IRI INTERNATIONAL RESEARCH INSTITUTE FOR CLIMATE PREDICTION

Linking Science to Society

WORKSHOP ON

Interannual Climate Variability and Pelagic Fisheries

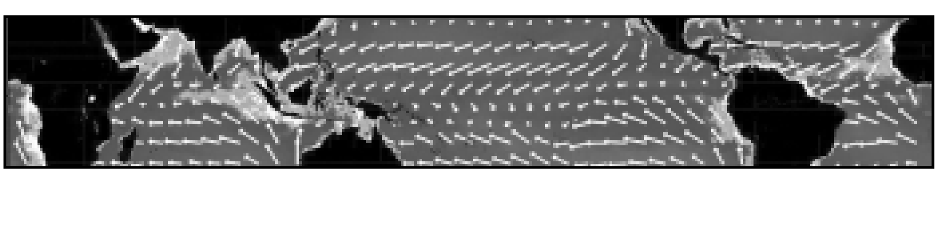
Nouméa, Nouvelle Calédonie
6th – 24th November 2000

Co-organized with
IRD

Additional support from
IOC, NASA, GLOBEC, NOAA/OGP, SPC

COLUMBIA UNIVERSITY

The figure on the front cover shows a sample of the global data that were available for the analyses carried out during the workshop. Shading indicates the distribution of surface chlorophyll (mg Chla/m^{3}*) observed by the SeaWiFS ocean color sensor (McClain et al., 1998). The superimposed vectors indicate the magnitude (m/s) and direction of near-surface winds extracted from the NCEP reanalysis dataset (Kalnay et al., 1996). The pictured fields are three-month means for the October-December 1997 period, which was the height of the 1997/1998 El Niño. Participants used interannual variability in such global datasets to provide physical and biological context for their regional environmental and fisheries data. Figure developed by Jerry Wiggert (ESSIC) building on an analysis carried out during the workshop.*



Report of the Workshop on Interannual Climate Variability and Pelagic Fisheries

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Published by the International Research Institute for Climate Prediction as Publication IRI-CW/01/3. This report and presentations showing the results of participants during the workshop may be found at http://iri.columbia.edu.

Report of the
Workshop on Interannual Climate Variability and Pelagic Fisheries

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6th - 24th November 2000

M. Neil Ward
Editor

Co-organized and co-sponsored with IRD (DIC/DME)
Institut de Recherche pour le Développement (Délégation à l'Information et à la Communication / Département Milieux et Environnement)

Hosted by IRD/Nouméa

With additional support from: IOC, NASA, GLOBEC, NOAA/OGP, SPC
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Preface

The IRI has now initiated a number of training courses and workshops aimed at building the capacity and advancing the multi-disciplinary framework that is needed for the application of seasonal climate forecasts and other modern climate information. In November 2000, the IRI joined with partners to organize the Workshop on Interannual Climate Variability and Pelagic Fisheries, which was hosted by IRD in Nouméa, Nouvelle Calédonie. The workshop was co-organized and co-sponsored with IRD, with further contributions from IOC, NASA, GLOBEC, NOAA/OGP and SPC. The workshop was attended by leading scientists interested in the interface between variability in the climate system, the marine ecosystem and the pelagic fishery. One aim was to provide opportunity to advance thinking on this challenging scientific problem, and the application of the scientific information in the sustainable management of pelagic fisheries. Of equal importance for the workshop, was the attendance by a number of young scientists and operational fishery scientists, who may be referred to as the trainee participants, though in many instances the level of knowledge was already extremely high in their own professional area. During the workshop, the trainee participants (i) were exposed to the current scientific understanding and debates, (ii) undertook some preliminary analysis of environmental and fishery datasets relevant to their research or professional operation, and (iii) were encouraged to think about ways in which improved knowledge of climate and pelagic fishery could improve the practical management of the pelagic fish resource.

Co-chair of the international steering committee, the workshop's success owes much to Yves Tourre. The members of the steering committee are thanked for their contributions to the planning of the workshop structure. The local organizing committee arranged for excellent facilities with auditorium and meeting rooms, workshop meals and student accommodation. The IRD/Nouméa Director provided for a number of memorable social events including trips to a local island and a local park. The availability of ten networked PCs (supplied together by IRD/Nouméa and SPC) for the practical work and the computer support personnel to solve technical problems was a key contribution. The IRI Director is thanked for his support of the workshop. Dr. Amy Clement, who attended under IRI sponsorship, prepared introductory statistical analysis material and played a key role in assisting trainee participants with their analyses during the workshop. On site secretarial support from Jacqueline Thomas and from Maria Salgado and Sandy Vitelli during the planning stages at IRI is also greatly acknowledged. Overall, the workshop seems to have left many with warm memories and enthusiasm for the scientific challenges.

M. Neil Ward
Editor

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The Workshop Organization, Structure, and Aims

The Workshop on Interannual Climate Variability and Pelagic Fisheries was hosted by the Institut de Recherche pour le Développement (IRD)/Nouméa, Nouvelle Calédonie, during the period November 6th - 24th, 2000. It was co-organized by the International Research Institute for Climate Prediction (IRI) and IRD, with the help of a Local Organizing Committee, and an International Steering Committee. Workshop activities took place in the facilities of IRD/ Nouméa, who together with the Secretariat of the Pacific Community (SPC), provided a network of 10 personal computers for the practical analysis component of the workshop. The members of the Local Organizing Committee and International Scientific Steering Committee are listed in Annex I.

The workshop was attended by science lecturers at the cutting edge of their disciplines and trainee participants who were active in scientific aspects related to fisheries management. Some were young research scientists at scientific institutions, while others were professionals involved with fishery management. Though referred to as the trainee participants, many already had detailed knowledge in their own professional area and were aiming to benefit from broadening their knowledge on the impact of climate on fishery. Most of the 20 expert lecturers were present for one or two weeks of the workshop, while a few were present for the whole period. All 20 trainee participants and one observer were present for the full three weeks. During most of the mornings of the first two weeks, expert lecturers made presentations on the spectrum of knowledge that contributes to better understanding the link between climate and pelagic fish. Most examples were taken from the Pacific, although some examples were also provided for the Atlantic and Indian Oceans for comparison. During most of the afternoons of the first two weeks, and for most of the third week, trainee participants formed small teams to analyze data on climate and pelagic fish, interpreting the results in the light of the scientific lectures.

The goals of the workshop were:

- To review (i) our ability to model and observe the climate system and the marine ecosystem as it relates to pelagic fisheries; (ii) the evidence for climate impacts on marine ecosystems and fish populations; (iii) the use of climate information in fisheries and ecosystem models.
- To identify methodological and theoretical gaps in current knowledge and explore the possibilities for resolving them.
- To conduct analyses which apply the principles covered in the workshop to specific cases and evaluate results in relation to the needs of fisheries management.

There were two distinct training objectives within the workshop, depending on the background of each participant. This is because participants were involved in either scientific aspects of operational fishery management or pure research:

(i) For those participants oriented more toward operational fishery management, the goal was to provide an overview of current understanding of the climate impact on fish stock variability and explore how to quantify that impact with a view toward better incorporating climate information within operational decision making in fishery management.

(ii) For those participants who were emerging researchers in the field, the goal was to provide the overview of climate and fishery science so that the scientist became equipped to undertake further research addressing the key science questions that will lead to further improvements in the incorporation of climate information into fishery management.

A further broad objective was to contribute to building a network of regional scientists and fishery managers better aware of climate and its potential role in marine ecosystem variability. It was also intended for the expert science lecturers to benefit from the multi-disciplinary interaction during the workshop and that this interaction would assist in identifying the key scientific questions to be addressed by research in the near future. There is already evidence of the workshop having contributed to the development of new research and collaborations among climate, marine ecosystem and fishery scientists, both in universities and more operational government institutions.

Attending the Workshop

The trainee participants were selected on the basis of their application statements, their experience and their qualifications. The requirements included:

- Minimum academic qualifications of a university degree or equivalent experience in a relevant discipline. Participants will include scientists with experience ranging from pure research to active involvement in fisheries management.
- Applicants must have academic and/or professional background in climate (especially oceanography) and marine ecosystem sciences (especially related to fisheries).
- Applicants must be affiliated with a research, educational, or resource management institution (governmental or non-governmental).
- Applicants should be familiar with statistical methods like correlation and regression and concepts like hypothesis testing. In addition, participants also need to be familiar with the PC computing environment and data base management.
- Applicants need sufficient command of written and spoken English.

A list of the trainee participants is at Annex II. Expert lecturers were invited on the basis of their expertise in relevant fields and their interest in working at the interface of climate and fishery science (see Annex III).

