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Table of Contents

Abstracts

Fish-habitat relationships in Amazon floodplain lakes: a remote sensing approach to the pirarucu (*Arapaima gigas*) fishery

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The Amazon floodplain is a complex mosaic of forests, lakes and channels, seasonally inundated by sediment-rich whitewater of Amazonian rivers. When the water level raises, the floodplain becomes inundated and many fish species migrate and spawn. However, during receding water, fishes migrate back into main river channels and lakes in search for survival during the dry season. The giant and obligate air-breathing fish, pirarucu, is a key element of rural inhabitants of Amazonian rivers margins culture and economy, and it landings have decreased significantly in the last decades and it is now considered overexploited. Understanding the temporal and spatial variations of pirarucu abundance in lakes is important for science, conservation and also for local economy. This paper investigates the relationship between pirarucu abundance and the average difference between the dry season open-water surface (DSOW) and flooding season open water surface (FSOW) in Mamirau Sustainable Development Reserve. TM Landsat images acquired during dry season (low water level) were used to compute DSOW for 30 lakes from 2002 to 2008. FSOW was computed for a cloud free TM Lansat scene available for the highest water level in 11 years (1997). The difference between FSOW and DSOW (DFDOW) was regressed against pirarucu abundance (pA) data for each lake. The results indicated a linear relationship between pA and DFDOW. The model (pA = 1458.9 DFDOW – 4843.4) with $r^2 = 0.84$ at a confidence level of 95% indicates that the larger is the amplitude between the low and high water, the greater is pirarucu abundance. These results suggest that climate changes which might affect yearly amplitude of dry and flooding seasons may pose a threat to pirarucu.

Earth geo-observation: climate change and sea surface temperature

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Climate change is an unprecedented challenge that the world is facing. Regional Climate Models are useful tools for generating high-resolution climate change scenarios for use in climate impacts and adaptation studies. This study aims to describe the regional climate modeling of sea surface temperature in the Bay of Bengal. The results obtained from satellite imageries like MODIS are compared with *in situ* sea surface temperature found from buoy measurements. Thus, the differences in values between these two data sources spring up from the systematic errors between the skin temperature measured from satellite sensors and bulk temperature measured from *in situ* measurements. The comparison of the results with the rainfall data proved that, as the sea is getting warmer, the monsoon is being affected and thus, the amount of rainfall decreases. Further, a regional climate model for sea surface temperature (Bay of Bengal) has been developed and validated. This regional climate model is based on various parameters that aggravate the sea surface temperature. This also discusses the impact of aerosols in the warming of sea surface. Thus, it goes a long way in explaining the relationship between climate change and sea surface warming.

Interaction of the Kuroshio with the northern biocol shelf: implications on biological productivity

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MODIS chlorophyll and sea surface temperature were used to examine the current-shelf interaction in the northern Bicol shelf influenced by strong western boundary flow. The formation of cyclonic gyres off the northern Bicol shelf was observed as the flow encounters a shelf promontory. The peak in the monthly mean chlorophyll *a* distribution within the shelf was observed during winter when strong wind and wave action induces mixing of the water column. Results of empirical orthogonal function (EOF) analysis of chlorophyll *a* data showed that the first two modes explained the highest percentage of the total variance. The first mode (74%) represents the strong chlorophyll *a* gradient between the shelf and offshore areas. The second mode (5%) highlights an area of high chlorophyll *a* concentration northwest of the shelf during the summer months. The elevation of chlorophyll *a* concentration in the offshore region is likely due to eddy activity. EOF analysis of SST compresses the major variances in 3 statistical modes. The second mode (12%) highlights the variability due to eddy activity west of Baler and Aurora. The region is characterized by warmer temperature as the eddy entrains a southward flowing jet off the coast of Baler-Aurora area.

Medium resolution remote sensing in the coastal zone: a frame for small-scale fisheries assessment in Patagonia (Argentina)

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Management of small-scale fisheries targeting sedentary stocks requires integration of information about processes operating, and observable, at different spatial scales. Biological data on commercial stocks are often gathered systematically, but they are myopic: informative only about local phenomena. Information about oceanographic processes that shape meso-scale components of the population dynamics is usually unavailable or fragmentary in coastal environments. Remote sensing can provide the missing macroscopic frame. We developed an integrative strategy, with a scallop fishery from a small semi-enclosed basin in Patagonia as a demonstrational case. A multi-sensor approach was used to identify circulation patterns, which, combined with information from fishery surveys and recruitment experiments, allowed us to link oceanography and population dynamics. We identified a frontal system that splits the gulf into two oceanographic domains (east and west) with distinct hydrographic regimes. At the west domain, where circulation is highly advective and governed by turbulent fluxes, post-larval settlement on artificial collectors was insignificant and no important scallops grounds were found. At the east domain, where the main fishing grounds occur, post-larval settlement was variable between sites and years, but always important. Within this domain, growth rates showed a strong decline, decreasing clockwise from the gulfs mouth, reflecting inferred circulation and nutrient-extinction. These patterns would be uninterpretable in the absence of our integrative approach.

Impact of potential fishing zone advisories in drift gillnet fishing along the Kerala coast: a comparative study on the technical efficiency of two different drift gillnet fishing sectors off Kerala

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Since the success of drift gillnet fishing is related to the occurrence/abundance and migration of shoaling pelagic fish in space and time, attempts have been made to validate PFZ advisories among artisanal, motorized and small mechanized sector fishermen along Kerala coast. This is in order to compare the advantages derived for gillnet fishing operations/targeted species during the past few years on a project mode funded by the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad (Ministry of Earth Sciences, Government of India).

The average fish catch in drift gillnetters operated within and outside PFZ along Kerala coast during 2006-2009 were compared with earlier results. 'Sector A' showed little difference between the catches outside PFZ and earlier results. A proportionate increase in the average catch within the potential fishing zones of 'Sector A' and 'Sector B' was evident from the results. Comparatively higher returns per trip were also reported in the case of large sized drift gill netters (mechanized wooden fishing vessels of 9.1-13.6 m OAL, 60-90 HP IBM) engaged in a single-day fishing activity within the PFZ of 'Sector B'. Substantial increase observed in the average fish catch within the potential fishing zone of 'Sector A' and 'Sector B' proved that drift gillnet is one of the best-suited fishing gears for fishing in notified areas along Kerala coast.

In situ estimation of the underwater light field during the northeast monsoon in the Bay of Bengal

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The west India coastal current and its merger with eastward flowing southwest monsoon current near south of Sri Lanka had significant influence on the monsoon rain in the west coast of India. The present study was aimed at determining the bio-optical characteristics of oceanic waters during northeast monsoon in Bay of Bengal using hyper-spectral radiometry. The upwelling irradiance was found to decrease from surface to deeper waters and the light intensity was halved every 10 m in depth. Upwelling irradiance maxima exhibited at 490 nm and the intensity was highest in surface waters. The upwelling irradiance was significant at 0-50 m and in deeper waters the absorption was confined to 490 nm and a sharp peak was observed. Downwelling irradiance (Ed) was significantly higher in surface waters during noon and morning hours. The Ed absorption peaks were recorded at wavelengths 374, 412, 470, 490 and 520 nm. The Ed values reduced to half every 10 m in depth as in the case of Lu. Photosynthetically active radiation (PAR) was higher at 13:45 h and was up to 0-40 m depth. CDOM concentration increased from surface to deeper waters and maximum concentration was recorded at 9:40 h in samples at depths studied, except 40-50 m depth. Lowest concentration was recorded during 11:45 h in all the depths except 20-40 m depth. At 20-30 m depth lowest CDOM concentration was exhibited during 13:45 h. This further highlights the characteristics of the euphotic zone where chlorophyll concentration was highest. The CDOM increased beyond 50 m during evening hours, which was due to the downward movement of plankton and other organic material. Increased concentrations of chlorophyll *a* were exhibited at 20-50 m depths and chlorophyll maxima were found to change with time.

Monitoring the southwest Indian Ocean marine and fish resources: the AMESD program

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The need for timely access to accurate and reliable satellite-based information was stressed as one of the top priorities at the World Summit on Sustainable Development held in Johannesburg in August 2002. As a response to this urgency, the Africa Union and European Union launched the "African Monitoring of the Environment for a Sustainable Development" (AMESD) programme. This continental-wide project is financed by the European Development Fund to the tune of 21 Million Euros and is destined to the Regional Economic Communities in Africa. The project is implemented by the African Union and is supported by a Project Management with Technical Assistance team.

The main objectives of the project, which will last for four years, are to: 1. improve access by African users to existing basic Earth Observation data; 2. develop regional information services so as to improve decision making process by African institutions; 3. strengthen political and policy development frameworks and 4. develop human resources through the organisation of trainings, staff exchange, fellowship programmes, etc.

The Mauritius Oceanography Institute (MOI) has been mandated with the implementation of the southwest Indian Ocean (SWIO) component of this project. The latter has as overall objectives to set up in the Indian Ocean Commission countries (i.e. Mauritius, Seychelles, Comoros, Madagascar and Reunion) and riparian countries of the Mozambique canal (i.e Kenya, Tanzania, Mozambique) with operational services using satellite Earth Observation data for the monitoring of their marine and fish resources.

Two kinds of operational services will be developed: 1. help for the management and control of fishing activities and fishing resources (mainly Tuna) and 2. provide regional data sets in physical oceanography and marine climatology.

Several EUMETSAT satellite receiving stations will be installed in the SWIO region so

as to put into operation the services. All these regional project activities will be undertaken by the Mauritius Oceanography Institute (MOI) in collaboration with several regional partners: Fisheries Monitoring Centres, oceanography and fisheries research institutes, meteorological services and ministries of fisheries.

Utilizing multi-temporal eo-1 ali, aster data and gis for assessment of environmental changes on the Cuddalore Coast, Tamilnadu

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The detection of changes in the natural environment is of special interest since increasing global environmental problems are affecting and threatening our basic living conditions. Coastal ecosystems are transitional environments that are sensitively balanced between open water and upland landscapes. Remote sensing is one of the most efficient methods for environmental monitoring in coastal areas. To analyze environmental change, change-detection technologies that use multi-resolution and hyperspectral satellite images simultaneously must be developed and linked to each other. The purpose of this study is to understand the nature and state of geomorphic environment changes occurred in Pichavaram mangrove coast in Cuddalore district, Tamilnadu. Multi-temporal EO-1 ALI and ASTER data were utilized in a geographic information system (GIS) to evaluate the environmental and land-use changes. This study demonstrates the applicability of Hyperspectral data to detect changes in the coastal environment. The results of this study clearly shows the environmental degradation, and it suggests the possibility that future natural disasters could trigger unexpected damages to inhabitants and the environment in this area.

Temporal variability of primary production in the Benguela and Agulhas ecosystems

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Anchovy and sardine are important components of the Benguela and Agulhas food webs as they are significant predators of plankton and important prey for fish, birds and marine mammals. Pelagic fish spawn over the Agulhas Bank south of Africa and are transported into the Southern Benguela to the west and to the Natal Bight to the east. Since phytoplankton is the base of the marine food web, a study was undertaken using satellite ocean colour data to investigate the temporal variability in the mean, maximum and minimumprimary production in four areas of interest; the Southern Benguela, the Western and Eastern Agulhas Bank, and the Natal Bight.

Mean summer production in the Southern Benguela was 2 gC m^{-2} d^{-1} for 1998-2006, while on the Natal Bight the production was 1 gC m^{-2} d^{-1}. On the Western Agulhas Bank, mean summer production was 1.7 gC m^{-2} d^{-1} for 1998-2002 and then decreased to 1.3 gC m^{-2} d^{-1} during 2003-2006. Similar production rates and decreases were observed on the Eastern Agulhas Bank but for the periods 1998-2003 and 2004-2006. Maximum production, indicative of blooms, reached 10 gC m^{-2} d^{-1} in the Southern Benguela during 1998-2001, but then declined to 8 (2002-3), 7 (2004-5) and 6 gC m^{-2} d^{-1} by 2006. In contrast, Natal Bight maxima were 1.6-2.8 gC m^{-2} d^{-1}. Decreases in maximum production were also noted on the Western and Eastern Agulhas Bank during 2003-2006 and 2004-2006 respectively. Peaks in maximum production usually occurred in mid-summer during November-January in all areas, but secondary peaks were also noted in some years during March-April on the Western and Eastern Agulhas Bank, except for 2003 when a secondary peak was observed in early winter during June.

Use of remote sensing to detect harmful algal blooms off southern Africa

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Ocean colour radiometry offers considerable potential for the observation of harmful algal blooms (HABs) – HAB-related observations are often seen as high impact motivating factors for ocean colour and/or bio-optical components of coastal observing systems. However, effective HAB detection, monitoring and analysis requires an appreciation of the sizable uncertainties associated with ocean colour applications in the optically complex coastal zone. There is also a need for observation systems to be cognisant of the ecological role of the wide variety of potentially harmful algal blooms across global coastal ecosystems; and information regarding the suitability of available ocean colour techniques for HAB application to different ecosystems. A short "consumer's guide" to ocean colour-based harmful algal bloom methods is presented, summarising various HAB ecosystem types, and the state of knowledge with regard to potentially suitable ocean colour techniques.

A broad variety of HABs are classified by their harmful impacts, and HAB-prone ecosystems are briefly discussed based on GEOHAB Core Research Structures. These include upwelling, eutrophic, stratified and embayment systems, typical controlling/forcing mechanisms, and HABs as ecologically significant phenomena within these systems. HAB classification and succession schemes are also explored. Methodological challenges for ocean colour application in coastal and inland waters, and current and emerging HAB related ocean colour techniques are briefly summarised and demonstrated. These include a variety of empirical algorithms, anomaly detection techniques, spectral discrimination techniques, and semi-analytical inversion algorithms.

