gonad somatic index. Fecundity, ova diameter; Fish eggs and larvae

Suggested Reading

1. Karl F. Lagler, John E. Bardach, Robert R. Miller, Dora R. May Passino. 1977. *Ichthyology*, 2nd Edition, 528p.
2. Clark, Frances Naomi, 1934. Maturity of the California sardine (*Sardina caerulea*): determined by ova diameter measurements, *California Fish and Game*. 42:1-49.
3. Prabhu, M S (1956) Maturation of intra-ovarian eggs and spawning periodicities in some fishes. *Indian J. Fish.*, 3 (1): 59-90.
4. Qasim, S Z (1973) An appraisal of the studies on maturation and spawning In marine teleosts *from the Indian waters. Indian Journal of Fisheries*, 20 (1). pp. 166-181.
5. C. F. Hickling and E. Rutenberg. 1936. The Ovary as an Indicator of the Spawning Period in fishes, *Marine Biological Association of the United Kingdom*, 21(1): 311-317.
6. Wood H. 1930. Scottish herring shoals. Pre spawning and spawning movements. *Scottish Fish. Bd. Sci. Invest.* 1:1-71
7. Khanna S S and H R Singh. 2003. *A Text Book of Fish Biology and Fisheries*, Narendra Pub., 524 p,
8. Biswas S. P. 1993. *Manual of methods in fish biology*, South Asian Publishers.
9. Biswas S. P. 2002. *Fundamentals of ichthyology*. Narendra Pub. House.

FRM 512 REMOTE SENSING AND GIS FOR FISHERIES MANAGEMENT 1+1

Objective The students will be familiarized with remotely sensed information and its application in fisheries resource management.

Theory

Unit I Basic terms and concepts; Electromagnetic radiation and its properties, atmospheric interactions, target interactions; Digital image processing and interpretation

Unit II Sensor platforms – boats, balloons, air-crafts and satellites, Sensor systems – global acquisition systems and sequential acquisition systems, Environmental satellites – The Landsat series, NOAA, IRS and Oceansat;

Unit III Elements of GIS and RS application for planning and development.

Unit III Applications of remote sensing in marine environmental studies, identification of PFZ, CRZ, cyclone and tsunami warning systems.

Practical Study of satellite information, interpretation of satellite imageries for resource management, case studies on remote sensing and GIS applications. Digitization

Suggested Readings

1. Meaden G.J., and J. M. Kaptesky 1991. Geographical information systems and remote sensing in inland fisheries and aquaculture. FAO Fisheries Technical paper. No.318. FAO, Rome. 262 p.
2. Patel, A.N. and Surendra Singh. 1992. Remote sensing – Principles and Applications. Scientific publishers, Jodhpur. 161 p
3. Palacz A. P., M. A. St. John, R. J. W. Brewin, T. Hiria and W. W. Greg 2013 Distribution of phytoplankton functional types in high-nitrate low-chlorophyll waters in a new diagnostic ecological indicator model *Biogeosciences* (5):8103-8157. DOI: 10.5194/bgd-10-8103-2013
4. Agarwadkar Y. Y. Y.*, Azmi S., Apte M., Inamdar A. B 2012 Framework for Analysing Coastal Vulnerability Due to Sea Level Rise and Coastal Floods using R. International Conference in Recent Trends in Information Technology and Computer Science (ICRTITCS - 2012)

Objective: To acquaint the student on the causes, consequences and solutions to climate change with reference to aquatic ecosystems and fisheries

- Unit 1 Introduction to climate science: Climate & biosphere, climatic forcing factors, history of earth's climate
- Unit 2 Causes of climate change; Anthropogenic activities, greenhouse gases
- Unit 3 Consequences of climate change: Physical, chemical and biological properties, biodiversity, fisheries, livelihood
- Unit 4 Adaptation options: Climate change vulnerability and risk assessments, improved governance, enhancing resilience of communities, disaster management, institutional mechanisms
- Unit 5 Mitigation: Emission reduction, Life cycle assessment, , carbon sequestration, carbon economy, improved governance

Practical:

