RESULTS OF THE FISHING DISCUSSION GROUP PROCESS, FALL 2003:

FISHING IN THE PROPOSED NORTHWESTERN HAWAIIAN ISLANDS NATIONAL MARINE SANCTUARY

Prepared for:

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Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve
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EXECUTIVE SUMMARY

In August 2003 a multidisciplinary team of independent researchers was assembled at the request of NOAA National Marine Sanctuary Program (NMSP) to conduct background research on commercial fishing in the Northwestern Hawaiian Islands (NWHI), and to present and refine information on the state of knowledge of the fisheries and their possible ecological effects. The effort was designed as a collaborative process involving representatives of NMSP, the other stakeholder agencies including U.S. Fish and Wildlife Service, State of Hawaii Department of Land and Natural Resources, National Marine Fisheries Service (NOAA Fisheries), and Western Pacific Regional Fishery Management Council (WPRFMC); in addition to the fishing industry, researchers, native practitioners, and NGOs. Its impetus and primary purpose was to assist NOAA NMSP in providing guidance to WPRFMC for the development of fishing regulations for the proposed NWHI National Marine Sanctuary.

The project's objectives were two-fold: (1) to develop a range of possible fishery regime alternatives, and recommend those most consistent with the principles and purposes of the proposed Sanctuary as articulated in relevant statutory and policy documents; and, (2) to involve NOAA and the invited participants in a process toward clarifying the facts concerning the fishery resources of the NWHI and that the range of fishery management alternatives developed reasonably represent these facts, as well as the principles and purposes.

The process involved assembling more than 50 participants represented by agencies, commercial fishers, researchers, native practitioners, and NGOs, and conducting 18 facilitated meetings from August through November 2003, with a follow-up period to respond to participants' advice on filling information gaps. Discussion groups were assembled for each of six topics delineated by NOAA NMSP, as largely determined by the existence of WPRFMC Fishery Management Plans (Precious Coral, Crustaceans, Bottomfish, Pelagics) along with discussion groups on subsistence fishing and zoning. Working documents were developed on each topic by the researchers based on literature review, expert interviews, and feedback from the discussion group participants.

Following the meeting process and information gathering, the consulting scientists further considered the compatibility of commercial fishing with the proposed Sanctuary in light of the past history and current status of fisheries, fishery science and fishery management. The criteria used to consider compatibility included: (i) the purpose and goal of the proposed Sanctuary, (ii) accepted marine ecosystem conservation and management and fisheries management science and associated policy, (iii) existing evidence of the degraded condition of the Hawaii's regional coral reef ecosystem and its vulnerability to further stresses including overfishing, and (iv) the requirement under the National Environmental Policy Act (NEPA) that a reasonable alternative support the proposed action's purpose and need.

In addition to the report's finding concerning the compatibility of commercial fisheries with the objectives of the proposed Sanctuary (described below), two other critical findings emerged from the research and meeting process and supplementary information gathering. First, as documented by the responsible agencies' themselves, commercial fishing and fishery management in the NWHI has had a problematic history in terms of its economic and ecological viability. This is due in large part to the responsible agencies' difficulty in integrating the multiple (often conflicting) mandates of fishery development, sustainable resources management, and environmental protection. Second, the agencies

have made progress toward understanding past fishery management failures in the NWHI. This is reflected, for example, by the current efforts underway by NOAA Fisheries' scientists to reorient their research programs toward an ecosystem-based approach. In view of this developing capacity, the NWHI National Marine Sanctuary designation process represents an historic opportunity to manage biologically intact as a reference site, representative of one of the world's most valued and threatened ecosystems.

This reorientation in fishery science and management also constitutes a shift in decision-making methodology and its scientific basis, involving fishing and all other uses, in the design and management of the proposed Sanctuary. Decision-making must be consistent with the primacy of the proposed Sanctuary's purpose and goal. Based on the consultant's interpretation of the relevant policy documents, including feedback provided by the fishing discussion group participants, this is to maintain intact, and in its relatively natural condition, the ecosystem and its biodiversity. This relatively intact condition is referred to in the scientific literature as ecological or biological integrity. Sanctuary uses, including fishing, require determination of their compatibility with this purpose and goal of the proposed Sanctuary. In the case of fishing, this determination involves a shift in the scientific basis for the decision to open or close a fishery. This requires a reversal of the scientific burden of proof from that historically employed in fishery management for the NWHI and elsewhere, which was to demonstrate fishing would have negative ecological consequences. In the context of the proposed Sanctuary (as well as the existing Reserve) the scientific burden of proof required is to demonstrate a fishery management regime will not compromise the Sanctuary's purpose and goal.

None of the proposed or currently operated fisheries in the NWHI have met this standard. Three are judged as clearly incompatible with the proposed Sanctuary on the basis of the above decision criteria, and the fishery-specific information resulting from the fishing discussion group process. The proposal for a precious coral fishery is based on flawed and incomplete analysis, and precious coral harvesting poses a potential threat to a unique component of the NWHI marine ecosystem for which no mitigating management measures are known. A lobster fishery, also currently non-existent, collapsed in 1990 following an ecosystem shift and overfishing. It was closed in 2000 by court order due to a potential impact on the endangered monk seal and by NOAA the same year due to uncertainties in the stock assessment. The bottomfish fishery, currently being operated in the absence of adequate stock data, exhibits signs of both overfishing and possible effects on components of ecological integrity. Following their rapid growth and peak catches in the 1980's, both the lobster and bottomfish fisheries experienced significant declines in revenues, number of vessels participating and indicators of profitability. Biological and economic information on the only other fishery currently in operation in the NWHI, the pelagic fishery, is inadequate to assess either the status of its stocks or indicate whether possible negative ecological consequences associated with it are significant.

Several "next steps" are recommended for the ongoing management planning and NEPA analysis required by the Sanctuary designation process. These include: implementing protective measures as fishing under the current management regimes is phased out; initiating a systematic science-based zoning design process in the context of developing a comprehensive zoning strategy; assembling expert working groups to assist with an expanded participatory process; and integrating traditional Native Hawaiian knowledge and perspectives. In addition to this traditional indigenous knowledge, these steps and groups should incorporate expert disciplinary knowledge in marine conservation biology, protected area design, ecosystem management, and ecosystem-based fishery management.

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1.0 PURPOSE AND GOALS

Sustainable Resources Group Int'l, Inc. (SRGII) was contracted to conduct background research and facilitate a series of fishing discussion group (FDG) meetings to present and evaluate information and findings as developed through the period of August through November 2003. The purpose was to gather, discuss and synthesize information, and to provide recommendations and advice to the National Marine Sanctuary Program (NMSP) related to the Northwestern Hawaiian Islands (NWHI) Coral Reef Ecosystem Reserve (hereafter referred to as the Reserve) and proposed National Marine Sanctuary. The impetus for conducting the process during this period of the management planning process was NMSP's requirement to provide guidance to the Western Pacific Regional Fishery Management Council (WPRFMC) on the development of fishing regulations as provided for under Section 304(a)5 of the National Marine Sanctuaries Act (NMSA). In this regard the effort had two primary goals:

- To develop a range of possible fishery regime alternatives; recommending to the NMSP the criteria for fishing regulations most consistent with the principles derived from NMSA as well as the vision, mission, guiding principles, and goals for the Sanctuary.

- To involve the stakeholder agencies and invited experts in a process toward reaching agreement 1) on the facts concerning Northwestern Hawaiian Islands (NWHI) fishery resources, and 2) that the range of fishery management alternatives developed reasonably represent these facts and principles.

In addition, the consulting scientists overseeing and conducting the analysis reached an overall conclusion concerning the compatibility of commercial fishing in light of the stated goals and objectives of ecosystem conservation for the proposed Sanctuary. The basis for this conclusion, and further synthesis and documentation are provided in the Appendix to this document containing *Decision Criteria, Information Synthesis and Findings*. This was produced independently of the research and FDG meeting process for the purpose of describing scientific concepts and decision criteria upon which the compatibility finding was made.

2.0 METHODS AND APPROACH

The initial effort, conducted from August through November 2003, involved literature review, expert interviews, development of the working documents, and 18 Fishing Discussion Group meetings involving more than 50 participants. As a consequence of the need to provide guidance to WPRFMC on fishing regulations, NOAA NMSP identified the need to address six fishing and fishing-related topics. The outcome of the planning resulted in the establishment of four Fishing Discussion Groups (FDG) as well as a Subsistence Discussion Group and Zoning Discussion Group. The FDG categories were determined by the existence of WPRFMC Fishery Management Plans for each of the topics (Precious Coral, Crustaceans, Bottomfish, Pelagics (and Recreational) Fishing). The discussion group participant lists, materials distributed at the meetings, the alternatives discussed, and notes and other materials, including transcripts from the subsistence group are provided in the appendices to this report.

The NMSP worked with the consultant to develop a series of criteria for selecting members of the fishing discussion groups. The criteria for group membership included relevant agency affiliation, commercial

fishing experience, subject matter expertise (species level, ecology, marine mammal, etc.), expertise in relevant Native Hawaiian issues, RAC representation, and non-agency conservation interest representation. Meeting schedules were set, consisting of three meetings planned for each of the groups, and the participants were invited. The original meeting schedules required modification during the process to accommodate unanticipated needs and conflicts. By the end of the process at least three meetings had been held for each FDG addressing the fisheries associated with WPRFMC fishery management plans (FMPs). The consultant conducted two meetings each for the Subsistence Discussion Group and the Zoning Discussion Group.[1] These meetings were scheduled to run for three hours, and were run with the assistance of a professional facilitator.[2]

Concurrent with the meeting scheduling and planning six researchers with backgrounds in marine or fisheries biology were assigned the tasks of separately gathering and organizing information to be addressed by each of the discussion groups. The information gathering was accomplished primarily through interviews and analysis of reports and references obtained from the same government agencies and often the same individuals making up the discussion groups, as well as the primary scientific literature.

The meetings consisted primarily of the presentation and discussion of information derived from background research on the history and current status of fisheries in the NWHI, and solicitation of feedback concerning its validity and assistance in correcting or obtaining additional information. This information, updated based on the feedback received from participants between and after the meetings ended, was developed into a total of six working documents. The working documents represent a summary of the current state of knowledge, the current management regime, and possible environmental impacts for use in the discussions. The information contained is derived primarily from background research, feedback from fishing discussion group meetings, and expert interviews. They do not represent the full extent of existing knowledge and data on each topic. Their content, plus some additional pertinent material, is summarized in Section 5 of this document. In addition, Section 5 contains a brief summary of the socio-economics of NWHI fisheries based in part on a seventh document reviewing economic aspects of the fisheries. The framework, concepts, and criteria for developing Sanctuary management regime alternatives consistent with the consultant's interpretation of the purpose and goal of the proposed Sanctuary were also presented and discussed at meetings with the FDGs.

[1] An additional Zoning meeting was held with representatives from State and Federal Agencies with NWHI management jurisdiction.

[2] With the exception of the Subsistence Discussion Group meetings for which it was felt it would be unnecessary and culturally inappropriate to operate the meeting using Western facilitation procedures.

3.0 KEY RESULTS AND OUTCOMES

The process produced the following results:

1. Alternatives framework and an array of possible alternatives (not necessarily reasonable under NEPA); and documentation of the background research and the fishing discussion groups' input for six topic areas.
2. Criteria and decision framework, related to the state of knowledge on marine ecosystem management, used as a basis for judging what uses, including fishing, are compatible with the proposed Sanctuary.
3. Documentation, based on a collaborative, participatory process of what agency representatives, experts, and other informed stakeholders considered factually correct regarding the history and status of fishing in the NWHI, and their biology, economics, and management.
4. Finding concerning the compatibility of fishing with the proposed Sanctuary, based on the information assembled on the status of the fisheries as described in the working documents, the statutory and policy basis for Sanctuary designation, the state of scientific knowledge about marine ecosystem and biodiversity conservation, and the consulting scientists judgment.
5. Recommended next steps required for completing the management planning process for the proposed Sanctuary.

The key finding of the consulting research team, the basis for which is described in greater detail in the *Supplemental Notes on Decision Criteria, Information Synthesis and Findings* appended to the end of this report, is that commercial fishing and fishery management in the NWHI has had a problematic history in terms of 1) economic and ecological viability, and 2) the capacity of the responsible agencies to effectively meet multiple objectives of fishery development, sustainable resources management, and environmental protection.

This history is amply documented by the agencies themselves, particularly NOAA Fisheries, in published research articles, administrative reports, and in fishery management plans and accompanying environmental assessments and environmental impact analyses. This also was described and discussed at length by Fishing Discussion Group participants representing agencies, as well as those representing the fishing industry, research institutions, and environmental and conservation organizations.

The pattern of ongoing conflict between scientific facts (including the lack of resolution of issues bearing on the economic sustainability of fisheries and ecosystem impacts) and commercial fishery development in the NWHI is characteristic of marine fisheries and ecosystems worldwide[3], in addition to Hawai'i. The consequential economic decline and collapse of fisheries and associated degradation of globally significant ecosystems such as coral reefs, along with biological diversity of incalculable value, is

[3] Ludwig, D., R. Hilborn, C. Walters. 1993. Uncertainty, Resource Exploitation, and Conservation: Lessons from History (in Policy Forum), *Science*. Vol. 260. (Apr 2), p. 17+36; Pikitch, E.K. 2002. The Scientific Case for Precautionary Management: Current Fishery Problems Traced to Improper Use of Science. In *Managing Marine Fisheries in the United States*. Proceedings of the Pew Oceans Commission Workshop on Marine Fishery Management, Seattle, Washington, 18–19 July 2001. Pew Oceans Commission, Arlington, VA.

documented in numerous scientific journals and policy reports.[4] A number of these focus specifically on the failure of conventional fishery development and management systems (comprised of the agencies responsible for research, planning, environmental assessment, regulatory promulgation and enforcement), and recommendations for significant changes based on the substantial body of research.[5] This body of work also includes research focused on policy and practical approaches proving efficacious for both restoring commercial fishery production and conserving ecosystem resources vital to tourism and ocean recreation industries.[6] The key finding emerging from the research and discussion group effort is that the proposed NWHI National Marine Sanctuary designation process presents a uniquely historic opportunity for the participating agencies to base the design specifications and management plan on this available science. It also was found that NOAA Fisheries scientists doing research on the NWHI are well aware of past fishery management failures and working to reorient their research programs to be consistent with the findings in the body of research cited above.[7]

Other key findings pertain to the compatibility of fishing with the purpose and goal of the proposed Sanctuary and the socioeconomic considerations bearing on the overall social costs and benefits of fishing. These issues, highlighted above, are described in more detail below.

3.1 ALTERNATIVES DEVELOPMENT

The consultant produced an alternatives framework based on resource valuation and ecosystem management principles, including a range of strategies for Sanctuary management based on an ecosystem approach and protected area design and conservation principles. This provided the necessary context for developing alternative fishery management regimes consistent with the National Environmental Policy Act (NEPA), and currently accepted protected area design and conservation principles for marine

[4] Hughes, T.P., A.H. Baird, D.R. Bellwood et al. 2003. Climate Change, Human Impacts, and the Resilience of Coral Reefs. *Science*. Vol 301. (Aug 15): 929-933; Pandolfi, J.M., R.H. Bradbury, E. Sala, T.P. Hughes, K.A. Bjorndal, R.G. Cooke, D. McArdle, L. McClenachan, M.J.H. Newman, G. Paredes, R.R. Warner, J.B.C. Jackson. 2003. Global Trajectories of the Long-Term Decline of Coral Reef Ecosystems. *Science*. 301 (Aug 15): 955-958; Pauly, D., V. Christensen, J. Dalsgaard, R. Froese, F. Torres Jr. 1998. Fishing Down Marine Food Webs. *Science*. Vol 279. (Feb 6): 860-863; Pew Oceans Commission. 2003. *America's Living Oceans: Charting a Course for Sea Change. A Report to the Nation: Recommendations for a New Ocean Policy*. May 2003. Pew Oceans Commission, Arlington, VA; Pikitch 2002 (op cit).

