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# APPLICATION OF GIS TO CEPHALOPOD FISHERIES: WORKSHOP REPORT

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Geographical information systems (GIS) are implementations of computer-based techniques for managing, mapping and analysing geo-referenced data. GIS technology integrates common database operations, such as queries and statistical analyses, with the unique visualisation and geographic analysis benefits offered by maps. Such systems can yield information, on the spatio-temporal structure and relationships of variables, which would otherwise not have been apparent in the source data sets.

The domain of GIS concerns geo-referenced data, integration and analysis, which converts raw data into meaningful information and supports management decisions. The first step is the measurement of natural processes from spatial and temporal perspectives. These measurements are then related to features, attributes and relationships in a GIS database, stored in digital form in a computer database, and can be linked to features on a digital map. The data can be of five main types: points, lines, and polygons (vector) as well as pixels and voxels (raster). The combined analysis of collected measurements from multiple datasets, to produce new (derived) data and to discover new relationships, by numerical manipulation and modelling, comprises the main core of GIS techniques. It is the combined analysis of GIS that provides meaningful information on natural processes. The communication medium of GIS analysis and output is the depiction of the measured or analysed data in some type of display, e.g., maps, graphs, lists, reports or summary statistics.

GIS has developed over the last 30–40 yrs from simple data collection and mapping in the 1960s and 1970s, to the present availability of sophisticated commercial software packages which encompass database management, data processing, spatial and temporal analysis and modelling, dynamics and 3-D visualization. GIS techniques have been used in a wide range of disciplines, including environmental science, traffic management, land management, agriculture, forestry, hydrology, public health, and oceanography (see Maguire, et al., 1991, for a detailed review of development and applications).

The application of GIS to the marine domain, especially to fisheries, has been slow and limited, for a number of reasons (Wright, 1999; Meaden and Do Chi, 1996). In contrast to many terrestrial systems, it is important to include the vertical dimension of the marine environment. The marine environment is highly dynamic, in terms of both processes (e.g., upwellings, gyres, fronts, etc) and objects (e.g., populations of fishery resource species; Meaden, 1999). There are also logistic problems: huge areas must be covered, data collection is expensive and there are both commercial and political obstacles to collating fisheries data from different communities and nations. Finally, most of the functions of GIS software (overlaying, buffering, classification, Boolean operators) were developed for dealing with terrestrial data. In spite of such difficulties, the potential value of GIS in marine fisheries management has been widely recognized and applications have rapidly expanded. Applications of GIS in fisheries have included data management, environmental monitoring, ecosystem studies, stock assessment, forecasting, and fishery management (Meaden and Do Chi, 1996; Lunetta, et al., 1997; Fogarty and Murawski, 1998; Anon. 1999a; Meaden, 1999; Bellido, et al., 2001; ; Zheng, et al., 2001;

Georgakarakos, et al., 2002; Valavanis et al., 2002). In 1999, the First International Symposium on GIS in Fishery Sciences was held (2–4 March 1999, Seattle, Washington), with more than 130 presentations and attended by more than 200 participants from 28 countries (Anon., 1999a).

Despite having been fished commercially for several decades, cephalopods are still thought of as relatively 'new' fishery resources (Boyle, 1990), and their short-life-cycles have limited the application of traditional assessment and management techniques (Pierce and Guerra, 1994). On the other hand, the sensitivity of cephalopod distribution and abundance to environmental variation in time and space (e.g., Coelho, 1985) makes them a particularly appropriate focus of studies based on GIS techniques. Cephalopod fisheries are among the few in the world still with some local potential for expansion and, as groundfish landings have declined globally, cephalopod landings have increased (Caddy and Rodhouse, 1998). Thus there is a need for development of assessment and management strategies targeted at cephalopod fisheries.

