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ECONOMIC RESEARCH ON THE NWHI – A HISTORICAL PERSPECTIVE

BY

SAMUEL G. POOLEY[1] AND MINLING PAN[1]

ABSTRACT

Economic research on the Northwestern Hawaiian Islands (NWHI) living marine resources began as early as the State of Hawaii's fishery development plan in the late 1970s. Subsequently, there was more detailed economic research on the NWHI lobster and bottomfish fisheries. More recently, there has been economic analysis concerning the value of the NWHI as a coral-reef ecosystem. While the economic value of fisheries is fairly straightforward, valuation of ecosystems is much more difficult. In this paper we review the literature and offer suggestions for future research directions.

INTRODUCTION

Commercial operations have been conducted in the NWHI since the early birding, sealing, and guano mining operations in the 1800s and early 1900s. Commercial fisheries have been conducted since at least the immediate post-World War II years, and it is likely there were economics studies conducted on these fisheries and fishing opportunities during those formative periods that we have not uncovered. We are aware of economic research and analysis of these fisheries since the late 1970s, when the State of Hawaii's *Fishery Development Plan* (1979) was prepared. We surveyed economic research that has been published (including some papers that were released as technical reports) for both the NWHI fisheries and its ecosystem as a whole. Given the broad variety of research available, we subdivided this research into four categories based on research objective and topic (Fig. 1). These categories include production economics (e.g., cost-earning studies, production efficiency, and harvest capacity), marketing, decision support, and ecosystem and natural resource valuation. We first summarized the economic research in each category, and then assembled a bibliography of all research articles reviewed and referenced.

[1]NOAA Pacific Islands Fisheries Science Center, 2570 Dole St., Honolulu, Hawaii 96822 USA, E-mail: Samuel.Pooley@noaa.gov

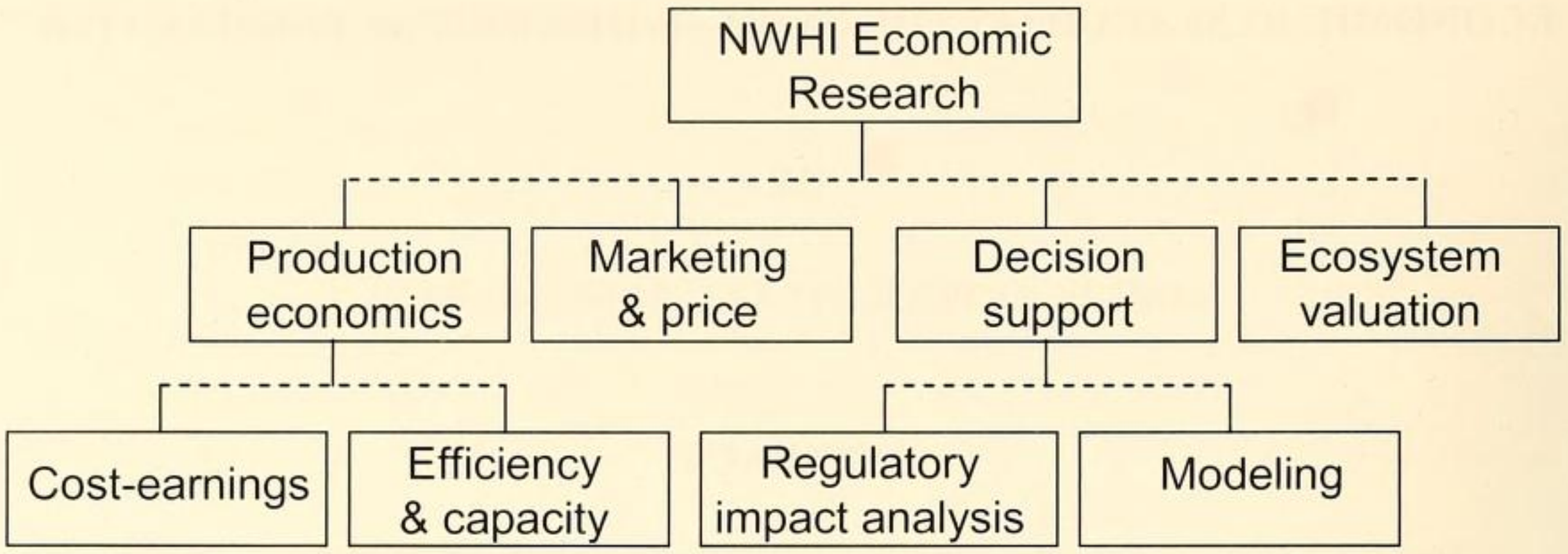

Figure 1. Categorization of NWHI economics research..

PRODUCTION ECONOMICS

Economic research in the late 1970s addressed the potential for expansion of fishery production in Hawaii.. The first *Fishery Development Plan* for the State of Hawaii was prepared by the Department of Land and Natural Resources in 1979 where the economic benefits of potential expansion of Hawaii's fishing industry were estimated in terms of landings, value, and employment. The central components for the NWHI portion of this plan were lobster and bottomfish, where the estimated present discounted value of direct income derived from the projected increase in catch was $168 million through the year 2000.

