The Pacific Ocean and global OBIS: a New Zealand perspective

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Introduction

New Zealand is the most oceanic nation of significant size, in the world's largest ocean. It is more than 1600 km from the nearest continent, has a land area of 268,200 km^2 (103,552 square miles), and a very large Exclusive Economic Zone (EEZ), almost 4.2 million km^2, that spans 30º of latitude and exceeds fifteen times the land area (Figure 1). This large sea area constitutes both a huge resource reservoir and a huge challenge to a country with only 3.8 million people. And, although the scales vary, similar challenges exist for the many small Pacific Island states with EEZs vastly exceeding land areas. The Ocean Biogeographical Information System (OBIS) and Census of Marine Life (CoML) concepts have particular appeal to New Zealand oceanographers and fisheries scientists who are in the process of developing regional equivalents that can also link with the global system. Here, I review New Zealand's ocean information systems, current challenges and constraints, and the potential to contribute to a global OBIS/CoML, in the context of the Pacific Ocean.

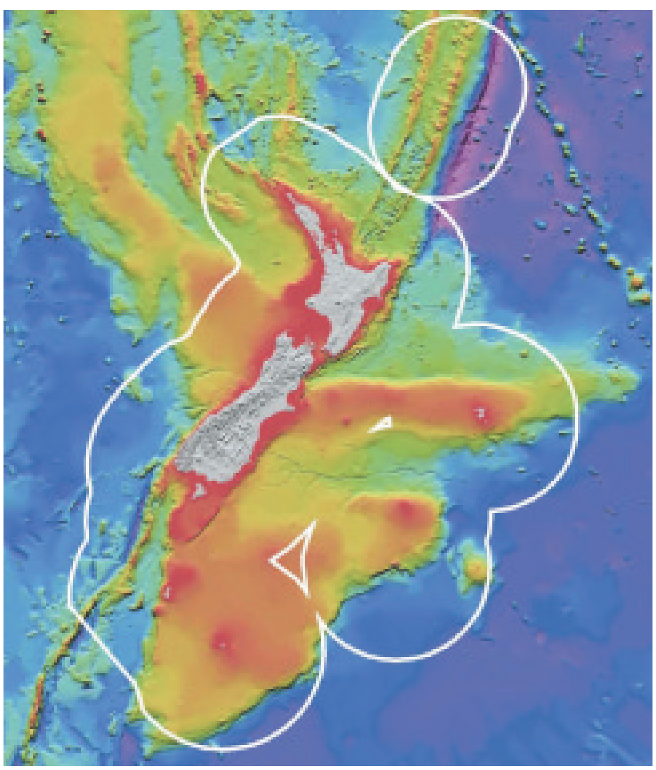

Figure 1. Undersea New Zealand, showing major seafloor features - continental shelves, plateaus, ridges, trenches, and the deep sea floor - and the boundary of the 200 nautical mile EEZ. Figure courtesy of the CANZ Group, NIWA.

NIWA – a one-stop data shop

One positive consequence of New Zealand's small population base is the concentration of ocean-exploration resources in one main organization. This is the National Institute of Water & Atmospheric Research (NIWA), one of nine Crown Research Institutes that emerged in 1992 from a restructuring of government science. Today it is New Zealand's second-largest

TABLE 1
Number of NIWA data sources for biological distributions, 1961–present.

Method		Count
Fisheries trawls		27,315
Bottom trawls	24,101	
Midwater trawls	3,214	
Non-fish trawls		1,785
Plankton net		5,578
Ichthyoplankton	3,478	
Non-fish plankton	2,100	
Dredge		5,709
Grab		4,305
Core		3,162
Shore collection		1,869
Sediment trap		89
Scuba		
Epibenthic sled		
Other		
TOTAL		**49,812**

TABLE 2
Number of Ministry of Fisheries data sources for commercial fish and squid catch-effort data, 1989–present. Data earlier than 1989 are not yet in an available format.