Application of GIS in cephalopod fisheries has lagged behind developments in many other marine fisheries. However, research over the last 5 yrs, including projects funded by the CEC, has started to fill this gap. The Millennium Conference of the Cephalopod International Advisory Council, with the theme of Cephalopod Biomass and Production, provided the forum for a Workshop on the Application of GIS Techniques to Cephalopod Fisheries. The workshop was held in the Department of Zoology at the University of Aberdeen on 3–4 July 2000. There were 47 registered participants (Appendix 1).

The objectives were as follows:

- To hold a workshop on the application of GIS techniques to cephalopod fisheries, bringing together scientists in the fields of GIS, fisheries and cephalopod biology
- To review the application of GIS techniques in cephalopod fishery management and evaluate prospects for future development
- To review experience of the different software packages available including appropriate databases and associated statistical tools
- To make recommendations on appropriate procedures and software, and the integration of GIS into cephalopod fisheries management.

The Workshop consisted of a series of themed sessions of oral presentations (see Appendix 2) followed by a general discussion session. The present report attempts to summarise the main points arising from the Workshop and presents the conclusions and recommendations arising.

## Current Research Applications of GIS, Statistical Tools and Databases in Cephalopod Fisheries

GIS Applications for European Cephalopod Fisheries.—A major impetus to development of GIS for applications in research on cephalopod fisheries was provided by the CEC funded project, Cephalopod Resources Dynamics: Patterns in Environmental and Genetic Variation (CEPHVAR, FAIR CT 97 1520), under which parallel development took place of GIS for the northern Northeast Atlantic (based at the Universities of Aberdeen and Caen), Iberian Peninsula and Saharan Bank (based at the Instituto de Investigação das Pescas e do Mar and the Instituto Español de Oceanografía) and the eastern Mediterranean (Institute of Marine Biology, Crete). This project also funded parallel studies in the SW Atlantic (British Antarctic Survey).

One of the longest established marine information systems is the Greek Seas GIS, held at the Institute of Marine Biology in Crete. Since 1997, this has been developed to include information on cephalopod fishery resources (see Valavanis et al., 2002). The system is a customisation of a workstation ARC/INFO® environment and features a series of GIS map-overlay and integration routines for analysis of survey, fishery statistical, and remote-sensed data. The system also features a custom-made user-interface. Geo-referenced data sets include fishery statistical data on cephalopod catches and landings, coastline and bathymetry, aerial ortho-photos and RoxAnn® sonar data for bottom sediment mapping, satellite sensor data (AVHRR/sea surface temperature and SeaWiFS/chlorophyll-a concentration) and climatological data sets (e.g. sea surface salinity). A major innovation of this marine system is the integration of species life-history data (e.g., depth range, spawning season, spawning substrates, temperature range, and migration habits) into GIS analysis. In addition to facilitating analysis of temporal and spatial patterns of variation in life-history parameters, and their relationships with environmental variation, the system is being used to identify areas of suitable habitat and to predict spawning areas and migration routes.

Studies on cephalopod fisheries in the NE Atlantic have also involved GIS. The cephalopod GIS held at the University of Aberdeen (UK) was developed based on UNIX® ARC/INFO® v7.21. INFO tables™, and Arcstorm™ are used for the GIS database. Related databases make use of PC Microsoft® Access. The GIS was designed for data management, spatial and time-series analysis, and for application to modelling, forecasting, and displaying cephalopod distribution in relation to environmental and biological variables (see Pierce et al., 2001). Much of the research carried out using this system is yet to be published, although some preliminary results relating to the distribution of the squid *Loligo forbesi* in British waters appear in Waluda and Pierce (1998) and Bellido et al. (2001).

A second GIS platform for studies on northern NE Atlantic cephalopods is based at the University of Caen (France), where work has focussed on patterns of distribution and abundance of loliginid squid (*Loligo forbesi* and *L. vulgaris*) and cuttlefish (*Sepia officinalis*) in the English Channel.

