GREAT LAKES FISHERY COMMISSION
Research Completion Report *

APPLICATIONS AND EXTENSIONS OF THE ECONOMIC ASPECTS OF FISHERIES MANAGEMENT: AN ANNOTATED BIBLIOGRAPHY

by

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Complaints about the lack of economic analysis in fisheries management planning are common. Managers, environmentalists, users, and economists alike feel that doing more such work is necessary to improve the information base upon which fisheries management decisions are made. Of course, the motivation for doing economic research and the fisheries-related issues of concern varies among these groups, but the interest in analytical analyses is widespread.

There are many reasons for this absence. Historically, it may have been a lack of understanding of basic fisheries economics principles by many of the critical participants in the management process. This is becoming less and less of a problem, however, primarily due to the interest of these participants and the wide availability of general literature on the economic aspects of fisheries management. There are many volumes which describe the basic concepts of the economics of fisheries management, some of which are suitable for economic novices, and a bibliography of such sources is attached to this introduction.[1]

While the level of general economic knowledge is improving, the real issue is how to *expand* and *apply* the economic theory to address the many complexities faced by modern fisheries management in both the commercial and the recreational fishing sectors. If open-access will lead to over-capitalization of the fleet and depletion of the stock, what advice can be offered about the appropriate combination of fleet and stock size to avoid this situation? Additionally--and regardless of whether the fishery is one newly opened or an existing one in which open access has led to over exploitation--over what time period and at what rates should the fleet and stock size be changed? What types of regulations will prove useful in achieving a change in stock and fleet size, and how will they affect the different types of participants? How might projects outside or exogenous to a fishery affect it, and how can these effects be mitigated? Is it even worth the effort to do so? What social, industrial, and/or political problems might the fisheries manager anticipate? More generally, can the regulations be enforced at a reasonable cost? What will be the benefits to consumers of fish and/or to participants in the industry?

The purpose of this annotated bibliography is to provide an up-to-date compilation of accessible existing works which address these and related issues. We have included articles which provide extensions of the basic theory as well as those which involve practical applications. In most

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[1] The bibliography includes books, manuals prepared by FAO and other organizations, and chapters in intermediate and advanced economics of natural resource economics texts. One (Anderson, 1992) is a companion piece to this volume.

instances the applications will provide fishery-specific information, i.e., information about the particular fishery being studied. The applications will not only be useful for the bottom line data, however, but also for the explanations of how to use particular methodologies and for the discussions of their relative strengths and weaknesses.

The studies are broken down into the nine categories listed in Table 1. Although the groupings are not mutually exclusive, the categories have been selected to focus attention on specific problems and issues. The first two categories are concerned with empirical and theoretical applications of the basic bioeconomic models of fisheries economics. The third section contains studies on the economic effects of various types of management. Some of the articles deal directly with the managerial applications of bioeconomic models. Others address more pragmatic aspects of management such as the effects different strategies will have, data and statistical needs, and even more descriptive aspects of fisheries management such as the evolution and development of management in particular areas. Those that utilize the results of bioeconomic studies--unlike those in the first two sections that focus on the general implications of the biological-economic relationships in fisheries--emphasize the *effects* of various types of regulations on fisheries participants and on the stock(s).

The fourth section, Production Functions, deals with aspects of fisheries production from both applied and specialized econometric analyses of the relationship between inputs (boats, days fishing, etc.) and landings to studies of those economic, biological, and even environmental factors that can change production in a fishery.

The Market Studies section includes papers which study various supply and demand issues that arise in different types of fisheries. These papers cover a diverse range of topics from describing the relationships between harvester and consumer to the impact of marketing strategies on national and international prices.

The section entitled Recreational Fisheries contains both theoretical and empirical studies of fisheries that have a recreational component. Most of the articles focus on the valuation of the non-market aspects of recreational fishing and utilize a fairly comprehensive cross-section of the available methodologies. Of those articles that do not involve valuation per se, many are concerned with valuing the effects of external forces on the value of the fishery, i.e., how such things as congestion or stock levels affect a fishery's value. In those cases where the fishery also has a

Table 1

Topical Bibliography Categories	
A.	Empirical Bioeconomic Studies
B.	Theoretical Bioeconomic Models
C.	Management Studies
D.	Production Functions
E.	Market Studies
F.	Recreational Fisheries
G.	Mitigation, Habitat, and Valuation
H.	Economic Impact Studies
I.	Politics, Political Science, and Sociology

commercial component, the articles have been included in this section to demonstrate practical work on joint commercial-recreational fisheries management.

Although not very large, the Mitigation, Habitat, and Valuation section lists papers dealing with a range of the important issues pertaining to the economic values of things typically *not* associated with markets or dollar values. The papers address such topics as the valuation of fisheries habitat, the economic effects of pollution on fisheries utilization, and the potential benefits from stock rehabilitation. The articles provide a fairly representative selection of the available methodologies and their application. One of the articles provides an overview of the correct underlying theory behind these sorts of valuation studies and comes complete with caveats about how *not* to do or use such studies.

The Economic Impact section consists of those papers which have measured the economic impact of fisheries in a certain region or the economic impacts of different regulations. Care needs to be taken when interpreting these studies results because they are not directly transferable to other situations and because there is a difference between the net economic value of a fishery and its gross economic impact.

The final section--Politics, Political Science and Sociology--contains papers dealing with a spectrum of the political, institutional and socioeconomic aspects of management. The topics

presented range from legislative histories and workforce characterizations to interactions between regulators and fisheries constituencies, both at the national and international levels. The examples include case studies of herring, lobster, prawn, salmon, scale, shrimp, and groundfish fisheries. These studies provide useful information about the reasons for the successes and failures of fisheries policies and management.

One must remember that a work such as this can only be as timely as the date of the last entry, and the very fact that the majority of these articles have been published ages them somewhat. Similarly, it is only as comprehensive as the range of articles included; undoubtedly there are more articles that could have been incorporated. New methodologies and new data will always become available; however, until such new methods are constructed and disseminated, we believe that the studies in this bibliography provide useful information and helpful examples. In a more general sense they also demonstrate the types of work that can--or could--be done given the appropriate information and data, thus providing insights for designing new research and management strategies. Furthermore, by noting where such works are published enables the interested reader can keep current by keeping track of new issues. (Table 2)

Table 2

Source of Article	Category of Article (from Table 1)									
	A	B	C	D	E	F	G	H	I	Sum
The American Economic Review		1								1
American Journal of Agricultural Economics	5	1	5	1	3	1				16
American Journal of Economics and Sociology			1							1
Atlantic Economic Journal					1					1
Australian Bureau of Agricultural and Resource Economics		1	1							2
Australian Journal of Agricultural Economics			2							2
The Bell Journal of Economics		1								1
California Sea Grant								1		1
Canadian Journal of Agricultural Economics	1				3	1				5
Canadian Journal of Economics	2	3	1							6
Canadian Journal of Fisheries and Aquatic Sciences	8	3	4	3	1					19
Canadian Public Policy			1		1				1	3
Coastal Zone Management Journal								1		1
Cornell University, Working Papers in Ag. Economics	1									1
Deviant Behavior									1	1
East-West Center Press					1					1
Economic Inquiry			1							1
Environmental Management			1							1
Environmental Science and Technology			1							1
FAO	2		1							3
Fishery Bulletin				2	3					5
Fishery Economics Research Unit Occasional Papers Series			1							1
Fisheries Management Foundation & Fisheries Research Institute			1							1
Fisheries Research		1								1
Florida Sea Grant								1		1
Geoforum			1							1

Source of Article	Category of Article (from Table 1)									
	A	B	C	D	E	F	G	H	I	Sum
Human Organization									3	3
Institute of Fisheries Economics	1									1
International Economic Review		1								1
Journal of Agricultural Economics	1									1
Journal of Business Administration									1	1
Journal of Contemporary Business						1				1
Journal of Econometrics				2						2
Journal of Environmental Economics and Management	5	3	4	2		1	2			17
Journal of the Fisheries Research Board of Canada	2	3								5
Journal of Law and Economics			1							1
Journal of Institutional and Theoretical Economics			1							1
Journal of Political Economy	1		1		1					3
Journal of Shellfish Research							1			1
Land Economics		3	7	1	1	2	1	1		16
Marine Fisheries Review			2					1	1	4
Marine Policy		1	8	1	1				2	13
Marine Resource Economics	5	5	18	4	2	1	5			40
Mathematical Biosciences	1									1
Michigan Sea Grant									1	1
National Marine Fisheries Service	2		4		1	1				8
Natural Resource Modeling		1	1							2
NOAA Technical Memorandum	2								1	3
North American Journal of Fisheries Management	2	1	5	2	1		3		1	15
Northeastern Journal of Agricultural and Resource Economics					1					1
Ocean Development and International Law			1		1					2
Ocean Management			3							3
Ocean & Shoreline Management	1						1			2
Operations Research and Management in Fishing			1							1

Source of Article	Category of Article (from Table 1)									
	A	B	C	D	E	F	G	H	I	Sum
Policy Sciences									1	1
Public Choice			1							1
Rand Journal of Economics				1						1
Research in Economic History			1							1
Resources and Energy		1								1
Resources for the Future								1		1
South Australian Department of Agriculture and Fisheries			1							1
Southern Economic Journal	1			1						2
Southern Journal of Agricultural Economics					2					2
Southern Methodist University					1					1
Texas A & M University Sea Grant Program					1					1
Transactions of the American Fisheries Society			2			2			1	5
The Chr. Michelsen Institute	2									2
University of Alaska Sea Grant					2					2
University of California Giannini Foundation					1					1
University of Hawaii Sea Grant					1					1
University of Maryland					1	1				2
University of Minnesota	1									1
UNC Sea Grant College Publication			1		1					2
University of Rhode Island, Marine Technical Report								1		1
University of Stirling (Scotland) Discussion Paper			1							1
Virginia Sea Grant						1				1
Water Resources Research						1				1
Weltwirtschaftliches Archiv	1									1
Western Journal of Agricultural Economics					1					1
Work and Occupations									1	1

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Empirical Bioeconomic Studies

The term bioeconomic study can be used to describe a very broad set of topics related to fisheries biology, fisheries economics, and fisheries management. What distinguishes a bioeconomic study from others, however, is the joint utilization of economic and biological theory *and* data. The goal is to better understand the feedback and implications of changes in one arena on the others. In cases presented here, the models consider the effects of various anthropogenic and environmental conditions or situations in an empirical fashion; the next section of the bibliography provides articles with models that cover these issues in a theoretical manner.

The studies here may be grouped by the general categories they address. Both open and restricted access situations are covered, and these are dealt with from both static and dynamic perspectives. In those circumstance where authors have looked beyond the basic open access situation, the articles look at the effects of moving away from open access as well as the different management strategies that can be used to move toward optimal utilization.

The studies that do examine open access situations include those that look at general open access equilibrium models--and such issues as the effects that population dynamics and the population structure's peculiarities can have on the models. Others take these modified models and apply additional twists to the basic scenario. For example, some of the studies move beyond the single stock of a single age scenario to incorporate biological twists such as the effects of different age classes, density dependent growth, biologically interdependent species, more than one species in the fishery, and even changes in stock abundance. Other studies have looked less at potential *biological* modifications to the basic open access bioeconomic model and instead have focused on *anthropogenic* factors that can affect the results of the basic models. This category of studies includes those that examine the effects of changing prices, of technologically independent fleets, of multiple commercial fleets, of commercial and recreational fleets, and/or of sequential fisheries. All of these variations exist in the real world--as evidenced by these empirical studies, and they all serve to illustrate new and slightly different conditions under which to examine the workings of the basic open access model.

The category of studies that focus beyond the open access scenario and that look at the effects of different strategies for moving away from open access towards optimal utilization illustrate

the variety of scenarios to which the phrase "optimal utilization" can be applied. There are articles that deal with the optimization of such things as a fishery's timing (season), its value in terms of its net present value or net consumer surplus, its regulation, the level of effort applied in it, the fleet size, and the rent derived from it. Optimal timing, for instance, is shown to differ for annual and for flash fisheries, as it does for fisheries in which one or in which several species are harvested. This category also include articles that address the welfare effects of different optimization strategies--including those that result in privatization or at least the definition of property rights within the fishery. Welfare effects are also examined using game theory for the different cases of a single stock, a transboundary stock, and multiple species fisheries. Additionally, there are articles that identify the effects of a variety of policy variables--man made or induced and natural--on the optimal, defined property rights scenario.

The fisheries represented in this section include transboundary, sedentary, sequential, migratory, pelagic and demersal stocks. A partial list of the species studied includes crab, cod, halibut, haddock, harp seals, salmon, crawfish, whiting, hard clam, alewife, lake trout, lake whitefish, herring, capelin, tuna, prawn, shrimp, mackerel, spat, sardine, alewife, bay scallop, flounder, and lobster.

Citation: Allen, P. M., and J. M. McGlade 1986 "Dynamics of Discovery and Exploitation: The Case of the Scotian Shelf Groundfish Fisheries" Canadian Journal of Fisheries and Aquatic Sciences 43:1187-1200.

Fishery: Groundfish, Canada, Scotian shelf

Management Issue: Consideration of actors/fishers in fishery systems

Technique: Dynamic modeling

Summary: This paper begins with a section describing the bases and shortcomings of models using the logistic equation and the Volterra-Lotka equation for fisheries management. Given the need to incorporate fluctuating parameters of complex systems in order to develop realistic models, an alternative set of models, partly based on the Volterra-Lotka equations, are described. For a system (such as the Nova Scotia fishery) that generally would go to a stable stationary state, the authors use a dynamic, multispecies, multi-fleet spatial model and find that human responses to random changes in a fishery's recruitment can amplify, not dampen, Volterra-Lotka type oscillations.

In applying this dynamic, multispecies, multi-fleet spatial model to the Nova Scotian groundfish fisheries, the concepts of "discovery" and "exploitation" are discussed with the identification of two types of fishermen: "stochasts" and "cartesians," who are characterized respectively as hunters/high risk takers and followers/low risk takers. The significant results presented here include the pertinence of model calibration, the relationship between the abundance and the location of highly sought species, the critical nature of changing information (real, coded, and misinformation) and the real world relevance of models that account for flexibility and creativity between a variety of actors and operators within a system.

Keywords: Logistic, Volterra-Lotka, population dynamics, systems, cod, haddock, pollock, Nova Scotia, Canada, groundfish

Citation: Bell, Frederick W. 1972 "Technological Externalities and Common-Property Resources: An Empirical Study of the U.S. Northern Lobster Fishery" Journal of Political Economy 148-158.

Fishery: American lobster, U.S.

Management Issue: Effects of effort on production

Technique: Econometrics

Summary: This paper provides empirical estimates of the losses in economic efficiency in the northern U.S. lobster fishery that are the result of its being a common property resource. After estimating a production function and the industry's marginal and average cost functions, there is a discussion of the level of effort (and, hence, production) under open and optimal economic management. The results show the economically efficient level of effort would be obtained with approximately half the current level of effort; however, the author cautions that the application of the criterion of economic efficiency should be tempered with socio-economic considerations such as employment.

Keywords: Externality, economic efficiency, common property resources, American lobster, U.S.

Citation: Bell, Frederick W. 1986 "Mitigating the Tragedy of the Commons" Southern Economic Journal 52:653-664.

Fishery: Crawfish, U.S., Louisiana

Management Issue: Social welfare changes of privatization

Technique: Econometrics, demand analysis

Summary: This paper quantifies the gains in social welfare that occur with the privatization of a public resource such as (craw)fish. The case studied here is the emergence of the private, pond-reared crawfish industry as an alternative for the harvest of wild Louisiana crawfish.

The study uses 1978 data from the wild and pond-reared sectors to estimate demand, the wild crawfish biological yield function, as well as the costs of supplying each type. Although the increases in the supply brought about by increased production of privately reared crawfish production make harvesting the wild fishery unprofitable, the gains accruing in the privately reared sector more than make up for this loss. The authors estimates that private crawfish farming reduces welfare losses by 76 percent.

Keywords: Commons, competition, crawfish, fish farming, rent dissipation, welfare, U.S., Louisiana

Citation: Bell, Frederick W. 1986 "Competition from Fish Farming in Influencing Rent Dissipation: The Crawfish Fishery" American Journal of Agricultural Economics 68(1):95-101.

Fishery: Crawfish, U.S.

Management Issue: Social welfare changes of privatization

Technique: Model building, regression analysis

Summary: When fish farming competes with wild commercial harvest, rent dissipation and consequently welfare losses may be reduced. Although aquaculture increases the quantity of (craw)fish supplied, pushing prices down and subsequently reducing the amount supplied by the commons, the author shows that welfare gains from fish farming will occur only when marginal cost increases faster than average cost. Using 1978 data from Louisiana pond and wild crawfishing industries, it is shown that crawfish farming reduced potential welfare loss by 78%. This is a useful example about how existing data can be used to estimate fishery revenue and cost curves. The model is made more realistic by introducing the effects of water level and water temperature.

Keywords: Fish farming, rent dissipation, crawfish, U.S.

Citation: Berkes, Fikret, and Turker Gonenc 1982 "A Mathematical Model on the Exploitation of Northern Lake Whitefish with Gill Nets" North American Journal of Fisheries Management 2:176-183.

Fishery: Lake whitefish, *Coregonus clupeaformis*, Canada, James Bay

Management Issue: Mesh size strategies

Technique: Population modeling

Summary: This paper tests and supports the hypothesis that the use of a mix of mesh sizes (76.2-127 mm) is more compatible with the natural population structure than the use of one large mesh size alone, if fishing intensity is controlled, in trying to maintain the natural population's age structure. The importance of such results is, in part, based on the assumption that the existence of many year classes is a reflection of the species' adaptation to environmental fluctuations and thus is a useful characteristic to nurture in order to avoid stock collapse, especially in previously unexploited fisheries such as these of arctic and subarctic Canadian lakes.

The numerical results generated here are the product of a three-step process. First a hypothetical lake whitefish (*Coregonus clupeaformis*) population's growth and mortality curves are combined to yield a length-frequency distribution. Then a gill-net selectivity model is used to calculate the number of fish caught by different mesh sizes at different exploitation rates. Finally these numbers of harvested fish are subtracted from the fish caught from the unexploited population. Some of the population parameter assumptions as well as the choice of gill-net selectivity curves were verified against James Bay area field data. Because the authors show that a lower harvest rate over more year classes may be preferred to highly intensive effort directed at older and larger fish, a switch to a management regime where multiple gill-net sizes are employed and where the focus is on regulating effort may be preferable to continuing to regulate by limiting mesh size.

Keywords: Population structure, mesh size, gill net, selectivity, lake whitefish, *Coregonus clupeaformis*, Canada, James Bay

Citation: Bjorndal, Trond and Jon M. Conrad 1987a "Capital Dynamics in the North Sea Herring" Marine Resource Economics 4(1)63-74.

Fishery: North Sea herring

Management Issue: Entry and exit of vessels

Technique: Econometrics

Summary: The rate at which vessels enter a fishery, both in the short and long-run, is a very important aspect of open-access and optimal utilization of fisheries. While there has been much theoretical discussion of this point, there has been very little empirical work. This paper presents an empirical analysis of boat dynamics in the North Sea herring fishery using a discrete time model which is lagged to reflect adjustment time to changes in profits. The results indicate that vessel entry and exit depend primarily on current period profits but that the opportunity cost of capital is considered. The results also indicate that sometimes the opportunity cost of capital is best formulated as an opportunity cost in terms of returns in alternative fisheries and that construction time was considered to be only minimally important. Contrary to accepted thinking, the elasticity of entry with respect to positive profits was not significantly different than the elasticity of exit with respect to negative profits.

Keywords: Entry, exit, North Sea, herring

Citation: Bjorndal, Trond and Jon M. Conrad 1987b "The Dynamics of an Open Access Fishery" Canadian Journal of Economics 20(2):74-85.

Fishery: North Sea herring, Norway

Management Issue: Open access utilization

Technique: Econometrics

Summary: The nature of open access utilization is important for fisheries management because it represents the status quo from which management actions must be compared. Knowledge about a fishery's open access equilibrium (if one exists) and the path to that equilibrium is of considerable significance, particularly for avoiding stock extinction. This paper presents a discrete time non-linear model for an open access fishery and applies it to the North Sea herring fishery. Alternative production functions for the Norwegian purse seine fleet exploiting this fishery are estimated. Bioeconomic equilibrium and the corresponding approach dynamics are demonstrated when prices and costs are changing. Because of herring's schooling behavior, even when the stock is severely depleted it can be caught relatively profitably, and this is translated in the model to the weak yield-stock elasticities estimated at 0.56 and 0.61. There is just very little impetus for rapid exit of vessels from the fishery--even after the stock has begun to decline. It is likely that the closure of the fishery in 1977 saved it from severe overfishing.

Keywords: Open access, extinction, Norway, North Sea herring, production

Citation: Bjorndal, Trond 1988 "The Optimal Management of North Sea Herring" Journal of Environmental Economics and Management 15(1):9-29.

Fishery: North Sea herring

Management Issue: Dynamic optimal economic yield

Technique: Dynamic modeling

Summary: The motivation for this study lies in determining the optimal time path to the optimal stock size for the North Sea herring, a fishery which is currently recovering from the effects of overfishing that occurred during the 1960s and the 1970s. To do this, a discrete time dynamic bioeconomic model is developed for the North Sea herring. This model can calculate the point of maximization of discounted net revenues subject to changes in stock size. The population dynamics are described by a delay-difference equation and comparisons are made between Ricker, Beverton-Holt, Cushing, and quadratic forms. Natural growth and recruitment are related to stock size, although recruitment takes place with a time lag.

Because harvesting costs for herring are shown to not be density dependent, costs will not affect the maximization problem. This, combined with a fixed price of output, mean that the optimal path is a periodic or pulse approach, although a somewhat more constant pattern of harvesting will not cause the net present value of the fishery to fall by more than a few percent. The size of the optimal spawning stock is fairly sensitive to discount rate changes; the harvest rate is much less sensitive. The stock's schooling behavior is such that, given the constant cost of fish, open-access stock extinction is possible.

Keywords: Optimal economic yield, dynamic, North Sea, herring, Ricker, Cushing, Beverton-Holt, Norway

Citation: Botsford, Louis W., Richard D. Methot, Jr., and Warren E. Johnston 1983 "Effort Dynamics of the Northern California Dungeness Crab (*Cancer magister*) Fishery" Canadian Journal of Fisheries and Aquatic Sciences 40:337-346.

Fishery: Dungeness crab, *Cancer magister*, U.S., California

Management Issue: Dynamic response of fishing effort to abundance

Technique: Theoretical modeling

Summary: Both the lags in market expansion/contraction and fishery participants' entry/exit result in discrepancies between stock abundance and harvest levels. Such dynamics of fishing effort responses to fishery cycles are very relevant to the California Dungeness crab fishery, where the lagged response--despite having decreased over the last 30 years--can potentially cause such catch cycles. This paper addresses this issue of the impact of lagged response on catch cycles and shows how neither a predator-prey mechanism (with man as the predator) nor a price-dependent escapement mechanism (with price dependent on past catch) causes these cycles. An interesting result is that time-varying effort does seem to have a substantial effect on the resulting catch record and population dynamics, so any density-dependent recruitment mechanism in this population (which has been proposed) may be exacerbated by such a lagged response. Because previous estimates do not account for this lengthening effect, estimates of the expected period of cycles are probably low. If one could regulate the fishery in such a way as to remove or at least minimize this response, it could potentially stabilize the fishery.

Keywords: Effort, Dungeness crab, *Cancer magister*, harvest rate, predator, prey, price, cycle

Citation: Butlin, John A., and Judith M. Tomkins 1975 "A Theoretical and Empirical Approach to Fisheries Economics" Journal of Agricultural Economics 26(1):105-125.

Fishery: Manx herring, U.K.

Management Issue: Optimal utilization

Technique: Econometrics, bionomic model

Summary: This paper develops and then applies a bioeconomic fisheries model of the open access over-exploitation that can theoretically and did actually occur in the Manx herring fishery. As a solution to the externalities associated with open access, the author suggests that the fishery be appropriated (by the government), thereby establishing rights to its use. This article was written at a time when there was much debate regarding the traditional freedom of the seas, and can thus be perceived as a call for the extension of property rights and jurisdiction over the seas as well as a clearly described fisheries model and case study.

Keywords: Growth, sustainable yield, fishing effort, economic efficiency, Manx herring, U.K.

Citation: Campbell, H. F. 1989 "Resource Rent Rivalry in the Western Pacific Tuna Fishery: Cooperative and Non-Cooperative Solutions" Ocean & Shoreline Management 12:179-187.

Fishery: Tuna, Western Pacific, South Pacific Forum

Management Issue: Resource rent rivalry

Technique: Theoretical, game theory

Summary: Coastal states such as those of the South Pacific Forum have a rather monopolistic control over their fishing resources and the right to harvest them. On the other hand, the distant water fishing nations tend to have a rather monopsonistic power over fish products from these fisheries. These two groups can either wield their respective power in a cooperative or in a non-cooperative manner, and because the economic benefits associated with each are different, it is useful to have an idea of how behavior will affect these benefits. This paper takes a game theory look--using a Nash-Cournot model--as modeling behavior between coastal states and foreign fishing nations wishing to exploit the stocks in the coastal states' Exclusive Economics Zones (EEZs). The benefits of cooperative behavior are shown to be larger than those of non-cooperative behavior.

Keywords: Monopsony, monopoly, Cournot-Nash, tuna, Western Pacific, South Pacific Forum, Japan, U.S., behavior

Citation: Charles, A. T., and W. J. Reed 1985 "A Bioeconomic Analysis of Sequential Fisheries: Competition, Coexistence, and Optimal Harvest Allocation Between Inshore and Offshore Fleets" Canadian Journal Fisheries Aquatic Sciences 42(5):952-962.

Fishery: General, Canada

Management Issue: Optimal exploitation of sequential fisheries

Technique: Bioeconomic optimization

Summary: Just as one can consider optimal fleet mix and capacity for a single stock, this paper looks at the optimal harvest of a sequential fishery in which harvest by one fleet does not necessarily occur at the same time or in the same location as does harvest by the other fleet. A bioeconomic model is used to determine the optimal allocation of harvest between the "inshore" and the "offshore" fleet, first for the case of chinook salmon (*Oncorhynchus tshawytscha*) in British Columbia, Canada and then (as a special case of the model) to pink salmon (*Oncorhynchus gorbuscha*) and British Columbia Pacific herring (*Clupea harengus pallasi*). Coexisting fleets, inshore only, and offshore only cases for optimal escapement are analyzed to determine the socially optimal policy for maximizing the present value of total rent. Price and cost ratios as well as parameters related to the stock's age structure strongly influence whether or not two fleets should coexist. Finally, the authors discuss the use of landings taxes on the respective inshore and offshore fleets as well as the use of catch quotas and catch monitoring. The authors suggest that the model is generally applicable to a fishery such as the Newfoundland northern cod (*Gaddus morhua*) fishery.

Keywords: Bioeconomic equilibrium, sequential fishery, dynamic optimization, British Columbia, Canada, Pacific herring, pink salmon, chinook salmon

Citation: Clark, Colin W., and Geoffrey P. Kirkwood 1979 "Bioeconomic Model of the Gulf of Carpentaria Prawn Fishery" Journal of the Fisheries Research Board of Canada 36(11):1304-1312.

Fishery: Prawn, Australia, Northern Australia, Gulf of Carpentaria

Management Issue: Optimal fleet size and capacity

Technique: Bioeconomic modeling

Summary: This paper describes a bioeconomic model for determining the optimal number of vessels in and deployment of the Gulf of Carpentaria prawn fishery fleet, a fleet composed of primarily two vessel types that both exploit several types of prawns. Although data gaps caused the numerical model to be somewhat simplified, the estimates generated are helpful for determining targets for improving the commercial fishery's economic performance.

The case of optimal utilization by a single fleet is discussed first, with the issue of allocation between two fleets subsequently covered. The authors conclude that while the optimal fleet consists of only one type of vessel, no preferred vessel type emerges. Regardless, the optimal number in each vessel class can be estimated.

Keywords: Limited entry, prawn, Australia, bioeconomic modeling, Gulf of Carpentaria, Northern Australia

Citation: Conrad, Jon M. 1982 "Management of a Multiple Cohort Fishery: The Hard Clam in Great South Bay" American Journal of Agricultural Economics 64(3):463-474.

Fishery: Hard clam, *Mercenaria mercenaria*, U.S., New York, Great South Bay

Management Issue: Dynamic optimal utilization

Technique: Regression, Leslie matrix

Summary: For cases where the population's age structure directs a stock's recruitment and fecundity, logistic growth equations may not be adequate, nor may the density-dependent and -independent models that do not include cost dependencies in their yield maximization sections. This paper develops a reasonably general multiple cohort model for the case when spawning and first year growth are density independent but when subsequent growth may be density dependent. Given these spawning and recruitment constraints, the conditions are derived for optimal harvest and age structure. This is based on a discrete time control program which maximizes the NPV of net revenue. The model is applied to the hard clam resource of Great South Bay, Long Island, New York. The steady state optimum calls for exclusive harvesting of the younger and more valuable individuals, leaving the older and less valuable cohorts for a breeding stock. The determination of which cohorts will make up the optimal harvest as well as the determination of the transition to the optimal harvest and age structure are sensitive to output prices. A brief discussion of using either a system of taxes or transferable quotas is included.

This is an interesting first attempt to apply real world numbers to a very complex bioeconomic problem. Comments have been published which point out computational errors in the analysis, and they should be referenced before trying to use this model as a base for other work.

Hsiao, Yu-Mong 1985 "Management of a Multiple Cohort Fishery: Comment" American Journal of Agricultural Economics 67:674-675.

Conrad, Jon M. 1985 "Management of a Multiple Cohort Fishery: Reply" American Journal of Agricultural Economics 67:676-678.

Keywords: Multiple cohort, hard clam, *Mercenaria mercenaria*, U.S., New York, Great South Bay, density

Citation: Conrad, Jon M. 1990 "A Bioeconomic Model of the Pacific Whiting" Cornell University, Working Papers in Agricultural Economics 90-14. 42 pages

Fishery: Pacific whiting, *Merluccius productus*, hake, U.S.

Management Issue: Adaptive management

Technique: Bioeconomic modeling

Summary: The highly migratory Pacific whiting (*Merluccius productus*) are found over the continental shelf and slope off the west coast of North America. Spawning occurs off southern California and northern Mexico in January and a spring-summer migration of older fish moves them north towards central Vancouver Island. The level of recruitment appears to be independent of the size of the spawning population and varies greatly from year to year, although stronger year classes can support the commercial harvest when recruitment is low.

The author uses a bioeconomic model in which recruitment is independent to capture this aspect of the fishery. Production functions are estimated from data on U.S. catch, average annual biomass and the number of vessels in the U.S. fleet. Because of the problematic nature of solving the stochastic maximization problem of maximizing the expected value of industry profit, an alternative, certainty-equivalent problem is presented and solved. This gives both solution values for the stochastic equilibrium as well as an approximately-optimal rule that sets allowable catch based on an estimate of current-year biomass.

The yearly potential for large fleet size and total catch changes has prompted the author to characterize the Pacific whiting fishery as one to be considered on an opportunistic basis. When the price, biomass, fishing costs, vessel productivity and discount rate are "right," there can exist a short run optimal level of fishing. A copy of the BASIC program used for calculating the stochastic equilibrium as well as for adaptively managing given current biomass estimates is included.

Keywords: Bioeconomics, Pacific whiting, BASIC, adaptive management, Pacific whiting, *Merluccius productus*, hake, U.S.

Citation: Conrad, Jon M. and Richard Adu-Asamoah 1986 "Single and Multispecies Systems: The Case of Tuna in the Eastern Tropical Atlantic" Journal of Environmental Economics and Management 13:50-68.

Fishery: Tuna, yellowfin, *Thunnus albacares*, skipjack, *Katswonus pelamis*, bigeye, *Thunnus obesus*, Eastern Tropical Atlantic

Management Issue: Optimal utilization, biological interdependence

Technique: Regression, dynamic optimization

Summary: Two models are developed to examine the bioeconomics of the Eastern Tropical Atlantic (ETA) commercial fishery on yellowfin, skipjack, and bigeye tuna. In the first model the species are assumed to be biologically and technologically independent, while in the second yellowfin and skipjack are assumed to be ecologically related and to be harvested jointly but independently of bigeye. Landings, effort, cost, and revenue data from 1967 to 1980 are used to estimate the bioeconomic parameters for the model where all species are independent. Strong marginal stock effects are identified which result in optimal stock levels in excess of those associated with MSY. A similar analysis is performed on the interdependent model based on parameters from the single species models and plausible values for interaction and joint production coefficients. When interspecific competitors are subject to harvesting, the relative abundance of individual species can change significantly. In open-access a reduction of the yellowfin stock caused the skipjack stock to increase above its pristine level even when it was jointly harvested with yellowfin. In the multispecies optimum, the optimal level of purse seine effort is half of that called for in the independent models. It follows that it is difficult to extrapolate policy options for multispecies fisheries from single species models, particularly given the potential for coastal nations to engage in game theoretic behavior in cases like this one of transboundary stocks.

Keywords: Multispecies, optimal utilization, Gausian interspecific competition, tuna, yellowfin, *Thunnus albacares*, skipjack, *Katswonus pelamis*, bigeye, *Thunnus obesus*, Eastern Tropical Atlantic

Citation: Conrad, Jon and Trond Bjørndal 1989 "A Bioeconomic Model of the Harp Seal in the Northwest Atlantic" Institute of Fisheries Economics Discussion Paper Series No. 2.

Fishery: Harp seal, *Phoca groenlandica*, Northwest Atlantic

Management Issue: Maximization of net revenues (producer surplus)

Technique: Dynamic optimization

Summary: As populations of (somehow) protected species have grown, the issue of whether or not such populations should be protected or managed has resurfaced. If, in fact, such a population is to be managed, another question soon arises: on what basis should management occur? The authors use the criterion of maximizing the net present value of revenues from the hunt in their discussion of the harp seal (*Phoca groenlandica*). After a review of the biology and economics of harp seals, they construct a population dynamics model for pup production and seals one year of age or older. The explicit solutions for the long-run, zero-harvest, equilibrium are derived, a sufficient condition for stability is identified, and the model is simulated for the period 1952-1980. Such economic factors as pelt prices, marginal cost and discounting are included in the model. The authors then address the dynamic optimization problem of maximizing the present value of net revenues (producer surplus). Depending on what factors effect net revenue, explicit expressions for the optimal stock and harvest of pups can be derived. Using conditions that could have been plausible in 1976, the authors estimated the annual net revenues to range from $1,288,959 to $1,381,257 for the optimally managed fishery.