Subsequently, a number of discrete studies of the costs and earnings of commercial fishing vessels operating in the NWHI were conducted, primarily by economists at the National Marine Fisheries Service (NMFS) Honolulu Laboratory or others working with these economists. The lobster fishery for spiny and slipper lobsters was the dominant commercial fishery in the modern era, followed by the bottomfish fishery for snappers, groupers, and jacks. The first economic feasibility study on the lobster fishery was conducted by the NMFS Honolulu Laboratory as part of the fishery exploration and development effort of the late 1970s (Adams, 1978). Like much applied research, that study focused on what was then an important management question, the optimal harvest size of lobsters. Subsequently, studies focused more on the catch rates required for economic feasibility, which were the primary management tools following minimum size regulations. Clarke and Pooley (1988) conducted an intensive cost-and-earnings survey of all vessel owners (and in some cases, captains) in the NWHI lobster fishery. Interestingly, and probably not surprisingly, the authors showed that mid-sized, owner-operated vessels had clear economic advantages over larger or smaller vessels (larger vessels had high fixed costs while smaller vessels had trouble generating adequate revenue to cover travel costs), and over the vessels with hired captains (suggesting the classical principal-agent problem could be exhibited simply by looking at relative economic returns). Because the lobster fishery had some unique characteristics from an economic research perspective, the NWHI lobster fishery also attracted studies of fleet dynamics (Gates and Samples, 1986) and governance (see the following section on Decision Support).

Probably the most significant production economics study was the creation of an original bioeconomic model of the lobster fishery by Clarke et al. (1992). These authors wedded the earlier cost-earnings analysis to several surplus production models of the lobster resource, including a new variation on the Fox model. The economic model utilized an opportunity-cost-of-labor approach at open-access equilibrium to modeling wage rates, instead of proxy wage rates from other (usually shoreside) businesses, as used in most bioeconomic models. The conclusion of this study was that given the cost structure of the fishery (dominated by the travel distance to the fishing grounds), the fishery could be self-regulating, absent some exogenous event, which would spur new entry (e.g., the subsequent moratorium on longline fishing in Hawaii).

There were also two cost-earnings studies of the NWHI bottomfish fishery (Pooley and Kawamoto, 1990; Hamilton, 1993). Both studies were classic cost-earnings survey studies. Because the NWHI bottomfish fishery was more heterogeneous than the lobster fishery (in the sense of vessel characteristics and target species), fewer generalizations could be gleaned from these studies. An issue facing the NWHI bottomfish studies was the modeling of economic vs. financial returns for these vessels, particularly given a period of high economic returns for alternative investments. The average net economic benefit was found to be negative in both studies, but both studies also showed a positive financial return when standard accounting was applied to the cash flow. What was clear upon discussion with the fishermen was that bottomfishing was more of a way of life than lobster fishing, whereas the lobster vessel owners and captains tended to be more business-oriented in a classical microeconomic, opportunity-cost perspective.

Once the basic cost-earnings structure of the commercial vessels operating in these fisheries was determined, it became possible to undertake assessments of the economic efficiency and capacity of the NWHI lobster and bottomfish fleets as a whole. The first such study used a "topographic" approach to individual vessel operations data (termed "data envelopment analysis," *or DEA*) for the NWHI bottomfish fishery (Pan, 1994). This method was used to evaluate the impact of fishery regulations, ownership patterns, and ex-vessel fish prices on the production efficiency of bottomfish vessels. Results indicated that the large vessels fishing in the Ho'omalu Zone, the more distant limited-entry area, had higher production efficiency and more stabilized fishing behavior than the smaller vessels fishing in the Mau Zone, the open-access area when the research was conducted. The study also found that the owner-operated vessels were more efficient compared to vessels under hired captains (much as found by Clarke and Pooley, 1988, in the lobster fishery). Ex-vessel fish price received by each individual vessel also was a critical factor affecting its production efficiency.

Subsequently, NMFS originated a national approach to estimating the "capacity" of fishing vessels. Pan (2003) used the DEA approach to estimate fleet capacity in both the NWHI lobster and bottomfish fisheries. Preliminary results suggested there was excess capacity in both fisheries, with the very strong caveat that this may have been exacerbated by recent regulatory changes (e.g., the intermittent closures of the NWHI lobster fishery in the late 1990s, followed by its complete closure in 2000, and the effects of an Executive Order on operations of the NWHI lobster and bottomfish fisheries). The

second-stage capacity assessment, through applying a regression analysis, confirmed that over 70% of the excess capacity in NWHI lobster and bottomfish fleets resulted from regulatory changes and declining stocks (Pan and Nguyen, 2004).

MARKETING AND PRICES

Hawaii's commercial fisheries production is famous for responsiveness to quality, with most seafood being a fresh product. In a conceptual look at Hawaii's seafood markets, Pooley (1986) identified the combination of strong fresh-fish auctions and the ability of commercial fishermen to sell outside the auction systems as particularly important in maintaining a competitive market, ensuring price premiums for high-quality fish and providing some price stability for fishermen. The auctions provided a highly visible spot market where price information was centralized, while the bilateral arrangements between individual fishermen and wholesale dealers (and in some cases restaurants and other retail outlets) helped compensate for fluctuations in price.

This was not the case for most of the history of the NWHI lobster fishery, where a frozen-tail product was preferred. But even in this case, identifying Hawaiian spiny and slipper lobster tails as a high-quality product helped establish a strong market niche for their product form (although, ironically, one of the most successful vessels accomplished its profitability by minimizing costs at the expense of lower per unit revenue). Samples and Gates (1987) examined the market conditions facing the lobster fishery in the middle of its heyday. Subsequently, at the nadir of the lobster fishery, there was an effort to land live lobster for the Asian export market with mixed success largely due to recessions in many Asian economies at the time.

In the bottomfish fishery, in both the Main Hawaiian Islands (MHI) and the NWHI, the market was a critical determinant of success. Pooley (1987) examined price flexibility functions (the relationship of changes in price to changes in quantity supplied) for fresh bottomfish in Hawaii. As with an earlier study of Hawaii's commercial fishery markets (Adams, 1981), he showed strong competitive pressures in the market, as well as a long-term growth in demand. The latter accounted not only for demand growth in terms of Hawaii's resident population and as a tourist destination (particularly the growth of the Japanese tourist market in the 1980s) but also concerted efforts on the part of Hawaii's fishing and seafood industry, assisted by the State of Hawaii, in promoting locally caught fish for "white table cloth" restaurants.