Workshop Activities

A series of lectures were presented by leading experts in the fields of oceanographic and atmospheric sciences, physical and biological modeling, and relevant fisheries sciences (the full program is in annex IV). Lectures covered the following themes:
I: Global Climate Variability
II: Global Marine Ecosystem and Pelagic Fish Stock Variability
III: Fish Stock Management
IV: Monitoring the Global Ocean Marine Ecosystems

V: Climate, Marine Ecosystems and Fisheries Variability in the Pacific, Indian, and Atlantic Oceans
VI: Modeling the "Physical Environment - Marine Ecosystem" Coupled System

Though lectures fall into these themes, they were deliberately not presented sequentially. Thus each theme was broken into two or more parts during the workshop proceedings. The aim was stimulate thinking iteratively on climate and fishery issues. During the first few days, keynote lectures were presented covering the nature and causes of climate variability and fish stock variations. In addition, current methods for monitoring the climate and marine ecosystem, including fish stock, were presented. Keynote lectures also considered current approaches to fish stock forecasting, fish stock management, and institutional and social issues that such management raises. Further lectures presented detailed studies on the role of climate in the marine ecosystem, especially focusing on the Pacific Ocean. Simplified and complex simulation models of the climate and marine ecosystem variations were presented, including models suitable for forecasting future conditions.

After day 3, workshop trainee participants formed teams by region and/or common interest, and began analysis of data, applying the concepts that were being covered in the lectures. Participants worked closely with the multi-disciplinary team of expert lecturers to consider how to use available climate data, and shared regional experiences with each other. The analyses were undertaken using a variety of software, with CLIMLAB2000 (Tanco and Berri, 2000) forming a central tool for basic statistical analysis of climate and its relation to other environmental and social data. Basic statistical analysis using CLIMLAB2000 was taught by Dr. Amy Clement. This included principles of data distributions, hypothesis testing, univariate and multivariate correlation and regression analysis. Participants also made use of EXCEL for data manipulation and some graphics. In addition, some advanced statistical software was introduced by expert lecturers, including the Generalized Additative Models (extensions of the Generalized Linear Models) and made use of by some trainee participants using SPSS. CLIMPROD (Fréon et al. 1993) was also demonstrated and applied to identify possible uses of climate information in fishery management.

Toward the end of the second week, each team presented preliminary findings to all participants and lecturers, and gained feedback for finalization of the project work during week three. Formal presentations were made at the end of week 3 by each team using powerpoint software (see Annex V).

Data Employed

Climate Data - Global Sources
Some large scale climate datasets and indices are available within the CLIMLAB2000 software package itself. Many of these were utilized for the workshop projects. These included global sea-surface temperature (SST) at 2 latitude by 2 longitude resolution for 1950 to present (Reynolds, 1988), and various climate indices, such as the Southern Oscillation Index and the North Atlantic Oscillation Index.

Participants were also instructed on how to use the IRI data library to access and create indices for various atmospheric fields from the NCEP/NCAR reanalysis project (Kalnay et al. 1996). Particularly relevant to the project work were the fields of near surface winds and surface stress.

Local climate and oceanographic data
Participants brought with them a range of locally measured climate and environmental data relevant to fishery, obtained as part of field studies or ongoing monitoring projects. These included upwelling indices, ocean turbulence estimates, local rainfall and local temperature.

Global marine ecosystem data
A range of marine ecosystem data is available through global data sources on the internet. One of the key contributions to the workshop was the SeaWifs satellite data of ocean color (McClain et al. 1998). Many projects included comparisons between this satellite data and local data observations of ocean productivity.

Local marine ecosystem and fishery data
Participants brought with them a variety of data on features relevant to fishery. These included landing data, fish catch per unit area, total biomass, spawning biomass estimates and recruitment estimates.

It was emphasized that for participants to fully gain from the workshop, it was necessary for them to prepare for the practical part of the workshop in advance and bring appropriate digitized datasets. Participants responded to this request and their project work was able to make a contribution to the analysis of the complex climate fishery relationships that exist. By making preliminary analyses with the opportunity to discuss findings with some of the leading scientists in the field, the aim was for participants to learn much more than they would through a purely theoretical workshop. However, it is emphasized that most of the analyses made should be viewed as preliminary and exploratory, and the main aim was to empower participants to be able to continue with such research in a more comprehensive way after the workshop.

This section provides an overview of the project work undertaken by participants during the workshop. The powerpoint presentations created by the participants based on their work are in Annex V and further information on the work can be gained by contacting the authors, whose contact information is in Annex II.

Pelagic fisheries and environmental variability in the Southeast Asian seas

Penjan Rojana-anawat, Southeast Asian Fisheries Development Center, Thailand
Bambang Sadhotomo, Research Institute for Marine Fisheries, Indonesia
Abdul Ghofar, Center for Coastal and Marine Research, Indonesia

The aim was to identify the links (common and contrasting) between the pelagic fishery and environmental data in the Gulf of Thailand, the Java Sea and the Bali Straight. For example, Figure 1 compares Indo-Pacific Mackerel catch data for the Gulf of Thailand with local SST. The SST data are for the spawning period in the top panel, with the hypothesis that SST is a proxy for factors that impact relative recruitment. In the bottom panel, the SST data are for the fishing season itself, with the hypothesis that SST may be related to the relative abundance.

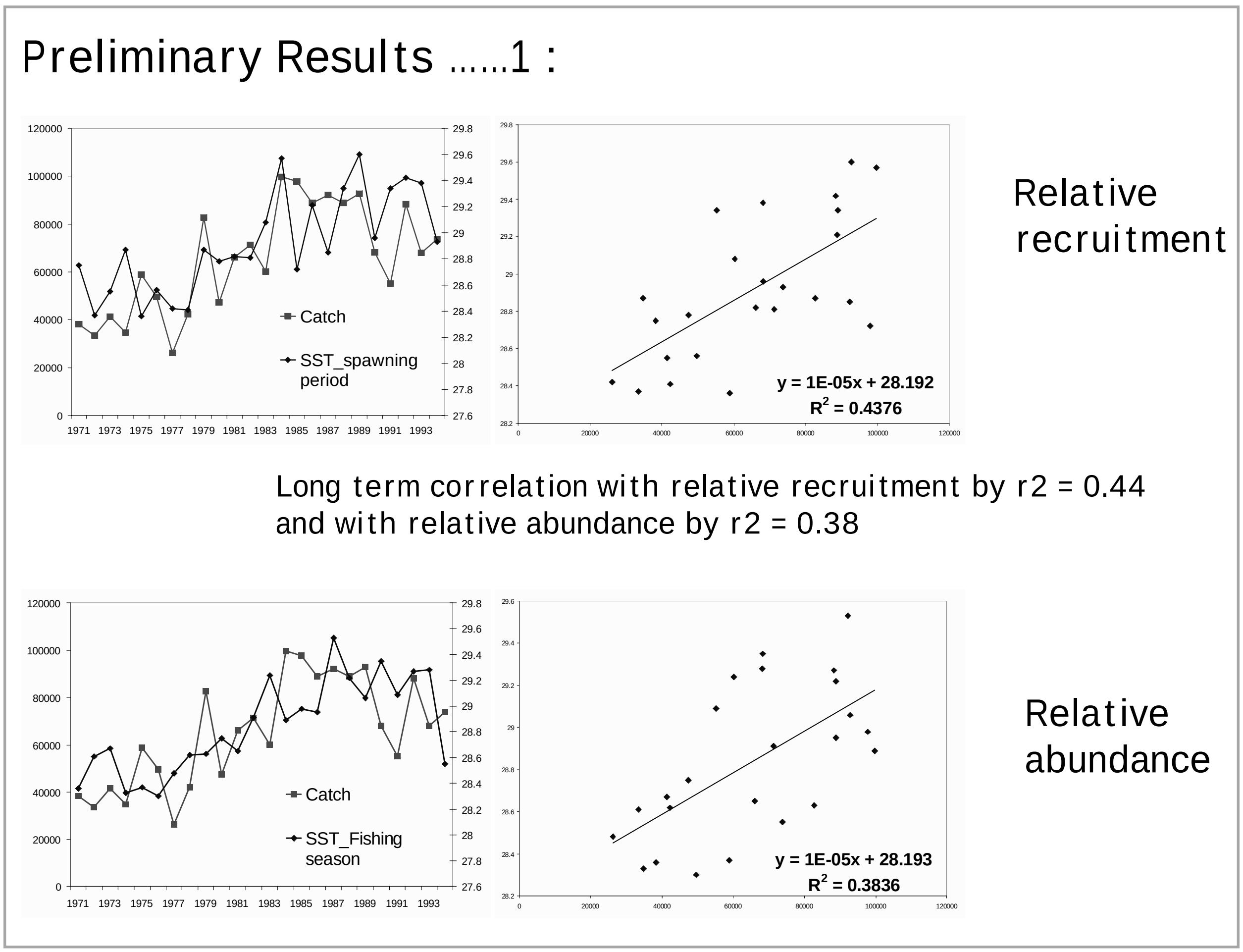


Figure 1. Studying the relationship of fish catch and local sea-surface temperature in the Gulf of Thailand.

The Bali Strait sardine fishery and climate variability

Abdul Ghofar, Center for Coastal and Marine Research, Indonesia

Strong and physically plausible linkages were identified between climate variables and data for sardine landings and fishing effort. Links were identified with the Southern Oscillation Index and, more strongly, with local near-surface zonal winds along the shore of Bali (Figure 2), the latter likely associated with upwelling in the region. There are no decadal trends in the variables used. The software CLIMPROD was applied to investigate the potential of using the climate linkages for management.