The paper concludes with a reminder that the value of the seal hunt may one day warrant harvest/management, particularly if the cultural and economic value of the seals and the fish they eat change.

Keywords: Harp seal, *Phoca groenlandica*, population dynamics, bioeconomics, producer surplus, Northwest Atlantic

Citation: Crutchfield, Stephen R., and John M. Gates 1985 "The Impact of Extended Fishery Jurisdiction on the New England Otter Trawl Fleet" Marine Resource Economics 2(2):153-173.

Fishery: New England trawl fishery, U.S.

Management Issue: Economic gains from open-access fishing

Technique: Simulation

Summary: This paper examines post-MFCMA trends for the New England otter trawl fleet for the years from 1977 to 1982 to determine the gains from excluding foreigners. The traditional analyses of exploited fisheries show that, in the absence of controls on entry into the domestic fishery, exclusion of foreign fleets will only yield temporary economic rents which will eventually be dissipated by additional domestic fishing effort. A major problem in assessing economic performance in a fishery is the lack of cost data. Even ignoring the problem of estimating the opportunity cost of labor, it is very difficult to estimate operating and capital costs. This study introduces a simulation model which incorporates regression coefficients based on survey data to estimate harvesting costs. The estimates are used with reported catch and revenue statistics and an estimate of labor opportunity costs to derive factor payments to New England trawlers. The model was used to calculate revenues and costs for representative vessels from four major New England ports from 1976 to 1982, and factor rents to owners, captains, and crew were estimated. For three of the four ports considered, the estimated real economic surplus for the typical vessel peaked in 1977-1978 and declined dramatically through 1982. While this finding indicates that some of the potential rents from the fishery may have been dissipated by a substantial increase in fleet size, other indicators show that the decline in economic surplus may have been due to costs raising faster than prices over the period. This is a very useful procedure because the problems of identifying production costs in fisheries cannot be underestimated. It would be very interesting to see an update of this study to compare the returns to the fishery since 1982 to those is this paper.

Keywords: Open access utilization, New England, U.S.

Citation: Dudley, Norman, and Geoffrey Waugh 1980 "Exploitation of a Single-Cohort Fishery Under Risk: A Simulation-Optimization Approach" Journal of Environmental Economics and Management 7:234-255.

Fishery: Prawn, Australia, Exmouth Gulf

Management Issue: Optimal capital investment

Technique: Dynamic programming model

Summary: This paper uses a single-cohort population as the basis for developing a model to analyze both short- and long-run capital investment levels in a fishery. These two cases are examined under the conditions of open access and socially optimal management (where socially optimal management results in the maximizing the net present value of revenues). First, the general dynamic computer programming model is presented and then it is compared with a simpler, analytical approach. The authors then begin to factor in randomness and examine the effects this has for ten different scenarios. For varying levels of investment and risk, the authors find that the timing of the fishery's season is more critical than selecting biomass targets. Finally, these results are compared with the socially optimal management scenario.

Keywords: Prawn, Exmouth Gulf, Australia, investment, capital

Citation: Eales, James, and James E. Wilen 1986 "An Examination of Fishing Location Choice in the Pink Shrimp Fishery" Marine Resource Economics 2(4):331-351.

Fishery: Pacific shrimp, U.S., California

Management Issue: Vessel short-run decision making

Technique: Multiple-choice logit

Summary: This paper presents a model which can explain daily fishing location choices of individual fishermen. The model is applied to the pink shrimp (*Pandalus jordani*) fleet fishing off the coast of northern California. Data were gathered for 17 commercial vessels making 3000 net sets over a season. A simple multiple-choice logit model was used to examine whether recent information on success in various regions aids in explaining location choice. The model assumes that fishermen start each day with an updated estimate of mean catches per set in each of eight areas and uses that data to calculate expected profit for a trip from the existing location to the potential sites. The probability that one site will be chosen is assumed to be positively related to expected profits. Results suggest that fishermen do account for economic factors in a manner consistent with economic theories of choice. The fact that fishermen are responsive on a day to day basis is very important for management policy. It shows that in addition to the efficiency losses that may be generated by too many boats, rents can also be dissipated by excessive moving of vessels to hot spots in the short run. The problem may even be more complicated because individual fishermen may also consider what other fishermen will do with short term biological information, and so their choice will depend upon the expected catch level of an area and the expected number of other boats that will be fishing there. Understanding this type of behavior is important in estimated net values generated by open-access as well as regulated fisheries.

Keywords: Switching, shrimp, U.S., California

Citation: Easley, J. E., Jr. 1982 "Property Rights in Shellfish Relay: Managing Fisheries for Higher Economic Returns" North American Journal of Fisheries Management 4:343-350.

Fishery: Shellfish, U.S., North Carolina

Management Issue: Economic gains from relaying shellfish/private ownership

Technique: Discussion with some numbers

Summary: This paper describes the North Carolina management of depuration--moving shellfish from polluted to clean water to purge them and prepare them for subsequent harvesting--and the economic gains associated with the ownership of the site having the clean water.

If the shellfish are moved to privately owned or leased bottom, the returns to the fishery are considerably higher than if they are moved to public bottoms. The case study used here provides insights about the magnitude of the increased return, about factors influencing the magnitude of the return, and about the implications of this on management.

Keywords: Property rights, shellfish, privatization, U.S., North Carolina, economic gains, relay

Citation: Edwards, Steven F., and Steven Murawski 1991 "Maximum Economic Yield from the Offshore Multispecies Groundfish Fishery of New England" National Marine Fisheries Service, Draft.

Fishery: Groundfish, U.S., New England

Management Issue: Potential economic yield

Technique: Bioeconomic modeling

Summary: This paper describes two bioeconomic models of the offshore New England groundfish fishery in the Gulf of Maine and on the Georges Bank in order to estimate the fishery's maximum economic yield. By doing so, the authors are drawing attention to the fact that the fishery is a public resource that, at least currently, is only being managed for the benefit of its participants and not for the benefit of society at large.

United States and Canadian data from 1976-1989 are used for estimating both the single-species and the multispecies models, although only three species' parameter estimates are provided for the multispecies model. The authors report the potential to increase the present value of the fishery by a few billion dollars; that is, if the stock size were increased four-fold, effort halved, and harvest increases by approximately 50%. The paper also discusses the pros and cons of several types of limited access regimes.

Keywords: Atlantic cod, *Gadus morhua*, haddock, *Melanogrammus aeglefinus*, yellowtail flounder, *Limanda ferruginea*, U.S., New England, individual quota, limited entry

Citation: Emerson, William and James Anderson 1989 "A Spatial Allocation Model for the New England Fisheries" Marine Resource Economics 6(2):123-144

Fishery: Cod, haddock, flounder, U.S., New England

Management Issue: Economic effects of changes in fishery conditions

Technique: Nonlinear mathematical programming

Summary: A deterministic nonlinear programming model of the New England groundfishery which maximizes net consumer surplus to determine the competitive equilibrium spatial allocation of harvesting, landing, processing, pricing, and consumption patterns among five regions was developed. The model was able to predict with reasonable accuracy the effects of the changing of the U.S./Canada maritime boundary and of the opening of the fish landing port in Brooklyn. Although the construction of the model ignored many supply side considerations, the results indicate that this may be a promising approach. Models such as this can estimate the effects of regulations, changes in market conditions, and perhaps of changes in stock conditions.

Keywords: Multi-species, markets, cod, haddock, flounder, U.S., New England

Citation: Everitt, Robert R., Nicholas C. Sonntag, Martin L. Puterman, and Patrick Whalen 1978 "A Mathematical Programming Model for the Management of a Renewable Resource System: The Kemano II Development Project" Journal of the Fisheries Research Board of Canada 35:235-246.

Fishery: Salmon, Canada, British Columbia

Management Issue: Impacts of regional development

Technique: Mathematical linear programming

Summary: This paper develops and applies a mathematical programming model that can help managers in choosing optimal levels of a variety of policy variables. The advantage of this sort of model (compared to a simulation model, for example, that is used for ecological modeling) is that it can maximize more than one objective.

The case study presented here looks at the impacts of a proposed hydroelectric project, Kemano II, on the northwestern British Columbia salmon fisheries. Such natural and man-made parameters as reservoir size, run-off effects, dams, and diversions are all components of the model. This enables one to derive insights on how many different management policies--directed at the fishery or at other activities--may affect the fishery.

Keywords: Mathematical model, fishery management, Pacific salmon, sensitivity analysis, Canada, British Columbia, runoff

Citation: Flåm, Sjur D., and S. Storoy 1982 "Capacity Reduction on Norwegian Industrial Fisheries" Canadian Journal of Fisheries and Aquatic Sciences 39(9):1314-1317.

Fishery: General, Norway

Management Issue: Optimal industrial structure

Technique: Linear programming

Summary: Because there are some 450 Norwegian vessels that exploit the North Sea pelagic fisheries, this paper focuses on concerns about over-capitalization and what the profitable fleet structure may be. The authors present a one-year horizon or view of what the minimum catch capacity could be given specific harvest quotas. The linear programming model that is used reflects the multi-boat-type, multi-species and multi-factory character of the fishery. The model is subjected not only to catch constraints, but also to fishing, transportation and processing capacity constraints. Although the model is linear and does not consider stochastic effects, it does provide short term optimal revenue estimates that can be used for deciding on longer-term harvesting strategies that maximize the net present value of the fishery.

Keywords: Linear programming, capacity, Norway, pelagic, fleet structure, capelin, sprat, whiting, mackerel

Citation: Gallastegui, Carmen 1983 "An Economic Analysis of Sardine Fishing the Gulf of Valencia (Spain)" Journal of Environmental Economics and Management 10:138-150.

Fishery: Sardine, Spain, Gulf of Valencia

Management Issue: Comparison of open-access and optimal utilization

Technique: Regression, Spence

Summary: Using data describing previous fishery exploitation, relevant biological and economic relationships are estimated and then used to estimate optimum levels of catch, effort, and stock size for the Spanish sardine fishery in the Gulf of Valencia. Because stock size data were not available, the author used a method developed by Spence where stock size may be inferred from the relationship between catch and effort over time. The results are quite sensitive to what parameters are used in the model. A comparison of open-access and optimal utilization show that effort should be reduced by about 50%. This reduction, although it would reduce catch, would significantly increase the fishery's annual net value. At a higher stock size, the opportunity cost of catching fish declines, but the author's results are not sensitive to the rate of discount. The shadow value of a unit of stock in place is estimated for the resource when at the optimal steady state solution. The author indicates that the rate of adjustment to the optimal effort and stock levels should be quite slow because of the lack of alternative employment opportunities for labor and fishing boats, in spite of the fact that the optimal path to the optimal steady state would be the most rapid one possible--closed season(s).

Keywords: Dynamic, optimal utilization, sardine, Spain, Gulf of Valencia

Citation: Gates, John M., and V. J. Norton 1973 "A Steady State Bio-Economic Model of a Fishery" National Marine Fisheries Service, File Manuscript No. 156.

Fishery: Yellowtail flounder, U.S., New England

Management Issue: Potential economic gains of rational management

Technique: Bioeconomic modeling, case study

Summary: This paper develops and estimates a biological yield function that incorporates the "crowding" externality which explicitly exists for a fixed fish stock. The approach used here is intended to improve upon some previous approaches by integrating biological and economic factors that affect the fishing industry. Both the steady state model and the comparative statics approach delineate the tremendous economic cost of allowing unrestricted entry into a common property fishery. By quantifying the potential economic gains that could be obtained if the commercial fishery management agencies--State and Federal--would establish a rational management program for yellowtail flounder, the authors have provided a strong argument for rational management.

Keywords: Bioeconomic, model, crowding, yield, yellowtail flounder, Beverton-Holt, mesh, U.S., New England

Citation: Griffin, Wade L., Ronald D. Lacewell, and John P. Nichols 1976 "Optimum Effort and Rent Distribution in the Gulf of Mexico Shrimp Fishery" American Journal of Agricultural Economics 58(November):644-652.

Fishery: Shrimp, Gulf of Mexico

Management Issue: Optimal economic harvest under a share system

Technique: Cost accounting

Summary: This paper focuses on how a traditional management scheme may result in inefficiencies and mismanagement if the costs of labor are assumed to be proportional to effort when, in fact, they are not and are instead proportional to catch. The case study used is the U.S. Gulf of Mexico shrimp fishery, and a conceptual framework is developed by the authors to consider optimal effort, catch, and rent distribution. Changing various assumptions about costs and the resulting outcomes lead the authors to call for the use of flexible management schemes.

Keywords: Common property, fisheries, rent, distribution, shrimp, Gulf of Mexico, optimal effort, share system, crew share

Citation: Hannesson, Rögnvaldur 1975 "Fishery Dynamics: A North Atlantic Cod Fishery" Canadian Journal of Economics 8(2):151-173.

Fishery: Cod, North Atlantic

Management Issue: Optimal harvest rate

Technique: Theoretical model, Beverton-Holt

Summary: This paper addresses the question of the appropriate exploitation pattern for a stock composed of multiple cohorts. Because the timing of harvest can vary from a periodic to a stationary or constant rate, effort (and its various manifestations such as fleet capacity and capital investment) can vary considerably.

The author expands from the single- to the multiple-cohort optimal harvest situation by simulating a Beverton-Holt model of a cod fishery. Costs, the discount rate, and stock size changes are considered as are the pragmatic aspects of periodic fishing. Under the assumptions of constant price, perfect foresight, and constant opportunity cost, pulse fishing is shown to yield a higher net present value of profits than would constant thinning of the stock. When these assumptions are relaxed, periodic harvest still has some advantage over a stationary rate, particularly if there are other stocks towards which the fleet could direct its effort when not harvesting cod.

Keywords: Beverton-Holt, optimal, harvest, pulse fishing, yield model, fleet size, cod, North Atlantic

Citation: Hannesson, Rögnvaldur 1988 Optimum Fishing Effort and Economic Rent: A Case Study of Cyprus. FAO Fisheries Technical Paper 299, Food and Agricultural Organization, Rome.

Fishery: Multi-species, Cyprus

Management Issue: Optimal Economic Yield

Technique: Schaefer model, case study

Summary: After discussing the reason for open-access over utilization and ways to correct for it, this study provides an excellent example of how to do basic fisheries economic analysis in a real world situation. Using an existing biological analysis which provide CPUEs on an area by area basis, the study estimates the cost of fishing effort and calculates existing economic rents. The economically optimum level of fishing effort is then estimated, and it is shown that effort must be reduced significantly in order to achieve economic efficiency. There is considerable detail on how to estimate revenues and costs using existing fisheries statistics and dockside interviews. While the basic analysis is static, it is shown that the results differ from a dynamic analysis by around 5%. It is concluded that a useful first step toward optimal management might be a license program with specifications for full and part-time fishermen backed up by a buy-back program financed by a tax on landings. Licenses were suggested because preliminary analysis showed that the size of the boat has little effect on fishing power given existing technology, and so capital stuffing is likely to be of little concern. It is stressed, however, that innovations might make a license scheme less useful and may require modifications to the system or the introduction of a different program.

Keywords: Optimal economic yield, limited entry, ITQ, licenses, buybacks, Cyprus

Citation: Hanson, Floyd B. 1987 "Bioeconomic Model of Lake Michigan Alewife (*Alosa pseudoharengus*) Fishery" Canadian Journal of Fisheries and Aquatic Sciences 44(Suppl.2):298-305.

Fishery: Alewife, *Alosa pseudoharengus*, salmonids, U.S., Lake Michigan

Management Issue: Optimal value and optimal feedback controls

Technique: Stochastic bioeconomic optimal control model

Summary: The Lake Michigan alewife (*Alosa pseudoharengus*) and salmonid fisheries are characterized in this stochastic bioeconomic model that estimates the optimal harvest rates that would maximize the fisheries' expected economic value. This integrated economic approach more closely resembles reality than would a single species model, and its results--namely, that the commercial alewife fishery provides smaller benefits than the salmonid sport fishery--support the results of other papers that take a steady state, deterministic approach.

This dynamic programming model includes salmonid-alewife interspecific competition in both the growth and interaction facets of a Beverton-Holt framework. The stochastic feedback approach is a new use of dynamic programming in that there are few models which include such a random shock component for the interacting species. The results show that the major factor affecting the alewife maximum expected economic value is salmonid recruitment, not the initial recruitment of alewives themselves, and that the stochastic shocks will reduce the fishery's value by 10-15% (although the results are relatively sensitive to the available, not always consistent, data).

Keywords: Beverton-Holt, bioeconomic, U.S., Lake Michigan, alewife, *Alosa pseudoharengus*, predator, prey, optimal value, salmonid

Citation: Henderson, J. V. and M. Tugwell 1979 "Exploitation of the Lobster Fishery: Some Empirical Results" Journal of Environmental Economics and Management 6:287-296.

Fishery: Lobster, Canada

Management Issue: Dynamic optimal economic yield

Technique: Regression analysis, Schaefer growth

Summary: This paper analyzes compares the outcomes of optimal and free market utilization fishery models of two Canadian lobster fisheries. A production function and a growth curve are estimated, and an analysis of the results show that the welfare losses from non-regulation are about 20 and 30% of the value of the open-access catch. The results show that the difference between the static and dynamic interior solutions are quite small. The authors note that the proper speed of adjustment from open-access to the optimal point--which could involve a reduction in effort of up to 75%--depends upon the alternative uses of labor and fishing gear.

Keywords: Dynamic, comparison of open-access and optimal yields, lobster, Canada

Citation: Hilborn, Ray 1985 "Fleet Dynamics and Individual Variation: Why Some People Catch More Fish than Others" Canadian Journal of Fisheries and Aquatic Sciences 42:2-13.

Fishery: Salmon, Canada, British Columbia

Management Issue: Effects and consequences of individual skills

Technique: Essay

Summary: This paper examines both fleet dynamics and the variation between individuals in a recreational fishery and in a commercial fishery. Literature covering the critical components of fishing fleets' dynamic behavior--investment, effort allocation, catching power and harvest efficiencies, and discard--is reviewed, and then the author moves to a discussion of the reasons for differences between individual's catches. A case study of the British Columbia, Canada purse seine (commercial) and the hook and line (recreational) salmon fisheries illustrates the differences between highliners (individuals who catch more than others) in the two fisheries. Bag limits are shown to be effective in reducing sport catch without adversely affecting many participants; because of the existence of commercial highliners, reducing the number of commercial vessels would not necessarily result in a reduction of the harvest. Data needs and a call for studying fleet dynamics are outlined.

Keywords: Fleet, management, dynamics, commercial, recreational, skill, Canada, British Columbia, salmon

Citation: Kellogg, Robert L., J. E. Easley, Jr., and Thomas Johnson 1988 "Optimal Timing of Harvest for the North Carolina Bay Scallop Fishery" American Journal of Agricultural Economics, February: 50-662.

Fishery: Bay scallop, U.S., North Carolina

Management Issue: Optimal timing of season

Technique: Bioeconomic model

Summary: This paper presents an empirical application of a general bioeconomic dynamic harvesting model to the seasonal North Carolina bay scallop fishery. Because fishery managers frequently face decisions regarding the opening and closing of a fishery, having an explicit criterion such as the maximization of net present value of the fishery on which to base the decision may make the process a less subjective one. An ex-vessel price equation, a fishing mortality equation, a cost equation, as well as an equation of motion (the change in population due to natural and harvest mortality) are estimated, with subsequent estimation of the optimal timing of the harvest.

Perhaps a less intuitive implication of the results presented here is that the fishery's optimal management--i.e., management of the fishery to maximize net revenue--would include delaying the opening of the season by several weeks and not opening it earlier. Population size, more than prices or costs, is shown to have a great influence on the timing of the opening of the season, and (assuming effort is constant throughout the season) the removal of harvesting restrictions so as to direct effort to harvesting during the optimal period could further improve the value of the fishery.

Keywords: Bioeconomic models, fishery management, bay scallop, North Carolina, season, optimal control, Brody-Bertalanffy

Citation: Kennedy, John O. S. 1987 "A Computable Game Theoretic Approach to Modeling Competitive Fishing" Marine Resource Economics 4(1):1-14.

Fishery: Southern bluefin tuna

Management Issue: International and inter-state joint use

Technique: Dynamic programming

Summary: In situations where there is a transboundary problem where stocks of fish are harvested in different political jurisdictions, optimal fisheries management is difficult. This paper outlines a multi-period model of two states that alternately harvest from different life stages of a common fish stock, that accounts for stock effects in the cost of harvesting function. Finding the optimal strategies of the two states is treated as a problem in dynamic non-cooperative game theory. The approach taken uses a feedback Stackleberg model with participants taking turns at being the leader. Using the 1983 population age structure as its starting point, the model is used to obtain numerical solutions that are compared them with the results of a joint maximization model. An interesting result of the model when applied to Australia-Japan joint utilization of the Southern Bluefin Tuna is that the returns of the two nations are differentially affected by playing non-cooperative instead of cooperative strategies: Australia gains but Japan loses relative to a joint maximization. This model could be useful in determining the bargaining positions of parties for cooperative quota setting.

Keywords: Co-operative and competitive joint use, transboundary, Stackleberg, Australia, Japan, joint maximization, Southern bluefin tuna

Citation: Kim, Chungsoo 1983 "Optimal Management of Multi-Species North Sea Fishery Resources" Weltwirtschaftliches Archiv 119(1):138-151.

Fishery: Demersal, North Sea

Management Issue: Optimal multi-species management regimes

Technique: Theoretical, case study

Summary: Applying the Schaefer fishery model of surplus production, this article estimates the potential economic rent--now largely dissipated by the traditional regime of open-access--of heterogeneous fishery resources which could be recoverable under alternative management schemes--including those of optimal economic sustainable yield, biological maximum sustainable yield, and uniformly profitable yield. The model is applied to the North Sea as a single fishing ground and uses data from the open access regime period of 1954-1973. A system of uniform user fees and a regime of uniform profitability are suggested because they are yield results close to the maximum economic yield solution and are perhaps more practical to implement in the face of uncertainty such as in the case where many nations have jurisdiction. The uniform profitability concept in fishery management could be achieved by selling fishing rights in auction, with the uniform user fee on catch determined through the bidding process. The bidding price of these marketable fishing rights would reflect the average expected profit rate of the random multi-species fishery on a given fishing ground.

Keywords: Multi-species, demersal, North Sea, user fee, rights, fishery, rent, cod, haddock, place, saithe, whiting, revenues, costs, efficiency, regulation, auction

Citation: Sancho, N. G. F., and C. L. Mitchell 1977 "Optimal Fishing Effort of Canada's Offshore Groundfish Fisheries--An Application of Economic Optimization Techniques" Mathematical Biosciences 34:157-166.

Fishery: Groundfish, Canada, Atlantic

Management Issue: Optimal utilization, optimal effort

Technique: Dynamic Programming

Summary: This paper uses a dynamic optimization model to estimate changes in the effort applied to Canada's northwest Atlantic groundfish fishery. Because of Canada's extension of jurisdiction, the quotas once assigned by the International Commission for Northwest Atlantic Fishermen (ICNAF) are now under Canada's jurisdiction and are determined as a function of the offshore fleet's fishing capacity. This change in management is viewed as a way of reducing the fleet's excess capacity (by harvesting more fish, not by reducing the number of vessels in the fleet). The calculated optimal present value of total profits and optimal effort are used to estimate the increase in effort necessary for increasing catch to the newly mandated levels.

Keywords: Groundfish, Atlantic, Canada, trawler, dragger, logistic, effort, landings, regression, offshore

Citation: Schnute, Jon, and John Sibert 1983 "The Salmon Terminal Fishery: A Practical, Comprehensive Timing Model" Canadian Journal of Fisheries and Aquatic Sciences 40(7):835-853.

Fishery: Chinook, *Oncorhynchus tshawytscha*, Canada, British Columbia

Management Issue: Salmon run timing

Technique: Likelihood model

Summary: Terminal or final fisheries are the critical and last point at which fishery managers can regulate escapement and, subsequently, future cohorts, yet fishery managers typically need to make real time decisions while the run is being harvested using very preliminary data. The general model presented here is one that uses catch, test catch, and escapement data to try to assist in making the opening/closing decision.

Salmon run curves, the time salmon spend in the fishery and are vulnerable to harvest, as well as the relationship between preliminary or test catch and the actual harvest rates are all part of the model. A likelihood function derives an objective criterion for estimating run timing, the test fishery and the fishery. The model is tested on 1978-1981 data for the chinook (*Oncorhynchus tshawytscha*) fishery in Barkley Sound and Alberni Inlet, British Columbia, Canada. The results show run timing to be remarkably consistent from year to year. The authors point out that the time spent by the fish in the fishery is ill-determined from the data, but that most other important parameters are relatively insensitive to this uncertainty.

Keywords: Chinook, *Oncorhynchus tshawytscha*, Canada, British Columbia, Alberni Inlet, Barkley Sound, run, escapement, terminal fishery, pool time, likelihood

Citation: Smith, Courtland L., and Susan S. Hanna 1990 "Measuring Fleet Capacity and Capacity Utilization" Canadian Journal of Fisheries and Aquatic Sciences 47(11):2085-2901.

Fishery: Groundfish, Oregon, U.S.

Management Issue: Measurement of fleet efficiency (capacity, utilization)

Technique: Mathematical Calculation

Summary: Because open-access fisheries typically have more harvest capacity than needed to harvest the stock on a sustainable basis, fishery management plans frequently involve effort controls such as gear restrictions, seasons, closed areas, and license limitations. Despite these input controls, fisheries are still subject to over harvesting and tend to be over capitalized. Management schemes that use individual transferable quotas (ITQs) are emerging as a means of resolving overcapacity problems because ITQs focus on managing output and thus remove incentive for overcapitalization and the need to race for fish.

This paper presents and applies a method for measuring fleet capacity and capacity utilization--two measures that can gauge how efficiently a fleet is using its capital. After discussing the various components of fleet capacity, the authors go into a detailed application in the Oregon bottom trawl fishery (1976-1985) and estimate number and size capacity measures as well as technical efficiency measures. They conclude that capacity utilization provides a critical measure of how well the markets for quotas are working to induce efficient fleet utilization.

Keywords: Management, capacity, utilization, groundfish, Oregon, U.S.

Citation: Smith, J. Barry 1980 "Replenishable Resource Management under Uncertainty: A Reexamination of the U.S. Northern Fishery" Journal of Environmental Economics and Management 7(3):209-219.

Fishery: Northern lobster, U.S.

Management Issue: Optimal harvest strategy

Technique: Stochastic optimization model

Summary: Because the natural environment and its resources are frequently subject to random events, it is helpful for resource managers to have models that incorporate this feature. Although this would be desirable, the modeling of renewable resources does not always address the stochastic nature of resources, making deterministic models open to questions regarding their applicability. This paper uses a stochastic replenishable resource management model that is based on a stochastic differential equation describing the northern lobster over the period of 1950-1970.

The author finds that, although overexploitation of the fishery is greater than previously estimated, uncertainty and random natural events do not greatly contribute to this; thus deterministic models are quite adequate in this situation. This lack of impact is peculiar to the fishery, however, because the author also briefly discusses how a stochastic model applied to 45 years of whaling data does give results that are 8% different from those given by a deterministic model.

Keywords: Stochastic, dynamic, stock size, lobster, U.S.

Citation: Ward, John M. 1989 "Feasibility Study of Vessel Entry and Exit Behavior Using the Gulf of Mexico Shrimp Fishery Data Set from 1965-80" NOAA Technical Memorandum NMFS-SEFC-231.

Fishery: Shrimp, U.S., Gulf of Mexico

Management Issue: Fleet dynamics

Technique: Econometrics

Summary: In any fishery, the modeling of vessel entry and exit behavior may require data regarding fleet structure and size. From a management perspective, having adequate data to do this is vital, because it allows one to develop models that elucidate the impacts of both regulatory and market changes on the fishery. This study examines the available data of the National Marine Fisheries Service (NMFS) to see if such modeling can be done for the Gulf of Mexico shrimp fishery. The author concludes that vessel operating units data, shrimp landings data, and the results of a cost and returns survey are indeed adequate to do this. The profitability of shrimp vessels is estimated using a general profit maximization model, allowing for determination of vessel entry and exit behavior.

Keywords: Shrimp, U.S., Gulf of Mexico, vessel, landings, costs, returns, entry, exit, structure, effort, inputs, Cobb-Douglas

Citation: Ward, John M. 1989 "Modeling Fleet Size in the Gulf of Mexico Shrimp Fishery, 1966-1979" NOAA Technical Memorandum NMFS-SEFC-229.

Fishery: Shrimp, U.S., Gulf of Mexico

Management Issue: Fleet Size

Technique: Econometrics

Summary: This interim report of a continuing study of the Gulf of Mexico shrimp fishing fleet describes a fleet size model being developed by the National Marine Fisheries Service. Then intent of this study is to determine if existing data is adequate to model the biological and economic changes' effects on the fleet's size and structure. Having such a model would enable managers to better anticipate regulatory, market and biological impacts on the fishery. The econometric models presented in this report indicate that the fleet does respond to changes in biological and economic conditions and that the fishery is likely overcapitalized in its current open access status.

Keywords: Shrimp, U.S., gulf of Mexico, profits, production, entry, exit, price, fleet size, elasticity of demand

Citation: Waters, James R., J. E. Easley, Jr., and Leon E. Danielson 1980 "Economic Trade-Offs and the North Carolina Shrimp Fishery" American Journal of Agricultural Economics 62:124-129.

Fishery: Shrimp, U.S., North Carolina

Management Issue: Incidental catch and discard

Technique: Benefit-cost analysis, simulation

Summary: This paper describes the North Carolina shrimp resource--North Carolina's most important fishery--that consists of three major species, brown (*Penaeus aztecus*), pink (*P. duorarum*), and white (*P. setiferus*). For two months of the year (August and September), brown and pink shrimp coexist in the major fishing area of Pamlico Sound but are at different stages of maturation, and thus represent different economic values. Because pink shrimp use the area while juveniles, precommercial-size pink shrimp constitute brown shrimp bycatch, bycatch that is discarded and largely dead.

When trying to maximize the net present value of a multispecies fishery, the concept of harvesting each species at its respective maximum economic yield may become complicated by bycatch issues. Although a lack of data makes this paper basically a 'what if' simulation exercise, the model serves to determine whether or not pink shrimp discard should be regulated. By varying the discard rate and mortality rates, the model provides an idea of the implication of various management measures. The authors conclude that the marginal benefits to the fishery do not outweigh the costs associated with protection of juvenile pink shrimp at this time.

Keywords: Shrimp, *Penaeus aztecus*, *Penaeus duorarum*, *Penaeus setiferus*, U.S., North Carolina, Pamlico Sound, incidental catch, discard

Theoretical Bioeconomic Models

The theoretical bioeconomic models in this section examine issues associated with resource utilization in three primary areas: utilization with respect to maximum economic yield, with respect to optimal effort (both its level and optimal application), and with respect to optimal (fleet) management and regulation. A fourth issue area, that of resource rent extraction, is also addressed, although more articles addressing this are found in the section on management.

The articles here that directly address the subject of maximum economic yield (MEY) go beyond the single stock, constant cost fishery case to consider various biological, economic, and social modifications of the basic model. One biological variation of this basic model considers those fisheries that exploit interrelated stocks; this scenario is examined for both the co-existing species case and for the case in which a predator-prey relationship exists. Other articles that modify the basic model to take into account economic issues look at such things as the effect(s) of various cost functions (e.g., increasing cost functions) and the discount rate on MEY. Yet another way in which the basic model is modified is via the inclusion of the effects of labor force satisfaction and, more generally, social welfare.

The articles that examine the derivation of the optimal level and the optimal time path of effort also offer extensions of the basic optimal effort model in several ways. As with the determination of maximum economic yield, the effects of such economic factors as costs and the discount rate are shown to change optimum effort levels; however, these are not the only factors that do so. Anthropogenic variables such as labor's use of a share system or the existence of government assistance programs are also shown to change the simple, base-case level of optimal effort. Additionally, some of the articles examine the effects that biological variables--for example, stocks that exhibit cyclical growth cycles or density dependent growth--can have on optimal effort.

The third category of theoretical bioeconomic models represented in this section relate to optimal management (particularly, optimal fleet management) and optimal regulation. Several of the models presented are concerned with the optimal fleet size case under different conditions of uncertainty--namely, those pertaining to the stock and its harvest--for transboundary stock situations, for developing fishery situations, for the case of a fishery in which there are interdependent fisheries, and for the case in which there are various degrees of capital malleability.

Additionally, one model that is concerned with optimal regulation addresses how development of a regulation may proceed in a situation where neither the optimal industry structure nor how the industry's participants will react is known.

The fisheries represented in this section range from those utilizing a great variety of stocks. Transboundary to sedentary, single to multiseason, irregular or cyclical or steady state, and overexploited to not yet developed stocks are included. Some of the species explicitly referred to include crab, surf clam, herring, capelin, shrimp, scallop, lobster, ocean quahog, krill, turbot, haddock, and hake.

Citation: Anderson, Lee G. 1975 "Analysis of Open-Access Commercial Exploitation and Maximum Economic Yield in Biologically and Technologically Interdependent Fisheries" Journal of the Fisheries Research Board of Canada 32(10):1825-1842.

Fishery: General, interdependent commercial

Management Issue: Interdependent stocks and maximum economic yield

Technique: Theoretical model

Summary: This paper mathematically and graphically develops a model of two fisheries that are either biologically or technologically interdependent. In each case the author compares the situations of exploiting the stocks under conditions of open-access and maximum economic yield to the situation of exploiting an independent stock, describing the various outcomes that can arise. The dynamic case of maximum economic yield is also presented for biologically interdependent stocks and compared to the open access equilibrium and static maximum economic yield, with presentation of the results pertaining to the similar technologically interdependent case. A critical conclusion is that, if managed independently for their respective maximum economic yields (MEYs), interdependent stocks will not be utilized for their joint MEY.

Keywords: Maximum economic yield, MEY, interdependent, independent

Citation: Anderson, Lee G. 1976 "The Relationship Between Firm and Fishery in Common Property Fisheries" Land Economics 52(2):179-191.