Method	Count
Bottom longline	236,595
Bottom pair trawl	13,233
Beach seine	19,982
Bottom trawl	829,556
Cod pot	60,402
Dredge	88,557
Diving	56,928
Dahn lines	18,209
Drift net	5,217
Danish seine	21,324
Eel pots	17,112
Fyke nets	87,828
Fish pot	33,348
Hand gathering	49,578
Handline	6,820
Midwater pair trawl	81
Midwater trawl	235,330
Pole lines	686
Purse seine	8,667
Rock lobster pot	469,146
Ring net	15,096
Surf cast net	27
Squid jig	31,832
Surface longline	36,631
Set net	341,790
Troll	80,482
Trot lines	4,448
Other	8,417
Total	**2,777,322**

research organization (after AgResearch), with approximately 600 staff, comprising oceanographic, fisheries, atmospheric, and freshwater scientists. This fruitful mix allows for the full range of multidisciplinary studies needed to investigate land-sea, seafloor-ocean, and ocean-atmosphere interactions. NIWA maintains several core databases including the Freshwater Fish Database, National Climate Database, and Hydrometric Database, and manages for the Ministry of Fisheries a large, diverse Fisheries Database and extensive acoustic-survey database. Of particular relevance to OBIS is the core database of the former N.Z. Oceanographic Institute (established in 1954 and subsumed by NIWA in 1992). This includes base data (station identifier, date, depth, gear) for about 66,000 benthic and midwater stations, mostly in the New Zealand EEZ but also in the surrounding ocean from the Cook Islands to the Ross Sea. More than 10,000 of these are benthic and sediment stations of which 4471 include both kinds of samples. Collectively, data types include benthic, planktonic/midwater, sediment/geology, and physical oceanographic. Ancillary data include taxa recorded or collected, sediment type, seafloor temperature, and water properties (e.g. salinity, conductivity-temperature-depth), depending on the type and purpose of cruise. A number of cruises also yielded bottom photographs, acoustic images, and seismic profiles. Tables 1 through 3 give the number and type of data sources for marine biological distributions and ancillary physical data held by or managed by NIWA.

The Biology Database contains specimen records (predominantly invertebrates) from seafloor sampling programs initiated in the early 1960s. The quality of the data is very variable, owing to the level in the taxonomic hierarchy at which organisms were identified (species to phylum!) and the taxonomic skill of the observer. There are also base-data transcription errors and spelling mistakes in species names that need correcting. Out of more than 120,000 invertebrate distributional records, 56,827 are for genera and 47,112 are for species. The sampling of the New Zealand non-vertebrate marine biota is still inadequate. Despite the density of benthic sampling stations achieved (now more than 10,000), the total area of seafloor sampled scientifically by trawls, dredges, epibenthic sleds, grabs, corers (but excluding SCUBA) is only about 1.5 km2. [The addition of museum and university records to this figure would still total less than 2 km2 – about one two-millionth of the area of the EEZ.] Approximately 80% of all such sampling has been carried out in the 0-1000 m

TABLE 3
Number of NIWA data sources for ancillary physical information, 1961-present.

Method		Count
CTD		6,135
Hydrocast		3,092
Photo		2,387
Acoustic image		
Seismic profile		
Water sample		1,897
Sediment sample		
Core		4,868
Drill	1,706	
Other	3,162	
Sonobuoy		1,541
Bathythermograph		339
TOTAL		**20,259**

TABLE 4
NIWA data on seamount features in the New Zealand EEZ and extra-territorial sea.
Seamounts are defined as having a vertical elevation >100 m.
Numbers are regarded as minimum estimates.
Depth is based on depth at base of seamount.

	<750 m	750-1250 m	1250-2500 m	>2500 m	TOTAL
Number in EEZ	11	126	119	133	389
No. with area data	7	88	104	131	330
Area (km^2)	2,233	1,647	8,067	88,460	100,407
No. fished (>5 tows)	3	101	38	3	145
No. extraterritorial	2	7	29	248	286

depth range, which is 28% of the sea-surface area of the EEZ (Nelson and Gordon, 1997).

Thanks to five decades of accumulated bathymetric data, and more recent GPS satellite navigation, swath mapping, and satellite altimetry, it has been possible to quickly ascertain from the NIWA database how many seamount features occur in the EEZ and local extra-territorial waters, their height above the seafloor, and their area (Table 4). This information has provided the background for a research program focusing on the biology of seamounts. There is considerable fishing pressure (for orange roughy, Hoplostethus atlanticus, and oreos, Oreosomatidae) on a number of seamounts, and underwater photographs of damaged coral plus collections of large and old coral specimens gives evidence of potential for significant negative impacts. Remote videography, already underway, is allowing censusing of biota on selected seamounts in the EEZ (Clark et al., 2000).

