

# Fourth International Conference on Artificial Habitats for Fisheries: A Convener's Perspective

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## INTRODUCTION

Following three previous international conferences in this field, the Fourth International Conference on Artificial Habitats for Fisheries was organized for 1987. This paper summarizes major findings of the latest conference and describes its organization as a reflection of growing world interest in the subjects covered.

In contrast with periodic meetings of established scientific societies or occasional congresses sponsored by natural resource ministries involved with research and management, the conference described herein is somewhat unique in two ways:

1. Its focus on a well-defined subject while still involving a broad range of technical and non-technical interests.
2. The ad hoc nature of its administrative organization and continuity.

Such characteristics warranted extra attention to ordinarily routine operations such as conference publicity, follow-up, and dissemination of results to scientific and semi-technical audiences. As such they are noteworthy for planning future and similar conferences.

## BACKGROUND

Despite the sophistication or relatively high financial cost of artificial habitat enhancement practices in certain areas of the world, notably Japan (Grove and Sonu 1985), typically such efforts to enhance fisheries are either less rigorous in terms of scientific and engineering rationale or are based on relatively low investment of capital and energy resources. The latter situation exists in both industrialized and developing nations. Some examples are the opportunistic use of surplus materials such as derelict ships in Florida, USA (Seaman and Aska 1985) or deployment of natural products (*e.g.*, palm fronds, brushpiles) as artisanal fishery attractors (Vande Vusse 1985). Hence, there has been a continuing need to exchange scientific information in this increasingly active field, to foster the transition from "art" to interdisciplinary science (Bohnsack and Sutherland 1985).

In addition to numerous local, state or provincial, and national meetings dealing with artificial reefs and related practices (*e.g.*, North American Great Lakes, 1983 [D'Itri 1985]; Florida, 1977 [Aska 1978]; Soviet Union, 1987

[A. Zhuikov, per. comm.]; Southeast Asia, 1988 [J. Polovina, per. comm.]); there have been four meetings billed as international in scope. They were held in 1974 in the USA (Colunga and Stone 1974), 1977 in Australia, 1983 in the USA (Buckley *et al.* 1985), and 1987 also in the USA. As a result, including acceptable manuscripts (and all abstracts) from the two most recent international conferences published by the Bulletin of Marine Science, a growing body of technical information has been organized.

The primary focus of the 1974 program, titled "Artificial Reef Conference," was just putting structures on the sea bottom; however, since that time, the conferences have evolved to embody a broader array of technologies. This conference included many descriptive presentations on local reef projects around the USA and a few reviews from other nations. The number of presentations dealing with pelagic and mid-water fish aggregating devices, for example, increased from one in 1974, and four in 1983, to eight in 1987, while emphasis on local programs and practices has decreased. Meanwhile, the number of nations represented, technical presentations, and sponsors has also increased (Table 1). Likewise, geographic range of attendees has broadened. At the 1974 conference, about 50% of the attendees were from Texas, the host state, while in 1987 77% came from outside the host state, Florida.

At the 1983 conference, held on the Pacific coast of the USA (Newport Beach, California), the steering committee of that program suggested an eastern USA location for the subsequent conference. Due to the extent of reef building in its waters (over 200 structures), Florida was the preferred location (Pybas 1987).

#### METHODS: ORGANIZATION OF THE 1987 CONFERENCE

The lack of a permanent administrative home (such as a professional society) for the series of international reef conferences led to an ad hoc arrangement for organizing the 1987 program. Initially, it was patterned after the 1983 effort. Since the time between conferences was significant, the program had to accommodate ongoing and new research and yet be sensitive to overall momentum and emerging needs in this subject area. The 1983 conference not only reported a large body of new technical information, but also identified priorities and triggered numerous follow-up studies initiated in 1984 and beyond (Buckley *et al.* 1985). Consequently, it was late 1985 before additional preliminary planning for another conference occurred.

#### Planning Committee

Informal discussion around the time of the 1983 conference between co-chairmen and members of that steering committee and staff of the Florida Sea Grant College Program (FSG) led to FSG's commitment to serve as the organizing and lead sponsor of the next such conference. Two years later,

**Table 1.** Trends in organization and participation of international conferences dealing with artificial habitats for fisheries. (Conference titles in footnotes).