Fishery: General, commercial

Management Issue: Firm-industry relationships

Technique: Theoretical model

Summary: This paper extended the generalized or standard fishery models that modelled the aggregate effort of a fleet to describe the firm-industry relationship of independent boats in a common-property fishery. The use of unitized individual fishing effort instead of aggregate effort in the analysis allows for a more explicit production model for the fishery as a whole. The model's results are presented with their implications for fishery management.

Keywords: Firm, industry, effort

Citation: Anderson, Lee G. 1980 "Necessary Components of Economic Surplus in Fisheries Economics" Canadian Journal of Fisheries and Aquatic Sciences 37(5):858-870.

Fishery: General, commercial

Management Issue: Consolidation and measurement of the workers' satisfaction bonus

Technique: Theoretical

Summary: This article presents a detailed theoretical analysis of the worker satisfaction bonus (WSB) that fishermen derive from their job. Because WSB is so frequently mentioned as a reason for being in the fishery labor force, its exclusion from fishery models may result in incorrect conclusions being drawn from the model results. Examples of this are provided throughout the article. The article is also helpful in clarifying just what social surplus is and describes how the misinterpretation of social surplus can lead to confusion in management settings.

Keywords: Fisheries economics, economic surplus, worker satisfaction bonus, maximum economic yield

Citation: Anderson, Lee G. 1982 "Optimum Effort and Rent Distribution in the Gulf of Mexico Shrimp Fishery: Comment" American Journal of Agricultural Economics 64(1):157-159.

Fishery: Gulf of Mexico shrimp

Management Issue: Share system of remuneration

Technique: Theoretical model

Summary: This comment corrects three errors in a 1976 article by Griffen, Lacewell and Nichols which discusses the distributional and efficiency implications of the crew share remuneration system. The author shows that the optimal level of effort is not dependent on the share rate chosen by the crew, corrects for a transfer payment that was designated in the other article as an opportunity cost, and, finally, points out that both the vessel owners and crew do not have to both be taxed to achieve the optimal level of effort.

Keywords: Gulf of Mexico, shrimp, share system, remuneration, rents

Citation: Anderson, Lee G. 1982 "The Share System in Open-Access and Optimally Regulated Fisheries" Land Economics 58(4):435-449.

Fishery: General, commercial

Management Issue: Share system of remuneration

Technique: Theoretical

Summary: This paper adds the traditional share system of remuneration to the traditional model of an exploited fishery. The implications of this inclusion are subsequently discussed with respect to market power and to fisheries regulated both by limited and non-limited entry. The author concludes that, although the share system will have no effect on an economically efficient level of output, it can result in cost inefficiencies unless revenues and costs are share at the same rate. Market power, held by either vessel owners or crew, can result in efficient operations, although the share rates will differ depending on who holds the market power. Various forms of regulation are also shown to affect the share rate.

Keywords: Share system, renumeration, market power

Citation: Anderson, Lee G. 1982 "Optimal Utilization of Fisheries with Increasing Costs of Efforts" Canadian Journal of Fisheries and Aquatic Sciences 39(1):211-214.

Fishery: General, commercial

Management Issue: Increasing versus constant cost industries

Technique: Theoretical

Summary: This article describes the effects that increasing cost of effort functions will have on economic efficiency in a fishery. A comparison of this with the constant cost of effort situation is provided to show that economic efficiency results in both cases if the physical production externality is corrected. The author also describes, however, the increasing cost of effort case in which both a physical production and a cost externality need to be accounted for in order to achieve the economically efficient outcome.

Keywords: Effort, costs, fisheries management, fisheries economics

Citation: Anderson, Lee G. 1983 "Exploitation of the Lobster Fishery: Comment" Journal of Environmental Economics and Management 10:180-183.

Fishery: Lobster, Canada

Management Issue: Optimal fishery utilization

Technique: Theoretical

Summary: This comment on J.V. Henderson and M. Tugwell's 1979 article "Exploitation of the Lobster Fishery: Some Empirical Results" Journal of Environmental Economics and Management 6:287-296 corrects their comment that the standard static model ignores the biomass effect--the effect of fishing on future stocks--and that this causes their comparison of dynamic and static results to differ from what they might otherwise be. The purpose of this note is to provide a correct interpretation of the difference between the received static and the dynamic model and to interpret the results of their comparison in that context. Biomass is, in fact, included in both static and dynamic models; the use of different discount rates makes these models appear different. The solutions are different because the static case assumes a discount rate of zero, making the optimal stock size larger and the appropriate level of effort smaller than they would be if determined using a dynamic model.

Keywords: Dynamic, static, biomass, optimal utilization, lobster, Canada

Citation: Anderson, Lee G. 1989 "Optimal Intra- and Interseasonal Harvesting Strategies when Price Varies with Individual Size" Marine Resource Economics 6:145-162.

Fishery: Lobster, shrimp

Management Issue: Size price relationships and optimal harvest

Technique: Theoretical

Summary: This article examines the size price trade-off occurring both in a single season fishery (shrimp) where only a single age/size cohort exists and in a multiseason fishery (lobster) where a multiple age cohort exists at any given time. The size price issue is described in terms of the size, natural mortality rate, and the discount rate. The author includes, however, the important caveat that management can consider these factors but must do so in light of institutional constraints, enforceability, recruitment, and the efficiency with which effort is produced. An appendix describes the optimal interperiod trade-off for the multicohort lobster model.

Keywords: Optimal harvesting, intraseason, interseason, variable price, fisheries management, lobster, shrimp

Citation: Anderson, Lee G. and A. Ben-Israel 1981 "Modeling and Simulation of Interdependent Fisheries, and Optimal Effort Allocation Using Mathematical Programming" In Applied Operations Research in Fisheries, K.B. Haley. New York: Plenum Press.

Fishery: Interdependent

Management Issue: Modeling of interdependent fisheries

Technique: Mathematical modeling, simulation

Summary: This article compares alternative methods of bioeconomically modeling a fishery in which the species are interdependent. Unlike earlier dynamic programming efforts in this category, the models described here determine the optimal allocation of effort among several different types of vessels in addition to between the two species. The biological portion of the models are designed so that the user can choose from a variety of production function forms (Ricker, Beverton-Holt, linear density dependent, and bi-modal), each of which has a stochastic and a deterministic mode.

The authors' use of two modeling approaches--namely, simulation and dynamic programming--allows for a comparison of the methods. Their respective results can be compared because the models are run using 14 years of hypothetical data from a yellowtail flounder and cod fishery. Optimal vessel effort is calculated for six classes of vessels in such a way as to reflect several different optimal population/exploitation time paths for a ten year period.

Keywords: Simulation, interdependent, yellowtail, cod, effort

Citation: Berck, Peter 1981 "Optimal Management of Renewable Resources with Growing Demand and Stock Externalities" Journal of Environmental Economics and Management 8:105-117.

Fishery: None. Renewable resources in general

Management Issue: Optimal renewable resource management

Technique: Theoretical model

Summary: This article uses a partial equilibrium model of renewable resources to examine issues related to the conditions of 1)increasing demand and 2) stock externalities. The article then goes on to show the difference in outcomes between the open access and competitive situation. Finally, the author examines the use of taxes as a mechanism for resolving the demand and stock externality problem. He concludes with the note that, while useful in some cases, taxes will not be as optimal a form of regulation as would be one that eliminates these problems (of demand and stock externalities).

Keywords: Renewable, externality, tax, demand, resource, management

Citation: Caddy, J. F., and J. A. Gulland 1983 "Historical Patterns of Fish Stocks" Marine Policy 7(4):267-278.

Fishery: General

Management Issue: Stock recruitment patterns and their management implications

Technique: Discussion

Summary: Because the effects of natural and human events can greatly impact fish stocks and because the assumption of stock stability is not a strong one, the authors of this paper use time series landings data to look at the stock recruitment patterns of a variety of stocks world wide. Four rough classes (on the basis of stock variability) are described: steady, cyclical, irregular, and spasmodic. The authors note that the use of such classifications may be useful for trying to avoid both overcapacity and overexploitation problems, because managers who have an idea of where in a cycle a stock may be can adjust management strategies accordingly to avoid pitfalls not predicted by models that do not incorporate such stock trends.

Examples of 'steady-state' fisheries include the North Sea turbot and the Georges Bank haddock fisheries. Cyclical fisheries include the Baleaves hake, the Bay of Fundy scallop, the California dungeness crab fisheries and the Pacific saffron cod fisheries. The Norwegian fishery for juvenile herring, the Magdalen Island lobster and the Georges Bank scallop fisheries are used as examples of irregular periodic stocks. Finally, the California sardine and anchovy, the Northwest Pacific sardine, and the Gulf of Maine shrimp fisheries are described as irregular or spasmodically producing fisheries.

Keywords: Fisheries, resource management, environment, stock variability, recruitment fluctuations, steady, cyclical, irregular, spasmodic stocks

Citation: Campbell, David and Jos Haynes 1990 "Resource Rent in Fisheries" Australian Bureau of Agricultural and Resource Economics Discussion Paper 90-10.

Fishery: General, Australia

Management Issue: Resource rent

Technique: Discussion

Summary: This paper is intended to provide a straightforward discussion of the issues associated with charging rent for the use of a public resource such as the fish in a fishery. The authors begin with a discussion of resource rents in various situations and then move to a discussion of possible resource rent charges. Practical considerations--such as equity issues, license values, new or virgin stocks, the costs of using or investing in a resource, different modes of operation--as well as a framework under which one could assess a resource rent charge are also covered. The motivation for this work is the hope that an understanding of the relationships between various management forms and the rent generated in a fishery will provide a clearer picture of what fishery management is intended to do for all parties involved.

Keywords: Resource, rent, charge, property rights, quasi-rent, individual transferable quota

Citation: Charles, Anthony T., and Gordon R. Munro 1985 "Irreversible Investment and Optimal Fisheries Management: A Stochastic Analysis" Marine Resource Economics 1(3):247-264.

Fishery: General

Management Issue: Uncertainty and optimal fishery investment

Technique: Stochastic analysis, deterministic analysis

Summary: In addition to the management problems associated with stock variability, fishery managers face difficulties related to the appropriate level of capital investment. Fleets are rarely perfectly malleable--i.e., they may not have alternative uses--and thus the investment pattern in a fleet can become quite an issue in fishery development. Models describing optimal fleet management exist, and this paper takes the issue one step further by considering optimal fleet/capital investment under conditions of annual stock uncertainty. Investment in the fleet is a function of the relative cost of capital (the lower the cost, the larger the fleet) and of the rate at which the stock size grows (the faster it grows, the larger the fleet).

Keywords: Nonmalleable, capital, irreversible investment, optimal investment, deterministic, stochastic, optimal control

Citation: Clark, W., Anthony T. Charles, John R. Beddington, and Marc Mangel 1985 "Optimal Capacity Decisions in a Developing Fishery" Marine Resource Economics 2(1):25-53.

Fishery: General, developing

Management Issue: Optimal fleet size

Technique: Theoretical modeling

Summary: The problem of estimating optimal fishing capacity for a developing fishery is very complex. Too small a fleet will prevent optimal initial catches, but the problem can easily be remedied by further construction. On the other hand, too large a fleet will result in over capitalization, depressed stocks and hence depressed future catches. The problem of getting rid of excess vessels is much more difficult that allowing new ones to be built, thus the effects that errors in fishing capacity can have are rather asymmetric. The authors have analyzed the problem of setting the initial fleet size using decision theory and adaptive control theory. Several models are discussed based on alternative hypotheses concerning age structures, catch-effort and stock recruitment relationships, and the manner in which uncertainty and information is handled. The results obtained indicate that quite good decisions can often be made on the basis of limited prior information about fish stock productivity, particularly if a conservative approach allowing for subsequent increases in capacity is employed.

Keywords: Fleet size, entry, exit, capacity, cohort, recruitment, optimization, developing, investment, Bayesian

Citation: Evans, Geoffrey T. 1981 "The Potential Collapse of Fish Stocks in a Developing Fishery" North American Journal of Fisheries Management 1:127-133.

Fishery: General

Management Issue: Stock collapse

Technique: Theoretical production model

Summary: Fisheries development often carries with it the risk of overexploitation and subsequent stock collapse. Depending on the shape of the stock growth function, stock monitoring and assessment activities may not necessarily detect population decreases in time to change exploitation levels and maintain sustainable yields. The model derived and simulated here shows that--under conditions of increasing development and, typically, yield--the management of effort as a strategy for managing yield will permit the detection of the maximum sustainable yield, while direct management of the yield may not.

Keywords: Production, collapse, yield, optimal stock size, mortality

Citation: Falk, Ita 1988 "A Dynamic Model of Interrelated Renewable Resources" Resources and Energy 10:55-77.

Fishery: General

Management Issue: Modeling of interrelated species

Technique: Bioeconomic modeling

Summary: In order to illustrate the bias and weaknesses inherent in single-species modeling, this paper analyzes and compares the effects of managing interrelated species as either separate stocks or symmetrically interrelated stocks, i.e. managing the species in a manner that reflects their ecological relationship. A theoretical dynamic bioeconomic model is used to describe the long run supply equilibria of three harvest strategies (joint harvesting, separate harvesting of the two species and single species harvest) under conditions of open access as well as under conditions of sole ownership.

Under open access, there is no difference between the ecological and the separate stock results; both fail to consider the long run impacts of harvest on the stocks, any potentially related impacts in the stocks or even recruitment. With sole ownership, more optimal management can occur, but even in this case--if the stocks are considered separately and not ecologically--suboptimal exploitation will likely occur and may lead to underexploitation of the stock that is less profitable.

Keywords: Interspecies competition, Gause, ecological competition system, interrelated species, bioeconomic model, dynamic model

Citation: Flaaten, Ola 1983 "The Optimal Harvesting of a Natural Resource with Seasonal Growth" Canadian Journal of Economics 16(3):447-462.

Fishery: General

Management Issue: Optimal management/modeling of seasonal fisheries

Technique: Bioeconomic model

Summary: This paper addresses the issue of considering seasonal changes in a resource and provides a model that accounts for cyclical changes in the resource stock as well as for cyclical changes in the resource's growth rate. Because fish stocks do not necessarily grow at a constant rate and do not, for instance, spawn continuously throughout the year, models such as this one provide a way to consider harvest strategies other than those found under open access conditions. Species that could be considered as representative of these cycles include krill, zooplankton, capelin, and herring.

The authors incorporate a cyclical logistic growth equation into a basic dynamic growth model and analyze four growth patterns: single cycle, homogenous cycles, wave-growth cycles and staircase growth cycles. The results support a management strategy whereby the optimal season length will be shorter than that under open access and whereby incentive to harvest corresponds to those periods in the cycle in which the optimal level of stock exists.

Keywords: Verhulst, seasonal, cyclical, logistic, optimal, krill, zooplankton, capelin, herring

Citation: Flaaten, Ola 1991 "Bioeconomics of Sustainable Harvest of Competing Species" Journal of Environmental Economics and Management 20:163-180.

Fishery: General (competing species)

Management Issue: Optimal harvest

Technique: Theoretical, bioeconomic modeling, Gausian interspecific competition

Summary: The focus of this paper is on the analysis and policy implications of managing a two stock fishery in which there is interspecific competition of either the predator-prey or the competing species type. Although presented here in a theoretical form, this extension of comparing open access with the optimal management of more than one species has very pragmatic applications given the large numbers of marine species interactions and, at a more abstract level, given the need for sustainable ecosystem development.

The author uses the Gausian model of two competing species as the basis for the model presented here and looks at the effects on the stocks' levels of trying to maximize the fisheries' economic rent and trying to maximize the present value of economic rent. Positive harvesting costs, discount rates, and harvest prices are shown to all affect the optimal steady state levels of the stocks.

Keywords: Maximum sustainable yield, bioeconomic, interspecific competition, predator, prey

Citation: Gulland, J. A., and M. A. Robinson 1973 "Economics of Fishery Management" Journal of the Fisheries Research Board of Canada 30:2042-2050.

Fishery: General

Management Issue: Management objectives and mechanisms

Technique: Essay

Summary: In open access situations overexploitation of the resource will often, if not always, occur, and this overexploitation is frequently accompanied by excess harvesting capacity. To the extent that the boats and labor in a fishery become fishery specific, the capital and labor involved may be quite immobile, making the process of reducing excess capacity an even more difficult one than it might otherwise be.

This article discusses the biological, economic and social problems associated with open-access fisheries and the potential benefits (and problems) that management can offer. The management objectives of maximizing sustainable yield and net economic return are considered as is the objective of maximizing the available food supply. The author examines the pros and cons of different management schemes--of controlling the size of the fish harvested, the amount of fishing that occurs, and excess capacity--and the potential value of licensing schemes.

Keywords: Economic, cost reduction, common property, overcapacity, licenses, fishery development, management

Citation: Hannesson, Rögnvaldur 1983 "Optimal Harvesting of Ecologically Interdependent Fish Species" Journal of Environmental Economics and Management 10:329-345.

Fishery: General

Management Issue: Optimal management of interdependent species

Technique: Theoretical model

Summary: In examining the issue of optimal harvest for ecologically interdependent species, the author of this article extends the (very minimal) literature on the subject. Moving beyond the distinctions between open access and socially optimal harvesting, he addresses such queries as what influence will changes in the discount rate, the species' respective prices, or harvesting costs have on both the more general results and on the predator-prey interdependent species scenario. He begins with a general multispecies model before introducing the Lotka-Volterra model. After examining the base case of a zero discount rate and zero harvest costs, the article describes the effects that changes in the harvest cost, discount rate, and product prices can respectively and together have on the results.

Keywords: Predator, prey, multispecies, density dependent, interdependent

Citation: Hannesson, Rögnvaldur 1986 "Optimal Thinning of a Year-Class with Density-Dependent Growth" Canadian Journal of Fisheries and Aquatic Sciences 43:889-892.

Fishery: General

Management Issue: Harvest time path in density-dependent fisheries

Technique: Theoretical model

Summary: This paper describes the circumstances under which the practice of thinning density dependent stocks as a means for increasing the growth and the yield of the remaining fish is a beneficial one. Thinning can be done all at one time (instantaneously) or more gradually over an extended period; the method of choice is shown to be a reflection of the density dependence of the stock in question. The author shows that, when harvesting costs are zero, the optimal strategy for harvesting highly density dependent stocks is instantaneous thinning. For stocks that are only somewhat density dependent, the zero harvest cost strategy is a more gradual one.

Keywords: Density dependent, optimal, thinning, harvest, time path

Citation: Hannesson, Rögnvaldur 1987 "Optimal Catch Capacity and Fishing Effort in Deterministic and Stochastic Fishery Models" Fisheries Research 5:1-21.

Fishery: General

Management Issue: Economics of fishery management

Technique: Static, dynamic, and stochastic models

Summary: This paper provides an overview of basic fishery economics, starting with the static theory foundations of open access overexploitation and the difference between maximum sustainable yield and maximum economic yield. From there the author moves to a discussion of how dynamic fisheries theory modifies the tenets of static theory (depending on what the discount rate is) and of how investment in the fishery is affected by the discount rate. Finally, the author looks at the need for and use of stochastic models, especially given the biases that deterministic models may impose on their results. The role of optimal investment capacity and the impact of population dynamics on stochastic models are contrasted to their respective effects in deterministic analyses.

Keywords: Static, dynamic, stochastic, exploitation, stock size, fleet capacity

Citation: Hannesson, Rögnvaldur 1987 "The Effect of the Discount Rate on the Optimal Exploitation of Renewable Resources" Marine Resource Economics 3(4):319-329.

Fishery: General

Management Issue: Dynamic economic yield

Technique: Theoretical analysis

Summary: This paper examines the effect the size of the discount rate will have on the optimal rate of exploitation and a resource's optimal stock size. As is the case for non-renewable resources, this effect is ambiguous, and the ambiguity depends on the dual role of the discount rate of return on a growing asset. For a renewable resource with a concave growth function, a higher rate of discount implies a smaller standing stock. On the other hand, the discount rate expresses the opportunity cost of capital to be invested in harvesting equipment. A higher discount rate thus means more costly harvesting, which in turn implies a less intensive optimal harvesting and a larger standing stock.

Keywords: Dynamic economic yield, optimal stock size, discount rate, investment

Citation: Howarth, Richard B., and Richard B. Norgaard 1990 "Intergenerational Resource Rights, Efficiency, and Social Optimality" Land Economics 66(1):1-11.

Fishery: None

Management Issue: Intergenerational resource allocation

Technique: Theoretical

Summary: Although economists are usually involved in the allocation of scarce resources, the authors of this article document how the distinction between efficiency and equity is often blurred, particularly when discussing the "optimal depletion" of a resource. A two generation, three-period equilibrium model is developed to show how different generational distributions of resource rights can result in different Pareto efficient solutions. The last section of the paper discusses the effects of different social welfare functions on optimal solutions. A call is made for incorporating different intergenerational equity issues into economic models of natural resources.

Keywords: Efficiency, equity, intergenerational, allocation, social, welfare, optimality, utility

Citation: Levhari, David, and Leonard J. Mirman 1980 "The Great Fish War: An Example Using a Dynamic Cournot-Nash Solution" The Bell Journal of Economics 11(1):322-334.

Fishery: General

Management Issue: Participants' strategic behavior

Technique: Theoretical, Cournot-Nash model

Summary: Fisheries management often can involve the resolution of two parties' differences over the use of a fishery resource, and the modeling of such duopolistic or oligopolistic situations is the focus of this paper. Given the two assumptions that 1) each party acts in its own self-interest to maximize the net present value of its utility and 2) each party takes the other's actions as given and then reacts to these, the authors present a model of a Cournot-Nash duopolist in a dynamic framework. The basic model is developed and then extended to a situation in which the two parties are not equals (and instead one is a sophisticated leader and the other a naive follower). The paper concludes with a discussion of the model's possible outcomes and the implication of these outcomes on the fishery's stock.

Keywords: Conflict, Cournot-Nash, duopoly, strategy, decision-making

Citation: Levhari, David, Ron Michener, and Leonard J. Mirman 1981 "Dynamic Programming Models of Fishing: Competition" The American Economic Review 71(4):649-661.

Fishery: General

Management Issue: Dynamic optimal exploitation

Technique: Dynamic programming model

Summary: The intent of this paper is to provide an easily understood, mathematical explanation of the use of a renewable resource for the case of open access and for the case of perfect competition/assigned property rights (under which the optimal use of the resource over time can occur). Although fish are the renewable resource discussed here, the authors point out that these models could apply to any capital stock--including exhaustible ones--and that extraction horizons will reflect this.

For each of these cases, two scenarios are covered: 1) when the harvest/extraction costs are unrelated to stock size, and 2) when harvest/extraction costs are a function of the fish stock's size. The dynamic models used are further described in the paper's Appendix.

Keywords: Time path, prices, output, dynamic programming, rate-of-return, renewable resource, competition

Citation: Lipton, Douglas W., and Ivar E. Strand, Jr. 1989 "The Effect of Common Property on the Optimal Structure of the Fishing Industry" Journal of Environmental Economics and Management 16:45-51.

Fishery: Surf clams, ocean quahogs, U.S.

Management Issue: Optimal industry structure

Technique: Theoretical analysis, case study

Summary: The issue of industry structure under open access and how it might change under management is one of great importance to fishery managers. The authors of this paper show that, when analyzing market structure, the important factor to consider is (the potential for) economy of scope. The market structure under open access may be inefficient compared to the social optimum, but the example used here illustrates that it may not be possible to determine the efficient market structure before regulation takes place. For the instance in which open access has been eliminated, it may be that more firms, not fewer, are optimal; in such a scenario, vessel buy-back schemes or entry restrictions may be inappropriate.

Keywords: Surf clam, ocean quahog, industry, structure, specialist, firm, generalists, coexistence, economies of scope, multispecies

Citation: Mirman, Leonard J., and Daniel F. Spulber 1985 "Fishery Regulation with Harvest Uncertainty" International Economic Review 26(3):731-746.

Fishery: General

Management Issue: Optimal regulation under harvest uncertainty

Technique: Theoretical, stochastic dynamic programming

Summary: In looking at the use of landings taxes and quotas, both respectively and together, this paper addresses the inherent randomness between effort put into a fishery and the yield subsequently derived from it. Because of the uncertainty that exists regarding yield, fishermen can exert non-optimal levels of effort in their search for and harvest of fish. Although regulating search effort is possible via the use of a landings tax, it may cause inefficiencies under those circumstances when large, easily caught harvests are possible. Similarly, quotas may limit the number of fish caught, but they may do so while encouraging larger-than-efficient levels of effort to be expended.

The dynamic model presented here first describes the unregulated firm case. The model is then modified to describe first the effect of a landings tax and next the effects of a vessel quota on effort and yield. Finally, the two forms of regulation are applied together as an optimal approach for regulating search effort and harvesting, respectively.

Keywords: Search, harvest, uncertainty, tax, quota, stochastic, dynamic, programming

Citation: Mitchell, C. L. 1979 "Bioeconomics of Commercial Fisheries Management" Journal of the Fisheries Research Board of Canada 36(6):699-704.

Fishery: General, Canada

Management Issue: Use of biology and economics in fishery management

Technique: Theoretical

Summary: Two perspectives on fisheries management exist: management from a biological and conservational perspective, and management from an economic and socioeconomic perspective. While these two perspectives do not operate in two isolated spheres, this article examines the management implications and potential of increased coordination between these approaches. The author reviews the major objectives of fisheries management as well as the economics and impact of economics on the management of (fishery) resources. He concludes that biological and economic management goals are not really so very apart and can supplement each other fairly readily.

Keywords: Management, biology, economics, bioeconomics, socioeconomic, Canada

Citation: Munro, Gordon R. 1979 "The Optimal Management of Transboundary Renewable Resources" Canadian Journal of Economics 12:355-376.

Fishery: General, transboundary

Management Issue: Optimal management

Technique: Theoretical

Summary: With the extension of national jurisdiction out to 200 miles, many fishery stocks are coming under the management (or, at least, jurisdiction) of a single country. For those stocks that ignore these political boundaries--i.e., for transboundary stocks--their exploitation and management may come under more than one regime. This paper examines the issues of transboundary stocks from the perspective of game theory. The basic game theory model is presented, and then three differences between the participants--differences in social discount rates, differences in harvesting costs, and differences in tastes/preferences--and the way these affect the management outcome are considered.

Keywords: Management, joint, transboundary, conflict, preferences, Nash, game theory

Citation: Plourde, C. G., and J. S. Ferris 1982 "Labor Mobility, Seasonal Unemployment Insurance, and the Newfoundland Inshore Fishery" Canadian Journal of Economics 15(3):426-441.

Fishery: Inshore, Canada, Newfoundland

Management Issue: Effect of unemployment insurance on fishery

Technique: Econometrics, regression

Summary: This paper examines the Newfoundland inshore fishery and presents a micro-economic model to relate legislative decisions to the supply and demand labor. The industry supply curve for labor (fishermen) derived here is subsequently modified to include the impact of the unemployment insurance program that took effect in 1957. Local industries have a regular season lay-off period during which they take advantage of unemployment insurance, thus cutting their own costs. The study predicts that seasonal unemployment insurance increases the size of the inshore fisheries, a result which is related to government assistance policies. Although the quantitative analysis is, in the author's words, "not strong," it provides evidence consistent with the underlying hypothesis of the paper; namely, that government assistance programs are related to productivity and employment in the fishery.

Keywords: Newfoundland, Canada, inshore, fishery, labor, mobility, unemployment, insurance

Citation: Plourde, Charles, and J. Barry Smith 1989 "Crop Sharing in the Fishery and Industry Equilibrium" Marine Resource Economics 6(3):179-193.

Fishery: General

Management Issue: Optimal economic yield, share system

Technique: Theoretical analysis

Summary: Previous analysis has shown that the share system will dominate wage contracts in stochastic environments and that output and employment will be greater as a result of such a system. This paper uses a bioeconomic equilibrium analysis and shows that privately optimal sharing contracts are not, in general, socially optimal and that employment and output differences between socially and privately optimal contracts are ambiguous. The management implications are that regulators must design policies subject to the constraint that firms will have incentives to adopt a particular contract form, but that such implicit contract incentives may reduce the net benefits of implementing the regulation. The basic question is to determine the optimal policy that provides firms with the appropriate incentives to adopt the socially optimal labor contract.

Keywords: Share system, labor, incentives, employment

Citation: White III, G. N., and P. Mace 1988 "Models for Cooperation and Conspiracy in Fisheries: Changing the Rules of the Game" Natural Resource Modeling 2(3):499-530.

Fishery: Bay of Fundy herring, Canada

Management Issue: Stability of coalitions

Technique: Theoretical, game theory

Summary: Although fisheries management is intended to mitigate, if not solve, the open-access, over-exploitative behavior of fishermen, it often fails to adequately consider their behavior to a new situation--that of management. The authors of this article analyze fishermen's behavior from a game theory perspective. After tracing the expansion (1930-1968) and then the collapse and restructuring (1968-1979) of the Bay of Fundy herring fishery, a model of the fishery is developed to consider the two situations of "racing" to get a piece of the fishery and of having an allocation for a portion of the fishery. The results indicate that the stability of the fishery's structure and changes in the structure of the industry have played important roles throughout the fishery's history.

Keywords: Game theory, coalition, cooperative, Bay of Fundy, herring, Canada

Management Studies

This section covers a broad spectrum of issues related to management goals and concerns, some of which are international, and others of which are more national, regional or local in nature. The topics addressed include the effects of regulation, data requirements for management, enforcement of management policies, and the types (and effects) of policies that can be used in fisheries management. Both qualitative and quantitative models of different types of regulations are included.

Fisheries management includes the consideration of not only economic, but also biological, social, and political factors, and this set of articles addresses and provides examples of many of the issues in these areas. For example, those articles describing economic considerations include discussions of rent capture, the use and effects of various discount rates, as well as the difference between the goals of economic efficiency and economic development or employment. The articles looking at biological factors that affect management include consideration of such things as: the maintenance of total allowable catches (TACs) with at-sea processing; the role of stochastic environmental factors and general biological uncertainty; and multispecies fisheries issues, including those related to by-catch. And, in the articles focusing on social issues, issues such as the impact of management programs on participants and management programs' acceptability (domestically and/or internationally) to participants are discussed.

In some of these articles the biological--and, subsequently, financial--effects of using different management strategies have been quantified, i.e., several articles directly assess the potential financial and economic gains that would accrue to a fishery if the stock in question was permitted to recover. Additionally, effects such as (non)compliance, market power, substitution of inputs, the redirection of effort (both intentionally and unintentionally), and changes in fleet composition (size, employment and profitability) are discussed within the context of a variety of fisheries.

Another aspect of management--the evolution of management--is also addressed by some of the articles in this section. Insights about the factors effecting management and its evolution, in the domestic and international arenas, as well as some of the lessons learned from the process are provided. This provides one with quite a broad perspective because the collection of articles

includes fisheries in France, Canada, the U.S., Japan, Australia, Tasmania, Africa, the U.K., New Zealand, and Ireland.

These articles cover all forms of management: gear/size restrictions, limited entry or license restrictions, individual transferable quotas (ITQs), taxes, quotas or total allowable catches (TACs), as well as areal or seasonal closures. Throughout the discussions of these different types of management, the issue of input versus output controls is raised--although this is not always done explicitly. Some of these papers also address the various aspects of management data needs, particularly those related to the management strategies such as taxes, licenses, enterprise allocations, ITQs, gear restrictions, and quotas. The subjects of statistics--economic, biological, and socioeconomic--and of how to get them are also covered by some of the publications.

The species in this section that are explicitly mentioned include cod, clams, capelin, cephalopod, crab, haddock, halibut, herring, lobster, oyster, shrimp, salmon, thornyhead, rockfish, whale, whitefish, mackerel, sole, tuna, and sablefish.

Citation: Acheson, James M., and Robert Reidman 1982 "Biological and Economic Effects of Increasing the Minimum Legal Size of American Lobster in Maine" Transactions of the American Fisheries Society 111(1):1-12.

Fishery: American lobster, *Homarus americanus*, U.S., Maine

Management Issue: Valuation of (foregone) revenues under increasing size restrictions

Technique: Bioeconomic modeling

Summary: Having quantitative knowledge of the effects of a proposed policy change can be very helpful in deciding whether or not to make the change. This study of the 1978 Comprehensive Management Plan (CMP) produced by the Northeast Marine Fisheries Board provides such information because it estimates both the biological effects of the CMP's proposed increases in carapace length of American lobsters, *Homarus americanus*, and the economic effects of the regulation on the industry. Increasing the carapace limit over a 5 year period was intended to increase egg production and, ultimately, recruitment, by allowing more lobsters to reach the egg bearing age and thus decreasing the probability of a stock collapse. The results of the authors work show that the proposed plan to increase these lobster size limits would result in losses for the industry for the 5 years of increasing size limits, but that the returns would then increase to a level 5.5% higher than the current internal rate of return. A detailed explanation is provided about the biological, supply, and demand models that they derive and estimate as well as about where the data can be found.

Keywords: Bioeconomic, return, size limitation, American lobster, *Homarus americanus*, U.S., regression

Citation: American Fisheries Society, Socioeconomics Section 1990 "Improving the Use of Social and Economic Data in Fisheries Management" Compiled by Southwick Associates, Arlington, VA.

Fishery: General

Management Issue: Data usage

Technique: Discussion

Summary: This report is the outgrowth of an effort to identify the information gaps that exist with regard to the social and the economic aspects of fisheries management. The membership of the Socioeconomics Section of the American Fisheries Society, individuals in the fishery profession, fishery managers, and academics were questioned, called, and otherwise asked for comments, draft papers, etc. pertaining to this issue, and Southwick Associates (formerly Leviathan Associates) compiled the information into this document.

Three priority areas to address information gaps are described: 1) the need for social policy to be incorporated into fisheries management; 2) the need for data, and 3) the need to capture changes in fisheries resource utilization. After identifying and prioritizing needs and issue areas that came to light within each of these three categories, the report lists and briefly discusses more explicit problems are listed and briefly discussed. Possible solutions are presented for each of the three priority areas. The report concludes with a call to make this process (of identifying gaps and the ways to close them) a dynamic, cooperative and coordinated one, in order to best meet the current and future needs of fisheries management.

Keywords: Policy, socio-economic, management, data, information, priorities

Citation: Anderson, Lee G. 1985 "Potential Economic Benefits from Gear Restrictions and License Limitation in Fisheries Regulation" Land Economics 61(4):409-418.