The Fisheries Database includes Ministry and NIWA research trawl-survey data (>24,000 trawls, 1961-1999) and industry catch records (Table 2). The research trawl-surveys were conducted to determine fish and squid distribution, abundance, changes, and diversity, and cover most areas of the EEZ, from about 5 to 1500 m depth (Figure 2). The data are analyzed to determine the distribution of species, the types and composition of fish communities, their changes in distribution and abundance over time, and whether these changes might be related to environmental fluctuations or fishing activity. Three atlases showing the distribution of the most frequently caught demersal, midwater, and pelagic species have been published (Anderson et al., 1998; Hurst et al., 2000; Bagley et al., 2000) and information in the database has been used to address the following questions: 1) Can discrete fish communities be identified in the New Zealand region?; 2) Do fish communities have distinct boundaries or do they merge into each other?; 3) Are the distributions of fish species and communities determined by physical factors such as depth and temperature? Pelagic species are also included in the database, based on aerial sightings by pilots working with purse-seine vessels. Since 1976, more than 52,000 sightings have been made from northern North Island to the mid-South Island, with data recorded on about 100 species. Single-species schools provide the best information on distribution. Current and future work will include more detailed analyses of subsets of the data. Data include prawn trawl records, as well as length-frequency and feeding data for fish and squid. The range of environmental variables associated with

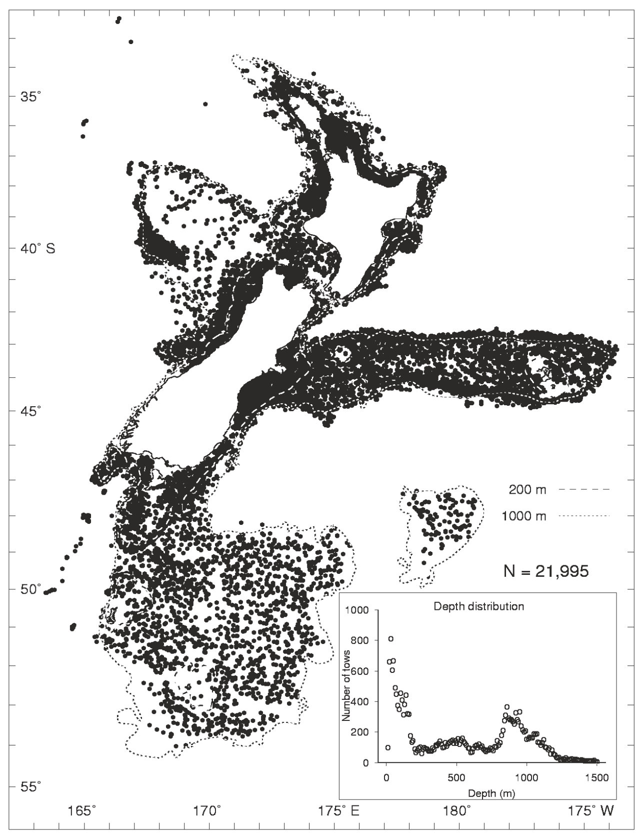

Figure 2: Location and depth of 21,995 bottom trawls in the NIWA Fish Communities Database, 1961-1997. Currently, the database represents more than 24,000 bottom trawls, recording >335,000 occurrences of 634 species. The trawl sites selected for the figure comprise those that were successful in yielding fish and squid for the database. This database is sourced from New Zealand Ministry of Fisheries data managed by NIWA. Figure courtesy of Owen Anderson, NIWA.