Bio-optical properties of a phytoplankton bloom in the coastal waters off Cochin during the onset of the southwest monsoon

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A phytoplankton bloom dominated by *Chaetoceros spp.* was detected in the Arabian Sea, off the Cochin coast during May 2009, coinciding the onset of southwest monsoon with an average chlorophyll *a* concentration of 8.42 mg m^{-3} at four stations (A, C, D and E) of a total of 7 stations studied in coastal waters situated between the latitudes 9°54' and 10°02' N and longitudes 76°05' and 76°12' E. All the stations were resampled after seven days and found that the average chlorophyll *a* concentration at the bloom stations has decreased to 2.91 mg m^{-3}. The inherent optical properties (chlorophyll *a*, specific phytoplankton absorption coefficient, chlorophyll scattering coefficient) of water were analyzed in the study area. The physico-chemical parameters like temperature, salinity, dissolved oxygen, pH, turbidity and secchi depth were estimated for surface waters in these stations using standard methods. The phytoplankton of the study area was identified and their density was recorded. The phytoplankton community composed primarily of diatom *Chaetoceros spp.* in all the stations, with a percentage composition greater than 55 at the bloom. The highest phytoplankton density recorded was 489, 578 cell l^{-1} at station D. Samples from the bloom showed higher specific phytoplankton absorption coefficient [$a^*_c(\lambda)$] than other stations; $a^*_c(435)$ varied from 4.11 to 5.68 m^2 mg^{-1} and a^*_c (665) from 1.45 to 1.80 m^2 mg^{-1}. A survey on the purse seine fishery showed a higher pelagic catch in close proximity to the bloom area during this period. Further investigation of absorption properties of blooms using remote sensing at complex case II waters is needed to interpret bio-optical properties as well as fisheries. The present study is the first attempt of this kind off Cochin coast.

Marine fishes captured under pfz and non-pfz regions through satellite imagery along the coast of the Ratnagiri District, Maharashtra State

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Dissemination of PFZ on local digital display boards was started in February, 2002. The response from fishermen was weak until the year 2006, as it required some time for awareness of the value of PFZ data to be developed. However, dissemination of the data was continued and fishermen were encouraged to use the data as an aid to location of fish aggregations. As more fishermen used the data, the benefits became clear. With a view to quantifying the value of the PFZ bulletins, three kinds of information were collected at landing centres: percent success; CPUE; and reduction in search time. Environmental properties such as pH, salinity, temperature, dissolved oxygen (DO) and wind direction, were also recorded. Temperature and DO differed markedly between PFZ and non-PFZ areas. Overall the PFZ advisories were found to be more beneficial to the purse-seine and trawl fisheries than to the gill net fishery. The INCOIS PFZ-Mission activity is now being extended on the coasts of Sindhudurg and Raigad districts.

Response of the two shrimp (*Farfantepenaeus californiensis*) and (*Penaeus stylirostris*) to long-term variability in the upper Gulf of California (Mexico) and adjacent areas

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Long climate variability can be evident in shrimp fisheries because of the fast life cycle of these species. A database of brown (*F. californiensis*) and blue (*P. stylirostris*) shrimp catches was created for the regions San Felipe (SF) (1985 to 2001) and Bahia Magdalena (BM) (1986 to 2008) and a time series (1998 to 2008) was generated for SST (AVHRR), chlorophyll *a*, CDOM, PIC, POC, Rrs412 and Rrs490 (SeaWiFS). Temporal patterns show that when there is a high abundance of brown shrimp, blue shrimp declines; the inverse is also observed. In BM, high blue shrimp abundances occurred during El Niño years while in SF, the high abundances of this species are associated with Non-El Niño years. We observed a negative correlation between brown shrimp's abundance, POC and CDOM (BM), while there was a positive correlation with chlorophyll *a* (SF). We suggest that higher precipitation rates during El Niño decrease salinity, increase nutrients, CDOM, POC and chlorophyll *a* and that these conditions are more favorable to blue shrimp in BM and brown shrimp in SF. The blue and brown shrimp catches can be an indicator of El Niño in BM and SF respectively.

Primary production estimates from biogeochemical models, satellite and *in situ* observations as input for a dynamic size-based fish model for the North Sea

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The global potential biomass and production of fisheries can be estimated from simple models that combine macroecology, life-history theory and food-web ecology with primary production (PP) and temperature data from satellite observations (Jennings *et al.* 2008). For productive shelf seas, such as Georges Bank and the North Sea, this approach may underestimate the potential fisheries biomass and productivity due to a number of factors including those which influence the reliability of the PP estimates (e.g. phytoplankton growth and production in sub-surface waters).

For the North Sea a number of approaches have been adopted to improve the estimates of PP used as input to these models. These include combining observations from SmartBuoys, satellites, Ferryboxes, and field measurements of photosynthetic activity (from PAM and FrrF fluorometers, and ^{14}C incubations) with ecosystem models. A 3-dimensional hydrodynamic model (GETM) coupled to a biogeochemical flux model (BFM) is being linked to a size-based fish ecology model to predict the potential biomass, production, size structure and trophic structure of consumer communities. Observations are used to validate the models, which consider horizontal transport and vertical exchange with the benthic compartment. Validated maps of production for the North Sea will be made available via the EMECO portal (www.emecogroup.org/).

Variability of primary productivity with heat content in the Arabian Sea

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Primary production in the ocean forms an important part of the global food chain. The distribution of primary productivity is a major parameter which helps us to understand the role of the ocean in the global bio-geochemical cycle. Temperature plays a very important role in this cycle. Penetration of solar radiation in the upper column of the oceans heats up the region and is used up by phytoplankton for photosynthesis. Changes in the heat content in the upper ocean, in turn, result in variability in productivity. An inverse relation is observed between heat content and productivity. With the growing influence of global warming on the oceans, the variability of primary productivity with respect to the heat content in the Arabian Sea is studied in the present work. The upper ocean heat content anomaly is observed to be related to TOPEX dynamic height anomalies with a lower sea surface height corresponding to cooler, denser waters and vice versa. Thus sea level anomaly can also be used to find the variability of primary productivity. An attempt is made to establish the relationship of heat content and sea level anomaly with primary productivity in the Arabian Sea.

Global marine primary production constrains fisheries catches

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Primary production must constrain the amount of fish and invertebrates available to expanding fisheries; however the degree of limitation has only been demonstrated at regional scales to date. Here we show that phytoplanktonic primary production, estimated from an ocean-color satellite (SeaWiFS), is related to global fisheries catches at the scale of Large Marine Ecosystems, while accounting for temperature and ecological factors such as ecosystem size and type, species richness, animal body size, and the degree and nature of fisheries exploitation. Indeed we show that global fisheries catch since 1950 have been increasingly constrained by the amount of primary production. The primary production appropriated by current global fisheries is 17-112% higher than that appropriated by sustainable fisheries. Global primary production appears to be declining, in some part due to climate variability and change, with consequences for the near future fisheries catches.

Assessing environmental preference of the northern Bay of Bengal pelagic fish species using catch-per-effort and remote sensing data

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Remotely sensed satellite data of sea surface temperature (SST), chlorophyll *a* and turbidity (TSS) data have been used to study relationship between the variations in the catch per effort of five common pelagic species (shad, pomfret, yellowfin seabream, Bombay-duck and mackerel) from commercial catch records (2004-2007). The study revealed a decreasing trend in shad, pomfret and mackerel catches and an increasing trend in yellowfin seabream and Bombay-duck catches during the study period in apparent association with the progressively increasing level of chlorophyll *a* and decreasing levels of SST. Shad and Bombay-duck catches were significantly higher on the warm side of surface thermal fronts associated with events of intensification. The fishing efficiency for all species was significantly higher during peak upwelling conditions, associated with cyclonic turmoil. The present results do not support the existence of a preferred SST range for these fish species. It is suggested that several mechanisms leading to the local concentration of prey provide adequate explanations for the aggregation of these species in the vicinity.

Partition of the Patagonian continental shelf based on remote sensing data: Identification of shortfin squid (*Illex argentinus*) fishing grounds

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In this study, we propose a partition of the Patagonian continental shelf (PCS) into a number of functional regions using remotely-sensed data of sea surface temperature (SST) and chlorophyll *a*. These data may be used to identify favorable fishing areas. The Argentinean shortfin squid, *Illex argentinus*, is a neritic-oceanic species distributed along the continental shelf and slope in the western south Atlantic Ocean. *I. argentinus* forms the bulk of the southwest Atlantic squid fishery and is the major exploited ommastrephid species in the region. Catches are made across the Patagonian shelf and in adjacent shelf slope waters. Fishery data collected by chartered commercial jiggers between January and May 2006 were analyzed in relation to environmental factors. Catch per unit effort (CPUE, kg per line hour), used as abundance index, of *I. argentinus* did not correlate with SST or with satellite-derived chlorophyll *a* values. Conversely, regions obtained using statistical analysis showed that clusters characterized by relatively high chlorophyll *a* concentration (center values around 3 mg m^{-3}) and relatively cold temperatures (11°C to 12°C) were associated with high CPUE values. This analysis suggests that partition into provinces may help predicting abundance of this short-lived species with applications in fisheries forecasting and management.

Primary production estimates for global continental margins: the impact of optically complex waters

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Over the last decade, two parallel international research initiatives have broadened the applicaiton of remotely sensed ocean colour data. The first is the development of semi-analytical algorithms to invert satellite measurements of radiance to retrieve geophysical parameters (e.g. chlorophyll, CDOM, and scattering/backscattering coefficients). The second is the use of ocean colour data to produce global estimates of net primary production. A current model intercomparison involves 15 different models. In applying these primary production models on global-scale data, processing generally uses one algorithm over continental shelf waters as well (with explicit disclaimers to its accuracy in these regions). A fundamental issue with applying these global models in shelf regions is that many of them are characterized by optically-complex water (termed case II) containing suspended and dissolved organic matter. These constituents do not necessarily co-vary with chlorophyll and may play an important factor in determining the underwater light field and therefore the light available for photosynthesis.

In the present study, I investigate the influence of these other constituents on estimates of primary production for continental shelves at global scales. I make a conceptual analysis of how multiple optical parameters influence the light field in these regions to evaluate the sensitivity of "global" primary production models to the presence of different optical water types. Subsequently I adopt a semi-analytical inversion algorithm based on a spectral-unmixing approach. The resulting optical constituents were then input to a multi-component model to define the diffuse attenuation of light which, in turn, was included in a primary production model.

The maximum photosynthetic rate is determined through a temperature dependency with a variable C:Chl ratio. The results of this analysis show that conventional primary production models s typically tailored to the open ocean, may overestimate primary production by a factor of up to 3-4 in coastal waters, depending on the optical water type of a given region. If we

look at bulk area-integrated estimates at the global scale, we find primary production estimates with a conventional global model to give an average of 10.5 Pg C y^{-1}, whereas with the model allowing for non-chlorophyll linked variability in the in-water constituents provide an estimate of 5.3 Pg C yr^{-1} (for all depths < 200 m). Implications of these findings for the global carbon cycle and estimates of natural marine resources will be discussed.

A Gulf Coast information system using remote sensing products and a 3-dimensional coastal model: assessing potential applications for fisheries

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The northern Gulf of Mexico is strongly influenced by the discharge of water, nutrients, dissolved and suspended particulate matter from the Mississippi-Atchafalaya River system, the largest in North America. It is also frequently impacted by energetic meteorological events that cause storm surge and impacts water quality of its coastal waters. To address these issues, a Gulf Coast Information System (GCIS) (http://gulf-coast.lsu.edu) was developed to serve near real-time and archived remotely sensed data and products from a number of NASA sensors such as MODIS ocean colour and SST, QuikSCAT winds and Jason-1 sea surface height anomaly data. Ocean colour products include chlorophyll, coloured dissolved organic matter (CDOM) and suspended particulate matter (SPM). GCIS also serves nowcast and 24-hour forecast outputs from a 3-dimensional coastal circulation model for the coastal states of Mississippi, Louisiana and Texas. Model outputs include sea level variations, temperature, salinity and currents at a 2 km spatial resolution. The combined satellite products and model outputs have been shown to be useful in monitoring fronts, sediment plumes during frontal passages and phytoplankton blooms following passage of hurricanes. Here we present results from this study and examine the potential use of the GCIS satellite products and model outputs to investigate environmental linkages to some fisheries parameters in the Gulf Coast.

Comparison of atmospheric correction schemes using modis-aqua data in the Arabian Sea

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The quality of the data products derived from the ocean colour satellite largely depend upon the atmospheric correction and the ocean colour algorithm used. Since the atmospheric contribution to the overall signal is the significant of the two, the present paper attempts to evaluate three atmospheric correction schemes. Through the SATCORE programme, *in situ* radiometer data in hyperspectral wavelengths are regularly collected in the northern Indian Ocean. Five match-up points were obtained following the SeaBAM protocols covering coastal and open ocean waters in the north Arabian Sea. The study included: single scattering, multi-scattering with 2-band model selection with NIR correction and with MUMM correction, with the NIR being the default correction scheme for MODIS-Aqua. The evaluation was based on the comparison of satellite derived and *in situ* normalized water-leaving radiances (nLw) and chlorophyll concentrations. The OC3M algorithm was used to retrieve chlorophyll concentrations from the satellite image. The remote sensing dataset included high resolution MODIS-Aqua bands. Statistical comparison indicated that the standard atmospheric correction scheme performs better with the chosen data set.

Remote sensing for artisanal fisheries in Peru

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Satellite images are used in the artisanal fishing industry in Peru and are mainly oriented towards increasing catches of pelagic species. Satellite images of sea surface temperature (SST) are used to provide updated information of thermal gradients and to help locate fishing grounds. Other variables, such as chlorophyll, winds and currents are being used more frequently to reduce the uncertainty in fishing. However, the increase of this fishing effort is resulting in fishing areas located father from the coast.