Factor	Year of Conference			
	1974 <sup>a</sup>	1977 <sup>b</sup>	1983 <sup>c</sup>	1987 <sup>d</sup>
No. Sponsors	3	1	12	22
No. Registrants (No. Nations Represented)	ca. 250 (4)	? (17)	150 (7)	349 (26)
Duration (Days)	3	2	2 1/2	4 1/2
No. Papers (Oral)	41	17	43	94
No. Posters	—	—	14	37
No. Nations Represented in Presentations	4	4	7	19
Major Session Topics	<ul style="list-style-type: none"> <li>•Artificial Reefs of the World</li> <li>•Scientific View</li> <li>•Building</li> <li>•Economic &amp; Legal Views</li> </ul>	<ul style="list-style-type: none"> <li>•Regional Studies</li> <li>•Artificial Reefs &amp; Fisheries Management</li> <li>•Problems &amp; Techniques</li> </ul>	<ul style="list-style-type: none"> <li>•Surface &amp; Mid-water</li> <li>•Siting &amp; Design</li> <li>•Recruitment &amp; Succession</li> <li>•Reefs</li> <li>•Aggregation &amp; Productivity</li> <li>•Natural vs Artificial</li> <li>•Mitigation</li> <li>•Fishery Applications</li> </ul>	<ul style="list-style-type: none"> <li>•Ecology</li> <li>•Mitigation</li> <li>•Engineering</li> <li>•Fishery Management</li> <li>•Economics &amp; Policy</li> <li>•Rigs-to-Reefs</li> <li>•Assessment &amp; Monitoring</li> <li>•Artisanal Fisheries</li> </ul>
Field Trips	No	Yes	Yes	Yes
Publication of Proceedings (No. Articles + Abstracts)	Gray Literature (32+0)	No	Journal (30+26)	Journal (in review)

<sup>a</sup> International Conference on Artificial Reefs

<sup>b</sup> Artificial Reefs Symposium, 5th World Underwater Congress

<sup>c</sup> Third International Artificial Reef Conference

<sup>d</sup> Fourth International Conference on Artificial Habitats for Fisheries

certain members of the previous steering committee met with a representative of FSG, by now serving as chairman, to organize the new planning committee (Table 2). Subsequently, these members drafted a program prospectus and achieved a consensus for conference goals by correspondence and telephone.

Autumn 1987 was targeted as a time to hold the conference, but April 1986 was the self-imposed deadline by the steering committee for determining financial feasibility of conducting the effort. When sufficient sponsor commitments were secured, the committee proceeded according to the schedule in Table 3. Organization of the steering and other committees is depicted in Figure 1.

Site selection within Florida was narrowed to two coastal areas with major reef programs, the Tampa Bay area and South Florida (Pybas 1987). The latter was selected due to the proximity of live, shallow coral reefs (for field trips) and extensive international airline connections. With administrative headquarters at

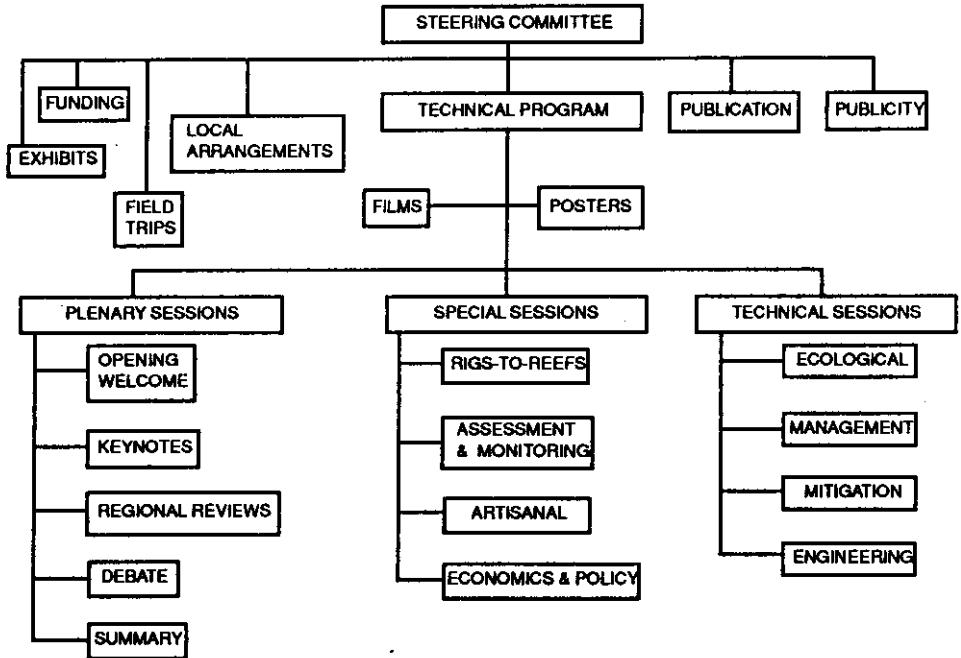
**Table 2.** Steering committee for the Fourth International Conference on Artificial Habitats for Fisheries.