[5] Dayton, P.K., S. Thrush, and F.C. Coleman. 2003. *Ecological Effects of Fishing in Marine Ecosystems of the United States*. Prepared for the Pew Oceans Commission, Arlington, VA; Eagle, J., B.H. Thompson, Jr. 2003. Answering Lord Perry's Question: Dissecting Regulatory Overfishing, *Ocean and Coastal Management* 46: 649-679; Pew Oceans Commission. 2002. *Managing Marine Fisheries in the United States*. Proceedings of the Pew Oceans Commission Workshop on Marine Fishery Management, Seattle, Washington, 18–19 July 2001. Pew Oceans Commission, Arlington, VA; Pew Oceans Commission 2003 (op cit).

[6] Birkeland, C. and A.M. Friedlander. 2002. *The Importance of Refuges for Reef Fish Replenishment in Hawaii*. The Hawaii Audubon Society and Pacific Fisheries Coalition, Honolulu, Hawaii.; Lubchenco, J., S.R.. Palumbi, S.D. Gaines, and S. Andelman. 2003. Plugging a Hole in the Ocean: The Emerging Science of Marine Reserves. *Ecological Applications*, 13(1) Supplement, pp. S3–S7; Hastings, A. and L.W. Botsford. 2003. Comparing Designs of Marine Reserves for Fisheries and for Biodiversity. *Ecological Applications*, 13(1) Supplement, pp. S65-S70; Palumbi, S. 2003. Marine Reserves: A Tool for Ecosystem Management and Conservation. Prepared for the Pew Oceans Commission, Arlington, VA; Pew Oceans Commission 2002 (op cit).

[7] See "In the Wake of Canoes, Building on Centuries of Knowledge, A Workshop on the Northwestern Hawaiian Islands: Information Needs for Conservation and Management, Preliminary Results", NOAA/NOS June 2003.

ecosystems.[8] In order to provide a broad starting point for discussion and analysis, the alternatives developed and presented were those considered "possible." This includes fishing regimes and regulatory conditions whether or not they may be "reasonable" under NEPA guidelines.

The framework, including the general descriptions of fishing management regime alternatives was presented to the FDGs for feedback and modification. The Groups' general response to the framework and overarching management regimes supported the rationale of the framework and the relative degree of reasonableness of the different alternatives. However, there was a substantial range of views of how fishing should be regulated under these alternatives. Determining the amount and modes of restriction of fishing (or any other uses) will require further data gathering as described below.[9]

During the Fishing Discussion Group process, protecting ecological integrity[10] was presented as the primary criterion for determining whether a fishing regime alternative would be compatible with the goals of the proposed Sanctuary, thus implicitly, whether the alternative was reasonable.[11] There was no disagreement, only discussion and comments supporting this view. However, as described below, it was not clear all participants understood the technical meaning of the term "ecological integrity" even after being provided an explicit written definition based on the scientific literature.

Following the information gathering and discussion group process, and further review of the information and refinement of the decision criteria described in the *Supplementary Notes on Decision Criteria, Information Synthesis, and Findings* (appended here), the consultant reached a general conclusion regarding reasonableness consistent with NEPA's guidelines. This finding is two-fold in that it pertains to adherence of a proposed overall management regime to the purpose and goal of the proposed National Marine Sanctuary and/or to the criteria for what is considered a reasonable alternative under NEPA. In view of the evidence that fishing historically has impacted components of the NWHI's ecological integrity and continues to do so in the case of the bottomfish fishing, commercial fishing as presently conducted under the Bottomfish Fishery Management Plan (FMP) and Executive Order (EO) is neither compatible with the mission and goals of the proposed Sanctuary nor any management regime alternative that could be considered in its management plan. Opening or re-opening any new or previously existing commercial fisheries is precluded for the same reasons. This does not preclude the possibility of re-establishing fisheries targeting bottomfish, crustaceans, precious corals, or any other potentially commercial valuable species. However, it first would have to be established that such uses would pose a negligible risk to the ecological integrity of the NWHI ecosystem, consistent with the shift in the

[8] See Appendix B1 *Alternative Management Regime Development* and Appendix B2 *Design Principles Appendix*.
[9] See Appendix B1 *Alternative Management Regime Development* and Appendix B3 *Compiled Comments*.
[10] As stated in the National Marine Sanctuaries Act (NMSA) (16 U.S.C. 1431 et seq., as amended by Public Law 106-513m (b) (6)), the purpose is to "maintain natural biological communities...and to protect, and where appropriate, restore and enhance natural habitats, populations, and ecological processes." In the scientific literature this is described as protecting ecological integrity. See Karr, J.R., K.D. Fausch, P.L. Angermeier, P.R. Yany, I.J. Schlosser. 1986. *Assessment of Biological Integrity in Running Water: A Method and Its Rationale.* Illinois Natural History Survey Special Publication 5. 28 p.; Karr, J.R. 1996. Ecological Integrity and Health are Not the Same. Pages 97-109 in P.C. Schulze (ed), *Engineering Within Ecological Constraints*. National Academy of Engineering, National Academy Press, Washington, DC; Woodley, S., J. Kay, and G. Francis. 1993. *Ecological Integrity and the Management of Ecosystems*. St. Lucie Press.
[11] The definition provided during the discussion group meetings, along with definitions of other key terms, were distributed in a glossary (Appendix A).

scientific burden of proof for the potential environmental consequences of fishing as described below, in the appended *Supplementary Notes*, and the scientific literature.[12]

3.2 DECISION FRAMEWORK AND CRITERIA

The establishment of the Coral Reef Ecosystem Reserve in the Northwestern Hawaiian Islands and the proposal for a NWHI National Marine Sanctuary recognizes the unique values, global significance, and ecological vulnerability of the NWHI.[13] The marine resources of the NWHI are valued for ecological, cultural, and economic reasons.[14] However, fisheries are one of these values which, because of this change in the region's status, now require consideration in light of broader values, concerns, and management goals that derive from the above recognition. As indicated above, marine ecosystem conservation is an increasing concern of the scientific community as well as policymakers, resulting in a number of important recent findings bearing on the management planning and assessment of compatible uses of protected areas and reserves. These developments have fundamentally important implications for all uses of marine protected areas, especially fishing. In particular, fishing must now be considered in the larger context of protecting the integrity of the ecosystem of which the fishery is a part.

The mission, goals, and objectives of the proposed Sanctuary, which are currently being drafted with the guidance of the Reserve Advisory Council, include those from and based on the following sources:

1. National Marine Sanctuary Program (NMSP): As stated in the National Marine Sanctuaries Act (NMSA) (16 U.S.C. 1431 et seq., as amended by Public Law 106-513m (b) (6)), the purpose is to "maintain natural biological communities...and to protect, and where appropriate, restore and enhance natural habitats, populations, and ecological processes." Another purpose is to "facilitate to the extent compatible with the primary objective of resource protection, all public and private uses…"
2. Coral reef conservation (e.g. as described by the U.S. Coral Reef Task Force[15])
3. Executives Orders 13178 and 13196 describing the purpose of establishing the NWHI Coral Reef Ecosystem Reserve.[16]

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[12]The scientific basis of this is described in Dayton, P.K. 1998. Reversal of the Burden of Proof in Fisheries Management. *Science*. Vol. 279. (Feb. 6): 821-822.

[13] Executive Order 13178, Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve. December 4, 2000, as finalized by Executive Order 13196, Final Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve. January 18, 2001.

[14] Cesar, H., P. van Beuikering, S. Pintz, and J. Dierking. 2002. *Economic Valuation of Hawaii's Coral Reefs*. Final Report. Hawaii Coral Reef Initiative. University of Hawaii; Clark, A.M. and D. Gulko. 1999. Hawaii's State of the Reefs Report, 1998. Hawaii State Department of Land and Natural Resources. Honolulu, HI, USA. 41 pp.; Iverson, R.T.B., T. Dye, and L.M. Paul. 1990. Native Hawaiian Fishing Rights, Phase 1, The Northwestern Hawaiian Islands, and Phase 2, Main Hawaiian Islands and the Northwestern Hawaiian Islands. Prepared for the Western Pacific Regional Fishery Management Council. Honolulu, HI, USA. Phase 1 77 pp., Phase 2 201 pp; Maragos, J. and D. Gulko (eds). 2002. Coral Reef Ecosystems of the Northwestern Hawaiian Islands: Interim Results Emphasizing the 2000 Surveys. U.S. Fish and Wildlife Service and the Hawai'i Department of Land and Natural Resources. Honolulu, HI. 46 pp.

[15] See http://www.coralreef.gov.

[16] The Reserve should be managed in accordance with the following principles: (a) The principal purpose of the Reserve is the long-term conservation and protection of the coral reef ecosystem and related marine resources and

4. Executive Order 13022, Administration of Midway Atoll
5. Executive Order 13089, Coral Reef Protection
6. Hawaii State Constitution
7. NWHI Interagency Draft MOU/MOA
8. Draft Hawaii Administrative Rules Chapter 60.5 of Title 13, Northwestern Hawaiian Islands Marine Refuge
9. NWHI Final Draft Reserve Operations Plan
10. Sanctuary designation 2002 scoping comments and 2000 visioning comments
11. Pew Oceans Commission Summary Report 2003

The principal goal to maintain the NWHI marine ecosystem, including its constituent biological communities, natural habitats, and ecological processes intact and with reference to their natural state, is operationally referred to in the scientific literature as maintaining (or protecting) ecological (or biological) integrity.[17] Consistent with the NEPA process, a statement of purpose and need was articulated and presented for use in developing the fishing alternatives during the FDG process.[18] Thus, as summarized and presented at the FDG meetings (both in terms of the purpose and goal of the proposed Sanctuary and as a 'purpose and need' for the proposed action as per NEPA), the purpose and goal of the proposed Sanctuary, and therefore the design and management regime, is as follows. First, it is to maintain 'ecological integrity' – protect intact and in its natural condition the ecosystem and its biodiversity – and, secondarily, it is to promote uses, including fishing, to the extent they are compatible with this primary goal. It was further described and feedback indicated it was understood that, as based on available science and policy, these should be accomplished using a cooperative, ecosystem-based management approach.[19] As widely understood and accepted in science, and among natural resource management agencies worldwide, this is ecosystem management with the overarching goal of ecosystem and biodiversity conservation. This understanding presented to the FDGs, as well as the above expression of

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species of the Northwestern Hawaiian Islands in their natural character; (b) The Reserve shall be managed using available science and applying a precautionary approach with resource protection favored when there is a lack of information regarding any given activity, to the extent not contrary to law (Executive Order 13178, December 4, 2000).

[17] See Jameson S.C., M.V. Erdmann, J.R. Karr, G.R. Gibson Jr, K.W. Potts. 2001. Charting a Course Toward Diagnostic Monitoring: A Continuing Review of Coral Reef Attributes and a Research Strategy for Creating Coral Reef Indexes of Biotic Integrity. *Bulletin of Marine Science*. 69:701-744. (available at http://www.epa.gov/owow/oceans/coral/charting/); Karr, J.R. et al. 1986 (op cit); Karr, J.R. 1996 (op cit); Woodley et al. 1993 (op cit).

[18] Although the process of developing fishing alternatives was conducted in a manner consistent with NEPA, it did not consider the full range of other activities or uses of the Sanctuary. For discussion, the statement of a purpose and need for the NWHI National Marine Sanctuary was approximated as follows: *The uniqueness and special quality of the NWHI – particularly as it is one of the Nation's most significant representatives of the historically under-represented non-terrestrial areas in the public domain – compels the need for a coordinated and comprehensive approach to its conservation and management implemented cooperatively by the appropriate agencies.* (see Appendix B2).

[19] Watkins, J.D. 2003. *Sustaining Our Oceans: A Public Resource, A Public Trust.* Remarks by the Chairman, U.S. U.S. Commission on Ocean Policy, before the National Academies/Ocean Studies Board, Fifth Annual Roger Revelle Commemorative Lecture, November 5, 2003. Washington, D.C.; Christensen, N.L., A.M. Bartuska, J.H. Brown, S.D. Carpenter, C. Antonio, R. Francis, J.F. Franklin, J.A. MacMahon, R.F. Noss, D.J. Parsons, C.H. Peterson, M.G. Turner, and R.G. Woodmansee. 1996. The Report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management. *Ecological Applications* 6(3): 665–691.

the purpose and goal of the proposed Sanctuary, met with no significant disagreement by participants at the FDG meetings.

Commercial fishery development and fishery-related research and management planning have been a primary focus of marine (non-terrestrial) natural resource management in the NWHI by the federal government over the past several decades. However, with the establishment of the NWHI Coral Reef Ecosystem Reserve and the proposed designation of the National Marine Sanctuary, marine ecosystem and biodiversity protection supersede commercial fishery development as the primary responsibility of NOAA.

3.3 MANAGEMENT PLANNING PROCESS

Conservation Science and the Planning/EIS Process. The consultant reviewed concepts and principles related to ecosystem management and biodiversity protection, as well as sustainable fishery management. This generated some discussion indicating the need for stakeholders to further clarify among themselves the meanings of key concepts pertaining to marine protected area design and management and their applicability to the proposed Sanctuary.[20] A continuation of dialogue and meetings in which these principles are addressed should contribute substantially to the development of an effective design and management plan for the proposed Sanctuary. When implemented, the plan will thus achieve goals consistent with those of the proposed Sanctuary. Gaining increased clarity and a common understanding of the accepted definitions, standards, and guidelines for the sustainable use of natural resources, including marine ecosystems and fisheries, is considered best practice as part of a stakeholder participatory process.[21]

Participation and the Planning/EIS Process. Working with NOAA NMSP, the consultant made initial progress toward implementing a collaborative, participatory approach in the process of conducting the Fishing Discussion Group meetings. However, a more systematic and comprehensive collaborative learning process will be required to achieve agreement on what the consultant has found to be acceptable levels of use and access consistent with the proposed Sanctuary's mission and goals. This management planning process requires the continued involvement of other agencies with jurisdiction in the NWHI (e.g. U.S. Fish and Wildlife Service, State Department of Land and Natural Resources, and NOAA Fisheries) as well as other stakeholders.

3.4 MANAGEMENT CONCERNS AND RECOMMENDED ACTIONS

The following general management concerns and recommended actions applicable to fishery management in the proposed Sanctuary emerged from background research and Fishing Discussion Group meetings. These are in addition to those related specifically to each of the fisheries that were investigated (see Working Documents). This information can contribute to future discussions involving the identification of management objectives and a range of alternative management regimes for covered fisheries. Many, if

[20] These concepts also apply to the currently existing NWHI Coral Reef Ecosystem Reserve.

[21] These can be found in the references on marine protected area design in this document. In addition the *Supplementary Notes on Decision Criteria, Information Synthesis, and Findings* appended here provides a general description of accepted practice and procedure for protected area establishment, design and management.

not most, of these management concerns were also identified at a recent workshop (May 2003), which focused on identifying data and research priorities for the management of the NWHI, which extends beyond the focus of fishery management.[22]

Monitoring Use and Access. More information is needed on the amount of use and access by vessels engaged in fishing in the proposed Sanctuary. This can be addressed by instituting a requirement that all uses be regulated by permit and/or licensed. Associated requirements (specific to each type of permit) should be developed, which include a report to be submitted subsequent to each trip. Permit requirements should be coordinated with other agencies exercising jurisdiction in the NWHI.

Surveillance and Enforcement. Information on trends in U.S. Coast Guard (USCG) and NOAA Fisheries enforcement actions in the NWHI is not readily available. This information is needed to determine how large a problem illegal fishing activities are in the proposed Sanctuary, and who is conducting the illegal activities. (see *Existing Environment* working document). An effort should be made to compile, review and analyze information on violations and enforcement actions in order to better inform the management planning process.