DECISION SUPPORT

There is a suite of studies focused on regulatory impact analysis which could be used by fishery managers in their decision process. Samples and Sproul (1987) predicted the potential gains in profitability of the NWHI lobster fleet from a hypothetical limited-entry program. In their subsequent study (1988), they assessed five different types of regulations to determine the feasibility and outcome of these management alternatives in the NWHI lobster fishery. This study indicated that all five management measures considered were enforceable, but only licensing could generate higher profits to the

NWHI lobster industry. After limited entry and catch quotas were implemented in the NWHI lobster fishery, Townsend and Pooley (1995) considered that the management regime might have created unnecessary uncertainty and hardship in the fishery, and they suggested a corporate management approach which invokes the same set of private incentives that a market economy relies on. Interestingly, evidence of private bargaining to reduce fishing effort (the number of participants) was found in the NWHI lobster fleet in 1998 (Townsend and Pooley, 2003). The authors suggested more sophisticated understanding of private and public decision-making, which might lead to a better way to manage fisheries.

In 1986, the Western Pacific Regional Fishery Management Council called for an annual report comprised of a series of independent reports (modules) on the aspects of each fishery. Pooley and Kawamoto (1988) presented the first economic "module" under the bottomfish fishery management plan for the Council. These modules compile economic data and research findings, and have provided fundamental information to support the decision-making process of fishery management in western Pacific areas.

The project "Economic Contributions of Hawaii's Fisheries (1997-1998)" by Sharma et al. (1999) measured the economic impacts of the various fisheries in Hawaii through an Input-Output (I-O) model by computing output, income, and employment multipliers for Hawaii's fishery sectors. NWHI fisheries were included as one of the five fishery sectors. These scientists provided estimates of the linkages of the fisheries sector to the other sectors of the State's economy, its relative importance compared to the other sectors, as well as income contribution effects. Therefore, this model can be used to help to assess the impact of fishery regulations on various sectors of Hawaii's economy. This model was updated and modified by SMS research Inc. (2004). Cai et al. (2005) applied this model to analyze the regulatory impacts of the swordfish closure to the fishing industry and Hawaii's economy.

Another set of research efforts was focused on building a functional model that allowed decision-makers to quantify regulatory impacts, and predicted changes in associated fishing activities. The first modeling effort associated with NWHI fisheries was a linear programming model of Hawaii's commercial fisheries developed by E.R.G. Pacific, Inc. (1986), subsequently modified and extended by the NMFS (Kasaoka, 1989 and 1990). The initial objective of the model was to analyze the potential impact of limited-entry programs on various fisheries and on the economic performance of various fishing fleets. However, the results of the baseline run of the model did not realistically depict the actual fishery situation in Hawaii, probably due to the omission of the micro-level decision-making by fishermen.

Pan (1998) and Pan et al. (2001) presented a Multilevel and Multiobjective Programming Model (MMPM) in an attempt to incorporate the micro-level decision of the fishermen. To depict the reality of the fisheries, the decision variables of the model were defined as fishing effort by fleet, target species, area, and season. The model covered nine fleet categories, ten target species, five areas, and four seasons. Catch per unit of effort (CPUE) included targeted and incidental catch species as a nonlinear relationship between CPUE and effort. Detailed formulations and data sources of the model were documented in technical reports by Leung et al. (1999) and Pan et al. (2000).

The NWHI lobster fishery was included in the MMPM as one of the fishing activities of the multipurpose fleets, and the NWHI bottomfish fishery was included as one of the activities of the commercial handline fleet.

However, direct applications of the MMPM in evaluating new area or seasonal closure regimes were limited given restrictions inherent in the model's area classification. Since area closures are a common practice in fishery management, it was necessary to modify the MMPM by incorporating a flexible area classification to meet the unique management needs of Hawaii's pelagic fishery. An on-going study is modifying the allocation model (MMPM) to include more flexible fishing areas and seasons and develop a user-friendly framework (Nemoto, 2004).

ECOSYSTEM AND NATURAL RESOURCES VALUATION

Traditionally, benefits associated with the consumption of fishery resources have been the main focus in fisheries economics research. However, since purported fishery interactions with protected species and related environmental issues recently threatened the continuation of the NWHI fisheries, there is also value to be gained from research on economic valuation of these non-tradable resources (e.g., protected species, coral reefs).

The first economic valuation of protected species (Hawaiian monk seals) in the NWHI was done by Hollyer (1989). Given that monk seals might have been harmed by fishery development, the study assessed the social costs and benefits of a closure of the <20-fathom range under a variety of discrete circumstances using the contingent-valuation method. Assuming a situation where there would be a 100% loss of the lobster fishery due to closure of the 10-20 fathom range, the study found that households in Hawaii would be willing to pay a lump-sum contribution to save monk seals. This study demonstrated that seals had a positive social value. However, as the author indicated, such conclusions were derived using a method with numerous caveats. In reality, the public's willingness to pay (WTP) might not be as large as the estimated $93.84 per household due to ambiguities in valuation based on inability to separate monk seal "values" from other endangered species values and on budget allocation problems within income categories. There was also a lack of solid evidence linking lobster fishing with the decline in the birth rate and general health of the monk seal population that challenged underlying premises of the WTP approach.