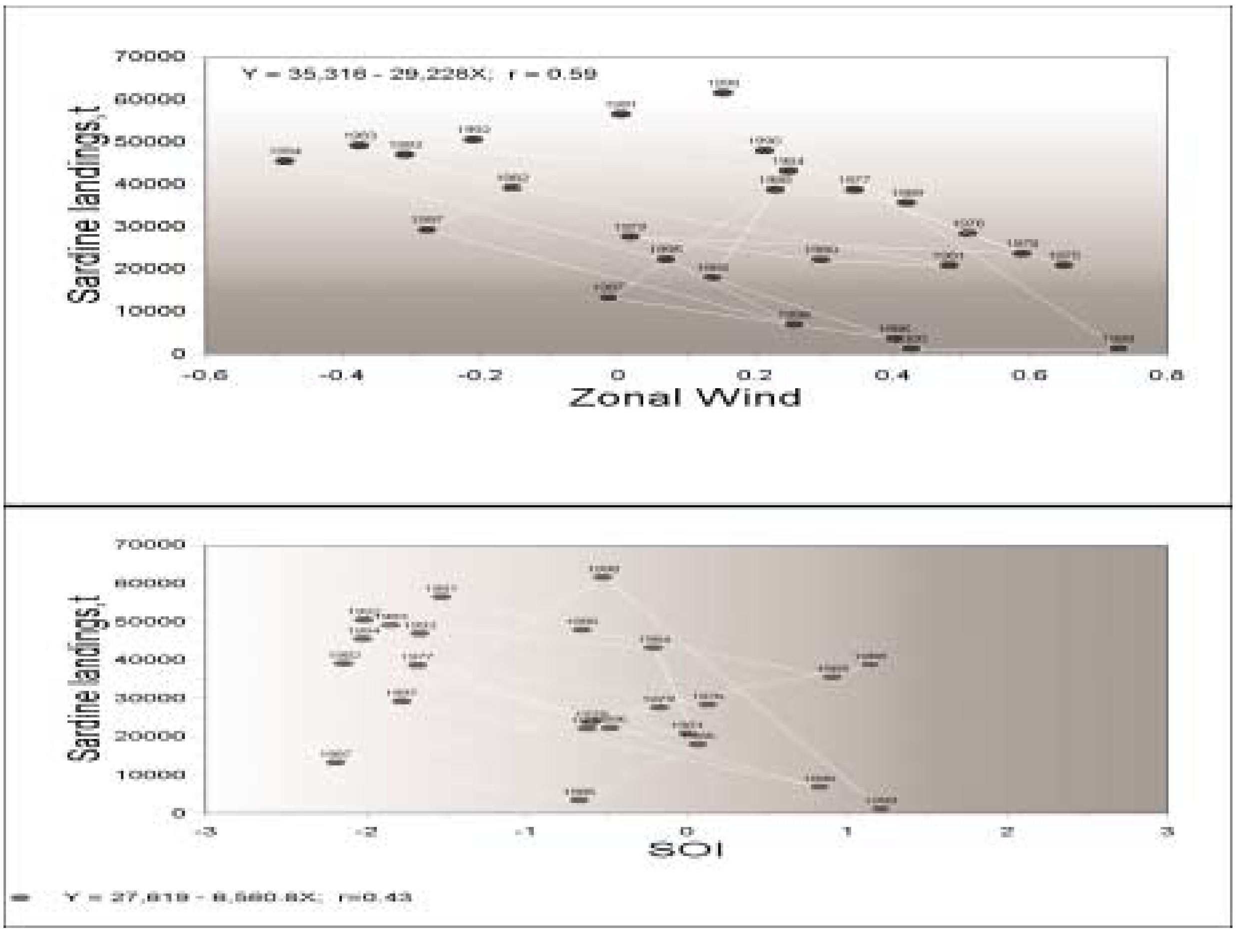


Figure 2. Studying the relationship of sardine landings in the Bali Strait with the Southern Oscillation Index (SOI) and a local near-surface zonal wind index.

Preliminary Study on the relation between chub mackerel (Scomber japonicus) and climate variability in the East China Sea

Richard H. J. Lu, National Taiwan Ocean University, Taiwan
Sukyung Kang, Pukyong National University, Korea
Jerry Wiggert, University of Maryland, USA

This study characterized decadal and interannual climate fluctuations in the East China Sea and compared these to fluctuations in chub mackerel stock and catch, and catch per unit area. Surface temperatures in the East China Sea are connected to the Pacific Decadal Oscillation (PDO) and the El Niño/Southern Oscillation (ENSO). During warm phases in the East China Sea, the fishery location appears to shift to the north. For Taiwan, a very strong negative correlation was found between fish catch and local SST indices, while for Japan, the relationship was reversed. The authors developed a hypothesis for interpreting the results, and it is shown schematically in Figure 3.

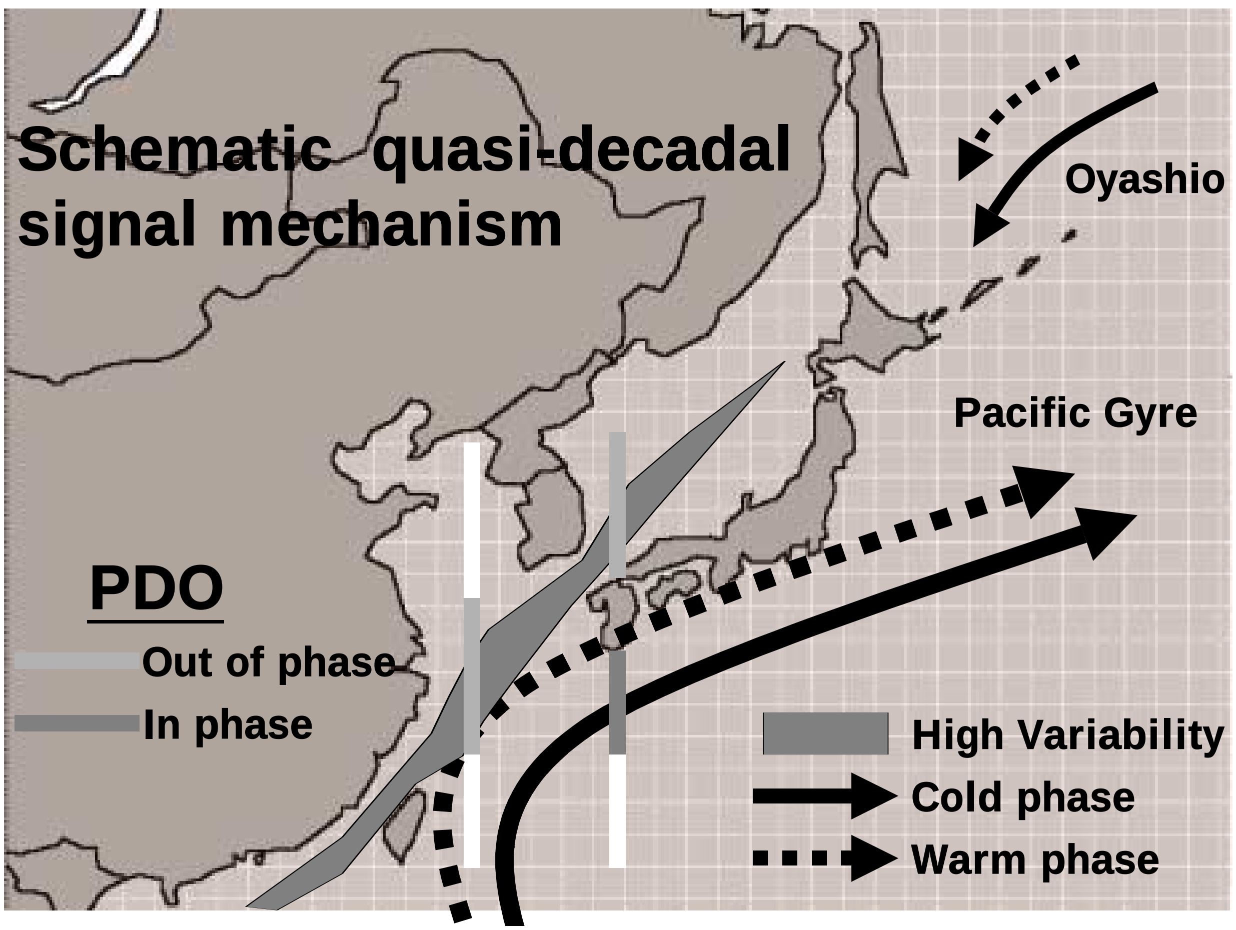


Figure 3. Developing a conceptual hypothesis to explain variations in regional fishery associated with the Pacific Decadal Oscillation (PDO).