The current level of surveillance and enforcement for illegal fishing activities within the proposed Sanctuary may not be adequate (see *Existing Environment* working document). An assessment should be conducted to determine the enforceability of existing Reserve prohibitions and proposed rules for the proposed Sanctuary that affect fisheries. This would include interviews with USCG, NOAA Fisheries, U.S. Fish and Wildlife Service (USFWS), Hawaii Department of Land and Natural Resources (DLNR), and other law enforcement staff. The NMSP should work with U.S. Coast Guard and other agencies to increase enforcement capability, and consider cross deputizing agency personnel.

Although the NMSP states that the Executive Order is self-executing, Executive Order prohibitions cannot be enforced without regulations and a penalty schedule (see *Existing Environment* working document). Clarification of the regulatory ability of agencies conducting enforcement is needed in the short-term. In addition, the proposed Sanctuary should prioritize the promulgation of enforceable regulations pertaining to management of fisheries and fishing activity.

Fishing zone boundaries are non-standard in their delineation and are difficult to understand and enforce (see *Zoning* working document). Zone boundaries should be based on nautical miles, converted to polygons with straight-line boundaries, and published on maps for ease of reference and enforcement.

Monitoring and enforcement of vessel traffic in the NWHI, with particular regard for Reserve Preservation Area (RPA) boundaries, is difficult (see *Zoning* working document). One possible solution is the use of VMS as a monitoring tool for the range of vessels entering the NWHI; its need and feasibility should be further investigated. If VMS is used, consider adopting a VMS data policy that protects the proprietary information of fishing vessels.

[22] Information from "In the Wake of Canoes, Building on Centuries of Knowledge, A Workshop on the Northwestern Hawaiian Islands: Information Needs for Conservation and Management, Preliminary Results", NOAA/NOS June 2003.

Oil Spills, and Vessel Groundings. There is limited information available on the degree of potential risk related to oil spills and vessel groundings from fishing vessels in the proposed Sanctuary. (see *Existing Environment* working document). An assessment of the degree of risk of these threats should be conducted. This assessment should consider the historical incidence of vessel groundings and oil spills from fishing vessels, and how large the threat of future spills and groundings from these vessels is.

Management authorities need to ensure that there is adequate preparedness to respond to oil spills and vessel groundings from fishing vessels in the proposed Sanctuary. Management measures and/or regulations to feasibly address the threat of oil spills and vessels groundings should be developed as part of the management plan for the proposed Sanctuary.

Interdiction of Alien Invasive Species. There is a threat from possible introductions of marine and terrestrial alien invasive species from vessels fishing within the proposed Sanctuary. Management measures and/or regulations to evaluate and address the threat of invasive species should be developed as part of the management plan for the proposed Sanctuary.

Protection of Special Status Species. There are known and potential interactions between fisheries and protected species with the proposed Sanctuary.[23] Fishing activity poses a threat to the recovery of the endangered Hawaiian monk seal and improved management measures are required to determine the extent of this threat and develop measures to reduce the impact.

Jurisdictional Issues. Certain jurisdictional issues need to be resolved to facilitate effective management of NWHI resources (see *Existing Environment* and *Zoning* working documents). Management planning process should be conducted in conjunction with other agencies that have jurisdiction in the NWHI. Jurisdictional issues should be resolved through this process.

Research Needs. There is a need to develop research priorities for the proposed Sanctuary (relating to fishery management and ecosystem conservation and management). These should be based on findings and recommendations from a scientific advisory committee, primarily whose members have expertise in conservation biology.

4.0 RECOMMENDED NEXT STEPS

The above general management concerns and those pertaining to the specific fisheries (summarized in Section 5) indicate that even under the current fishing regime there is a high level of uncertainty about the near and long-term effects of fishing. This uncertainty derives not only from a lack data but is inherent in fishery management.[24] Taking both sources of uncertainty into account is critical to designing the proposed Sanctuary and developing a management plan that will insure the proposed Sanctuary will

[23] NOAA Fisheries. 2002. Hawaiian Monk Seal (*Monachus schauinslandi*). NOAA Fisheries, Office of Protected Resources, Annual Stock Assessment Report (31 October 2002).
[24] Ludwig et al. 1993 (op cit).

achieve its primary goal of protecting ecological integrity. Some of this uncertainty can be reduced by further data gathering and analysis to produce the Sanctuary Management Plan and Environmental Impact Statement (EIS). But in large part it must be managed by producing a sound, science-based Sanctuary Management Plan in which managing for uncertainty is one of the core design principles and goals.[25] This will require a Sanctuary design and planning process expanding on the approaches used for the Fishing Discussion Group process, and should include the following as key components or tasks.

1. Insure an increased margin of safety for the protection of ecological integrity by expanding protected and no take (Refugia) areas by conducting a systematic process examining Zoning (including boundaries and RPAs) on the basis of available science and ecological data for the NWHI.[26]
2. Establish expert working groups to advise the planning process – consisting of Hawai‘i-based subject matter experts and internationally recognized experts in conservation science and marine protected area design and management.[27]
3. As commercial fishing is phased out, closely monitor, gather, and analyze data on both the fishery and ecosystem effects of the fisheries to insure minimal ecological impact.[28]
4. Conduct a meeting process similar to the Fishing Discussion Group process that considers and incorporates findings and advice of expert working groups in key areas of expert knowledge related to:
    - Marine conservation biology, protected area design, and ecosystem management[29]
    - Multi-agency management systems[30]
    - Integration of modern and traditional resource management systems[31]
5. Continue the participatory process[32] initiated with the Fishing Discussion Group meetings, providing an opportunity for all stakeholders to consider in depth the differing perspectives held, and the

[25] Gunderson, L.H., C.S. Holling and S.S. Lights (eds.). 1995. *Barriers and Bridges to the Renewal of Ecosystems and Institutions*. Columbia University Press, NY, NY; Hughes et al. 2003 (op cit); Ludwig et al. 1993 (op cit).

[26] For example, see “habitat-driven marine zoning” and the comprehensive zoning process described in Friedlander, A., J. Sladek Nowlis, J.A. Sanchez, R. Appeldorn, P. Usseglio, C. McCormick, S. Bejarano, and A. Mitchell-Chui. 2003. Designing Effective Marine Protected Areas in Seaflower Biosphere Reserve, Colombia, Based on Biological and Sociological Information. *Conservation Biology*. Vol. 17, No. 6, December. pp. 1-16.

[27] With the exception of expertise in traditional Hawai‘i resource management systems, there is a lack of groups or research institution-based units in Hawai‘i who can be considered an authority in these areas. Expert working groups will have to be assembled drawing largely from the U.S. mainland and elsewhere. See Pew Ocean Commissions (2003) report and U.S. Coral Reef Task Force authorship and membership (http://www.coralreef.gov) for interdisciplinary experts in marine and coral reef protected area design and conservation.

[28] An expert panel whose members include experts in marine ecology and conservation biology, along with fishery biologists, should be constituted to design and oversee this research and monitoring.

[29] See references above for concepts, principles, and focus of these disciplines.

[30] See for example Gunderson, L.H., C.S. Holling, and S.S. Light (eds). 1995. *Barriers and Bridges to the Renewal of Ecosystems and Institutions*. New York: Columbia University Press.; Berkes, F. and Folke, C. (eds.) 1998. *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*. Cambridge University Press. Cambridge, UK; Gunderson et al. (eds.) 1995 (op cit.).

[31] See for example Berkes and Folke (eds.) 1998 (op cit); Berkes, F., J. Colding, and C. Folke. 2000. Rediscovery of Traditional Ecological Knowledge as Adaptive Management. *Ecological Applications*. 10:(5) 1251-1262.

[32] Daniels, S. E. and Walker, G. B. 1996. Collaborative learning: Improving Public Deliberation in Ecosystem-based Management. *Environmental Impact Assessment Review*. 16, 71-102; Whyte, W.F. 1989. Advancing Scientific Knowledge Through Participatory Action Research. *Sociological Forum*. 4(3): 367-385.

compatibility of all current and potential uses in addition to fishing in the context of marine protected area and conservation biology principles.

5.0 SUMMARY OF FINDINGS FOR FISHERY MANAGEMENT

The following sections summarize the findings for each particular fishery based on background research (see Working Documents), meeting discussions (see Appendix C), and input on possible management regimes and associated criteria and considerations for fishery management (see Appendices B and D). More detailed discussion, including management concerns and recommended actions, are included in the working documents.

5.1 PRECIOUS CORALS

No domestic commercial precious corals fishery exists in the NWHI, nor has one ever existed. Executive Orders 13178 (4 December 2000) and 13196 (18 January 2001) prohibit harvest of precious corals within the NWHI Coral Reef Ecosystem Reserve. Thus, a NWHI precious corals fishery is not part of the status quo of fisheries in the NWHI.

The Precious Corals Fishing Discussion Group meetings focused on the results of background research and an assessment of the now partially defunct WPRFMC Precious Coral FMP.[33] Background research and an assessment of the WPRFMC Precious Coral FMP are summarized in the Precious Coral Working Document.[34] Fishing Discussion Group members agreed that 1) little was known about the distribution, abundance, or population dynamics of precious corals in the NWHI, 2) that precious corals are inherently susceptible to overfishing, and 3) that their harvesting may present a potential threat to a habitat component and biological community in the NWHI ecosystem.

Precious corals are slow-growing, long-lived, marine colonial organisms that live on solid substrates in deepwater benthic habitats. They include black coral, and the deepwater pink, gold, and bamboo corals. Forms of black coral appear in patches in the NWHI, but are not of commercial grade nor do they grow in concentrated beds. All three groups of deepwater precious coral occur in the NWHI. Little is known about the population ecology of precious corals in the NWHI. A life history strategy of slow growth, advanced age at first reproduction, a wide range of reproductively mature age classes, longevity, and low recruitment make precious corals susceptible to overfishing. Populations of precious corals appear to be recruitment limited, although the presence of many reproductively mature age classes in natural unfished populations may provide resilience (buffer) against years of poor recruitment. Because harvest of precious corals traditionally eliminates many of the reproductive age classes from a population, traditional MSY-based harvest strategies negatively alter population structure, and may reduce population resilience by severely truncating the number of reproductive age classes in a population.[35]

[33] WPRFMC FMP-PC. Fishery Management Plan for the Precious Coral Fisheries (and Associated Non-Precious Corals) of the Western Pacific Region. Western Pacific Regional Fisheries Management Council. 1979 – Present.
[34] Sustainable Resources Group Inc., Intl. 2004. Precious Corals in the NWHI. 35pp. Prepared for the NOAA-NMSP.
[35] See the Precious Corals Working Document for a more complete review of the population ecology of precious corals.

Careful study of the now partially defunct WPRFMC Precious Coral FMP showed several critical aspects to be scientifically flawed. For example, although nothing is known about rates of growth, reproduction, recruitment, or mortality of precious corals in the NWHI, and only little is known about the distribution and abundance of precious corals in the NWHI, the FMP blindly proposed MSY for precious corals on biologically unsurveyed beds in the NWHI. Proposed MSY's were based solely on 1) the population dynamics, distribution, and abundance of precious corals on one productive Established Bed of precious corals in the MHI and 2) the physical size of the unsurveyed bed in the NWHI (regardless of the species composition or abundance on that bed).[36] Further, because precious corals are recruitment-limited, and not density-dependent, traditional fisheries concepts of 'surplus yield' and MSY may not represent the best management paradigm for precious corals, especially with regard to ecosystem-based management. Existing evidence is not sufficient to support or reject the assumption that harvesting precious coral will not negatively affect their contribution to a habitat component and biological community within the NWHI ecosystem. Finally, fishing for precious corals is an expensive and dangerous activity; and without new and significant economic incentive, profitability is questionable in the NWHI. Imports of relatively inexpensive deepwater precious coral from Japan and Taiwan, and adequate availability of black and deepwater precious corals in the MHI, provide further economic disincentive to initiate a deepwater precious corals fishery in the remote NWHI. A decision not to initiate a deepwater precious corals fishery in the NWHI at this time does not represent a socioeconomic hardship for any segment of the population[37].

Participants of the Precious Corals Fishing Discussion Group provided a range of opinions concerning the possibility of precious coral harvesting management options. All participants agreed that little information exists about precious corals in the NWHI. Participants knowledgeable about fishery models agreed that the defunct WPRFMC MSY-based and Established-Bed-based models for potential precious corals harvest in the NWHI are neither fully scientifically supported nor consistent with ecosystem-based management, or expressed no opinion. Some participants expressed concern over the association between endangered Hawaiian monk seals and precious coral beds in the NWHI, and how a potential NWHI precious coral fishery might affect monk seal populations. Participants agreed that in the absence of ecological information for precious corals in the NWHI, a precautionary approach should be taken for their management. A representative from NOAA Fisheries presented an opinion in favor of further research in order to provide the necessary biological information for developing a NWHI precious corals fishery in the future. Regardless of the use of such research, the NOAA Fisheries representative suggested that deepwater precious corals in the NWHI are an invaluable (pristine) biological reference point for the deepwater precious corals in the MHI. All other participants supported the final recommendation that "The status quo of fisheries in the NWHI does not include a precious coral fishery, nor should one be considered as part of the proposed action in the NWHI", or expressed no opinion.

[36] See the Precious Corals Working Document for a more complete critique of the WPRFMC Precious Corals FMP.
[37] See the Precious Corals Working Document for a more complete review of the precious corals fishery in Hawai'i.

5.2 LOBSTERS

A commercial lobster fishery currently does not exist in the NWHI.[38] The previously existing lobster fishery was closed in 2000 by NOAA Fisheries and by court order. Reasons for closure include the lack of adequate stock assessment data and the potential threat posed to the endangered monk seal, respectively.[39] Also, the Executive Orders creating the Reserve cap commercial fishing permits, effort and take, including those for lobsters, limiting the annual level of aggregate take to the permittee's individual take in the year preceding December 4, 2000.[40]

Background research presented and feedback provided during the Crustacean Fishing Discussion Group meetings provided the basis of the foregoing summary. Participants varied in their views concerning such issues as the eventual outcome of research on the importance of lobsters in the endangered Hawaiian monk seals' diet, the extent of recovery of the lobster populations, and when, if ever, a lobster fishery could be reestablished in the NWHI. Opinions also varied concerning the compatibility of a lobster fishery with the purpose and need articulated for the proposed Sanctuary presented at the meetings. There was relatively little disagreement with the facts concerning the history and status of the lobster fishery, nearly all of which were either stated or provided by the participants themselves, as summarized below.

There are several species of lobster in the NWHI, though the historic crustacean fishery targeted the Hawaiian spiny lobster (*Panulirus marginatus*) and slipper lobster (*Scyllarides squammosus*).[41] The spatial structure of Hawaiian lobster populations mirrors the fragmented, insular character of its habitat—the discontinuous banks of the islands, atolls, and sea mounts along the length of the archipelago. Each species may be reasonably described as a regional population consisting of local, or subpopulations, distributed among discontinuous habitat banks.[42] Spiny lobsters are found in habitats at depths of 5-40 fm with highest concentrations between 15-25 fm. Slipper lobsters are found from 15-60 fm with greatest concentrations between 25-35 fm. They find protection from predators (e.g. fish and monk seals) by hiding in crevasses, cracks, and tiny caves from which they venture out to forage. Both species have protracted pelagic larval phases (spiny lobster [11-12 months] and slipper lobster [3-4 months]).[43]

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[38] The NWHI lobster fishery has been managed, since 1982, by WPRFMC through the *Final Combined Fishery Management Plan, Environmental Impact Statement, Regulatory Analysis and Draft Regulations for the Spiny Lobster Fisheries of the Western Pacific Region*, as amended.

[39] The history of the defunct NWHI lobster fishery is well documented, and key aspects were presented and discussed in the Fishing Discussion Group process. While being the most lucrative NWHI fishery in its peak years, the lobster fishery was beset with market, gear, stock assessment, and fleet management problems, along with significant conflicts with conservation in the NWHI from its initiation in the late 1970's to its closure in 2000.

[40] Section 7(a)(1)(C) of Executive Order 13178 was revised by Executive Order 13196 to read "The annual level of aggregate take under all permits of any particular type of fishing may not exceed the aggregate level of take under all permits of that type of fishing as follows: (2) All other commercial fishing – the annual aggregate level shall be the permittee's individual take in the year preceding December 4, 2000, as determined by the Secretary." A cap has not yet been set under the Executive Order by the Secretary of Commerce.