Monitoring waster rise in the Caspian Sea using advanced remote sensing, gis and gps technologies

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Sudden water rise in coastal areas may destroy different infrastructures, however, having slow water rise in coastal environments may create different opportunities for nearby residents. In this research, an attempt has been made to investigate coastal environmental changes in Gorgan Bay, northern Iran using advanced remote sensing, GIS and GPS technologies. To do this, remote sensing and ancillary data pertaining to the study area were collected and imported to the image processing and GIS software. Remote sensing data including TM, ETM and RADARSAT images were first co-registered to each other with reference to 1:50000 scale topographic map. Different image processing techniques, including band differencing, PCA, and fuzzy operations used to investigate the magnitude of change over study area. Shorelines were extracted through band multiplication, RGB to IHS and Brovey transformation of a combination of optical and radar data. The best extracted shoreline was selected via the use of real shoreline obtained using a GPS. Land use/land cover changes were also investigated through the comparison of maps prepared for different dates. The results show that shoreline extracted from the Brovey technique was the best among others and due to the water rise, a total area of 12,682 hectares from different land use land cover such as forest bushes, sandy areas, rangelands and mudflats were covered by water. Although the water rise in this area had unsuitable effects on environment, this phenomenon has given a good opportunities for the fishing of caviar fishes to residents in this area.

Phytoplankton size structure, distribution and primary production as the basis for trophic analysis of Caribbean ecosystems

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An oceanographic survey was conducted in Caribbean waters in April and May 2006 to assess the marine ecosystem. According to analyses of pigment and absorption data, the phytoplankton community was dominated by pico- and nano-phytoplankton, particularly at the deep chlorophyll maximum. From cluster analysis on remotely-sensed data, three dynamic provinces were defined for the region. A five-year time-series of sea-surface temperature and chlorophyll concentration provided information on the annual cycle of these properties and the phytoplankton response to ENSO events. To implement the computation of primary production on a synoptic scale, parameters characterising the biomass profiles and photosynthesis-irradiance relationships were assigned using four different protocols: two regional approaches, a regression with surface chlorophyll and the Nearest-Neighbour Method, the last of which has the advantage of assigning parameters on a pixel-by-pixel basis. Monthly images of primary production were computed over an annual cycle using MODIS chlorophyll *a* concentration and the Nearest-Neighbour Method emerged as the method of choice for parameter assignment. Finally, a new approach from remotely-sensed data was developed to estimate production-to-carbon ratios, a key input to Ecopath models. The results provide a contribution to ecotrophic analysis of the Lesser Antilles Pelagic Ecosystem project.

Condition factors of the northern pink shrimp (*Pandalus borealis*) in the northwest Atlantic

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We explore intra and inter-annual variability in the condition factor of the northern pink shrimp, *Pandalus borealis*, on the Canadian Scotian Shelf (43°N-47°N and 57°W-62°W), in relation to spatial and temporal changes in food availability, represented by phytoplankton loss rates and zooplankton abundance. Shrimp condition factor (Kn) was determined as the relative weight between observed and predicted (weight-length relationship based on the sampled population between 1995 and 2005) of non-ovigerous females from commercial fishery and scientific survey samples. Total daily phytoplankton loss from the mixed layer was estimated by combining remotely-sensed data on ocean colour with a model for daily mixed-layer primary production. Zooplankton abundance was represented by abundance of *Calanus spp.* copepodite stages I to V from continuous plankton recorder data. The three data sources were grouped and assessed at weekly time scale between 1998 and 2005. Shrimp condition factor was related to seasonal spring pulse of phytoplankton loss, as well as zooplankton abundance.

Remote sensing applications for fishing ground assessment in Indonesian waters

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Remote sensing applications for the determination of potential fishing zone in Indonesia waters began in 1990. In this paper will be described the application of remote sensing research to know the relationship between oceanographic parameters and catch of pelagic fish (oily sardine and bigeye tuna) in Indonesian waters. The results of research shows there is a significant relationship between oceanographic parameters (such as sea surface temperature, chlorophyll *a* concentrations, and sea surface high derived satellite) and fish productions.

Detecting chlorophyll *a* distribution and harmful algal blooms in the Vietnam coastal upwelling by optical satellite imagery high resolution

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Study on chlorophyll *a* distribution and harmful algal blooms (HABs) is essential in upwelling areas which constitute the main fishing grounds of Vietnam waters. Based on the numbers of high resolution satellite images and monthly *in situ* data during 2007-2008 in upwelling regions, spatial and temporal variations of chlorophyll *a* with algal blooms have been detected.

The results show that the anomalies of higher chlorophyll *a* concentration and HABs exist in different periods, especially: 1. An area of higher chlorophyll *a* concentration and algal bloom, dense patch type in PhanRi Bay during summer (April to September), related to southwest monsoon (SWM); 2. The lane type from Phan Ri to Phan Thiet Bays in winter (December to February), relates to the effect of the northeast monsoon (NEM) that brings nutrients to the coast; 3. chlorophyll *a* bloom in winter with dense patches in Phan Thiet Bay. These blooms existed during two monsoons and related to the occurance of harmful algal blooms during the SWM or local eddies during NEM and; 4. The bloom occured in coastal waters of Vung Tau, Mui Ne, and offshore of Phu Quy. This bloom appeared in the shape of silk lanes as a result of distinctive nutrient inflow from Mekong delta and from the pumping of nutrients by internal waves originating from coastal shallow waters.

Thus, the present study examines the distribution of chlorophyll *a* using satellite images and is directed towards comprehensive usage for fisheries resource management, environmental monitoring and in both oceanographic theories and experiments.

Can altimetry data be used to predict phytoplankton and zooplankton biomass associated with mesoscale eddies in the Mozambique Channel?

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Eddies are dynamic mesoscale features that may significantly impact ocean productivity, by enhancing primary production, entraining and retaining planktonic communities of coastal origin, and providing enhanced feeding conditions for upper trophic level fauna. Remote sensing has shown the prevalence of eddies in the Mozambique Channel, which form in the north and propagate southwards. We present data from cruises in 2007 and 2008 to investigate relationships between remotely sensed data and the *in situ* biotic communities associated with these eddies.

Discriminant Function Analysis, using sea surface height anomaly, geostrophic current speed and bathymetry as variables, revealed 5 water types: cyclonic, anticyclonic, frontal, divergence and shelf. Relative biomass of phytoplankton and zooplankton appeared well-coupled in all water types. Away from the variable shelf region, greatest integrated biomass was associated with cyclonic eddies, and lowest biomass with anticyclonic eddies. Differences in biomass between the eddy cores were greater for zooplankton, a possible consequence of zooplankton grazing. Frontal and divergence areas were characterized by intermediate to high biomass, suggesting widespread foraging opportunities for higher trophic level fauna. These results suggest altimetry data may be used to indicate relative plankton biomass associated with mesoscale features in the Mozambique Channel, but that absolute biomass is event-specific.

Satellite detection and countermeasure of red tides

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The red tide, often referred to as a harmful algal bloom, can be detected by satellite ocean colour, and the real time information is important for countermeasure to reduce aquaculture damage. In this presentation, recent examples of red tide detection by ocean colour remote sensing and the use for countermeasure in Japan will be introduced. *Cochlodinium polykrikoides* red tide often occurs in Korea and we developed spectral approach to identify the red tide based on red tide map and MODIS. MODIS chlorophyll *a* data was used to detect early development of Karenia mikimotoi in the western Seto Inland Sea, and the warning to fish farmers could successfully reduce the damage in summer 2008.

Site suitability analysis for seaweed culture using remote sensing, gis and multi-criterion analysis

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Seaweed farming becomes one of the coastal and marine prospects for improving the national economy and is thus an important component in coastal primary production. The growth and development of seaweeds depends on environmental conditions encompassing water quality parameters that lead to abundance and productivity of seaweed communities. Therefore, site selection determines the economic viability of the coastal community. Open-water, inshore and nearshore cultures require the main parameters like hydrographic and climatic conditions.

Remote sensing and geographical information systems (GIS) are ideal tools for optimizing the location of seaweed cultivation. The study area comprises good environmental conditions coupled with majors lagoons, like Kovalam and Kelveli, and forms the importance in selection the area from Kovalam to Marakanam, which covers two districts namely Kanchipuram and Vilupuram. The total extent of the study area is 80 km along the Tamil Nadu coast. Survey of India topo-sheets on 1:50,000 scale were used for a base map. Physio-chemical properties of coastal water are directly surveyed with coastal equipments for the parameters such as water depth, dissolved oxygen, salinity, temperature, nutrients, pH, and sediment distribution along with GPS coordinates. Since the observations are point data, all are interpolated and created as a thematic layer. Each thematic layer was assigned a weight, which was proportional to its importance. The weighted overlay of the thematic maps, derived from the satellite images and attribute data, are used as the inputs for the multi-criteria evaluation (MCE) technique. The techniques were employed in SPSS statistical package in optimizing the favourable zones for seaweed cultivation.

Socio-economic data such as population, occupation, house hold data ownership, family income etc. are collected from the appropriate Government Departments. Financial analysis such as net present values (NPV), benefit:cost ratio (BCR) and internal rate of return (IRR) are

calculated in justification to the outline of cost-benefit analysis was carried out for the viability of the project.

Macro planning for aquaculture development using remote sensing techniques and GIS

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Brackish-water aquaculture has continued to grow, irrespective of the recurring viral disease outbreaks and regulations laid down through the Coastal Aquaculture Authority (CAA) Act. Most of the problems could have been avoided if the sites were selected by applying scientific tools for site selection. An earlier estimate has identified about 1.2 million ha of coastal land as suitable for brackish-water aquaculture, but this has to be revalidated based the regulation of the CAA act. Remote sensing has a wide range of products with higher spatial, spectral and temporal resolutions; the combination of which can be applied in different themes based on the requirement of proper site selection and monitoring in the development of aqua farms using GIS. The situation is analogous to monitoring existing aquaculture operations in terms of its impact on nearby resources. Considering the present scenario and the need for the utilization of coastal resources in a sustainable manner, CIBA has developed the methodology for identifying suitable sites for the development of aquaculture using GIS. The land and resources were mapped from satellite data using EDRAS Imagine. Potential sites were derived using ArcGIS based on available land and water resources, their usage pattern, soil and water characteristics, buffer from different ecosystems and CAA guidelines. This methodology was evaluated in the coastal districts of Tamil Nadu and Andhra Pradesh and potential sites for the expansion of aquaculture have been identified from the unproductive waste lands and mud flats.

Monitoring *Trichodesmium* blooms in the Arabian Sea from *in situ* and satellite products during the past decade

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Trichodesmium blooms in the Arabian Sea were monitored for a decade (1998-2008) utilizing both *in situ* and satellite data products. Seven *Trichodesmium* blooms were identified in the Arabian Sea as per these *in situ* measurements, which were compared with the satellite images of the bloom on those respective days. The bloom images were analyzed using the 443, 490 and 555 channels of SeaWiFS as the pigments like phycoerythrin in *Trichodesmium* produces high reflectance in the near IR channels. Depending on the spatial distribution and the concentration, the chlorophyll *a* values ranged from 0.5-2.0 mg m^{-3}. The SST was observed to be around 25.5-27.0°C during the bloom conditions. The spatial dynamics of the blooms were studied using the satellite-derived surface currents in the region. In all the cases except one, the bloom was found to occur during the non-upwelling conditions, reiterating the fact that stratification of the water column is a necessary condition for the formation of *Trichodesmium* blooms, as this allows cells to float on the surface with the help of their gas vacuoles. The data on environmental variables as well as the *in situ* and remotely obtained data were utilized in developing identification criteria to detect *Trichodesmium* blooms in the ocean colour images. The results of the present study will be utilized in the continuous monitoring of *Trichodesmium* blooms, for which the Arabian Sea is an important breeding ground. With the availability of recently launched Oceansat-II high resolution data, this study provides vital information regarding the satellite monitoring of such blooms.

A framework for an operational ocean colour data processing chain

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The present paper describes the operational data processing chain (ODPC) for processing, mapping, and dissemination of ocean colour data products in near real-time (NRT). The ODPC broadly suits the need of Indias SATCORE Programme and also serves as the data backbone for the potential fishing zone (PFZ) Mission. The ODPC is simple and is built on an open source Ubuntu platform and is automated using bash and IDL scripts. The processing chain is composed of three stages: 1. processing, 2. Mapping using SeaDAS with runtime licensed IDL, and 3. dissemination using a web-ftp server. As the Indian Ocean component of the ChloroGIN, the data is disseminated in NRT mode to eight countries. The present domain of the ODPC is from 40°S to 31°N and 35°E to 103°E. Presently, the ODPC handles MODIS-Aqua data, and is designed to handle data from other ocean colour satellites too. The ODPC generates six image products: quasi-true colour, chlorophyll, sea surface temperature, water clarity, total suspended matter, and aerosol optical depth. The data is made available in three file formats: HDF, png and GeoTIF. The disseminated data on the web has limited WebGIS functionalities for data-analysis by the end-user.

Linking remote sensing data and food web models to predict consumer biomass in the global oceans

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Phytoplankton biomass estimates from processed ocean colour data can be used as inputs to food web models that predict consumer biomass, production and trophic level. Predicted values depend on the length of food chains leading to consumers, a consequence of consumer size, redator-prey size relationships and the size composition of primary producers. Since mean predator-prey size ratios in marine ecosystems do not depend on temperature or primary production, the size composition of the phytoplankton community has an overriding influence on food chain length. Phytoplankton size composition can be predicted using an approach that draws on statistical relationships between the size composition, temperature and chlorophyll concentration, or using absorption models that estimate size composition from ocean colour. Here, we predict the size composition of phytoplankton communities using both approaches and use simple food web models to assess how the approaches influence estimates of consumer biomass and food chain length in the global oceans. Differences in food chain length affect relationships between primary production and fish production, estimates of fisheries catch potential and the expected bioaccumulation of contaminants in consumers of a given body size.

Estimation of primary production for fisheries management in the south Brazil bight, southwestern-south Atlantic

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The primary production in the south Brazil bight (SBB) was estimated based on SeaWiFS ocean colour remote sensing and *in situ* data from four seasonal hydrographic cruises carried out during the summer and winter of 2001 and 2002, along the continental shelf and slope waters. Using a spectral vertically non-homogeneous numerical algorithm, the mean primary production for the 2 years is estimated to be 236 gC m^{-2} yr^{-1} for the shelf and 132 gC m^{-2} yr^{-1} for the slope. Interannual variation in production on the shelf ranged from 126 gC m^{-2} yr^{-1} in 2001 to 346 gC m^{-2} yr^{-1} in 2002. The mean primary production for the two-year period in the SBB is 188 gC m^{-2} yr^{-1}, and the potential primary production is 0.03 GtC yr^{-1}. The upper bound for sustainable fish yield was estimated using a food chain of 2.8 links and an average trophic efficiency of 10%. The resulting values are 30-60 times larger than the observed fish catch from 1991 through 2000. If this fish yield is an upper bound that will be decreased to 10% or 20% by environmental accessibility, the fishery resources in the SBB are likely to be food-limited.