Fishery: General, commercial

Management Issue: Gear restrictions and license limitation programs

Technique: Theoretical benefit-cost analysis

Summary: This article examines the effects of using the traditional commercial fishery management technique of gear restrictions and of using license limitation programs. With gear restrictions, the author shows how there may be some economic gains--but that these are more likely to occur in the case of an increasing cost industry. License limitation programs will also have net efficiency gains in the increasing cost industry case, as well as--for some programs--in the constant cost industry case. The author concludes the article with a discussion of the management implications for such results, noting that license limitation programs may be much simpler for managers and enforcers to implement.

Keywords: Gear restrictions, license limitation, management

Citation: Anderson, Lee G. and Dwight R. Lee 1986 "Optimal Governing Instrument, Operation Level, and Enforcement in Natural Resource Regulation: The Case of the Fishery" American Journal of Agricultural Economics 68(3):678-690.

Fishery: General, commercial

Management Issue: Natural resource regulation tools, enforcement, and operation

Technique: Theoretical

Summary: This article addresses three issues pertinent to optimal natural resource regulations, using fisheries as the resource in question. First, the actual regulation process is modelled with attention given to the choice of control variable. Second, the model addresses the evasion activities the regulated/fishery participants may undertake. Third, the article addresses the subject of implementation and enforcement of regulations--without which there is hardly any successful regulation. Before moving to the discussion of the choice of the optimal governing instrument, the model of government regulations is present along with a determination of optimal regulation and how to get there. The summary concisely describes the model's implications for real-life management situations.

Keywords: Common property, enforcement, fisheries, natural resources, regulation

Citation: Anderson, Lee G. 1989 "Enforcement Issues in Selecting Fishery Management Policy" Marine Resource Economics 6(3):261-277.

Fishery: General

Management Issue: Enforcement, designing management strategies

Technique: Discussion

Summary: The purpose of this article is to present a frame of reference in which to compare fisheries regulation and to identify enforcement issues that can be important in practical policy applications. The long list of issues discussed includes: dockside versus at-sea monitoring; ease of government implementation; period at risk when in noncompliance; ease and cost with which industry participants can achieve ability to comply; ease of distinction between honest mistakes, sloppy practices, and deliberate cheating; initial versus continued compliance; ease with which requirements can be communicated; ease with which noncompliance can be disguised; ease with which agents can detect noncompliance such that it is admissible as evidence; degree to which personal or social benefits from compliance can be demonstrated; potential for citizen cooperation in identifying offenders; likelihood of encouraging rent-seeking behavior by industry and of administrators being susceptible to it; ease with which illegal activities can be detected under various conditions; relative ability to which enforcement is efficacious with respect to different management objectives; and ease with which benefit-based priorities for enforcement can be identified.

Keywords: Management, enforcement

Citation: Anderson, Lee G. 1991 "Efficient Policies to Maintain Total Allowable Catches in ITQ Fisheries with At-Sea Processing" Land Economics 67(2):141-157.

Fishery: General, commercial

Management Issue: Regulation of at-sea processing

Technique: Theoretical with numerical example

Summary: This article develops the theory behind maintaining a total allowable catch (TAC) under conditions where at-sea processing occurs in a fishery that is managed by individual transferable quotas (ITQs). The author also provides a numerical application of the model that uses a Lotus 123 spreadsheet (and is available from the author). The cases of fixed and variable recovery rates are addressed. The concluding section discusses the practical issues associated with setting at-sea processing conversion factors (for converting green-weight to landed-weight) as well as equity and efficiency issues.

Keywords: Processing, at-sea, individual transferable quota, ITQ, green-weight, landed-weight

Citation: Anderson, Lee G. 1991 "A Note on Market Power in ITQ Fisheries" Journal of Environmental Economics and Management 21:291-296.

Fishery: General, commercial

Management Issue: Market power and individual transferable quotas (ITQs)

Technique: Theoretical

Summary: This note extends the work on market failures for transferable pollution permits to the case of market failure for individual transferable quotas (ITQs). Although ITQs establish property rights to produce a market product (fish) and whereas transferable pollution permits are for the right to produce a non-market joint product (pollution), both can result in market failures. This model shows how market inefficiencies can occur if there is a dominant firm in the fishery. The author shows how the type of inefficiency, however, will depend on whether the dominant firm is a net buyer or seller of ITQs and that the inefficiencies can differ from those occurring in the market for transferable pollution permits.

Keywords: Market power, individual transferable quota, ITQ, transferability, market failure

Citation: Androkovich, R. A. and K. R. Stollery 1989 "Regulation of Stochastic Fisheries: A Comparison of Methods in the Pacific Halibut Fishery" Marine Resource Economics 6(2):109-122.

Fishery: Halibut

Management Issue: Choice of management instrument

Technique: Stochastic dynamic simulation

Summary: This paper goes further than most theoretical and empirical work in fisheries economics by directly considering uncertainty. This is accomplished by simulating a stochastic dynamic program which uses parameters obtained from other empirical analysis of some fishery. The model is used to compare the effects of a taxation program with the effects of direct controls on season length or the number of boats. Although taxes are found to be superior, all three forms of regulation produce almost the exact amount of net social benefits as does an open-access competitive fishery. The reason taxes do not produce the results predicted by deterministic theory is that the level of the tax must be set in advance of the realization of the random variables. These results indicate that management by one of these methods will provide no net gains and cannot be justified on economic grounds. This is a plausible result but it should be checked for other types of regulation and for the effects long term open-access utilization may have on the stock.

Keywords: Management, uncertainty, season closures, tax, optimal economic utilization, halibut

Citation: Androkovich, Robert A., and Kenneth R. Stollery 1991 "Tax Versus Quota Regulation: A Stochastic Model of the Fishery" American Journal of Agricultural Economics 73(2):300-308.

Fishery: Pacific halibut, Canada

Management Issue: Optimal allocation

Technique: Dynamic programming

Summary: Although the use of taxes and quotas can lead--in theory, at least--to equivalent outcomes, it is of use to know whether they will result in equivalent outcomes in real life. To do this, the authors of this paper start by developing a fishery model and comparing the competitive, optimal, taxation, and quota equilibria. They then use the Canadian Pacific halibut fishery as a case study in which to apply their model. The simulation results suggest that the differences between using an optimal tax or an individual boat quota are indeed relatively small. In light of the political difficulties associated with implementing a (considerable) tax of the optimal size, quotas may be a practical alternative form of management strategy.

Keywords: Externality, quota, regulation, taxation, tax, uncertainty, Pacific halibut, Canada, welfare

Citation: Arnason, Ragnar 1990 "Minimum Information Management in Fisheries" Canadian Journal of Economics 23(3):630-653.

Fishery: General

Management Issue: Market-based management

Technique: Theoretical

Summary: Given that full information or even relatively adequate data is not always available to fisheries managers, it is easy to wonder what regulatory options exist that can provide efficient management without requiring large amounts of information. This paper begins by looking at the basic theoretical fisheries model and its conclusion that open access will result in over-exploitation of the resource because firms do not, in fact, equate their marginal income with their marginal costs. The author then examines the differences between two regulatory schemes--a tax on catch and the use of individual catch quotas--and the amount of information required for optimal management. Because the individual transferable share quota (ITSQ) system can make use of existing market information--i.e., the market price of a quota--little more than ITSQ price monitoring is needed to provide adequate information about the fishery. Taxes, on the other hand, require relatively large amounts of information about the industry in order to set them at the efficient level. The author does note that there is one critical feature of ITSQs required for minimal information management: the quota must be permanent.

Keywords: Tax, quota, management, individual, transferable

Citation: Blomo, Vito J., John P. Nichols, Wade L. Griffin, and William E. Grant 1982 "Dynamic Modeling of Eastern Gulf of Mexico Shrimp Fishery" American Journal of Agricultural Economics 64(3):475-482.

Fishery: Shrimp, Gulf of Mexico

Management Issue: Comparison of regulations' effects

Technique: Bioeconomic simulation

Summary: The impact of time and area closures on a shrimp fishery is analyzed and compared to a baseline and to the situation of optimal utilization using simulation techniques. The fishery's biological attributes (individual growth, recruitment and spatial movement, natural and fishing mortality) and economic characteristics (differences in price according to the size of shrimp and a heterogenous fleet) are modeled in the simulation. The results show that regulations which reduce effort on small shrimp in shallow waters allow for increases in net economic value but that area and time closures do not achieve the maximum net economic value. The authors do note, however, that closed seasons can reduce gear conflicts with the stone crab fishery.

Keywords: Management, season, closed area, shrimp, Gulf of Mexico, stone crab

Citation: Butlin, John A. 1979 "The Welfare Costs of Structural Adjustment in the U.K. Fishing Industry" Fishery Economics Research Unit Occasional Papers Series, No. 1.

Fishery: General, U.K.

Management Issue: Evaluation of management strategies

Technique: Discussion

Summary: The transition from a situation of an open access fishery to that of a completely managed fishery is not necessarily a simple change. This paper examines how the U.K. fishing fleet could make such a transition, and by what process it could be transformed from one characterized by excess capacity to one characterized by optimal/economically efficient capacity. Following a discussion of the policy tools that could be used to induce this transition, the author examines the benefits and costs associated with such a structural change, the rate of change, and how it would occur (vessel buy back or retirement schemes, retraining and relocation, etc.). The most preferred policy was one combining a restrictive licensing scheme--with the allocation of licenses done via an auction in order to capture some of the resource rents--with a scheme for facilitating the transition of marginal participants out of the fishery.

Keywords: U.K., European Community, management, benefits, costs, welfare, fleet size, license

Citation: Campbell, Harry F. and Robert K. Linder 1990 "The Production of Fishing Effort and the Economic Performance of License Limitation Programs" Land Economics 66(1): 56-66.

Fishery: General

Management Issue: License limitation

Technique: Theoretical

Summary: It has been shown that there are potential (although second best) gains from gear restrictions and license limitation programs (Anderson, 1985). Overall efficiency of a limitation program depends 1) on the effect of a reduction in the level of use of selected fishing inputs on the level of fishing effort applied to the fish stock, and 2) on the extent to which total cost of fishing effort under a license limitation program exceeds the minimum total cost necessary to generate the same level of effort in an unrestricted fishery. The purpose of this paper is to examine the parameters of the production function for effort on the likely net social benefits of license limitation. Using a Schaefer model, they show that the restricted input will have to be reduced by greater than 50% in order to minimize the second-best gains. Then, using a constant elasticity production function for effort, they show that limitation programs will be more effective when non-restricted inputs cannot be easily substituted for restricted inputs (i.e., the elasticity of substitution is low) and when the restricted inputs enter the production function with a reasonably high productivity coefficient which implies that they are a significant proportion of total factor cost. Tables are provided which show the percentage of potential rent achieved as a function of productivity factors, input substitution, and percentage reduction in restricted inputs. The values range from 8% to 98%. Care should be taken when/if extrapolating these results to different fishery production models and different effort production functions.

Anderson, Lee G. 1985 "Potential Economic Benefits from Gear Restrictions and License Limitations in Fisheries Regulations" Land Economics 61(4):409-418.

Keywords: Limited entry, licenses

Citation: Campbell, H. F. 1991 "Estimating the Elasticity of Substitution between Restricted and Unrestricted Inputs in a Regulated Fishery: A Probit Approach" Journal of Environmental Economics and Management 20:262-274.

Fishery: Rock lobster, Tasmania

Management Issue: Estimating production models

Technique: Econometrics

Summary: License limitation schemes imitate the scarcity of a resource, and knowing the elasticity of substitution between inputs is of paramount importance because fishermen--when faced with limitations--will search for and adopt alternatives in order to continue unimpeded production activities. In this paper the authors estimate the elasticity of substitution between restricted and unrestricted inputs of the Tasmanian rock lobster fishery in order to determine the effectiveness of a license limitation program. A probit function is used to consider seasonal as well as locational choices made by the fishermen and then is incorporated into the Cobb-Douglas production function. The results show an elasticity of substitution between regulated and unregulated inputs to be 0.75, suggesting that a buy-back program for licenses may succeed in increasing rent from the fishery because alternative, unregulated inputs will not likely be substituted on a one-to-one basis.

Keywords: Production function, model, elasticity of substitution, Cobb-Douglas, inputs, license limitation, rock lobster, Tasmania

Citation: Clark, Ian N., Philip J. Major, and Nina Mollett 1988 "Development and Implementation of New Zealand's ITQ Management System" Marine Resource Economics 5(4):325-329.

Fishery: Multi-species, New Zealand

Management Issue: Control of effort, individual transferable quotas

Technique: Interpretive essay

Summary: Individual transferable quotas have the potential to correct for both the biological and economic weaknesses of traditional regulation techniques and limited license programs. New Zealand has the only full fledged ITQ system in the world, and it would behoove any agency considering ITQs to study the that country's experience carefully. This article and the one referenced below provide a good start for understanding their system. The details are so complex that no real summary is possible. However, the papers do discuss the initial allocation scheme (based on recent catch history with a buy-back program), the quota management system (how individual harvests are matched with individual quota holdings and how transfers of quota are reported and the results used to enforce the program), changes in industry structure, and current key issues. How to handle by-catch in a multi-species fishery has always been a management problem, and it does not go away with ITQs. Although participants can buy and sell quota units to account for by-catch, inadvertent catch of secondary species for which no quota is held will be inevitable. The system allows for this through forfeiture or quota swaps although both of these programs have weaknesses. Overfishing can sometimes be a problem for similar reasons. The amount of catch taken can be more than an individual's quota holdings. Retroactive trading and forfeiture are possible ways of addressing these problems. Another problem was that individual quotas were initially stated in terms of tons of fish, but to allow flexibility in setting total allowable catches, they are now measured as percentages of the annual TAC.

Note: See also Clark, Ian N. and A. J. Duncan 1986 "New Zealand's Fishery Management Policies - Past, Present, and Future" In Nina Mollett (ed), Fishery Access Control Programs Worldwide: University of Alaska Sea Grant College Program.

Keywords: Management, individual transferable quota, New Zealand, multi-species

Citation: Cohen, Marc-David 1989 "A Methodology for the Analysis of Fishery Management Policies, with an Example of the North Carolina Brown Shrimp Fishery" UNC Sea Grant College Publication, UNC-SG-WP-89-1.

Fishery: Brown shrimp, *Penaeus aztecus*, U.S., North Carolina

Management Issue: Optimal decision functions

Technique: Simulation model, discriminant analysis

Summary: The path towards a final management decision is neither a straight nor a clear-cut one; as a result, having an explicit decision making framework can be quite helpful. This paper provides a step-by-step methodology that can be used for analyzing the effects of various fishery management policies and provides an example of how to do this by applying the model in a case study of the North Carolina brown shrimp, *Penaeus aztecus*, fishery. Although the simulation model that is created here is described as a single comprehensive multiple cohort simulation model, it is really composed of several submodels that, respectively, deal with the fishery's population, biomass, economics, and revenues using a population dynamics model, a recruitment model, a biomass model, an economic model, and a revenue model. The decision making process is also formalized using the criteria of maximizing the fishery's net expected return. The methodology that is described and applied here provides an explicit, technical framework for formalized decision making.

Keywords: Brown shrimp, *Penaeus aztecus*, U.S., North Carolina, methodology, decision making, multiple cohort, discriminant analysis, Monte Carlo

Citation: Comitini, Salvatore, and Sutanto Hardjolukito 1986 "Economic Benefits and Costs of Alternative Arrangements for Tuna Fisheries Development in the Exclusive Economic Zone: The Case of Indonesia" Ocean Management 10:37-55.

Fishery: Tuna, Indonesia

Management Issue: Economic comparison of indigenous and state development

Technique: Benefit-cost accounting

Summary: This paper considers a variety of institutional arrangements for the harvest of a species within a coastal state's Exclusive Economic Zone (EEZ). Because there may be both indigenous and foreign enterprises that want to harvest a resource, knowing that the economic benefits associated with various combinations of access can provide a government with valuable management information.

Before Indonesia's 1980 declaration of a 200 mile EEZ, the tuna was largely exploited by state enterprises or under agreement with Japanese longline tuna fishermen. Although there is now an EEZ, these two groups are still the main ones wishing to harvest tuna in Indonesian waters; what now is useful to know is the economically optimal balance between these two groups.

Estimates of the benefits and costs are made for various arrangements using 1981 through 1985 data. The results show that, even with relatively low license fees, a licensing arrangement with foreign fleets is more economically efficient than promoting an indigenous fleet. These results are, as it is clearly stated, dependent on what the government seeks to optimize. If it has objectives other than economic efficiency, these may result in support of an indigenous fleet.

Keywords: Tuna, indigenous, development, policy, Indonesia, economics, benefits

Citation: Cook, B. A. and Parzival Copes 1987 "Optimal Levels for Canada's Pacific Halibut Catch" Marine Resource Economics 4(1):45-61.

Fishery: Pacific halibut, Canada

Management Issue: Potential economic gains from effort control

Technique: Bioeconomic modeling, Schaefer production model

Summary: A bioeconomic model is used to estimate the maximum economic yield of the Canadian halibut fishery. The maximand includes consumer surplus, resource rent, and intra-marginal rents to highliners. The last item is rarely considered in economic analysis, but it is of interest because fishermen often have different abilities and hence costs. A yield effort relationship (where effort is measured in standardized "skate soaks") and a market demand curve are estimated; cost data is obtained from previous studies. Optimum effort and catch are estimated, and it is shown that effort will have to be reduced. The analysis shows that by properly including consumer surplus and highliner rent, the required reduction in effort is less than would otherwise be the case. It is noted that translating reductions in skate soaks into reductions in vessels can be difficult.

An extension of the paper by one of the co-authors expands the discussion by including a dynamic analysis. No new empirical work is performed. The results show that, no matter what discount rate is used, the optimal stock size is on the right half of the growth curve (which indicates that the marginal stock effect is relatively large) and that the higher the discount rate, the lower the optimal stock size.

Note: See also Cook, B. A. 1988 "Discount Effects and Canada's Pacific Halibut Fishery" Marine Resource Economics 5(1):71-77.

Keywords: Management, optimal economic yield, dynamic analysis, highliner, Pacific halibut, Canada

Citation: Copes, Parzival, and B. A. Cook 1982 "Rationalization of Canada's Pacific Halibut Fishery" Ocean Management 8(2):151-175.

Fishery: Pacific halibut, Canada

Management Issue: Strategies for economic management

Technique: Interpretive essay

Summary: This paper traces the development and evolution of the Pacific halibut fishery--in particular, the Canadian Pacific halibut fishery--and its management in order to set the stage for a discussion of the fishery's rationalization, i.e., its more economically efficient management. Although the imposition of Canada's 200-mile limit reduced the size of the Canadian fishery, it also established the situation in which a more profitable fishery could potentially exist--if its current structure was changed. Various restructuring options such as the use of buy-back, licensing and tradable quota schemes are presented as ways to reduce the excess capacity in the fishery, to redirect effort to other fisheries, and to improve regulation of the fishery.

Keywords: Pacific halibut, jurisdiction, effort, economic efficiency, policy, Canada, joint management, U.S.

Citation: Crutchfield, James A. 1961 "An Economic Evaluation of Alternative Methods of Fishery Regulation" The Journal of Law and Economics 4:131-143.

Fishery: General

Management Issue: Results (unintentional and intentional) of management strategies

Technique: Essay

Summary: Although written more than two decades ago, this paper provides a lucid and extraordinary presentation of two issues that are still exceedingly pertinent to fisheries management and which are still not solved. The author accepts the assumptions that rational fisheries utilization requires limiting mortality and goes on to ask what is the effective method of doing so and which method will do so at the lowest long-run cost. The methods analyzed are those that either reduce mortality (e.g., the number of boats, area or time of fishing, gear used, amount harvestable, etc.) or regulate the age/size of the harvested fish (e.g., area, seasonal, or gear regulations). For each case the author presents a description or example of the form of regulation being analyzed and then discusses how such a regulation would affect the industry and, very importantly, how the industry might respond.

Keywords: Regulation, management, mortality, harvest, effort

Citation: Devaraj, M. 1982 "A Critique on Indian Ocean Fisheries Development" Ocean Management 8:97-123.

Fishery: General, Indian Ocean

Management Issue: International development and management

Technique: Interpretive essay, cost accounting

Summary: The underlying premise that the author of this article makes is that the primary objective of fisheries development is to contribute to general economic development, but that secondary objectives such as fisheries as a source of protein, employment, and export earnings cannot be ignored and may even take, in areas of the world such as those of the Indian Ocean region, primary importance.

An overview of the current status of fisheries' values and potential rates of growth precedes a discussion of the various development requirements such as production inputs of labor and capital, stable legal regimes, and (the role of) international programs. Having presented the state of the ocean and development needs, the paper ends with an analysis of the development prospects and needs for the nine geographical/ecological provinces that extend from east Africa to Western Australia.

Keywords: Development, geographical management, policy, programs, Indian Ocean

Citation: DeVoretz, Don, and Richard Schwindt 1985 "Harvesting Canadian Fish and Rents: A Partial Review of the Report of the Commission on Canadian Pacific Fisheries Policy" Marine Resource Economics 1(4):347-367.

Fishery: Salmon, herring, Canada

Management Issue: Reduction of effort

Technique: Econometrics

Summary: In 1982 a Canadian Royal Commission recommended a joint scheme of catch royalties and a license auction plan to alleviate the problem of excess effort in the west coast fisheries. This paper investigates the impact of these two policies. First, the total royalty revenue is measured and then the royalty incidence across fishermen, processors, and consumers is estimated. Using estimates of demand and supply elasticities for the different fish, the different way they can be processed, and the different markets where they can be sold, the authors conclude that harvesters will bear only part, sometimes as little as one third, of the burden of the taxes. Depending on the exact situation, the rest will be passed on, in varying proportions, to foreign consumers, domestic consumers, and processors. It is estimated that the overall burden of the tax program will not be too onerous. Looking at it from the other way around, the revenues raised will be so small that they will make only a minor contribution to the cost of buy back and enhancement programs. The license auction scheme is also analyzed in order to calculate the costs of purchasing the licenses to the fishermen and the net proceeds to the government after the retirement of one-half the fleet under alternative possible selling strategies of fishermen. It is shown that the revenues generated by the license and the tax programs together could most likely fund the buy back program with some left over. However, the auction scheme introduces considerable uncertainty into fishermen's decision making, especially during the transitional period. This paper is a good example of how to use basic economic theory to estimate the efficiency and distributional effects of various policies.

Keywords: Taxes, buyback, salmon, herring, Canada

Citation: Doulman, David J. 1987 "Licensing Distant-water Tuna Fleets in Papua New Guinea" Marine Policy 11(1):16-28.

Fishery: Tuna, Papua New Guinea

Management Issue: Extraction of resource rents

Technique: Discussion

Summary: This paper examines the domestic and foreign fleets' exploitation of tuna in Papua New Guinea. Because biologists have determined that the maximum sustainable yield presently exceeds quantity harvested, the licensing of fleets is evaluated form the perspective of trying to balance biological and economic considerations. Current access agreements, fees, harvesting information, and total revenue received are analyzed to see how regional management agreements, specifically by the Nauru group countries, can coordinate objectives in forming a licensing strategy. Because of the burdensome enforcement costs of such agreements, compliance (and sanctions in cases of non-compliance) is perceived to be critically important as part of a concerted effort. For the best strategy, Papua New Guinea will have to require equal access fees to all distant-water fishing fleets, and these fees ought to cover the costs of administration, surveillance and enforcement.

Keywords: Access, fees, tuna, Papua New Guinea, distant-water fleet, resource rent, license

Citation: Dupont, Diane P. 1991 "Testing for Input Substitution in a Regulated Fishery" American Journal of Agricultural Economics February, 155-164.

Fishery: Salmon, Canada, British Columbia

Management Issue: Efficacy of input restrictions

Technique: Econometrics

Summary: Because fishing regulation often includes restriction of various inputs (such as gear) into a fishery, this paper addresses the issue of the extent to which such restrictions merely result in the use of substitute inputs. Elasticities of intensity are estimated for the seine and gillnet-troll fleets, two fleets that are represented as two extreme forms of inputs (gear) subject to management in the British Columbia, Canada salmon fishery. (In cases where some inputs are regulated, the calculation of the elasticity of input substitution is measured using the elasticity of intensity.) There are both direct and indirect substitution effects, making the use of input control/gear restriction programs as a management tool a difficult task, at best. The information provided here does, however, give managers ideas about the outcomes that may result when using such controls.

Keywords: Input substitution, regulation, price elasticity, salmon, British Columbia, Canada

Citation: Easley, J. E., Jr., and Fred J. Prochaska 1987 "Allocating Harvests Between Competing Users in Fishery Management Decisions: Appropriate Economic Measures for Valuation" Marine Fisheries Review 49(3):29-33.

Fishery: General

Management Issue: Allocation and distributional issues

Technique: Discussion

Summary: Conflicts between competing resource users is certainly not a new issue for fisheries managers, and allocation or distributional issues are frequently a sticking point in management decisions. To the extent that distributional issues are of importance to and influence managers, the authors question why the economic models--that are supposedly intended to held with decision making--do not incorporate distributional issues. They come up with two ways that economists could help managers in their decision making: 1) develop more complete and perhaps more general theoretical and quantitative models that deal with the allocation issue, and 2) consider property rights schemes as a mechanism for allocation harvest between competing user groups.

Keywords: Economic efficiency, management, criteria, social welfare, distributional issues, policy, property rights, allocation

Citation: FAO 1985 "Report of the Expert Consultation on the Acquisition of Socio-Economic Information in Fisheries (with particular reference to small-scale fisheries)" FAO Fisheries Report No. 344, 21 pages.

Fishery: General

Management Issue: Socio-economic information

Technique: Minutes of the 1985 Rome meeting, 30 July-2 August

Summary: The need for and use of socio-economic information in fisheries management and development planning are discussed, and the difficulties in acquiring such information are reviewed. The report concludes that the choice of the relevant kinds of socio-economic data and of the appropriate approaches to their acquisition will largely depend on the varied development and management decisions faced by fishery administrators and the specific problems and conditions of the fishery or fisheries under consideration. A tentative list indicating the sort of information requirements that are helpful for management is appended, as are the recommendations made at the meeting regarding desirable follow-up action.

Keywords: Development, welfare, income, management, policy, information, data

Citation: Fletcher, Jerald J., Richard E. Howitt, and Warren E. Johnston 1987 "Management of Multipurpose Heterogeneous Fishing Fleets under Uncertainty" Marine Resource Economics 4(4):249-270.

Fishery: Dungeness crab, salmon

Management Issue: Multiple stock management, switching, comparison of various management techniques

Technique: Bioeconomic model

Summary: This paper presents an approach to quantitative economic analysis of commercial fisheries that can provide useful management advice given existing theoretical and data limitations. The model provides an analysis of fishermen's decisions in both the short-run (where to fish in a season when the boat can not be changed drastically) and in the long run (what kind of changes to the vessel are possible). Because it is not possible to build a formal bioeconomic model, a multivariate, linear, time-series Box-Cox model is used to show intertemporal relationships for various policies for the Dungeness crab fishery. The intra-seasonal model shows that heterogeneous vessels in an open-access fishery results in inefficient allocation of the existing boats as well as long term over-capitalization. The intra-seasonal behavioral model and the inter-seasonal time-series model are combined in a Monte Carlo simulation to analyze the direct effects of catch limitation, license restrictions, and season changes on the crab fishery, and the indirect effects such changes have on the salmon fishery. The results show that a given program can have drastically different results on vessels of different size or configuration.

Keywords: Management, multiple species, Dungeness crab, salmon

Citation: Fogarty, Michael J., Andrew A. Rosenberg, and Michael P. Sissenwine 1992 "Sources of Uncertainty: A Case Study of Georges Bank Haddock" Environmental Science and Technology 26(3):440-447.

Fishery: Haddock, U.S., Georges Bank

Management Issue: Management under uncertainty

Technique: Risk analysis

Summary: Because resource managers are not typically faced with complete information, it is reasonable to conclude that management strategies could benefit from risk assessments that account for the uncertainties existing with respect to populations, harvests, and species interactions. This paper presents some ways to deal with risk and uncertainty in the three areas of (1) population estimation and demographic parameter errors, (2) randomness between or a lack of information about the spawning biomass and subsequent recruitment, and (3) ignorance about interactions among populations of the same species and of different species, i.e., intra- and interspecific interactions. The authors discuss some of the issues associated with conserving a species before shifting to their application to a case study of the Georges Bank haddock fishery. Caveats pertaining to the modeling assumptions conclude the article.

Keywords: Risk, assessment, depletion, conservation, extinction, probability, threshold, haddock, Georges Bank

Citation: Forrest, Janet E. 1981 "Development of the East Coast Fishing Industry: Assessment of Canadian Government Policies" Marine Policy October:294-301.

Fishery: General, Canada, East Coast

Management Issue: Alternative development options/practices

Technique: Essay

Summary: This paper examines Canadian fisheries policy since the extension of Canadian jurisdiction out to 200 miles (since 1976) and, in particular, three new policies that were implemented that are unique to the Canadian East Coast fishing industry: the 'over-the-side' sales policy, the developmental charter policy, and the commensurate benefits policy. The author describes the major beneficial and negative aspects of these programs, noting that the largest numbers of complaints have focused on the distribution of benefits that the programs provided to some, but not all, fishery sectors. (Although the developmental charter policy and the 'over-the-side' sales policy both increased Canadian fish sales, the benefits of these programs went to a relatively small sector of the industry.) The commensurate benefits policy has not had an overwhelmingly positive impact. The article concludes with a call for continued decreases in government intervention (these three policies were interim ones) and for increases in the level of policy-making involvement by the fishing industry.

Keywords: Development, technology, policy, sector, Canada, East Coast, Atlantic

Citation: Gardner, Michael 1988 "Enterprise Allocation System in the Offshore Groundfish Sector in Atlantic Canada" Marine Resource Economics 5(4): 389-454.

Fishery: Multi-species groundfish, Canada

Management Issue: Control of effort, individual transferable quota

Technique: Interpretive essay

Summary: Canada has a modified ITQ system called Enterprise Allocations (EA). They were implemented to reduce short term problems due to competitive fishery and not to address economic efficiency problems per se. EAs are not freely transferable and they may not be harvested with the technology that the owner may necessarily prefer. These restrictions obviously restrict the potential for efficiency maximizing behavior. Even so, EAs have been beneficial in promoting efficiency and value-maximizing behavior. The race of fish and its ill effects on quality, both in harvesting and processing, has been eliminated. Excess harvesting capacity has been retired and vessel replacements and modifications have been introduced which will promote better use of the resource. The EA system has allowed firms to become responsive to market demand in terms of harvesting strategies, rather than just trying to maximize catch. This has had some effect on worker compensation because share systems which encourage the greatest catch of what ever is there, does not necessarily produce what the market wants or what the company is allowed to harvest. The actual cost of harvesting and processing each unit of output has gone up in some cases, but this has been due to the opportunity to concentrate on quality output. The increase in the value of the output more that compensates for the increase in costs.

Keywords: Management, individual transferable quota, enterprise allocation, Canada, multi-species

Citation: Gates, Paul D., and Karl C. Samples 1986 "Dynamics of Fleet Composition and Vessel Fishing Patterns in the Northwestern Hawaiian Islands Commercial Lobster Fishery: 1983-86" National Marine Fisheries Service, Southwest Fisheries Center Administrative Report H-86-17C.

Fishery: Lobster, U.S., Northwestern Hawaiian Islands

Management Issue: Dynamics of fleet composition and operations

Technique: Interpretive essay

Summary: Over the decade of commercial exploitation of the Northwestern Hawaiian Islands' (NWHI) lobster stocks, both the fleet's composition and the geographic scope of activities have been quite dynamic, growing to be one of Hawaii's single most important commercial fisheries. (The 1985 landings of NWHI lobsters were roughly 2 million pounds and had an ex-vessel value of $4.9 million.) Although the expansion of this fishery has been documented, the dynamics of fleet composition and operations have not been examined in detail.

This report describes the operational dynamics--the changes in the fleet's composition and operations-- for the fishery during the period 1983-1986 when the fishery was under the Spiny Lobster Fishery Management Plan (FMP) for the western Pacific. Vessels' entry and exit, active and inactive vessels, fleet capacity, and the fishery's historical profile are characterized.

Keywords: Fleet composition, dynamics, lobster, Northwestern Hawaiian Islands

Citation: Geen, Gerry and Mark Nayar 1988 "Individual Transferable Quotas in the Southern Bluefish Tuna Fishery: An Economic Appraisal" Marine Resource Economics 5:(4):365-387.

Fishery: Tuna

Management Issue: Control of effort, individual transferable quota, comparison of management techniques

Technique: Bioeconomic simulation model

Summary: A bioeconomic model composed of a biological component (natural mortality, recruitment, spawning stock, stock abundance), a physical component (catch coefficients, catch per unit of effort, and total effort) and an economic component (revenue and cost per boat, expected profit per boat, vessel entry and exit) is used to examine the effects of alternative management regimes on fleet size, capital, employment, and profitability. The simulations compare an aggregate quota program (with unconstrained vessel entry and with a limited license program) to an individual transferable quota program. The simulation results for ITQs are similar to the actual behavior of the fishery, and the economic results confirm the theoretical expectations that ITQs will produce smaller fleet sizes and increased profit. The analysis distinguishes between resource rent and highliner rent and shows why the economic adjustment under ITQs was very rapid. The possibility of using the ITQs to transfer catch from the canning market to the Japanese fresh market caused large movements of quota to South Australia in a very short time.

Keywords: Management, individual transferable quota, tuna, Japan, South Australia

Citation: Gillmor, Desmond A. 1987 The Irish Sea Fisheries: Development and Curtailment of a Renewable Resource Industry" American Journal of Economics and Sociology 46(2):165-178.

Fishery: General, Ireland

Management Issue: Fisheries development

Technique: Discussion

Summary: The volume of the sea fish catch in the Republic of Ireland increased by 16 times during the period 1950-82. Influences contributing to development included active promotion by a State agency, government funding, fleet expansion, growth in the labor force, establishment of processing, and development of domestic and export markets. Fish landings became more concentrated in the major ports and along the less developed west coast. Fishery expansion is now curtailed by resource problems. These are partly the result of pressures exerted by foreign fleets, now within the context of the European Economic Community (EEC). Internal conflicts have arisen through competition between Irish fishermen for scarcer resources. The major needs in this new phase of the industry are for restructuring of the fleet, exploitation of new stocks, resource conservation, development of mariculture, more advanced processing and marketing, and comprehensive policy formulation.

Keywords: Fishery development, restructuring, policy, Ireland, EEC, European Community

Citation: Hagan, Philip, and Gary Henry 1987 "Potential Effects of Differing Management Programs on the Southern Bluefin Tuna Fishery" Marine Resource Economics 3(4):353-389.