The Iberian Peninsula Cephalopod GIS was also funded under the CEPHVAR project. The main aims of this were to create a user-friendly and geographically oriented database system to easily and quickly view, combine and analyse large amounts of geo-referenced environmental and biological cephalopod data. The system comprises an ArcView® platform, Microsoft® Excel spreadsheets converted to Arc shape files and user-friendly menus for data exploration and analyses, written with Avenue™ language. Permanent data sets held include the Iberian coastline, oceanographic data, wind force and direction time series, model outputs for currents and ocean floor topography, as well as a 20-yr series of data on the distribution, abundance and biological variables for 15 cephalopod taxa. Some paralarval distribution data and landings and effort data from fisheries of four commercial cephalopod categories are also included.

Fishery GIS Applications Outside Europe.—Research using GIS at British Antarctic Survey has focussed on the distribution of cephalopods in the Southern Ocean (Xavier et al., 1999). The most recent studies have concerned the distribution and abundance of the ommastrephid squid *Illex argentinus* in the South Atlantic in relation to remotely sensed meso-scale oceanography (Waluda et al., 1999, 2001a,b). Since 1989, under fishery regulations in Falklands Islands waters, all licensed fishing boats provide daily records of quantities and locations of squid catches. Fishery data have been gridded with a spatial resolution of 0.25° latitude and 0.5° longitude. Waluda et al. (1999) found that SST in the hatching area on the Patagonian Shelf was negatively correlated with fishery catches in the following season and also found a time-lagged link between El Niño events and the fishery. Remotely sensed SST data (Advanced Very High Resolution Radiometer data or AVHRR), available since 1993, allow composite images of SST during the fishing season to be assembled. Frontal features are identified from temperature gradients and shown to be persistent in shelf break areas throughout most of the fishing season. Overlay of fishery and SST data reveals catches to be higher at fronts than elsewhere (Waluda et al., 2001b). Interannual variation in catch rates can be related to the relative proportions of different water masses in the main hatching area (Waluda et al., 2001a).

The Instituto Español de Oceanografía (Spain) has developed a GIS for the hake and squid fisheries in the Patagonian Shelf area. Physical environmental data have been entered along with fishery CPUE data from 1989 to 1999, as collected by on-board observers. This has facilitated analysis of relationships between distribution, abundance and environmental parameters and establishment of species temperature (SST) and depth preferences. These relationships have been expressed more formally in generalised additive models (see Portela et al., 2001).

The Department of Fisheries, Ministry of Agriculture and Cooperatives (Thailand) is developing applications of GIS technology to assist in management of the country's fishery resources, many of which are overfished. A case study has been carried out using cephalopod fishery catch and water quality data for the southern coast of the Gulf of Thailand. The study species include cuttlefish, octopus and the squids *Loligo duvauceli* and *L. chinensis*. Relationships between abundance, egg production and water quality have been analysed visually and using multiple regression techniques.

Whilst various aspects of the chokka squid, *L. vulgaris reynaudii* life-history are well known, such as its spawning areas and feeding biology, little information is available concerning its movements, particularly with regard to recruitment patterns. A GIS for the southeast coast of South Africa has now been established, making use of fishery and (fishery-independent) survey data on the resource. The system will be used to collate, visualise and interpret the results in a multi-dimensional spatial and temporal manner. Spatial analysis of various biological parameters, such as percentage maturity and the distribution of different length classes, provides additional information concerning the movements of the population related to spawning activity and maturation.

## Databases

During the database session of the workshop, there was discussion of the structure of project and institutional databases as well as an introduction to CephBase, an internet-accessible species-level relational database covering all living species of cephalopods. This is based at the National Resource Center for Cephalopods, University of Texas Medical Branch in Galveston, Texas.

GIS-based research is facilitated by the increasing availability of databases of environmental information, particularly for ocean surface features, i.e., those available from remotely sensed sources. Information on below-surface conditions (e.g., sea bottom temperature) tends to be very patchy. The Marine Data Centre at the International Council of the Exploration of the Sea (ICES) holds compilations of such data for the NE Atlantic, supplied by institutes in member countries.

## Extending GIS Analysis

GIS offers tools for display and qualitative analysis of multiple data sets. However, quantitative description of spatial patterns and of temporal and spatial relationships between variables requires use of additional techniques, which may include geostatistical methods and generalized additive models.