The potential of remote sensing in fisheries management: the case of the northern shrimp

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Traditional fisheries management models seldom include environmental ecological data because of the complexities, uncertainties and variability associated with environment-fish production correlations. However, the advent of the Ecosystem Approach to Fisheries (EAF) has given new impetus to the development of more holistic assessment frameworks. Remote sensing can play an important role in reconciling these two fundamentally different approaches. Considerable progress has been made in linking remote sensing data to shrimp (*Pandalus borealis*) growth and recruitment. Here we review these results and show how they can be used directly as diagnostic indicators of stock health and in formulating management advice. The eastern Scotian Shelf shrimp fishery is illustrative of this approach and is presented as a case history.

Is the Arabian Sea responding to global warming?

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Response of the ocean to human-induced change is different in different basins and presently, it is unclear how the Arabian Sea is responding. In this presentation, we show that the impact of global warming on the Arabian Sea is the disruption of the natural decadal cycle in the sea surface temperature after 1995, followed by a secular increase in temperature. The Arabian Sea experienced a regional climate-shift after 1995 which was accompanied by a 5-fold increase in the occurrence of "most intense cyclones". Signatures of this climate-shift are also detectable over the adjacent landmass of India as progressively warmer winters and decreased decadal monsoon rainfall. The warmer winters are associated with a decrease in the decadal wheat production after 1995, while decreased decadal rainfall was accompanied by a decline of vegetation cover and increased occurrence of heat spells. The increased aridity enhances the dust-delivery from the surrounding landmass and induces the iron-fertilization which supports an increase in the phytoplankton biomass. This in turn is tightly-coupled to the increased oil Sardine catch in the eastern and western Arabian Sea after 1995. We propose that the upwelling-driven cooling provided a mechanism that offset the increase in SST in the Arabian Sea until 1995.

Phytoplankton patch and tuna forage: a study using irs p4 ocm

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Chlorophyll *a*, which can be detected from satellite sensors, can be used as an index of phytoplankton in the ocean. This study examines the distribution and persistence of phytoplankton patch and the formation of tuna forage on a spatial and temporal scales in the waters of India's exclusive economic zone (EEZ), using time-series chlorophyll *a* images derived from the Indian Remote Sensing Satellite P4-Ocean Colour Monitor (IRS P4-OCM). Critical patch length is found to be 22 km. Results based on exhaustive analysis indicate that phytoplankton patch and its persistence depends on both the length and the concentration of chlorophyll *a* within the patch. For a phytoplankton patch to mature to the tuna forage ground a minimum of 7 days is required. This has been validated using tuna catch data acquired from Fishery Survey of India (FSI). Validation results based on hindcasting indicate that the tuna forage ground derived from satellite data yielded high catch of tuna ($< 2\%$ hooking rate).

Recognising potentially harmful blooms of cyanobacteria by means of optical remote sensing

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Extensive blooms of phytoplankton possess a potential threat on aquaculture and fisheries. Some blooms cause problems (anoxia) for fisheries due to their high biomass while some phytoplankton species (like many cyanobacteria) produce toxins harmful to aquatic organisms. Conventional monitoring programmes cannot provide reliable monitoring results due to the high spatial and temporal heterogeneity of most blooms. We have studied the possibility to use remote sensing to recognise potentially harmful blooms of cyanobacteria and to monitor their development. Our results suggest that remote sensing sensors with sufficient spectral resolution are capable of separating waters dominated by cyanobacteria from those dominated by other phytoplankton. The only satellite sensor suitable for recognition of cyanobacteria is MERIS. However, our results also indicate that in such CDOM dominated and relatively turbid waters like in the Baltic Sea cyanobacteria become separable from other phytoplankton only if they are present in relatively high quantity (chlorophyll *a* 8-10 mg m^{-3}). Concentrations above 4 mg m^{-3} are already considered as a bloom. Thus, it is highly unlikely the remote sensing can be used for early warning of emerging potentially harmful blooms. On the other hand most optical satellites are suitable for monitoring of cyanobacterial blooms if there are no other potential causes of elevated water reflectance, e.g. high reflectance in the middle of the Baltic Sea in July-August can be caused only by cyanobacteria.

Use of satellite information in fisheries research in Argentina

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We will show examples of the use of satellite information to study the physical and biological environment, as well as two fisheries, in the Argentine Sea. Satellite images of SST show a permanent shelf-break front and several seasonal, coastal and tidal fronts. *In situ* observations also show salinity fronts associated with the shelf-break and estuarine regimes; for these, the use of salinity information from the Sac-D sensor is planned. Strong phytoplankton blooms and commercially important species of fish, crustaceans and mollusks are found at these frontal areas. Field estimates of surface chlorophyll *a* concentrations from 0.4 to 28.6 mg m^{-3}, and integrated production from 0.27 to 5.48 gC m^{-2} d^{-1}, have been registered during spring. Satellite models of primary production for the region are being tested. Satellite images of chlorophyll *a* are being used to explain the distribution, reproduction, population dynamics, migration, and its relationship with fishing operations, for the Patagonian red shrimp (Pleoticus muelleri) in the Golfo San Jorge region. Satellite and *in situ* chlorophyll *a* data are also utilized as input in ecotrophic models to study the trophic structure and long-term impact of fisheries on coastal demersal fish. This information is available for the ecosystem-based fisheries management.

Climate change and its impact on the distribution of marine fish species of coastal waters of Sundarbans, west Bengal

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Sundarban, from the perspective of global warming, is one of the most vulnerable mangrove ecosystems of the world. The lower marine zone of the system supports major commercial fisheries. Most pelagic species shows a declining trend, as evident from fish landing data from 2005 through 2009. In addition, during this time period, the northern part of Bay of Bengal exhibits a definite rising trend in terms of SST as observed from satellite data. The distribution of diatoms and dinoflagellates is changing with increasing SST, which affects the entire food chain. The distribution and abundance of pelagic fish species like *Tenualosa ilisha* and *Sardinella longiceps* is found to be changing significantly within this same time period. Fish spawning grounds in Sundarban are also under stress. Stock of *Tenualosa ilisha* in the west Bengal fishing ground is decreasing at 5% per year – the cause of which may be related to global warming. With the help of Remote sensing and GIS studies, this paper discusses the impact of rise of temperature and climate change on declining availability of specific fish species of Sundarban offshore areas.

Seasonal and interannual changes in oceanographic features and their impact on small pelagic catches off Kerala

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To understand the seasonal and interannual variations of oceanographic parameters and their influences on the small pelagic fishery, seasonal data on sea surface temperature (SST), zonal wind (U), meridional wind (V), salinity, sea level, multivariate El-Niño-southern oscillation index (MEI), southern oscillation index (SOI), coastal upwelling index (CUI), chlorophyll *a* concentration and estimated fish landings were collected. The data were gathered for three near shore locations in the southern, central and northern parts off Kerala (southwest coast of India), averaged and plotted to find out the annual and seasonal trends of some of the variables for the years 1967-2007 and their relationships with the catches of small pelagics during the years 1997 to 2007. In spite of the changes in the variables over the years, there is an increasing trend in oil sardine, mackerel, SST, meridional wind, MEI, and chlorophyll, while other sardine, salinity, sea level, zonal wind, CUI and SOI has a decreasing trend. Statistical analyses were performed to identify the oceanographic parameters that were significantly correlated with pelagic fish catch.

Chennai Coast vulnerability assessment using remote sensing and gis

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Remote sensing and geographic information systems (GIS) have proved to be extremely useful tools for understanding coastal processes and identifying coastal vulnerable spots in order to mitigate coastal zone hazards. Thus, a coastal vulnerability index (CVI) was used to map the relative vulnerability of the Chennai coast to future sea-level rise, especially between Kovalam and Mamallapuram. Variables such as geomorphology, coastal slope, rate of relative sea-level rise, historical shoreline change rates, mean tidal range, and mean significant wave height are given ranks in terms of their contribution to coastal change. The CVI signifies those regions where the physical effects of sea-level rise might be the greatest. The CVI demonstrates a useful methodology for long term evaluation and suggest optimal measures to combat sudden changes in coastal environment. The study area like Muttukaddu, in the Kovalam region, is dominated by brackish water and bare beach of Mamallapuram coast. The erosion was observed along the linear stretch of shores and accretion at the ridge of the shores. Further, measures are suggested from preventing the same in future.

Effects of environmental variability at frontal systems on zooplankton and fish of the southwestern Atlantic Ocean

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The continental shelf of the Argentine Sea (34-42°S) presents a variety of frontal systems, which are important reproductive grounds for fish of ecological and commercial importance, such as the Argentine anchovy, *Engraulis anchoita*. Analysis of 12 years of SeaWiFS data revealed the presence of dense spring phytoplankton blooms along a thermal coastal front off the Buenos Aires province. High interannual variability was observed in the magnitude and timing of the blooms, with highest concentrations of chlorophyll *a* recorded in 1997, 2002 and 2003. This coincides with maximum densities of small zooplankton, which are the main food of anchovy larvae. High abundances of larvae of *E. anchoita* were generally associated with the front. Variability in environmental factors that influence chlorophyll dynamics in this region is examined in terms of its potential influence on zooplankton abundance and reproductive success of *E. anchoita*.

The roles of local scientists for the build-up of sustainable fisheries systems using high technology, such as satellite information

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The need for marine biotic resources for human consumption is ever growing, but increasing catches is not compatible with planning for the sustainable use of fish resources. The effective regulation of fish catch, provision of scientific advice for protecting such resources and technical support to the fishing industry can all help to promote sustainable fisheries.

A relationship of mutual trust between government and fishermen is essential to regulate catches. In the absence of motivation, regulations laws are often disobeyed. Despite this, governments struggle to provide sustainable fisheries for their citizens. Fisheries scientists, especially local scientists, can work as a liaison between the two groups using high technology such as satellite information.

One such joint experiment between local governments, local fishermen and local scientists for building satellite fisheries information systems will be introduced. Many small-scale coastal fishermen have joined this experiment as volunteers. Fishermen sent reliable and real-time catch data to the fisheries institute where scientists analyzed the data in order to help advise local fishermen on finding effective fishing grounds using satellite data. Because of trust so established and given the incorporation of the fishing community into the science and policy, fishermen are more inclined to respect the local fishing laws and abide by catch limits. Ultimately, satellite information should be used for saving time and money in fishing activities rather than for increasing the catch size.

Spatial variability of bio-optical properties and algorithm development to retrieve algal bloom data from coastal waters of the eastern Arabian Sea

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Profiles of hyper-spectral radiance and irradiance of visible radiation, fluorescence of chlorophyll *a* along with CTD measurements were carried out during the pre-monsoon and post-monsoon periods of the year 2008 as a part of optical measurements under satellite coastal ocean observation (SATCORE) experiment. Nine cross shelf transects with 5 stations on each transect, spanning between Goa to Kochi, were considered for the study. Analysis carried out at a station off Goa, Mangalore and Kochi has revealed that subsurface chlorophyll maxima (SCM) was at 80 m, 50 m and 40 m, respectively. To further assess the reason for such variability, the attenuation of downwelling irradiance (Kd) for the euphotic zone of these stations was analyzed and it was found to be 0.0448, 0.0436 and 0.0677. The relation between Kd and SCM is 2.1903 x $\mathrm{Kd}(490)^{-0.96}$. To understand the role of thermohaline forcing in the Kd variability, temperature and salinity structure across the shelf was analyzed. Using three wavelengths, an algorithm was developed to retrieve chlorophyll *a* from the study area having a range of chlorophyll *a* from 0.1 μg l^{-1} to 25.5597 μg l^{-1}. The retrieval algorithm is: chlorophyll $a = 93.51x^3 - 47.25x^2 + 6.529x + 0.079$. Where $x = 1$ x $[\mathrm{R}_{rs}(663)]^{-1} - 1$ x $[\mathrm{R}_{rs}(610)$ x $\mathrm{R}_{rs}(636)]^{-1}$.

Fluorescence emission ratios as a method for determining the source of coloured dissolved organic matter in the Cochin estuary, southwest coast of India

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Coloured dissolved organic matter (CDOM) is a major impediment in the estimation of chlorophyll *a* concentration in coastal and near-shore waters from satellite ocean colour sensors. The extent at which CDOM in the estuarine and near shore regions is the remnant of terrestrial or marine *in situ* production depends upon the variations in environmental factors, such as salinity, riverine input and biological productivity. The fluorescent property of the CDOM and its fluorescence excitation and emission maxima are dependent upon the source and history of the organic matter. Multispectral *in situ* fluorescence measurements of CDOM in surface and sub-surface waters of the down-stream reaches of the Cochin estuary were carried out for one year: from August 2007 to July 2008. Ratios of fluorescence emission at several wavelengths were used as indices to differentiate between marine and terrigenous sources. Em ratios used were $F_{375/400}$ for Ex. 250 nm and $F_{430/540}$ for Ex. 307 nm. It was found that the fluorescence ratio values of < 1 were characteristic of terrestrial CDOM whereas those with values > 1 were indicative of marine CDOM. Estuarine waters, in general, had values < 1, with a few exceptions where there was less influence from the riverine input. It was also found that during monsoon season and low salinity regimes, the coastal waters also showed low ratios (< 1) indicating influence of riverine input. Such variability in fluorescence of CDOM during the course of one year itself shows the need for a regional algorithm for validation in the estuarine waters for accurate estimation of primary productivity using satellite data.

Monitoring and predicting harmful and nuisance algal blooms using EO data and ecosystem forecasts

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AlgaRisk is an innovative effort to apply an operational ocean ecosystem forecast to the problem of predicting harmful algal blooms (HABs) around the UK coast, incorporating validation against Earth observation (EO) data and *in situ* samples.

