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ACP-EU Fisheries Research Initiative

Proceedings of the INCO-DC Conference
Placing Fisheries in their Ecosystem Context

Galápagos Islands, Ecuador, 4-8 December 2000

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Preface

The Galápagos Islands are the quintessential 'home' of the Darwinian concept of evolution, embracing, as it does, the notion of adaptation to the environment – the 'goodness of fit' of organisms in their ecosystem. Holding this conference on 'Placing Fisheries in their Ecosystem Context' in the Galápagos Islands was thus bringing the science of fisheries home to its ecosystem roots.

Here, the conference participants were exposed to near pristine ecosystems, not far removed from their state at the time of Darwin, reinforcing the notion of integrity of ecosystem as the basis of sustainability of life in all its forms.

The foundation of the conference was centred on the use of Ecopath modelling software, including the dynamic programme Ecosim and spatial module Ecospace, in ecosystem analysis. This suite of programmes has been developing, since its first conceptualisation by Jeffrey Polovina in 1984, up to the present time in parallel with the growing scientific opinion that fisheries management has to take into account the effect of fisheries on the ecosystems in which they are embedded. The Galápagos conference represents the state of the art of the software and its application.

Some thirty presentations were made during the five days of the conference, ranging from descriptions of exploited marine ecosystems in the Atlantic and Pacific Oceans to applications of ecosystem analysis to fisheries and ecosystem management.

This report consists of short summaries of all the presentations, and thus forms an encapsulation of the latest findings of and progress in placing fisheries in their ecosystem context. Many of the papers that were applied as opposed to descriptive in nature will appear in full in a special issue of the journal Ecological Modelling.

We take this opportunity to thank the European Commission, particularly the programme for international scientific cooperation with developing countries (INCO-DC) and the ACP-EU Fisheries Research Initiative, for the support through the INCO-DC Concerted Action ERBIC18CT97175 that led to the present report, and which made the conference possible. We also thank the staff of the organizing institutions, notably of the Charles Darwin Research Station without whose dedicated work the conference would not have come to fruition.

The Editors

ACP-EU Fisheries Research Report Series

The ACP-EU Fisheries Research Reports is a series of publications that aim to share information about the development of the ACP-EU Fisheries Research Initiative and findings generated in order to maximise the impact of its activities. It includes proceedings of workshops and meetings, statements on policy and research activities under the Initiative. An increasing number of these goes beyond the framework of ACP-EU bi-regional S&T cooperation, in line with the global nature of the issues at hand.

Abstract

This report presents the proceedings of a five day scientific conference on "Placing Fisheries in their Ecosystem Context", held on 4-8 December 2000, at the Charles Darwin Research Station, Puerto Ayora, Galápagos Islands. The conference was hosted by the Charles Darwin Foundation for the Galápagos Islands and co-organized by Instituto de Ecologia Aplicada, Universidad San Francisco de Quito, Ecuador; the Charles Darwin Research Station, Ecuador; and the North Sea Centre, Denmark. The conference as made possible through support from the European Commission's INCO-DC Concerted Action programme ERBIC18CT97175. The conference was based on the recognition that the sustainability of fisheries worldwide depends on the maintenance of the ecosystems in which they embedded. The negative impact of fisheries on ecosystems, and thus on the sustainability of both the fisheries and the ecosystems, is becoming more and more obvious and must be addressed. This conference brought together practitioners with experience in a wide variety of exploited marine ecosystems, having in common their use of the Ecopath suite of ecosystem modelling software.

There were some 30 presentations at the conference, covering aspects of ecosystem-based management of fisheries; impact of fisheries on ecosystems; comparative ecosystem analysis; and ecosystem structure and dynamics, as well as a series of discussions. The presentations, which investigated marine ecosystems in many parts of the Atlantic and Pacific oceans, were based on the Ecopath approach to ecosystem analysis and offered many insights into the nature of and trends in these ecosystems. The presentations also showed the utility of this approach in providing ecosystem-based management options for fisheries in a wide variety of situations.