W.S. Alevizon, Florida Institute of Technology  
 J.A. Bohnsack\*, National Marine Fisheries Service, Florida  
 R.E. Brock\*, University of Hawaii  
 R.M. Buckley\*, Washington Department of Fisheries  
 J.J. Polovina, National Marine Fisheries Service, Hawaii  
 W. Seaman, University of Florida, Chairman  
 R.B. Stone\*, National Marine Fisheries Service, Washington, DC

\* Member of 1983 conference steering committee

**Table 3.** Timetable of critical milestones in organizing the Fourth International Conference on Artificial Habitats for Fisheries, November 2-6, 1987.

Date	Event
November 1985	First preliminary planning meeting
April 1986	Decision date for funding feasibility
June 1986	First steering committee meeting
September 1986	First notice of conference date and location
November 1986	Call for abstracts of papers and posters; second steering committee meeting
April 1987	Due date for abstracts
May 1987	Third steering committee meeting Review of abstracts
July 1987	Registration and preliminary program announcement mailed
September 1, 1987	Deadline for revised abstracts
September 18, 1987	Cut-off date for reduced registration fee
November 3, 1987	Deadline for manuscripts submitted for publication



**Figure 1.** Organization and responsibilities of conducting the Fourth International Conference on Artificial Habitats for Fisheries.

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FSG on the University of Florida campus 500 km away, on-site coordination of conference registration and local arrangements was contracted with the University of Miami School of Continuing Studies located at the Knight Conference Center adjoining the Hyatt Regency Hotel in Miami. This facility includes riverfront dockage that was ultimately used to stage offshore field trips and a dinner cruise during the conference.

### **Program Emphasis**

The Fourth International Conference on Artificial Habitats for Fisheries was established foremost as a research conference emphasizing quantitative information. As study of artificial habitats has evolved, early research simply to assess biological succession, qualitative reports on the status of individual reefs, and cursory or non-repetitive survey of other basic ecological descriptors has led to more experimental studies, more comparison of study sites, and longer-term research. Topics such as reef deployment techniques, site and permitting considerations, and other issues of short-term concern where the lay public is involved in reef building were de-emphasized in favor of basic research information related to fundamental long-term design, scientific management of reefs and other newer habitats, as well as associated species of fishes and invertebrates.

In recognition of the broadening technology in this field, the steering committee carefully worded the conference title to embrace diverse "artificial habitats for fisheries," rather than simply declaring it a reef conference. The intent was to establish a more comprehensive title that would serve as the title of future such conferences. A timely subtitle, "Functions, Benefits, and Uses of Artificial Reefs, Fish Aggregation Devices, and Related Technologies," was articulated to orient the conference agenda toward multi-disciplinary and analytical approaches and reflect the broadening scope of activities in recent years.

Due to continuing research emphasis in certain fields, technical sessions in Ecology, Engineering, Fisheries Management, and Mitigation were designated as priority areas for the focus of the 1987 conference and in the future. Complementary themes reflecting current issues were designated for additional 1987 sessions dealing with Rigs-to-Reefs (*i.e.*, conversion of obsolete petroleum production platforms to designated fish habitat), Economics, Policy, as well as Assessment and Monitoring; the theme of Artisanal Fisheries was added to broaden the international appeal of the program.

The steering committee also specified that the agenda address certain policy issues as well as the status of major habitat programs worldwide. These topics were included in plenary sessions that broadened the appeal to potential attendees and sponsors. Reviews of five regional reef programs were invited. Growing popularity and public interest in reefs motivated a panel of expert

presentations defending alternate viewpoints on levels and responsibilities of reef development, including the extreme case of not building any more reefs.