The Met Office runs an operational 3-dimensional model of the NW European continental shelf at 7 km resolution, giving 5-day predictions of the physical state, light conditions and biology including plankton biomass. The model complements the EO data in providing a number of additional parameters at the surface and within the water column, and fill in gaps where satellite coverage is limited by cloud cover.

A pre-operational service has been running in association with the UK Environment Agency (EA) southwest since 2007 to assess the feasibility of forecasting exceptional algal blooms in coastal waters. This combines EO observations, coupled physics-ecosystem model and meteorological forecasts in a rules-based (fuzzy logic) system to predict the probability of blooms occurring 1-2 days ahead in 10 defined coastal regions. A high probability results in increased monitoring of beaches by EA to validate the forecasts. Research is progressing on the discrimination of certain HABs from normal blooms, and to apply this across Europe within AquaMar, an EC GMES downstream project. PML is also providing algal bloom monitoring to the Scottish aquaculture industry.

Simplifying satellite ocean front maps and time-series analysis for applications in fisheries management

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This paper explores two novel techniques for visualising the location of thermal fronts – oceanographic features of great importance to the distribution and management of commercial fisheries. An automated clustering algorithm has been developed to simplify satellite-derived front maps into continuous contours, allowing frontal systems to be more easily visualised and tracked over long time-series in relation to fish catch data. Secondly, a 28-year time-series of satellite sea-surface temperature (SST) data has been analysed for frequently occuring fronts, enabling applications in the designation of biodiversity hotspots and marine protected areas. Visualisation of frontal locations using GoogleEarth is demonstrated, and experiments to generalise the algorithms for ocean colour fronts.

This research is based on the composite front map approach, which is to combine the location, strength and persistence of all fronts observed over several days into a single map, which allows intuitive interpretation of mesoscale structures (Miller, 2009). This method achieves a synoptic view without blurring dynamic features, an inherent problem with conventional time-averaging compositing methods. These advanced tools are also applicable to the study of certain other marine megafauna, including basking sharks, dolphins and seals.

Effect of coastal seawater temperature on the return rate of chum salmon in Hokkaido, northern Japan, and practical use of satellite data to support the stock enhancement program

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Chum salmon is one of the most important fish species for the commercial fishery in northern Japan and the chum salmon stocks are produced by intensive hatchery programmes. In Hokkaido, northern Japan, approximately one billion chum salmon juveniles are released from hatcheries in spring. The early marine phase is thought to be a critical period for hatchery-released chum salmon when mortality is highly variable. Using the satellite data, we analyzed the relationship between coastal sea surface temperature (SST) and return rate of chum salmon stocked along each coast of Hokkaido from 1985 to 2002. Significant effects are observed between SST and return rate in the eastern Hokkaido where the inter-annual variation of SST is large. The results of this study suggest that SST in the coastal areas and the release timing should be important factors affecting the survival of chum salmon in the eastern Hokkaido, while other factors, e.g. fish size and quality, would also affect the survival. Several types of satellite SST data are currently provided and some are provided in real-time. Satellite remote sensing can be a useful tool to monitor the coastal environmental conditions and to support stock enhancement programme of chum salmon in Hokkaido.

Fall and rise of the Egyptian marine fisheries off the Nile Delta: hypothesis, uncertainties and the role of satellite ocean colour data

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Marine Egyptian fisheries off the Mediterranean showed some apparent and rapid downward and upward shifts in the mid 1960s and early 1980s, respectively. There are two main hypotheses that attempt to interpret casual drivers responsible for these changes. The first refers to the fall and rise of marine fisheries from the improvement of fishing efforts and techniques, whereas the second assumes that nutrient enrichment through increased anthropogenic activities is responsible for the flourishing of these fisheries again. Despite research efforts, debate is still ongoing and reasons for these shifts are not fully resolved. Lack of long-term monitoring data and research studies on variability and trends in chlorophyll concentrations and primary productivity constrained previous research efforts and didn't provide conclusive facts for a resolution.

This paper aims to fill part of this gap and attempts to resolve the debate through trend analysis of long-term data relevant to ocean-colour remote sensing and fish landings. A time series analysis of total fish catch, pelagic to demersal (P/D) ratio and satellite-derived chlorophyll *a* concentrations in the Nile delta shelf and coastal lakes of the delta, allowed to provide several qualitative evidences for responsibility of surface nutrient enrichment for recovery of the Egyptian marine fisheries since early 1980s. Results of this study show the potential role and importance of ocean-colour satellite data for monitoring changes of marine productivity and hence, for proper management of the coastal and marine fisheries.

The relationship between coastal oceanographic features and the movement of several inshore line-fish species on the southwestern African coast

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Recent genetic analyses of populations of several linefish species on the west coast of southern Africa, namely the angolan kob (*Argyrosomus coronus*), geelbek (*Atractoscion aequidens*) and squid (*Loligo vulgaris reynaudii*), have found that two separate stocks exist in the northern and southern Benguela, respectively. It is thought that a dispersion barrier exists in the form of the Luderitz upwelling cell (27°S), the strongest and most permanent upwelling cell in the region. Different upwelling schemes occur northwards and southwards of this cell, creating a variation in environmental conditions and possibly, allopatric speciation. Intermittent corridors across the proposed dispersion barrier could halt any speciation process. These corridors can be explored through an analysis of satellite imagery (SST and chlorophyll *a*) as well as ship based oceanographic measurements. This study aims to understand the biological and oceanographic mechanisms which may result in the formation of these corridors and to investigate the frequency of such events. This information will then be used to try and predict (with the use of satellite forced ROMS simulations and a coupled IBM) the future distribution of these important inshore fishery species and enable the development of effective stock specific management strategies.

Impact of the cyclone Aila on brackish water aquaculture in west Bengal, India: lessons to be learned for preparedness and adaptive measures

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Several studies revealed that extreme climate events (ECEs) such as cyclones, floods, tsunamis and drought could cause significant damage to aquaculture. However, proper focus was not given to this sector, compared to agriculture, in terms of the extent of damage and relief measures. The east coast of India is subject to frequent cyclonic storms and occasional tidal waves which cause the loss of aquaculture stock and damage to aquaculture facilities. The Central Institute of Brackishwater Aquaculture (CIBA) assessed the impact of a severe cyclonic storm, AILA, to brackishwater aquaculture in Sandeshkalli-I and II, Basanti, Gosaba and Namkhana blocks of west Bengal. AILA crossed the west Bengal coast near Sagar Island on May 25, 2009 with a wind speed of 100-110 km h^{-1}, scattered heavy to very heavy rainfall and astronomical tidal wave of 4-5 m height at the time of landfall and caused severe damage to both traditional bherries and zero water exchange mono-culture systems. The tidal water in most of the farms was 0.6 m more than the bund height and the inundation was seen for 15 to 20 days. Water and soil quality assessment revealed the changes in water colour, salinity, and 1-2 inches of siltation on the pond bottom. The actual damage to the sector assessed through actual inspection, questionnaire interviews from the farmers and other stakeholders, and further calculations was much more than the Government figures, indicating the necessity in the refinement of damage assessment methodology. Like previous ECEs, during the present study also aquaculture was neglected compared to agriculture. More focused studies are required on the assessment of aquaculture related vulnerability and damage assessment. The paper also presents the approaches to be adopted to effectively use remote sensing and GIS-based decision support models in order to develop preparedness and adaptive measures and to plan for uncertainty associated with extreme weather events.

Landscape level management of seasonal floodplains to create resilient agro-ecosystems

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Floodplains continue to develop and diversify. A major contributor to floodplain change in the tropical zone is the growth of fish production. Building resilience, for people dependent on aquaculture as a source of food and money, through improved land and water productivity is critical for the food and livelihood security of millions, primarily rural households. One option for improving productivity from floodplains is through communal fish production. This paper presents a study using multi-scale and multi-temporal analysis supported by earth observation data and GIS tools to understand communal fish culture interventions at the landscape level. The study sites encompass a range of agro-ecological zones in low-lying seasonal floodplains in Bangladesh, Cambodia and Vietnam. As the human population in these regions increases, the value of floodplains to society increases, but so also do the pressures on them. We propose that spatial tools can contribute to the management of seasonal floodplain production systems and to evaluating the potential for up-scaling poverty-focused communal fish culture.

Applications of remote sensing in validations of potential fishing zones along the coast of north Tamilnadu, India

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The present paper deals with the application of remote sensing and advantages obtained in validations of potential fishing zones (PFZs) that are disseminated for the benefit of fishing community along the coast of North Tamilnadu, India. Mapping chlorophyll content (CC) and surface seawater temperature (SST) using satellite remote sensing as a tool to study the distribution and abundance of fishery resources is gaining momentum. The periodic potential fishing zones advisories, released by the Indian National Center for Ocean Information Services (INCOIS), would be of great benefit for the fishing communities of the entire coastline of India – in the timely location of fish shoals resulting in the saving of valuable human efforts, fuel cost and searching time for fish shoals resulting in an overall reduction in fishing cost. The fish catch in the PFZs is 3-4 times higher when compared to outside the PFZ area. The PFZ validations and feedbacks were undertaken through selected groups of active fishermen identified at the major fish landing centres along the coast of north Tamilnadu, India from January 2007 to December 2009. With a view to validate the advisories and to qualify the potential benefits of the technology, concurrent validations have been taken up. The results of the PFZ validations and feedbacks data obtained during the present studies are discussed.

Ocean colour remote sensing for fishery resource distribution and management: a case study from Cuddalore and Pondicherry – east coast of India

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Ocean colour remote sensing is one of the powerful tools to retrieve information for assessing the distribution of potential fishing grounds in nearshore and offshore coastal waters. In this study, an attempt has been made to identify the spatial distribution of fishing grounds and to correlate various environmental data in relation to the distribution of various fish species along the Cuddalore and Pondicherry coasts. The parameters include the retrieval of ocean chlorophyll *a* and sea surface temperature data for hotspots (discharge locations and estuary mouths), coastal and off-shore waters using MODIS and SeaWiFS satellite data. Meteorological parameters such as wind speed and wind direction were collected from satellite data. Bathymetry of the ocean floor was obtained from NHO charts and C-Map data. The chlorophyll *a* values were found to be relatively high near the hotspots and in coastal waters. Highest chlorophyll *a* concentrations were observed at Cuddalore in the post-monsoon and were 3.56 mg m^{-3}. Sea surface temperatures were always close to 29.59 ± 1.25°C. Seasonal and spatial variation in temperature was small (typically less than 1°C) outside the hotspots. The results were integrated in GIS and correlated with statistical analysis for formulating future strategies in fisheries management.

Coastal dynamics around Vedaranyam

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The Coastal Belt is becoming vitally important due to the immense growth of population. Waves are one of the important agents of sediment transport in the beach zone, which causes shifting of sand from sandy beaches leading to instability of the coastal zones. Although beaches appear stable under conditions of small waves, beaches are eroded so rapidly that, when attacked by storm waves, they may completely change their character or even disappear in a few hours. In addition to the cyclic changes, beaches undergo large permanent modifications due to human activities. As a result, understanding the causes of beach development and destruction is of considerable economic importance. The direction of sediment movement can be clearly identified from satellite data. Sediments move towards north during southwest monsoon and vice versa during northeast monsoon. As the sediments are transported by the longshore currents, the directions indicate the movement of currents. The above observations from satellite data agree with the longshore current direction perceived through conventional methods. Analysis shows that shoreline movement along Vedaranyam coast is towards the sea, i.e. the coast is progressing with an average rate of 5 m yr^{-1} between 1930 and 2004. From the investigation, it is found that the environmental stress in the coastal waters of Vedaranyam is limited.

Remote sensing applications to fisheries: Indian initiative to the improvement of the socio-economics of fishing communities

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India, with a vast coastline of 8100 kms and EEZ of 2.02 million km^2, has a huge potential for marine resources and coastal communities are dependent on fishing activities for their livelihood. Though India has a sustainable potential of 3.9 MMT of marine resources, they are not fully exploited as fish stocks dwindle and move further offshore increasing the searching-time for the shoals, fuel consumption and human effort. With this challenge, India has formulated an advisory service to the fishermen community called Potential Fishing Zone (PFZ) Advisories by adapting the satellite and ICT technologies available. This paper presents the importance of various environmental parameters that influence fish distribution, abundance and migration and the active role of remote sensing in monitoring these influential factors. The paper also describes the processes and improvements made from acquiring the digital data to feature digitization and describes the ICT technologies that have been adopted for disseminating the reliable, accurate and timely advisories to the fishing community. In addition, this paper provides details of the scientific experiments that have revealed the socio economic benefits fishermen have been benefiting due to usage of these PFZ advisories.

Mesoscale oceanic structures in the Canary upwelling system: possible indicators of transport and retention areas for sardine and anchovy ichthyoplankton

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Small pelagic fish, such as anchovy and sardine, are resources of great economic importance in upwelling regions, and represent the majority part of world fish catches. Recently, it has been demonstrated that physical mesoscale characteristics play an important role in the life cycles and distribution of pelagic fishes. In this study, we used a methodology of automatic detection of frontal structures based on an improved version of the Cayula-Cornillon algorithm for upwelling regions. A specific algorithm to identify the filaments based on the object-oriented programming was created. The work was focused on the Canary upwelling system, (36°N-21°N). We used 3976 daily satellite images at 1 km resolution of sea surface temperature and chlorophyll, computed from MODIS raw data (2002-2008) to create indices of frontal and filament activity. On the other hand, we used model data from an individual-based model to study the early life history of anchovy and sardine, and to explore their relationships with the observed mesoscale spatial patterns. A good convergence is found between both approaches, also showing their complementarity.