Geostatistical tools can be used to describe spatial variability in abundance (or environmental) data, to interpolate missing values and thereby derive improved abundance estimates. The experimental semi-variogram is employed as a descriptor of the spatial structure of the data, indicating the extent of spatial autocorrelation between parameter values at points differing distances apart, and whether this is similar in all directions. This is useful both to help define appropriate units for spatial analysis and to identify underlying causal factors.

Generalized additive models offer a flexible methodology to model temporal and spatial relationships between a dependent variable and multiple, possibly inter-related, independent variables. Bellido et al. (2001) presented one of the first published applications to cephalopod fisheries. However, further applications to cephalopod fisheries in UK and French waters formed part of the Cephalopod Resources Dynamics: Patterns in Environmental and Genetic Variation project and should be published in the near future.

Applications of GIS to cephalopod fisheries thus far explored include elucidation of relationships with environmental variables and prediction of suitable habitats and migration routes. However, given detailed biological data, e.g., on size-frequency or age-frequency composition of samples it may be possible to start to relate environmental conditions to growth rates. Several recent studies have been able to make clear connections between season of hatching (i.e., seasonal water temperature) and cohort body size at recruitment into a fishery. Paralarval squids exposed to warmer water grow faster than peers that hatch in cooler waters and the cumulative effects on growth rate and size at age are significant even with very small temperature differences due to the exponential growth rates of young squids.

Matching appropriate GIS technology with an ideally suited target species should provide extremely useful analyses for general fisheries analyses. Further, GIS-based studies my lead to improved understanding of the impacts of both short-term (El Niño/La Niña) and long-term (global warming) environmental temperature fluctuations on important cephalopod stocks.

## Questionnaire

To assist in constructing a synthesis of current experience with using GIS, the workshop organisers circulated a questionnaire to all workshop delegates. The responses received and discussion during the workshop are summarised below.

Types of Application.—At present, GIS is mainly used as a research tool: for organizing research data, exploring data and providing input for models of spatio-temporal patterns of distribution and abundance. Ultimately, uses in fishery management or commercial products are envisaged. However, most of the systems discussed in this paper were set up using short-term (project-based) funding and their ongoing use and maintenance is dependent on further funding being obtained.

As noted above, extant GIS systems concern areas of the NE Atlantic, Mediterranean, Saharan Bank, SW Atlantic and South African waters, generally centred on single fisheries or fishery areas. The typical area covered has linear dimensions of some hundreds of kilometers, i.e., areas of tens or hundreds of thousands of kilometers. The abundance data on study species range from point data representing catches at a single location and single instant (usually from research trawling) to aggregated fishery data referring to broad areas (e.g., ICES rectangles, sometimes larger areas) and periods of up to one month. Time-series of data range from a few months to 30 yrs. Data often lack a vertical dimension, although for most neritic cephalopods catches are taken at or near the seabed.

In some cases (e.g., in South African and Falkland Islands squid fisheries) data are logged and analysed shortly after they are collected, facilitating use in real-time management decisions. However, more usually data are available to scientists and managers only retrospectively, with delays of a year or more. Thus the applications are more to do with improving understanding of underlying patterns and processes than with directly assisting management decisions.

Products available to end-users may include (a) an efficient, organised relational database, (b) maps of resource distribution patterns at appropriate time intervals (e.g., monthly) and with appropriate overlays of environmental data, (c) a user-friendly interface, perhaps accessible via the Internet, (d) data analysis or export capabilities. Questions answered using GIS may include identification of spawning and recruitment periods and areas, determination of resource species movement patterns and quantification of associations between resource distribution and meso-scale oceanic features.

Implementation Issues: Software, Hardware and Logistics.—The most familiar packages are the ESRI® products ArcView® and ARC/INFO®. Other software available includes IDRISI®, Xerox Parc®, PC Raster®, and TNT-mips®. There is generally a trade-off between power and user-friendliness. ARC/INFO® is available in UNIX and Windows versions, the former being more comprehensive, and the latter somewhat user-friendlier. ArcView® is relatively easy to use, notably in terms of the user interface and for visualisation of data, but lacks power. TNT-mips® is good for modelling applications such developing terrain models of the sea floor.