[41] Green spiny lobster (*P. penicillatus*), ridgeback slipper lobster (*S. haanii*), and Chinese slipper lobster (*Parribacus antarcticus*) are also found and caught in low amounts.

[42] DiNardo, G.T. and R. Marshall. 2001. *Status of Lobster Stocks in the Northwestern Hawaiian Islands, 1998-2000*. Southwest Fisheries Science Center Administrative Report H-01-04. June.

[43] This has implications for recruitment, which is "likely dependent, in part, on lobster reproduction at surrounding banks: populations inhabiting discrete bank populations are connected by the dispersal of larvae between banks. This results in banks acting as either recruitment sources, sinks, or both." (DiNardo and Marshall 2001 (op cit)).

Harvest of lobster on a commercial scale in the NWHI began in the late '70s, after abundant stocks were discovered at Necker Island and Maro Reef, first as a local live spiny lobster fishery followed by a frozen lobster tail fishery managed by federal authority under the 1983 Fishery Management Plan (FMP).[44] Shortly after, and as spiny lobsters began to decline and slipper lobster were targeted, NOAA Fisheries combined both species into a single management unit. The data unequivocally show that the level of harvest for this period, from the mid-1980's to the early 1990's, was excessive and far exceeded some of NOAA Fisheries MSY calculations.[45] Declining catch per unit effort (CPUE) provided further evidence of overfishing throughout nearly this entire period.[46] The fishery was closed in 1993 as a result of overharvesting, coupled with a natural decline in the productivity of the ecosystem.[47] Efforts to revive it over the subsequent decade through various amendments to the FMP, based in part on attempts to refine MSY estimates, proved futile.[48] Although the fishery reopened in 1994, catches remained depressed, although increases were seen from 1997 to 1999, before the fishery was closed in 2000.[49]

A major part of the problem identified by NOAA Fisheries is the inapplicability of MSY models to NWHI lobster populations due to their metapopulation structure.[50] According to NOAA Fisheries, recent data indicate recruitment of lobsters at Necker Island, a key fishing ground, remains depressed. As a result of this, and uncertainty with regard to the status of NWHI lobsters in general, a NOAA Fisheries

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[44] Although the fishery initially targeted spiny lobster, by the mid-1980's both spiny and slipper lobsters were being harvested in similar numbers as catch of the former began declining. After reportedly growing in 1981 to 10 vessels, 350 metric tons and an ex-vessel value of $2.7 million, the local market was unable to absorb the volume of live lobster. As a result, the prices dropped and the fleet contracted. By 1986 the fishery rebounded by transforming into a frozen lobster tail fishery, consisting of a reported 16 boats harvesting over 2 million lobster (~1000 mt) annually with an ex-vessel value of over $6 million (Clarke, R.P., S.S. Yoshimoto, and S.G. Pooley. 1992. A Bioeconomic Analysis of the Northwestern Hawaiian Islands Lobster Fishery. *Marine Resource Economics*. 7:115-140).

[45] In 1981, NMFS scientists estimated MSY at between 200,000 to 378,000 lobsters and noted that by 1981 "estimated catch already exceeds the MSY range." (Skilman, R and Ito, B. *The Present Status of the Spiny Lobster Fishery in Hawaiian Waters*. Southwest Fisheries Center, Honolulu Lab, NMFS, October 1981, pg.3.) The MSY estimate for spiny and slipper lobsters (combined) was increased to 1 million lobsters in 1989 (cited by Charles Karnella, Administrator, Pacific Islands Area Office, NMFS, letter to Isaac Harp, May 8, 2002.). In 1989, however, the combined spiny and slipper harvest was 1,815,100, with a reported spiny lobster harvest of 1,482,000 (DiNardo and Marshall 2001 (op cit)). The total reported catch and landings of lobsters peaked in 1985 at approximately 2,736,000 lobsters caught and 2,031,000 lobsters landed, and generally declined from 1986 to 1992. Catches of slipper lobster remained high from 1985 to 1987, then generally declined from 1988 to 1992. Catches of spiny lobster remained high until 1990, then declined precipitously in 1991. (Table 3; Fig. 3; DiNardo and Marshall 2001 (op cit)).

[46] CPUE is the number of lobsters per trap haul. In 1983 overall lobster CPUE was 3.8 (2.8 kept). This value showed a relatively steady decline to 1.2 (0.6 kept) through 1992 (DiNardo and Marshall. 2001 (op cit)).

[47] Polovina, J.J. and W.R. Haight. 1998. Climate Variation, Ecosystem Dynamics, and Fisheries Management in the Northwestern Hawaiian Islands. In *Ecosystem Approaches for Fisheries Management*. pp. 23-32. Lowell Wakefield Fisheries Symposium Series. Anchorage, AK. 30 Sept – 3 Oct 1998. Published by University of Alaska Seagrant.

[48] Measures in the FMP and amendments designed to prevent overfishing include gear design restrictions, catch report requirements, a limited access program, a limit on number of traps per vessel, minimum size requirements, seasonal closures, area closures, and bank specific harvest guidelines.

[49] In 1995 total lobster catch was about 99,000, landings were about 38,000. In 1999 (subsequent to the establishment of a 'retain all' fishery, total lobster catch and landings were about 232,000. (DiNardo and Marshall. 2001 (op cit).)

[50] Dinardo and Marshall. 2001 (op cit).

lobster researcher present at the Fishing Discussion Group meeting stated that the NWHI lobster fishery should remain closed while further research on the status of the population is carried out. Research on the stock status and the lobster fishery is ongoing, though recent analysis has found indicators of both stock decline and uncertainty in estimating stock status.[51] The level of overfishing, particularly of what fishery researchers now realize is a population characteristically more vulnerable to destabilization,[52] has reportedly contributed not only to depletion of the resource base but has significantly altered the relative abundance of spiny and slipper lobsters.[53] Within-species changes also occurred in the size- and age-structures of the populations in the areas fished.[54] In fact, overfishing at Maro Reef apparently resulted in the collapse of the spiny lobster population at Laysan Island (closed to fishing) some 60km away.[55] This is a demonstration of the source-sink phenomena found in metapopulations in which some local populations, such as that at Laysan, persist primarily through recruitment of individuals from other sites where apparently more favorable conditions allow higher spawning rates.

Ecosystem level effects of lobster fishing (or of natural fluctuations in lobster numbers) on other components, particularly the endangered monk seal are a separate matter. Research on monk seal dependency on lobsters is ongoing. Definitive proof of a direct link between lobster fishing and continued decline in the monk seal population has not yet emerged. Yet, the present condition of the monk seal population, judged by conservation scientists to be sentinel of the health of the NWHI ecosystem, suggests it could become virtually extinct before such a linkage was confirmed.[56] From a conservation biology perspective, the monk seal is precariously close, if not already below, a minimum threshold for long term population viability.

Significant scientific uncertainty remains concerning the effect of lobster fishing on the monk seal population, as well as the status of the stocks and the population biology of the lobster species, which was the basis for closing the fishery. However, even if scientific information became available that could be used as a basis of developing a biologically sustainable harvest regime posing an insignificant risk to monk seal recovery, some critical problems would remain. These include the decision to operate a 'retain all' lobster fishery[57], "ghost traps" migrating into the USFWS Refuge, and socio-economic costs versus benefits of managing a lobster fishery that would provide an adequate margin of safety for the protection of non-commercial use values consistent with Reserve and the proposed Sanctuary goals. Current information, however, indicates that, in addition to documenting the recovery of the lobster population, the development of a sustainable NWHI lobster fishery would need to be operated under a management regime that was substantially more restricted and controlled (fishing zones, season length, boat numbers - in addition to all the current gear and other restrictions) to present a viable opportunity for commercial

[51] "Excessive fishing likely led to the depletion of many local populations of spiny lobster in NWHI. Despite a reduction in commercial fishing activities in the NWHI, local populations of spiny lobster remain depressed exhibiting no signs of rebuilding." DiNardo and Marshall. 2001 (op cit).
[52] Hanski, I. 1994. A Practical Model of Metapopulation Dynamics. *Journal of Animal Ecology*. 63: 151-162.
[53] Slipper lobster concentrations have increased in shallow areas (15-25 fm) as spiny lobster concentrations have decreased subsequent to the commencement of commercial exploitation (DiNardo and Marshall. 2001 (op cit)).
[54] DiNardo, G.T., E.E. DeMartini, and W.R. Haight. 2002. Estimates of Lobster-handling Mortality Associated with the Northwestern Hawaiian Islands Lobster-trap Fishery. *Fisheries Bulletin*. 100:128-133.
[55] Polovina and Haight. 1998 (op cit).
[56] Marine Mammal Commission. 2001. *2000 Annual Report to Congress*. 31 March. Bethesda, MD.
[57] This practice is contrary to managing for the sustainability of a stock as it negatively impacts recruitment.

fishery development.[58] Environmental variation in the form of dramatic shifts in ecosystem carrying capacity driven by climate change[59] uniquely characteristic of the NWHI may prevent the development of reliable stock assessments and a stable fishery. In addition, in view of the possibility of lobster fishing impacts on the monk seal and the continued decline of the population,[60] if it indeed ever recovers it likely will require decades before it is deemed healthy enough to accept the risk of such possible negative effects.

The performance of the lobster fishing measured in terms of ex-vessel revenues and landings approximates a "boom and bust" cycle. During the mid-1980's the lobster fishery had grown to become Hawaii's most valued commercial fishery, with ex-vessel revenues exceeding $6 million. However, due to a variety of cost constraints and operational problems only 3 of a total maximum of 16 vessels in the fleet during this peak period were clearly profitable.[61] A second economic phase developed after 1990, along with a dramatically different management regime, affected by a combination of economic and regulatory constraints driven by the depressed status of the spiny lobster population. The shift in abundance of spiny versus slipper lobsters affected revenues, which fell from $10-11 in 1996 and 1997 to approximately $5 in 1999, due to the smaller average size and lower market value of slipper lobster. These declining values, and other economic factors, in changes in the international market, are described by Kawamoto and Pooley as having contributed to an evaporation of economic incentives for fishing.[62]

5.3 BOTTOMFISH

The bottomfish fishery in the NWHI is a restricted fishery, currently operating under the prohibitions of Executive Orders 13178 and 13196 which "capped all currently existing Federal fishing permits and current levels of fishing effort and take" (as of December 2000) and delineated areas where fishing is allowed and prohibited.[63] Currently there are nine boats fishing in the NWHI – four (mostly full-time boats) in the Ho'omalu Zone and five (primarily part-time boats) in the Mau Zone. The commercial bottomfish fishery includes a portion of the non-Federally permitted commercial pelagic fishery, particularly in the Mau Zone where pelagics comprise about 50% of the overall pounds kept.[64]

Bottomfish are primarily high level carnivores that live in waters 30-150 fm deep. Species are non-migratory and school, spawn, and feed in rocky areas, cliffs, dropoffs, pinnacles and holes and their distribution is closely linked to suitable physical habitat. The bottomfish fishery in Hawai'i targets 15

[58] This view, as paraphrased here, was stated during the Lobster Discussion Group Meetings by NMFS fishery biologist Gerard DiNardo.
[59] Polovina and Haight. 1998 (op cit).
[60] NOAA Fisheries. 2002. Hawaiian Monk Seal (*Monachus schauinslandi*). NOAA Fisheries, Office of Protected Resources, Annual Stock Assessment Report (31 October 2002); Marine Mammal Commission. 2001 (op cit).
[61] Clarke, R.P., and S.G. Pooley. 1988. An Economic Analysis of Lobster Fishing in the Northwestern Hawaiian Islands. Technical Memorandum. Southwest Fisheries Science Center, National Marine Fisheries Service, NOAA. Honolulu, HI.
[62] Kawamoto, K., and S. Pooley. 2000. Annual Report of the 1999 Western Pacific Lobster Fishery, Preliminary Draft. Southwest Fisheries Science Center, Honolulu Laboratory, NMFS, NOAA. Honolulu, HI.
[63] Fishing caps have not yet been set under the Executive Order.
[64] Ehler, R. 2003. NWHI Bottomfish Trip Daily Log Data, Draft Economic Analysis, November 20, 2003. Developed by Rod Ehler, economist with the NOAA National Marine Sanctuaries Program. Presented at the Bottomfish Discussion Group Meeting.

species, including snappers, jacks, and a single species of grouper.[65] Commercial exploitation of bottomfish may have begun prior to the twentieth century, but use is well documented by the 1920's. Use fluctuated for approximately the next half century, but by the 1970's there were sustained commercial operations harvesting NWHI stocks and supplying bottomfish to the local Hawai'i market. The commercial fishery has been managed by WPRFMC under the Fishery Management Plan (FMP) for Bottomfish and Seamount Groundfish Fisheries, completed in 1986 as amended.[66]

Bottomfishes have life history patterns that make them inherently susceptible to overfishing and ecological characteristics which limit their ability to recover from this pressure. Further, there is a lack of adequate biological and fishery data to guide their long-term management – including the difficulty of establishing reliable measures of overfishing.[67] The potential of overfishing in the NWHI is recognized by management agencies and reflected in on-going adjustments to the management regime.[68] There is a lack of information to accurately or sufficiently identify the existing or potential ecological impacts of fishing (e.g. population size, population structure, community structure) on bottomfish stocks in the NWHI. This includes limited data and unrecognized effects of environmental and recruitment variability on the condition of stocks. In fact, while this is a multi-species fishery, as a consequence of this lack of species-specific population data, it is being managed as though it were a single stock. NWHI bottomfish populations, particularly in the Mau Zone, may be stressed.[69] Ecosystem level effects of bottomfishing are

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[65] In addition to the targeted bottomfish species, permitted bottomfishers report catches of pelagic species and small numbers of coral reef related and other species (Ehler 2003 (op cit.)). As indicated in the Fishing Discussion Group, boats may fish in waters as shallow as 15 fm. Amendment 8 to the Bottomfish and Seamount Groundfish Fishery Management Plan (FMP) proposes additional species for listing as bottomfish management unit species which are pending approval.

[66] The need for the FMP, as outlined by WPRFMC in 1986, was in part a response to several indicators that were pointing to the potential for overfishing in the Hawaiian bottomfish fishery. These included "the average size (weight) of bottomfish, e.g. approximately 36% by number of opakapaka, caught around the main Hawaiian Islands are below the size of first reproduction; harvest capacity of the existing fleet exceeds the best estimate of MSY from the entire charted Hawaiian bottomfish market; unstable patterns have been observed in the entry/exit pattern of fishermen in the NWHI bottomfish fishery; and there have been significant increases in the total bottomfish landings in all areas of the FCZ." (WPRFMC. 1986. Combined Fishery Management Plan, Environmental Assessment and Regulatory Impact Review for the Bottomfish and Seamount Groundfish Fisheries of the Western Pacific Region. As Amended. Honolulu, HI. March.)

[67] WPRFMC. 2002. *Magnuson-Stevens Act Definitions and Required Provisions: Overfishing Provisions*. Prepared by Western Pacific Regional Fishery Management Council. December. WPRFMC is currently developing revised measures to comply with provisions of the Sustainable Fisheries Act. These measures include specifying MSY-based control rules and overfishing thresholds for multi-species stock complexes. Secondary reference points would be used to ensure that no particular species within the complex becomes overfished (applied to only those component stocks (species) for which adequate data are available).

[68] FMP amendments have attempted to provide for the long-term productivity of the bottomfish populations and to improve the economic stability of the fishery. Limited access programs have been established in both zones. Monitoring and evaluation procedures have been established for the fishery. Overfishing criteria is defined (pending adjustment to comply with the Sustainable Fisheries Act). The need to evaluate the potential interactions of the fishery with the endangered Hawaiian monk seal is included.