Monitoring chlorophyll *a* concentration using remote sensing: a case study of Jakarta Bay

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Chlorophyll *a* is one of the water quality parameters which has a strong optical property and plays an important role in the process of trophic state determination in natural waters. Hence, futher observation of its variaton and pattern are needed. The use of band 1, 3, and 4 of MODIS imagery sensors with 500 m resolution has selected based on chlorophyll *a* optical characteristics. In this reaserch, seasonal variation of chlorophyll *a* is monitored temporally and spatially in Jakarta Bay in 2004. From the pattern results, during the months of the west moonson (December, January, February) the pattern of chlorophyll *a* concentration shows an uniform pattern in the whole object area with concentration vary from 0.5-7.5 mg m^{-3}. Meanwhile in west-east moonson (March, April, May), the pattern of chlorophyll *a* concentration shows higher number in east side of Jakarta Bay in early moonsoon, influenced by the wind direction which flies to the east, while in the end of the season the wind influence decreases. In this season chlorophyll *a* concentration varies from 1.5-7.5 mg m^{-3}. During east moonson (June, July, August), the pattern shows a higher concentration along the coastal area in Jakarta Bay with small distribution to the offshore, and moves to the east as the wind and current flows in the same direction. The concentration varies from 0.25-10 mg m^{-3}. In east-west moonson (September, October, November) the concentration pattern is much more influenced by the light intensity, and its direction distibution generally higher than the east moonson with concentration varies from 0.25-7.5 mg m^{-3}.

Integrated monitoring and forecasting of harmful algae bloom events in coastal waters for use by aquaculture

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Over the last several decades, the aquaculture fish farming industry in Norway has experienced a massive expansion. Although there has been improved capability for safe operations, the industry is still vulnerable to outbreaks of massive harmful algal blooms (HABs) and changes in environmental conditions in coastal waters. Based on this, several monitoring precautions are undertaken in Norway for the early detection and monitoring of potential harmful algae blooms and accordingly, to be better prepared for the initiation of mitigation measures.

Since 1998, the Nansen Center has regularly utilized satellite Earth observation data as a supplement to monitoring of harmful algal bloom situations in waters of Norwegian interest. Starting with the SeaWiFS data in 1998 and, since 2005, the daily use of both MERIS and MODIS ocean colour satellite data, a range of HAB events have been detected early and their development and decay monitored.

This paper will present the evolution of this service, its common and tailored algorithms and the modelling efforts performed, as currently presented at http://HAB.nersc.no and http://interrisk.nersc.no. Based on a similar concept, monitoring algal blooms and water quality is also provided in other waters, such as the Central American waters, the Venetian Lagoon, southern North Sea, the Barents and the White and Kara Seas.

Potential fishing zone advisories for the benefit of coastal fishermen along the Kerala coast: a case study

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Intensive validation of Potential Fishing Zone (PFZ) advisories generated by the Indian National Centre for Ocean Information Services (INCOIS) along the Kerala coast during the period 2003 to 2009 revealed a positive relationship between PFZ and the occurrence/abundance of commercially important pelagic fishes. In this paper, the usefulness of PFZ advisories for artisanal, motorized and mechanized sector fishermen towards obtaining comparatively higher catch per unit effort for the major pelagics and thereby improving the economics of fishing operations is highlighted. An attempt is also made to observe prevailing oceanographic conditions within and outside notified areas for possible correlation with fish abundance.

Applications of satellite remotely-sensed oceanographic data in research on loggerhead sea turtle pelagic ecology

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Over the past decade more than 200 loggerhead sea turtles (*Caretta caretta*) have been tracked in the north Pacific Ocean with electronic tags. Satellite remotely-sensed sea surface temperature, surface chlorophyll, sea surface height, and surface winds have all proven extremely useful in complementing the tracking data to advance our understanding of the ocean habitat used by these turtles. SeaWiFS ocean colour data showed us that loggerhead turtles travel east and west along a strong gradient in surface chlorophyll that forms the boundary between the low surface chlorophyll subtropical gyre on the south and the vertically mixed high surface chlorophyll of the transition zone on the north. Satellite altimetry data has shown that loggerhead turtles frequently occupy cyclonic and anticyclonic eddies often for several months at a time as well as Kuroshio Extension Current meanders. Finally, weve developed a fishery advisory product called TurtleWatch. TurtleWatch is a map that forecasts the area within the Hawaii longline fishing ground with the highest probability of interactions between fishing gear and loggerhead turtles, hence a region to be avoided by fishers. It is calculated with near-real time satellite remotely-sensed sea surface temperature and altimetry and distributed electronically to the fishing fleet.

Binning algorithm of irs-p4 ocm chlorophyll images for the north Indian Ocean

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Ocean colour, remotely sensed by satellite, has revolutionised our ability to forecast harmful algal blooms and to aid in fishing operations, fisheries management and coastal zone management. The time series' generated by years of such observations have already led to explanations of haddock and shrimp recruitment fluctuations in the northwest Atlantic. There is great potential for other archives of satellite images of ocean colour to provide similar benefits elsewhere. IRS P4 OCM launched by the Indian Space Research Organization, has been in operation since 1999 and has already generated voluminous datasets. Its 360 m spatial resolution is the highest of any other available ocean colour sensors. The pass wise swath data at 12 noon for every alternate day over NIO during February, 2004 were used to compare the existing algorithms for binning the data. The binning is done weekly as well as monthly. Three averaging algorithms: arithmetic mean (AVG), geometric mean (GEO) and maximum likelihood based (MLA) were used in the comparative study. The analysis shows that AVG algorithm is best suited compared to the other two algorithms. Based on this result, the AVG was selected for operational averaging algorithm for OCM over the NIO to generate an atlas.

GIS-based physical models for Japanese kelp (*Laminaria japonica*) aquaculture and site selection in southwestern Hokkaido, Japan

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Japanese kelp, *Laminaria japonica*, is an important seaweed species cultured and harvested in Japan. To ensure both success and long-term sustainability of providing kelp production, identification and selection of suitable sites is an important step in any aquaculture operation. This study was conducted to identify the most suitable site for hanging cultures of Japanese kelp in southwestern Hokkaido, Japan based on measured physical parameters and modeled using geographic information system (GIS) models. Four physical parameters that influence kelp aquaculture were selected: sea surface temperature (SST), suspended solids, bathymetry and slope. SeaWiFS and MODIS data were used to extract most of these parameters. A series of GIS models were developed to identify suitable sites for kelp cultures using a multi-criteria evaluation approach. Suitability scores were ranked on a scale from 1 (least suitable) to 8 (most suitable). Approximately, 74% (1,139 km^2) of the total potential area with bottom depths less than 60 m had the highest scores (scores 7 and 8). Local sensitivity analysis was used to test the robustness of the model output. Based on this analysis, the order of importance of the variables affecting the model was as follows: suspended solid > SST.

IRS-P4 OCM-derived distribution of chlorophyll off Karwar, central west Coast of India: implications for potential fishing zones

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Spatial distribution of chlorophyll *a* data was retrieved from IRS-P4 ocean colour monitor sensor (OCM) off Karwar, west coast of India. The spatial variations of satellite derived chlorophyll *a* for the post-monsoon and summer seasons largely concur with the *in situ* values for chlorophyll *a*. *In situ* measurements of SST depict spatial variations ranging from 25.90-31.50°C during the post-monsoonal season to 23.20-35.85°C during the summer. A minor plume with an area of 157 km^2 during the post-monsoonal season was identified and contrastingly the plume enlarges to an area of 978 km^2 during the summer. Chlorophyll *a* values vary from 3.20 to 10.61 mg m^{-3} during the post-monsoonal season to 1.36-9.08 mg m^{-3} during the summer. Isolation of Potential Fishing Zones (PFZ) dwells on chlorophyll *a*, SST, and other parameters. Fish catch data for three years depicts an increase from 8818.5 tonnes to 22056.6 tonnes for six fish landing centers. The higher values of chlorophyll *a* generally imprint the waters towards the coast and offshore the values decrease. The fishing community using traditional methods could benefit from fishing off the shallow waters and would benefit from the PFZ data provided by INCOIS, Hyderabad and the Ministry of Earth Sciences, Government of India.

Estimation of chlorophyll concentration in Abu Dhabi waters using different satellite imagery

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The Emirate of Abu Dhabi, situated in the southern Arabian Gulf, has been undergoing extensive coastal development and has witnessed recurrent algal bloom incidents. In response to growing concerns on the impact of harmful algal blooms on the marine resources, ecosystems and human health, a study was initiated by the Environment Agency in Abu Dhabi to document the harmful algae in the waters off Abu Dhabi. Since chlorophyll concentration is a measure for algal blooms and productivity, surface chlorophyll *a* concentration in Abu Dhabi waters have been estimated from satellite data and ground data. Previous studies in other areas have reported chlorophyll *a* concentration extracted from satellite images differ from ground-truth data. The present study considered algorithms such as OC2, OC4 and applied the same to data collected between 2003 and 2009 using images such as MODIS, SeaWiFS, etc. Image enhancement and processing techniques like NDCI were applied on the satellite data. The field data used for ground-truthing included chlorophyll *a* measurements from 8 hydrographic stations distributed over the western, central and eastern regions of Abu Dhabi. Some of these stations were covered multiple times over the period 2003 to 2009.The effectiveness of each algorithm was assessed by statistical comparisons of satellite-derived estimates of chlorophyll *a* concentration with spatial and temporal measurements of chlorophyll *a* concentration from field observation on each sampling site. Further, the paper discusses the applicability of various algorithms in Abu Dhabi waters through the correlation between *in situ* observations and satellite derived estimates.

Status of the deep sea prawn fisheries of Kerala, southern India, with special reference to sustainability issues and conservation efforts

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The deep sea environment is generally regarded as being one of low energy and low productivity. The innovative small and medium shrimp trawlers ventured in to the deep sea prawn fishing for the first time in the history of Kerala (south India) in November 1999 defying the long-held concept that deep-sea prawn resources could be harvested only with the help of large trawlers. Deep sea prawns like *Heterocarpus gibbosus*, and *H. woodmasoni* have slow growth rates and high longevity compared to traditional commercial species from the coastal waters off Kerala. They have low levels of sustainable yields, are vulnerable to over fishing and have slow recovery rates; yet they are often high value species. This has maintained interest in the development of new fisheries for deep sea prawn species. Due to the encouraging results realised from the deep sea trawling operations during the first two years, more and more boat owners modified their trawlers, equipped them for deep-sea trawling and started venturing to greater depth zones. As a result, the deep-sea prawn fishery showed a drastic decline from 48675 t to 19285 t within two years, thus registering a reduction of 60.35% in the deep sea prawn landings. A reduction in the catch-per-hour of 53.57% during the second year is also worth noting. Depth-wise catch-per-hour also showed a drastic decline during the second year. Monthly variation in the catch-per-hour and CPU of various species were also found and the results showed that the catch-per-hour of *H. gibbosus* declined from 6.69 kg in the preceding year to 5.66 kg during the succeeding yea, while in *H. woodmasoni*, the catch-per-hour remained the same (12.75 kg). The catch-per-hour of *Aristeus alcocki* showed a drastic decline from 9.72 kg in the first year to 5.39 kg. Similarly, in *Parapandalus spinipes* and *Metapenaeopsis andamanensis*, a decline of 3.26 kg and 3.15 kg, respectively was observed in the second year. The percentage of berried pandalid shrimps was very high in the population (in the range of 71.33% to 91.25%) and a decline of the fishery registered during the second year can well be attributed to the indiscriminate exploitation of

berried females in the commercial landings. From the results arrived at on the growth rates of deep sea prawns, based on monthly distribution of length frequency, it appeared that the growth rate of deep sea prawns is very slow when compared to their counterparts inhabiting coastal waters. This paper also discusses various measures for the sustainable exploitation and management of deep sea prawns off Kerala.

Remote sensing applications for marine fishery resources: Validations off the A.P. coast, India

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Features such as ocean fronts, meandering patterns, eddies, rings and upwelling areas are proven to be prospective areas for fish aggregation. The distribution of fishes is generally related to the prevailing environmental conditions – mainly food and temperature. Satellite-derived chlorophyll and sea surface temperature (SST) are being utilized for identifying such oceanic features and issuing potential fishing zone (PFZ) forecasts by the Indian National Centre for Ocean Information Services for the benefit of the fishing community. In an attempt to validate these advisories, catch data was collected from fisherfolk and cruises along Andhra Pradesh coast, from both notified and non-notified areas, during 2005 through 2009.

Analysis of catch data from fisherfolk and cruises showed that average catch per unit effort (CPUE) was more in notified areas (135.5 kg h^{-1}) compared to non-notified areas (73.5 kg h^{-1}) and the percentage of extra quantity of fish caught in the notified areas is about 46.5%. Considering the value of fish-catch, notified areas supported richer fishery (INR 4,135.0 h^{-1}) compared to non-notified areas (INR 2,360.5 h^{-1}) and the percentage of monetary benefit obtained in the notified areas is about 47.5%. From this, it can be understood that PFZ advisories are very useful in locating better fishing grounds and consequently in reducing the searching time, consumption of diesel and also man-hours.

Interannual variability of chlorophyll concentration in the Arabian Sea using gis

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The Arabian Sea is one of the most productive regions of the world ocean. While the reason for the summer and winter blooms are known to a great extent, we do not yet understand the inter-annual variability. Using remote sensing data and GIS software, we analyzed the chlorophyll concentration, aerosol optical thickness, diffuse attenuation coefficient and sea surface temperature (SST) during the period 1998 to 2008. The study showed a strong inverse correlation between chlorophyll and SST. To understand the inter-annual variability in upwelling, the annual mean chlorophyll pigment concentration within the 26°C isotherm were analyzed. The result showed that though the chlorophyll concentration increased significantly during the study period; the area under upwelling did not show any trend. Interestingly, chlorophyll concentration during the June-August period did not show any significant trend, while during September-October and November-March the linear trend line showed a significant increase. This clearly showed that it was not increased upwelling that resulted in the increase in chlorophyll. The increased chlorophyll during November-March must be due to increased winter cooling and convection while that during September-October must be driven by dust input as inferred from increase in the aerosol optical thickness.