User interfaces are written using software such as Avenue™ or Visual Basic®. Some software offers Internet access facilities, e.g., ArcView® has ArcExplorer® as a freeware version or the more sophisticated MapObject® Server. The CephBase team are using Cold Fusion® software.

It is usually necessary (or at least desirable) to link the GIS with database software, e.g., Oracle®, Microsoft® Access, SQL Server®, Dataease®. As noted, the most powerful GIS software is available for UNIX platforms but systems can be set up on a PC. Although software licences are expensive, the host institution generally meets these costs; thus the main costs are the PC and the researcher's salary.

Some computer literacy is essential to set up a GIS and programming skills are useful. For all but the most basic applications, a thorough understanding of GIS skills is needed, i.e., not just attending a 1-wk course. Knowledge of spatial/geo-statistics and models (e.g., GAMs, LOESS) is also useful if the qualitative and visual information generated by the GIS is to be expressed in more formal quantitative terms. Although GIS can be set up on a project basis, unless skilled staff and funding are available on an ongoing basis, the system will rapidly become obsolete. While design and maintenance of a system require GIS-skilled people, the end-product may be a user interface accessible to, and useable by, biologists, oceanographers and, perhaps, fishermen.

The spatio-temporal scope and resolution of the coverage of the GIS depend in part on the available data. It may be appropriate to hold data with different spatial resolutions, e.g. survey abundance data usually refer to single points in space and time whereas fishery data are usually aggregated. Thus, in the ICES area, some countries collect and publish fishery data on a monthly ICES rectangle (1° longitude, 0.5° latitude) basis. Some environmental data sets are available with monthly 1º × 1º resolution. Higher spatial or temporal resolution may be available by going to the original source (e.g., fish market records, log books, satellite images) but increased cost and processing time are likely disadvantages. Data ownership or copyright is also an issue.

Certain features of marine systems, e.g., their dynamic and 3-dimensional nature, are arguably still not well catered for in standard GIS. Static pictures (maps) of surface features are not necessarily useful. Further insight can be derived by overlaying data sets from different time-periods (visualising time-lagged effects) but there is undoubtedly a need for methods to explore and describe temporal and spatio-temporal variation, e.g., to follow a resource species through its life-cycle.

Data Acquisition and Processing.—Underlying data structures include vector and raster formats. Vector data are more accurate and utilize less memory. A general need is to convert data from multiple sources to a common format referenced to a common underlying grid structure. With most if not all input data, some prior screening of data is also necessary, to identify and eliminate errors. These tasks are not trivial, although screening may be aided by software such as S-PLUS®.

Where coverage of data is incomplete, there are options for interpolation to fill gaps, e.g., using kriging (a geostatistical method). However, this may be more applicable to some types of data than others, e.g., sea bottom topography can be modelled whereas interpolation of abundance data is more risky, especially when the original data are sparsely distributed (as for many trawling surveys).

Certain environmental variables turn up in most marine GIS applications, reflecting their accessibility and likely usefulness, notably bathymetry and sea surface temperature (SST). SST is one of several variables now available from satellite-derived data - others include chlorophyll-a concentration, a useful indicator of primary productivity. It should be noted that some degree of processing is required to estimate SST from satellite images (e.g., dealing with cloud cover) and web-accessible data sets are generally a product of both raw data and model output. SST data can also be processed to reveal temperature gradients and, in particular, location of frontal systems. SST is often incorporated in analyses even when no direct association with distribution or abundance is expected, since it may be a useful proxy for other variables, e.g., it may be an indicator of water mass identity.