Cesar et al. (2002) conducted an economic valuation of Hawaii's coral reefs. This study estimated the total economic value based on the goods and services provided by the ecosystem. The total economic value of coral-reef ecosystems was derived from use (including direct use and non-direct use) and non-use values. Since the total economic value was estimated mainly by goods and services provided by the coral-reef ecosystem, the study concluded that the economic importance of the MHI outweighs that of the NWHI where non-market use was limited. Thus, the value of Hawaii's coral-reef ecosystem focused solely on the MHI. Based on the estimation by Cesar et al., the average annual value of Hawaii's coral-reef ecosystem amounts to $364 million; of that, 70% was recreational value.

FUTURE DIRECTIONS

This broad variety of economic research on the NWHI fisheries has provided information useful to fishery management. As fishery management moves toward an ecosystem approach, economic research on Hawaii's fisheries will face new and challenge issues including 1) non-market valuation of ecosystems, protected species, and fishing as a way of living, 2) impacts of fishing restrictions on local supply to restaurants (tourists) and residents, 3) fishermen's (commercial and non-commercial) behavior and how they respond to ecosystem-based regulatory changes, and 4) user-friendly decision support models for fishery managers. While the economic value of fisheries is fairly straightforward, particularly where most value is commercial and not non-market, putting a market value on an ecosystem such as coral reefs or protected species presents a major challenge. That begins with the design and establishment of a data-collection system that views the fishery as one element in terms of the benefits fishery resources provide in an ecosystem setting.

BIBLIOGRAPHY

Adams, M. F. 1978. The economic feasibility of lobster fishing in the Northwestern Hawaiian Islands. Southwest Fisheries Center Administrative Report H-78-23.

The author evaluates the economic efficiency of a vessel's lobster-harvesting operations given projections of investment cost, operating cost, and revenues. The economic feasibility of the investment was based on a discounted cash-flow analysis for different combinations of discount rate, sustainable catch rate, average lobster weight, and ex-vessel price. The study concluded that for a likely range of discount rates (0.05 to 0.15), the minimum feasible catch rate was between 1.00 and 2.50 for all the average lobster sizes considered.

Adams, M. F. 1981. Competition and market structure in the Hawaii fish industry. Southwest Fisheries Center Administrative Report H-81-5.

The objective of the paper was to determine if market structure conditions exist in Hawaii's fishing industry which would permit sellers or buyers to exercise market power and create market distortions. This paper was prompted by previous studies which concluded that sellers or buyers of fish in Hawaii collude. This paper concluded that the market structure conditions do not exist in Hawaii's fishing industry which would permit sellers or buyers to exercise market power and create market distortions. This conclusion was based on the presence of a large number of sellers and buyers who operate in the industry, the share of the market for the largest sellers and buyers, entry conditions, and how the largest firms maintain their market shares over time.

Cai, J., P. S. Leung, M. Pan, and S. G. Pooley. 2005. Economic linkage impacts of Hawaii longline fishing regulations. Fisheries Research 74:232-242.

The authors updated the previous Hawaii Fisheries Input-Output (I/O) Model with the most current data and modified model structure so the current version of the model can be used to assess the regulatory impacts of the swordfish closure to the fishing industry and Hawaii's economy. Based on the updated model estimation, if swordfish fishing were shut down (the first scenario), the industry sector's $23 million of output, $11 million in value-added, $5.6 million in income, 218 jobs, and $0.67 million in state tax revenue would be lost.

Cesar, H., P. V. Beukering, S. Pintz, and J. Dierking. 2002. Economic valuation of the coral reefs of Hawaii. Cesar Environmental Economics Consulting, the Netherlands.

The objectives of the study were 1) to assess the economic value of selected case study areas and of Hawaii as whole, 2) to determine the economic costs of reef degradation; and 3) to compare the costs and benefits of various management options. The authors estimated the total economic value based on the goods and services provided by the various reef ecosystem functions. Each of these goods and services has an associated economic benefit. The total economic value of coral reef ecosystems was subdivided into use and non-use values. Use values are benefits that arise from the actual use of the ecosystem, both directly and indirectly, such as fisheries, tourism, and beach-front property value. Non-use values include an existence value, which reflects that value of an ecosystem to humans, irrespective of whether it was used or not. Since the total economic value was estimated by goods and services, the study concluded that the economic importance of Main Hawaiian Island coral reef ecosystems outweighs that of the Northwestern Hawaiian Islands, and it focused solely on the Main Hawaiian Islands. Based on the estimation, the average annual value of the coral reef ecosystem amounts to $364 million. This leads to a net present value at a discount rate of 3% (within 50 years) of nearly $10 billion.

Clarke, R. P., and S. G. Pooley. 1988. An economic analysis of Northwestern Hawaiian Islands lobster fishing vessel performance, NOAA Technical Memorandum, NOAA-TM-NMFS-SWFC-106.

The economic and operational performance of three classes of lobster fishing vessels in the NWHI was examined. Operational information, from logbook catch and effort data, and economic information, with emphasis on cost-earnings data, was supplied by 12 vessels active during the 1985 and 1986 seasons. Only the Class II, midsized owner-operator vessels were clearly profitable, whereas the larger Class I vessels faced a variety of cost constraints, and the Class III hired-captain vessels faced a number of operational problems. Return on investment was estimated to be 4.0, 36.0, and –8.5% on Classes I, II, and III, respectively. Lobster prices were determined outside Hawaii's

fishery and most often reflected worldwide conditions. The authors indicated that one particular problem had been the rapid turnover of vessels participating in the NWHI lobster fishery.

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.

The authors applied several surplus production-based bioeconomic models to the NWHI commercial lobster fishery. They found the model which best explains the biological dynamics of the fishery was a modification of the Fox model developed by the authors. Economic costs were applied within a number of conceptual frameworks to develop the first integrated bioeconomic model of the fishery. In another development, the opportunity cost of labor based on crew share at the open-access equilibrium level of fishing effort was used instead of proxy way levels. Given the costs incurred, the fishery appeared to be self-regulating in terms of long-term fishing effort for maximum sustainable yield. However, exogenous events existed, which could bring a large influx of new vessels into the NWHI lobster fishery. Therefore, interest in limited entry returned.