[69] Two parameters that are currently used to indicate the health of the stocks are Catch Per Unit Effort (CPUE) and Spawning Potential Ratio (SPR). Per WPRFMC guidelines, if CPUE for the current year is less than 50% of the average CPUE for the first three years of available data, there 'may be cause for concern'. Recent 2001 data show CPUE in the Mau Zone is 36% (trip-based) and 66% (daily-based) – a 'borderline' condition, while CPUE in the Ho'omalu Zone is 65% (trip-based) and 74% (daily-based) – a 'healthy' condition. A 20% SPR value defines recruitment over-fishing under the FMP. Although the SPR values have not decreased below the threshold, the lower bound of the 95% confidence intervals around values of SPR's calculated for each of the five principal BMUS

also a concern. Removing significant amounts of biomass and nutrients from the ecosystem is likely to have secondary trophic level effects on other species, species guilds and communities. Bycatch plays a role in the bottomfish fishery with up to 25%, by number, of the catch being discarded[70] and an unobserved mortality related to fish that either escape from the hook or hooked fish that are eaten by predators.[71] In addition, there is limited information about interactions with other related species, including the endangered Hawaiian monk seal and fish species in the coral reef ecosystem.

Economically, the NWHI (sub-divided into two zones) is considered a separate fishery from the MHI, however WPRFMC manages species ecologically as single stocks throughout the archipelago.[72] In recent years (1997-2001) the annual ex-vessel value of bottomfish landings from the NWHI has averaged about $1.02 million, a significant decline from its peak in 1987 (~$3.5 million).[73] The poor economic performance of the fishery has resulted in a high turnover pattern of entry and exit in the fishery, including vessels arriving from overfished mainland U.S. fisheries on a 'look-see' basis.[74] Economics analysis of the bottomfish fishery suggests that a lifestyle component, rather than profitability, keeps the fishery active. Phasing out or otherwise terminating the bottomfish fishery would have an effect on a small segment of the population.[75] Any potential buyout would incur relatively minimal costs because of the limited value of the fishery. There are other economic concerns including the effect of a closure of the NWHI on the supply of fresh fish for the Hawai'i market and the potential for increased pressure on overfished MHI stocks. These economic consequences must be weighed in light of the possible effect of bottomfishing in the NWHI on the incremental decline of the health of the marine ecosystem of the Hawaiian Archipelago as a whole and consequential effects on social welfare.

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species in the Mau Zone was less than 25% for 2001. In addition, although mean weights of fish in the NWHI catch appear generally stable over time, there is a notable exception with onaga, where recent declines in mean weight have been observed for both the Mau and the Ho'omalu Zone. WPRFMC. 2003. *Bottomfish and Seamount Groundfish Fisheries of the Western Pacific Region: 2001 Annual Report.* WPRFMC, Honolulu, HI.

[70] The majority of the bycatch is comprised of three bottomfish management unit species: kahala (less than 5% of catch retained; implicated in ciguatera poisoning), white ulua, and butaguchi; and sharks. The ulua, butaguchi and sharks have relatively low market values and do not keep well. The mortality rate of discarded fish varies among species and is difficult to measure. Information on bycatch is drawn from logbook data and from observer programs. Significant differences between the reported values suggest likely shortcomings of the logbook data; in particular that there may be underreporting of commonly discarded species. WPRFMC. 2002. *Magnuson-Stevens Act Definitions and Required Provisions: Bycatch Provisions*. Prepared by Western Pacific Regional Fishery Management Council. December.

[71] Losses due to predation may be 23-27 fish for every 100 fish boated. WPRFMC 2002. (ibid).

[72] Their rationale is that discernable mixing of the NWHI and MHI populations occurs within the archipelago as indicated by genetic and larval advection research. (URS Corp. 2003. *Draft Environmental Impact Statement Bottomfish and Seamount Groundfish Fisheries in the Western Pacific Region*. Prepared for Western Pacific Regional Fishery Management Council. Honolulu, HI. August 25.)

[73] Since 1993 when Ho'omalu Zone vessels realized a positive return of $2,238 per vessel, revenues have showed a downward trend and in 2000 these vessels averaged a loss of $38,047 per vessel. In recent years the average vessel fishing in this zone has failed to cover its total annual costs through bottomfish fishing. Mau Zone vessels averaged a loss of $21,947 per vessel in 1993, and more recent information indicates that the net revenue of the average boat is still negative (-$7,796 in 2000). URS Corp. 2003. (op cit).

[74] WPRFMC. 2000. *Draft Measure to Establish Eligibility Criteria for New Entry into the NWHI Mau Zone Limited Access System*. Prepared by Western Pacific Regional Fishery Management Council. 17 November.

[75] Estimates indicate the fishery makes a small contribution to the overall economic activity in the state, contributing approximately $1.4 million of output (production) and $0.48 million of household income to the economy, and creating the equivalent of 25 full time jobs. (URS Corp. 2003 (op cit).

Feedback from the Fishing Discussion Group allowed clarification of key points and identification of gaps in knowledge related to the fishery. A portion of the Fishing Discussion Group process focused on gathering feedback on specific operational components of the fishery. However, because both the data and analysis on the status of the fishery and its ecosystem level effects is lacking, the operational components could not be discussed in a context relevant to environmental consequences in terms of fish stocks in particular or the ecosystem in general. In particular, overarching ecosystem management concerns and objectives need to be fleshed out in detail to describe the desired outcome of particular fishery regimes.

5.4 PELAGICS

The pelagic fishery is currently operating under the prohibitions of the Executive Orders 13178 and 13196, which "capped all current levels of fishing effort and take" (as of December 2000) and delineated areas where fishing is allowed and prohibited.[76] Despite the existence of a WPRFMC FMP for the Pelagic Fisheries of the Western Pacific Region, the NWHI fishery is effectively not managed, as there are currently no federal regulations, other than the Executive Order, or permit requirements restricting troll or handline fisheries in the proposed Sanctuary.

Pelagic fishes are widely distributed throughout the tropical and sub-tropical oceans and are highly migratory. Pelagic fishes in the NWHI Reserve are transient and populations are believed to be small in relation to the total populations of species throughout their range in the Pacific.

Pelagic fisheries in the NWHI can be divided into three main types – Commercial, Recreational, and Charter. There is substantially less pelagic fishing effort in the NWHI since exclusion of longline vessels from inshore areas of the NWHI and closure of a recreational fishery at Midway Atoll. Few boats that have the capability of transiting the long distance to the NWHI to fish for pelagics commercially. A portion of the commercial pelagic fishery is conducted in association with the federally permitted bottomfish fishery. There are also a commercial pelagic handline/troll fishery, and recreational and charter fishing boats. Commercial information on pelagic fishing in the NWHI is collected through the State of Hawai'i's Commercial Marine License program. There are no Federal or State reporting requirements for the recreational fishery.

Little is known about the status and trends of the number of participants, fishing locations, effort, catch, and CPUE for either commercial handline and troll fisheries, or recreational and charter fisheries in the NWHI. Some information on commercial activities (including charter) can be derived from the State's Commercial Marine License database. Information on recreational activities is more difficult to gather. Analysis of this information should be conducted prior to developing management recommendations for pelagic fishing – commercial or recreational – in the NWHI. This analysis is also required as there is limited information available to establish a scientifically based precautionary cap on pelagic fishing effort and catch as called for by the Executive Order. Feedback obtained from the Fishing Discussion Group process provided information on specific operational components of the fishery that can be incorporated into future recommendations for fishery management.

[76] Fishing caps have not yet been set under the Executive Order.

The ecological effects of pelagic fishing are probably proportional to the relatively small number of vessels and activity in the NWHI. In general, feedback from the Fishing Discussion Group indicated that the current level of fishing effort for pelagic species in the Reserve likely has a nominal effect on pelagic fish stocks. However, significant gaps in knowledge about and understanding of the fishery exist. There are possible significant direct and indirect adverse environmental effects from commercial and recreational pelagic fisheries,[77] along with socio-economic and operational and management considerations that need to be examined. The pelagic fishery may only be of nominal economic value, however, this remains to be determined.[78] No evidence exists to support or refute claims that pelagic fishing is incompatible with the goals of the proposed Sanctuary.

5.5 SUBSISTENCE FISHING

A subsistence fishery per se does not exist in the NWHI, although aspects of subsistence use[79] exist and are practiced as they relate to traditional Hawaiian values and knowledge. In the Hawaiian cultural context, subsistence[80] was the traditional way of life, reflected in the relationship shared between nature and the *kānaka* (people). Subsistence is multi-faceted, including: knowledge of the natural resources (from mountains to ocean depths); spiritual attributes; and a physical relationship.

Indigenous knowledge is accepted in international policy as integral to the global protection of biodiversity[81] as well as scientifically informed resource management planning.[82] The potential for integrating local indigenous knowledge and practices locally in Hawaii has significant precedent,[83]

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[77] Limited available information documents interactions between the pelagic fisheries and protected species (e.g. seabirds and Hawaiian monk seals), though the extent of these interactions or their impact on the protected species is unknown.

[78] The pelagic fishing that is conducted as a part of the bottomfish fishery provides significant economic benefits to those operations, particularly in the Mau Zone. Recent analysis by Ehler (2003) (op cit) indicates that in the NWHI approximately 24% of the overall pounds kept and 16% of the value were pelagic species and 74% of the overall pounds kept and 83% of the value were bottomfish species. In the Mau Zone, approximately 50% of the overall pounds kept and 39% of the value were pelagic species, while in the Ho‘omalu Zone pelagics constituted about 4% of the pounds kept and 3% of the value.

[79] Subsistence use is defined as a mode of resource use involving the direct, non-commercial use of natural resources to meet basic, existential needs, and which is multiple use in character reflecting an entire lifeway.

[80] The Hawaiian word for subsistence, *hānai a ‘ai*, translates to English as ‘To care for and eat from’.

[81] “Indigenous and local communities have been developing, conserving and sustainably using the biological resources on their lands and territories for millennia. Indigenous and local communities have a close knowledge of the flora and fauna and of the ecological processes of the ecosystems they inhabit and have developed a wide variety of plants and animals for food, medicine and other purposes. Traditional knowledge has and will continue to give critical clues to scientists in the agricultural, medicinal and industrial fields. In addition, traditional knowledge provides important directions for natural resource use and ecosystem management. Indigenous and local communities not only have extensive knowledge of their surrounding environment, but they also have an important role in implementing any conservation policy on the ground.” Convention on Biological Diversity (UNEP/CBD/COP/3/19). Available at http://www.biodiv.org

[82] Holling, C.S., F. Berkes and C. Folke. 1998. Science, Sustainability and Resource Management. In Berkes, F. and Folke, C (eds). *Linking Social and Ecological Systems. Management Practices and Social Mechanisms for Building Resilience*. Cambridge University Press. Pages 342-362.

[83] Poepoe, K. K., P. K. Bartam, and A. M. Friedlander. 2003. The Use of Traditional Hawaiian Knowledge in the Contemporary Management of Marine Resources. In Haggan, N., Brignall, C. and Wood, L (eds). *Putting Fishers’*

demonstrating that knowledge held and practices of native and local fishers can contribute to and compliment limited scientific information regarding fisheries management in the NWHI.

The Subsistence Fishing Discussion Group discussed issues and concerns about fishing within the context of the NHWI Coral Reef Ecosystem Reserve and the proposed Sanctuary. The group consisted largely of individual's of Native Hawaiian ancestry, including several fisherman and others familiar with traditional Native Hawaii perspectives, values and practices concerning natural and natural resources. As described in more detail in the Subsistence Fishing Discussion Group working document, and as evident in the meeting transcripts (see Appendix C7), the discussion process yielded information and provided perspectives on NWHI fisheries that are of critical importance in the consideration and assessment of fishing in the NHWI as well as the Sanctuary designation process more generally. Some of the major points emerging from the discussions are briefly highlighted here.

The components of subsistence fishing presently in the NWHI include culturally-based gathering of marine resources (practiced occasionally) and use of the NWHI for cultural renewal and education (e.g. during Hokulea voyages). The knowledge held and the perspectives provided by Native Hawaiian fishers, including some with extensive experience in the NWHI, is of significant value in management planning and environmental assessment. In particular, among all Fishing Discussion Groups, including those dominated by professional resource managers and scientists, this is the only group in which the discussion of ideas and concepts and the information on fishing methods and practices was closely aligned with sustainable use as recognized by international authorities. Participants recounted, from their experiences, many instances of depletion of local stocks in the NWHI. Native Hawaiian fishers in the discussion group also expressed strongly held beliefs about the spiritual and ethical dimensions of fishing in the NWHI. They voiced concern that fishing practices and fishery management has not been consistent with values traditionally associated with subsistence use, and that this has placed the resource at great risk. One fisherman, whose experience fishing in the NWHI and MHI stretches back over fifty years ago, stressed the critical importance of protecting the NWHI fish stocks as refuge for replenishing the MHI overfished stocks. The group as a whole strongly believed that traditional Hawaiian knowledge, practices and perspectives need to be integrated into the management planning process for the Reserve/proposed Sanctuary. The overall conclusion by *kūpuna* and native fishers is that, in their perspective, commercial fishing is incompatible with the Reserve/proposed Sanctuary.

5.6 ZONING

Zoning is a process of defining boundaries to assist with management objectives and, in the case of marine protected areas, an overarching conservation strategy. Typically, the establishment of zones allowing different kinds and degrees of use (including no-take or no-use) represents a foundation of marine protected area design (see Appendix B2).[84] Currently accepted procedures for determining boundaries in protected areas are based on spatial analyses of the distributions of habitat, communities and species. Zones are designed to provide a margin of safety from various threats, including overfishing,

Knowledge to Work. Conference Proceedings. Fisheries Centre Research Reports, The University of British Columbia. Pages 328-339.

[84] Kelleher, G. 1999. *Guidelines for Marine Protected Area Design*. World Commission on Protected Areas, Best Practice Protected Area Guidelines Series No. 3, IUCN – The World Conservation Union.

and to ensure persistence of species, as well as to assign allowable uses to specific areas. Of particular importance in zoning in the context of ecosystem protection is to encompass habitat areas of sufficient size to "capture" intact biological communities and maintain viable populations of their component species. Evidence indicates that marine protected areas, including no-take zones, provide important benefits for achieving both conservation goals and any associated fishery management, when combined with broadscale measures to buffer/mitigate marine pollution and debris.[85]

Currently, zoning in the NWHI Reserve/proposed Sanctuary includes zones established under State and Federal jurisdictions (e.g. state-managed waters, National Wildlife Refuges) and the Reserve Preservation Areas (RPAs) established by the Executive Order. These RPAs, whose boundaries were based on depth contours surrounding the islands, shoals, and banks, restrict fishing and other activities and are aimed at protecting the sensitive shallow water habitats of the NWHI coral reef ecosystem. Discussion has been ongoing between the agencies with jurisdiction in the NWHI[86] to work through major management concerns including, 1) the existence of multiple overlapping jurisdictions and need for integrated co-management, 2) the need for a comprehensive zoning scheme that will meet goals and objectives of the proposed Sanctuary, and 3) the need for zoning to be comprehensible and enforceable.[87]

The Zoning Discussion Groups were held to help facilitate this process and included other stakeholders in addition to the agencies. Two meetings were held with the Fishing Discussion Group to define general zone types and criteria appropriate for the NWHI and to attempt an initial evaluation of the existing RPAs. An additional meeting was held with the jurisdictional agencies to initiate planning for co-management by recognizing and building on existing, agreed upon policies and zoning. Although the meetings produced a set of recommended zone types and associated design criteria[88], the Zoning Group did not feel sufficiently informed to apply the recommended zoning criteria to the designation of specific Refugia (Preservation) zones, citing a lack of readily available scientific information.[89] Analysis of these data, which exist primarily in an unpublished form among experts who have completed assessments, and expert scientific opinion should be used to determine the extent to which the current protected area boundaries meet zoning goals and criteria or should be modified. This is required to achieve a zoning strategy consistent with accepted marine protected area design procedures and the imperative to use available science.