Fishery: Southern Bluefin tuna

Management Issue: International joint management

Technique: Bioeconomic simulation

Summary: This paper develops a model of the Southern Bluefin Tuna fishery to explore the likely biological and economic consequences of various management regimes. Issues addressed include both regional and international aspects since these fish are exploited by Japanese, New Zealand, and Australian fishermen. The model was constructed by the Australian government to help devise its negotiating position with the Japanese on joint utilization of the stocks. Different management regimes can be simulated by setting a global catch limit and allocating it to the different sub-fisheries. The model estimates how many fish would have to be caught to catch the quota, and how many boats producing what amounts of effort would be needed to catch that many fish. The economic profit of each fleet can then be calculated. The status of the stock is updated by figuring cohort size based on natural and fishing mortality and recruitment. The process is then repeated. Simulation results from the model suggest that there exists an annual sustainable level of catch on the part of Australian and Japanese fishermen which would maintain fish stocks at a "safe" level; however, this level of catch, as well as its composition, is not unique and thus there is room for negotiation between the major fishing nations on a mutually agreeable management program. The model also suggests that the effects of heavy fishing of younger fish early in their migratory path has disproportionate consequences for all other users of the resource, and that there exists some form of socially acceptable tradeoff between biological and economic objectives.

Keywords: International management, Southern Bluefin tuna, Japan, Australia, New Zealand

Citation: Hannesson, Rögnvaldur 1990 "Are Stable TAC's Desirable" In A. Guimaraes Rodrigues (ed.), Operations Research and Management in Fishing, Kluwer Academic Publishers, 111-122.

Fishery: Arcto-Norwegian cod

Management Issue: Comparison of mortality- and effort-based management

Technique: Bioeconomic simulation

Summary: If fisheries management can result in populations that are stable over time, the question of how to management the (subsequently) stable total allowable catch (TAC) can arise. This paper addresses the issue of whether TACs should be set on a basis of constant fishing mortality or whether they should be set at a stable, unchanging level. The argument around setting stable annual catches hinges on two issues: 1) the degree to which the industry is risk adverse and would prefer constant catches, even if they may miss out on potential harvest during "good" years; and 2) the degree to which stable catches may be more profitable than variable ones. The model developed here considers whether effort levels will be destabilized by stable TACs or if the profit level of the industry will increase; it is applied in a case study and simulation of the Arcto-Norwegian cod fishery. On the basis of this application, the author concludes that the difference between these two approaches is relatively small.

Note: An expanded version of this paper (also in this bibliography) is:
Hannesson, Rögnvaldur, and Stein Ivar Steinshamn 1991 "How to Set Catch Quotas: Constant Effort or Constant Catch?" Journal of Environmental Economics and Management 20:71-91.

Keywords: Management, TAC, quotas, total allowable catch, Arcto-Norwegian cod

Citation: Hannesson, Rögnvaldur, and Stein Ivar Steinshamn 1991 "How to Set Catch Quotas: Constant Effort or Constant Catch?" Journal of Environmental Economics and Management 20:71-91.

Fishery: Arcto-Norwegian cod

Management Issue: Optimal management strategies

Technique: Bioeconomic simulation

Summary: This paper is an expansion of R. Hannesson's 1990 paper "Are Stable TAC's Desirable?" that is also in this bibliography. The author considers the issue of setting total allowable catch (TAC) for a fishery on the basis of either a constant, annual quantity or as a constant level of effort. The theoretical discussion is expanded in this paper to include the effects of cost and revenue functions and profit, and the application of the model to the Arcto-norwegian cod fishery has been expanded to consider a number of cost and revenue functions/cases.

Keywords: Total allowable catch, TAC, management, quota, Arcto-Norwegian cod, effort

Citation: Harris, Curtis C., Jr., and Virgil J. Norton 1978 "The Role of Economic Models in Evaluating Commercial Fishery Resources" American Journal of Agricultural Economics 60(5):1013-1019.

Fishery: General

Management Issue: Choice of economic framework for fishery decisions

Technique: Analytical discussion

Summary: If there are multiple users of a limited resource, there is a tendency for conflicts to arise between users. To help settle such conflicts, it is helpful to have estimates of how the respective users value the resource. These estimates are, in fact, required when planning federal fishery research and development projects, and they can be useful in resolving conflicts between commercial and recreational fishermen, between domestic and foreign fishermen, or between the fishing industry and other industries.

The authors focus on the less-used measurement approach of the market-value, on the grounds that the other form of valuation technique--the willingness-to-pay approach--has received more attention, and they look at how static and dynamic input-output models provide regional information about the economic impacts of management. Their conclusion is that input-output models--particularly dynamic ones--provide valuable regional information for fisheries managers.

Keywords: Management, willingness-to-pay, input-output, market value

Citation: Higgs, Robert 1982 "Legally Induced Technical Regress in the Washington Salmon Fishery" Research in Economic History 7:55-96.

Fishery: Salmon, U.S., Washington

Management Issue: Evolution of Management

Technique: Essay

Summary: This article tells the story of the Washington salmon fisheries' decline that has, in many senses, been imposed on the fishery by means of inefficient management. The author details the fishery's decline from a legal perspective and shows how the changing legal organization of the fishery caused many of its problems. The article contains neat explanations of the physical and biological rudiments of the fishery, the aboriginal fishery, and its evolution prior to and after 1934--when a key, legislatively imposed change in the fishery's management occurred. An appendix describing salmon fishing gear is included.

Keywords: Management, salmon, property rights, Puget Sound, Columbia River, law

Citation: Holt, Sidney 1985 "Whale Mining, Whale Saving" Marine Policy July:192-213.

Fishery: Whales

Management Issue: International management

Technique: Essay

Summary: This paper traces the evolution of the International Whaling Commission (IWC), detailing the events of 1979 and 1982, and what has happened since, thus providing the sort of comprehensive background needed to be able to understand the problems that go along with a whaling moratorium. The authors describes the sorts of difficulties that can be encountered in a resource management group composed of a broad spectrum of resource users.

Keywords: Management, whaling, International Whaling Commission, IWC, moratorium, Convention on International trade in Endangered Species of Fauna and Flora, CITES

Citation: Huppert, Daniel D. 1988 "Managing Alaska Groundfish: Current Problems and Management Alternatives" Fisheries Management Foundation and Fisheries Research Institute, FMF-FRI-001.

Fishery: Groundfish, U.S., Alaska

Management Issue: Management problems and alternatives

Technique: Interpretive essay

Summary: Rich fishery resources can provide fishery managers with a dual that is both delightful and problematic, and the Alaska groundfish fishery in the Gulf of Alaska and the Bering Sea is a marvelous example of this. The fishery has enormous economic potential, yet it represents an extremely complicated management task because of the potential physical damage it may inflict on other valuable fisheries in the area s well as the potential economic "damage" that may occur with overcapitalization and overexploitation of the resource.

After outlining the fishery's current problems, the author details a variety of management goals and the conventional regulations that may be implemented to achieve these. He then discusses an alternative form of regulation--limited access--and its associated advantages and disadvantages. Two strategies--a license limitation system that is followed by an ITQ system and a system that immediately implements the use of ITQs--for the groundfish fishery's future management are presented in a step-by-step description of how they could be, respectively, implemented.

Keywords: Management, Alaska, U.S., groundfish, limited access, rights, individual transferable quotas

Citation: Huppert, Daniel D., and Dale Squires 1987 "Potential Economic Benefits and Optimum Fleet Size in the Pacific Coast Trawl Fleet" Marine Resource Economics 3(4):297-318.

Fishery: Multi-species trawl, Pacific coast

Management Issue: Potential economic gain from management

Technique: Mixed integer programming

Summary: This paper reports on a study using a mixed integer programming model to measure the potential economic returns to the Pacific coast groundfish fishery. The fishery is represented using a linear production model which assumes that each type of effort is supplied at fixed costs and that the catch is proportional to effort. The model computes the fishery's maximum economic surplus subject to the constraints on allowable catches and on the amount of effort each boat can produce. Fish prices, fixed and variable costs, and catch rates are estimated from real world data and are used to generate the solution which provides the optimum number of vessels, the optimum allocation of fishing effort, and maximum economic value. The results show that a maximum economic profit of about $12 million could be generated by a trawl fleet that is about 38 percent smaller than the baseline 1984 fleet if there was a 23 percent reduction in the number of weeks fished. Another important conclusion is that economic profits would suffer if fishing vessels were prevented from shifting among groundfish, pink shrimp, and joint venture fisheries.

Keywords: Optimal economic yield, multi-species, Pacific, groundfish

Citation: Jacobson, Peter C., and William W. Taylor 1985 "Simulation of Harvest Strategies for a Fluctuating Population of Whitefish" North American Journal of Fisheries Management 5:537-546.

Fishery: Whitefish, *Coregonus clupeaformis*, U.S., Lake Michigan

Management Issue: Comparison of management strategies

Technique: Simulation model

Summary: Comparisons of management strategies that, ostensibly, achieve the same management goal can be helpful for spotting strengths of weaknesses of different forms of regulation. This is especially useful if, as in this instance, the type of regulation has not yet been chosen. The simulation model presented here examines the two strategies of constant yield (via a constant quota) and of constant effort and uses the lake whitefish (*Coregonus clupeaformis*) of northern Lake Michigan as a case study. Because the lake whitefish populations have a tendency to fluctuate, the model is a continuous time, age-structured, dynamic pool model that incorporates a stock-recruitment function that captures the density-independent randomness of the fishery's recruitment pattern. The growth, mortality, recruitment, and yield functions are described independently before the authors move to a discussion of the way that the computer implementation and simulation was done. The simulation results show that the effort management strategy would result in a higher sustainable yield than would the quota management system, and that it would do so with less risk of stock collapse. The smaller yields under a quota system would, however, result in less variable harvests.

Keywords: Management, whitefish, *Coregonus clupeaformis*, U.S., Lake Michigan, quota, effort

Citation: Karpoff, Jonathan M. 1984 "Insights from the Markets for Limited Entry Permits in Alaska" Canadian Journal of Fisheries and Aquatic Sciences 41:1160-1166.

Fishery: General, U.S., Alaska

Management Issue: Permit pricing

Technique: Econometrics

Summary: This paper examines the Alaskan entry limitation program's effect on market structure through the purchase and sale of permits. In order to determine if permits truly reflect information about a multitude of issues--fishermen's incomes, predictions of expected income, anticipated stock sizes, the effects of the state loan program for permit purchases and investment risks--permits are treated as capital assets. The author examines these assets to determine which issues are responsible for price changes and to clarify how the permit price levels may vary, i.e., as fishermen revise their expectations. The author shows that prices are a function of income level and are influenced by the Alaska Department of Fish and Game's forecast of fish run, the availability of low-interest loans, past experiences relating to long-term investment, and an average nominal discount rate that is related to risk. Permit prices appear to be revised every 2.56 years and the nominal risk premium (averaged across all the salmon fisheries) was estimated to be 13.95% during the 1976 to 1981 period.

Keywords: Limited entry, permit price, U.S., Alaska, income, expectations

Citation: Karpoff, Jonathan M. 1984 "Low-Interest Loans and the Markets for Limited Entry Permits in the Alaska Salmon Fisheries" Land Economics 60(1):69-80.

Fishery: Salmon, Alaska, U.S.

Management Issue: Supply and demand analysis

Technique: Econometrics

Summary: In 1973 the State of Alaska passed the Limited Entry Act to limit entry to its salmon fisheries and to mitigate some of the rent dissipation occurring under open access to the fisheries. Although the intent of the limited entry program was to limit entry into Alaska's salmon fisheries, the state also set up a loan subsidy program to help fishermen, particularly new ones, purchase permits to enter the fisheries. This paper quantifies the impacts of Alaska's program to provide low interest loans for the purchase of limited access permits in salmon fisheries.

To quantify the effects of the loan subsidy program, the author has used a supply and demand analysis that evaluates changes in the supply of permits, their price, and the market for them. Permit price data from 1979 is used for the empirical work on price changes, and a monthly time series with data from 1975 through 1982 was used for estimating volume of, or changes in the number of, transfers. The results show that, in the year after the loan program took effect (1979), prices increased 23% over and above any speculation about the quality of that season and that permit transfers increased 21.9%.

Keywords: Salmon, U.S., Alaska, limited entry, subsidy, loan, permits, prices, supply, demand

Citation: Karpoff, Jonathan M. 1985 "Non-Pecuniary Benefits in Commercial Fishing: Empirical Findings from the Alaska Salmon Fisheries" Economic Inquiry 23:159-174.

Fishery: Salmon, Alaska, U.S.

Management Issue: Estimation of non-pecuniary benefits of fishing

Technique: Econometrics

Summary: One of the motivations for using limited entry systems is that they can help reduce the level of effort going into a fishery, often by reducing the number of participants who are not making a profit. This paper looks at the limited entry permit system that is in effect for the Alaska salmon fisheries, focusing on those participants who might be expected to leave the fishery because of low revenues. The prices of the transferable permits have risen considerably since the 1975 initial allocation occurred, although profits have not necessarily risen for all participants by the same amount. This led the author to inquire whether or not the permit holders derived more than just monetary benefits from the fishery. Data on net incomes was examined to determine if non-pecuniary benefits did exist. The consistent financial losses that some fishermen bore indicated that non-pecuniary benefits were a factor, particularly for low revenue fishermen.

Keywords: Non-pecuniary, limited entry, licenses, income, rent, permit price, utility

Citation: Karpoff, Jonathan M. 1987 "Suboptimal Controls in Common Resource Management: The Case of the Fishery" Journal of Political Economy 95(1):179-194.

Fishery: General

Management Issue: Discrepancy between theory and regulation

Technique: Theoretical analysis

Summary: If economic models can so clearly depict the inefficiencies that fisheries managers know all too well, why do inefficient regulatory schemes persist? The author proposes and supports two joint hypotheses as to why such schemes persist. The basis for his conclusion rests on a theory that virtually each and every fisherman has considerable incentive to act in his own self interest. To the extent that such traditional controls as gear and vessel restrictions promote a redistribution of wealth--a redistribution that is not necessarily towards the most efficient fishing operations, but that can result in personal gain--the author concludes that fishermen will support regulations that promote this feature. Drawing from work he has done regarding the Pacific salmon, the author provides evidence that regulations are, in fact, the product of non-homogeneous individuals acting in their respective self-interest.

Keywords: Management, income distribution, self-interest, incentive

Citation: Katz, Philip L., and L. J. Bledsoe 1977 "Alaska Shellfish Regulations: Present Impacts on Fishery Participants" Transactions of the American Fisheries Society 106(6):505-529.

Fishery: King crab, tanner crab, shrimp, U.S., Alaska

Management Issue: Impact of regulation on participants

Technique: Essay

Summary: This paper looks at the effects of the 1975-1976 Alaska shellfish regulations that allocated catch between different types of vessels in the shellfish fisheries in the Gulf of Alaska (west of Yakutat) and the Eastern Bering Sea. Regulations in the form of area restrictions, season and scheduling restrictions, and catch allocations were intended to conserve stocks. In addition to the stated intent of conservation, the regulations also created advantages and disadvantages for participants and non-participants, respectively. Because vessels could also move into the potential groundfish fishery, some of the side effects of crabbing regulations on these participants were also examined from the perspective of how shellfish vessels might exploit both fisheries.

Keywords: King crab, tanner crab, shrimp, groundfish, national standards, state, regulation, federal, politics, U.S., Western Gulf of Alaska, Eastern Bering Sea, Alaska Board of Fish and Game

Citation: Katz, Eliakim, and J. Barry Smith 1988 "Rent-Seeking and Optimal Regulation in Replenishable Resource Industries" Public Choice 59:22-36.

Fishery: General

Management Issue: Quotas as a management tool

Technique: Theoretical analysis

Summary: A considerable amount of attention has been devoted in fisheries management literature to the problems of exploiting a common property resource (and the accompanying lack of socially optimal utilization of a resource) and to how these problems may be resolved so that the resource rents are not dissipated. However, much less effort has been directed towards analyzing how the existence of positive rents can affect the firms' behavior, what the implication are of the rents on the resource stock, and how rents can affect the time path for achieving the resource's management goals. Does rent seeking behavior, the authors ask, inevitably dissipate all the rents, all the potential gains of the resource that is managed in an economically efficient manner? The authors conclude that rent seeking behavior will increase the economically efficient level of fishery production relative to the economically efficient output level that does not account for rent seeking behavior.

Keywords: Management, quota, rent, welfare, social

Citation: Kennedy, John O. S., and James W. Watkins 1985 "The Impact of Quotas on the Southern Bluefin Tuna Fishery" Australian Journal of Agricultural Economics 29(1):63-83.

Fishery: Southern bluefin tuna, Australia, Japan

Management Issue: International management, stock rebuilding

Technique: Recursive quadratic programming

Summary: Recent increases in the harvests of southern bluefin tuna, particularly by Australian fishermen, have led to the recognition that the fishery is overexploited. A model is developed to examine the effects that quotas on Australian and Japanese harvesting would have on economic welfare and on stock levels. Recursive quadratic programming is used to simulate harvesting decisions through time, with and without the imposition of quotas. With no quotas it is assumed that harvest will be at a level where average cost equals average revenue. The biological benefit of the quotas will be the difference between the two harvest levels. Recursive programming involves myopic sub-optimization on a year to year basis. In each year, the decision maker is assumed to discount the future because of uncertainty so that only current profits are considered. This model is appropriate for open-access fisheries because they are subject to uncertainty regarding prices, costs, and stock size and, in addition, the lack of property rights to the fishery make it rational for individuals to use myopic decision making. The results indicate that while quotas will increase stock size, open-access utilization will not drive the stock to low levels because profits will become negative before that occurs.

Keywords: International management, Australia, Japan, southern bluefin tuna

Citation: Kennedy, John O. S., and James W. Watkins 1986 "Time-Dependent Quotas for the Southern Bluefin Tuna Fishery" Marine Resource Economics 2(4):293-313.

Fishery: Southern Bluefin Tuna, Australia

Management Issue: International management

Technique: Dynamic programming

Summary: Evidence suggests that the southern bluefin tuna fishery has been overexploited and that harvests must be controlled. This paper presents a dynamic programming model applicable to multicohort fisheries which can estimate approximately optimal time-dependent quotas. The quotas are specified by age group and year. The model takes the differences in the harvesting sector of two competing fishing countries into account. The harvesting costs of each fleet are assumed to vary with the level of harvest of each age category and on the operations of the other country's fleet. The price of output depends upon quantity harvested and the landing location. The model can be used for a single period or for optimization over many periods, and it can consider the gains to either country or to both. Results from applying the model to the southern bluefin tuna fishery indicate that restricting or eliminating the Australian catch of under 4-year-olds would benefit both countries. Because the optimal utilization of fisheries is fundamentally a dynamic problem, dynamic programming is a potentially useful tool for analysis. This paper is a good example of how it can be used.

Keywords: Management, multiple cohort, southern bluefin tuna, Australia

Citation: Koslow, J. Anthony 1982 "Limited Entry Policy and the Bristol Bay, Alaska Salmon Fishermen" Canadian Journal of Fisheries and Aquatic Sciences 39(3):415-425.

Fishery: Salmon, U.S., Alaska, Bristol Bay

Management Issue: Socioeconomic impact of limited entry licensing

Technique: Survey, interpretive essay

Summary: Because the socioeconomic impact of limited entry on a fishery depends on the character of the fishing community and the limited entry program, and because the economic gains that limited entry is intended to generate may involve trade-offs within the community, it is useful to know both how and who a limited entry program affects. The Bristol Bay, Alaska salmon fishery is such a fishery where a limited entry program was instituted and the variety of social fishing groups--full- and part-time fishermen, those with and without alternative incomes, and those who are part of traditional fishing families or culture--makes the study of the program's impact on these groups more consistent. (The data for the study is the result of surveys taken during 1979.)

The author found that the limited entry system reduced access of the local population to the fishery for several reasons. First, because of the reporting requirements on which the initial allocation was made, a large proportion of the local fishermen were initially denied entry permits. Second, the poorer fishing earnings of local fishermen and the generally poor local economy led to a drain of permits from the local areas (as permits were sold out of the community). The gains of the limited entry system mostly accrued to urban Alaskan and non-Alaskan fishermen who were more politically effective. The author concludes that limited entry programs need to be based on a better understanding of the socioeconomic and cultural characteristics of the communities involved in order to avoid such redistributions of wealth.

Keywords: Limited entry, U.S., Alaska, Bristol Bay, salmon fishery, socioeconomic, *Oncorhynchus nerka*, fishery management, participants, aboriginal

Citation: Libecap, Gary D. 1989 "Distributional Issues in Contracting for Property Rights" Journal of Institutional and Theoretical Economics 145:6-24.

Fishery: General

Management Issue: Assignment of property rights

Technique: Essay

Summary: Although common property situations exist in a variety of resource settings, the solution of problems arising from the lack of defined property rights has not generated a coherent system in which rights are defined in a predictable manner. The author of this article compares four solutions to common property problems using case studies of private rights for minerals (on federal lands), for crude oil production, for timber and agriculture production, and for fisheries. These cases differ in their complexity and in the degree to which rights are definable; the more complex the assignment of rights has been, the greater were the conflicts over distributional issues and the smaller were the benefits after accounting for resolving these conflicts.

Keywords: Management, property rights, minerals, fisheries, timber, oil, common property

Citation: McElroy, J. K. (editor) 1983 "Provisional World List of Computer Programmes for Fish Production (Including Aquaculture) and Fisheries Management" University of Stirling (Scotland) Discussion Paper No. 37.

Fishery: World

Management Issue: Fishery production and management computer programs

Technique: Annotated catalogue

Summary: This report is an annotated compilation of the computer programs--dealing with fisheries development, management, and production--that were available as of early 1983. The programs are from Australia, Canada, Norway, the United Kingdom, and the United States. The catalog includes information about the originating organization (and its address), the source/creator of the program, the language, and the topics covered.

Keywords: Management, programs, models, language, simulation, development

Citation: McKelvey, Robert 1986 "Economic Regulation of Targeting Behavior in Multispecies Fisheries" Natural Resource Modeling 1(1):171-189.

Fishery: Multispecies

Management Issue: Intraseasonal management

Technique: Theoretical analysis

Summary: Just as anywhere, in a multi-species trawl fishery there are some species that are more valuable than others and which are thus targeted for harvest. This paper presents a short-run or intra-seasonal model that describes the dynamics of the behavior of targeting specific fish stocks within a larger, multi-species group in an effort to judge the impact that short-run regulations can have in changing the targeted species. The case of an individual landings tax on a by-species-landed basis is considered for redirecting effort to other stocks and away from the most valuable one.

Keywords: Management, multi-species, heterogeneity, license limitations, tax, quota

Citation: Marasco, Richard J. and Joseph M. Terry 1982 "Controlling Incidental Catch: An Economic Analysis of Six Management Options" Marine Policy 6(2):131-139.

Fishery: Groundfish, U.S., Bering Sea

Management Issue: Management of incidental catch

Technique: Economic analysis, essay

Summary: Although this article addresses six management options for controlling incidental catch in the Alaskan groundfish fishery where incidental catch of halibut, salmon, and crab is a problem, the economic methodology (which is spelled out in an Appendix) is applicable to any fishery confronted with this problem. The six options analyzed are 1)to use a total allowable catch (TAC) for the prohibited species, 2) to calculate and manage on the basis of fishery-specific incidence rates for prohibited species, 3) to use economic disincentives to control incidental catch, 4) to use time and area closures to minimize incidental catch, 5) to use gear restrictions, or 6) to decrease the optimum yields (OYs) of the groundfish species. The use of the third option, i.e., the use of economic disincentives, is chosen as the most enforceable (hence, successful), least costly, and maximally beneficial management strategy.

Keywords: Fisheries, incidental catch, U.S., Bering Sea, Pacific halibut, salmon, crab, groundfish

Citation: Meuriot, Eric 1986 "Fishing Fleet Replacement: The French Policy from 1945 to 1983" Marine Policy October:294-309.

Fishery: General, France

Management Issue: Fleet replacement strategies

Technique: Interpretive essay

Summary: This paper provides an analysis and critique of France's fishing fleet replacement policy as a case study of governmental policy and its domestic effect on natural resource management. The author points out problems such as the conflict between domestic and foreign fleets and the government's focus on short-term allocation. By describing the policy as it stands and analyzing its outcome, the author hopes to provide insight and direction for future policies.

Keywords: Fleet, limited access, capacity, replacement, competition, Europe, France, institutions

Citation: Mitchell, Bruce, and Paul King 1984 "Resource Conflict, Policy Change and Practice in Canadian Fisheries Management" Geoforum 15(3):419-432.

Fishery: General, Canada

Management Issue: Management problems

Technique: Essay

Summary: Written several years after the extension of Canada's jurisdiction out to 200 miles and shortly after the 1982 Constitution Act that gave the federal government legislative responsibility for the fisheries, this paper takes a look at what has happened to Canada's Atlantic and Pacific fisheries from a management perspective. The fisheries are first described from a structural perspective that covers the social, economic, technological, political and biological issues facing the sector, and then the recent changes in federal policies and management are discussed and analyzed.

Keywords: Management, Atlantic, Pacific, Canada, conflict, policy, allocation, salmon

Citation: Overholtz, William J. 1985 "Managing the Multispecies Otter Trawl Fisheries of Georges Bank with Catch Optimization Methods" North American Journal of Fisheries Management 5:252-260.

Fishery: Demersal, Georges Bank

Management Issue: Optimal yield in multispecies fishery

Technique: Linear programming

Summary: Many issues are associated with the harvest of species in which there is considerable bycatch. This paper addresses the question of how to manage the harvest of groundfish species on the Georges Bank using linear programming to differentiate between the maximum yields of two different groundfish harvest combinations--a directed fishery for all species and directed fisheries for two or more species that would include bycatch of the other species. Using 1978 data, the model's results show that under the single species approach a great many factors (such as species diversity, relative abundance, seasonal location, and respective quotas) affected the results, thus making all maximum harvests virtually, if not completely, impossible to catch.

Keywords: Management, demersal, multispecies, Georges Bank, linear programming, dynamics, bycatch

Citation: Owers, James E. 1975 "An Empirical Study of Limited Entry in Alaska's Salmon Fisheries" MFR Paper 1152. Marine Fisheries Review 37(7):22-25.

Fishery: Salmon, Alaska

Management Issue: Limited entry

Technique: Interpretive essay

Summary: Although written after the 1973 passage of limited entry legislation in Alaska, this paper was written prior to the implementation of the limited entry program in support of limited entry as a mechanism by which fishermen's incomes could be raised. The data analyzed by the author includes earnings data as well as the length of time and the degree of participation a fisherman has had in the fishery. The implications of limited entry on the fisherman are discussed, as is its anticipated effect on incomes. The author concludes that limited entry will not, as some social scientists believe, cause social upheaval and displace those with few alternative forms of employment.

Keywords: Limited entry, salmon, Alaska, earnings, license limitation, income, commercial

Citation: Pearse, Peter H. 1981 "Fishing Rights, Regulations and Revenues" Marine Policy 5(2):135-146.

Fishery: General

Management Issue: Design of rights systems

Technique: Essay

Summary: The economic inefficiencies of overexploitation and overcapitalization that frequently occur in fisheries that lack clearly defined property rights, i.e., in open-access fisheries, have often resulted in fisheries management, yet it is not clear that fisheries management has been able to eliminate or even minimize these inefficiencies. Responding to this issue, the author has designed a framework of regulatory policy in which quantitative access rights are given--via a variety of means--to participants. Consideration is given to the substance and terms of these rights as well as to their initial allocation, their transferability, and their enforcement.

Keywords: Management, development, economic, yield, rights, common property, regulation, allocation, transferability, enforcement

Citation: Pikitch, Ellen K., Daniel L. Erickson, and John R. Wallace 1988 "An Evaluation of the Effectiveness of Trip Limits as a Management Tool" NOAA/NMFS/Northwest and Alaska Fisheries Center (NWAFC) Processed Report 88-27.

Fishery: Groundfish, U.S., West Coast

Management Issue: Effectiveness of management practices

Technique: Interpretive essay

Summary: The U.S. West Coast groundfish fishery off California, Oregon, and Washington is a mixed-species fishery, with landings obtained primarily by trawl gear. The fishery expanded greatly during the late 1970's following the enactment of the Magnuson Fishery Conservation and Management Act, and a stringent management regime was put into effect during the early 1980's. There were two major objectives of this new regime: to prevent overharvest of individual species, and to maintain a year-round fishery. To achieve this, a combination of annual landing limits, limited landings per trip, and limited trips was implemented. This paper assesses the effectiveness of the regulations on this mixed species groundfish trawl fishery.

Keywords: Groundfish, U.S., California, Oregon, Washington, multi-species, trawl, quotas, discard, limits, regulation

Citation: Richardson, Edward J., and John M. Gates 1986 "Economic Benefits of American Lobster Fishery Management Regulations" Marine Resource Economics 2(4):353-382.

Fishery: American lobster

Management Issue: Effects of regulation

Technique: Simulation

Summary: This paper describes a simulation model which is used to compare regulation options for the American lobster fishery; specifically, increases in the minimum legal size and a modest reduction in aggregate fishing mortality are evaluated. The gains of the alternative management regulations that would be distributed among consumers and producers are also quantified. This is a very detailed model which considers demand curves for lobsters of different sizes, costs of harvesting, and growth rates of individual lobsters. The model is especially useful because it considers the time necessary for regulations to have an effect and shows how the restrictions can eventually pay off. The results indicate that (1) both an increased minimum size and a reduction in fishing mortality are economically justified in the sense that net benefits are positive; (2) increasing the minimum size without an adjunct regulation to prohibit entry will cause present fishermen to suffer an initial short-term reduction in revenues for which there will no long-term gain; (3) increased minimum size can be justified on the basis of consumer benefits even when potential gains from preventing recruitment failure are not considered; 4) a program of effort reduction which reduces the fraction of available lobsters captured annually by 20% is projected to generate $1 of producer benefits for every pound of lobster landed. Reducing the annual harvest fraction by 20% results in a level of fishery benefits greater than increasing the minimum size to 89 mm (3.5 in.) and increases the coincidence of short-run costs and long-term benefits among those affected by the fishery's management.

Keywords: Minimum size, lobster, simulation

Citation: Roy, Noel, William E. Schrank, and Eugene Tsoa 1982 "The Newfoundland Groundfishery: Some Options for Renewal" Canadian Public Policy 8(2):222-238.

Fishery: Groundfish, Canada, Newfoundland

Management Issue: Comparison of management strategies

Technique: Regression

Summary: In order to anticipate the effects of the extension of Canada's jurisdiction out to 200 miles on the Newfoundland groundfish fleet, the authors look at the case of the inshore and offshore cod fisheries and compare the cost-effectiveness of various management strategies. After estimating the relative efficiencies of different forms (vessel size and gear used) of fishing, the analysis is extended to look at what harvesting method and its accompanying level of employment would offer the best exploitation of the new, larger fishery.

The analysis leads to the conclusion that the current use of gillnets and handlines is inefficient, as are cod traps. Longlining, particularly when done from smaller vessels, is more cost-effective. The authors conclude that the gains of extended jurisdiction are likely to be minimal given the existing amount of overcapitalization.

Keywords: Management, groundfish, Newfoundland, Canada, inshore, offshore, cost-effectiveness

Citation: Samples, Karl C., and John T. Sproul 1987 "Potential Gains in Fleet Profitability from Limiting Entry into the Northwestern Hawaiian Island Commercial Lobster Trap Fishery" National Marine Fisheries Service, Southwest Fisheries Center Administrative Report H-87-17C.

Fishery: Lobster, U.S., Northwestern Hawaiian Islands

Management Issue: Potential gains of limited entry

Technique: Cost accounting

Summary: Ideally, resource managers have explicit information about the impacts of regulation and about the impacts that changes in regulation will have on the resource and those consuming/using the resource. In reality, changes in management are sometimes made with very little information about how the new management regime will differ from the existing one.

This report provides an example of how to compare current management with new management strategies in order to have an idea about how a proposed scheme may affect the industry. As part of a series about the Northwestern Hawaiian Island (NWHI) commercial lobster fishery, this paper provides estimates about how the fishery might operate under its current management scheme and under a proposed limited entry program. Two forms of effort control under limited entry are examined: trap restrictions and vessel restrictions. Under the former, the level of effort is limited; under the latter, the cost of landing (a pound of) lobster is minimized. The results of these hypothetical situations are compared with the fishery's 1986 profit levels. The authors conclude that, with a limited entry program in which aggregate effort and the classes of vessels are regulated, the annual profits in the fishery would increase from roughly zero to $2,331,000.

Keywords: Limited entry, economics, gains, costs, profits, effort, effort limitation, lobster, U.S., Northwestern Hawaiian Islands

Citation: Schrank, William E., Noel Roy, and Eugene Tsoa 1986 "Employment Prospects in a Commercially Viable Newfoundland Fishery: An Application of 'An Econometric Model of the Newfoundland Groundfishery'" Marine Resource Economics 3(3):237-263.

Fishery: Canadian groundfish, Canada, Newfoundland

Management Issue: Employment effects of regulation

Technique: Econometrics, simulation

Summary: Distribution and employment effects are very critical in everyday fisheries management decisions. While management by its very nature must restrict behavior and will therefore affect individuals' level of income and perhaps even their ability to obtain employment, it is useful to know how different regulations will affect different segments of the fishery and by how much. This paper describes how a 1,000 equation econometric model can be utilized to simulate the effects of a major policy change in a large Canadian fishery if all government assistance were withdrawn and the industry were placed on a commercially viable basis. Under nearly ideal conditions of marketing and harvesting, harvesting employment would fall drastically--from approximately thirty thousand fishermen to approximately six thousand. There would be a concurrent decrease in seasonal fish plant employment, and a severe decrease in those federal transfer payments (e.g. unemployment insurance) currently generated by extensive seasonal employment in both harvesting and processing sectors of the fishery. The policy analysis consists of simulations with an econometric model which integrates the demand, processing, and harvesting sectors of the fishery. This is a major economic tool to study a drastic change in fisheries policy; nevertheless, it can provide guidance on how to do similar studies on more common changes in regulations with less complicated economic models.

Keywords: Employment, distribution, Canada, Newfoundland, groundfish

Citation: Sinclair, Peter R. 1986 "The Survival of Small Capital" Marine Policy April:111-118.