Phytoplankton size-spectrum from remote sensing by sequential data assimilation

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The size spectrum of phytoplankton biomass is an important indicator of structure and function of the pelagic ecosystem. Thus far we have made only limited progress to recover phytoplankton biomass partitioned into sizes of individual cells from remote sensing. Here we present a method for estimating phytoplankton size-spectrum from remote sensing. We develop a dynamic size-structured model for phytoplankton and nutrient in the oceanic mixed-layer, and apply the model to extract biomass fractions of phytoplankton at discrete sizes. General relationships between cell size and bio-physical processes (such as sinking, grazing and primary production) of phytoplankton have been implemented in the model through a bottom-up approach. Sequential data assimilation has been implemented to derive the model trajectories from a chlorophyll time series obtained by remote-sensing. Phytoplankton size spectrum is calculated over a period of 9 years. We demonstrate that the seasonal means of phytoplankton size spectrum are related to those of mixed-layer depth, nutrient concentration and observed chlorophyll. The results derived have important implications in the context of size succession, phytoplankton blooms, and time-dependent biomass flux in pelagic ecosystems.

Validation of pfz advisories along the Ganjam coast of Orissa, east coast of India

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The growing concern over the livelihood of the fisher folk vis-à-vis government of Orissa is well illustrated. The need of the hour is the proper implementation of the PFZ advisories, the state-of-the-art remote sensing technology in the entire coastal districts of Orissa.

Potential fishing zone (PFZ) advisories received from the Indian National Center for Ocean Information Services (INCOIS), Hyderabad during November 2003 to February 2004 were validated along Ganjam coast. Feedback was collected for both the PFZ and non-PFZ locations in the prescribed format of INCOIS. The feedback contains the date of fish catch, time of hauling, latitude, longitude, name of the ship or boat, type of net used, depth of catch, distance away from the coast, direction, catch in kg, major catch in kg and major variety. The catch per unit effort (CPUE) is computed by dividing total fish catch by number of hours of actual fishing per haul. Then, the CPUE data were compared for both PFZ and Non-PFZ area.

Results reveal that the CPUE is more in boats operated in PFZ areas than non-PFZ areas in all the sectors of Ganjam coast. In Rushikulya base, the CPUE is more in February 2005 followed by December 2004. The CPUE is the maximum in January 2005 in Gopalpur Harbour, Gopalpur and Sonepur sectors. The average catch per unit vessel in PFZ areas has been computed month-wise. The catch shows more or less similar trends at all stations. However, in Gopalpur, the catch seems to be the maximum.

Search time analysis for boats operated in notified and non-notified areas reveals that the search time is less where the PFZ advisories were utilised. It is concluded that the fishermen take more time to search the fish school without utilizing the PFZ advisories. In fact, the fishing hour is also more, followed by less catch, for boats operated in non-notified areas.

An operational use of remote sensing and marine-GIS for sustainable fisheries and aquaculture

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This paper discusses key issues of global concern for the sustainable use of fisheries and aquaculture resources. Satellite remote sensing, marine-GIS for fisheries and aquaculture have been developing operational uses, required for sustainable development and management. We demonstrate the case studies for capture fisheries of Japanese common squid, skipjack tuna and Japanese scallop aquaculture. TOREDAS (Traceable and Operational Resource and Environment Data Acquisition System) provides fishermen with fishing ground forecasts and helps them to gather geo-locations of each fishing fleet through the function of VMS (Vessel Monitoring System), which is very important tool for sustainable fisheries management. Using VMS data, we examined the behavior of fishing activities for optimum fisheries operation. Sustainability of scallop production is influenced by the change of environmental condition through the impact on climate change. In this study, to model the potential impact of climate change on the scallop aquaculture, we carried out two steps of analyses: 1. the suitability of sites for Japanese scallop aquaculture using integration of remote sensing and marine-GIS and 2. the climate change impacts through increasing sea surface temperature (SST) values. These prediction models show that climate change has a detectable impact on the development of scallop aquaculture through changes of their suitability areas.

Environmental monitoring with the topaz forecasting system

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The TOPAZ forecasting system is run on a weekly basis in the north Atlantic and Arctic. TOPAZ currently produces 10-day forecasts of temperature, salinity, and currents. Surface temperature, sea surface anomalies as well as ARGO profiles are assimilated in the model. The system will be upgraded to include a coupled bio-physical model and the coupled operational system is planned to be ready for demonstration in 2011. Methods for assimilation of satellite-derived chlorophyll are also under development, optimally combining the heterogeneous information coming from the model and the observations. The system will provide 3-dimensional fields of nutrients and phytoplankton in addition to the physical fields. Such analysis and short-term forecasts of the primary production will become increasingly useful to environmental agencies for monitoring algal blooms and fish habitats. Physical ocean variables alone represent valuable information for fisheries, as they influence their growth conditions. For Norway, an important issue is the possible movement of fish populations following the sea-ice retreat from the Norwegian Arctic to the Russian Arctic, having diplomatic implications. Here we will present the forecasting system, the coupled biological physical model and assimilation system for chlorophyll. Possible applications for fisheries science and monitoring will be presented.

Medium-scale interannual costal dynamics in a northwest Atlantic area (Galicia, northwest Spain): analysis of oceanographic satellite data (czcs, seawifs and avhrr)

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Coastal management is one of the main challenges of spatial planning and the sustainable use of natural resources in the Galician region. A suitable management strategy needs a wide knowledge of oceanographic processes taking place in the coastal ecosystems, as well as quick and affordable methods for their monitoring. The current report offers a preliminary approach to the study of the coastal dynamics, but from a new perspective, using a time-series of satellite images, and general linear models (GLM) that were used to adjust oceanographic data matrixes allowing the observation of differential behaviors of each variable in relation to the area and season, as well as the detection of long-term general trends.

The study covers the marine area comprised by the Seno de Corcubión (NW Galicia) Images used for this study were acquired with oceanographic sensors: coastal zone colour scanner (CZCS), sea-viewing wide field-of-view (SeaWiFS) and advanced very high resolution radiometer (AVHRR) for the period 1984-2004. These images provided information about the variables: surface temperature, chlorophyll concentration, and turbidity, extracted through a mesh of 85 points, distributed among 4 sub-areas. Moreover, multispectral images (Landsat and Spot) were used for an overall characterization of water masses, allowing for the subdivision of the study area in homogeneous sub-areas.

In addition, time series of agricultural use, burnt area and rainfall in the watershed flowing into the study area were collected. Relationships between oceanographic variables and terrestrial drivers were evaluated using GLM.

Relationship between climate change and shrimp fisheries in the Gulf of California (Mexico) and adjacent areas

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Climate change has the potential to cause severe economic impacts to the fishing industry. Specifically, changes in precipitation and temperature are important factors in this global change. To infer whether the shrimp fishery off the Mexican coast of the Pacific Ocean is affected by climate change, we generated a database of total, artisanal and industrial catches from 1994 to 2008 for San Felipe, Bahia Magdalena, Mazatlan and Sonora. These data were compared to SST (AVHRR) and chlorophyll *a*, CDOM, PIC, POC, $R_{rs}412$ and $R_{rs}490$ (SeaWiFS) as indicators of climate change. We used PCA, trend, factor and cluster analysis to evaluate this relationship. Results show that SST was associated with shrimp catches with the exception of Sonora. Trend analysis showed that only in San Felipe did catches and SST have clear increases with time. In this area, SST is positively correlated with shrimp catches; this can be explained because warm waters with low variability help reproduction, nursery and larvae survival. San Felipe can be classified as the location with the greatest sensibility to climate change.

Identification of biologically productive zones along the Pacific coast of Colombia

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The Pacific coast of Colombia is an area with high levels of ecological inter-connectivity and complex oceanographic features. We identified spatial and temporal patters of sea surface temperature (SST) front formation over a six-year period from 2003 to 2008 using monthly 4 km level 3 SST data from Moderate Resolution Imaging Spectroradiometer (MODIS) sensor from the NASA earth observing system (EOS) satellite. SST data were analyzed using Cayula-Cornillon edge detection algorithm to identify thermal fronts. Two zones of persistent and intense fronts were observed, one near the coast in the northern region and another far from the coast. Both were observed in the first two trimesters (December-February, March-May). The third (June-August) and fourth (September-November) trimester exhibited very less persistent fronts near the coast and along the southern coast respectively when compared to the other months. Thermal fronts were present in all months except August. Wind data from QuikScat satellite suggest that wind may be a driving force for the formation of these fronts. Frontal regions are demarked where possible pelagic fish aggregation is expected. Preliminary comparison show that the identified thermal fronts coincides with the industrial fishing fleet activities in the region.

A comparative study on pre-monsoon inherent bio-optical properties of estuarine and coastal waters of Cochin

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Monitoring the optical properties of coastal and estuarine waters could provide diagnostic information on the ability of local waters to transmit sunlight to planktonic, macrophytic and other submerged vegetation for photosynthesis. The present study deals with the spatial patterns of bio-optical properties of the coastal and estuarine waters of Cochin during the pre-monsoon period. A total of 4 stations were studied in Cochin estuary, between 9°55' N and 76°14' E, and 9°58' N and 76°18' E. The Four stations sampled in coastal waters are situated in between 9°54' N and 76°05' E, and 9°59' N and 76°15' E. Profiles were obtained for remote sensing reflectance, net flux irradiance, water temperature, chlorophyll *a*, salinity and photosynthetically available radiation (PAR). Remote sensing reflectance was obtained using a hyperspectral radiometer. The environmental parameters, such as temperature, salinity, dissolved oxygen, pH, turbidity, secchi depth and chlorophyll *a* were also estimated for surface waters. The relationships of PAR to chlorophyll, CDOM to chlorophyll and turbidity to net downward irradiance have been analyzed. In coastal waters, the CDOM values were found to vary between a mean value of 1.45 ppb l^{-1} and 18.73 ppb l^{-1}. The coastal chlorophyll *a* mean profile hyperspectral downcast ranged in between 1.11 μg l^{-1} and 25.94 μg l^{-1}. The highest CDOM value recorded in estuary was 14.63 ppb l^{-1} while lowest was 7.87 ppb l^{-1}. The estuarine chlorophyll mean profile hyper spectral downcast corresponded to a maximum of 213.84 μg l^{-1} and a minimum of 0.06 μg l^{-1}.

The application of satellite remote sensing for assessing productivity and fisheries yields of the worlds large marine ecosystems

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In 1992, the world community of nations convened the first global conference of world leaders in Rio to address ways and means to improve the degraded condition of the global environment (UNCED 1992). Ten years later at a follow-up World Summit on Sustainable Development (WSSD), world leaders agreed in 2002 to a Plan of Implementation for several specific ecosystem-related targets including: achievement of substantial reductions in land-based sources of pollution by 2006; introduction of the ecosystems approach to marine resource assessment and management by 2010; designation of a network of marine protected areas by 2012; and the maintenance and restoration of fish stocks to maximum sustainable yield levels by 2015. More recently in Copenhagen 2009, world leaders agreed to non-binding actions to reduce emissions of greenhouse gasses. Now in 2010, the international community of maritime nations is pursuing solutions for recovering depleted marine fish stocks, restoring degraded habitats, and controlling pollution, nutrient overenrichment, ocean acidification, conserving biodiversity and adapting to climate change. The recovery effort has become global in scope and ecosystems oriented in approach, leading to applications of advanced technological methods for applying time-series metrics to measure the effects of management actions to improve global environmental conditions. Among the many technologies available to the marine science community, the application of satellite remote sensing is gaining support as a unique approach in the new methodologies for measuring spatial and temporal environmental conditions of the worlds 64 Large Marine Ecosystems (LMEs). Applications of satellite remote sensing technology to support management practices in the worlds LMEs are described in relation to an emerging international movement for assisting economically developing nations to plan and implement ecosystem-based projects to restore and sustain goods and services annually contributing an estimated $12.6 trillion to the global economy.

Synergistic analysis of signatures of satellite-derived ssha, sst and chlorophyll for the exploration of fishery resources

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The study comprised synergistic analysis of signatures of chlorophyll concentrations (CC), sea surface temperature (SST) and sea surface height anomaly (SSHa) derived from IRS-OCM, NOAA-AVHRR and Topex/Poseidon-Altimeter, respectively. The images were compared and prominent meso-scale features like eddies were delineated and monitored. Spatial profiles of selected areas were generated to understand the patterns of variability in distribution of each variable, their persistence and interrelationship. SSHa data in ASCII format were derived from raw data using BRAT (basic radar altimetry toolbox) software to generate spatial spectra of SSHa. Simultaneously, spatial spectra of same tracks of synchronous chlorophyll and SST were generated. It was observed that spectra of SST and SSHa are co-varying in many cases, while chlorophyll and SST spectra are inversely related. The waters of areas of negative SSHa were consist of high CC and relatively low SST. From this observation, it can be inferred that negative SSHa areas consist of nutrient rich dense water and can be used as an indicator of enhanced biological production sites. Fishing operations statistics were procured from the Fishery Survey of India, Mumbai. Catch contours were generated from the respective monthly catch data. High to medium catch contours were found with respect to peak spectra of chlorophyll and declined spectra of SSHa and SST. The vice-versa patterns of spectra were observed in areas of poor catch contours. Chlorophyll and SST features are found persisted for days to weeks while SSHa signatures of respective features persisted for longer duration. Chlorophyll and SST are subject to short term variability while SSH anomalies are less subjected to short period variability. Hence, Altimeter derived SSH can be used as an index of long-term variability along with SST and CC to characterize living marine resources habitat in the off shore waters. This study will improve our understanding of interrelationship between the oceanic variables to develop the methodology for long term potential fishing zones (PFZs) forecast.

Evolution of ocean colour radiometry: the role of the IOCCG

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Satellite ocean-colour radiometry (OCR) measurements were first recorded by the CZCS sensor, which operated from 1978 to 1986. Oceanographers quickly realised the enormous potential of the data which permitted unprecedented views of the global ocean, allowing a better understanding of the role of the oceans in biogeochemical cycles. CZCS laid the scientific background for the new generation of ocean-colour sensors launched in the late 1990s, after an unfortunate 10 year gap in the ocean-colour data record. Around this time the International Ocean Colour Coordinating Group (IOCCG) was established to help ensure future continuity of the OCR data stream, as well as to serve as a communication and coordination channel between the agencies providing the data and the global user community. For over a decade now, the ocean-colour community has enjoyed a wealth of high quality, global satellite ocean-colour data from a number of different sensors. Much has been accomplished with this time series of ocean-colour observations especially in the field of climate change and global warming studies (examples will be given). However, current satellite instruments are all past their planned mission lifetimes, and future missions capable of providing high quality, global ocean-colour datasets are still a few years away. This is one of the issues currently being addressed by the newly-formed IOCCG ocean colour radiometry-virtual constellation (OCR-VC) which aims to prevent further gaps in the ocean-colour data stream. Other issues addressed by scientific working groups of the IOCCG include technical requirements for global-scale, operational and scientific OCR missions, remote sensing of ocean colour in coastal waters, binning and merging OCR datasets, ocean-colour algorithms (including atmospheric correction algorithms), and societal benefits of ocean-colour technology. New technologies are also being addressed by IOCCG working groups, including the placement of bio-optical sensors on Argo floats for calibration/validation purposes, and ocean-colour observations from a geostationary platform. Another important role that the IOCCG has played in the ocean-colour arena over the past decade is that of broadening the user community for OCR data through advanced training courses, workshops, news bulletins and websites.