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[85] Lauck, T., C.W. Clark, M. Mangel, G.R. Munro. 1998. Implementing the Precautionary Principle in Fisheries Management Through Marine Reserves. *Ecological Applications*. 8(1) Supplement. pp. S72-S78; Palumbi 2003 (op cit); Special issue of *Ecological Applications:* The Science of Marine Reserves. 2003, 13(1) Supplement (see Appendix B2).

[86] Including U.S. Fish and Wildlife Service, State Department of Land and Natural Resources, NOAA Fisheries and the National Marine Sanctuary Program.

[87] This includes the development of straightline boundaries as prescribed for in the Executive Order.

[88] The Zoning Group recommended the use of four zone types, differing in their level of protection. The following zone definitions were supported by the majority of participants: Refugia (no-fishing, no public access except as permitted and required by management agencies to achieve goals of protection and preservation); Low-impact (no-fishing, permitted access for approved low-impact activities); and Managed-impact (access and fishing allowed by permit and strictly managed so as not to impact ecosystem integrity); Transit (to allow transiting vessels to harvest for personal consumption enroute). Design criteria for the recommended zone types should promote long-term conservation of the area and should facilitate voluntary compliance and enforcement.

[89] This data includes information on monk seal foraging habitat, fish, coral, invertebrate and algal abundance and diversity, including rare and endemic species and unique assemblages, habitat diversity, spatial distribution of commercial fishing activities.

The background research and the discussion group process revealed the following needs. Although jurisdictional conflicts in the current zoning scheme can be resolved in the short-term, there is a need to conduct a systematic science-based process to evaluate the boundaries of NWHI protected areas. This must occur in the context of developing a comprehensive zoning strategy that involves all the agencies with management responsibilities and jurisdiction in the NWHI, rather than an ad hoc opportunistic approach. Furthermore, this comprehensive zoning strategy must be framed in the context of the overarching ecosystem management goals and objectives of the Reserve/proposed Sanctuary, including the uses that will be allowed or disallowed. Furthermore, any zoning strategy must be applied with an effective system for permitting, enforcement and regulations on permitted uses.

5.7 ECONOMICS

Although a discussion group to address economics was not assembled, economic valuation concepts used as a basis for the Alternatives framework were presented to the FDGs. This included describing the distinction between production versus protection values based on currently accepted economic theory.[90] Participants were made aware of the distinctions between values aligned with fishery development and those aligned with ecosystem protection. A major issue raised by some participants was the need to consider the potential effects of fishing in the NWHI on the marine ecosystem health of the Archipelago as a whole (including impacts on charismatic species such as turtles and the monk seal). This point was emphasized in terms of the economic value of the tourism and ocean recreation industries in Hawaii which are based in part on the attraction to these and other coral reef ecosystem associated species. During fishing discussion group meetings some participants pointed out the vastly greater economic importance of protecting Hawaii's reef ecosystem compared the relatively poor economic performance of NWHI fisheries, suggesting as irrational the acceptance of the potential trade-off in terms of risk to the health of Hawaii's coral reefs. In fact, the total asset value of Hawaii's coral reefs recently was estimated at nearly $364 million compared with $2.5 million annually for all Hawaii's fisheries.[91] This is consistent with the recent finding of a global synthesis of economic studies comparing the economic value derived from ecosystems kept intact with that derived from exploited ecosystems, including coral reef.[92]

The preliminary economic analysis[93] conducted as part of the background research for this project addresses only the economic issues associated with various fishery management options, relying on available data and other background information. It is presented from the perspective of the producer/resource user and includes all costs and benefits that affect the individual. The results show that only two fisheries, the bottomfish fishery and pelagic/recreational fishery, are of any significance in this

[90] Principles and concepts employed and presented during the Discussion Group meetings are those found, for example, in syntheses provided by Pearce, D.W. and R.K. Turner. 1991. *Economics of Natural Resources*. Johns Hopkins University Press. Baltimore, MD *and* Perrings, C. 1995. Economic values of biodiversity. In V.H. Heywood (ed.), *Global Biodiversity Assessment*. Cambridge University Press. See Appendix B2.

[91] Cesar, H., P. van Beuikering, S. Pintz, and J. Dierking. 2002. *Economic Valuation of Hawaii's Coral Reefs*. Final Report. Hawaii Coral Reef Initiative. University of Hawaii.

[92] Balmford, A., A. Bruner, P. Cooper, R. Costanza, S. Farber, R.E. Green, M. Jenkins, P. Jefferiss, V. Jessamy, J. Madden, K. Munro, N. Myers, S. Naeem, J. Paavola, M. Rayment, S. Rosendo, J. Roughgarden, K. Trumper, R.K. Turner. 2002. Economic Reasons for Conserving Wild Nature. *Science*. Vol. 297: 950-953.

[93] See *Economic Aspects of Selected Fisheries Management Options for the Northwestern Hawaiian Islands* working document.

assessment. Previously proposed (precious corals) or previously existing fisheries (lobster) have no present commercial value. Existing data, including that drawn from bottomfish fishery management plan environmental assessments, indicates that on average the nine boats currently in the fleet run an essentially "break-even" business. This suggests a buy-out would be relatively inexpensive. Virtually no data exist on the pelagic/recreation segment, although its value appears relatively small given the fairly small number of vessels apparently involved.

However, no economic value in this analysis is assigned to other benefits (lifestyle choices, or option, bequest, or existence values) and the economic numbers presented do not include any social welfare costs (e.g. management, enforcement, or research) or related benefits.[94] Although some of these components are difficult to measure,[95] others can be included in overall cost-benefits analyses of the fisheries. There is a need to develop a quantitative statement of administrative, management, and enforcement costs of fishery management in the NWHI. In addition, while some costs may change depending on the status of any particular fishery (open or closed), other costs will remain. For example, although closing a fishery would reduce or eliminate most of the administrative costs of managing the fishery, enforcement costs might be less affected, as other threats to the resources exist. Research costs might remain, although funding would no longer be targeted at commercial fishery development, but rather at understanding the indicators of ecological integrity in this representative, relatively pristine, coral reef ecosystem.

6.0 CONCLUSIONS

Included in the table below are the findings for each of the fisheries/topic areas based on an analysis of the information for each topic (current status and management of the fisheries as summarized in Section 5 and included in the Working Documents) and the decision-making criteria presented in the *Supplementary Notes on Decision Criteria, Information Synthesis and Findings* appended to this report. Our analysis led to an overall conclusion concerning the compatibility of fishing with the goals of the proposed Sanctuary. Given these decision criteria (in particular that management to protect ecological integrity requires a shift in the burden of proof regarding the effects of fishing) and the current state of knowledge concerning fisheries and the marine ecosystem in the NWHI, two conclusions can be drawn concerning fishing in the NWHI. First, under the management planning and environmental analysis process currently underway, an alternative management regime for the proposed Sanctuary that includes fishing must include the requirement that these criteria be met to be considered as reasonable under NEPA. Second, because the commercial fisheries currently or previously managed in the NWHI (as well as those proposed) have not met these criteria, and there is evidence that the ecosystem's integrity has been and continues to be negatively affected by commercial fishing, such fishing should be terminated to insure the ecological conditions providing the values (including fishing) for which protection is sought are not irrevocably damaged.

[94] These could include the economic benefit to the MHI of protecting the NWHI (e.g. an increase in fish stocks supporting the MHI commercial and recreational fisheries; the value of marine-based tourism in MHI related to existence of sea turtles or the endangered Hawaiian monk seal).

[95] It is possible to estimate economic values for some of these components (e.g. ecosystem goods and services) using methods such as the contingent valuation method.

Summary of Findings

Fishery/Topic	Summary of Findings
Precious Corals	Incompatible with the proposed Sanctuary due to the inherent slow growth of precious corals and their lack of demographic resilience in response to harvesting. The existing, partially defunct, Precious Coral FMP does not describe an approach or methodology for developing or managing a precious coral fishery in the NWHI consistent with sustainable fishery nor ecosystem protection criteria.
Lobster	Incompatible with the goals of the proposed Sanctuary due to (1) the depressed state of the spiny lobster population following the ecosystem shift and overfishing more than a decade ago, (2) unequivocal evidence that lobster are a component of the endangered monk seal's diet and the absence of definitive evidence that lobster fishing does not significantly effect monk seal survival or reproduction, (3) evidence that overfishing has significantly altered a component of ecological integrity (the relative proportions of slipper and spiny lobster) at some sites, (4) the absence of scientific data and a fishery management plan to provide guidance for a sustainable lobster fishery.
Bottomfish	Incompatible with the goals of the proposed Sanctuary due to: (1) indicators of declining fish stocks and possible effects on components of ecological integrity in bottomfish communities of the Mau Zone, (2) data indicating the significant removal of target and bycatch species and biomass in the absence of adequate stock assessment or ecological data demonstrating no significant ecological consequences, (3) data showing interactions with protected species including incidents of mortality for which the consequences have not been determined to be biologically insignificant, (4) evidence of spatial and ecological overlap among coral reef fish and bottomfish communities, in the absence of data or analysis demonstrating bottomfish fishing does not have significant a negative effect on the coral reef community, (5) fishery management plan that does not yet incorporate recently accepted stock assessment methodology and management practice for a multi-species fishery.
Pelagic and Recreational	Compatibility with the goals of proposed Sanctuary needs to be considered in light of the effects on seabirds and potential violations of the Migratory Bird Treaty Act. No evidence of overfishing or potentially significant effects on components of ecological integrity, although interactions with protected monk seals and seabirds are recorded.
Subsistence Fishing	Traditional Hawaiian knowledge, practices and perspectives need to be integrated into the management planning process for the proposed Sanctuary.
Zoning	Need to conduct a systematic science-based process to evaluate the boundaries of protected areas in the context of developing a comprehensive zoning strategy framed in the context of the overarching ecosystem management goals and objectives of the proposed Sanctuary, including uses that will be allowed or disallowed.

LIST OF PREPARERS

Summary Preparers/Bios

Bruce Wilcox has over 25 years of experience as a researcher and consultant in biological conservation and environmental management, while holding research and faculty positions at Yale University, University of California at San Diego (UCSD), Stanford University, and University of Hawaii at Manoa. In the 1970's he pioneered applications of island biogeography and population biology to conservation area design and is a co-founder of the field of conservation biology, co-authoring the field's first text and helping establish the international journal *Conservation Biology* (Blackwell). He has served as an advisor and an expert committees and panels related to biological conservation and ecosystem management for a number of U.S. and international agencies including the United Nations. Recently Dr. Wilcox led the development and became editor-in-chief of the new international journal *EcoHealth* (Springer-Verlag, New York), which publishes research in conservation medicine, global change and human health, and ecosystem sustainability. His experience in Hawai'i includes project lead on a number of integrated natural and cultural resources management planning, environmental assessments, or related projects involving coastal ecosystems and watersheds, endangered species, coral reefs, as well as cultural resources. He has an A.B. (Biology) from UCSD (1973), a M.S. (Ecology and Evolutionary Biology) from Yale University (1975), and a Ph.D. (Population Biology and Ecology) from UCSD (1980). Dr. Wilcox is an Affiliate Faculty of the Graduate Program in Ecology, Evolution and Conservation Biology, and Professor and Chair of the Division of Ecology and Health, John A. Burns School of Medicine, University of Hawaii at Manoa.

Kristin Duin has nine years of experience as an environmental scientist with experience in environmental and natural resources management and policy; geographic information systems, and their applications to environmental assessment; and resource management planning, land use, and cultural assessment. She has extensive experience with environmental and natural resources management planning guidelines and policy, has been an assistant project manager and co-author of the first INRMPs developed using an ecosystem management approach for DOD installations in Hawaii, and has worked on a range of watershed assessment and restoration projects in Hawaii and California. Her field survey and management planning experience includes Northern and Central California, the Ko'olaupoko District on the Island of Oahu, and East Maui, Hawai'i, as well as Thailand (coral reef surveys). Ms. Duin has a B.S. (Biological Sciences) from Stanford University (1994), and a M.S. (Energy and Resources) from the University of California, Berkeley (2000).

Jennifer Shafer is broadly trained in marine ecology and resource management. She has over ten years of research, teaching, and consulting experience in conservation and management of coral reefs and fisheries in Hawaii. As an EPA STAR Graduate Fellow, her current research involves modeling the human-environment interactions of a coral reef fishery using a complex systems approach, in particular assessing fishery performance under various management alternatives. Ms. Shafer has a B.A. (Biology, Magna Cum Laude) from Wellesley College, Wellesley, MA (1991), a M.S. (Zoology (Marine Biology)) from the University of Hawaii, Manoa (1996) and is a Ph.D Candidate (Geography (Marine Resources Management)) at the University of Hawaii, Manoa. She is an Instructor of Biology in the Marine and Environmental Sciences Program at Hawaii Pacific University.

David Shafer is trained in marine ecology and fisheries science. He has over 16 years of research, teaching, and consulting in marine science. His background is in fisheries ecology, with an emphasis on fish early life history, age and growth, recruitment, and the interaction between biology and physical oceanography in marine fish populations. His broad research experiences involve working on populations of marine and freshwater fishes ranging in habitat from the Arctic Circle to the tropics to Antarctica. In particular, his research has examined the effects of environmental vicissitudes, especially changes in ocean temperature, on marine populations, the importance of critical nursery habitat for supporting marine populations, and the application of this research to fisheries management. Dr. Shafer has a B.A. (Biology) from Wabash College in Indiana (1987) and a Ph.D. (Zoology: Marine Biology) from the University of Hawaii, Manoa (1998).

The following researchers assisted with the development of the working papers:

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SUPPLEMENTARY NOTES ON DECISION CRITERIA, INFORMATION SYNTHESIS, AND FINDINGS: FISHING IN THE PROPOSED NORTHWESTERN HAWAIIAN ISLANDS NATIONAL MARINE SANCTUARY[1]

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1.0 DISTINGUISHING FISHERY MANAGEMENT AND ECOSYSTEM CONSERVATION

The shift required by NOAA given the primary mandate to protect marine biological communities, natural habitat, and ecological processes that accompanies the designation of the NWHI Coral Reef Ecosystem Reserve and the proposed National Marine Sanctuary can be understood in terms of how systems being managed primarily for ecosystem protection and those for resource development differ in definition, conservation and management goals, and assessment of risk from over-use. Different paradigms are held by individuals, including researchers, associated with agencies whose mission is primarily ecosystem conservation and those associated with agencies whose mission is fishery development. This difference may be most readily appreciated in view of the distinction between a commercial fishery and a natural ecosystem. A *fishery* is one or more commercially valuable fished stocks and the related capital and market infrastructure for catching and marketing, along with research, monitoring, enforcement and administrative, management planning and other activities connected with its development and maintenance. A *natural ecosystem* is an assemblage of possibly millions of interacting species, from microbes to large mammals along with their habitat, the food webs and trophic structure they comprise, and the flows and cycling of energy and materials they help generate.

Consequently, marine ecosystem management and fishery management are not the same. They have different management paradigms, goals, sustainability criteria and scientific burden of proof. One of our findings based on participant discussion during the FDG meetings is there is a need to reinforce this distinction among stakeholders during the management planning and environmental assessment process for the proposed Sanctuary. The process should draw on concepts and principles based on and widely accepted in several areas of pure and applied science and policy including: marine protected area design and management, conservation biology, ecosystem management, ecosystem science, and studies of marine biodiversity and coral reef ecology. Modern fishery management science can itself be added to this list since a growing body of scientists and policy analysts are documenting a litany of failed fisheries due a combination of inadequate science, improper policy, and inadequate enforcement.[2] Data from NOAA Fisheries indicates that of the commercially fished stocks in the U.S. whose status is known over

[1] These supplementary notes constitute material from a paper in preparation by the authors to be published independently. They were not developed as part of the Fishing Discussion Group process nor under contract to NOAA.

[2] Botsford, L.W., J.C. Castilla, C.H. Peterson. 1997. The Management of Fisheries and Marine Ecosystems. *Science*. 277 (Jul 25): 509-515; Pew Oceans Commission. 2002. *Managing Marine Fisheries in the United States*. Proceedings of the Pew Oceans Commission Workshop on Marine Fishery Management, Seattle, Washington, 18–19 July 2001. Pew Oceans Commission, Arlington, VA.