Sea bottom temperature (SBT), and sea surface and bottom salinity (SSS, SBS) data tend to have more localized coverage due to reliance on ship-based surveys to collect data. Databases of such information include that held by ICES. A worrying trend is that such baseline data collection is decreasing in line with available funding. Ship-based surveys also yield information on bottom substrate, which can be assumed to not vary greatly over time. Information on surface and sub-surface currents tends to be derived from models, although limited experimental information is also available. Other relevant data may include atmospheric pressure, rainfall, waves, turbidity, oxygen concentration, nutrient concentrations, and phyto-zooplankton densities.

Projects on loliginid squid have generated much of the impetus to develop cephalopod-orientated GIS applications and the majority of the applications presented at the workshop were for loliginid squid. This reflects their relatively high commercial importance in many areas. Even if loliginid squid are of particular interest, it will usually be helpful to have available data on other resource species present, if only as a means of describing the biotic environment in which squid are found.

Some low resolution aggregated cephalopod fishery data are held in the ICES and FAO databases. However, a major inhibition to common GIS analysis of data across wide areas is the inconsistency and incompatibility in the ways fishery data are collected by different national governments. This is an issue that has been raised, virtually on an annual basis, in reports by the ICES Working Group on Cephalopod Fisheries and Life History over the last decade (e.g., Anon., 1992, 1999b).

Ideally, fishery or fishing survey data should provide spatially referenced abundance indices. These can be based on catch (or landings) per unit effort, provided that information is available on the structure of the fishing fleets and CPUE data can then be standardised to take account of variation in fishing power. In practice this may involve calculation of separate abundance indices from different components (gear-types or métiers) of the fishery.

The basic spatial unit for UK and French fishery landings and fishing effort data is the ICES statistical rectangle but this has yet to be adopted by most other European countries with significant Atlantic cephalopod fisheries and, even within the UK and France, differences and changes in the methods used for categorization and estimation of fishing effort make it difficult to establish standardised abundance indices.

Another problem, evident in those countries with important artisanal fisheries for cephalopods (e.g., Spain, Greece), is that very little information from such fisheries enters official records. These fisheries include those for *O. vulgaris* (using fyke-nets and pots), *Sepia officinalis* (trammel nets and traps) and *L. vulgaris* (beach-seines and hand-jigs). The CEC has funded several Study Projects to quantify artisanal catches. Thus, the project "Analysis and evaluation of the fisheries of the most commercially important cephalopod species in the Mediterranean" recorded data on fisheries for five cephalopod species (*L. vulgaris*, *S. officinalis*, *O. vulgaris*, *Eledone moschata*, and *Eledone cirrhosa*) in the Thracian Sea (Mediterranean) during 1998–1999.

Fishery data derived from logbooks are subject to errors and biases consequent on misreporting or falsification of data. This can occur for a variety of reasons, including disguising breaches of fishery regulations, tax avoidance, or to create a track record of catches for licensing purposes. Thus, in the UK, even though squid are mainly a by-catch and not subject to quota regulation, catch locations of squid may be wrongly declared to avoid disclosing that quota fish species had been taken in an area for which no quota was available, fish landings may be declared as squid landings for the same reason, and squid may be declared as fish to help build up a track record of landings of the fish species in question. On-board observers may provide a more reliable source of fishery catch data.

Trawl survey data provide some information on cephalopod abundance, e.g., for Portugal (Cunha et al., 1995) and Scotland (Pierce et al., 1998), but many national fishing survey programs collect no data on cephalopods.

Other biological data, if available in a spatially references format, may also be useful in a GIS context, including length, weight, sex ratio, and maturity. Integration of such data may help in identification of spawning and recruitment areas.

CUSTOMER SATISFACTION.—Most researchers were satisfied with the results achieved from using GIS, with the caveats that:

- A considerable investment of time is needed to start to reap the benefits of GIS, and there is initially a steep learning curve
- The full potential of GIS is still not being used, partly due to lack of understanding of its capabilities; GIS is more than just a mapping tool
- Limitations are imposed by availability and quality of data. Much research data is collected without spatial considerations in mind.

The need for tools to take account of the dynamics and 3-dimensionality of marine systems has already been noted. Another, more prosaic, need identified is for more powerful statistical tools to be incorporated into GIS rather than data being exported from the GIS for statistical analysis.