Introduction to the models used for climate change
SST measurements and adaptation

Suggested Reading

1. Allison, E. H., Perry, A. L., Badjeck, M. C., Neil Adger, W., Brown, K., Conway, D. and Dulvy, N. K. 2009. Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and fisheries*, 10(2): 173-196.
2. Badjeck, M. C., Allison, E. H., Halls, A. S. and Dulvy, N. K. 2010. Impacts of climate variability and change on fishery-based livelihoods. *Marine Policy*, 34(3): 375-383.
3. Brander, K. M. 2007. Global fish production and climate change. *Proceedings of the National Academy of Sciences*, 104 (50): 19709-19714.
4. Daw, T., Adger, W. N., Brown, K. and Badjeck, M. C. 2009. Climate change and capture fisheries: potential impacts, adaptation and mitigation. *Climate change implications for fisheries and aquaculture*, 107 pp.
5. Ficke, A. D., Myrick, C. A. and Hansen, L. J. 2007. Potential impacts of global climate change on freshwater fisheries. *Reviews in Fish Biology and Fisheries*, 17(4): 581-613.
6. Glantz, M. H. (Ed.). 2005. *Climate variability, climate change and fisheries*. Cambridge university press.
7. Glantz, M. H. 2001. *Currents of change: impacts of El Niño and La Niña on climate and society*. Cambridge University Press.
8. Kizhakudan, J. K., Mohamad Kasim, H. and Jasper, B. 2008. Experimental methods to assess the impact of climate change on plankton-Winter School on Impact of Climate Change on Indian Marine Fisheries held at CMFRI, Cochin 18.1. 2008 to 7.2. 2008.
9. Mohamed, K. S. 2008. Evidences for Climate Change-Winter School on Impact of Climate Change on Indian Marine Fisheries held at CMFRI, Cochin 18.1. 2008 to 7.2. 2008.
10. Parry, M. L. (Ed.). 2007. *Climate Change 2007: impacts, adaptation and vulnerability: contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on Climate Change* (Vol. 4). Cambridge University Press.
11. Pörtner, H. O. and Peck, M. A. 2010. Climate change effects on fishes and fisheries: towards a cause-and-effect understanding. *Journal of Fish Biology*, 77 (8): 1745-1779.
12. Roessig, J. M., Woodley, C. M., Cech Jr, J. J. and Hansen, L. J. 2004. Effects of global climate change on marine and estuarine fishes and fisheries. *Reviews in Fish Biology and Fisheries*, 14(2): 251-275.
13. Salagrama, V. 2012. *Climate change and fisheries: perspectives from small-scale fishing communities in India on measures to protect life and livelihood*. International Collective in Support of Fishworkers.

14. Sharp, G. D. 2005. Climate change, the Indian Ocean tuna fishery, and empiricism. *Climate Variability, climate change and Fisheries*, 377 pp.
15. Vass, K. K., Das, M. K., Srivastava, P. K. and Dey, S. 2009. Assessing the impact of climate change on inland fisheries in River Ganga and its plains in India. *Aquatic Ecosystem Health & Management*, 12(2): 138-151.
16. Vivekanandan, E. 2006. Impact of climate change on marine fisheries. *CMFRI Newsletter No. 112 October-December 2006*, 112: 1-4.
17. Vivekanandan, E. 2011. Marine Fisheries Policy Brief-3; Climate change and Indian Marine Fisheries. *CMFRI Special Publication*, 105: 1-97.
18. Vivekanandan, E., Hermes, R. and O'Brien, C. 2012. Climate change effects in the Bay of Bengal Large Marine Ecosystem. *Frontline Observations*, 97 pp.
19. Vivekanandan, E., Rajagopalan, M. and Pillai, N. G. K. 2009. Recent trends in sea surface temperature and its impact on oil sardine.
20. Westmacott, S., Cesar, H. S., Pet-Soede, L. and Lindén, O. 2000. Coral bleaching in the Indian Ocean: Socio-economic assessment of effects. *Essays on the Economics of Coral Reefs. HSJ Cesar (ed.)*, 94-106.