Fishery: Dragger, Canada, Newfoundland

Management Issue: Management's impacts on the small capitalist enterprise

Technique: Interpretive essay

Summary: If policy makers understand the structure of a fishery's fleet and how management of the fishery has or has not (as the case could be) affected the fleet's structure, they may have a better idea of the impact(s) that regulatory changes or reform might have on the fishery. This paper provides an analysis of how the small capitalist enterprise of the dragger fleet in the Gulf of St. Lawrence has evolved over the last few decades. Particular emphasis is given to how the Canadian government's involvement in and management of the fishery (via its provision of unemployment insurance and capital investment programs) has affected the fleet. The similarities of the goals of state managers, a major processor, and these small capitalists appears to have aided the dragger fleet's survival.

Keywords: Management, dragger, Canada, Newfoundland, subsidy, limited entry, investment

Citation: Smith, Courtland L. 1977 "The Failure of Success in Fisheries Management" Environmental Management 1(3):239-247.

Fishery: Chinook salmon, *Oncorhynchus tshawytscha*, Pacific halibut, *Hippoglossus stenolepis*, U.S.

Management Issue: Obstacles to successful management

Technique: Regression

Summary: By examining the history of management in and the difficulties associated with the chinook salmon and Pacific halibut fisheries before the enactment of the Fishery Conservation and Management Act of 1976 (FCMA) or the conclusion of the United Nations Law of the Sea (UNCLOS) negotiations, this paper provides a springboard for managers who (in 1977 when this was published) were looking for new directions in fisheries policy. The management goals at that time--namely, more predictable and larger harvests--are shown to be subject to two difficulties: first, the ability of fishermen to increase their harvests even under increasingly strict regulation; and second, the fact that social priorities might cause unanticipated changes in fishery managers' plans.

The results offer a helpful approach to analyzing the degree to which management goals are or are not met; however, the discussion of whether or not these goals are appropriate ones does not go beyond mentioning that successful management should be dynamic and flexible.

Keywords: Management, social system, chinook salmon, *Oncorhynchus tshawytscha*, halibut, *Hippoglossus stenolepis*, U.S.

Citation: Somerton, David A., and Jeffrey June 1984 "A Cost-Benefit Method for Determining Optimum Closed Fishing Areas to Reduce the Trawl Catch of Prohibited Species" Canadian Journal of Fisheries and Aquatic Sciences 41:93-98.

Fishery: Red king crab, *Paralithodes camtschatica*, yellowfin sole, *Limanda aspera*, U.S.

Management Issue: Determination of conservation zones

Technique: Benefit-cost analysis

Summary: The closure of an area in order to protect one or some species implicitly involves a tradeoff of limiting the harvest of other species also found in that area. To clarify the tradeoffs made, this paper offers an explicit framework within which such tradeoffs can be estimated. The framework described is that of benefit-cost analysis, and the case study provided is that of Red king crab (*Paralithodes camtschatica*)--a prohibited species that is incidentally caught by United States trawl fisheries for yellowfin sole (*Limanda aspera*)--and other groundfish in the eastern Bering Sea. Using benefit-cost analysis, the authors provide a method for determining king crab conservation zones--where trawling would be prohibited. The gross revenues potentially gained by the yellowfin sole fishery and lost by the king crab fishery are estimated for equal-size areas. The areas are assigned relative values equal to the value of groundfish minus the value of king crab, using exvessel prices and species density estimates. The conservation zone is delimited as those areas in which relative values are negative. This allows for maximizing the potential gross revenues from king crab and groundfish.

Keywords: Management, Bering Sea, red king crab, *Paralithodes camtschatica*, yellowfin sole, *Limanda aspera*, U.S., groundfish, benefit

Citation: Squires, Dale 1990 "The Effects of Individual Transferable Quotas on Industry Structure" National Marine Fisheries Service, Southwest Fisheries Center, Administrative Report Series LJ-90-16.

Fishery: Thornyhead, U.S., Oregon, California

Management Issue: Potential effects of individual transferable quotas (ITQs)

Technique: Econometrics

Summary: This article addresses some of the concerns relating to individual transferable quota (ITQ) programs by developing both a general theoretical and a specific, applied model of multispecies fishery under an ITQ program. The theoretical portion of the paper is written not in terms of a fishery, but in the broad terms of industrial organization and international trade. The model was applied to the open access multiproduct trawl fishery harvesting thornyheads off the coast of northern California and southern Oregon. Although the methodology is specifically applied, it is intentionally developed to apply to any production-managing situation in which profit or revenue maximization is the goal.

The companion piece (included in this bibliography) directly focusing on the thornyhead fishery is:

Squires, Dale 1991 "The Potential Effects of Individual Quotas in Multiproduct Pacific Fisheries" NMFS Southwest Fisheries Center, Administrative Report Series LJ-91-13.

Two related articles that use a linear programming model approach for simulating ITQ markets prior to their implementation are:

1) Lanfersieck, John and Dale Squires 1991 "Planning Models for Individual Transferable Quotas" forthcoming in Canadian Journal of Fisheries and Aquatic Sciences, and

2) Squires, Dale, Mohammad Alauddin, and James Kirkley 1992 "The Potential Effects of Individual transferable Quotas in the Fixed Gear Sablefish Fishery" NMFS Southwest Fisheries Science Center, Administrative Report LJ-92-08.

Keywords: Thornyhead, U.S., Oregon, California, individual transferable quota, ITQ, efficiency, structure, rent, industry

Citation: Squires, Dale 1991 "The Potential Effects of Individual Quotas in Multiproduct Pacific Fisheries" National Marine Fisheries Service, Southwest Fisheries Center, Administrative Report Series LJ-91-13.

Fishery: Thornyhead, U.S., Oregon, California

Management Issue: Potential effects of individual transferable quotas (ITQs)

Technique: Econometrics

Summary: This article directly addresses some of the concerns about individual transferable quota (ITQ) programs using a model of a multispecies fishery exploited by two vessel groups. The model was applied using information from the open access multiproduct trawl fishery that harvests thornyheads off the coast of northern California and southern Oregon using 1984 data (i.e., data prior to the subsequent, extensive micro-management). The results indicated that a more concentrated industry structure was likely to emerge for the larger vessels, but that the number of smaller vessels might not change much. The article concludes with a comment about how the simplicity of ITQ programs, particularly in comparison with the 1991 level of command-and-control management, makes their consideration quite worthwhile.

For an article with a broader perspective on ITQ programs, see also (in this bibliography): Squires, Dale 1990 "The Effects of Individual Transferable Quotas on Industry Structure" NMFS Southwest Fisheries Center, Administrative Report Series LJ-90-16.

Two related articles that use a linear programming model approach for simulating ITQ markets prior to their implementation are:

1) Lanfersieck, John and Dale Squires 1991 "Planning Models for Individual Transferable Quotas" forthcoming in Canadian Journal of Fisheries and Aquatic Sciences, and

2) Squires, Dale, Mohammad Alauddin, and James Kirkley 1992 "The Potential Effects of Individual transferable Quotas in the Fixed Gear Sablefish Fishery" NMFS Southwest Fisheries Science Center, Administrative Report LJ-92-08.

Keywords: Thornyhead, U.S., Oregon, California, individual transferable quota, ITQ, efficiency, structure, rent, industry

Citation: Staniford, Andrew 1987 "The Effects of the Pot Reduction in the South Australian Southern Zone Rock Lobster Fishery" Marine Resource Economics 4(4):271-288.

Fishery: Rock lobster, Australia, South Australia

Management Issue: Effect of regulatory programs

Technique: Econometrics

Summary: In order to increase economic efficiency in this lobster fishery, a scheme was instituted which mandated a 15% per participant reduction in pots, and which specified a minimum and maximum number of pots. The effects of this on the amount of effort in the fishery was estimated in a model that related current effort to effort in the previous period, output price, stock abundance, season length, and number of pots. While the pot reduction program is shown to have on small effect of total fishing effort, it does not really lead to economic rationalization. Fishermen tend to work the smaller number of pots more intensely. This means that gear restriction policies will need to restrict inputs by an amount proportionally greater than the desired reduction in effort. It is shown that a gear reduction program may successfully reduce fishing effort but that the effect on economic efficiency will depend upon the benefits of reduced effort relative to the additional costs arising from input substitution.

Keywords: Gear restriction, rock lobster, econometrics, inputs, Australia, South Australia

Citation: Staniford, Andrew J. 1988 "The Influence of the Supply and Demand Characteristics of Fisheries on the Benefits from Economic Improvement Programs" Australian Journal of Agricultural Economics 32(1):50-59.

Fishery: Rock lobster, Australia, South Australia

Management Issue: Social cost of overexploitation

Technique: Partial equilibrium model

Summary: Resource managers spend a great deal of effort on devising management schemes that will allow the recognition of the economic benefits of a resource. Fisheries managers are no exception to this; a great deal of effort can be spent on trying to devise management schemes that increase economic efficiency in fisheries.

This paper does not follow the relatively standard approach of modeling and estimating a production function for a specific fishery and then measuring the economic benefits of a rationalization program. Instead, the author has taken an alternative approach of deriving a general partial equilibrium model, modeling the impacts of an economic improvement program, and then of applying this framework to the rock lobster fishery case. The potential economic benefits of such management are shown to be, in part, dependent on the level of exploitation of the fishery and on the elasticity of demand for the fishery's output. He concludes that the fishery's supply and demand characteristics will determine the extent to which economic improvement programs will result in large social gains.

Keywords: Rock lobster, Australia, South Australia, elasticity, open access, overexploitation, social costs, benefits

Citation: Stokes, Robert L. 1981 "The New Approach to Foreign Fisheries Allocation: An Economic Appraisal" Land Economics 57(4):568-582.

Fishery: Foreign, U.S.

Management Issue: Foreign allocation schemes

Technique: Essay

Summary: With the enactment of the Fishery Conservation and Management Act of 1976 (FCMA) and the enclosure of fisheries historically exploited by foreign fishing fleets, the issue of how to allocate fishing resources among foreign nations has become increasingly pertinent. This paper looks at the use of market mechanisms, including user fees, as tools for allocating resources.

The author describes how surplus fisheries resources are allocated as well as the value of those resources to distant-water nations. He then moves to a general discussion of the use of competitive allocation systems to extract some of the resource rent as either revenue or other forms (social, economic, political) support. Specific allocation measures such as lump sum payment, foreign policy concessions, and fisheries development benefits are discussed from an efficiency perspective. A discussion of the effects of monopsony power of distant-water nations (such as Japan and the U.S.S.R.) on the U.S. position is included.

Keywords: Management, allocation, distant-water, Fisheries Conservation Zone, FCZ, rent, U.S.

Citation: Stollery, Kenneth 1986 "A Short-Run Model of Capital Stuffing in the Pacific Halibut Fishery" Marine Resource Economics 3(2):137-153.

Fishery: Pacific halibut

Management Issue: Effects of regulation

Technique: Econometrics

Summary: One of the predicted effects of license limitation or season closures to curtail overfishing is "capital stuffing" where, in response to the generation of rents by the reduction of effort, each remaining boat is induced to increase its capacity. This effect will reduce the gains of the original regulation. The paper describes a short-run competitive fishery model which can assess the effects of quotas and season restrictions in the Pacific halibut fishery. The results in this case show labor productivity (a proxy for capital intensity) to be less strongly related to the length of the fishing season than to the price of halibut, implying that the main effect of the quota may be an indirect one that works by restricting supply and raising the price. This model demonstrates how effects of regulations can be derived and how to properly interpret the econometric results.

Keywords: Licenses, season closures, Pacific halibut

Citation: Sutinen, Jon G., Alison Rieser, and John R. Gauvin 1990 "Measuring and Explaining Noncompliance in Federally Managed Fisheries" Ocean Development and International Law 21:335-372.

Fishery: Groundfish, U.S., New England

Management Issue: Noncompliance

Technique: Essay

Summary: Without compliance, no law will ever be enforced, yet how is compliance or non-compliance measured? This paper addresses the issue of non-compliance, starting with a theoretical analytical framework and then applying the theory to a case study of the northeast (U.S.) groundfish fishery in which non-compliance was very prevalent during the years 1986-1988. The authors conclude that such biological factors as low stock levels and economic forces on the participants, when coupled with a relative lack of enforcement and penalties, contributed to non-compliance. They anticipate that without stricter enforcement of stricter penalties the fishery will be in extremely poor condition.

Keywords: Compliance, groundfish, U.S., New England, Georges Bank, enforcement, Fishery Management Plan, FMP, sanction

Citation: Terkla, David G., Peter B. Doeringer, and Philip I. Moss 1988 "Widespread Labor Stickiness in the New England Offshore Fishing Industry: Implications for Adjustment and Regulation" Land Economics 64(1):73-82.

Fishery: Offshore, U.S., New England

Management Issue: Labor mobility

Technique: Essay

Summary: This study examines the question of whether change in an industry occurs at a single adjustment margin that can be defined by the marginal productivity of labor. The New England offshore fishing industry is generally characterized by "sticky" labor (although the degree of stickiness varies throughout the industry), and this results in a labor adjustment process that varies both across industry groups and across ports. This study examines the fishermen of the Gloucester and New Bedford ports who have strong ties of kinship to the industry and who are strongly dependent on their local communities, partially due to weaknesses in the large port economies. These ties, coupled with the more traditionally cited reasons of fishermen's lack of marketable skills and attitudes toward fishing, imply that the less productive fishermen may not necessarily exit the industry. The authors point out that not only is an understanding of the role of labor stickiness in the industry adjustment process important for efficient management policies, but that it also can be linked with alternative economic development strategies in an effort to provide comparable onshore employment, thereby decreasing the potential or need for labor to be "sticky."

Keywords: Offshore, New England, U.S., labor, mobility, opportunity cost, employment, kinship, Gloucester, New Bedford, capitalist, social cost

Citation: Tettey, Ernest, Wade L. Griffin, John B. Penson, and John R. Stoll 1986 "Implications of Tax Policy on Investment in a Common-Property Resource" North American Journal of Fisheries Management 6:100-104.

Fishery: Shrimp, U.S., Gulf of Mexico

Management Issue: Investment impacts of tax policy

Technique: Financial analysis

Summary: The authors of this paper have applied a financial model to the Gulf of Mexico shrimp fishery to determine the impacts of implementing a tax program for entry limitation. Specifically, two types of tax policies are considered--investment tax credits and income taxes. The aggregate investment model is applied to annual Gulf shrimp fishing vessel data from the 1965-1977 period. The estimates derived are used to simulate both the short-term and the long-term impacts of tax policies on real net investment in fishing vessels. The authors find that an increase in the investment tax credit, a decrease in the income tax rate, or a combination of both would increase investment incentives into the industry, thus aggravating the overcapitalization problem; the converse would serve to control overcapitalization. As a result, they suggest implementing a tax policy that would curtail investment tax credits in overcapitalized fisheries thus increasing the long-run revenues of vessel owners. A brief discussion is included on the potential of using an alternative policy such as limited entry.

Keywords: Shrimp, U.S., Gulf of Mexico, investment, tax, financial, capitalization, limited entry

Citation: Townsend, Ralph E. 1985 "An Economic Evaluation of Restricted Entry in Maine's Soft-Shell Clam Industry" North American Journal of Fisheries Management 5:57-64.

Fishery: Soft-shelled clam, *Mya arenaria*, U.S., Maine

Management Issue: Comparison of open access and limited entry

Technique: Econometrics

Summary: A comparison of open access and limited entry to a fishery provides information about the economic efficiency of--and, thus, the economic welfare of the participants managed under--these two forms of management. The Maine soft-shell clam (*Mya arenaria*) fisheries provide a good case study for such a comparison because roughly one half of the towns in Maine limit entry to the resource via ordinances.

A production model is derived and estimated using 1978 through 1980 data, and two hypotheses regarding limited entry are tested: first, does limited entry result in higher yields per unit effort, and second, does increasingly limited entry result in increase yields. Management by limited entry is shown to increase yield by approximately 15%, and increasingly restrictive entry limitations are shown to increase yield per unit effort. The author concludes that even modest attempts at limited entry management can increase the welfare of the resource users.

Keywords: Soft-shelled clam, *Mya arenaria*, U.S., Maine, limited entry, local governance, ordinance, labor, benefits, welfare

Citation: Townsend, Ralph E. 1986 "A Critique of Models of the American Lobster Fishery" Journal of Environmental Economics and Management 13:277-291.

Fishery: American lobster, U.S.

Management Issue: Model choice

Technique: Comparative analysis

Summary: Because the information provided by models can directly affect decision making, the accuracy of such models is of obvious importance. Here, the author looks at studies of the American lobster fishery that have use the Schaefer yield-effort model and show how, in a setting where minimum size rules are applied, the previous studies' results may not be quite accurate. To remedy the situation, the author suggests and presents the use of the Beverton-Holt yield-per-recruit model.

Note: For a comment about a similar article see (also in this bibliography): Anderson, Lee G. 1983 "Exploitation of the Lobster Fishery: Comment" Journal of Environmental Economics and Management 10:180-183.

Keywords: Management, dynamic, deterministic, model, American lobster, U.S.

Citation: Townsend, Ralph E. 1990 "Entry Restrictions in the Fishery: A Survey of the Evidence" Land Economics 66(4):359-378.

Fishery: Limited entry

Management Issue: Evaluation of limited entry programs

Technique: Essay

Summary: Limited entry has received a great deal of attention on the basis that it, in theory, establishes a set of rights in a setting where property rights are conspicuously absent and thus it allows for the collection of rents from a fishery resource. However, much less attention has been focused on the quantifying these gains. To begin this process, this paper categorizes 26 limited entry programs into three classes on the basis of their respective success at generating benefits larger than the costs associated with the program. He concludes that, although somewhat subjective, six inferences can be drawn: 1) The restrictiveness of the limited entry plan and the appearance of economic rents are positively correlated. 2) The complexity of the regulated resource and the economic success of a limited entry program are inversely related. 3) Social and political institutions significantly affect a plan's success. 4) Rents are primarily generated because short-run crowding externalities, not long-run stock externalities, are resolved. 5) Entry moratoria risk becoming a permanent and rather inefficient form of regulation and not a means towards a more efficient end. 6) The generation of rents under limited entry inevitably results in political pressure to increase the number of licenses. All of these inferences illustrate that the practical aspects of limited entry programs really do need to be considered when describing the potential for limited entry success.

Keywords: Management, limited entry, Japan, Australia U.S., Iceland, New Zealand, South Africa, Canada

Citation: Villegas, Luis, Albert C. Jones, and Ronald F. Labisky 1982 "Management Strategies for the Spiny Lobster Resources in the Western Central Atlantic: A Cooperative Approach" North American Journal of Fisheries Management 2:216-223.

Fishery: Spiny lobster, *Panulirus argus*, *Panulirus laevicauda*, Western Central Atlantic

Management Issue: International regional management strategies

Technique: Essay

Summary: Spiny lobsters, particularly *Panulirus argus* and *Panulirus laevicauda*, are important fishery resources for most western central Atlantic countries. This paper is the result of a 3-day meeting/workshop for fishery professionals from 23 countries in the western central Atlantic that was sponsored by the Gulf and Caribbean Fisheries Institute (GCFI), the UNDP/FAO Interregional Fisheries Development and Management Programme (WECAF Project), and the Intergovernmental Oceanographic Commission Association for the Caribbean and Adjacent Regions (IOCARIBE). Six major issues formed the core of the discussions: management objectives and the planning process, biological research, economics, regulations, administration, and cooperative programs. As a result of the discussions, consensus recommendations were formulated regarding improved spiny lobster management. These included: 1) the preparation of a fishery development and management policy by those countries lacking such a policy (first priority); 2) the maintenance of a basic research program to monitor stocks; 3) the economic evaluation the impacts of regulation and overcapitalization; 4) the standardization of regulations throughout the region; 5) the promotion of infrastructure to facilitate efficient fisheries management; and 6) an increase rate of technology-transfer.

Keywords: Management, spiny lobster, *Panulirus argus*, *Panulirus laevicauda*, Western Central Atlantic, biology, economics, priorities

Citation: Walker, K. D., R. B. Rettig, and R. Hilborn 1983 "Analysis of Multiple Objectives in Oregon Coho Salmon Policy" Canadian Journal of Fisheries and Aquatic Sciences 40(5):580-587.

Fishery: Coho salmon, *Oncorhynchus kisutch*, U.S., Oregon

Management Issue: Decision analysis as a management tool

Technique: Multiattribute utility analysis

Summary: The authors of this paper apply the technique of multiattribute utility analysis (MUA) to the Oregon coho salmon fishery to see if it can be used to help fishery managers with harvest rates and release strategies. Because managers are concerned with preservation of genetic diversity as well as with maximization of fish production over time, a technique such as MUA could potentially be very valuable for analyzing the outcomes of different policies.

After deriving a utility function for the fishery, the authors consider twelve various policy strategies and the impact of uncertainty on survival; Monte Carlo simulation is used for the empirical tests. The major conclusion drawn is that MUA can be used as a decision making tool for comparing outcomes, but that it may be more helpful in the process of clarifying and crystallizing policy questions.

Keywords: Utility, simulation, multiattribute utility analysis, wild, hatchery, Coho salmon, *Oncorhynchus kisutch*, U.S., Oregon

Citation: Wallace, Stein W., and Karl Brekke 1986 "Optimal Fleet Size When National Quotas Can Be Traded" Marine Resource Economics 2(4):315-329.

Fishery: Norwegian capelin

Management Issue: International management, optimal fleet size

Technique: Linear stochastic optimization model

Summary: This paper presents a model that can estimate the optimal fleet size for one of two countries jointly utilizing a common fish stock with stochastic quotas. The authors assume that national quotas can be traded and that having stable national quotas is a political goal, thus expected profit is maximized given the assumption that national quotas can be traded. The model is applied to the Norwegian purse seiner fleet and the summer capelin fishery in the Barents Sea. This is a very interesting fishery because optimal utilization must consider 1) total harvest, 2) optimal utilization of boats on crowded fishing grounds, 3) optimal transportation times and carrying capacity of vessels to get the fish to processors, and 4) optimal scheduling of vessels at various processors to minimize transportation costs and waiting time at processors. The results show that the purse seine fleet should be reduced from 160 to 40 or 50 boats and that only the largest vessels should be kept because of their comparative advantage in transporting harvested fish.

Keywords: International management, fleet size, Norway, capelin, Barents Sea

Citation: Wang, Der Hsiung, Louis J. Goodreau, and Joseph J. Mueller 1986 "Economics of Atlantic Sea Scallop Management" Marine Resource Economics 3(2):111-135.

Fishery: Atlantic scallop

Management Issue: Effect of regulations

Technique: Econometrics

Summary: This paper provides a methodology to evaluate minimum sizes and effort reductions for the Atlantic scallop fishery. The authors develop an econometric model to analyze adjustments in the fishery and to describe the short-term impacts of various policies. The econometric model is merged with a Beverton-Holt population dynamics model to evaluate long term effects. The econometric model contains retail, wholesale, and ex-vessel demand curves, as well as demand curves for effort and landings functions for various areas. The results show that the demand for sea scallops at all market levels is price inflexible. Income price flexibility is positive but less than 1 for demand at all market levels. Cross-price flexibility is positive but also less than 1 and is approximately the same for demand at all market levels (between 0.36 and 0.37). In general, fishing effort elasticities for each fishing area with respect to scallop abundance for that area are larger than 1. It is shown that reduction in fishing effort or in meat count would generate positive benefits to the sea scallop industries and to consumers, and that the greater the reduction in effort and/or in meat count, the larger the benefits under long-term equilibrium conditions. Within the range of alternatives considered, effort reductions were a more effective policy than were meat count reductions. However, the short-term economic impacts of the various management strategy scenarios are generally the reverse of the long-term benefits.

Keywords: Size restrictions, effort reductions, Atlantic scallop

Citation: Warren, John P., Wade L. Griffin, and William E. Grant 1982 "Regional Fish Stock Management: A Model for North-west Africa" Marine Policy 6:121-130.

Fishery: Cephalopod, north-western Africa

Management Issue: Flexible management systems

Technique: Bioeconomic simulation model

Summary: The enclosure of fishery resources under the extension of national jurisdiction has created a situation whereby nations could increase both their fishery and their national development. In north-western Africa, for instance, this has led to the enclosure of the cephalopod fishery, making it more possible for nations to capture their fisheries' rents.

Using a bioeconomic model, the authors analyze two different fishery management plans--limiting entry (and reducing the total number of vessels) and a two month seasonal closure of the fishery. The model's results (based on 1975 data) show that both schemes would increase rents, with the two month closure increasing them more. The appendix describes the methodology, data, and the economics used.

Keywords: Management, Atlantic, cephalopod, octopus, *Octopus vulgaris*, squid, *Loligo spp*, cuttlefish, *Sepia spp*, Cape Garnett, Cape Barbosa, Cape Verde, Cape Blanc, Nuoakchott, bioeconomic

Citation: Wilen, James E. 1988 "Limited Entry Licensing: A Retrospective Assessment" Marine Resource Economics 5(4):313-324.

Fishery: General, salmon, herring

Management Issue: Control of effort, cooperative behavior

Technique: Interpretive essay

Summary: This is a useful summary of the arguments for and against licensing programs and of the general results of existing programs. The author concludes that the central lesson from past experience is that license programs have failed to address the problem of incorrect incentives for individual operators. He states that while some programs have generated rents, none do anything to encourage efficiency and cost saving. Incentives for waste exist not only in the construction of vessels but in such things as mobility over the range of the stocks and searching activities. In addition, the programs do not reduce excessive inputs. They have almost always resulted in a pattern of action and reaction by fishermen and regulators, with the latter continually stifling increases in aggregate capacity with changes in season length, area closures and gear restrictions. The fishermen then respond by trying to increase their catching power given the new rules. Wilen concludes that while there are many possibilities for substituting inputs when controls limit one dimension of effort but not another, restrictions which control terminal gear characteristics such as net depth and length offer the most promise because there are few further other dimensions to pursue. He does not discuss the enforceability of such options, however. On a positive note, he suggests that in some fisheries where there are specific aggregations of fish such as with herring and salmon, adding an area designator to the licenses may provide encouragement for the limited number of operators in each area to cooperate and may possibly produce the same results as privatization.

Keywords: Management, licenses, salmon, herring

Production Functions

The articles in this section are about fisheries production. They look at production in a variety of situations, under an array of conditions, and use an assortment of production models--including surplus production, dynamic pool, stock recruitment, and simulation models--to do this.

As evidenced by the spectrum of topics included this category, production functions address many issues. Economic issues related to efficient production levels are addressed by models designed to first estimate optimal production levels and to then use these estimates to derive measures of optimal vessel size, capital intensity, or capacity utilization. Other models address issues related to biological or environmental factors that can affect production in a fishery. To do this, they look at fisheries in which by-catch, disease, schooling characteristics, environmental factors, and stock cyclicity are influential factors. In yet another category of models, the authors address the need to derive bioeconomic parameters when there is the standard catch and effort data available but when there is very little biological data about stock abundance available. Finally, another category of articles looks at production functions when stock size is not influenced by harvest, as in the case of a near-shore fishery on a stock that extends beyond the fishery's reach.

The majority of the models are surplus or stock production models and use a logistic population growth function such as the Cobb-Douglas production function; however, both the shortcomings of this model and alternatives to it are presented in the form of more generalized harvest functions. While some of the articles describe static production models, others address the dynamic nature of fisheries using temporary equilibrium models.

The species described in these articles include anchovy, cod, crab, flounder, haddock, hake, halibut, herring, lobster, perch, oyster, redfish, rockfish, sardine, scallop, shad, shrimp, sole, salmon, turbot, and tuna.

Citation: Agnello, Richard J., and Lawrence P. Donnelley 1975 "Prices and Property Rights in the Fisheries" The Southern Economic Journal 42(2):253-262.

Fishery: General, U.S., oyster

Management Issue: Effect of property rights on harvest and market prices

Technique: Theory with econometric case study

Summary: The authors have developed and applied a model that examines the effect that the lack of well defined property rights will have on fishery production. In particular, they look at the issues of ex-vessel price and the quantity harvested. They show--theoretically and empirically--how the lack of a defined property rights structure lowers the ex-vessel market price due to the higher than otherwise harvest. They also show that the harvest occurs earlier than it optimally should, due to the participants' race to claim a portion of it. A comparison of the management options available to the oyster fishery--namely, leaving it a common property resource, partially privatizing the resource, or fully privatizing the resource--and the different effects these would have is included.

Keywords: U.S., Atlantic, oyster, common property, open access, harvest, season, price

Citation: Agnello, Richard J., and Lawrence P. Donnelley 1975 "Property Rights and Efficiency in the U.S. Oyster Industry" Journal of Law and Economics 18:521-533.

Fishery: Oyster, U.S.

Management Issue: Effect of property rights on labor productivity

Technique: Econometrics

Summary: The authors of this article provide an empirical measurement of the inefficiencies in a fishery where there is an absence of well defined property rights. Specifically, the authors measure the extent to which labor productivity (using the average product of labor or APL) of the oyster fishery is affected by private property rights, capitol intensity, biological factors (such as disease), and the industry wage rate.

The data used for the study consists of 19 years of data from the Atlantic and Gulf coastal states from Massachusetts to Texas. Twenty-five years of data from Maryland and Virginia are also used for a time series analysis of the oyster fisheries in these two states. Because the Maryland and Virginia fisheries occur in the same body of water and yet they have different systems of property rights, the authors attribute the 59 percent difference in these two states' average APL to the well defined property rights structure in the Virginia fishery. They conclude the article with some estimates of the gains--in wages and employment--that would likely accrue to the coastal states if a private property rights scheme was instituted for the entire oyster fishery.

Keywords: Oyster, productivity, labor, property rights, U.S.

Citation: Agnello, Richard J., and Lee G. Anderson 1981 "Production Responses for Multi-species Fisheries" Canadian Journal of Fisheries and Aquatic Sciences 38(11):1393-1404.

Fishery: Atlantic cod, haddock, flounder, redfish, herring

Management Issue: Fisheries production and yield

Technique: Econometric model

Summary: The authors of this article have estimated production functions for five major species in the Northwest Atlantic. These fisheries are ones in which bycatch results in a significant portion of each species' harvest. Using the results of their log-linear regression models, the authors find that excess capacity for some fleets would likely exist, given the existing harvest quotas.

Keywords: Fish, production, fisheries economics, multi-species harvesting, Northwest Atlantic fisheries, International Commission for the Northeast Atlantic Fisheries, ICNAF

Citation: Anderson, Lee G. 1978 "Production Functions for Fisheries: Comment" Southern Economic Journal 44(3):661-666.

Fishery: General, commercial

Management Issue: Effort management

Technique: Theoretical model

Summary: This comment makes the point that the production function for a common-property resource--and, in particular, for the case of a fishery--is perhaps best thought of in terms of a two-step process that distinguishes between the use of effort to produce a good and the use of various inputs to produce that effort. The author's derivation also shows how such a two step function serves to integrate biological and economic information, more clearly outlining issues such as the use of inputs and the unique character of production using common property resources.

Keywords: Production, common property, effort

Citation: Austin, C. Bruce 1977 "Incorporating Soak Time into Measurement of Fishing Effort in Trap Fisheries" Fishery Bulletin 75(1):213-218.

Fishery: Spiny Lobster, *Panulirus argus*, U.S., Florida

Management Issue: Management of effort

Technique: Econometrics

Summary: The amount of effort invested in a fishery is an important factor of catch and, consequently, profit maximization. In the trap fishery for Florida Spiny lobster, *Panulirus argus*, soak time is an important component of effort that is not always considered, potentially biasing calculations of effort and stock size.

The model developed here--where catch is a function of soak time--is subsequently related to the relative abundance of spiny lobster, with the conclusion that soak time (and thus the number of times a trap is hauled) is likely to vary with abundance. The number of trap days can thus reflect varying levels of effort as well as varying stock levels. The author suggests that better measurement of catch per unit effort in a trap fishery could be obtained if one adjusted trap days data with data regarding the catch-soak time relationship.

Keywords: Soak time, trap, spiny lobster, U.S., Florida, effort

Citation: Bell, Frederick W., and Richard K. Kinoshita 1973 "Productivity Gains in U.S. Fisheries" Fishery Bulletin 71(4):911-919.

Fishery: General, U.S.

Management Issue: Labor productivity

Technique: Statistical analysis

Summary: Labor productivity analyses can be used to compare how an industry is competing with others in the same sector and with other sectors that might produce substitute products. In the fishery sector low or negative productivity gains can indicate lagging profits, wages, and employment because much of any competitive advantage is the result of improved productivity.

This study examined the productivity gains in 17 U.S. fisheries over the 1950-1969 period and showed that--although productivity increased in 11 of these fisheries--the overall increase in U.S. fishing labor productivity was lower than that for total U.S. labor productivity, much lower than that in the meat and poultry sectors, and also lower than the productivity gains in foreign fishing sectors. A more detailed study of three fisheries (included in this paper) showed that increased fishing effort's impact on stocks had reduced labor productivity, but that it had been offset by the increased effort of fishermen and the technology they used.

Keywords: Labor, productivity, effort, productivity growth rates, U.S., Pacific halibut, inshore America lobster, eastern tropical yellowfin tuna, skipjack tuna

Citation: Bjorndal, Trond 1989 "Production in a Schooling Fishery: The Case of the North Sea Herring Fishery" Land Economics 65(1):49-56.

Fishery: North Sea herring

Management Issue: Effects of regulation, catch function

Technique: Econometrics

Summary: This paper derives and estimates the harvest function for the North Sea herring fishery using cross sectional data from 1968, 1971 and 1975. Because the schooling behavior of herring allows for very effective use of purse seines and because modern fish finding gear makes harvesting both possible and profitable even at low stock levels, these stocks could be potentially subject to overfishing. The model assumes that vessel harvest is a function of boat days, trips, gross registered tons, engine horsepower, and year built, and the results show that there can be rising marginal product to variable inputs. The author uses these results to study the effects of regulations on the fishery, and he shows that total quotas and closed seasons can be ineffective and may cause boats to operate inefficiently. This is a good paper for showing how econometrics can be used to estimate harvest functions. Although the results are specific to schooling fisheries, the methodology can be used on other stocks. A related study is:

Bjorndal, Trond 1987 "Production Economics and Optimal Stock Size in a North Atlantic Fishery" Scandinavian Journal of Economics 89(2):145-164.

Keywords: Regulation, herring, North Sea

Citation: Bosch, Darrell J., and Leonard A. Shabman 1989 "The Decline of Private Sector Oyster Culture in Virginia: Causes and Remedial Policies" Marine Resource Economics 6(3):227-243.