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Table of Abbreviations

ACP	African, Caribbean and Pacific Countries entertaining development cooperation with the European Union in the framework of the Lome and Cotonou Conventions
CDRS	Charles Darwin Research Station, Galápagos Islands
CRODT	Centre de Recherches Océanographiques de Dakar-Thiaroye
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DIFRES	Danish Institute for Fisheries Research
EC	European Commission
ENEA	Ente per le Nuove Tecnologie, l'Energia e l'Ambiente, Italy
ENSO	El Niño southern oscillation
ETP	Eastern tropical Pacific
EU	European Union
EwE	Ecopath with Ecosim
GAM	generalised additive model
GDP	Gross Domestic Product
IATTC	Inter-American Tropical Tuna Commission
IBAMA	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis, Brazil
ICES	International Council for the Exploration of the Sea
ICRAM	Central Institute for Scientific and Technological Research Applied to the Sea, Italy
IEO	Instituto Español de Oceanografía, Spain
IOUSP	Instituto Oceanográfico, Universidade de São Paulo, Brazil
INCO-DC	International Cooperation in Science and Technology with Developing Countries
INVEMAR	Instituto de Investigaciones Marinas y Costeras, José Benito Vives de Andréis
IPN	Instituto Politécnico Nacional, Mexico
MSVPA	Multispecies virtual population analysis
MSY	Maximum sustainable yield
NMFS	National Marine Fisheries Service, USA
NWHI	North West Hawaiian Islands
P/B	Production/biomass
PPR	Primary production required
SBB	South Brazil Bight
S&T	Science and Technology
TL	Trophic level
UBC	University of British Columbia
UNAM	Universidad Nacional Autónoma de México, Mexico

Participants in the ACP-EU Conference: “Placing Fisheries in their Ecosystem Context”, Charles Darwin Research Station, Galápagos Islands, Ecuador, 4-8 December 2000.

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Executive summary

This report presents the proceedings of a five-day scientific conference on "Placing Fisheries in their Ecosystem Context", held on 4-8 December 2000, at the Charles Darwin Research Station, Puerto Ayora, Galápagos Islands, Ecuador under the auspices of the Charles Darwin Research Foundation, North Sea Centre, Universidad San Francisco de Quito, and Galápagos National Park, and made possible through support from the European Commission's INCO-DC Concerted Action ERBIC18CT97175. The conference was based on the premise that the sustainability of fisheries worldwide depends on the maintenance of the ecosystems in which they embedded. Fisheries science, as presently applied, does not embrace this concept. However, the negative impact of fisheries on ecosystems, and thus on the sustainability of both the fisheries and the ecosystems, is becoming more and more obvious. This conference brought together practitioners with experience in a wide variety of exploited marine ecosystems, who have used the Ecopath suite of ecosystem modelling software.

The presentations covered four areas: ecosystem-based management of fisheries; impact of fisheries on ecosystems; comparative ecosystem analysis; and ecosystem structure and dynamics. In the first, the use of Ecopath related to management of fisheries in Hawaii, the Northeast Atlantic, and Pacific and Atlantic coasts of Mexico was reported. These presentations showed the utility of Ecopath as a base for assessing management options in a wide variety of fisheries.

Fisheries impact, observed and as assessed via Ecopath, was presented for marine ecosystems in the North Sea, Mediterranean, eastern tropical Pacific, continental shelf of north-eastern South America, and Brazil. These presentations highlighted the trophic decline observed in the fisheries concerned, verifying the observed global decline in trophic level of fisheries catches over time.

In the third session, there were temporal comparisons of ecosystems (the southern Benguela upwelling; central Chilean coast, Brazilian coast, and lagoons in Italy and the Canary Islands), which showed the effects of management strategies on ecosystem development, and the effects of changing ecosystems on the fisheries. There were also comparisons made of the Ecopath software with another ecosystem modelling approach in assessing ecosystem behaviour, which showed a basic similarity in the findings from each approach. Ecosystem structure and dynamics presentations were made for Caribbean and Pacific coasts, for coral reefs in the Caribbean, the exploited marine ecosystems of a number of coastal ecosystems in western Africa.

The conference marks the terminal event of the four-year INCO-DC Concerted Action "Placing Fisheries in their Ecosystem Context". This Concerted Action has brought together researchers from 31 institutions over a four-year period, with the aim of introducing and exploring the use of ecosystem modelling for fisheries management, as well as to establish or strengthen research cooperation between the participating institution and researchers.

Placing fisheries in their ecosystem context: the scientific perspective

Villy Christensen and Daniel Pauly (North Sea Centre; UBC)

The 95 States represented at the International Conference on the Sustainable Contribution of Fisheries to Food Security in Kyoto, Japan, December 1995, agreed that ten immediate actions should be taken by the States, including "[t]o conduct, within their competences, and where appropriate, in cooperation with regional and other intergovernmental organizations, integrated assessments of fisheries in order to evaluate opportunities and strengthen the scientific basis for multispecies and ecosystem management." (http://www.fao.org/fi/agreem/kyoto/kyoe.asp)

There are still lessons to be learned before we can live up to this part of the Kyoto Declaration. In order to manage exploited marine ecosystems, we must increase our knowledge of the resources they contain. For this reason fisheries management has for decades focused on obtaining information on catches, and on stock sizes of the exploited resources. This has been done, however, largely in a species by species manner. Over time it has become increasingly clear that fisheries resources interact strongly, and that their interaction have implications for how fisheries should be managed. A preliminary study as an example estimates that on a global scale predation outweighs the fishery more than threefold (Christensen 1996). For this reason it is necessary to obtain far more information of how the fish resources interact, most notably of their feeding ecology.