TUPAS, Limited (Tuvalu, Papua New Guinea, and American Samoa)

Tupulaga Poulasi, Department of Fisheries, Tuvalu
Joel Opnai, National Fisheries Authority, Papua New Guinea
Christopher Evans, Dept. of Marine and Wildlife Resources, American Samoa

Data for a range of species were considered, including skipjack, yellowfin, bigeye tuna and South Pacific albacore. Being located within the heart of the ENSO phenomenon, very strong linkages of local climate to ENSO were demonstrated for each of the three study sub-regions. Despite the very strong year-to-year ocean-atmosphere variations associated with ENSO, establishing climate-fishery linkages using the available data proved difficult. For example, Figure 4 shows Papua New Guinea (PNG) total catch versus depth of the 15 degrees Celsius isotherm. Some lags in the relationships of several years were identified that require careful interpretation. A decrease in fishing activity during El Niño years was also noted, but this could also be related to socioeconomic factors.

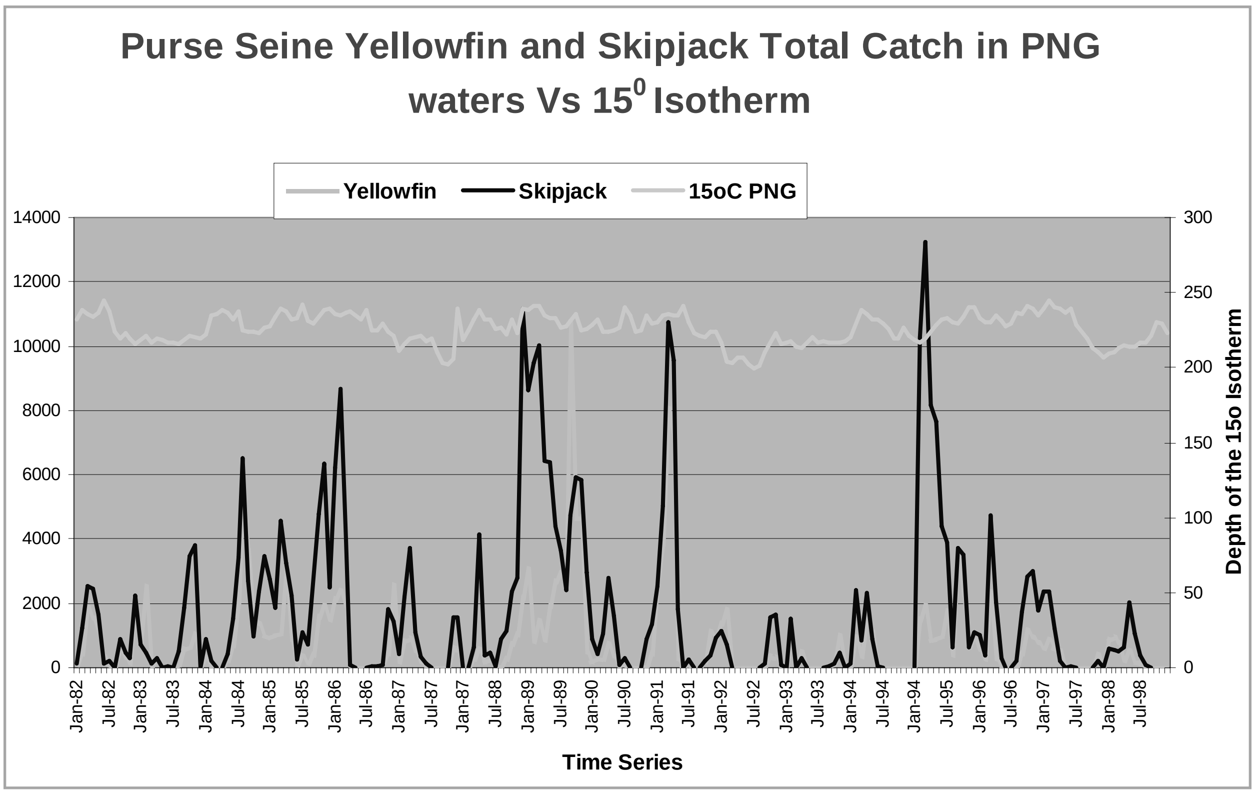


Figure 4. No clear relationship was found between the local depth of the 15^o Celsius isotherm and these sets of fish catch data for Papua New Guinea (PNG).

Exploring regime scale symmetry and synchrony of global climate and fisheries

Vera Agostini, University of Washington, USA
Georgi Daskalov, Institute of Fisheries, Bulgaria
Salvador E. Lluch-Cota, Centro de Investigaciones Biologicas del Noroeste, Mexico

This study employed a global perspective. It is known that there has been some synchrony amongst regional fish populations around the world. Given the near-global nature of some climate teleconnections, one hypothesis suggests the fish synchrony is at least partially a result of teleconnected climate forcing. Using data available at the workshop, the authors extended the analysis of the synchrony of fish populations. For example, they identified five ways in which species have varied over 1950-1998 (Figure 5). Low-pass filtering of maps of global tropics SST reveals decadal variations that match some of the fish population fluctuations.

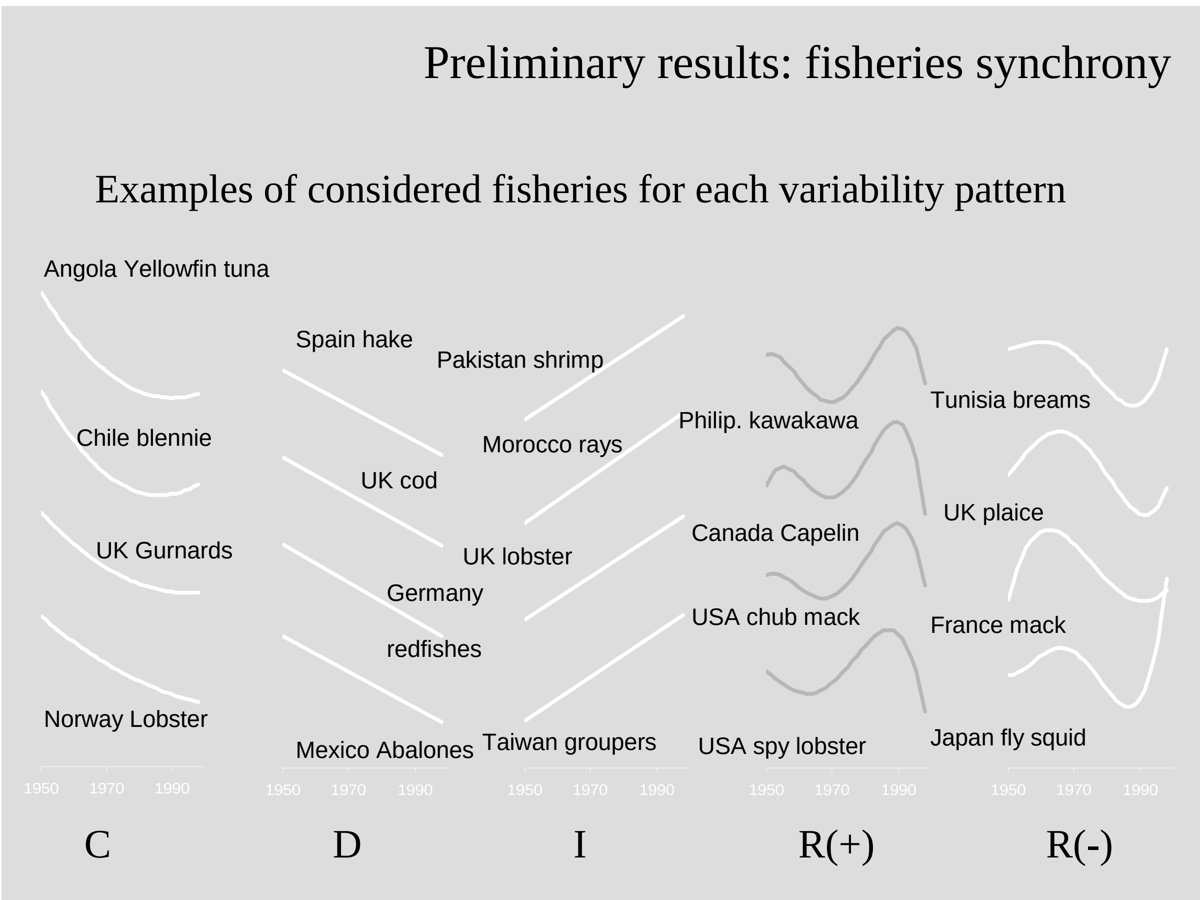


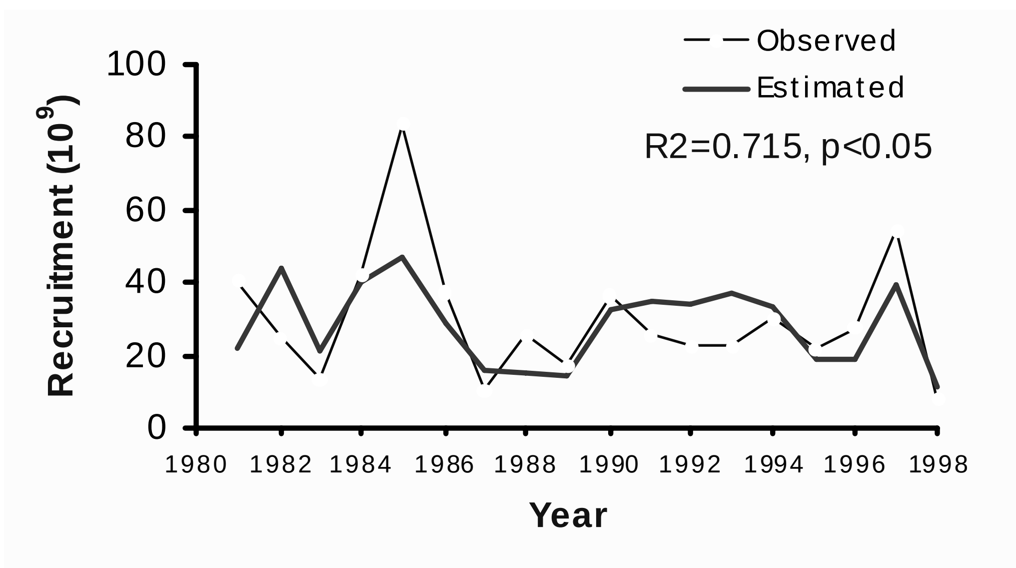
Figure 5. Finding common patterns in the variations of regional fish populations over the period 1950-1998.