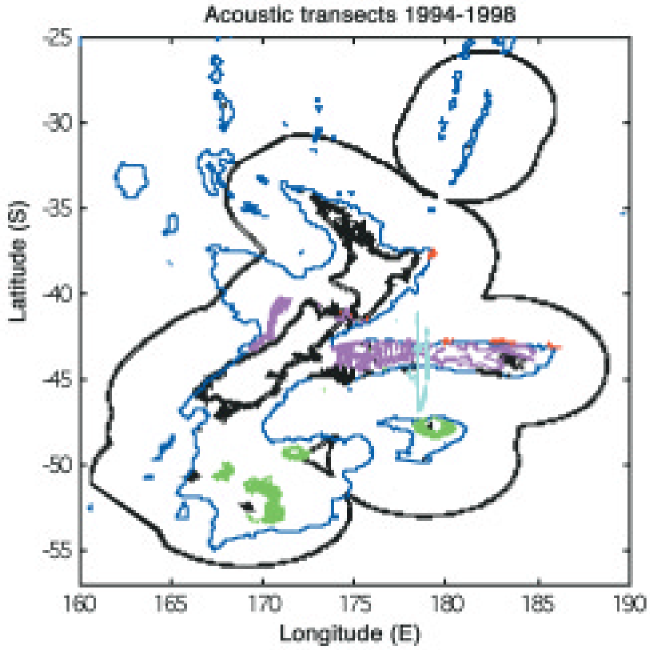

Figure 3: Example of the regional coverage of acoustic transects in the NIWA acoustic database. Purple transects = hoki surveys, black transects = orange roughy and oreos, green transects = southern blue whiting, light-blue transects = oceanographic research. The solid black line is the boundary of the EEZ. Blue lines indicate the 1,000 m contour. Figure courtesy of Dr. S. McClatchie, NIWA.

fish distribution will be extended to include salinity, water masses, thermoclines, sediments, and ocean color. This will enable investigation of pelagic and mid-water communities, identify areas of juvenile and adult distribution and abundance, examine community structure at finer spatial and temporal scales, and determine general feeding relationships.

NIWA also manages large datasets from acoustic surveys conducted between 1987-2000 around New Zealand. Regional coverage is focussed on areas supporting commercial fisheries for hoki *(Macruronus novaezelandiae)*, orange roughy *(Hoplostethus atlanticus)*, oreos *(Oreosomatidae)*, and southern blue whiting *(Micromesistius australis)*, but considerable data are also available from oceanographic voyages on the Chatham Rise (Figure 3). The acoustic database stores the raw acoustic data (both phase and amplitude) to facilitate processing for species discrimination or calculation of biomass estimates as acoustic target strength relationships are refined. The database includes both single beam and split beam data from a variety of frequencies including 3.5, 12, 38, and 120 kHz. Acoustic data are stored in conjunction with navigational information, which facilitate comparison of acoustic and extensive trawl catch data that often accompanies biomass surveys (such as catch by species and or number, size by species and ancillary biological information). A database of echograms characteristic of specific epi-benthic and mid-water fish species is being compiled. Ongoing studies at NIWA are using modelling of scattering from different fish species to design new broad-band acoustic systems to improve discrimination of species such as orange roughy and oreos (Barr, in press).

TABLE 5
How many species in the sea?

Group	New Zealand: Described	New Zealand: Known unreported/ undescribed	Global Described
Protista + Fungi	2,010	95	24,540
Seaweeds + plants	687	78	5,970
Sponges	410	255	5,000
Hydroids, corals, etc.	572	395	7,025
Comb jellies	13	6	80
Flat worms, etc.	155	90	6,795
Bryozoans	600	310	5,700
Entoprocts	9	5	150
Ribbon worms	18	6	1,250
Annelid worms	497	244	8,335
Molluscs	3,588	1,174	32,890
Lamp shells	30	0	405
Arrow worms	18	1	100
Round worms	130	60	4,200
Crustaceans, etc.	2,009	381	33,780
Sea-stars, etc.	588	160	6,150
Acorn worms, etc.	4	1	90
Sea squirts, salps, etc.	187	50	1,300
Fish, marine mammals	1,212	140	13,845
All other groups	48	23	1,705
Totals	**12,785**	**3,435**	**159,310**

TABLE 6
New Zealand's marine species diversity

Group	Described species	Known unrecorded species	Estimated unknown species	Totals rounded
Protista, Algae, Fungi, Plants	2,697	173	1,200-2,100	4,070-4,970
Invertebrates	8,876	3,122	4,320-5,440	16,320-17,440
Vertebrates	1,212	140	160	1,510
Totals	**12,785**	**3,435**	**5,680-7,700**	**21,900-23,920**

A National Biodiversity Information System

In 1999, a team of NIWA scientists proposed the development of a National Aquatic Biodiversity Information Strategy (NABIS) (Glasby et al., 1999).