As a result of the move toward ecosystem management fisheries research in especially the northern temperate areas has in recent years paid increased attention to the impact of multispecies interactions. This has led to development of a number of tools, but not yet to consensus on any methodology of analysis.

In tropical waters multispecies assessment is in its infancy. Here, emphasis has been on developing and disseminating methods for single-species analysis, notably in form of analytical models wherein size, (i.e., length) replace age, thus enabling application of the theory of fishing even in situations where fish cannot be readily aged. The problem of species interaction may however be of even bigger importance in tropical waters than it is in temperate, and hence there is considerable interest in moving toward multispecies assessment.

Unfortunately, the methods developed for multispecies analysis in temperate areas are not directly applicable for data sparse, tropical use as they are far too data-intensive. Hence, considerable interest has focused in developing countries around the use of relatively simple trophic, mass-balance models, which paves the way to multispecies management. Such models are structured by feeding interactions, and the resulting fluxes of matter or energy, and can be used to link fisheries resources with their supporting ecosystem, (i.e., the prey and predators of the resource species).

Ecopath modelling

At present work with mass-balance models has been published or is underway among a large number of fisheries scientists worldwide – with a close to even split between developing and developed countries, see Figure 1. This development has to a large degree been pioneered by the introduction and use of a methodology called Ecopath, which is based on work by Dr. J. Polovina at the South West Fisheries Center, Hawaii, USA, (Polovina 1984). The Ecopath software (Christensen and Pauly 1992), has been widely distributed since 1990, and now has more than 2200 registered users in 124 countries, while a large number (>150) of models of aquatic ecosystems have been published.

Figure 1. Registered users of the Ecopath ecosystem modelling approach and software, which provides the common ground for the participants in the INCO-DC Concerted Action "Placing Fisheries in their Ecosystem Context". The areas of the circles are proportional to the number of users in each country. The total number of registered users is 2200 in 124 countries as of late 2001.

One interesting aspect of the Ecopath approach is that models can be constructed combining local, and previously under-utilized data sets, with regional, published information, and with estimates from empirical models. The data requirements for getting started with Ecopath models is thus very limited: for all important ecosystem resources, from primary producers over exploited fish species to marine mammals, the information must detail both how abundant the resources are (biomasses), their productivity (or mortality rates), how they interact (diet compositions and consumption rates), and how efficiently the resources are utilized in the ecosystem. In addition information on human exploitation is needed on a species and preferably fleet/gear basis. Seasonality can, where crucial, be incorporated in the models.

At present the knowledge of multispecies interactions of importance for ecosystem management may seem very sparse. However, large amounts of scattered information are available from previous and ongoing studies – often retrievable through the ACP-EU funded FishBase activity (www.fishbase.org; Pauly *this vol.*). It is fundamental that such disperse information can be placed in context through mass-balance ecosystem analysis, and thence be of use for ecosystem management.

Not all information needs to be available for input though; based on an assumption of mass-balance the software estimates one parameter for each group in a model so as to secure mass-balance. What is more, this can be done through explicit consideration of uncertainty in input parameters and calculated parameters through a Bayesian approach, while sensitivity analysis enables formal studies of parameter dependencies.

The first results of Ecopath analysis are information of the ecosystem resources, and how they impact each other in a given situation. A time dimension can be added to this in two ways. Firstly, by constructing several models, each covering different time periods, and subsequently comparing these. This is as an example demonstrated by many of the contributions in (Christensen and Pauly 1993). Secondly, through the integrated, dynamic simulation module, Ecosim, developed primarily by Prof. Carl Walters of the Fisheries Centre, University of British Columbia, Canada (Walters et al. 1997, 2000). In Ecosim the system of coupled linear equations underlying each Ecopath model is re-expressed as a system of coupled differential equations, allowing simulations of ecosystem perturbation in time. The resulting dynamic simulation models requires very limited additional parameters and assumptions, making it possible for users to concentrate on data analysis, not on model construction *per se*. This represents a strong contrast to almost all other modelling approaches.

Spatial considerations, for instance in connection with the use of marine protected areas as part of fisheries management procedures can be incorporated through the use of the Ecospace module of the Ecopath with Ecosim model package (Walters et al. 1999), see Zeller and Reinert (*this vol.*) for an application of the Ecospace model.

With Ecopath models bio-economic factors can be considered through inclusion of market prices, for the exploited components of an ecosystem thus allowing comparison of revenue flows when evaluating alternative management strategies (on a gear or fleet basis), and the resulting ecosystem states. Through inclusion of non-exploitative sectors, e.g., eco-tourism, it becomes possible to compare revenues of exploitative versus non-exploitative resource uses.