Pelagic fisheries in Central-Southern Chile: recruitment, abundance and availability patterns related to environmental variability

Luis Cubillos, Instituto de Investigacion Pesquera, Chile
Rodrigo Montes, Universidad de Concepcion, Chile

The recruitment rate of anchovy and sardine appear to fluctuate inversely. It is hypothesized that environmental factors such as local SST, upwelling, rainfall and river runoff during the spawning and pre-recruitment phase are positively impacting the recruitment of one species and negatively impacting the other. Applying low-pass filters demonstrates that low-frequency (greater than several years) SST variations have accompanied low-frequency fish population variations. It is suggested that these changes may be driven by near-surface winds. For the recent period, models incorporating spawning biomass, local SST and turbulence predict well year-to-year recruitment for these species. For jack mackerel, it is postulated that catchability is associated with penetration of oceanic warmer waters toward the coastal zone. Indeed, year-to-year recruitment is well related to spawning biomass and the latitude of the 16 degrees Celsius isotherm (Figure 6).

•Jack-mackerel recruitment model (1980-1998):



Independent variables	Value	Std.Error	t-value	Pr(>|t|)
(Intercept)	2.793	0.282	9.916	0.000
Spawning biomass	-0.195	0.036	-5.468	0.000
Lat.Pos. 16°C	-0.004	0.001	-3.774	0.002

Figure 6. Studying the relationship of jack-mackerel recruitment to ocean temperature and spawning biomass.

Quantitative index of anchovy fisheries

Miguel Ñiquen, Instituto del Mar del Peru, Peru

The goal is to create a quantitative index describing the current state of the anchovy fisheries. The index might be used in a practical form by the Ministry of Fisheries for making fisheries management decisions. In order to create such an index, it is necessary to know how the range of potential fishery indicators are connected to fish abundance and catch. The first principal component (PC) of a range of anchovy and environmental variables was computed, to identify the leading way in which the variables are cross-correlated, and the time evolution of the leading mode (Figure 7). It suggests recruitment is a critical factor in determining the state of the fishery stock. The analysis was also repeated for sardine. The two quantitative indices for sardine and anchovy are clearly inversely related.

Nou3a1 - Anchovy - With only 6 variables and without landings

Data

Biom.Total

Recruitment

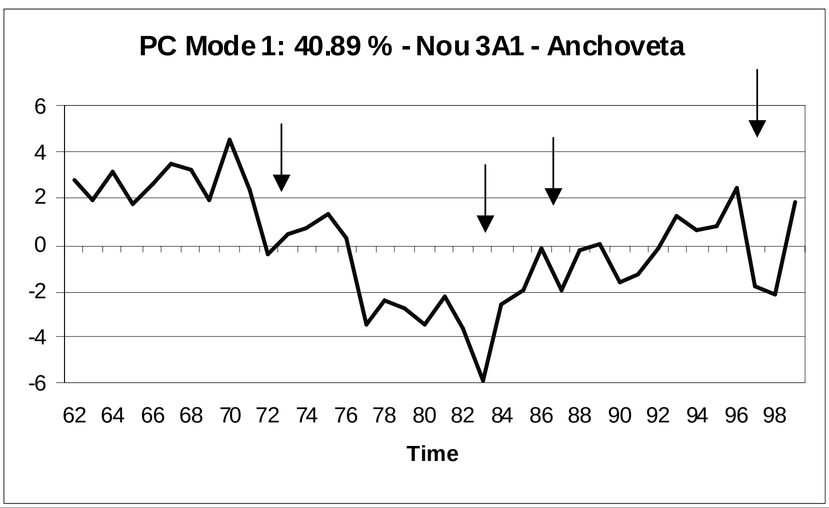
Anomalies

Upw. Index

S O I

% Anch

	Eigenvalue	Std. Error	Var. Exp.	Acum. Var
Mode 1	2.39	1.38	40.89	40.89
Mode 2	1.58	0.91	27.03	67.93
Mode 3	0.93	0.54	15.88	83.81
Mode 4	0.42	0.24	7.25	91.06
Mode 5	0.32	0.18	5.4	96.46
Mode 6	0.21	0.12	3.54	100



Determine 40 % in first component.

Incidence of EL Niño

3 regimes

Determines 68 % with 2 modes

Figure 7. The first principal component (PC) of six environmental and fishery variables creates a potentially useful monitoring index of the Peruvian anchovy fishery.

Climate variability and small pelagic fisheries in Northern Chile

Claudio Silva, Catholic University of Valparaiso, Chile
Eleuterio Yañez, Catholic University of Valparaiso, Chile

Relationships between sardine and anchovy fisheries and environmental variables were explored. Extensive use of the GAM (Generalized Additive Model) was made, where nonlinear regressions are fitted, here using the weighted local regression smoother called LOESS. This allows identification of optimal environmental windows for recruitment. Figure 8 shows examples for anchovies. Results indicate an optimum window for a near-surface time-mean windspeed of about 5.6m/s. For sardines, the results indicate a favoring for warm episodes, particularly associated with the interdecadal.

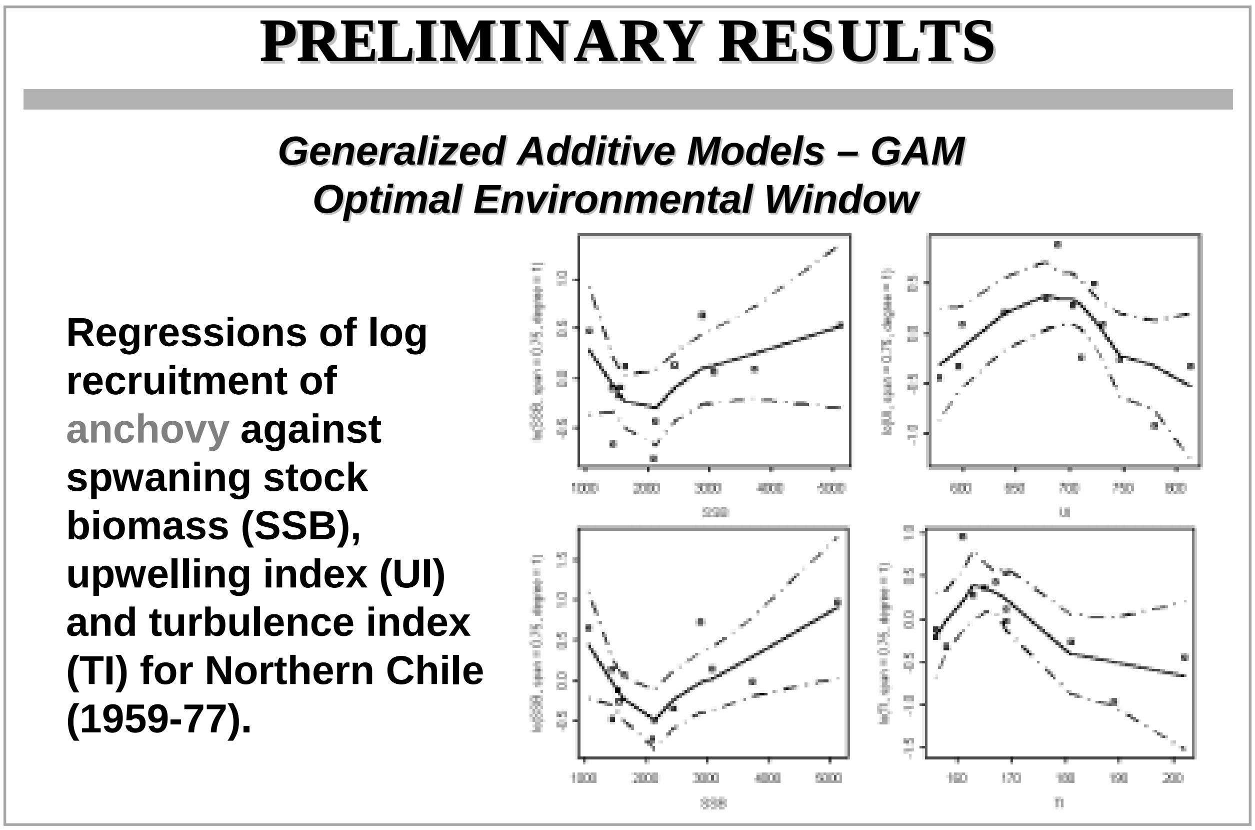


Figure 8. Applying the optimal environmental window concept to the study of anchovy recruitment off northern Chile.