Through the NABIS we envisage that "All of the available data on New Zealand's freshwater and marine biodiversity is digitally archived for future security and made accessible to stakeholders through an integrated system of databases in order to improve the understanding, sustainable utilization and management of our aquatic environments." The initial focus – to develop a marine benthic information strategy and concurrently upgrade NIWA's marine benthic database – was broadened to include and integrate freshwater biodiversity

TABLE 7
Summary of major challenges facing New Zealand and Pacific Island nations in marine biodiversity assessment, living marine resources inventory, and censusing of marine life. And some possible solutions.

CHALLENGES	*SOLUTIONS*
The sampling challenge • Large size of 200 nm EEZ • Small population (i.e. human resource) base • High cost of ocean survey and sampling • Urgency (because of anthropogenic impacts) including global warming	*The sampling challenge* • increased use of remote technologies and partnerships with key technological agencies • increased quantitative sampling of selected areas of seafloor (including the deep sea) and of smaller meiobenthic faunas • application of marine BioRap* procedures for rapid assessment of assemblages in priority areas in relation to sediment and hydrographic factors and map their distributions
The taxonomic challenge • shortage (or lack) of specialists for most taxonomic groups • urgency (because of aging practitioners, little training, and few new recruits and jobs) • validation of shipboard identifications yet to be carried out for many species records	*The taxonomic challenge* • publication of more and varied identification products • baseline review of all known taxa (cf. Species 2000: NZ) • development of national taxonomic strategies • increase in capacity-building and training of new recruits for regional initiatives
Data and analytical challenges • biodiversity data mainly non-quantitative presence-absence type • many biodiversity data not yet captured electronically • many biodiversity data not yet, or only partly analyzed (e.g. identifications to family or genus only, few cluster analyses to ascertain relationships in assemblages) • many ancillary data (e.g. sediments) not yet digitized • existing databases need upgrading to accommodate new information fields and to permit linkages	*Data and analytical challenges* • development of national or regional biodiversity information systems (cf. NIWA's newly formulated strategy NABIS–National Aquatic Biodiversity Information System) and/or linkage with OBIS/CoML • upgraded database systems, based on international standard(s) • increased rate of capture of biodiversity data from published and unpublished sources to databases • digitization of untransformed ancillary data • conformity to data standards
Policy challenges • too many disparate agencies and pieces of legislation relating to the marine environment • often no clear hierarchy of responsibility or effective mechanism for protecting marine biodiversity, either in-country or for extra-territorial waters • no cohesive strategy or timetable for marine-protected areas	*Policy challenges* • development of national and regional ocean policies • simplification of the complex legislation and management structures and increased international cooperation • development of national and regional strategies and timetables for protection of marine areas • willingness of national and international agencies to increase support for ocean science (which should include biodiversity studies and database upgrading)
The educational challenge • need for more education concerning marine conservation values, especially in the fishing industry	*The educational challenge* • increased education about marine conservation values to all citizens • more reviews and syntheses of available scientific data and their communication to all potential users of the information

*See Ward et al., 1998

TABLE 8
The areal biodiversity and data-management challenge - Pacific Ocean EEZs in relation to land area and population base (adapted from SPREP 1999).

State/Territory	*Land area km²*	*EEZ area km²*	*EEZ vs land area (times larger, rounded)*	*Population*
American Samoa	197	390,000	1980	57,000
Cook Islands	180	1,830,000	10,167	18,100
Fiji	18,376	1,290,000	70	768,700
French Polynesia	3,521	5,030,000	1,429	221,300
Guam	549	218,000	397	150,000
Kiribati	727	3,550,000	4,883	80,400
Marshall Islands	720	2,131,000	2,960	56,500
Micronesia (Fed. States)	702	2,978,000	4,242	125,100
Nauru	21	320,000	15,238	10,400
New Caledonia	19,103	1,740,000	91	186,800
New Zealand	268,200	4,199,100	16	3,800,000
Niue	258	390,000	1,512	2,200
Northern Marianas	475	1,823,000	3,838	71,800
Palau	500	629,000	1,258	16,900
Papua New Guinea	461,690	3,120,000	7	4,173,200
Pitcairn	5	800,000	160,000	50
Samoa	2,934	120,000	41	163,900
Solomon Islands	29,785	1,340,000	45	375,000
Tokelau	12	290,000	24,167	1,600
Tonga	696	700,000	1,006	98,900
Tuvalu	26	900,000	34,615	9,900
Vanuatu	12,189	680,000	56	168,300
Wallis & Futuna	124	300,000	2,419	14,700
Total	**820,989**	**34,768,100**		**10,570,800**

data and associated aquatic environmental information from all potential providers in New Zealand (including museums, marine laboratories, Regional Councils, and Department of Conservation conservancy offices). The NABIS will be developed and implemented over the next several years in three phases: 1) Database development/preparation for networking within New Zealand; 2) Web–based integration and interrogation, i.e., integrating New Zealand marine benthic databases with those of museums and oceanographic institutes in Europe and North America for mutual interrogation using standard data–interchange protocols; 3) Modeling and estimating biodiversity in relation to environmental variables and human activities.