The INCO-DC Concerted Action

As a response to an INCO-DC call for proposals in September 1997 a concerted action was outlined with the purpose of linking researchers in Europe, Africa, the Caribbean and Latin America working with mass-balance models of marine ecosystems through open and voluntary cooperation. The proposal was subsequently funded and started its work in September 1997, with an emphasis on two major regions: the Pacific coasts of Latin America, and Atlantic and Caribbean waters (Christensen and Pauly 1997).

The concerted action was designed to promote an intercontinental 'laboratory without walls' where scientists in the 31 participating institutions were given a forum for cooperation. As the major part of the partners come from ACP/EU countries this offers an avenue for cooperation with the ACP/EU Fisheries Research Initiative (http://europa.eu.int/comm/development/research/0intr-en.htm). The wide participation should be viewed as a feat in itself, made possible not the least by the Dialogues conducted as part of the ACP/EU Fisheries Research Initiative. Notably, the 2nd and 3rd Dialogues in Dakar and Belize served to facilitate both communication about and participation in the ecosystem modelling activity, (Anon. 1996, 1997), as did the 1998 Ocean Food Webs and Economic Productivity Conference facilitated by the ACP/EU FRI, and convened at the Ocean'98 exhibition in Lisbon (Pauly et al. 1999).

Emphasis has throughout the activity been on research that leads to ecosystem management in both ACP and EU countries. This is much in line with the Fisheries Research Initiative, which has as a major purpose to adopt and implement a strategy for the conservation of Large Marine Ecosystems by coastal states and the international community. As part of this, resources have to be assessed, the dynamics of ocean/coastal resource interactions understood, resource management mechanism developed, and sustainable yields ensured. Methodologies for reaching such aims still have to be further developed, but it is clear at the end of the Concerted Action that is has had contribution to offer toward these aims.

Important aspects are that the activity has focused on analyses and management of exploited ecosystems, not just on management of their components. In order to construct mass-balance models information is needed on resources at all trophic levels, and experience shows that the process of obtaining such information strengthens inter- and intra-institutional cooperation. In addition the scientists involved in the modelling gain information on both ecosystem functioning and management, leading to insights very different from what can be obtained from traditional fisheries management. This is illustrated by a large number of the studies reported in the current publication.

Comparisons have served an important role for the concerted action. Time series of ecosystem impact of fisheries are very sparse in the scientific literature. Thus, inter-ecosystem transects are a scientifically important tool for gaining new understanding of ecological and fishing-related processes. This has been demonstrated previously by a number of large international studies. The concerted actions had originally planned to focus on such comparisons, notably latitudinal and inter-island transects, as well as comparisons between continents. However, the development of ecosystem-based approaches for fisheries management has, in the course of the activity mutated into studies of

time trends within ecosystems. Therefore, emphasis in the concerted action has gradually shifted toward facilitating such time series studies.

Activities

The INCO-DC Concerted Action 'Placing Fisheries in their Ecosystem Context' started its work in September 1997, and conducted three international workshops during the first year of activity. This was one more than originally planned as the workshop for West Africa and Europe, originally scheduled for the second year, was moved forwards due to requests from partners in these regions.

The first workshop was held at the University of Cape Town, Cape Town, South Africa from December, 9-17, 1997, introducing the Ecopath software to 20 participants from South Africa. Of the 20 participants the Concerted Action funded only four, while the rest participated through other funding. Seven models of different ecosystems were prepared or improved during this workshop.

The workshop series continued in April 1998 at the Marine Biology Station, Puntarenas, Costa Rica over 6 working days during the period 21-28 April 1998. The workshop included four interrelated modules:

1) Construction and validation of mass-balance trophic models of aquatic ecosystem (Ecopath);
2) Studying the ecosystem impact of various fishing regimes (Ecosim);
3) Studying the ecological consequences of habitat preferences for ecosystem structuring, and the impacts of marine protected areas (Ecospace);
4) Preparation and presentation of models constructed by participants, and discussion of the ecosystems they represent, their exploitation and status, and the potential for screening of ecosystem management policies.

A total of 30 scientists participated; of these 16 were partners whose participation was funded by the Concerted Action, while 12 were funded by their own organizations. A very notable aspect was that two participants had personally funded their participation (including international travel), thus documenting a strong interest in the training workshop. Twelve models were prepared or improved during the workshop.

The third major event was an international training workshop held at the North Sea Centre, Hirtshals, Denmark, in August 1998. The workshop had a total of 31 participants and 3 resource persons. The participants came from 19 countries, including 10 in West Africa. All seven West African and nine European partners of the INCO-DC Concerted Action were represented at the workshop, as were a number of other organizations participating through other funding.

A fourth workshop of the Concerted Action was held during 30 November to 5 December 1998, at Instituto Oceanográfico, Universidade de São Paulo (IOUSP), São Paulo, Brazil, with twenty-five participants from 15 institutions. Most participated at the cost of their respective organizations, and only the costs for nine representatives for partner institutions were covered through the Concerted Action. The workshop was conducted in Portuguese, Spanish and English, and a total of thirteen models was prepared or improved as a result of the workshop.