Namibian sardine fisheries and its interaction with environmental conditions

Anja Kreiner, National Marine Information and Research Centre, Namibia
Dawid Mouton, Ministry of Fisheries and Marine Resources, Namibia

The sardine biomass off Namibia has declined dramatically since the mid-1960s (Figure 9). The aims were (i) to explore long term changes in environmental variables that may be connected to the decline and (ii) see if ocean color has an influence on the distribution of sardine in Namibian waters. The monthly SeaWiFS ocean color data were judged insufficient for this application. The results suggest that the near-surface wind data may hold the best promise as an environmental index related to the fishery.

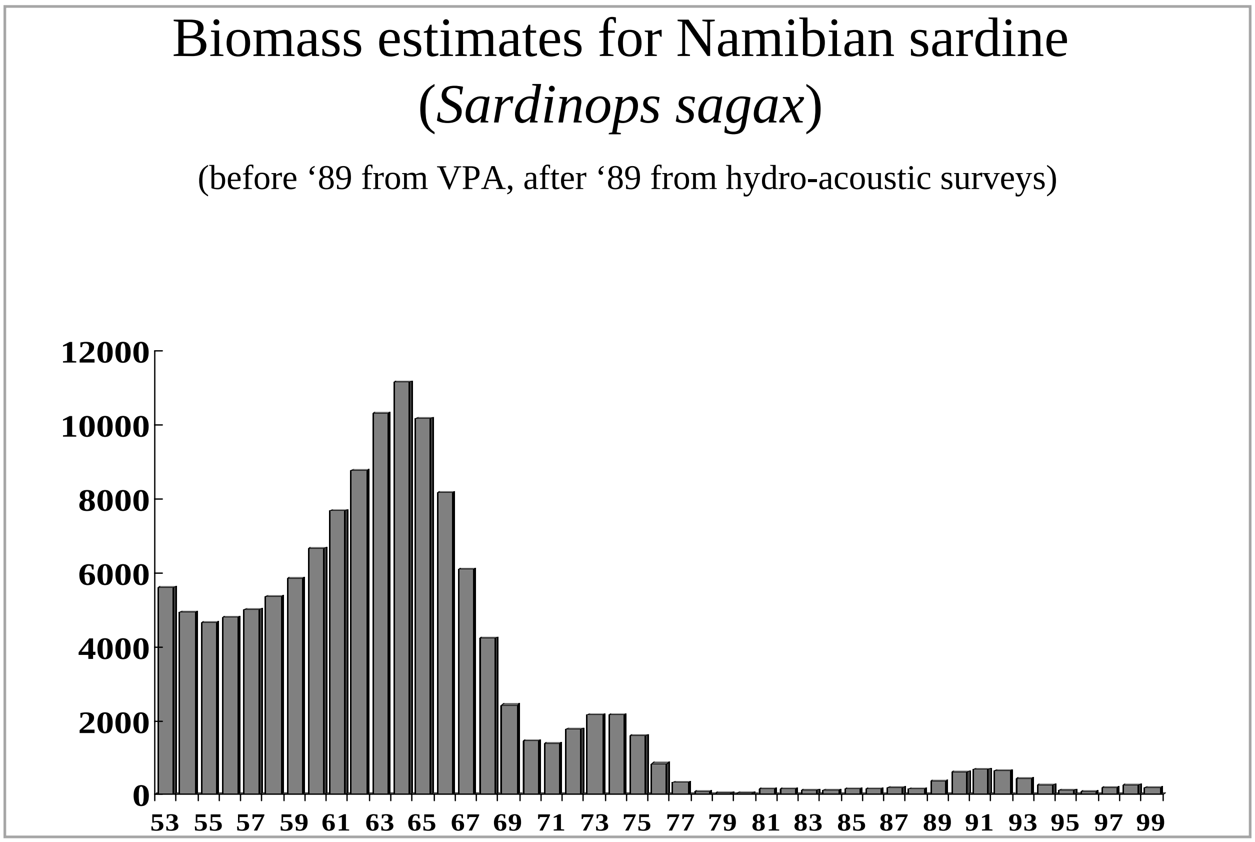


Figure 9. Explaining this fluctuation of the Namibian sardine was the project's aim.

North Atlantic Oscillation impact on primary productivity in the coastal Moroccan upwelling

Soukaina Zizah, Institut National de Recherche Halieutique, Morocco

The aim was to make progress in identifying the linkages between large-scale atmospheric circulation, regional and local SSTs off the coast of Morocco, near-surface local winds, local upwelling, ocean color data and fish catch landings. The leading mode of large-scale climate variability in the region is the North Atlantic Oscillation (NAO). A clear NAO impact on SST was found, strongest in the northern part of the region. Some agreement was found between upwelling index and chlorophyll concentrations, with both high in 1994 and 1995. High resolution cruise ship SST data led to the conclusion that such high resolution SST (higher than in CLIMLAB2000) is needed to detect the important coastal features. Despite physically plausible inter-correlation amongst environmental variables (e.g. the relationship between a local near-surface wind index and local upwelling index, Figure 10), no obvious relationship with fishery landing was found for the years with data available (1994-98).

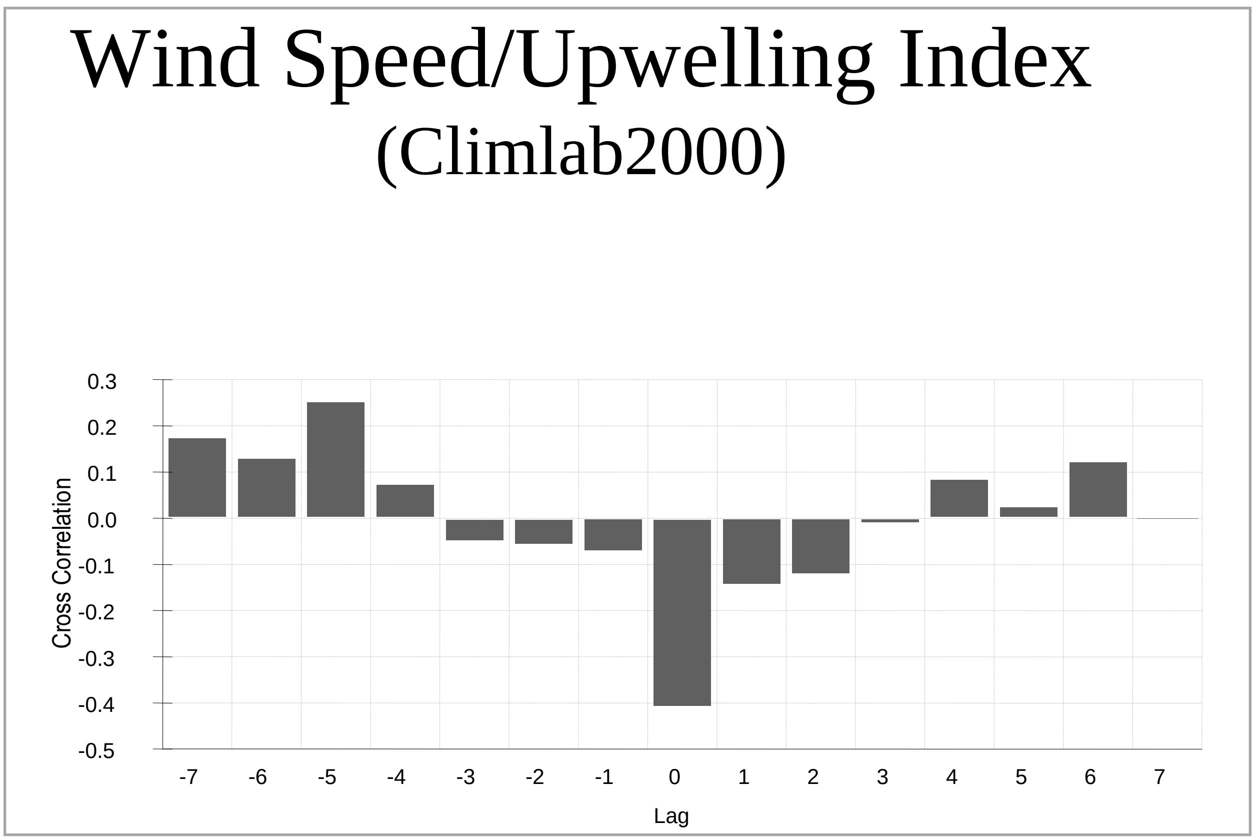


Figure 10. Studying the inter-relationship of environmental factors off the coast of Morocco.