### **Sponsorship**

Minimum budget needs included:

1. Steering committee operations, particularly meetings and publicity;
2. Journal publication;
3. Travel for invited speakers, particularly from non-U.S. locations to assure balanced geographic participation in the program.

Early major commitments for direct financial assistance came from the U.S. Department of Commerce, National Marine Fisheries Service, Sport Fishing Institute, and Offshore Operators Committee. Lesser amounts were committed by the American Fisheries Society and McIntosh Marine. No one sponsor was approached for the total budget; a partnership of sponsors was preferred as a means of building a network among reef-interested organizations.

The broad coverage of the conference program, particularly the special sessions on Rigs-to-Reefs and Artisanal Fishing, enabled solicitation to a wider array of potential sponsors including the offshore petroleum production industry and related agencies, and the international food (fisheries) development and natural resources management community. Thus, potential networks and funding channels included not only U.S. fisheries agencies and private non-profit organizations, but also industry, trade associations, and international interests.

### **Program Components**

In addition to technical, special, and plenary sessions for oral presentations, sessions for posters, exhibits, and field trips were scheduled. Ancillary meetings of related interest groups from agencies or areas were encouraged.

All contributed abstracts were subjected to standard review criteria and evaluated by all seven steering committee members, plus individual session organizers as appropriate. Technical merit as well as considerations of geographic representation and breadth of subject matter coverage, particularly for special sessions, were used to place abstracts in presentation or poster sessions. At this time, requests for travel assistance grants were considered. Session moderators were given some latitude to solicit selected additional presentations to insure breadth of coverage. Concurrent (dual) sessions were scheduled to handle the large number of presentations.

The poster session reflected a special effort to solicit state-level program reviews to facilitate exchange among local, state, and regional reef program coordinators from particularly the U.S., and also elsewhere. It also included certain contributions that simply could not be accommodated in the oral

presentations and provided an appropriate vehicle for reports of work in progress or pilot studies.

Detailed guidelines for authors of oral and poster presentations were distributed with acceptance notices. All authors were given the opportunity to submit technical manuscripts for possible publication by the *Bulletin of Marine Science*, for which funds were budgeted. All abstracts were to be published.

### **Publicity and Information Transfer**

Mailing lists from the 1983 conference and the publisher of a recent reef book by D'Itri (1985) served as the core database for distributing conference information. Ultimately a list of 2700 names of individuals and organizations was compiled. In addition, notices were published in periodicals produced by major fishery organizations, including the International Center for Living Aquatic Resources Management, Sport Fishing Institute, and American Fisheries Society.

An initial announcement of the conference date and place was distributed in 1986. A printed call for abstracts was mailed in November 1986, and the preliminary program agenda with registration information was sent in July 1987 (Table 3). Materials also were distributed at several fishery conferences, and a special announcement was sent to potential exhibitors.

Due to the magnitude and reputation of Japanese reef efforts, emphasis to include appropriate reports on the agenda was directed by the steering committee. Ultimately a secretariat acting as an arm of the committee was designated through Oceanauts Limited of Tokyo, Japan. This firm translated publicity material and arranged for organization of a scientific and commercial delegation.

Abstracts of all presentations and posters were distributed as a 144-page document to conference registrants. Summary of the conference was planned according to multiple formats. Session moderators were assigned a common outline for reporting achievements and issues, both orally in the closing plenary session and written as part of a technical summary article for journal publication. This material also was intended for use in a post-conference semi-technical newsletter to summarize priorities and needs, and thereby enhance information flow from the conference to scientists, managers, and the public.

### **RESULTS: CONFERENCE SUMMARY**

The Fourth International Conference on Artificial Habitats for Fisheries was held November 2-6, 1987 in Miami, Florida, USA. Registration was 349, including 67 individuals who reside outside the U.S. Persons from 26 nations participated, including authors of 33 posters and 94 presentations from 19 nations (Table 1). Subject matter coverage in the technical program (Table 4)



**Table 4.** Subject matter addressed by contributions to principal sessions of the Fourth International Conference on Artificial Habitats for Fisheries.

Emphasis of Session	Number of Papers	
	Oral Presentations	Posters
Artisanal Fishing	9	4
Assessment and Monitoring	7	4
Ecology	21	3
Economics and Policy	10	1
Engineering	5	3
Fishery Management	14	1
Mitigation	7	2
Rigs-to-Reefs	21	—
State/Regional Programs	—	19

included topics for all advertised sessions. One recurring session, Ecology, and one special session, Rigs-to-Reefs, had the highest number of papers, together accounting for 44% of all presentations.