Department of Land and Natural Resources. 1979. Hawaii Fisheries Development Plan. State of Hawaii, Honolulu, Hawaii.

The goal of the "Fisheries Development Plan" was to increase the productivity of Hawaii's fishing industry in terms of landings, value, and employment. This plan indicated there was resource potential for marine fishery development in the Hawaii region. While most of the potential exists in the open-ocean tunas, whose boundaries have been defined arbitrarily as 1,500 miles from Honolulu, the potential for development of most other fisheries, essentially all of the bottomfish, lobster, shrimp, *akule*, and *opelu* potential, exists within the NWHI. The authors indicated a highly positive return from fishery expansion. However, a variety of constraints and alternatives may affect the development of the fishery.

E.R.G. Pacific Inc. 1986. Project Summary: Linear programming model of Hawaii commercial fisheries. Technical in-house report for National Marine Fisheries Service, Honolulu, Hawaii, March 1986.

The initial intent of the model was to analyze the potential impact of limited-entry programs on various Hawaii fisheries and on the economic performance of various fishing fleets. In the original Hawaii fishery model, several different fleet types could target various fish and crustacean species. Seven submodels were created from this generic model of fixed-cost accounting.

Gates, P. D. and K. C. Samples. 1986. Dynamics of fleet composition and vessel fishing patterns in the Northwestern Hawaiian Islands commercial lobster fishery: 1983-86. Southwest Fisheries Center Administrative Report H-86-17C.

The authors examined the dynamics of fleet composition and operations of the NWHI lobster fleets during 1983-1986, the period of the expansion of the fishery. The number of permits issued had increased markedly over time. Eleven permits were issued for the 1983 permit season compared with the 51 that were valid during the 1986 permit season. Active vessels increased to 19 in 1986, compared to 1983 when there were only 3 active vessels. Trip effort increased also, and fishing trips had become longer in 1986. The fleet had exerted substantial fishing effort throughout the NWHI. Even though more areas had been fished each year, approximately two-thirds of the total fishing effort was concentrated around three areas.

Hamilton, M. 1993. Vessel activities, costs, and economic returns. Southwest Fisheries Center Administrative Report H-94-1C.

This report examined the activity patterns, economic returns, and number of economically sustainable vessels for both the entire NWHI and its components, the limited-entry Ho'omalu Zone and open-access-permit Mau Zone. On average, vessels in the Ho'omalu Zone in 1993 were making a profit on an annual basis, while vessels in the Mau Zone were not making a profit on an annual basis.

Higuchi, W. K. and S. G. Pooley. 1985. Hawaii's retail seafood volume. Southwest Fisheries Center Administrative Report H-85-6.

This report presented new and revised tables on Hawaii's 1981 retail seafood volume based on a stratified survey of retail seafood establishments. It provided estimates of retail seafood purchases by source and product state (fresh, frozen, or processed), retail seafood sales by destination, and retail seafood volume by country and species.

Hollyer, J. R. 1989. Economic allocation of the 10-20 fathom range of the Northwestern Hawaiian Islands: lobster fishery or Hawaiian monk seal critical habitat? Thesis for the degree of Master of Science, University of Hawaii at Manoa.

In 1986, NMFS signed legislation designating a critical habitat within 10 fathoms for the monk seal. However, the Monk Seal Recovery Team recommended that the best way to reduce risk to the monk seals was to create a critical habitat encompassing the 20-fathom range. This study assessed the social costs and benefits of a closure of the 20-fathom range under a variety of discrete circumstances, using the contingent valuation method. Given that monk seals may be harmed by fishery development, the study suggested that if society chooses to manage the NWHI, a disputed area should be closed to lobster fishing. Such a conclusion was supported by the analysis where: 1)

there will be a 100% loss of the lobster fishery due to closure of the 10-20 fathom range; and 2) households of Hawaii indicated they would willing to pay a lump-sum average contribution of $93.84, or an annual sum of $8.83, to save the monk seals. This study indicated in reality that willingness to pay (WTP) might not be as large as $8.83, but it was important to note that seals had a positive social value that was comparable to the value of lobster fishing. However, the author also indicated several caveats in the study. The most glaring omission was the lack of solid evidence concerning the correlation between lobster-fishing activities and a decline in the birth rate and general health of the monk seal population.

Laurel D. K. 1990. A linear programming model for the Northwestern Hawaiian Islands multi-fishery. Southwest Fisheries Center Administrative Report H-90-04C.

The purpose of the project was to modify and expand the linear programming (LP) model for Hawaii's commercial fisheries that was developed initially by Dr. Dennis M. King of E.R.G. Pacific, Inc. This project combined two submodels to form one multifishery model as a new baseline. Many features from the NWHI bottomfish fishery LP model, developed in 1988, were incorporated into this new version. The version of the model enabled the user to simulate different fishery scenarios that may reflect potential industry trends. The model allocated the limited fishing time of each vessel type among fishing areas and target species for each fishing season so as to maximize fleet-wide profits. However, the results of a baseline run of the model did not realistically depict the actual fishery situation in Hawaii. In particular, this baseline solution falsely showed that aku (skipjack tuna) never were caught in any season from any area.

Leung, P. S., M. Pan, F. Ji, S. T. Nakamoto, and S. G. Pooley. 1999. A bilevel and bicriterion programming model of Hawaii's multifishery. *In*: U. Chakravorty and J. Sibert (eds.), Ocean-scale management of pelagic fisheries: economic and regulatory issues, P. 41-63. Proceedings of an international workshop organized by the Pelagic Fisheries Research Program, JIMAR, University of Hawaii at Manoa, Honolulu, Hawaii, 1997, SOEST 99-01, JIMARContribution 99-321.