Application of ocean color in fisheries research

Jerry Wiggert, University of Maryland, USA.

In collaboration with many of the other participants, the satellite based estimates of ocean color from SeaWiFS (1997-2000) and CZCS (1982-1984) were evaluated. The data potentially allow insights into seasonal distributions of phytoplankton biomass at fishery sites for real-time management. Here, the data are evaluated for their ability to capture seasonal and interannual variations in chlorophyll distribution, primary productivity, and fishery activity. For example, Figure 11 shows the annual cycle evolution of mean chlorophyll as estimated from SeaWiFS for the period Jun-Aug through Sep-Nov in the Java Sea/Bali Straight. The figure shows a general transition of chlorophyll (and, by inference, associated primary productivity) to the south of the island in Sep-Nov.

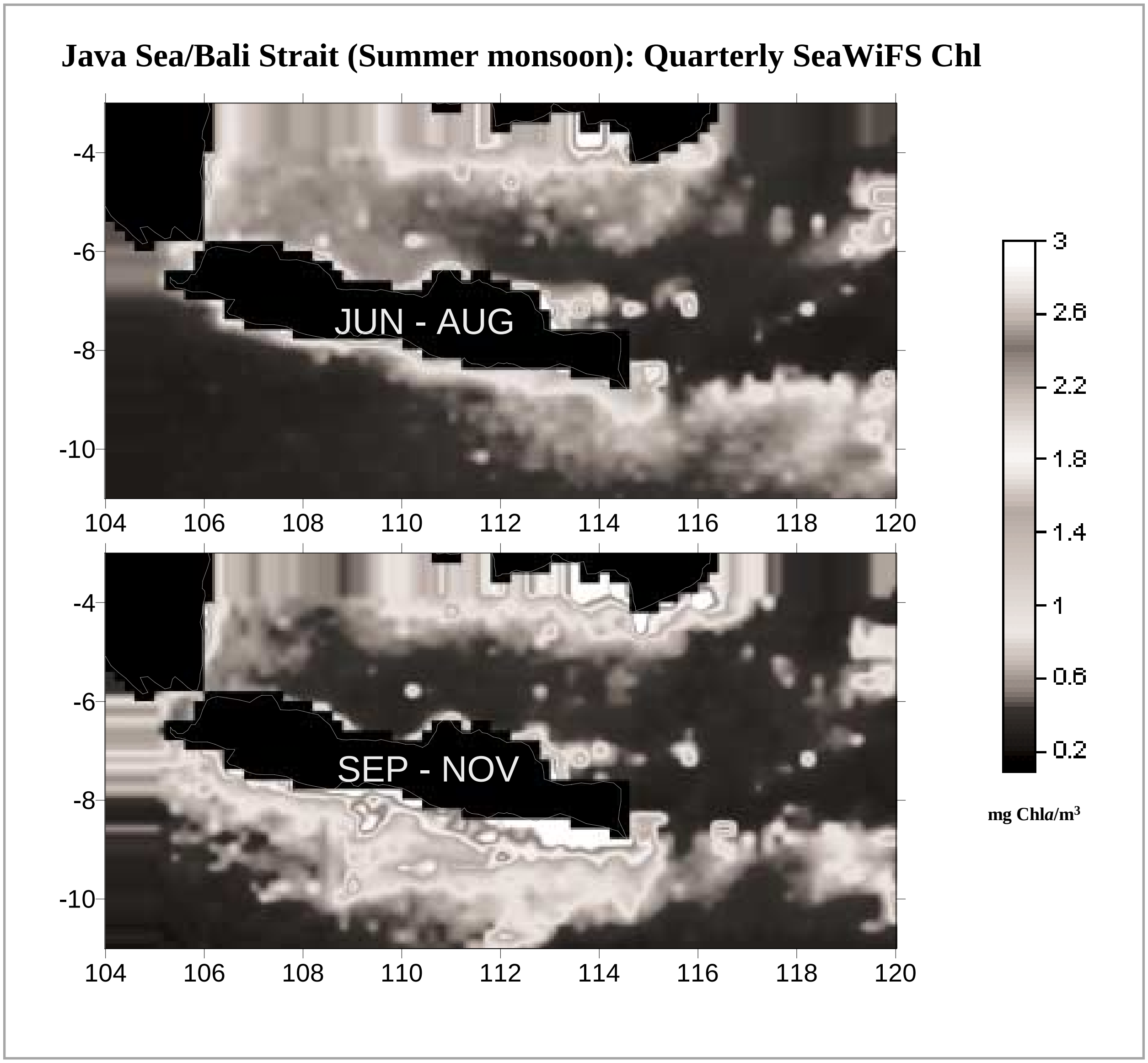


Figure 11. Studying variations in ocean colour as measured by satellite can provide information on environmental variables that impact fishery.

1. There is a need to better understand the ways in which interactions take place between climate, the marine ecosystem and the pelagic fish resource. This should continue to be undertaken through a mix of diagnostic analysis and modeling.
2. There is a danger of research seeking too many linear correlations in isolation. This approach has limited potential to answer fundamental questions because of the shortness of the historical record, and the loss of degrees of freedom in datasets with low frequency multi-year variability.
3. A more promising approach is to develop hypotheses based on theoretical expectations and test those hypotheses systematically using available data.
4. An alternative is to take the comparative study approach. That is, to consider ALL relationships across ecosystems and seek to identify common patterns. Such common patterns will give scientifically sound clues to processes.
5. The optimal window hypothesis implies that non-linear relationships between environment and fishery variables are to be expected. The GAM method is one potentially useful approach to identify the domes that indicate the optimal window for given variable(s).
6. The training component of the workshop can be viewed as a contribution to building a worldwide capacity to make the types of analyses described in 3-5.
7. There is a need for a data inventory to be available on the climate, marine ecosystem and fishery datasets that is either freely available, or available through collaboration. There should be a description of the strengths, weaknesses and potential applications of each data type.
8. Some discussion at the workshop encouraged further consideration of establishing an easy interface between the simple climate analysis software CLIMLAB2000 and the fishery software CLIMPROD.
9. In the context of seasonal to interannual climate predictions, discussion indicated that these were already being applied, especially in regions where the ENSO impact was very strong. For example, industries understandably use the information to catch more fish. Such responses are not necessarily helping with sustainable management, which may require specific studies.
10. For quantitative prediction of the marine ecosystem, in many instances there will be a need to downscale the ocean-atmosphere seasonal forecast to the critical scales at which climate and the marine ecosystem interact, often requiring high vertical resolution in the ocean mixed layer and high spatial resolution of the atmospheric climate forecast.
11. Discussion noted that if we understand climate-fish linkages, then monitoring of climate can allow us to anticipate marine ecosystem developments. The monitoring can be from a mix of local in situ measurements and satellite derived products, such as for high resolution SST and ocean color (e.g. SeaWiFS). Nonetheless, there is still the issue of how to use the information for sustainable management of fishery.
12. This raises institutional, socioeconomic and political questions. A first step can be to put the science in place so that we are confident of creating the information that can be potentially used for more sustainable management. Nonetheless, there is a need for parallel thinking on the ways in which available information can be integrated into a sustainable strategy for management of the worldwide pelagic fish resource. This is a challenge to international institutions and bodies, and international policy makers.

Fréon, P.; Mullon, C.; Pichon, G., 1993: CLIMPROD. Experimental interactive software for choosing and fitting surplus production models including environmental variables. FAO Computerized Information Series (Fisheries). No.5. Rome, FAO. 1993. 76p. ISBN 92-5-103335-8

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ANNEX I - Organizing and Steering Committees

Local Organizing Committee

Christian Colin (Director, IRD/ Nouméa)
Thierry Delcroix (IRD/ Nouméa)
Patrick Lehodey (SPC/ Nouméa)
Tony Lewis (SPC/ Nouméa)
Jacqueline Thomas (Direction Information et Communication, IRD/Nouméa)

International Steering Committee

Yves Tourre (Co-chair)
Neil Ward (Co-chair)
Joel Picaut (IRD Coordinator)
Kenneth Broad
Antonio Busalacchi
Philippe Cury
Michael Glantz
Michael Hamnett
Patrick Lehodey
Jacques Merle
Bruno Voituriez

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WEEK 1
Monday November 6th

9:00-9:15 Workshop Opening: C. Colin (IRD), L. Pangelina (SPC)

9:15-10:00 Workshop Background: Y. Tourre (IRI)
Mission and Structure of IRI: Y. Tourre (IRI)
Goals and Objectives of the Workshop: K. Broad (IRI)
Participants and Agenda : Y. Tourre (IRI)
Logistics: J. Thomas (IRD)

Theme I: Global Climate Variability
- Nature and Causes on Timescales of Seasonal to Interannual, Decadal and Multidecadal

10:30-11:45 The Ocean-Atmosphere Component of the Climate System: Y. Tourre (IRI)

11:45-12:30 Global Ocean Spatio-Temporal Variability: W. White (SCRIPPS)