By the deadline for receipt of abstracts, 96 titles were received of which 22% were from non-U.S. authors. Ultimately 161 abstracts were submitted. The large attendance of non-U.S. residents (19%) was noteworthy compared with the preceding conference, at which only 7 nations were represented. Of all non-U.S. attendees 86% were self-sufficient regarding travel funds. The conference was able to award full or partial travel grants to seven participants from overseas (65% of this budget item) and nine speakers from the U.S. (35%) including three students. Additional funds for at least two other non-U.S. attendees were arranged by the World Bank in cooperation with agencies in Norway and West Germany.

Sponsorship came from 23 organizations as direct grants to the conference budget to support individual participants or as matching in-kind contributions (Table 5). Approximately 25% of the grants were specified for support of the rigs-to-reefs agenda, and 12% of these funds were for mitigation topics. Sectors providing direct financial support were industry (33%), U.S. federal agencies (44%), and non-profit organizations (22%).

Expenditures of direct conference grants included commitments for journal publication (22%), non-U.S. participant travel (19%), domestic participants (9%), steering committee meetings (33%), and operating expenses such as printing, postage and supplies. On-site conference expenses (*e.g.*, audio-visual equipment, food, registration desk) were paid by individual registration fees (\$100 U.S. early, \$125 late) and exhibitor charges (\$250 for two days).

#### **Overview of Global Efforts**

Better known, more extensive regional habitat enhancement programs in

**Table 5.** Sponsors and cooperating organizations in the Fourth International Conference on Artificial Habitats for Fisheries (listed alphabetically). Categories include sponsors that granted funds to defray conference expenses and that provided in-kind contributions of staff time, office expenses, etc.

<b>Direct Financial Support</b>	<b>Matching Services<sup>b</sup></b>
American Fisheries Society	American Samoa, Office of Marine and Wildlife Resources
Amoco Foundation	Florida Institute of Technology
Bread for the World, Federal Republic of Germany	Florida Sea Grant College Program <sup>c</sup>
Exxon Corporation	Washington Department of Fisheries
Fish America Foundation	
Florida Conservation Association	
Goodyear Tire and Rubber Company	
International Association of Fish and Wildlife Agencies	
McIntosh Marine, Inc.	
Offshore Operators Committee	
Royal Norwegian Ministry of Development Cooperation <sup>a</sup>	
Southern California Edison	
Sport Fishery Research Foundation	
U.S. Fish and Wildlife Service	
U.S. Minerals Management Service	
U.S. National Marine Fisheries Service	
University of Hawaii	
University of Miami	
World Bank <sup>a</sup>	

<sup>a</sup> Support (all or in part) provided directly to individual conference participants

<sup>b</sup> Includes support of staff involved with steering committee

<sup>c</sup> Administrative headquarters

Japan, Australia, Europe, Southeast Asia, and North America were reviewed by all invited speakers, while individual contributions from other locations augmented knowledge of worldwide effort. Although geographic coverage of international conference presentations obviously reflects bias toward the site of the program and accessibility of attendees from the host country, fully 27% of all abstracts submitted to the present conference came from outside the USA. Thus reef-related efforts in 26 different nations were identified by the conference (Table 6). In addition, known reef programs exist in New Zealand and the Soviet Union, although they were not reported.

With the goal of food production, the most extensive national marine fisheries habitat enhancement program is conducted in Japan. For two six-year

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**Table 6.** Countries for which abstracts describing reef-related research and management were submitted for potential inclusion on the agenda of the Fourth International Conference on Artificial Habitats for Fisheries.

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Australia	Maldives
Canada	Micronesia
Colombia	Monaco
Costa Rica	Nepal
Federal Republic of Germany	Peoples Republic of China
Guatemala	Philippines
India	Romania
Indonesia	Scotland
Israel	Sri Lanka
Ivory Coast	Taiwan
Italy	Thailand
Jamaica	United States of America (including
Malaysia	American Samoa, Puerto Rico,
	and Japan/Virgin Islands)

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fishery plans in 1976-1988, the national government committed \$250,000,000 and \$500,000,000 respectively for reefs alone. Subsequent and in addition to developments reported by Grove and Sonu (1985), Mottet (1981), and Haga and Vik (1982), information presented at the conference indicated that heavy industry continues to be involved in fabrication of building-size and multi-story structures, principally of concrete and steel. A new multi-year plan, the "Third Coastal Fishing Ground Development Project," proposes one-and-a-half times the effort devoted to reefs in the current program. To date 1801 km<sup>2</sup> of fishing grounds have been constructed in Japan (Yamane 1987). While engineering and construction practices appear well-documented, aspects of ecology continue to receive attention. Particular emphasis seems to have been placed on structural

modification of nutrient upwellings.