A preparatory one-week Ecopath training course was organized and conducted by IOUSP for 11 Brazilian participants representing 8 institutions in the week prior to the INCO-DC Workshop. The INCO-DC Concerted Action partly funded the preparatory course while most participants were covered from other sources.

During the two years from the fourth workshop ended in São Paulo, Brazil on 5th of December 1998 to the international conference started on 4th of December 2000, the emphasis of the Concerted Action was on cooperation, further development of the ecosystem modelling activities, and preparations for the final conference. The following section gives an overview of some of the outcome from the Concerted Action, with an emphasis on the modelling activities and how they have been reported.

The following list gives an overview of the preliminary ecosystem models that were initiated or improved in connection with the ecosystem modelling workshops conducted as part of the INCO-DC Concerted Action 'Placing Fisheries in their Ecosystem Context'. The list includes an incomplete overview of related, subsequent publications by the participants. Abstracts of the model representations are available at www.ecopath.org.

It should be noted that the Concerted Action has operated through voluntary cooperation, and that the support to the activities mainly has been through guidance, where experienced modellers associated with the CA, has helped or assisted less experienced partner, newer to the field. Further, the Concerted Action has facilitated and partly funded editing of a number of manuscripts prior to their submission to international journals.

Cape Town Workshop, December 1

Cape Town Workshop, December 1997

1) Modelling the Northern Benguela Ecosystem; Sheila Heymans. (Heymans and Baird 2000a)

2) Modelling the Southern Benguela Ecosystem; Lynne Shannon, Larry Hutchings, Rob Crawford. (Jarre-Teichmann et al. 1998, Shannon and Jarre-Teichmann 1999, Shannon et al. 2000)

3) Modelling the Southern Benguela ecosystem in the 1950s; Rob Crawford, Larry Hutchings, Hans Verheye, Lynne Shannon.

4) A model of the southern Agulhas Bank in summer; Anthony Richardson, Mark Gibbons, Hans Verheye, Sarah Wolmsley, Larry Hutchings, and Philippe Cury.

5) Modelling energy flows on the stony reefs of KwaZulu Natal; Veronica Toral and Coleen Moloney. (Toral-Granda 1998, Toral-Granda et al. 1999).

6) Energy flow budgets of a Kelp bed ecosystem; John Field. (Subsequently defined as a M.Sc. topic for a student of Prof. Field)

7) Comparing Network and Ecopath outputs Dan Baird, Deo Winter, Sheila Heymans, Joseph Sara. (Heymans and Baird 2000b)

Costa Rica Workshop, April 1998

8) Model of the penaeid shrimp grounds, Campeche, Southwest Gulf of Mexico; Sherry Manickchand-Heileman. (Manickchand-Heileman et al. 1998b, Arreguín-Sánchez 2002)

9) Preliminary trophic model of coral reef systems from the Mexican Caribbean; S. Díaz-Ruiz, E. Barba-Macías & M. A. Salcedo-Meza.

10) Discovery Bay, Jamaica; John L. Munro, Karl A. Aiken and Gale Persaud. (Multiple publications in prep.)

11) Galápagos central shelf model; Günther Reck and Rodrigo H. Bustamante.

12) A preliminary trophic model of the outer zone of the Gulf of Nicoya, Costa Rica; Anne van Dam, Luis Sierra, Fernando Aguilar, Kherson Ruiz and Huberth Araya.

13) Modeling the ecotrophic system in the inner part of Golfo de Nicoya, Pacific Coast, Costa Rica; Tito Marin Aldave, José Palacios, Jorge Rodríguez and Anne van Dam.

14) Preliminary modelling approach on the bycatch of soft-bottom benthic systems, Gulf of California, Mexico; Raúl Hernando López-Peralta, Carlos Alberto Trujillo-Arcila and Nayibe Madrid-Cortes.

15) Analysis of management of introduced and native *pescado blanco* in the Huyamilpas Lake, Mexico, based on food web information; Miguel Angel Salcedo-Meza, Silvia Diaz-Ruiz and Everardo Barba-Macias.

16) A preliminary trophic model of Huizache-Caimanero, a coastal lagoon in Pacific Mexico; Manuel Zetina-Rejón, Rodrigo Moncayo Estrada, and Olga I. Palomino Ramírez

17) Trophic model of a hypersaline lagoon: Laguna Madre, Tamaulipas, Mexico; Barba-Macias, E.; S., Diaz-Ruiz and M. A. Salcedo-Meza.

18) Trophic interactions and biomass flow in the Gulf of Paria, North-eastern South America between Trinidad and Venezuela; Sherry Manickchand-Heileman, Jeremy Mendoza, Amoy Lum - Kong, Freddy Arocha and Xiomara Chin.