Fishery: Virginia oyster, *Crassostrea virginica*, U.S., Virginia

Management Issue: Fish disease

Technique: Simulation

Summary: Oyster production from private grounds in Virginia has declined significantly since 1960, a decline which is often attributed to the oyster disease MSX. By using a simulation model which, in addition to normal business analysis, takes into account variations in growth rates and MSX incidence with changes in salinity, the authors show that increases in the effective price for oyster seed have had a greater effect on profits than MSX mortalities. This is a unique study dealing with private culture of marine organisms which is not directly transferable to analysis of capture fisheries; however, it is a useful example of how changes in environmental conditions can be incorporated into the analysis of stock growth and then into the economics of the fishery, and there are many instances when such an approach would be useful. The result of the study is interesting because it shows that problems in fisheries management are not as obvious as they may appear. Conventional wisdom would have called for research that would lead to reductions in MSX disease, while the results of this study show that efforts to reduce seed price may be a more direct way to reverse the decline in the oyster production.

Keywords: Habitat, oyster, *Crassostrea virginica*, MSX, disease, U.S., Virginia

Citation: Caddy, J. F., and J. A. Gulland 1983 "Historical Patterns of Fish Stocks" Marine Policy 7(4):267-278.

Fishery: General

Management Issue: Stock recruitment patterns and their management implications

Technique: Discussion

Summary: Because the effects of natural and human events can greatly affect fish stocks and because the assumption of stock stability is not a strong one, the authors of this paper use time series landings data to look at the variability of a variety of stocks world wide. Four rough classes (on the basis of stock variability) are described: steady, cyclical, irregular, and spasmodic. The use of such classifications may be useful for trying to avoid both overcapacity and overexploitation problems, because managers who have an idea of where in a cycle a stock may be can adjust their management strategies accordingly to avoid pitfalls not predicted by models that do not incorporate such stock trends.

Examples of 'steady-state' fisheries include the North Sea turbot and the Georges Bank haddock fisheries. Cyclical fisheries include the Baleaves hake, the Bay of Fundy scallop, the California dungeness crab, and the Pacific saffron cod fisheries. The Norwegian fishery for juvenile herring, the Magdalen Island lobster and the Georges Bank scallop fisheries are used as examples of irregular periodic stocks. Finally, the California sardine and anchovy, the Northwest Pacific sardine, and the Gulf of Maine shrimp fisheries are described as irregular or spasmodically producing fisheries.

Keywords: Fisheries, resource management, environment, stock variability, recruitment fluctuations, steady, cyclical, irregular, spasmodic stocks

Citation: Capalbo, Susan M. 1986 "Temporary Equilibrium Production Models for a Common-Property Renewable-Resource Sector" Journal of Econometrics 33:263-284.

Fishery: North Pacific halibut

Management Issue: Dynamic optimal control

Technique: Dynamic optimization

Summary: In a common property renewable resource sector, investment in the resource may not occur in a manner that ultimately will lead to simultaneous biological and economically efficient equilibria. This paper develops a temporary equilibrium production model that incorporates biological dynamics for an open-access and for a sole-owner fishery; the model is empirically tested using the North Pacific halibut fishery.

Open access conditions lead producers to behave as if the shadow value of the resource is zero and to not consider the impact that current production activities have on the resource stock in the future. Under sole ownership such an impact, the author shows, would be considered, with the result that output levels and resource use would be altered; thus, a monopsonistic, profit motivated processing sector would try to conserve stocks for its own long-term benefit. As an alternative to entry limitations as a means of profit maximization, this paper considers the option of increasing concentration in the (already relatively concentrated) processing sector.

Keywords: Shadow value, bioeconomic equilibrium, dynamic optimization, control model, North Pacific halibut

Citation: Chambers, Robert G., and Ivar E. Strand, Jr. 1986 "Estimating Parameters of a Renewable Resource Model Without Population Data" Marine Resource Economics 2(3):263-274.

Fishery: General, shad, *Alosa sapidissima*, U.S., Florida

Management Issue: Estimating production models

Technique: Econometrics, maximum likelihood

Summary: This paper describes a method of determining parameters of traditional bioeconomic models when information about the resource's abundance is unknown. The model draws on both the biological (Beverton-Holt) and economic (Koyck) literature, and it allows for the estimation of intraseasonal production parameters (catchability coefficients) and of endogenous intertemporal biological parameters (natural mortality and recruitment). The methodology does require catch and effort data, but there is no need for information on the stock. The model is based on the notion that recruitment will change the current stock size which in turn will influence future stock size and catch. By structuring the intertemporal and intratemporal relationships among catch, stock, and effort, the authors show that it is possible to estimate important bioeconomic parameters. Although the general model is described in terms of a typical fishery, the methodology is applied to the St. John's River shad fishery in Florida for the period 1950 to 1976. The results, considering the illustrative nature of the analysis, are promising and suggest avenues of additional research.

Keywords: Bioeconomic models, yield functions, shad, *Alosa sapidissima*, U.S., Florida

Citation: Georgianna, Daniel L., and William V. Hogan 1986 "Production Costs in Atlantic Fresh Fish Processing" Marine Resource Economics 2(3):275-292.

Fishery: Groundfish, scallops

Management Issue: Processing costs

Technique: Econometrics, cost accounting

Summary: This paper shows how production costs for fresh Atlantic groundfish and scallop processing can be estimated using direct observation, linear regression analysis, and cost accounting. The authors postulate that processors use production techniques which have constant marginal costs over a wide range of output. (This makes sense because of the predictable and unpredictable variation in product demand and exvessel supply to which they are subject.) This postulate allows for linear regression estimation of the marginal cost for non-fish inputs using data on ex-vessel and wholesale prices. The results are compared to those from a cost accounting analysis. Also, regression results for physical yield from fish inputs are compared to estimates from the U.S. Department of Commerce. The similarity in results between these independent forms of estimation supports the hypothesis of constant marginal cost over a wide range of production.

Keywords: Processing costs, groundfish, scallops

Citation: Hannesson, Rögnvaldur 1983 "Bioeconomic Production Function in Fisheries: Theoretical and Empirical Analysis" Canadian Journal of Fisheries and Aquatic Sciences 40(7):968-982.

Fishery: General, Norway, Lofoten

Management Issue: Fisheries production

Technique: Bioeconomic modeling, integration of effort approach, production analysis

Summary: This paper first estimates a fishery production function and then uses it to estimate an effort frontier production function that provides a basis for estimating optimal vessel size and optimal capital intensity for the Lofoten fishery. Because of the independence of fishing effort and fish abundance implicit in the fishery economics effort approach to modeling production as a function of effort, the author uses a Cobb-Douglas production function. (The fish in the Lofoten fishery exhibited increasing availability as the stock was depleted, making such a model necessary.)

A linear programming model is applied to selected Norwegian fisheries in order to estimate optimal vessel size. Finally, the optimal capital-labor ratios for these fisheries are estimated. The author concludes that the vessels may be somewhat smaller than optimal and that they may not be overly capital intensive.

Keywords: Cobb-Douglas, production function, fishing effort, bionomic equilibrium, vessel size, capitalization, Norway, Lofoten

Citation: Lam, C. F., J. D. Whitaker, and F. S. Lee 1989 "Model for White Shrimp Landings for the Central Coast of South Carolina" North American Journal of Fisheries Management 9:12-22.

Fishery: White shrimp, *Penaeus setiferus*, U.S., South Carolina

Management Issue: Stock-recruitment relationships

Technique: Regression, Beverton-Holt

Summary: This paper presents a model for forecasting fall landings in the white shrimp *Penaeus setiferus* fishery in the central South Carolina coastal area. The most significant environmental factor affecting landings--August water salinity--was identified using a stepwise regression procedure. However, because of the large deviations between predicted and observed landings a Beverton-Holt equation was also estimated. On its own, the Beverton-Holt equation accounted for 54% of the fall landings' variability. By combining the Beverton-Holt equation and the water salinity variable, the authors were able to account for 87% of fall landings' variability. They conclude that the abundance of spawners and environmental conditions can be important factors in South Carolina's shrimp production.

Keywords: Beverton-Holt, stock, recruitment, white shrimp, *Penaeus setiferus*, U.S., South Carolina, commercial, production, salinity, temperature

Citation: McCarl, B.A. and R.B. Rettig 1983 "Influence of Hatchery Smolt Releases on Adult Salmon Production and its Variability" Canadian Journal of Fisheries and Aquatic Sciences 40:1880-1886.

Fishery: Salmon, U.S., Oregon

Management Issue: Effect of hatchery releases on adult production

Technique: Econometrics

Summary: The authors use an econometric variability estimating technique and apply it to the case in which hatchery-reared smolts are released to augment adult salmonid production. The econometric technique used here is novel in that it does not make as many assumptions about the nature of the variability in the fishery's production as some other models do. Although the main emphasis of the paper is the application of this technique, the results of its application yielded a surprising and debateable result: increased hatchery releases may negatively affect adult production due to coho's density-dependence for survival.

Keywords: Salmon, U.S., Oregon, release, hatchery, production, coho, *Oncorhynchus keta*, *O. kisutch*

Citation: Morey, Edward R. 1986 "A Generalized Harvest Function for Fishing: Allocating Effort among Common Property Cod Stocks (A Generalized Harvest Function)" Journal of Environmental Economics and Management 13:30-49.

Fishery: General, Cod, North Atlantic

Management Issue: Optimal harvest modeling

Technique: Theoretical, empirical case study

Summary: This article specifies and estimates a general harvest function that is more general than either the Schaefer harvest function or the Cobb-Douglas function that incorporates biomass and effort. In fact, the Schaefer and Cobb-Douglas functions are shown to be special cases of this general harvest technology. By considering more inputs, allowing for more substitutability between inputs, and allowing for the possibility that the marginal product of effort declines, the author has essentially hybridized the Beverton-Holt and the Schaefer harvest functions.

The general harvest technology model that is developed here assumes that harvest from a stock is a function of effort, biomass, the size of the recruit class, and an index of other stock characteristics. In the empirical application of this model to five North Atlantic cod stocks, it is assumed that each country's effort allocation is intended to minimize total harvest costs. Neither the Schaefer nor the Cobb-Douglas function is empirically acceptable under such a scenario.

Keywords: Cobb-Douglas, Schaefer, optimal control, dynamic optimization, harvest technology, recruitment, Beverton-Holt, cod, North Atlantic, Barents Sea, Iceland, Greenland, Labrador, Newfoundland

Citation: O'Rourke, Desmond 1971 "Economic Potential of the California Trawl Fishery" American Journal of Agricultural Economics 53:583-92.

Fishery: Trawl, U.S., California

Management Issue: Potential optimal economic use

Technique: Econometrics

Summary: Using the California trawl fishery as an example, this paper sets out a simple technique for estimating a fishery's yield function using readily available information. Economic models for supply, marginal cost, and demand are derived and estimated, with particular emphasis on the difference--especially in this case--between maximum sustainable yield and maximum economic yield.

The empirical results show that the fishery is and has operated at or above its maximum sustainable yield and that a roughly 50% reduction in landings would be needed to maximize the economic benefits of the fishery. Such a change, concludes the author, would not likely happen without public control.

Keywords: California, U.S., trawl, sole, rockfish, potential, revenues, costs, yield, maximum sustainable yield, optimal

Citation: Sathiendrakumar, R., and C. A. Tisdell 1987 "Optimal Economic Fishery Effort in the Maldivian Tuna Fishery: An Appropriate Model" Marine Resource Economics 4(1):15-44.

Fishery: Tuna, Maldives

Management Issue: Optimal effort

Technique: Econometrics

Summary: The purpose of this paper is to obtain revenue and cost functions in order to describe the economically optimal level of effort in the Maldivian tuna fishery. The research shows that production functions based on either a Schaefer or a Fox model do not perform well. The authors believe that, since the fishery is prosecuted within 25 km of land, it is unlikely that fishing will affect the stock size; they therefore estimate a production function which does not consider stock size and find that it performs very well. Production functions are then estimated for different sections of the fishery and--with cost data--estimates of optimal effort and yield are generated. It is shown that even with what amounts to a tax on fish, the existing levels of effort are higher than optimal. This is a very good example of how existing data and imaginative approaches that adapt existing models to special cases can be used in valuation studies.

Keywords: Optimal effort, tuna, Maldives

Citation: Segerson, Kathleen and Dale Squires 1988 "On the Measurement of Economic Capacity Utilization for Multi-product Industries" Journal of Econometrics 44:347-361.

Fishery: Multi-species, U.S., New England

Management Issue: Capacity utilization

Technique: Theoretical with application

Summary: This article extends measures of capacity utilization (CU) beyond the single-product firm case to provide several measures of CU for multi-product firms, such as those found in the multi-species New England otter trawl industry. The empirical application of CU to this industry is intended to give policy makers a better idea of where and to what extent over-capitalization may exist in the industry as well as to show the usefulness of having CU measures when considering license limitation programs. (Because license limitation programs frequently limit the number--but not necessarily the capacity--of the vessels employed to harvest a resource, keeping track of how vessel capacity is being used can be helpful.) The authors conclude that in 1980 the New England otter trawl industry was indeed overcapitalized, but that this overcapitalization varied by product.

Keywords: Multi-species, U.S., New England, cod, flounder, haddock, redfish, pollock, capacity utilization, multi-species, multi-product

Citation: Squires, Dale 1987 "Fishing Effort: Its Testing, Specification, and Internal Structure in Fisheries Economics and Management" Journal of Environmental Economics and Management 14:268-282.

Fishery: Multispecies, U.S., New England

Management Issue: Multiproduct fishery profits

Technique: Econometrics

Summary: The concept of effort is pervasive in fishery regulation, in stock assessments (via the use of catch per unit effort and landings data) and in bioeconomic models; however, the use of this concept depends on two assumptions: 1) that production technologies can, in fact, be considered as exhibiting homothetic input separability (i.e., that an aggregate input exists); and 2) that jointness in inputs exists (i.e., that all inputs are required to harvest all outputs). The testing of these assumptions and the construction of an effort index allows for a better understanding of the implications of fisheries management policies, especially those directed at changing effort.

After specifying the conditions for formation of effort, the existence of effort and jointness in inputs assumptions are tested using data from the New England otter trawl fishery. The multiproduct function applied here supports such conditions, and an effort index is created for use in bioeconomic models, resource assessments, and regulatory studies.

Keywords: Multispecies, U.S., New England, effort, inputs, multiproduct, otter trawl, jointness, bioeconomic, homothetic, input separability

Citation: Squires, Dale 1987 "Public Regulation and the Structure of Production in Multiproduct Industries: An Application to the New England Otter Trawl Industry" RAND Journal of Economics 18(2):232-247.

Fishery: Multispecies, U.S., New England

Management Issue: Multispecies management

Technique: Econometrics

Summary: Fisheries do not always exist in an isolated fashion in the sense that species are often harvested using the same technology and even in the same location as are other species. The New England otter trawl fishery provides just such an example, harvesting several species of which cod, haddock and yellowtail flounder are the most important. Although this multispecies fishery has existed for may years, management of the fishery can be considered a failure because it has not considered the fishery as one composed of multiproduct firms.

By focusing on firms' multiproduct cost structures, their transformation and substitution possibilities, the jointness of their inputs, and the level of input and output aggregation, the author shows that traditional bioeconomic models may not, in fact, provide accurate descriptions for fishery managers. Fishermen do appear to optimize species mix and their revenues, making jointness of inputs an important regulatory consideration; single species management is not necessarily the way to go. Similarly, by regulating a limited number of species one can actually regulate many more because of the complementarity of outputs. Regulation of the inputs of the respective firms may be the choice for multispecies fisheries management in order to increase economic rents and to allow the stocks to recover.

Keywords: Multispecies, U.S., New England, multiproduct, profit, otter trawl, joint production, interdependence, elasticity, Cobb-Douglas

Citation: Taylor, Timothy G., and Fred J. Prochaska 1984 "Incorporating Unobserved Cyclical Stock Movements in Fishery Catch Equations: An Application to the Florida Blue Crab Fishery" North American Journal of Fisheries Management 4:67-74.

Fishery: Blue crab, *Callinectes sapidus*, U.S., Florida

Management Issue: Stock cyclicity/seasonality

Technique: Regression, spectral analysis

Summary: Just as increased effort may not result in increased catches, changes in the catch per unit effort may occur as a result of cyclical of seasonal changes in a fish population. If such changes are not considered as part of fishery management models, the models' use may result in biased management.

The authors provide a mechanism for identifying otherwise undetectable (largely due to a lack of time series data) stock periodicity. The technique of spectral analysis relies on the use of a spectral density function--a fourier transform of the autocovariance function--and can be used as an alternative to using autocovariances when characterizing a time series. This technique is applied in an analysis of the west coast Florida blue crab (*Callinectes sapidus*) fishery in an effort to provide a more accurate catch equation describing catch per unit effort.

Keywords: Blue crab, *Callinectes sapidus*, U.S., Florida, regression, spectral analysis, cycle, seasonality, output, elasticity

Citation: Tsoa, E., W. E. Schrank, and N. Roy 1985 "Generalizing Fisheries Models: An Extension of the Schaefer Analysis" Canadian Journal of Fisheries and Aquatic Sciences 42:44-50.

Fishery: Atlantic cod, *Gadus morhua*, Canada

Management Issue: Comparison of population and productivity models

Technique: Dynamic programming

Summary: The restrictions of the Schaefer model--namely, that in the Cobb-Douglas production function the exponents for fishing effort and fish population are one--are tested in this paper to see if such restrictions should be assumed or estimated. Because population figures are not always available, this procedure generates population estimates and thus provides an alternative to cohort analysis.

The model is applied to the northwest Atlantic cod fishery. Because this fishery is harvested by both Canadian and European fleets, accurate assessments of populations are of great interest. This generalized model produces estimates that are considerably different the equilibrium catch and population estimates generated by Schaefer models, so its use could result in large changes in quota allocations as well as in the time paths for optimal utilization.

Keywords: Schaefer, Cobb-Douglas, generalized, population, production, Newfoundland, Canada, Atlantic cod, *Gadus morhua*, dynamics, bycatch, model

Market Studies

The articles in this section address a cross section of market-related issues. Although the markets for and the marketing of fishery products is the main thrust of these articles, they also delve into such related topics as product demand and price analysis (at both the national and international levels) as well as the topic of investment potential and/or development potential of various fisheries (for wild and cultivated or farmed fish). Not to be limited to these topics, however, other articles examine the effects of different types of management on markets. Some consider the effects of gear, season, or other input restrictions on price and profitability, while yet others examine the effects of extended jurisdiction on markets. Finally, there are those articles that look at the effectiveness of various marketing strategies and efforts. In these articles, potential markets--both at the national and international level--are discussed from the perspective of identifying, promoting, and investing in (optimally and otherwise) potential markets.

These models are used to address the sorts of things that could affect a fishery's prices, and the lengthy but not comprehensive list includes such things as: the (potential or real) existence of substitute fisheries (aquaculture of the same species or even different species), the imposition of duties or taxes, the extent of foreign fleets' access, the availability of imports, the status of national and international/world inventories, and the effects of exogenous changes in inputs such as energy, labor, or environmental conditions. Some of the models also examine the effects that limited entry fisheries have on 1) the market to enter the fishery and 2) the market for the fishery's products. Related limited entry issues--such as how to determine the willingness-to-pay (WTP) and the setting of user fees for access to a fishery--are also covered by some of the authors.

Examples of financial analyses and investment decision-making models are included, as are examples using constant elasticity of substitution (CES), Box-Cox, inventory adjustment-price expectations and simultaneous equation models to provide either static, partial adjustment, or dynamic models of price determination. The main features or components of these models include parameters intended to capture technical and managerial skills, the types of vessels in the fleet(s), the capital intensity of the fishery, and the fishery's financial features in addition to the more standard input parameters of labor, capital, and even energy or fuel. Two other parameters used by authors in some of the articles are those of the fishery's capacity and capacity utilization.

Domestic and international fisheries are represented in this section. Some are transboundary fisheries; others produce products that enter both domestic and international markets. The species mentioned include cod, crab, flounder, haddock, halibut, herring, lobster, menhaden, ocean perch, redfish, salmon, shrimp, striped bass, tuna, and wetfish.

Citation: Adams, Charles M., Fred J. Prochaska, and Thomas H. Spreen 1987 "Price Determination in the U.S. Shrimp Market" Southern Journal of Agricultural Economics 19(12):103-111.

Fishery: Shrimp, U.S.

Management Issue: Price determination

Technique: Causality tests, econometrics

Summary: Although the U.S. shrimp industry (characterized in terms of dockside value) is the most important value component of the U.S. commercial fishing industry, it is also overcapitalized and fully exploits a resource that is increasingly subject to pressures from rising imports and an increase of cultured products. To assess the competitiveness of the U.S. industry and to better understand the impacts of policy measures, the authors look at the relationship between prices of adjacent levels of the market, i.e. at the relationships between prices at the harvesting, processing, and distributional levels. This is done because of the dynamics of prices between adjacent market levels can provide an improved understanding of the price linkages between these levels, which in turn can illustrate how various policy or trade impacts that are directed at different levels of the industry will effect the entire industry.

Of the three empirical methods available for analyzing casual price relationships (the Granger, Sims, and Haugh-Pierce methods), the Haugh-Pierce method is applied to size classes of raw-headless shrimp. This method is applied because it uses different techniques for determining casual inferences and residual cross correlation between two time series. The results can then be used in regression to better define the nature the nature of leads/lags between the two series. No level within the shrimp market system is shown to have market power that could alter the gain or costs of trade, although trade policy may have a greater effect on the industry if directed at lower levels in the market. Because larger sized shrimp are shown to be more consistently supplied, closings of domestic fisheries to protect small shrimp may result in an abundance of the large size class.

Keywords: Shrimp, prices, causality, markets, U.S., Haugh-Pierce, Sims, Granger

Citation: Allen, P. Geoffrey, Tryggvi Felixson, and David A. Storey 1987 "An Econometric Model of the Market for Fresh New England Groundfish with Emphasis on the Role of Canadian Imports" Northeastern Journal of Agricultural and Resource Economics 16(1):24-34.

Fishery: Groundfish, U.S., New England

Management Issue: Effects of countervailing duties on domestic market prices

Technique: Econometrics, regression

Summary: Although previous econometric studies have shown that imports have little effect on domestic groundfish prices, local New England fisherman have claimed otherwise, previous econometric studies have yielded different conclusions regarding the effects of imports on the domestic industry. While one study showed that imports cause damage to domestic producers, another showed that groundfish imports have relatively small effects. This paper tries to identify shortcomings of previous research and develops a new, five equation model focusing on the fresh fish market that serves as one of the primary outlets of for the sale of New England groundfish. After developing the model, it is used to simulate the effects of countervailing duties on Canadian imports. The results show that imports would drop by roughly 9% in the first year and that domestic fish prices would rise roughly 10%. The results also indicated that consumers would likely eat less fish. Thus, besides hurting consumers, the increased domestic price would put even more pressure on domestic groundfish stocks.

Keywords: Groundfish, cod, flounder, haddock, ocean perch, prices, imports, duties, U.S., New England, econometrics

Citation: Bird, Peter J. W. N. 1986 "Econometric Estimation of World Salmon Demand" Marine Resource Economics 3(2):169-182.

Fishery: Salmon

Management Issue: Market valuation

Technique: Econometrics

Summary: This paper describes a single-equation econometric model of the world market price of salmon over the period 1958-1982. The dynamically specified equation estimated explains the equilibrium price in terms of world salmon landings, OECD consumer expenditures, and the price of a substitute. The results imply there are relatively elastic short-run responses of demand to price and income changes, together with the persistence of habits over a longer period. This paper demonstrates both how to estimate demand curves and how to interpret the results in view of modeling restrictions.

Keywords: Market demand, salmon

Citation: Blomo, Vito, J., and Nancy C. White 1986 "A Productivity Analysis of Major North Carolina Commercial Fisheries" UNC Sea Grant College Publication, Working Paper UNC-SG-86-2, 40 pages.

Fishery: General, U.S., North Carolina

Management Issue: Fishery production

Technique: Productivity measurements

Summary: This paper presents an analysis of fishing patterns in North Carolina's major commercial fisheries. Using productivity as their measure, the authors develop criteria for identifying major commercial fisheries, characterize the productivity of existing commercial fisheries, and identify potential new ones. The productivity measures used include the catch per fisherman per vessel and per gear as well as the real and nominal dollar values of catch. All the major species fisheries are characterized as relatively mature fisheries, especially the flounder, croaker, grey trout and blue crab fisheries.

Keywords: Menhaden, shrimp, flounder, blue crab, croaker, commercial, productivity, exvessel value, comparative analysis, U.S., North Carolina

Citation: Comitini, Salvatore 1977 "An Economic Analysis of the State of Hawaiian Skipjack Tuna Fishery" University of Hawaii Sea Grant Program, Sea Grant Technical Report UNIHI-SEAGRANT-TR-78-01, 46 pages.

Fishery: Skipjack tuna, U.S., Hawaii

Management Issue: Characterization and options for development

Technique: Interpretive essay, econometric supply side analysis

Summary: This study of the Hawaiian tuna skipjack industry was done to study the economic effectiveness of the pole-and-line method, a technology which is used in other skipjack fisheries in the Pacific. After characterizing the fishery's catch, vessel and trip trends, the author develops and estimates three alternative production functions. The results showed that the instability of the Hawaiian skipjack fishery is mostly due to the natural random stock size fluctuation, although the cost of live bait represented another constraint on the fishery's success. The authors concluded that the industry was limited by an increase in opportunity cost of production even though the resource potential was sustained.

Keywords: Skipjack tuna, regression, Hawaii, industry, policy, U.S., production

Citation: Comitini, Salvatore, and David S. Huang 1967 "A Study of Production and Factor Shares in the Halibut Fishing Industry" Journal of Political Economy 75(4):366-372.

Fishery: Pacific halibut

Management Issue: Characterization of production

Technique: Econometrics

Summary: In order to avoid some of the problems associated with using aggregate data, this study takes a relatively detailed data set to examine the industry's form of production and the nature of any technical changes. Regulation of the halibut fishing industry has been previously based on providing maximum sustainable yield of halibut, without consideration of other production data. A Cobb-Douglas production function is estimated for 37% of the Seattle halibut boats using a constant elasticity of substitution form (CES). The results of this estimation show that the industry probably exhibits constant returns to scale and that the elasticity of substitution is likely equal to 1. Because the authors found evidence of technological progress during their study of the years 1958-1964, they also tested and found support for the "good captain" hypothesis, thus demonstrating that managerial skills were important in increasing the productivity of the industry.

Keywords: Production function, Pacific halibut, Cobb-Douglas, econometrics, productivity, skill

Citation: Crutchfield, Stephen R. 1983 "Estimation of Foreign Willingness to Pay United States Fishery Resources: Japanese Demand for Alaska Pollock" Land Economics 59(1):16-22.

Fishery: Alaska pollock, U.S., Alaska

Management Issue: User fee determination

Technique: Econometrics

Summary: With the extension of exclusive U.S. fishery jurisdiction to 200 miles, the balance between domestic and foreign fleet access to U.S. fisheries can be viewed as a balancing of domestic needs versus foreign fleets' willingness to pay. The management of domestic fisheries must include the opportunity cost of lost foreign access fees, because foreign fleet willingness to pay for access into U.S. waters represents potential revenue losses for domestic producers. This study uses an econometric analysis to determine the Japanese market for Alaskan pollock. The author estimates Japan's willingness to pay for access fees is in the range of $196 to $293 million. Because these estimates are so high, the author concludes that the fishery could profit from continued allocation to foreign fisheries much more so than from access limitation.

Keywords: Willingness to pay, access, fees, welfare, factor rents, allocation, Alaska, U.S., pollock, Japan

Citation: Fletcher, Jerald J., and Warren E. Johnston 1984 "An Economic Analysis of Eureka Crabber-Troller Vessels" University of California, Giannini Foundation Information Series No. 84-2.

Fishery: Dungeness crab, U.S., California, Eureka

Management Issue: Analysis of economic trends and cycles

Technique: Cost/revenue accounting

Summary: This study is intended to provide a more in-depth analysis of North Coast fisheries than the standard cost/revenue analysis that covers a one year period. The authors take a time-series perspective (using the years 1974-1976) for their financial analysis of the Eureka Dungeness crab fishery. The study's results are presented in such a way that fishery participants may use the data for comparison with their own cost, return, and revenue values. Data from 1946 to 1981 regarding the multipurpose fleets that also catch shrimp, groundfish, salmon and albacore is included, providing information on landings values and exvessel prices. While the vessel cost analyses and gross revenue estimates focus on a shorter time period, the combined results are intended to serve as an aid to management planning.

Keywords: Vessel costs, Dungeness crab, trollers, U.S., California, Eureka

Citation: Griffin, Wade L., Newton J. Wardlaw, and John P. Nichols 1976 "Economic and Financial Analysis of Increasing Costs in the Gulf Shrimp Fleet" Fishery Bulletin 74(2):301-309.

Fishery: Shrimp, U.S., Gulf of Mexico

Management Issue: Vessel investment and profitability

Technique: Financial analysis, regression

Summary: This paper analyzes the profitability of investing in different sizes of Gulf shrimp vessels during the early 1970's, a period when fuel prices jumped 76% (between 1971 and 1973). When coupled with the concurrent inflation, the fishery's large fleet expansion resulted in low investment profitability for many of the vessel size classes. In this paper the Gulf shrimp fleet has been divided into categories of vessel type and size and then analyzed for cost and return. Only one size class turned out to be profitable under the 1973 to 1975 conditions. The results prompted the authors to suggest management schemes that decrease fleet expenses and that might improve the efficiency of the fishery, i.e., management schemes such as tariffs, quota and fuel subsidies, limited entry, as well as a "do nothing" option.

Keywords: Cost, return, cash flow analysis, break-even, investment, financing, vessel class, financial, shrimp, trawler, Gulf of Mexico, U.S.

Citation: Griffin, Wade L., Linda A. Jensen, and Charles M. Adams 1983 "A Generalized Budget Simulation Model for Fishing Vessels" Texas A&M University Sea Grant Program, TAMU-SG-83-203.

Fishery: General

Management Issue: Budget simulation system installation

Technique: User installation manual

Summary: This is a manual for installing and testing either the Aquaculture Budget Simulation System or the Vessel Budget Simulation System. The basic design of each system is similar enough that installation procedures are the same except for reference-to-file names specific to one system of the other. This manual is written in general terms; specific references to the individual systems are in the tables.

The Budget Simulation System (BSS) contains two programs, COBOL and FORTRAN. The BSS is designed to create and maintain an inventory of data for firm operation (either vessel or aquaculture facility). These functions are provided by the COBOL program. The retrieval of specific pieces of data, the creation and maintenance of the tax table, and the actual simulation of the firm's financial activity occurs in the FORTRAN program. The BSS also requires a set of files to support its stored budget processing capacities and additional files to use as temporary scratch pads for current runs. Correct BSS installation not only demands compilation of source codes, but also provision of the support file access that the system requires.

Keywords: Budget, COBOL, FORTRAN, aquaculture, vessel, programming

Citation: Herrmann, Mark, and Biing-Hwan Lin 1988 "The Demand and Supply of Norwegian Atlantic Salmon in the United States and the European Community" Canadian Journal of Agricultural Economics 36:459-471.

Fishery: Atlantic salmon, Norway

Management Issue: Factors affecting demand

Technique: Econometrics

Summary: The effect of the increasing supply of farmed Norwegian salmon and its impact on both the U.S. and European salmon markets is of interest both to salmon farmers and to those harvesting wild stocks. The authors of this paper have put together a simultaneous-equation model that includes supply and demand functions for the roughly 90% of Norwegian Atlantic salmon exports that the U.S. and European Community (EC) receive. The model estimates the effects of various supply levels of Norwegian salmon and exchange rate changes, as well as price changes in other species (i.e., chinook, sockeye), and the results of their model are presented along with a sensitivity analysis. The demand for Norwegian Atlantic salmon is found to be price and income elastic in all markets with alternative salmon species being only weak substitutes. They find that exports of farmed salmon have not greatly effected the Pacific salmon market, although in the future it may have a greater influence.

Keywords: Salmon, price elasticity, exchange rates, demand, supply, farming, United States, European Community, substitutes, Norway, Atlantic

Citation: Hudgins, Linda Lucas, and Samuel G. Pooley 1987 "Growth and Contraction of Domestic Fisheries: Hawaii's Tuna Industry in the 1980s" In Tuna Issues and Perspectives in the Pacific Islands Region, David J. Doulman (ed.), Honolulu: East-West Center Press, Chapter 13:225-241.

Fishery: Tuna, U.S., Hawaii

Management Issue: Changing industry structure

Technique: Interpretive essay

Summary: The authors of this paper trace the relatively recent changes in Hawaii's commercial fishing industry, focusing on changes that have occurred in the tuna industry. In the early 1980s the Hawaiian tuna industry changed from one dominated by skipjack to one in which other species, such as yellowfin, bigeye and albacore, had an increasing market share in the Hawaiian fresh fish market. Although it was probably the result of a longer decline in the fishery's productivity and problems of its fleet, the 1984 closing of a major skipjack tuna cannery represented a turning point in the fishery's history. At the same time, the more aggressive expansion of other species into fresh and frozen markets increased competition in local markets, thus facilitating their market development.

Keywords: Catch, market structure, longline, tuna, Hawaii, cannery, fleet size, pole-and-line, skipjack tuna

Citation: Huppert, D. D. 1980 "An Analysis of the United States Demand for Fish Meal" Fishery Bulletin 78(2):267-276.

Fishery: General, U.S.

Management Issue: Demand analysis

Technique: Econometrics, maximum likelihood

Summary: The motivation for the demand analysis described by this paper came, in part, from the 1976 Fishery Conservation and Management Act's requirement for economic evaluation of management plans. The market demand for a product (such as fish meal) can be influenced--via price--by the availability of the fish (that are used to make the meal). And, if one is to determine the optimal supply of fish to be used in making fish meal, the estimation will need to include estimates of how the price will fluctuate with changes in demand, i.e., the price elasticity of demand for fish meal. The author has done a good job of describing the important variables to consider as well as the model forms that are used. The results of the models--one static and one a partial adjustment model--are also thoroughly covered. The paper concludes with a concise discussion of the management implications of the price dependent results (i.e., when fish meal prices are high, the demand and elasticity is low, and vice-versa).