This technical report described the fisheries considered and the procedures and justifications to build a bilevel and bicriterion programming model of Hawaii's multifishery (multiple-species, multi-gear fisheries). The NWHI lobster fishery was included in the model as one fishing activity (target) of the multipurpose fleet, and the NWHI bottomfish fishery was included as one fishing activity (target) of the commercial handline fleet. To illustrate how the model can be used for decision support, the economic tradeoff between the recreational and commercial fisheries was estimated by the model, and results were presented in the report.

Nemoto, K. 2004. Project progress report: Regulatory impact analysis framework for Hawaii pelagic fishery, Pelagic Fisheries Research Program, JIMAR, University of Hawaii. (http://www.soest.hawaii.edu/PFRP/economics/economics.html)

The objective of this project was to enhance the multilevel, multiobjective programming model for Hawaii's fisheries that was developed under a previous Pelagic Fisheries Research Program project. This would involve making the basic model structure more tractable for regulatory analysis. It should allow more flexible time-area specification and facilitate updating the underlying data. The update focuses on the Hawaii-based longline fishery. The final technical report is under preparation.

Pan, M. 1994. Vessel operating efficiency of commercial bottomfish fishery in NWHI. Master of Science thesis in Agricultural and Resource Economics, University of Hawaii.

This study evaluated the production efficiency of individual bottomfish vessels operating in the NWHI. Through the data envelopment analysis (DEA) method, the study evaluated the impact of fishery regulation, ownership of operation, and fish prices on production efficiency of bottomfish vessels. Vessels fishing in the Ho'omalu Zone, the limited-entry area, had higher production efficiency and more stabilized fishing behavior than vessels fishing in the Mau Zone, the open-access area. In the two areas combined, the owner-operated vessels were more efficient in using owner-paid operating costs than the vessels under hired captains. Ex-vessel fish prices received by each individual vessel also were a critical factor affecting its production efficiency.

Pan, M. 1998. Multilevel and multiobjective programming model for the Hawaii fishery management. Doctoral Dissertation, University of Hawaii.

This study developed a multilevel and multiobjective programming model to assist decision-making in Hawaii's fishery. Under various objectives or policy options, the model developed in this study provides optimum solutions by fleet mix, spatial and temporal distribution of the fleet, and harvest level of fish resources.

Pan, M., P. S. Leung, F. Ji, S. T. Nakamoto, and S. G. Pooley. 2000. A multilevel and multiobjective programming model for the Hawaii fishery: model documentation and application results. SOEST 99-04, JIMAR Contribution 99-324, University of Hawaii at Manoa.

The authors document the justifications of the formulations of a multilevel and multiobjective programming model and the data that were used to operate the model. To depict the reality of the fisheries, the decision variables of the model were defined as effort by fleet, target species, area, and season. The model covers nine fleet categories, 10 target species, five areas, and four seasons. Catch per unit of effort (CPUE) includes targeted and bycatch species. A nonlinear relationship between CPUE and effort was incorporated into the model. In addition, the current model also improves upon the previous model in the following aspects: 1) the model allows for the inclusion of other fishery management objectives in addition to maximizing fleet-wide profits, 2) several micro-level entry conditions at the fisher's level were incorporated in the current model,

3) unlike the previous model, where fixed cost was charged by season, the current model charges annual fixed cost as long as the vessel was active at least in a season. A baseline model was run, and the model results were compared to the actual fishery activities and performance.

Pan, M., P. S. Leung, and S. G. Pooley. 2001. A decision support model for fisheries management in Hawaii – a multilevel and multiobjective programming approach. North American Journal of Fisheries Management 21:293-309.

The authors developed and applied a multilevel and multiobjective programming model to assist decision-making in Hawaii's fisheries. The multilevel aspect of the model incorporated objectives of both policy-makers and fishermen. The use of a multiobjective model was considered essential in fishery management, because the typical fishery policy problem was characterized by more than one objective or goal that decision-makers want to optimize. The current model was applied to evaluate several management issues facing Hawaii's fisheries.

Pan, M. 2003. Report on quantitative measurement of fishing capacity in Western Pacific Region. National Report to Congress on National Capacity Assessments, National Marine Fisheries Services, NOAA.

The author presents quantitative analysis of fishing capacity using Data Envelopment Analysis (DEA). The excess capacity defined in the study simply means that a fleet was able to harvest more than it presently does, without being compared with any desired catch level such as maximum sustainable yield. This study covers capacity analysis for four major fisheries under the management of the Western Pacific Regional Fishery Management Council. They were 1) NWHI lobster, 2) NWHI bottomfish, 3) Hawaii longline, and 4) American Samoa longline. Excess capacity may exist in NWHI lobster and bottomfish fisheries. However, additional analyses were needed to determine if the excess capacity resulted from too many boats or from changes in regulations, reduced stock abundances, or fluctuation of the oceanic environment.

Pan, M. 2004. Quantitative measurement of excess capacity and the implication to fishery management. Proceedings of NMFS Social and Economics Workshop, New Orleans.

The author discussed the definitions and measurement methods of excess capacity. The study suggested that additional analysis was needed to evaluate excess capacity measurement and to identify possible causes of excess capacity measured by the quantitative methods recommended by NMFS National Capacity Task Force. Through an empirical approach , the study presented analytical tools to examine the causes of excess capacity and to assess whether excess capacity could be a result of changes in regulations, reduced stock abundances, or fluctuation of the oceanic environment. Over 70% of excess capacity of NWHI bottomfish and lobster fisheries may result from regulatory changes and stock reduction.