Impacts of the Indian Ocean dipole on major pelagic fish species on the southwest coast of India

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The Arabian Sea is the most biologically productive oceanic zone of Indian Ocean. The biological productivity which fisheries exploit varies in relation to oceanographic conditions that change inter-annually, as well as inter-seasonally, due to climatic events like the Indian Ocean dipole (IOD). Among the major oceanographic parameters, the variability in both temperature and salinity has an effect on oil sardine, mackerel, anchovy and tuna landings; these species being the dominant pelagic fish species of the southwest coast of India. The relative impacts of the IOD, associated with the global climatic event ENSO, on SST and sea surface salinity of the eastern Arabian Sea during the period 1991-2008 have been analysed along with the upwelling patterns of the southwest coast of India. During October, the peak phase of the IOD, SST showed a positive anomaly during positive IOD events and a negative anomaly during negative IOD events. Sea surface salinity showed a decrease during positive IOD events. During the decade 1991-2000, the IOD and ENSO events were strong and frequent. The magnitude of the dipole mode index was very high from 1991 to 1997 and was normal from 1999 to 2008. The upwelling index showed an opposite trend when compared to DMI. During 1991 through 1997 the upwelling index was very low compared to the years 1999 to 2008. The oil sardine and tuna landings showed significant correlations with DMI.

Impact of the 2004 earthquake on the coral environs using remote sensing and gis: a case study of north Sentinel Island, Andaman

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The Andaman and Nicobar Islands are the largest Archipelago system in the Bay of Bengal associated with the fringing coral reefs, with a biodiversity of about 200 coral species. The study area is the North Sentinel Island of approximately 470 ha. The data from the Advanced Wide Field Sensor (AWiFs) onboard the Indian Remote Sensing Satellite (IRS) Resourcesat-1 satellite were acquired for the dates: December 11, 2004 and January 04, 2005, representing the pre- and post-tsunami periods, respectively. These data sets were geometrically corrected to a common projection system using a reference image and necessary radiometric corrections. The eco-morphological classes were extracted using appropriate digital classifications techniques. These eco-morphology layers pertaining to the pre- and post-tsunami were integrated and overlaid to estimate the spatial and temporal changes. The results show that 96.5% of the total reef area was exposed, causing degradation after tsunami. The main cause was the uplift of the area due to the tectonic effect induced by the December 26, 2004 Sumatra earthquake, causing large scale destruction of the coral environs, thus affecting the biological production of the region. Live coral environs are one of the spawning grounds for the fishes, thus the coral degradation can be attributed to the reduction in the fish stock and species heterogeneity due to resulting poor fish recruitment. The remote sensing and GIS techniques used in the study precisely demonstrate the spatio-temporal changes in the coral environs.

A multi-band ratio scheme for the detection and monitoring of algal bloom events in the Arabian Sea

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A multi-band ratio scheme is developed for the detection and monitoring of the algal bloom events in the open ocean using MODIS Aqua. The main objective of the study is to develop a bloom index (BI), with real-time satellite data, on operational basis to build a regular monitoring system for red tide waters. Two reported bloom events dated February 20-March 11, 2004 and March 1-7, 2003, in the northeastern Arabian Sea (NEAS) and southeastern Arabian Sea (SEAS), respectively, were selected for the study. The methodology included the visual analysis of false and true colour composite (FCC and TCC) images for qualitative preliminary analysis. Six BI models, which are different band combinations of remote sensing reflectance (R_{rs}), water leaving radiance (L_w) and normalized water leaving radiance (nL_w), at wavelengths: 443, 488, 531, 551 nm, along with satellite-derived chlorophyll and its anomaly were evaluated. The result shows that BI using R_{rs} fails to discriminate between bloom and non-bloom waters. The BI models having band combinations of 443, 531 and 551 nm performs better in the detection of bloom waters. In addition, it was found that the chlorophyll data is not an ideal proxy for algal blooms in case II waters. Application of this algorithm for the development of a species specific detection scheme is a future prospect of this study.

Monitoring the bloom of *Enteromorpha* (Ulvophyceae, Chlorophyta) using satellite remote sensing in the Yellow Sea

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Enteromorpha is a widespread filamentous Cholorophyte and is frequently observed in eutrophic waters where it can produce large nuisance blooms. These blooms can have detrimental effects on fishery, macrofauna, macrophytes and may threaten sustainability. Vast green algae blooms invaded the Olympic venue in China during June and August 2008, drifting from the Yellow Sea to the eastern coastal city (Qingdao). The first recorded Ulvophyceae bloom in China was recorded in summer 2007. This study introduces research on Remote Sensing monitoring of *Entermorpha prolifera* by satellite, using information on distribution, coverage area and path on the Yellow Sea. Further applications in bloom monitoring will also be briefly discussed.

Oceanographic preferences of bigeye tuna (*Thunnus obesus*) in the southern Indian Ocean, Java-Bali, Indonesia

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Bigeye tuna promises high economic value for Indonesian fisheries. This tuna species is commonly captured by long-liners in the Indian Ocean and southern Java-Bali. The aim of the research is to better understand bigeye tuna abundance and distribution based on its oceanographic preferences in the Indian Ocean and southern Java Bali.

Bigeye tuna catches were derived from logbooks of the operational long-line fishing industry within the research area. The data set encompasses a two-year period (2005-2006). Sea surface temperature (SST) and sea surface chlorophyll *a* concentration (SSCC) which encompasses the same period for bigeye tuna data were derived from MODIS Aqua/Terra sensors. Sea surface height anomaly (SSHA) from merged altimetry satellite data were derived from AVISO. Subsurface temperatures at 200 m depths from Argo float observations were derived from CORIOLIS. Bigeye tuna GPS plot data were overlayed with oceanographic variables at the same period. A generalized additive model was applied to explain relationships among bigeye tuna abundance and observed oceanographic variables.

The statistical model indicates that SSHA was the most significant oceanographic variable that influenced the bigeye tuna distribution. Bigeye tuna distribution in the Indian Ocean, southern Java-Bali occupies a range of between -5-18cm of SSHA. Although other oceanographic variables did not show statistical signifigance, bigeye distribution occupies a range of between 24°C-31°C of SST, 0.02-2.5 mg m^{-3} of SSCC and 14.2°C-17.70°C of subsurface temperature at 200 m depth.

Contribution of remote sensing and *in situ* data in fishery ecosystem management in the San Matias Gulf, Argentina

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The San Matias Gulf, located in northern Patagonia on the southern Atlantic Ocean, is the second largest gulf in Argentina, with an area of around 20, 000 km^2. One of its main characteristics is the presence of abundant biological resources of fishing interest, in particular, the Argentine hake (*Merluccius hubbsi*). This gulf presents different environment scenarios generated by physical, weather and topographic conditions that influence the behavior and productivity of this resource. The identification and characterization of these scenarios, with the objective of linking the environmental and the biological fisheries data, has been the main task of multidisciplinary studies carried out since 2004. Temporal series of SST maps obtained from AVHRR sensors, chlorophyll *a* maps from SeaWiFS, and data from a bottom trawl fishing fleet, where analyzed. This procedure generated two main results. The first showed that in spring-summer a thermal front divides the gulf into two regions: the northern region, with higher temperatures and lower chlorophyll *a* concentration; the southern region had the opposite pattern. The second indicates a strong association between the dynamics of the bottom trawl fleet and the position of this thermal front. Both results are important inputs for designing measures to achieve the implementation of a fishery ecosystem management framework for the San Matias Gulf.

Developing a bayesian network to relate *in situ* measurements to satellite remote sensing surface observations for estimating primary production and fisheries potential

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Bayesian networks offer a practical method for discovering probabilistic information in databases and for building models for predictive applications. In this poster we introduce probabilistic graphical models (Bayesian networks) as a data mining technique for inferring the relationships between the sub-surface vertical distribution of phytoplankton and surface oceanic/atmospheric variables of the southern Benguela upwelling region. We describe the process of using Bayesian techniques to derive the structure of a network using an archive of over 3,900 *in situ* sub-surface profiles of chlorophyll *a* related to corresponding remote sensing observations of ocean colour, sea surface temperature and wind. The Bayesian network is then used to "predict" the most likely subsurface chlorophyll structure of the water column from daily remote sensing observations. To evaluate the skill of the model in predicting chlorophyll profiles, the network is tested on a subset of data excluded from the training set. To improve the skill of the model, a dynamic Bayesian network is proposed that is more suited to capture the temporal structure of the upwelling and relaxation cycles. This method can then be linked to a primary production light algorithm, to estimate daily primary production for each pixel for an ecological region. These in turn can be used to estimate fisheries potential of large marine ecosystems.

Using bayesian networks to estimate primary production and fisheries potential from a combination of satellite surface remote sensing and *in situ* observations in the Benguela upwelling region

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The strength of Bayesian networks and methods is in extracting probabilistic relationships among variables from a synergy of real-world data and expert knowledge. Here we introduce Bayesian networks as a data mining technique for learning the relationships between the sub-surface vertical distribution of phytoplankton and surface ocean/atmospheric variables. We first train the network using surface remotely-sensed surface data of ocean colour, sea surface temperature and wind only. Then over 3900 recorded chlorophyll profiles around the west and south coast of South Africa are related to geo-referenced and concurrent remotely-sensed surface data. Also included with each profile is the season, location and bottom depth (a proxy for distance offshore). This database is then used to learn the relationships between each of 16 clustered profile categories and the suite of environmental variables. The resulting Bayesian network can then be used to predict the most probable profile for each pixel of remotely sensed data and provide insight into the strengths of dependent relationships encoded in the network. Here we develop an intuitive Bayesian network structure from our understanding of the cause and effect physical and biological processes involved in primary production. A companion poster describes the method in more detail. The next stages will be to use the monthly predicted chlorophyll profiles for each pixel to estimate light fields, primary production and fisheries potential for the Benguela large marine ecosystem.

The rocky research to operations transition of ocean color – what's fisheries got to do with it?

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The aim of the SAFARI project is to accelerate the assimilation of earth observation data into fisheries research and management on a global scale by facilitating the application of rapidly evolving satellite technology. An aim which assumes that these data sources will be available in the future. However, for ocean colour data, that assumption unfortunately may not be true, and of the many types of satellite data (i.e. sea-surface temperature, sea-surface height, ocean colour and surface vector winds) ocean colour data is inarguably the most important to fisheries. The current ocean colour sensors, SeaWiFS, MODIS-Aqua, and MERIS, are all operating beyond their planned end of life. While the US has been the leader for ocean colour data, that is not likely to continue; the next US ocean colour sensor to be launched, VIIRS on NPP in 2012, is not expected to deliver science-quality data. While the research community is cognizant of the value of satellite ocean colour data and the need for continuity in these measurements, advocacy from the operational community, particularly fisheries management, has been lacking. The absence of an easily identifiable operational need for ocean colour data is largely responsible for the forthcoming gap in the continuity of US ocean colour.

Coastal upwelling along the coast of southern Sri Lanka during the southwest monsoon for the period 2003 to 2007

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MODIS aqua data for the period 2003 to 2007 has been used to explore possible coastal upwelling areas around southern Sri Lanka during the southwest monsoon. Ocean colour and sea surface temperature (SST) derived from MODIS data for the waters surrounding Sri Lanka are studied to understand the variability and the relationship of the two data sets. MODIS level-2 data were mapped within an area of latitudes between 2.0°N and 13.5°N and longitudes between 72.5°E and 88°E. The southwest monsoon arrives roughly in May and generally lasts till September. The chlorophyll concentration varies between 0.01-10.0 mg m^{-3} (even higher values in some coastal waters) and SST varies between 24°C and 33°C in the waters surrounding the island during the year. The monthly composites of chlorophyll *a* show high productive waters of over 5 mg m^{-3} average concentration in most of the southern coastal ocean during the months of June through August. SST drops by 2-3 degrees (centigrade) in coastal ocean waters in the south where high chlorophyll concentrations are detected compared to surrounding waters. Chlorophyll and SST data indicate strong negative correlation (over 70% in most areas) between the two parameters in the southern coastal ocean regions where high chlorophyll and low SST values are detected. This may be due to the upwelling phenomenon that occurs in the coastal waters. Surface currents and thermal fronts in the region are also used in locating strong upwelling zones. Correct identification of upwelling zones would be highly beneficial in the countrys fishery industry.

Phytoplankton phenology on the Scotian Shelf

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The impact of physical forcing on seasonal and interannual dynamics of phytoplankton biomass is examined using SeaWiFS chlorophyll data, AVHRR sea-surface temperature data and climatology of hydrographic and nitrate data for the Scotian Shelf and Slope. The properties of spring phytoplankton bloom are characterized by fitting the chlorophyll data for a shifted Gaussian function of time, using a genetic algorithm. The rapid shoaling of mixed layer depth in Spring promotes the early spring bloom on the middle Scotian Shelf and Slope, when the averaged light in the mixed layer reaches 15 W m^{-2}. The duration of the spring bloom is prolonged in the Slope Water, such that there is a discontinuity in bloom duration between the shelf and slope water masses. The position of the duration front is correlated with that of the shelf-slope front in the sea-surface temperature (r = 0.96). The amplitude of spring bloom is correlated with the nitrate inventory in the surface layer at the end of the winter (r = 0.87). The position of the shelf-slope front influences the interannual variability of bloom characteristics.