Theme II: Global Marine Ecosystem and Pelagic Fish Stock Variability
- Nature and Causes

14:00-15:30 Pacific Tuna Fisheries: Overview and Variability: T. Lewis (SPC)

16:00-17:30 Response of Large, Mobile Fish Populations to Climatic, Biotic Changes: A. Bakun (IRD)

Tuesday November 7th

Theme I: Global Climate Variability (continued)
- Seasonal to Interannual (SI) Climate Prediction

8:00-11:30 Existing Capabilities in S-I Climate Prediction and Prospects for Future Development: N. Ward (IRI)

Theme II: Global Marine Ecosystem and Pelagic Fish Stock Variability (continued)
- Nature and Causes

15:00-16:30 World Small Pelagic Fisheries and Environmental Changes: Data Models and Hypotheses: P.Cury (IRD)

Theme III: Fish Stock Management

17:00-17:45 Climate Variability and Management of Marine Living Resources:
Part I-Defining the Issues: J.-P. Troadec

17:45-18:30 Part II-Fishing for Solutions: J.-P. Troadec

Wednesday November 8th

Theme IV: Monitoring the Global Ocean and Marine Ecosystem
- Methods and Real-time Availability of Data, and its Uses

8:00-9:30 Observing the Physical Ocean: W. White (SCRIPPS)

10:00-10:45 The MULTIFAN-CL Model (Fish Stock Mgt.): J. Hampton (SPC)

10:45-11:30 Overview of IRI Climate Library and IRI Website: Y. Tourre (IRI)

-participants move to computer room-
15:00-15:30 Familiarization of participants with computing facilities, software.

15:30-16:30 Statistics Tutorial - IRI Climate Data Library & IRI Website, Part I: A. Clement (LDEO)

17:00-18:30 Begin to formulate ideas for Workshop Projects

Feedback from each participant on what they have heard so far, and how their perceptions on what they can achieve from the workshop are evolving.

Thursday November 9th

Theme V: Examples of Climate, Marine Ecosystems and Fisheries Variability
- Focusing on the Relevant Ocean Features for Marine Ecosystems

8:00-8:45 ENSO signature in the Tropical Pacific Ocean: An Overview: T. Delcroix (IRD)

8:45-9:30 Equatorial Pacific Upwelling and EWPCZ Variability and Physical Mechanisms: J. Picaut (IRD)

10:00-11:30 ENSO and Tuna Fish: P. Lehodey (SPC)

15:00-15:45 Dominant Climate Signals in the Indian Ocean (Part I): R. Murtugudde (ESSIC)

-participants move to computer room-
16:00-16:30 Statistics Tutorial - IRI Climate Library & IRI Website, Part II: A. Clement (LDEO)

17:00-18:30 Continue Development of Workshop Projects

Friday November 10th

Theme VI: Modeling the "Physical Environment - Marine Ecosystem" Coupled System

8:00-8:45 Linking the Physical Climate and Marine Ecosystems: A Coupled Dynamical-Ecosystem Model - Part I: R. Murtugudde (ESSIC)

8:45-9:30 Linking the Physical Climate and Marine Ecosystems: A Coupled Dynamical-Ecosystem Model - Part II: R. Murtugudde (ESSIC)

10:00-10:45 Coupling "Ocean Dynamics - Ecosystems": L. Memery (LODYC)

10:45-11:30 SEPODYM - Spatial Environmental Tuna Population Dynamics Modeling: P. Lehodey (SPC)

-participants move to computer room-

15:00-16:30	Statistics Tutorial - IRI Climate Data Library & IRI Website, Part III: A. Clement (LDEO)
17:00-18:30	Continue Development of Workshop Projects

WEEK 2
Monday November 13th

Theme V: Examples of Climate, Marine Ecosystems and Fisheries Variability
- Focusing on the Relevant Ocean Features for Marine Ecosystems (continued)

8:00-9:30 Pacific Climate Variability and Pacific Upwelling Ecosystems: F. Chavez (MBARI)

Theme VI: Modeling the "Physical Environment - Marine Ecosystem" Coupled System (continued)

10:00 11:30 Population Dynamic Models Incorporating an Environmental Variable: Can we make it simple? P. Fréon (IRD)

15:00-16:30 Scale Issues and Physical-Biological Coupling: F. Chavez (MBARI)

17:00-17:45 Exploring the Influence of the Environment using Generalized Additive Models: P. Cury (IRD)

17:45-18:30 Discussion of Workshop Project Outlines

Tuesday November 14th

Theme V: Examples of Climate, Marine Ecosystems and Fisheries Variability (continued)
- Atlantic and Indian Oceans

8:00-8:45 Dominant Climate Signals in the Indian Ocean (Part II): R. Murtugudde (ESSIC)

8:45-9:30 Dominant Climate Signals in the Atlantic Ocean: Y. Tourre (IRI)

10:00-11:30 ENSO Impacts on Tuna Fisheries: F. Marsac (IRD)

15:00-18:30 Participants present workshop project outlines and initial results.

Wednesday November 15th

08:00-9:30 Comparative Study of Impact of Climate Variability on Small Pelagic Fish in the Atlantic and the Pacific. J. Alheit (Baltic Sea Research Institute)

Theme IV: Monitoring the Global Ocean and Marine Ecosystem (continued)

10:00-11:30 Tuna Database and Dissemination of Data-OFP Statistics: P. Williams (SPC)

15:00-18:30 Participants work on Projects

Thursday November 16th

Theme III: Fish Stock Management (continued)
- Incorporating a varying climate

8:00-8:45	Tuna Fisheries Typology versus Environmental Conditions (Atlantic and Indian Oceans): F. Marsac (IRD)
8:45-9:30	The IRI Project in Peru: K. Broad (IRI)
10:00-12:00	Open Discussion: "Management Based on ENSO Information". Discussion leaders: A. Bakun (IRD) and K. Broad (IRI)
15:00-18:30	Participants work on Projects

Friday November 17th

Theme V: Examples of Climate, Marine Ecosystems and Fisheries Variability (continued)

8:00-8:45	CLIMPROD - Environmental Variables in Surplus Production Models: P. Fréon (IRD)
8:45-9:30	Small Pelagics in Upwelling Systems: Patterns of Interaction and Structural Changes in "Wasp-Waist" Ecosystems: P. Cury (IRD)
10:00-11:30	Spatial Modeling in an Upwelling Ecosytem: Coupling a 3-D Hydrodynamic Model to an Individual Based Model and Recruitment Processes: P. Fréon (IRD)
15:00-18:30	Discussion of Participants' progress on their projects

WEEK 3
Monday November 20th

8:00-12:00 and 15:00-18:30 Project Work, Group Discussions.

Tuesday November 21st

8:00-12:00 and 15:00-18:30 Project Work, Group Discussions.

Wednesday November 22nd

8:00-12:00 and 15:00-18:30 Project Work, Group Discussions.

Thursday November 23rd

8:00-12:00 and 15:00-18:30 Project Presentations by Participants

Friday November 24th

8:00-12:00	Project Presentations by Participants
16:00- 16:45	Closing Ceremony: C. Colin (IRD)

ANNEX V - Results of Participants - Presentations

Pelagic fisheries and environmental variability in the Southeast Asian seas
http://iri.columbia.edu/outreach/training/course/noumea2000/html/p1.htm

The Bali Strait sardine fishery and climate variability
http://iri.columbia.edu/outreach/training/course/noumea2000/html/p2.htm

Preliminary Study on the relation between chub mackerel (Scomber japonicus) and climate variability in the East China Sea
http://iri.columbia.edu/outreach/training/course/noumea2000/html/p3.htm

TUPAS, Limited (Tuvalu, Papua New Guinea, and American Samoa)
http://iri.columbia.edu/outreach/training/course/noumea2000/html/p4.htm

Exploring regime scale symmetry and synchrony of global climate and fisheries
http://iri.columbia.edu/outreach/training/course/noumea2000/html/p5.htm

Pelagic fisheries in Central-Southern Chile: recruitment, abundance and availability patterns related to environmental variability
http://iri.columbia.edu/outreach/training/course/noumea2000/html/p6.htm

Quantitative index of anchovy fisheries
http://iri.columbia.edu/outreach/training/course/noumea2000/html/p7.htm

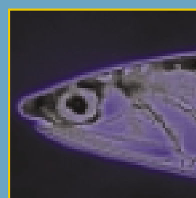
Climate variability and small pelagic fisheries in Northern Chile
http://iri.columbia.edu/outreach/training/course/noumea2000/html/p8.htm

Namibian sardine fisheries and its interaction with environmental conditions
http://iri.columbia.edu/outreach/training/course/noumea2000/html/p9.htm

North Atlantic oscillation impact on primary productivity in the coastal Moroccan upwelling
http://iri.columbia.edu/outreach/training/course/noumea2000/html/p10.htm

Application of ocean color in fisheries research
http://iri.columbia.edu/outreach/training/course/noumea2000/html/p11.htm

The IRI was established as a cooperative agreement between U.S. NOAA Office of Global Programs and Columbia University.



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