30 percent are overfished or are experiencing overfishing.[3] Of several key factors discovered, high on the list is the lack of realism of stock assessment models based on MSY and the inherent complexity and unpredictability of ecosystems.[4] Overfishing is widely accepted in science as the major factor not only in the collapse of fish stocks but of the marine ecosystems of which they are a part. Recognizing the need to change its management approach, NOAA Fisheries has made a commitment to using ecosystem-based management in protecting, restoring and managing ocean resources.[5]

Even the best fishery management plan based on accurate stock assessment methods proceeds from the standpoint of sustaining harvest of the target species. Incidental ecological effects such as those due to bycatch are considered but bear the burden of proof. Ecosystem management planning, where maintaining ecological integrity is the goal, proceeds from the standpoint of determining how to keep an ecosystem structurally and functionally intact, as well as maintaining its biodiversity. That fishing or other uses will not diminish these features bears the burden of proof (see Table 1).[6]

Table 1. Critical Decision Criterion for Developing/Opening/Closing a Fishery

Natural Resource Management Goal	Decision Criterion	Burden of Proof
Development and management of a fishery	Determination (historically)[7] of whether the stock can sustain a fishery?[8]	Is there definitive evidence fishing will have negative environmental consequences?
Design and management of a marine protected area (e.g. CRER/proposed Sanctuary)	Determination of whether the ecosystem can sustain fishing (and maintain its integrity)?[9]	Is there definitive evidence fishing will not significantly effect ecological integrity?

The distinction between management and conservation from a fishery perspective and an ecosystem perspective is exemplified in the contrasting definitions of overfishing (of a fish population) and what is referred to as "ecosystem overfishing".

[3] The status of 32 percent of all stocks is known, the status of 68 percent of stocks is not known. (National Marine Fisheries Service. 2002. *Fisheries of the United States, 2001*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Silver Spring, MD.)

[4] Ludwig, D., R. Hilborn, C. Walters. 1993. Uncertainty, Resource Exploitation, and Conservation: Lessons from History (in Policy Forum), *Science*. Vol. 260, No. 5104. (Apr 2), p. 17+36

[5] NOAA Fisheries. 2003. *Priorities for the 21st Century: NOAA Fisheries' Strategic Plan for FY 2003 – FY 2008*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. July.

[6] Dayton, P.K. 1998. Reversal of the Burden of Proof in Fisheries Management. *Science*. Vol. 279. (Feb. 6): 821-822.

[7] Fishery science is in the process of making a transition to ecosystem-based management.

[8] i.e. the fishery management regime will prevent fishery overfishing.

[9] i.e. the fishery management regime will prevent ecosystem overfishing.

> *Overfishing* means a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield [MSY] on a continuing basis.[10]
>
> *Ecosystem overfishing* refers to fishing-induced ecosystem impacts, including reductions in species diversity and changes in community composition; large variations in abundance, biomass, and production in some of the species; declines in mean trophic levels within ecological systems; and significant habitat modifications or destruction.[11]

Catch levels considered sustainable under traditional single-species management may adversely affect ecological integrity, representing ecosystem overfishing. Further, use of the MSY model in fishery management has been widely discredited. As recently pointed out in a report developed for the Pew Ocean Commission, historically, "[t]he pitfalls of using this [MSY] concept as a reference point for managing fisheries are many, including the fact that the maximum sustainable yield cannot be determined without first exceeding it (overfishing), and that it has been used as a target point rather than a limit. In addition, what might be deemed a sustainable yield for a single species lacks consideration for the complex relationships existing between the exploited species and its competitors, prey, and predators."[12]

2.0 CONSERVATION AREA DESIGNATION: ACCEPTED PRACTICE

A common set of procedures and practices established internationally (UNESCO, IUCN) and nationally (State Heritage programs) exists providing the scientific basis for protecting global, regional, and local biodiversity in protected areas.[13] In addition to legal action designating a conservation or protected area, the process of establishing a conservation area requires, as standard practice, the development and implementation of a management plan using a science-based determination of what and how to manage. This includes a determination of physical dimensions (i.e., boundaries and zoning) and the actions taken on and off-site in support of the stated mission, goals, and objectives. The disciplines of ecosystem management and sustainable systems assessment, planning, and management, referred to as ecosystem-based management, along with the conservation biology have developed in parallel since the 1970's. The integration, often called *ecosystem conservation*, provides the scientific basis for the planning, design, and management of areas designated primarily for protecting biodiversity (which by definition includes biological communities, natural habitats, and ecological processes).[14]

Operationally, ecosystem conservation involves describing, based on continuing assessments, (i) conservation significance, (ii) ecosystem boundaries, and (iii) present condition as well as the condition in which its conservation is sought. These have been long accepted as the basis of *in situ* conservation of

[10] As defined in the Sustainable Fisheries Act of 1996.
[11] Dayton, P.K., S. Thrush, and F.C. Coleman. 2003. *Ecological Effects of Fishing in Marine Ecosystems of the United States*. Prepared for the Pew Oceans Commission, Arlington, VA.
[12] Dayton et al. 2003 (op cit).
[13] For example see IUCN World Commission on Protected Areas (http://www.iucn.org/themes/wcpa/).
[14] See for a thorough description of biodiversity conservation science and strategies, United Nations Environment Program (UNEP). 1995. Global Biodiversity Assessment. Cambridge University Press.

biodiversity.[15] These descriptions can be found stated explicitly or implied in the language in the documents establishing the Reserve and the Sanctuary designation process.[16] These foundational characteristics or features provide the basis for judging what types of fishing and other uses are compatible with the overall conservation goals and management objectives.

2.1 CONSERVATION SIGNIFICANCE

Although the biodiversity and ecological processes directly associated with coral reefs makes up only a portion of the NWHI Coral Reef Ecosystem Reserve, the protection of the coral reef ecosystem is the principal motivation for ecosystem conservation in the NWHI.

Coral reef ecosystems, along with tropical forests, are recognized by science as simultaneously being the biologically most productive, richest and most endangered ecosystems on Earth. Recent studies, including a series of reports published in *Science* magazine, show the world's coral reef ecosystems in an alarming decline collectively trending downward along a scale ranging from pristine to ecologically extinct.[17] No coral reef ecosystem in the world is considered pristine. Already 30% are seriously damaged and nearly 60% are projected to be lost over the next 25 years.[18] Overfishing is cited as historically the major cause of this trend. However, coral bleaching and disease have been contributing increasingly in recent decades.

Hawaii is one of the World's 18 centers for coral reef biodiversity.[19] The NWHI are the most remote large-scale intact coral reef ecosystem on the planet and perhaps the last major coral reef ecosystem where large predators dominate.[20] The NWHI Coral Reef Ecosystem Reserve is the second largest marine protected area in the world after the Australian Great Barrier Reef and the NWHI contain 69% of coral reef area under U.S. jurisdiction. The NWHI coral reef ecosystem has possibly the highest levels of taxonomic endemism of any large-scale coral reef ecosystem in the world[21] and the reef fish communities of NHWI appear to be close to pristine condition[22]. In addition to their global significance in this regard, the conservation significance of the NHWI also has been explained in terms of their natural and cultural

[15] Office of Technology Assessment. 1987. Technologies to Maintain Biological Diversity. Congress of the United States, Office of Technology Assessment. Washington, D.C.

[16] They have been described generally, but not always explicitly. New information based on ongoing research is continuously emerging to assist in refining these descriptions. Their specification provides the 'terms of reference' for design, planning, and management objectives and consideration of uses such as commercial fishing.

[17] Pandolfi, J.M., R.H. Bradbury, E. Sala, T.P. Hughes, K.A. Bjorndal, R.G. Cooke, D. McArdle, L. McClenachan, M.J.H. Newman, G. Paredes, R.R. Warner, J.B.C. Jackson. 2003. Global Trajectories of the Long-Term Decline of Coral Reef Ecosystems. *Science*. 301 (Aug 15): 955-958.

[18] Hughes, T.P., A.H. Baird, D.R. Bellwood et al. 2003. Climate Change, Human Impacts, and the Resilience of Coral Reefs. *Science*. Vol 301. (Aug 15): 929-933.

[19] Roberts, C.M., C.J. McClean, J.E. Veron, J.P. Hawkins, G.R. Allen, D.E. McAllister, C.G. Mittermeier, F.W. Schueler, M. Spalding, F. Wells, C. Vynne, T.B. Werner. 2002. Marine biodiversity hotspots and conservation priorities for tropical reefs. *Science* Vol. 295 (Feb. 15):1280–1284.

[20] Maragos, J. and D. Gulko (eds). 2002. *Coral Reef Ecosystems of the Northwestern Hawaiian Islands: Interim Results Emphasizing the 2000 Surveys*. U.S. Fish and Wildlife Service and the Hawai'i Department of Land and Natural Resources. Honolulu, HI. 46 pp.

[21] Maragos and Gulko 2002 (op cit).

[22] DeMartini, E.E. and A.M. Friedlander. (2003, in press) Are spatial patterns of endemism in Northwestern Hawaiian Island reef fishes caused by local reseeding?

resources value to the people of the U.S. and the State of Hawaii. This clearly is evident and described in detail in the legislative documents establishing the various forms of protection under multiple federal and state jurisdictions.

2.2 ECOSYSTEM BOUNDARIES

Defining ecosystem boundaries is a principle of ecosystem conservation and an essential feature of ecosystem management planning. This includes recognition that protected area boundaries and even some apparent natural geographic or oceanographic boundaries do not necessarily correspond to actual ecosystem boundaries. That is, they do not actually "bound" ecosystem processes or components that are functionally essential to maintaining an intact, self-sustaining system. Organisms, energy and materials flow across such boundaries and between adjacent, and even distant ecological or habitat zones. Understanding ecosystem boundaries has critically important implications to fishery management as well as ecosystem conservation management and protected area design for the NWHI. Two dimensions of this have emerged as problematic in reconciling fishing and ecosystem conservation in the NWHI.

The Hawaiian Archipelago. Establishment of the NWHI Coral Reef Ecosystem Reserve, and the proposal for a Sanctuary to be managed using an ecosystem approach, suggests the NHWI and the Main Hawaiian Islands are distinct ecological entities. This can imply they are functionally independent, and that the populations of marine species occupying coral reef as well as benthic and pelagic habitat in the Main Hawaiian Islands are not dependent for their long term survival on the status of NWHI populations – or vice versa. In fact, the distinction between Northwestern Hawaiian Islands and Main Hawaiian Islands is mainly geographic. The distinction is perpetuated in much of the literature due to differences in island geology, the degree of isolation from human impact, and management convenience. However biologically, the Hawaiian Archipelago is recognized as single biogeographic unit whose atolls, reefs, submerged banks, and shallow benthic environments share a largely common set of species.[23] There are no clear faunal boundaries within the archipelago, and there is almost no evidence of consistent genetic or morphological differentiation suggestive of biological isolation within any of these species. Furthermore, although information on the distribution of pelagic fish larvae is very sparse, the rapid colonization of the archipelago by non-indigenous marine species indicates reef and shallow benthic species readily disperse the distances between emergent islands and submerged islands across the entire chain.[24] Protection of the NWHI coral reef ecosystem (and its design and management) is integral with that for the entire Hawaiian marine ecosystem.

Coral Reef Ecosystem. In fishery discussions, reef fish and bottomfish are distinguished as distinctive groups based on habitat. Coral reef habitat is not to be confused with coral reef ecosystem. However, neither can be precisely drawn on a map. Habitat is defined primarily by structures; ecosystem by functions or processes. A functional boundary does not exist at the edge of reef habitat. A coral reef ecosystem is a more general conception that includes species movement and interactions, as well as physical environmental influences, extending far beyond reef habitat, that determine the characteristics (and survival) of the reef biological communities and habitat. Functionally, bottomfish and pelagic

[23] Mundy, B.C. (In review) A checklist of the fishes of the Hawaiian Archipelago. Submitted as a B.P. Bishop Museum Bulletin of Zoology. 1382 ms p.
[24] Jeff Polovina, personal communication, 29 January 2004.

communities and habitat are not independent, but rather are part of an extended coral reef ecosystem. Although the impacts on the integrity of coral reef communities due to bottomfishing are poorly understood, it is certain that at some level harvesting of bottomfish will impact coral reef health.

Most significant from a conservation perspective, existing evidence supports a metapopulation model for many if not most of the marine species whose ranges extend across the artificial NWHI-MHI boundary, especially for smaller species including shallow-water and reef and benthic substrate dependent fish and invertebrate species. These species exist as local populations dependent on a patchwork of habitat fragments for a part or all of their lifecycle that does not stop at the NWHI-MHI boundary. The key distinction between a metapopulation structure and unstructured populations is that a metapopulation persists over time in a region although many of its local populations are fluctuating in and out of existence due to natural processes. When humans further fragment these populations by disturbing habitat or adding to natural mortality, the frequency of local extinctions begins exceeding that of recolonization. For example, the spiny lobster population at Necker Island, which remains significantly depressed due to a current-induced ecosystem shift and overfishing, is demographically distinct enough from its neighboring populations that whatever larval recruitment is receives externally is insufficient to contribute to its demographic resilience.[25] However, if it were to fluctuate to zero (or to a density providing insufficient self-seeding for it to grow to previous levels), it eventually would be recolonized from another bank, assuming spawning rates from potential source populations were not suppressed due to overfishing or natural stresses. Thus, it may possibly flourish again under improved environmental conditions. Of course, recolonization of an "empty" habitat patch is less likely as source populations occurring in other habitats along the archipelago are depleted or extinguished.

2.3 CONDITION: THE STATE OF THE NWHI MARINE ECOSYSTEM

Ecological Integrity as a Management Objective

Possibly the most fundamental requirement of protected area design and ecosystem management planning is the articulation of its purpose and goal in terms of the state in which the system for which protection is sought.[26] This may be the same or different from its current state and, indeed, the goal can change. In any case, this must be articulated, and present and desired future states characterized. This includes identifying a reference or baseline condition and current trajectory.

The overarching goal for the proposed Sanctuary, as can be ascertained from all the relevant documents, including the NMSA and the values stated by the Reserve Advisory Council, is to protect the NWHI marine ecosystem in its relatively natural condition. This has been explicitly stated as "maintain natural biological communities...and to protect, and where appropriate, restore and enhance natural habitats, populations, and ecological processes."[27]

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[25] DiNardo, G.T. and R. Marshall. 2001. *Status of Lobster Stocks in the Northwestern Hawaiian Islands, 1998-2000*. Southwest Fisheries Science Center Administrative Report H-01-04. June.

[26] "State" refers to attributes including composition, structure, and functions; change (including direction – trajectory); with reference to components of ecological integrity; and emerging properties of *resilience*, organization, and productivity. The "desired state" of the NWHI coral reef ecosystem is the state in which its native biological communities, natural habitat, and ecological processes are intact.

[27] National Marine Sanctuaries Act [16 U.S.C. 1431 et seq., as amended by Public Law 106-513m (b) (6)]

The state in which an ecosystem's natural biological communities, natural habitat, and ecological processes are intact is referred to in the scientific literature as *ecological integrity*.[28] Determining that a given use will not impair ecological integrity is therefore the standard that must be met in considering whether a use is compatible with the proposed Sanctuary.

Components of Ecological Integrity

The response of an ecosystem to any use can be characterized operationally in terms of the change in specific components of ecological integrity.[29] These include the demographic (including life history) and genetic attributes of species, community composition, interspecies interactions, tropic structure and biomass. This recently has been described for marine ecosystems' response to overfishing.[30] Ample evidence now exists that most if not all of these components of ecological integrity have been significantly altered in the Main Hawaiian Islands portion of the Archipelago's regional coral reef ecosystem.[31] The NWHI, although described as being in a relatively pristine condition in comparison to the MHI, nonetheless has experienced effects from overfishing on components of ecological integrity. Individuals with long term fishing experience in the NWHI provided accounts of cases of several of overfished stocks that apparently have never recovered.[32] Additional historically or scientifically documented examples are as follows.