Although similar to Japan in basing their reef programs on the goal of food production, other countries have pursued much lower cost artisanal fishing strategies. The Philippines, Jamaica, India, Sri Lanka, and Papua New Guinea are among the nations that have deployed fish attraction and production efforts using floating and benthic structures including bamboo rafts, brushpiles, coconut fronds, steel drums, and discarded tires. Motivation for this work includes restoration or replacement of degraded coral reefs, seagrass beds, and mangrove forests; reducing overcapitalization and exploitation in existing fisheries; and creating new fisheries. International development assistance agencies, such as the World Bank, Bread for the World, and the United Nations have provided some assistance.

Enhancement of commercial fishing characteristic of more industrialized areas has been conducted in Taiwan, Australia, Italy, Israel, France and Monaco. More expensive reef deployment typifies these efforts. Using cranes on barges to place material on the seafloor is one example. Materials, however, tend to be opportunistic or surplus, such as tires and concrete blocks. Deployment of reefs to direct fishing effort in the direction of or away from certain zones was reported for Italy, Monaco, and elsewhere. While benthic reefs are most commonly used, fish aggregation devices, FADs, are firmly entrenched worldwide in fisheries for pelagic stocks.

A less widespread reason for deployment of reefs to enhance recreational fisheries is more typical of North America and also is reported for Australia, certain European locations, and Indonesia. However, only Japan has implemented such extensive design and fabrication programs to achieve its goals. Typically, low-cost materials of high density are used. They usually are obtained either as surplus (*e.g.*, derelict vessels) or as new materials used for purposes for which they were not intended originally (*e.g.*, concrete blocks). Limited deployment of baitfish attractors has occurred. Apparently the only other national plan for reefs was written in the United States (Stone 1985). However, reefs in the USA typically are developed in individual states by governmental or private interests not by a federal agency. At the state level, few plans exist, although several states and even some local governments employ a reef coordinator.

Finally, recreational diving as a motivation to build reefs has received a very limited effort. The Puget Sound region in Washington and the conference site, Miami, has seen a small charter boat industry develop to support this interest.

### **Research and Technological Advances**

Due to the conference agenda of dual sessions for all oral technical reports, it was only physically possible for any one attendee to listen to half of all the

presentations. The format of the closing plenary session accounted for this situation. Moderators of all sessions presented brief summaries, reflected briefly in the following account, which also draws from individual abstracts of posters and oral reports.

As apparent from the preceding overview of global efforts, practices to enhance fisheries by means of artificial habitats reflect greatly varying levels of commitment of financial investment, national or local initiative, objectives and overall planning, and availability of scientific data. Ecology and engineering aspects of artificial habitats, particularly benthic reefs, are better known due to increased research in the past several years. Comparisons of structures for design and siting criteria, for example, have provided quantitative data on physical performance in the environment.

Ecological research has described physical oceanographic factors around reefs, such as current and wave influences, as well as fish community succession, zonation and seasonality. This research has been accomplished partially from the perspective of answering basic ecological questions. Artificial habitats were recognized as appropriate sites for additional classical studies of behavior and ecology; yet conversely principles pertinent to natural ecosystems (*e.g.*, coral reefs and rain forests) were commended to workers in this field. Further interdisciplinary research, such as in the examination of physical modification of nutrient upwelling, was endorsed.

Newer areas of inquiry have started in only the last 10-15 years, and these areas include: the economics and impact of artificial habitat development; the use of reefs in mitigation of environmental alteration; and the application of more accurate and technologically advanced methods of fishery science to assess and monitor reef communities. Economic performance (*e.g.*, improved catch or decreased cost per unit of effort, overharvesting, an user conflicts) has not been well measured for many commercial or recreational fisheries (in only the past 10-15 years), although the value of catches derived from artificial habitats has been calculated for several locations. Artisanal fisheries appear to be the most cost-effective. Examples of using reefs to mitigate environmental impacts come only from the Pacific coast of the USA mainland, and are nonexistent or unreported from other locations. Yet from limited work in this field has come a predictive index for reef effectiveness, which is worthy of testing and application in other areas.