Much information on coastal and shallow–shelf non–fish species records in New Zealand – species lists, distribution maps, and relative abundance estimates – is contained in student theses, unpublished reports, and published literature. One of the goals of the NABIS strategy is to make these data available electronically and to improve standardization of data protocols (e.g. locality, depth, species, and time periods). These data will feed into another NIWA project, which is to map the benthos of the EEZ. Very little of the New Zealand seafloor has been sampled quantitatively but the high density of sampling in some areas may be adequate to allow the use of presence–absence data in characterizing species distributions and the identification of benthic assemblages. These will be mapped, area by area, over the continental shelf and eventually into the deep sea. The picture that emerges, at alpha, beta, and gamma levels, will be helpful in a number of ways. Knowing the distribution of species and assemblages over the wider region will give an objective measure for deciding what and where to protect, and what criteria to use, e.g. representativeness, genetic or habitat rarity, ecological attributes, resource potential, etc. Knowledge of species and assemblages will provide opportunities to identify large–scale distributional trends, biodiversity hotspots, and areas for more detailed study, e.g.

transitional areas, areas under fronts, areas of economic interest, or subject to environmental/anthropogenic perturbations.

Biodiversity and other challenges – and some solutions

Among the challenges facing New Zealand, and especially the small island states of the Pacific, is biodiversity inventory, especially in deeper water which is subject to exploitation but which has not been intensively sampled or characterized scientifically. A species inventory of the entire New Zealand biota, known as *Species 2000: New Zealand*, is providing a snapshot of biodiversity at the turn of the century. A five–day symposium in February 2000 featured kingdom– and phylum–by–phylum reviews of knowledge to date, and chapters will shortly be collated into a volume to be published in 2001 (International Biodiversity Observation Year – IBOY). Interim estimates of marine species richness in Tables 5 and 6 suggest that, at the present rate of discovery and formal recording of new species and records, it will take at least a century to finish the task of marine inventory. Tallies for New Zealand marine species (EEZ) in Table 5 are summarized in the first two columns of Table 6, which also gives conservative estimates of undiscovered species in column three. The totals of 9,115 to 11,135 for columns two and three combined are estimates of the numbers of species yet to be formally recorded or described. At the present rate of reporting additions to our marine biota (<100 species per year), it will take another 90 to 110 years to complete the task. Certainly the rate of discovery of new taxa (e.g. one new fish species/record per fortnight) exceeds the ability of the New Zealand taxonomic community to keep abreast of it (Gordon, in press). We are finding, as we receive fresh bycatch from observers on commercial fishing vessels in deep water (>1000 m), that species previously thought to be rare are commoner than we thought. At the same time, many new species are being found, some quite spectacular. The discouraging aspect is that the fishing methods yielding the new taxa are very likely severely impacting the habitats from which they are taken.

There are numerous other challenges to achieving New Zealand and Pacific Island contributions to an OBIS and Census of Marine Life. These, and some suggested solutions, are summarized in Table 7. Many Pacific Island nations have ratified the 1992 Convention on Biological Diversity or are signatory to it and, while all have very large EEZs in relation to their land area (Table 8), integrated coastal (and ocean) management (ICM) are only now beginning to gain attention in many of them (SPREP, 1999). Partnerships are the only way most Pacific Island countries will be able to inventory, document, and benefit from biodiversity information, using common data standards and architecture. Fortunately, regionalism is an important characteristic of the Pacific Islands. There are a number of intergovernmental agencies and NGOs helping Pacific Island nations deal with ICM problems, especially those that are of such scale that they can only be dealt with on a multi–country basis. OBIS and CoML are concepts that have great appeal and potential for the island nations of the world's largest ocean who, however, will need technical and financial assistance for reciprocal benefits.

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