19) A preliminary trophic model of the coast of Tamaulipas and north Veracruz, Gulf of Mexico; Olga I. Palomino Ramírez, Rodrigo Moncayo Estrada, Manuel Zetina-Rejón.

20) Preliminary analysis of a trophic model of Laguna de Zacapu, Michoacan, using the Ecopath with Ecosim program. Rodrigo Moncayo Estrada, Manuel Zetina-Rejón, and Olga I. Palomino Ramírez.

21) Gulf of Mexico ecosystem modeling, Francisco Arreguín-Sánchez and Sherry Manickchand-Heileman. (Arreguin-Sanchez and Manickchand-Heileman 1998, Arreguin-Sanchez 2000, Manickchand-Heileman et al. 1998a)

Hirtshals Workshop, August 1999

22) A trophic model of Lac Nokoue - a lagoon in Benin, West Africa. Emile Didier Fiogbe, Benin, and Hanna Stokholm, Denmark.

23) Coastal marine fisheries ecosystem model of Cameroon. Theodore Djama, Cameroon

24) Trophic model of the Cape Verde continental shelf. Anibal Medina, Cape Verde, Kim Stobberup, Portugal, and Teresa Paula Barros, Cape Verde. (Ramos et al. 2001)

25) Spatial trophic mass balance model of a coral reef ecosystem, Tiahura Sector, Moorea Island, French Polynesia. J.E. Arias-González, A. Lo-Yat, V. Dufour, and R. Galzin, France. (Arias-Gonzalez et al. 1997, Arias-Gonzalez 1998, Arias-Gonzalez et al. 1998)

26) An ecosystem model of the continental shelf of Ghana. John Blay and Kobina Yankson, Ghana.

27) Trophic modeling of the Guinean EEZ marine environment. Samba T. Diallo and M. Oury Diallo, Guinea. (Diallo and Guénette 2001)

28) A Dynamic Simulation of a Mediterranean Lagoon Ecosystem. R. Ceccarelli and C. Pianese, Italy.

29) Bay of Revellata, Corsica. Assessing the importance of planktivorous fishes to the functioning of the Mediterranean rocky sublittoral ecosystem. J.K. Pinnegar & N.V.C. Polunin, U.K.

30) Bonny Estuary Ecosystem, Niger Delta, C.O. Dublin-Green, Nigeria

31) Ecopath model for the Barents Sea. Torstein Pedersen, Are Dommasnes, and Gabriella Bianchi. (Dommasnes et al. 2002)

32) Trophic model of the estuary of the River Saloum. Birane Samb, Senegal.

33) A trophic model of the Senegambian upwelling ecosystem. Taib Dioub and Birane Samb, Senegal and Asberr Mendy, The Gambia. (Mendy 2001)

34) A trophic ecosystem model of the marine resources of the Sierra Leone shelf. P.A.T. Showers, Sierra Leone, and J.M. Vakily, Philippines.

35) Southern Benguela ecosystem. Lynne Shannon, South Africa. (Shannon 2001, 2002)

36) Impact of the artisanal fishery on neritic waters of oceanic islands (Canary Islands). José Juan Castro & Teresa Moreno, Gran Canaria, Spain.

37) Trophic structure of the Maspalomas Lagoon, (Gran Canaria, Canary Islands), after collapse and recolonization processes. Teresa Moreno and José Juan Castro, Gran Canaria, Spain. (Moreno and Castro 1998)

38) Cantabrian Shelf ecosystem. I. Olaso and F. Sánchez, Spain.

39) Trophic models of high latitude ecosystems with strong seasonality in food input. Thomas Brey, Germany.

São Paulo Workshop, December 1998

40) Trophic modelling as a tool to evaluate fisheries impacts on the coastal ecosystem of the South Shetland Island, Antarctica; Gonzalo R. Olivares

41) Alternative policies for managing the fisheries of San Matias Gulf, Argentina: a preliminary exploration using Ecopath with Ecosim; Mario Lasta & Marcelo Pájaro (Fernanda et al. 2002)

42) An ecosystem model of the Itaipu-Piratininga lagoon, Southern coast of Brazil; Maria Helena Carvalho da Silva

43) A trophic model of the Caeté estuary mangrove ecosystem, Bragança, Brazil; Manuel Contreras and Victoria Isaac. (Wolff et al. 2000)

44) A trophodynamic model of the fringing reefs of the Abrolhos archipelago, Bahia State, Brazil. Marcelo Dantas Telles & Eduardo Teixeira da Silva. (Silva 1998, Telles 1998)

45) Description of a stream ecosystem in Parana State, Brazil using Ecopath; Abes, S. S. and A. A. Agostinho