Within three years of its discovery in 1928, the black-lipped pearl oyster was harvested to near extinction and has never recovered. The species was over-harvested to a point where there were not enough adults left to provide a critical mass of spawning stock. Over-harvesting in the lobster fishery contributed not only to the significantly depressed population levels of spiny lobster in the NWHI, that have yet to recover, but to a shift in relative abundance and habitat occurrence of the two target species on the heavily fished banks. Slipper lobster concentrations have increased in shallow areas (15-25 fm) as spiny lobster concentrations have decreased subsequent to the commencement of commercial exploitation.[33] Depletion of lobsters at Maro Reef, subsequently discovered to be the source of recruitment at adjacent Laysan Island, an area closed to commercial fishing, resulted in near extinction of Laysan's spiny lobster

[28] Karr, J.R., K.D. Fausch, P.L. Angermeier, P.R. Yany, I.J. Schlosser. 1986. *Assessment of Biological Integrity in Running Water: A Method and Its Rationale.* Illinois Natural History Survey Special Publication 5. 28 p.; Karr, J.R. 1996. Ecological Integrity and Health are Not the Same. Pages 97-109 in P.C. Schulze (ed), *Engineering Within Ecological Constraints*. National Academy of Engineering, National Academy Press, Washington, DC; Woodley, S., J. Kay, and G. Francis. 1993. *Ecological Integrity and the Management of Ecosystems*. St. Lucie Press.

[29] This is being operationalized through the development of an Index of Biotic Integrity for Coral Reefs. See Karr, J. R. and E. W. Chu. 1999. *Restoring Life in Running Waters: Better Biological Monitoring*. Island Press, Washington, DC, 206 p.; Jameson S.C., M.V. Erdmann, J.R. Karr, G.R. Gibson Jr, K.W. Potts. 2001. Charting a Course Toward Diagnostic Monitoring: A Continuing Review of Coral Reef Attributes and a Research Strategy for Creating Coral Reef Indexes of Biotic Integrity. *Bulletin of Marine Science*. 69:701-744. (available at http://www.epa.gov/owow/oceans/coral/charting/).

[30] Dayton et al. 2003 (op cit).

[31] Friedlander, A.M. and E.E. DeMartini. 2002. Contrasts in Density, Size, and Biomass of Reef Fishes Between the Northwestern and the Main Hawaiian Islands: The Effects of Fishing Down Apex Predators. Marine Ecology Progress Series. Vol. 230: 253–264.; Maragos and Gulko 2002 (op cit).

[32] See transcripts from Subsistence Fishing Discussion Group meetings in Appendix C7.

[33] DiNardo, G.T. and R. Marshall. 2001. *Status of Lobster Stocks in the Northwestern Hawaiian Islands, 1998-2000*. Southwest Fisheries Science Center Administrative Report H-01-04. June.

population.[34] We are not aware of any evidence for recovery as yet at either site. As another indication of impairment of a component of the NWHI's ecological integrity, the mean body size (a correlate of life history attributes of a species including size and age to maturity and reproductive potential) of onaga, a target species in the NWHI bottomfish fishery, has declined significantly.[35]

Possibly the best indicator of ecological integrity of Hawaii's regional marine ecosystem, including the NWHI segment, is the health of marine vertebrates known to be sensitive to system-wide human impacts including fishing. Sea turtles, sea birds, and marine mammals recently have been described as "sentinels" of marine ecosystem health.[36] Monk seals fall into this category. Of three species globally, the Caribbean monk seal is believed extinct and the Mediterranean monk seal nearly so with only a few hundred animals remaining. The decline of both species mirrored the development in their respective regions, including increasingly intensive fishing and degradation of coral reef ecosystems. Although little is known of the pattern of historic decline of the Hawaiian monk seal, precipitous decline in juvenile survival of Hawaiian monk seals since 1990 followed a climate-induced shift in ecosystem carrying capacity along with overharvesting of lobsters, a known prey item of juvenile seals.[37] Monk seal-fish and -fishing interactions have been documented in all NWHI fisheries.[38] It is highly likely that the cumulative effects of fishing commercial fishing activity negatively impacts the monk seal population through both direct and indirect (ecosystem level) mechanisms. If true, it is unlikely this can be determined definitively unless observed by allowing commercial fishing to continue in or adjacent to monk seal habitat.

Pandolfi et al. (2003) provide a ranking system that encompasses the components of ecological integrity by measuring the extent to which the major species "guilds' comprising a coral reef ecosystem are intact. The system features five levels of condition, ranging from pristine to ecologically extinct (see Table 2, Figure 1). Preliminary analysis of data on the Northwestern portion of Hawaii's regional coral reef ecosystem ranks at approximately 30 percent degradation. The evidence suggests the MHI segment ranks at approximately 75 percent degradation. The entire coral reef ecosystem of the Hawaiian Archipelago is at about 53 percent degradation using this indicator.[39] As with most of the world's coral reef ecosystems at present, the condition of the Hawaiian Archipelago according to this measure is not considered to be stable but degrading from an historical perspective.

[34] Polovina, J.J. and W.R. Haight. 1998. Climate Variation, Ecosystem Dynamics, and Fisheries Management in the Northwestern Hawaiian Islands. In *Ecosystem Approaches for Fisheries Management*. pp. 23-32. Lowell Wakefield Fisheries Symposium Series. Anchorage, AK. 30 Sept – 3 Oct 1998. Published by University of Alaska Seagrant.

[35] WPRFMC. 2003. *Bottomfish and Seamount Groundfish Fisheries of the Western Pacific Region: 2001 Annual Report*. WPRFMC, Honolulu, HI.

[36] Aguirre, A.A. and Tabor, G.M. 2004. Marine Vertebrates as Sentinels of Marine Ecosystem Health. *EcoHealth*, Supplementary Issue, Vol.1, Issue 2, EcoHealth. Springer. In press.

[37] Polovina and Haight. 1998 (op cit); Marine Mammal Commission. 2001. *2000 Annual Report to Congress*. 31 March. Bethesda, MD.

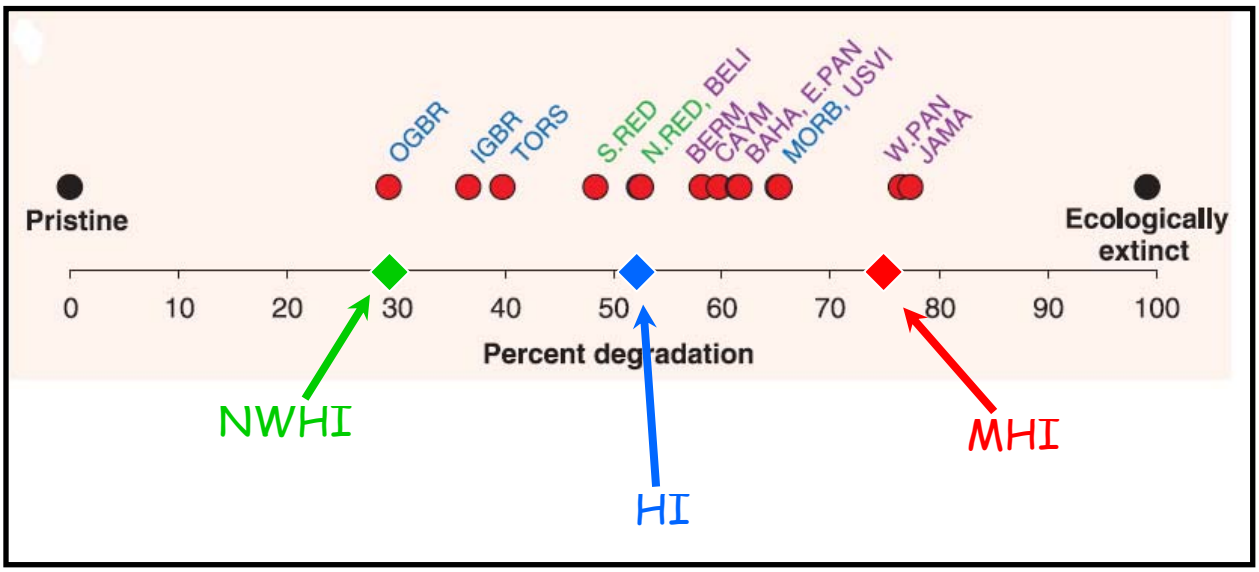
[38] NOAA Fisheries. 2002. Hawaiian Monk Seal (*Monachus schauinslandi*). NOAA Fisheries, Office of Protected Resources, Annual Stock Assessment Report (31 October 2002).

[39] Analysis of the Hawaiian archipelago is contained in Pandolfi et al. 2004 (in prep), obtained through personal communication with John Pandolfi, 19 February 2004.

Table 2: Ecological States and Criteria (from Pandolfi et al. 2003)

Ecological State	Criteria for classification	NWHI Example
Pristine	Detailed history of marine resource use lacks any evidence of human use or damage; Example: Fossil coral assemblages	
Abundant/ common	Human use with no evidence of reduction of marine resource; Example: No reduction in size of fish vertebrae in middens or relative abundance of species	
Depleted/ uncommon	Human use and evidence of reduced abundance (number, size, biomass, etc.); Examples: Shift to smaller sized fish; decrease in abundance, size, or proportional representation of species	Onaga
Rare	Evidence of severe human impact; Examples: Truncated geographic ranges; greatly reduced population size; harvesting of pre-reproductive individuals	Lobster, Monk seal
Ecologically extinct	Rarely observed and further reduction would have no further environmental effect; Examples: Observation of individual sighting considered worthy of publication; local extinctions	Black-lipped pearl oyster
Globally extinct	No longer in existence; Example: Caribbean monk seal	

Figure 1. State of Hawaii Coral Reef Ecosystem on the Pandolfi et al. Scale



Considerations Unique to the NWHI

Management, and how it can achieve the goal of protecting ecological integrity of the NWHI ecosystem, requires consideration in light of the currently stressed condition of MHI fisheries. Consideration also must be given to the existing scientific evidence that Hawaii's regional coral reef ecosystem currently is in a historically downward trend away from its original state of ecological integrity. These findings also apply to National Marine Sanctuaries Act's (as well as the Sustainable Fisheries Act's) mandate to not only maintain but, where "appropriate", restore components of ecological or biological integrity. Thus the increasing sensitivity of the NHWI to human and natural disturbances, including fishing, as a consequence of the degraded state of the Hawaii's fish stocks and ecological integrity in general, bears the decision of whether commercial fishing currently is compatible with the purpose and goal of the proposed Sanctuary.

The isolation and lack of proximity of the NWHI to the closest commercial port not only limits its value to host economically viable commercial fisheries but makes monitoring and enforcement problematic, if not practically or economically infeasible, or both. These and other difficulties related to the physical circumstances, have contributed to a history of fishery mismanagement in the region. On the other hand, inaccessibility is an asset where ecological integrity is a management goal, particularly for coral reef ecosystems which are being degraded globally due largely to coastal development and overfishing.

The marine habitat and associated biological communities including fish species assemblages of the Hawaiian Archipelago including the NWHI are highly insular. This is demonstrated by a high proportion of endemic species and by a history of scientifically documented and anecdotal local extirpations of populations under fishing pressure. It is well established scientifically, and an axiom of the field of island biogeography, that species and biological assemblages that exist under these circumstances (i.e., remote, small geographic areas) are inherently more vulnerable to human disturbance than assemblages of similar species on a larger, contiguous continental shelf. In addition to the intrinsic vulnerability of NWHI ecosystem, the combination of increased vulnerability due to global climate change, and risks to coral reef ecosystems from invasive species introduced by vessels, are much higher the previously thought. These threats to the ecological integrity of NWHI arguably make any kind of use involving entry of vessels a concern that needs significant further study and consideration in the development of a management plan.

A high degree of scientific uncertainty exists concerning the direct and indirect ecological effects of fishing, including the current fishing regime in the NWHI. This uncertainty is in part a result of a lack of research, and management uncertainty will persist due to the inherent variability of the environment and the behavior of the ecosystem.

3.0 CONCLUDING NOTES ABOUT THE COMPATIBILITY OF FISHING AND ECOSYSTEM PROTECTION IN THE NWHI

Two conclusions can be drawn with regard to assessing the compatibility of fishing or other uses when considering the conservation significance, boundaries and condition of the NWHI ecosystem. One is that the actual and potential ecosystem level effects of fishing must be referenced to a historically previous state of the ecosystem, and in consideration of how to restore that state. The second is based on new, undisputed evidence of anthropogenically induced increasing ocean temperatures, causing increasing episodes of coral bleaching.[40] This includes evidence concerning the mechanism of temperature stress-induced bleaching and recovering suggesting Hawaii's coral reefs are inherently less resilient due to the archipelago's extreme isolation from recolonization sources. Fishing pressure has been unequivocally linked to the reduced resilience of coral ecosystems, preconditioning them to be more severely impacted by coral bleaching and disease.[41] Evidence that the maintenance of biodiversity (in a relatively intact state) is a critical determinant of ecosystem resilience thus the sustained production of natural resources, including those derived from coral reef ecosystems, also is widely supported by current research.[42] Combining these considerations significantly raises the standard for allowing any uses of NWHI that not only might further compromise ecological integrity, thus resilience, but might also introduce invasive or disease organisms.

Overfishing (fishery as well as ecosystem overfishing) is common even among managed fisheries. It is responsible for depleting fish stocks and transforming a significant component of Hawaii's marine ecosystem to a degraded ecological state, and has occurred in one of the two managed fisheries targeting shallow water habitat (>150 fms) in the NHWI. As has been the practice nearly everywhere else, commercial fishery development in Hawai'i, including research, monitoring and stock assessment with the goal of designing sustainable management regimes, generally has proceeded with the assumption that the existing data and analysis will support a fishery that is both economically and ecologically sustainable. Yet, as with the case of the NWHI lobster fishery, and currently with the bottomfish fishery, harvesting is allowed to continue in spite of significant scientific uncertainty and mounting evidence of negative ecological consequences. Review of past and current fisheries of the NWHI and fishery management plans, including that for the previously proposed precious corals fishery,[43] reveals a troubling pattern of management policies and practices disconnected from the science generated (or lack of it) by fishery research. While both fisheries management and research have tended to be disconnected from ecosystem-oriented conservation science.

[40] Aeby, G.S., J.C. Kenyon, J.E. Maragos, D.C. Potts. 2003. First record of mass coral bleaching in the Northwestern Hawaiian Islands. *Coral Reefs*. 22: 256; Hughes, T.P. et al. 2003 (op cit).
[41] Hughes, T.P. et al. 2003 (op cit).
[42] Elmquist, T., C. Folke, M. Nystrom, G. Peterson, J. Bengtsson, B. Walker, and J. Norberg. 2003. Response diversity, ecosystem change, and resilience. *Frontiers in Ecology and the Environment*. 1:488-494.
[43] Summarized in the *Results of the Fishing Discussion Group Process*.

Table 3. Considerations Regarding Compatibility of Use

Protected Area Design and Management Criterion	Application to Proposed NWHI Sanctuary
Burden of Proof	Adoption of ecosystem-based management and ecological integrity as goal requires suspending all uses until met.
Conservation Significance	NWHI is ranked among the world's most valuable relatively intact *natural* ecosystems.
Boundaries	Hawaii's coral reef ecosystem is one ecosystem, a major part of which currently is heavily overfished, stressing the entire coral reef ecosystem.
Condition	Available science demonstrates that ecosystem-based management of coral reef ecosystems requires maintaining resilience, resilience is correlated with ecological integrity, and both show indications of being compromised and historically trending downward in NWHI.
Fishery Management Success	The modest success rate (possibly ~70%) of fisheries under management in avoiding overfishing probably is optimistic for NWHI due to the metapopulation structure of inshore species. Reasons are poor stock assessment data, metapopulation structure of inshore species, environmental variation (carrying capacity change due to climate shifts).
Ecosystem Vulnerability	NWHI may be becoming more vulnerable to ecosystem effects of overfishing due to the increasing frequency of thermal stress events causing coral bleaching.