Pooley, S. G. 1986. Competitive markets and bilateral exchange: the wholesale seafood market in Hawaii. Southwest Fisheries Center Administrative Report H-86-8.

This paper explores a seafood market with mixed product forms and types of markets. The Honolulu auction represents a dramatic difference from seafood markets in most places in the U.S. As an auction, it serves to pool information on price, quantity, and quality, creating a quasi-public good in market information and to provide a baseline for nonauction transactions. On the other hand, long-term bilateral arrangements between commercial harvesters and wholesalers serve to overcome transactional problems associated with uncertainty and limited information. As a result, Hawaii's seafood market combines aspects of bilateral exchange with the advantages of a spot market. This study suggested that a combination of competitive auctions and bilateral exchange was a solution to improving the transactional quality of the market.

Pooley, S. G. 1987. Demand considerations in fisheries management – Hawaii's market for bottomfish. *In:* J. J. Polovina and Ralston, S. (eds.), Tropical Snappers and Groupers: Biology and Fisheries Management, (p. 605-638). Boulder, CO: Westview Press.

This paper described the market for fresh snappers and groupers in the U.S. as a whole, but emphasized Hawaii in particular. Then the demand for fresh bottomfish in Hawaii was estimated through price-flexibility functions. Finally, some management implications that derive from market demand estimation were explored. Examination of Hawaii's market for bottomfish showed some price volatility in the short run, and long-term demand had been significantly positive, most closely associated with increasing population, tourist arrivals, and exports. Therefore, the author suggested fishery management decisions must take into account the impact of changing supply conditions on the availability and price of fresh bottomfish in the market, since changes in supply may have significant impacts on processors, wholesalers, and the final consumer.

Pooley, S. G. and K. E. Kawamoto. 1988. Economic report on Hawaii's commercial bottomfish fishery, 1986. Southwest Fisheries Center Administrative Report H-88-1.

This report described the recent history of Hawaii's bottomfish fishery, provided a preliminary estimate of revenue in Hawaii's bottomfish market for 1986, analyzed fleet dynamics, provided estimates of revenue per vessel for 1986, and proposed a number of research items for Hawaii's fishery.

Pooley, S. G. and K. E. Kawamoto. 1990. Economic analysis of bottomfish fishing vessels operating in the Northwestern Hawaiian Islands, 1984-88. Southwest Fisheries Center Administrative Report H-90-13.

The limited-entry provision of the Western Pacific Regional Fishery Management

Council's Bottomfish Fishery Management Plan required an estimation of the economic profitability of bottomfish fishing vessels operating in the NWHI. This report provides cost-earnings analysis based on a sample of seven bottomfish vessels, which represented one-quarter of the active vessels in the NWHI bottomfish fishery in 1987. The estimated net revenue on a fleet-wide basis was negative during the period of 1986-1988.

Pooley, S. G. 1993. Economic analysis of the economic cost of alternative bottomfish regulations. Southwest Fisheries Center, Honolulu Laboratory manuscript 001-93H-MRF.

Two biological regulations were proposed for Hawaii's bottomfish fishery in the early 1990s. This study estimated the economic cost of those regulations using present-value analysis. The study estimated the annualized present value of the difference in the yield from the fishery over a 14-year period by comparing the baseline (no biological regulations) with three alternatives: a 3-pound size limit, a 3-pound size limit with different assumptions about fishing mortality, and a 3-month seasonal closure. It concluded that revenue in the fishery would decline in the first years of the regulation as yield dropped with a rebuilding schedule then being developed. The yield from the fishery under regulation exceeded the baseline after 6 years of the regulation. However, the cumulative present value of the fishery after implementation of the regulation did not meet the cumulative present value without the regulations. Therefore, this study considered whether the biological benefits from these regulations (especially in terms of reduced risk of catastrophic overfishing) were worth this economic cost.

Pooley, S. G. 1996. Limited entry in Hawaii's major commercial fisheries. The Economic Status of U.S. Fisheries: 1996. NOAA Technical Memorandum NMFS-F/SPO-22.

This article discussed the evaluation of limited-entry fishing in Hawaii with an emphasis on the economic impacts. Limited entry had not been a panacea for any of the federally regulated commercial fisheries in Hawaii. Neither of the two NWHI fisheries had prospered in terms of maintaining total revenue from the fisheries. In neither fishery were the population dynamics well understood. Moreover, the potential value of the permits made rebuilding the NWHI fisheries economically viable, with a number of participants in the NWHI lobster fishery agreeing on multiyear closures if required.

Pooley, S. G. 1996. Economic determination of the optimal number of Northwestern Hawaiian Islands bottomfish vessels. Southwest Fisheries Center Administrative Report H-96-07.

The author indicated the optimal number of Northwestern Hawaiian Islands bottomfish vessels, through an economic analysis. The procedure of the analysis included: 1) estimating the annual bottomfish pounds taken per NWHI fishing vessel at various levels of economic operation, based on cost-earnings simulators, 2) determining the MSY level of bottomfish in the NWHI and its two regulatory zones, and 3) dividing

the MSY by the annual bottomfish pounds per vessel under various levels or scenarios of economic operations to estimate the optimal number of vessels for the NWHI bottomfish fishery. It was suggested that the optimal number of vessels was 18.

Samples, K. C. and P. D. Gates. 1987. Market situation and outlook for Northwestern Hawaiian Islands spiny and slipper lobsters. Southwest Fisheries Center Administrative Report H-84-4C.