46) Ecological modeling of the upwelling system in the Cabo Frio region, Brazil; Eduardo Tavares Paes and Flavio da Costa Fernandes

47) Modeling the trophic dynamics of Restinga da Marambaia sandy beach (Rio de Janeiro, Brazil) using Ecopath; Veloso, Valeria G. and M. Josefina R. Kurtz

48) Quantitative model of the trophic interactions in the Southeastern Brazilian Bight, as a starting point for the analysis of fisheries; Maria de los Angeles Gasalla, Maria Cristina Cergole and Luiz Arnaud Britto de Castro. Maria Gasalla holds an ISF Grant for continued Ecopath work

49) The Corumbá river ecosystem (Goiás State, Brazil), before and after impoundment; Benedito-Cecilio, E., E.A. Reis et al.

50) Trophic modelling of the shelf system from the northern São Paulo State, Brazil; Gecely Rodrigues Rocha, Ana Maria S. Pires-Vanin, Lucy S.H. Soares and Elizabeti Y. Muto. (Rocha 1998, Rocha et al. 1998)

51) A trophic mass-balance model of the continental shelf ecosystem off Central Chile. Hugo Arancibia and Sergio Neira.

52) Preliminary ecotrophic model of the shrimp fishery area in Tumbes, Northern Peru. Teresa Jeri

Galápagos Conference, December 2000

53) Application of Ecosim to investigate impact of lobster fishery on endangered monk seals in Hawaii; Jeffrey Polovina, Frank Parrish, and Evan Howell. (Polovina, this vol.)

54) Impact of fishing harvesting polices on the ecosystem structure of Huizache-Caimanero lagoon, Mexico; Manuel J. Zetina-Rejón and Francisco Arreguín-Sánchez. (Zetina-Rejón et al., this vol., Zetina-Rejón et al., in review).

55) Ecosystem based fisheries management: Modelling the effects of policy variations in a temperate marine ecosystem of the Northeast Atlantic; Dirk Zeller and Jakup Reinert. (Zeller and Reinert, this vol., Zeller and Reinert, in review).

56) An analysis of the artisanal fisheries in the ecosystem of La Paz Bay, Baja California Sur, Mexico; Francisco Arreguín-Sánchez, Agustín Herrera, Mauricio Ramírez-Rodríguez, and Horacio Pérez-España. (Arreguín-Sánchez et al., this vol., Arreguín-Sánchez and Calderón-Aguilera 2002, Arreguín-Sánchez et al. , in review).

57) Cantabrian Sea ecosystem model as a fisheries resources management tool; Francisco Sánchez and Ignacio Olaso. (Sánchez and Olaso, this vol., Sánchez and Olaso, in review).

58) Simulated responses to harvesting strategies of an exploited ecosystem in the southwestern Gulf of Mexico; Francisco Arreguín-Sánchez, Sherry Manickchand-Heileman and Manuel Zetina. (Arreguín-Sánchez et al., this vol., Arreguín-Sánchez et al., in review)

59) Interactive effects of climate variability and fishing: A modeling analysis for the eastern tropical Pacific pelagic ecosystem; Olson, R.J., G. M. Watters, K. Y. Aydin, C. H. Boggs, T. E. Essington, R. C. Francis, J. F. Kitchell, J. J. Polovina, and C. J. Walters. (Olson et al., this vol.)

60) Study of the impacts of bottom trawling on the ecosystem of the Gulf of Paria, based on mass-balance trophic models constructed using historical and current data; Sherry Manickchand-Heileman, Jeremy Mendoza, Amoy Lum Kong and Freddy Arocha. (Manickchand-Heileman et al., this vol., Manickchand-Heileman et al., in review)

61) The contribution of ecosystem analysis to investigating the effects of changes in fishing strategies in the South Brazil Bight coastal ecosystem; M.A. Gasalla and C.L.D.B. Rossi-Wongtschowski. (Gasalla and Rossi-Wongtschowski, this vol., Gasalla and Rossi-Wongtschowski, in review).

62) Predicting indirect effects of fishing in Mediterranean rocky littoral communities using a dynamic simulation model; J. Pinnegar and N. Polunin. (Pinnegar and Polunin, this vol., Pinnegar 2000, Pinnegar and Polunin, in review).

63) Ecopath with Ecosim: an overview (Christensen and Walters, this vol., Christensen and Walters, in review)

64) A comparative analysis of the North Sea based on Ecopath with Ecosim and Multispecies Virtual Population Analysis. Christensen, V., J.E. Beyer, H. Gislason and M. Vinter. (Christensen et al. this vol.)

65) Analysis of trophic interactions and of the marine ecosystem structure off Central Chile (33ºS-39ºS), in the years 1992 and 1998; Sergio Neira, Hugo Arancibia & Luis Cubillos. (Neira et al. this vol., Neira et al., in review)

66) Seasonal dynamics of Ubatuba continental shelf system through mass-balance trophic models; Rocha, G. R. A., Rossi-Wongtschowski, C. L. D. B., Pires-Vanin, A. M. S. & Soares, L. S. H. (Rocha et al., this vol.)