Much was addressed toward the formerly nagging and long-standing "attraction versus production" issue, (*i.e.* do reefs simply attract fishes from other areas or do they actually increase biomass in a given area?). The alternate idea of viewing this issue as being on a continuum, depending on specific characteristics of a given site, was expressed as preferable to the "either-or" dichotomy created by forcing a choice of the attraction or production position. Indeed, data appropriate to various points on a continuum of

attraction/production were presented.

Despite implementation of artificial habitat practices in a growing number of countries, these efforts largely have perpetuated existing technologies. Much of this perpetuation has been through opportunistic use of traditional materials. A newly available substrate is the petroleum production platform used by the offshore oil and gas industry. Although centers of activity exist in the North Sea, northern South America, and Southeast Asia, efforts to convert these massive obsolete structures into submerged fishery reefs have been most pronounced in the U.S. Gulf of Mexico (Reggio 1987). The ultimate possibility of utilizing 4000 U.S. platforms, mainly off Louisiana, instead of disposing of them on land has stimulated industry, fishery, and agency efforts to secure oil rigs as dedicated fish habitats. It is noteworthy that fisheries can and do develop insitu around actively producing platforms: For example, a significant recreational fleet operates around Louisiana rigs. In contrast to the situation in the U. S. Gulf of Mexico, active fisheries have been discouraged in the North Sea. However, in California harvest of mussels from operating rigs supplies nearly all of that state's consumption, while serving to remove a biofouling organism.

In addition to exhibits by 11 industry and governmental organizations, a special evening presentation was made by the 10-member delegation from Japan. The latter included representatives of six reef construction businesses.

### **Emerging Needs and New Priorities**

Of striking importance to this field was the consensus from many independent quarters that reefs and other habitats must be used for more than purposes of exploitation. Instead, they could be employed as tools to manage fishery stocks, other aquatic organisms, and the ecosystem. In other words, the view is passing that they are to be used simply to aggregate organisms for capture or to increase harvestable biomass produced in an area. Consideration of their broader role to conserve stocks or actually rehabilitate species or populations was endorsed. Enhancement of stocks through juvenile recruitment was forecast. Remarkably, such a more holistic view emerged independently from a variety of disciplines, including ecology, economics, and management. Furthermore, actual management of fishing interests to control access to and harvest from reefs by different users was endorsed.

Disciplinary lines also converged to encourage the acquisition of long-term databases to quantify the performance of artificial habitats. Their ecological role vis à vis natural ecosystems, economic benefits and costs, and their role in fisheries productivity and mitigation can be documented only through extensive studies over time. Some of the topics needing research include food, shelter, and recruitment limitation. Little is known about how manipulation of specific design features can affect abundance of species at different life stages.

Coordination of research at regional levels is essential. Due to exchanges at

the conference, it is likely that bi- or multi-national joint projects may be undertaken. An important caveat for research planning was for scientists to have a grasp of the overall management objectives established for the resource prior to initiating study. New methodologies and effective means of comparing results from different techniques will be required.

The effectiveness of small-scale artificial habitats to enhance artisanal fisheries in rural villages of developing countries will encourage future efforts. However, continuing improvement in engineering and construction techniques is recommended. Integration of artificial habitat technology and mariculture may promote new opportunities for food production. Competition and conflict will continue to require attention in these and also in more costly industrial and recreational situations.

Several organizations used the conference as an opportunity to conduct adjunct meetings or send delegations to exchange information. For example, the reef committee of the Atlantic States Marine Fisheries Commission held a business meeting, while an initial ad hoc reef committee of the Great Lakes Fishery Commission also met. The reef fish scientific committee of the South Atlantic Fishery Management Council attended.

Finally, regarding future conference planning, there was clearly a mandate to continue such formal exchange of information, probably in the next three or four years. While a non-U.S. site may be available, the option to again meet in the USA was also deemed viable because of several sponsor travel awards and the high degree of self-sufficiency attained in 1987 by persons traveling to the USA. Meanwhile, advance publicity of three years may be highly appropriate, and a lead time of at least two years will be necessary to broaden even more the sponsorship of international agencies that were linked in the network fostered by this conference.