FUTURE PROSPECTS.—While several examples of GIS applications were presented in the workshop, for most scientists working in cephalopod research, GIS remains something of a mystery. Among those with experience of using GIS, views on its utility were wide-ranging. Probably no-one regards GIS as 'the new rock'n'roll', not least because it is no longer particularly new. Nevertheless, its use has become 'fashionable' among marine biologists and it has, arguably, generated a new research paradigm. As with any research tool, GIS should be used in an appropriate research context rather than throwing data at it and hoping for the best. Nevertheless, the availability of GIS makes it possible to erect hypotheses that would not previously have been amenable to test and, indeed, might otherwise never have been proposed.

At some level, GIS is available to all researchers: there are entry level software packages that will run on a desktop PC and can be learned relatively quickly, allowing overlay and display of different data-sets. On the other hand, if the research questions require something more sophisticated than drawing simple maps, then GIS implementation can rapidly move beyond the scope (in terms of time, money and the need for specialist training) of the individual researcher.

Some workers apparently regard GIS with suspicion and several responses emphasised negative points, e.g., that GIS was not a panacea. More specific observations concerned the user-unfriendly nature of the most commonly used software, and the unresolved problems of applying the methodology to 3-dimensional and dynamic marine systems.

GIS clearly has an important role in addressing questions about spatial patterns and scale, and for investigating large-scale marine system processes. Marine and fisheries applications of GIS have greatly expanded in recent years and, arguably, marine biologists (and certainly those working on cephalopods) have not so far used the full potential of GIS.

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## APPENDIX 1

### REGISTERED WORKSHOP PARTICIPANTS

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Emma Hatfield
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Didier Jouffre
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Eugenia Lefkaditou
Marek Lipiński
Genevieve Maharaj
Christine Malaka
Tom Marlow
Belinda McGrath
David Middleton
Leonard Olyott
Gretta Pecl
João Pereira
Angel Perez
Graham Pierce
Silvana Pineda
Julio Portela
João Quintela
Mike Roberts
Jean-Paul Robin
Phil Sahlqvist
Warwick Sauer
Michael Steer
Phil Trathan
Vasilis Valavanis
Yukio Ueta
Claire Waluda
Jianjun Wang
James B. Wood
Xiaohong Zheng

## Appendix 2

### List of Oral Presentations at the Workshop

#### Theme 1 — GIS Implementation

*Vasilis Valavanis* — "The Greek Seas GIS"
*Jianjun Wang* — "GIS for NE Atlantic Cephalopod Fisheries"
*João Pereira* — "The Iberian Peninsula GIS"
*Jean-Paul Robin* — "GIS for English Channel Waters"
*Claire Waluda* — "GIS Applications in the SW Atlantic"
*Julio Portela* — "GIS Applications in Squid and Hake Fisheries"
*Cherdchinda Chotiyaputta* — "GIS for Fisheries Data in Thailand"
*Len Olyott* — "The Development of a Cephalopod Fishery Information System Using GIS Techniques and Multi-Source Data"
*Phil Sahlqvist* — "GIS in Fisheries Analysis"

#### Theme 2 — Databases

*James Wood* — "Databases"
*Eugenia Lefkaditou* — "Coastal Cephalopod Fishery Database"

#### Theme 3 — GIS Applications and Modelling

*Lisa Hendrickson* — "GIS Applications for Squid Stock Assessments"
*Jose Bellido* — "GAMs and Geostatistics"
*Vincent Denis* — "GAM Models for English Channel Cephalopod Fisheries"
*Vasilis Valavanis* — "Predicting Cephalopod Distribution"
*John Forsythe* — "Using a GIS Approach to Combine Fisheries Catch Data with Satellite Sea Surface Temperature Data to Interpret Cohort Growth of the Pacific Bigfin Squid, *Sepioteuthis Lessoniana*"
*Mike Roberts* — "Design of a Model to Predict Chokka Squid Jig Catches"