The purpose of the report was to portray the past and current marketing situation for NWHI lobsters, and to project market conditions for the next several years. All indications suggested a positive market outlook for NWHI lobsters. Demand for NWHI lobster products was projected to grow over the next 2 to 3 years following the general growth in U.S. consumer demand for lobster products, which would tend to generate modest increases in the real price of spiny and slipper lobster tails, somewhere in the range of 3 to 7 percent, annually. This study concluded that given firm market conditions, NWHI lobster fishermen would have little difficulty marketing their catch.

Samples, K. C. and J. T. Sproul. 1987. Potential gains in fleet profitability from limiting entry into the Northwestern Hawaiian Island commercial lobster trap fishery. Southwest Fisheries Center Administrative Report H-87-17C.

The Western Pacific Regional Fishery Management Council proposed a limited-entry program for the fishery in the mid-1980s. Two general forms of entry management were analyzed: control over the types of vessels permitted to fish, and control of the total number of traps permitted. This purpose of this research was to predict the potential economic gains that could be realized through a hypothetical limited-entry program. This analysis indicated that, at best, a fully effective limited-entry program, with control over aggregate effort and classes of vessels allowed to fish, would potentially increase annual fleet economic profit from nearly zero to $2.3 million. However, this report also indicated that there were numerous reasons why gains from an actual limited-entry program may not reach this upper limit. Actual gains would depend on the composition of the fleet fishing under the limited-entry regime.

Samples, K. C. and J. T. Sproul. 1988. An economic appraisal of effort management alternatives for the Northwestern Hawaiian Islands commercial lobster fishery. Southwest Fisheries Center Administrative Report H-88-12C.

A variety of analytical tools were used in this report to conduct an *ex ante* evaluation of the feasibility and outcome of effort management alternatives. This report assessed five different types of regulations in terms of their legal and enforcement feasibility, potential for effort reduction, effects on industry profits, and creation of economic hardship. The long-run effects of effort management regulation on industry profits were mixed. Only licensing can generate higher profits due to physical limits placed on effort expansion by licensed operators, or by the potential entrance of new enterprises into the fishery.

Sharma, K. R., A. Peterson, S.G. Pooley, S. T. Nakamoto, and P. S. Leung. 1999. Economic contribution of Hawaii's fisheries. SOEST 99-08, JIMAR 99-327, University of Hawaii.

The purpose of this research was to estimate the direct and indirect linkages of various fishery sectors, including the NWHI lobster and bottomfish fisheries, to Hawaii's economy. The study modified the Hawaii Input-Output model and incorporated the recent cost-earnings information of Hawaii's various fisheries into the model. Therefore, this model could be used to assess the economic significance of each fishery sector to the state economy, in terms of output and income employment. This model can be used to estimate economic impact of new fishery regulations on fishery sectors themselves as well as the other economy sectors.

Townsend, R., and S. G. Pooley. 1995. Distributed governance in fisheries. *In:* S. Hanna and M. Munasinghe (eds.), Property rights and the environment,. World Bank.

Dissatisfaction with traditional fishery regulation led to great interest in distributed governance of fisheries. In examining the alternative models of distributed governance, the authors found that rights-based management distributes a very well defined, but narrow, set of responsibilities to individual fishers. This study suggested that corporate governance, that implements contractual management of fisheries, was an important and powerful alternative for distributed governance in fisheries. The model of distributed governance, that combines the external structure of contractual management with the internal governance structure of corporate organization, could find applications in the management of other common-pool resources.

Townsend, R., and S. G. Pooley. 1995. Distributed governance in the Northwestern Hawaiian Islands lobster fishery. *In:* S. Hanna and M. Munasinghe (eds.), Property rights and the environment,. World Bank.

Alternative management approaches for the governance of the NWHI lobster fishery were evaluated. Because of the relatively simple nature of the fishery, a wide array of governance structures could be applied to this fishery. If management options were limited to the traditional rights-based approaches, either individual transferable quota management or transferable trap regulation could be expected to increase the economic rents that the industry would earn. The administration of either type of rights-based management would be relatively straightforward in this fishery. On the other hand, the fishery presents a unique opportunity to move beyond government-centered, rights-based management to a contractual model of management between the government and a local cooperative or corporation.

Townsend, R. and S. G. Pooley. 1995. Corporate management of the Northwestern Hawaiian Islands lobster fishery. Ocean & Coastal Management 28:63-83.

Limited entry and catch quotas were implemented in the lobster fishery of the NWHI in 1991, during a period of declining stock abundance. However, ancillary rules, such as the use-it-or-lose-it requirement and within-season quota adjustments, had combined to create unnecessary uncertainty and hardship in the fishery. This paper introduces a dramatically different management regime that would create ownership rights in a private management corporation for the current limited-entry permit holders. The corporate management approach invokes the same set of private incentives that a capitalist market economy relies upon for management of most of its natural resources.

Townsend, R. and S. Pooley. 2003. Evidence on producer bargaining in the Northwestern Hawaiian Islands lobster fishery. Maine Resource Economics 18:195-203.

The authors documented an example of private bargaining to reduce fishing effort in the NWHI lobster fishery. By 1997, the industry was confronted with a classic derby fishery. In that year, nine boats decided to fish. In the fishing year 1998, holders of 14 NWHI permits agreed that only 4 of the 14 vessels holding permits would fish. Holders of the other 10 permits received compensation not to fish from those who fished. This agreement was frequently referred as the "Hui," which is the Hawaiian word for "group." While ancillary issues frequently deflect regulations, the Hui illustrates low transaction costs of private bargaining as compared to public decision-making. The holders of 14 permits were able to bargain a simple set of rules in a remarkably short period of time, and expensive enforcement mechanisms were avoided entirely. The authors suggested that a more sophisticated understanding of private and public decision-making might lead us to combine their strengths, instead of relying entirely on a government-dominated model of fishery decision-making.