### **Summary**

Harvest of finfish and invertebrate species associated with artificial habitats in marine and freshwater environments has become significant in a number of areas of the world. Interest in and application of technologies to develop artificial habitats for fisheries has spread from a limited number of nations to at least 30 in this decade. Historically, proven practices utilizing cheaply acquired materials predominate in artisanal, commercial, and recreational fisheries. Validation of design procedures has been most advanced in engineering studies, particularly related to fabrication of benthic reefs in Japan, which is unique in its massive financial investment to achieve seafood sufficiency as a national goal. Especially in the areas of evaluation and prediction of the performance of artificial reefs and other devices, ecological and economic studies have lagged in development of short and long-term databases.

A limited number of countries have a national plan and program to enhance

fisheries habitat in a coordinated manner. Otherwise, individual projects are conducted. There is, however, growing realization that reefs and other structures must be employed in a comprehensive management strategy that encompasses conservation as well as exploitation, user interests, and components of the ecosystem other than targeted fishery stock. Newer applications of artificial habitat technology to mitigate environmental alteration are being evaluated.

Among the 349 conference attendees and 23 sponsors, enhanced information exchange was achieved, and avenues for future collaboration were established. Reduced duplication of effort will enable better expenditure of research and development budgets. Priority needs include quantification of design and siting criteria, determination of species life history needs in relation to artificial habitats, and management options for fisheries (both fish stocks and users) and ecosystems affected by deployment of artificial habitat. A fifth conference sometime in 1990-1991 is anticipated

#### ACKNOWLEDGEMENTS

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#### REFERENCES

- Anonymous. 1987. The ocean with unlimited possibilities—its exciting future. The National Coastal Fishery Development Association, Tokyo, Japan.
- Aska, D.Y. (ed.) 1978. Artificial reefs in Florida. Florida Sea Grant College Program. Report No. 24.
- Bohnsack, J.A. and D. Sutherland. 1985. Artificial reef research: a review with recommendations for future priorities. *Bull. Marine Sci.* 37(1):11-39.
- Buckley, R., J. Grant and J. Stephens, Jr. 1985. Third International Reef Conference 3-5 November 1983, Newport Beach, California. *Bull. Marine Sci.* 37(1):1-2.
- Colunga, L. and R. Stone. 1974. *Proceedings of an international conference on artificial reefs*. Center for Marine Resources, Texas A&M University, college Station, Texas. TAMU-SG-74-103.
- D'Itri, F.M. (ed.) 1985. *Artificial reefs: marine and freshwater applications*. Lewis Publishers, Inc., Chelsea, Michigan.
- Grove, R.S. and C.J. Sonu. 1985. Fish reef planning in Japan. Pp. 187-251 in:



- F. D'Itri, ed. *Artificial reefs: marine and freshwater applications*. Lewis Publishers, Inc., Chelsea, Michigan.
- Haga, J.Y. (translator) and S.F. Vik (ed.) 1982. Japanese artificial reef technology.
- Mottet, M. 1981. Enhancement of the marine environment for fisheries and aquaculture in Japan. Washington State Department Fisheries, Olympia. Tech. Rep. No. 69.
- Pybas, D. 1987. Atlas of artificial reefs in Florida. Florida Sea Grant Extension Bull. SGEB-13.
- Reggio, V.C., Jr. 1987. Rigs-to-reefs. *Fisheries* 12(4):2-7.
- Seaman, W., Jr. 1986. Helping to build your artificial reef. Florida Sea Grant College Program, SGEF-4.
- Seaman, W., Jr. and D.Y. Aska. 1985. The Florida reef network: strategies to enhance user benefits. pp. 545-561 in: F. D'Itri, ed. *Artificial reefs: marine and freshwater applications*. Lewis Publishers, Inc., Chelsea, Michigan.
- Stone, R.B. (compiler). 1985. National Artificial Reef Plan. U.S. Department of Commerce, National Marine Fisheries Service, NOAA Tech. Memo. NMFS OF-6.
- Vande Vusse, F.J. 1985. Artificial reefs in developing countries: what is appropriate? *Bull. Marine Sci.* 37(1):402. abstr.
- Yamane, T. 1987. Situation and future plan of artificial reef project in Japan. P. 133 in: Fourth International Conference on Artificial Habitats for Fisheries: Abstracts. Florida Sea Grant College Program, Gainesville, Florida.