67) Long-term analysis of the trophic level of the fisheries in Central Chile (33ºS-39ºS), and their impact on the most important fishery resources; Hugo Arancibia & Sergio Neira. (Arancibia and Neira, this vol., Arancibia and Neira, submitted).

68) The comparative analysis of trophic network to explore the environmental management effects in a shallow water basin; Brando, V.E., Ceccarelli R., Libralato S., and Ravagnan G. (Brando et al., this vol., Pranovi et al., Libralato et al. in review, Brando et al., in review)

69) Trophic structure of the Maspalomas Lagoon (Gran Canaria, Canary Islands) before collapse and after a new settlement process; Teresa Moreno & José Juan Castro. (Moreno and Castro, this vol., Moreno and Castro, in review)

70) Ecosystem states and causes of change in the southern Benguela upwelling ecosystem; C. Moloney and L. Shannon. (Shannon et al., this vol., Shannon et al., MS, Shannon et al., in review)

71) A balanced trophic model of a Galápagos subtidal rocky reef for evaluating zone-based fisheries and conservation policies; Thomas A. Okey, Stuart Banks, Rodrigo Bustamante, Mónica Calvopiña, Graham Edgar, José Miguel Fariña, Lauren E. Garske, Günther K. Reck, Sandie Salazar, Scoresby Shepherd, Petra Wallem, Abraham F. Born and Eduardo Espinoza. (Okey et al. this vol.)

72) Fishery-mediated trophic role of small pelagic fish in a tropical marine ecosystem; Luis O. Duarte and Camilo B. García. (Duarte and García, this vol.) (Duarte and García) (Duarte and García 2002)

73) Contributions to the study of trophic relationships in the southern neritic region of the Colombian Pacific; Carlos E. Fernandez (Fernandez, this vol.)

74) Trophic flows in a tropical coastal ecosystem: the southern Pacific Ocean of Colombia; Raúl Hernando López Peralta and Carlos Alberto Trujillo Arcila. (López Peralta and Trujillo Arcila, this vol.)

75) Trophic structure as an ecological tool for assessing coral reef ecosystems; J. Ernesto Arias-González, Enrique Nuñez-Lara, Carlos González-Salas and René Galzin (Arias-González et al., this vol., Arias-González et al., in review)

76) Simulating community effects of sea floor shading by plankton blooms over the West Florida shelf; Thomas A. Okey, Gabriel A. Vargo, Steven Mackinson, Marcelo Vasconcellos, Behzad Mahmoudi and Cynthia A. Meyer. (Okey et al., this vol., Okey et al., in review)

77) The northern Benguela ecosystem: changes over three decades: 1970s, 1980s and 1990s; Johanna J. Heymans, Lynne J. Shannon and Astrid Jarre. (Heymans et al., this vol., Heymans et al., in review)

78) Structure and dynamics of the marine fisheries off Cameroon ; Theodore Djama. (Djama, this vol.)

79) A Tropic Ecosystem Model of a West African Shelf, Sierra Leone; Percival A.T. Showers (Showers, this vol.)

80) Trophic modelling of the Senegal-Gambian upwelling system; Taib Diouf, Birane Samb and Asberr Mendy. (Diouf et al., this vol., Samb and Mendy 2001)

81) An Ecopath model of the southeastern Spain Mediterranean; Sonia Rodríguez-Ruiz and José Luis Sánchez-Lizaso. (Rodríguez-Ruiz and Sánchez-Lizaso, this vol.)

For the majority of the presentations at the Galápagos Conference scientific descriptions have been prepared and submitted to Ecological Modelling for consideration in a special issue of this

international journal. The manuscripts were under review at the time of publication of the present report.

Outlook

The ACP-EU Concerted Action on placing fisheries in their ecosystem context is closing down, but the cooperation that has been its reason for being is still in place. Initial contacts were established prior to the start of the Concerted Action, they have been strengthened by it, and will continue through an array of mechanisms and vehicles of opportunity. Centrally placed among these will be initiatives associated with the ACP-EU Fisheries Research Initiative, notably in connection with the FIAS/SIAP project (see http://europa.eu.int/comm/development/publicat/fish/099928.pdf).

What is probably the most significant result of the ACP-EU Concerted Action is that ecosystem modelling has been introduced to a large number of the ACP-EU countries, as well as to countries in the European Union. For many of the participating institutions it was the first time that they embarked on this challenging task, and in conclusion we dare offer that the activity has indeed had a contribution to offer toward the tasks set forth by the Kyoto conference on Sustainable Contribution of Fisheries to Food Security.

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