Keywords: Maximum likelihood, California, U.S., Atlantic, Gulf of Mexico, menhaden, anchovy, fish meal, static, dynamic, price elasticity of demand, regression

Citation: Huson, R. M., D. Rivard, W. G. Doubleday, and W. D. McKone 1984 "Impact of Varying Mesh Size and Depth of Fishing on the Financial Performance of an Integrated Harvesting/Processing Operation for Redfish in the Northwest Atlantic" North American Journal of Fisheries Management 4:32-47.

Fishery: Redfish, Northwest Atlantic, Canada, Labrador, Newfoundland

Management Issue: Assessment of management options/strategies

Technique: Bioeconomic analysis

Summary: Mesh size regulations of the redfish fishery established by the Northwest Atlantic Fisheries Organization's (NAFO) provided the motivation for this bioeconomic study--a study that translates the implications of the mesh size of otter trawls' codends into financial terms. Catch rates are determined for the various categories of mesh, and then the average production yields are estimated. After estimating and deducting total vessel and total processing costs, profit margins are estimated. The sensitivity analysis of the profit margins involves changing such parameters as vessel hold capacity, labor costs and catch rates. Finally, with their estimation of the long run implications of constant harvests, the authors note that the current fishing mortality is really three times higher than the long term optimally profitable mortality rate.

Keywords: Otter trawl, Labrador, Newfoundland, redfish, Atlantic, mesh size, operating costs, revenues, Canada

Citation: Kabir, M., and N. B. Ridler 1984 "The Demand for Atlantic Salmon in Canada" Canadian Journal of Agricultural Economics 32(November):560-568.

Fishery: Salmon, Atlantic, Canada

Management Issue: Effects of increased salmon production

Technique: Econometrics

Summary: This paper is the first of two analyses by the authors on the subject of domestic demand for Canadian Atlantic salmon, and it focuses on the demand for fresh as well as frozen salmon. Demand equations are formulated and estimated using 1955-1981 data. The income and price elasticity estimates are high for both the fresh and the frozen plus fresh models, indicating that the market can absorb considerable amounts of salmon and will do so in a very competitive fashion. The implication of this is that any limitations on fishermen's catch of salmon are likely to be more than overcome by increased farmed salmon production.

See also:

Lin, Biing-Hwan, and Nancy A. Williams 1985 "The Demand for Atlantic Salmon in Canada: A Comment" Canadian Journal of Agricultural Economics 33(July):243-249.

Keywords: Elasticity, income elasticity, price elasticity, demand, farming, salmon

Citation: Kabir, M., and N. B. Ridler 1986 "The Market for Atlantic Salmon" Atlantic Economic Journal March:125.

Fishery: General, Salmon, Atlantic, Canada

Management Issue: Effects of increased salmon production

Technique: Econometrics

Summary: This one-page article summarizes the results of an demand equation estimated for the domestic Canadian fresh salmon market. The market demand equation is one of four in a system of simultaneous equations for estimating demand, supply, export demand, and the market clearing situation. Domestic demand is estimated as a function of disposable income, per capital consumption of fresh salmon and the price of lobster. Income elasticity is estimated to be 4.1, and price elasticity is estimated to be 16.7--indicating the large amount of salmon the domestic market could absorb as well as the potential for the market to expand in the long run.

Keywords: Market, price, income, elasticity, salmon, Atlantic, Canada, price, elasticity, demand

Citation: Karpoff, Jonathan M. 1985 "Time, Capital Intensity, and the Cost of Fishing Effort" Western Journal of Agricultural Economics 10(2):254-258.

Fishery: General

Management Issue: Vessel capitalization

Technique: Theoretical analysis

Summary: This paper provides a micro-theoretic approach to and explanation of the observation that--in fisheries experiencing frequent seasonal closures--the larger and more heavily capitalized vessels do not earn the highest profits. The implications of this are two-fold: 1) it may not be an optimal strategy for a fisherman to become a capital intensive operator, and 2) if regulators wish to redistribute wealth from capital to less capital intensive operations, one way to do so may to use length-of-season regulations.

The model derived here is based on the fact that fishing effort is a function of, among other things, capital intensity and the length of the fishing season. It reveals that the shorter the season, the more favored are the less capital intensive vessels.

Keywords: Season, effort, cost, capital intensity, average cost, microanalysis

Citation: Kim, Dae K. 1983 "Energy Substitution in the Gulf of Mexico Shrimp Fishery" Southern Journal of Agricultural Economics 15(2):1-6.

Fishery: Shrimp, U.S., Gulf of Mexico

Management Issue: Effects of energy prices

Technique: Econometrics

Summary: Because energy costs are inherently tied into production, energy substitution is a crucial factor in the survivability of an industry, thus the subject of energy conservation poses an interesting question for fisheries production and management. This paper estimates substitution elasticities of fuel, capital and labor for the Gulf of Mexico shrimp fishery using 1977 data and a translog cost function. The largest contributor to total costs turned out to be fuel cost, although the elasticity of substitution away from fuel varied by vessel type and size. Because the capital and labor elasticities of substitution for energy were both positive, the author noted that any policy either raising the price of fuel relative to these or encouraging the use of capital and/or labor would decrease--all else equal--the use of fuel. He concluded that, as a fuel conservation policy, if output in the fishery were to be held constant, incentives to increase capital and/or labor use would indeed lower energy consumption.

Keywords: Shrimp, U.S., Gulf of Mexico, fuel, labor, capital, elasticity of substitution, energy, costs

Citation: Lane, Daniel E. 1988 "Investment Decision Making by Fishermen" Canadian Journal of Fisheries and Aquatic Sciences 45(5):782-796.

Fishery: Commercial, Canada, British Columbia

Management Issue: Fishermen's investment decisions

Technique: Dynamic modeling, case study

Summary: Entering into a fishery can be considered as an investment decision of whether or not to enter a continually changing and high risk market, and the author of this paper has constructed a decision making model that incorporates the decisions of capital investment, setup costs, and expected profit gains. More specifically, the investment decision modelled here describes investment as dependant on the risk or probability of surviving in the business over a specific, planned period, and the model consists of a discrete time probabilistic dynamic programming formulation. Annual investment decisions are made with the goal of maximizing the business' net profit by the end of the planned time period. When this model is applied to the British Columbia, Canada salmon troller fleet, the results show that low income trollers are less likely to have accurate perceptions about future incomes than are high income trollers.

For a similar, earlier paper, see: Lane, Daniel E. 1985 "Forecasting Aggregate Investment: The Case of British Columbia Salmon Trollers" University of British Columbia, March.

Keywords: Behavior, decision making, investment, Canada, British Columbia, troller, dynamics, commercial, stochastic dynamic modeling, Pacific salmon, license, capital, dynamics

Citation: Lin, Biing-Hwan 1988 "The Demand for Atlantic Salmon in Canada: Issues of Functional and Parameter Stability" University of Alaska Sea Grant Report No. 88-6, October.

Fishery: Salmon, Canada, Atlantic

Management Issue: Market potential of farmed salmon

Technique: Demand analysis, econometrics

Summary: This study builds on a demand analysis for Canadian atlantic salmon done by Kabir and Ridler in an effort to better determine the Canadian market potential for cultivated salmon. The model's log-log functional form, used by Kabir and Ridler is tested by comparing it to the results of a Box-Cox flexible functional form, and the parameter estimates are examined to determine their stability. The Box-Cox functional form is shown to perform better than the (albeit adequate) log-log form in estimating the price, income and cross price elasticities. The author also finds that price elasticity for salmon is high, implying that stock enhancement programs would increase Alaskan fishermen's revenues. The high estimate of income elasticity implies that the wealth of industry producing this luxury good will swing widely with changes in the economy. Additionally, lobster is shown to be a close substitute for Atlantic salmon.

Keywords: Atlantic, salmon, demand, demand function, elasticity, cross price elasticity, elasticity of demand, Box-Cox, Canada

Citation: Lin, Biing-Hwan, Hugh S. Richards, and Joseph M. Terry 1987 "An Analysis of the Exvessel Demand for Pacific Halibut" Marine Resource Economics 4(4):305-314.

Fishery: Pacific halibut

Management Issue: Effect of season length on price

Technique: Econometric demand analysis

Summary: Estimating demand curves is a critical part of fisheries valuation. This study provides an example of how this can be done and ties the results to management issues. Due to the way it has been managed, the Pacific halibut fishery has experienced drastic reductions in season length. This study estimates the effect of season length on exvessel halibut demand by incorporating it in the model along with other variables such as landings, cold storage holdings, and prices of substitutes. Data is obtained from the Halibut Commission and other government statistical bulletins. Various functional forms (including an extended Box-Cox) are investigated, and parameter stability is tested using the Farley-Hinich test and recursive residuals. Exvessel demand is shown to be price elastic which means that management programs that increase catch will also increase gross fishing revenue. Cold storage holdings have a inverse relationship to exvessel price. Since the level of cold storage holdings decreases as the fishing season approaches, the date of the first opening will affect the exvessel price. Finally the length of the halibut season is shown to have a positive relationship with exvessel price, thus management strategies such as limited entry that increase season length will increase price.

Keywords: Demand, season length, Pacific, halibut

Citation: Lin, Biing-Hwan, and Mark Herrmann 1988 "An Econometric Analysis of Atlantic Salmon Markets in the United States and France" University of Alaska Sea Grant Report No. 88-5, October.

Fishery: Salmon, Norway, Atlantic

Management Issue: International market analysis

Technique: Econometrics, demand analysis, supply analysis

Summary: This paper analyzes the changes occurring in the salmon markets of the United States and France in a response to Pacific salmon fishermen's growing concern that increases in Norwegian farmed Atlantic salmon imports will effect the demand for their products. Specifically, the authors examine how the increased supply would effect Pacific salmon demand from three perspectives: 1) whether cultured Atlantic salmon is a substitute for the wild Pacific salmon and if so, to what degree; 2) the nature of the Norwegian supply of salmon and the U.S. demand for it; and 3) the extent to which Atlantic and Pacific salmon are substitutes in the French market. Their empirical answers are based on three independent equations and show, respectively, that 1) the Norwegian salmon is only a weak substitute for fresh Pacific chinook and that the U.S. demand for Atlantic salmon is both price and income elastic; 2) the Norwegian supply to the U.S. depends in part on the amount the world market is willing to pay; and 3) the Atlantic and Pacific salmon are not substitutes in the French market. The results indicate the need to develop a simultaneous demand equation including all of these three areas of concern and that will thus reduce existing biases in the equation.

Keywords: United States, Norway, Atlantic, salmon, markets, supply, demand, substitutes, imports

Citation: Lin, Biing-Hwan, Richard S. Johnston, and R. Bruce Rettig 1986 "U.S. Demand for Selected Groundfish Products, 1967-80: Comment" American Journal of Agricultural Economics, November:1021-1024.

Fishery: Groundfish, U.S.

Management Issue: Effect of extended fisheries jurisdiction

Technique: Demand analysis

Summary: This paper offers an analysis of an econometric model for the demand of U.S. groundfish that was published by Tsoa, Schrank and Roy (TSR). TSR's work indicated that groundfish demand was price-inelastic, and the authors of this paper compare that finding to other demand models' results and then discuss the policy implications of the various results. Because domestic fisherman have gained control of the groundfish fishery under extended fisheries jurisdiction (a result of the Magnuson Fishery Conservation and Management Act) and are likely to increase the supply of groundfish to the market, the implication is that--if demand is indeed price-inelastic--this could mean a decrease in prices to the fishermen.

The article referred to by TSR is: Tsoa, Eugene, William E. Schrank, and Noel Roy 1982 "U.S. Demand for Selected Groundfish Products, 1967-80" American Journal of Agricultural Economics 64(3):483-489.

Keywords: Elasticity, income elasticity, price elasticity, demand, groundfish, U.S., Magnuson Fishery Conservation and Management Act, MFCMA, imports

Citation: Lin, Biing-Hwan, and Nancy A. Williams 1985 "The Demand for Atlantic Salmon in Canada: A Comment" Canadian Journal of Agricultural Economics 33(July):243-249.

Fishery: General, Salmon, Atlantic, Canada

Management Issue: Commentary on model specification in Kabir, M., and N. B. Ridler 1984 "The Demand for Atlantic Salmon in Canada" Canadian Journal of Agricultural Economics 32(November):560-568.

Technique: Comment

Summary: This short commentary outlines the deficiencies of the Kabir and Ridler model for demand of Atlantic salmon in Canada. The authors suggest that the use of a simultaneous equation framework may be more appropriate and may represent a broader choice of price variables and different price shifters. Additionally, the discussion focuses on the need for considering the intertemporal nature of policy ramifications. The results of the more accurate demand model induce the need for policy change.

The comment is followed by a short rebuttle from Kabir and Ridler.

Keywords: Simultaneous equations, price, demand, income, elasticity, salmon, Atlantic, Canada

Citation: MacDonald, J. Douglas, and R. L. Mazany 1984 "Quality Improvement: Panacea for the Atlantic Fishing Industry?" Canadian Public Policy X(3):278-286.

Fishery: Atlantic, Canada

Management Issue: Management versus markets

Technique: Interpretive essay

Summary: The failure in the Canadian Atlantic fisheries to break into new markets has prompted an investigation into the quality of their products. The question raised here is whether quality improvement and new marketing strategies can strengthen the industry. The authors conclude that external conditions and the common property character of the fishery are more significant contributors to the market decline than are changes in quality. Their in-depth comparison of these issues concludes with a discussion of alternative solutions.

Keywords: Quality, market, Atlantic, Canada, price, management, competition

Citation: Omar, Ishak Haji 1983 "Malaysian Trawlers: Economics of Vessel Size" Marine Policy July:220-222.

Fishery: General, trawl, Malaysia

Management Issue: Weather's effects on management

Technique: Econometrics

Summary: This study looks at the optimal vessel size for the demersal and shrimp trawlers of Mersing, Malaysia with the intention of providing assistance for future investment decisions. The author did an econometric analysis of costs to determine the most efficient vessel size to be used in the fishery. (The industry faces an atypical economic constraint of operating in a monsoon affected multispecies fishery.) Monsoons were shown to have the most substantial negative impact on larger trawlers, but the large trawlers exhibit the greatest returns during the rest of the year. In contrast, smaller vessels were shown to not experience much difference between the season where monsoons occurred and the regular season.

Keywords: Monsoon, trawlers, Malaysia, Mersing, demersal, shrimp, cost, optimal size, vessel

Citation: Prochaska, Fred J. 1978 "Theoretical and Empirical Considerations for Estimating Capacity and Capacity Utilization in Commercial Fisheries" American Journal of Agricultural Economics 60(5):1020-1025.

Fishery: Commercial

Management Issue: Optimal economic capacity, utilization

Technique: Theory, case study

Summary: One of the effects of the 1976 enactment of the Fishery Conservation and Management Act has been to prompt an evaluation of fishery management in terms of capacity and capacity utilization in the effort to harvest optimum yield. This paper examines capacity in terms of its theoretical design, the associated empirical considerations of methodological and measurement problems, and the examples of capacity--such as hold capacity and volume produced--which are currently used in fisheries. The paper also provides methods for determining capacity and capacity utilization. In their summary the authors point out the need for further research and data in order to provide a more complete analysis, and they present implications of capacity issues related to management plans. Three FMP's that do consider more than just harvest and that do address capacity issues are the Northwest Atlantic Herring Fishing Plan, the Gulf of Alaska Groundfish Plan, and the Northern Anchovy Fishing Plan.

Keywords: Optimal, yield, capacity, investment, elasticity, fleet, management, FCMA, Fishery Conservation and Management Act

Citation: Samples, Karl C., and Paul D. Gates 1987 "Market Situation and Outlook for Northwestern Hawaiian Islands Spiny and Slipper Lobsters" National Marine Fisheries Service, Southwest Fisheries Center Administrative Report H-87-4C.

Fishery: Lobster, U.S., Northwestern Hawaiian Islands

Management Issue: Market(s) and marketing

Technique: Interpretive essay

Summary: This paper examines in detail the past (1979-1984) trends in supply of, demand for, and market strategies for lobster of the Northwestern Hawaiian Islands (NWHI) in an effort to determine current possibilities of enhancing the position of lobster in the U.S. market. Future market projections are made on the basis of survey data. The authors recommend enhancing the current marketing efforts, reflecting their positive expectation of increased demand for NWHI lobster.

Keywords: Dealers, brokers, spiny lobster, slipper lobster, Northwestern Hawaiian Islands, trade, imports, marketing, markets, U.S., consumption

Citation: Stokes, Robert L., and Brian H. Offord 1981 "Alaska Groundfish: A Financial Feasibility Analysis" Ocean Development and International Law Journal 9(1-2):61-76.

Fishery: Groundfish, U.S., Alaska

Management Issue: Investment/development potential

Technique: Financial analysis

Summary: In attempts to take advantage of the development of underexploited fisheries (an objective set forth by the Fishery Conservation and Management Act) Alaskan fisherman have begun to expand into the groundfish industry that is presently (1978/1979) almost completely exploited by foreign fisherman. This paper presents a financial analysis of the costs associated with developing a new, high-volume groundfish fishery. Given the current market for groundfish and the costs of initiating such an industry, the authors conclude that the necessary investment would be marginally feasible. An alternative, future possibility may be to develop joint ventures with existing foreign fleets.

Keywords: Groundfish, U.S., Alaska, investment, price, development, feasibility, production, Fishery Conservation and Management Act

Citation: Strand, Ivar E., Virgil J. Norton, and James G. Adriance 1981 "Economic Aspects of Commercial Striped Bass Harvest" In: Marine Recreational Fisheries 51-62, and University of Maryland Technical Reprint, UM-SG-RS-81-08.

Fishery: Striped bass, *Morone saxatilis*, U.S.

Management Issue: Harvest economics

Technique: Price analysis, regression

Summary: The recent (late 1970s) decline in catch of Atlantic striped bass prompted a re-evaluation of the commercial industry and its management policies, and this paper presents a quantitative price analysis of the fishery that examines the economic variables characteristic to the commercial industry. The analysis includes the various harvesting methods in the New England, the Mid-Atlantic, and the Chesapeake regions.

In order for the industry to continue, new management strategies must be implemented, yet these will involve serious trade-offs in a variety of areas. The authors provide an analysis of the various allocation, regulatory, and enhancement issues that arise in a situation like this and the respective management implications. They conclude that all regions will need to collaborate their management of the stock, and that without such a management scheme the high price for striped bass in relative to the comparatively low costs of fishing will result in the extinction of the species.

Keywords: Striped bass, *Morone saxatilis*, U.S., commercial, harvest, revenue, price, regression

Citation: Tettey, Ernest, Christopher Pardy, Wade Griffin, and A. Nelson Swartz 1984 "Implications of Investing under Different Economic Conditions on the Profitability of Gulf of Mexico Shrimp Vessels Operating out of Texas" Fishery Bulletin 82(2):365-373.

Fishery: Shrimp, U.S., Gulf of Mexico

Management Issue: Investment potential

Technique: Financial analysis

Summary: The recent great fluctuations of landings in the Gulf of Mexico shrimp fishery have motivated several investment analyses of the fishery, including this one. Unlike the others that have focused on fishing vessels, this study compares vessel investment returns during periods of low, medium and high inflation for different sizes of steel and wooden vessels. Cost, revenue, and investment data are analyzed by vessel type and size as well as by their investment period (1971-1980, 1977-1980, and 1979-1980). Earlier investments were more successful than later ones due to an increase in capital and vessel costs, but the authors' further analysis showed that the more recent investment in steel may prove to be successful. The newer steel vessels can better withstand bad weather (thus can stay out longer) and have shown better landings per trip when compared to wooden vessels of roughly the same size.

Keywords: Shrimp, U.S., Gulf of Mexico, Texas, financial, investment, profit, vessel size, efficiency, commercial, income, cash flow

Citation: Tsoa, Eugene, William E. Schrank, and Noel Roy 1982 "U.S. Demand for Selected Groundfish Products, 1967-80" American Journal of Agricultural Economics 64(3):483-489.

Fishery: Groundfish, Canada, U.S.

Management Issue: Product demand

Technique: Inventory adjustment-price expectations model

Summary: This paper examines the impact of extended national fisheries jurisdiction on the U.S. market for Atlantic groundfish. Both Canadian and U.S catches are sold to the U.S. market, and the extension of the fisheries zone out to 200 miles potentially increases the amount caught by U.S. fishermen to sell in the domestic market. The Nerlovian inventory adjustment-price expectations model estimated here suggests that the demand for U.S. groundfish will fluctuate with changes in the U.S. economy, but that the relatively inelastic price elasticity of demand indicates that an increase in the supply of groundfish will drive down the price. The authors conclude that the present marketing arrangements--i.e., allowing Canadian and U.S. caught groundfish into the U.S. market--may not lead to a realization of all the benefits of extended fisheries jurisdiction.

Keywords: Extended fisheries jurisdiction, groundfish, Canada, U.S., Atlantic, inventory, price, expectations, elasticity, Nerlove, Zellner

Recreational Fisheries

The majority of the articles in this section are ones that address the issues of valuing extra-market fisheries, i.e., those issues related to fisheries in which there is not necessarily a market for what is produced. Models like the ones covered here can serve many uses; one of the most basic applications is to measure the value of a resource such as a recreational fishery. Others extend this basic scenario and model situations not uncommon in recreational fisheries--situations such as what happens to the value of a recreational experience when there is congestion, when there is also a commercial fishery, when stock enhancement programs are being used to bolster a stock, or even the case of when water levels could be changed to alter the population level of a stock. Another sort of model that is presented in this section is one that analyzes the production components of recreational fishing, i.e., one that examines not only the factors that get people out to fish recreationally, but also the factors such as season and success that cause the amount of their fishing to change.

There are several techniques that can be used to estimate the value of different aspects of recreational fisheries: the hedonic method, the travel cost or Clawson-Knetch model, the direct survey, the replacement cost model, benefit-cost analysis, and the economic impact or input-output model. All of these techniques are discussed in various articles, along with descriptions of *what* these different methods actually measure.

The topic of recreational fishery management is also addressed here by an article which examines the legal and economic components constraining public administrators. The author shows how these constraints may result in management that, while well meaning, does not have the intended results.

Most of the articles in this section are general in their application, but there are also some that explicitly analyze the fisheries for winter flounder, salmon, striped bass, and trout. Other articles concerned with the subject of valuing non-market goods (but which are not necessarily directed at the subject of recreational fishing) can be found in the Mitigation, Habitat, and Valuation section.

Citation: Adamowicz, W. L., and W. E. Phillips 1983 "A Comparison of Extra Market Benefit Evaluation Techniques" Canadian Journal of Agricultural Economics 31(3):401-412.

Fishery: Recreational, Canada, Alberta

Management Issue: Extramarket benefit valuation

Technique: Hedonic, travel cost, direct survey methods

Summary: This paper analyzes the three major models used in recreational benefit estimation--the travel cost, the direct and the hedonic price models. Using a common data set from a survey sent to recreational anglers residing in Alberta, Canada, the three approaches are examined in terms of the assumptions they incorporate, the way they treat the various aspects of recreational valuation, the variables used in each, the empirical results they yield, and the pros and cons of each method. (For example, with hedonic price models the choice of variables and how time is treated is important, whereas the travel cost methods are more sensitive to the location where applied.) Finally, the authors support the idea that the similarities between these models imply that a more encompassing, general form of recreational model will likely emerge in the future.

Keywords: Survey, travel cost, hedonic price, recreation, benefit, estimation, extramarket, Alberta, Canada

Citation: Anderson, Lee G. 1980 "Estimating the Benefits of Recreation Under Conditions of Congestion: Comments and Extension" Journal of Environmental Economics and Management 7:401-406.

Fishery: None. Recreation.

Management Issue: Measurement of recreational benefits

Technique: Theoretical

Summary: This comment examines the use of the Clawson-Knetch travel cost model and derives the appropriate consumer surplus measure for a recreational experience in which congestion occurs. The author's derivation also shows the optimal level of use for a recreational resource when congestion occurs and that this level of use does not occur when the price for use is zero, i.e., that the optimal level of use occurs when some user-fee is charged.

Keywords: Recreation, consumer surplus, congestion, welfare

Citation: Anderson, Lee G. 1983 "The Demand Curve for Recreational Fishing with an Application to Stock Enhancement Activities" Land Economics 59(3):279-286.

Fishery: General, recreational

Management Issue: Optimal recreational fishing management

Technique: Theoretical

Summary: This article extends previous works about recreational fishing models using a demand curve model. The advantage of this model is that the quality of fishing as well as the quantity (in days) of fishing can be explicitly and individually described. The author notes that the model could be used to describe a variety of situations, including the situation of joint recreational-commercial exploitation. Here, it is applied to the situation of recreational fishing where stock enhancement is also occurring.

Keywords: Recreation, demand, stock enhancement, management

Citation: Andrews, Elizabeth J., and James E. Wilen 1988 "Angler Response to Success in the California Salmon Sportfishery: Evidence and Management Implications" Marine Resource Economics 5(2):125-138.

Fishery: Pacific salmon

Management Issue: Recreation participation

Technique: Econometrics

Summary: Using log book data from charter and party boats, a harvest production function and an effort response function are estimated. The production function shows that catch increases more than proportionately with effort. This result may be due to searching and information sharing which is more efficient with more participants, or it may mean that "good" anglers show up in more numbers when catch rates are high. The effort response function shows that while in-season changes in success will change participation rates, the seasonal pattern with its mid-summer peak is more influential. This is a possible explanation for the odd results of some travel cost studies in which success affected valuation with the wrong sign. If researchers sample over a season without considering the seasonal patterns, it would be possible to get results showing high willingness to pay with low abundance and hence low success rates. An important conclusion is that recreational catch will increase more than proportionally with increases in abundance. This occurs because there is both a direct effect of increased catch due to increased stock size and an indirect effect of increased effort due to the higher success rates associated with larger stocks. For example, in the San Francisco area the authors estimate that a 10% increase in stock size will increase effort by 6.9% and catch by 19.52%.

Keywords: Recreational success rate, recreational participation rate

Citation: Bell, Frederick W. 1979 "An Economic Impact Analysis of Recreational Versus Commercial Fishing" Journal of Contemporary Business 10(1):111-127.

Fishery: Commercial, recreational, U.S., Florida

Management Issue: Comparison of commercial and recreational economic impacts

Technique: Impact analysis, gross expenditure, user value

Summary: Economic comparisons such as the one in this paper are intended to help policy makers when making tough choices about how to resolve conflicts or allocate money for projects that may affect the resource base on which industries depend. More specifically, by looking at the relative sales and employment generated by commercial and recreational fisheries in Florida in 1975, this paper provides a rough economic comparison of the importance of commercial and recreational fisheries to the state. The respective valuations of the recreational and commercial fishing sectors begin with brief discussions on how the concept of value applies to the particular fishery under examination before moving to the empirical production and employment analyses.

Keywords: Tourism, recreation, economic impact, user values, commercial

Citation: Edwards, Steven F. 1990 "An Economics Guide to Allocation of Fish Stocks between Commercial and Recreational Fisheries" NOAA Technical Report, NMFS 94.

Fishery: General, commercial and recreational

Management Issue: Allocation between recreational and commercial users on the basis of economic value.

Technique: Essay

Summary: The author of this guide put together a document that conveys the basic economic elements of fisheries economics in a straightforward, comprehensible way. After a clear introduction to the language, derivation and uses of economic value, the guide provides a clear explanation and comparison of the use of benefit-cost and input-output analyses for deriving the economic value of both commercial and recreational fisheries. To further help readers, commonly used and generally incorrect economic-sounding arguments are exposed with explanations as to why such arguments are incorrect. The author has also included three appendices: a glossary (with and index) of the economic terms used; a more technical presentation of input-output analyses/modeling; and a derivation of general equilibrium demand for the multi-market supply and demand relationships that occur in the landings, wholesale and retail marketplaces.

Keywords: Value, commercial, recreational, benefit-cost, input-output, economic impact, allocation

Citation: Johnson, Neal S., and Richard M. Adams 1988 "Benefits of Increased Streamflow: The Case of the John Day River Steelhead Fishery" Water Resources Research 24(11):1839-1846.

Fishery: Steelhead, U.S., Oregon

Management Issue: Value of increased streamflow on a recreational fishery

Technique: Bioeconomic model

Summary: This article extends the relationship between a fishery and instream flow beyond biological and hydrological criteria to include determining the economic value of changing instream flow on the John Day River, Oregon stock of steelhead trout sought by recreational anglers. The authors' model is developed in several stages. First, the fishery's production function is modelled with the inclusion of an environmental factor to capture stock changes due to changes in instream flow. The angler-streamflow relationship is then estimated as the elasticity between changes in hours fished and changes in flow. To determine anglers' willingness-to-pay to improve conditions (as measure by more hours of fishing) the authors designed and used a contingent valuation (CV) survey. The value--as measured by changes in fishing quality (the hours fished to catch a steelhead trout)--for this particular instream use was estimated at $2.36 in 1987 dollars for the addition of an acre-foot of water.

Keywords: Steelhead, *Salmo gairdneri*, production, U.S., Oregon, trout, recreation, valuation, econometrics

Citation: McConnell, Kenneth E. 1979 "Values of Marine Recreational Fishing: Measurement and Impact of Measurement" American Journal of Agricultural Economics 61:921-925.

Fishery: Recreational, winter flounder, U.S., Rhode Island

Management Issue: Valuation of recreational fishing

Technique: Theoretical with case study

Summary: In response to what the authors perceived as a bias among some resource/fishery policy makers to basically ignore the value of recreational fishing, this article describes and empirically derives estimates for the value of the winter flounder fishery. The economic analyses presented here (the author uses a household production function and the travel cost approach) provide empirical support for the very real consumer surplus that is derived from recreational fishing. The article closes with a discussion of why policy makers may not be willing to accept economists' measures of changes in welfare along with a call for economists to arm policy makers with better details regarding the implications of a variety of different management strategies.

Keywords: Valuation, recreational, travel cost, consumer surplus, production, winter flounder, U.S., Rhode Island

Citation: Marshall, Anne R., and Jon A. Lucy 1981 "Virginia's Charter and Head Boat Fishery: Analysis of Catch and Socioeconomic Impacts" Virginia Sea Grant Program, Special Report in Applied Marine Science and Ocean Engineering No. 253.

Fishery: Recreational, U.S., Virginia

Management Issue: Sectoral characterization

Technique: Interpretive essay

Summary: This document presents and summarizes the results of a study of Virginia's charter and head boat fishing industry. The data from surveys and log books of the 1979 season includes such information as the home port by type of operation, vessel size, revenues, trips, fish species targeted and caught, and indirect expenditures generated by the head and charter boat businesses.

Keywords: Head boat, charter boat, Virginia, U.S., catch, effort, target species, interview, economic impact, multiplier, socio-economic

Citation: Meyer, Philip A. 1979 "Publicly Vested Values for Fish and Wildlife: Criteria in Economic Welfare and Interface with the Law" Land Economics 55(2):223-235.

Fishery: General resources

Management Issue: Non-market valuation

Technique: Essay

Summary: The author of this paper takes a legal perspective when he examines the (lack of) monetary and economic valuation of natural resources that lack pecuniary value. Beginning with a review of nine different economic approaches for valuing non-market goods such as fish and game, the author then goes on to cover a variety of demand-related approaches and the differences between willingness-to-pay and demand for compensation. The focus of the paper then shifts to how the law deals with the issue of economic welfare and to the legal and economic requirements that can constrain public administrators or, at least, lead to outcomes quite different than those intended.

Keywords: Welfare, willingness-to-pay, law, empirical, theory, public policy, non-pecuniary, valuation, social welfare

Citation: Norton, Virgil, Terry Smith, and Ivar Strand, eds. 1983 "Stripers: The Economic Value of the Atlantic Coast Commercial and Recreational Striped Bass Fisheries" University of Maryland Sea Grant Program.

Fishery: Striped bass, U.S.

Management Issue: Resource value and valuation

Technique: Economic valuation, economic impact

Summary: This Sea Grant publication is a result of the contributions of seven investigators who where charged to assess the economic value of the striped bass fisheries in the eastern coastal states of the U.S. as a result of the Chafee Bill (otherwise known as the Emergency Striped Bass Act). The fisheries are located in New England, the Mid-Atlantic, the Chesapeake, and the South Atlantic. The authors present a picture of the entire fishery from 1970 through 1980, beginning with descriptions of the commercial and recreational fisheries and the participants in them. Attention is next focused on the economic values of the benefits of the commercial and recreational fisheries before shifting to an analysis of the economic impact of these fisheries. The economic impact analysis compares three scenarios--the past, the present, and the potential (given proposed policy changes)--for the fisheries to provide some perspective about the resource's contribution. This report reflects only a portion of the striped bass studies generated by the contributors, and readers seeking further information are urged to contact regional participants.

Keywords: Striped bass, valuation, recreational, commercial, management, economic impact, U.S.

Citation: Weithman, A. Stephen, and Mark A. Haas 1982 "Socioeconomic Value of the Trout Fishery in Lake Taneycomo, Missouri" Transactions of the American Fishery Society 111:223-230.

Fishery: Rainbow trout, *Salmo gairdneri*, U.S., Missouri, Lake Taneycomo

Management Issue: Sport fishery valuation

Technique: Replacement cost method, income multiplier method, travel cost method

Summary: This paper provides estimates of the value of a rainbow trout, *Salmo gairdneri*, fishery using three methods: the replacement cost method, the travel cost method, and the income multiplier method. Because both the travel cost and income multiplier methods required survey data, a discussion of survey design is included, as is a listing of recreational fishing expenditure studies. The results of the study illustrate how specific they are to the assumptions of the method used and to what the method estimates.

Keywords: Recreational, survey, angler, rainbow trout, *Salmo gairdneri*, U.S., Missouri, Lake Taneycomo, valuation, income multiplier, travel cost, replacement cost

Mitigation, Habitat, and Valuation

This collection of articles provides both theoretical and empirical examples of how to derive dollar value estimates for of things that typically are not bought and sold in a market. Most of the articles examine and measure the sorts of factors that can either positively or negative influence the health of a fishery--and its economic value.[1]

While some of the articles deal with providing dollar value estimates for habitat, the ones more useful from a management perspective extend this idea to estimate the value of *changes* in habitat. Some of the changes are beneficial ones such as improved water quality, but other changes examined include the degradation of habitat from pollution, accidental spills, land erosion, or even environmental changes (as in the case of brown tides). Yet another article addresses the subject of measuring the dollar value of the effects of management; more specifically, it measures the dollar value of the impact of effort controls in a fishery that has both commercial and recreational participants.

A fairly large sample of the current methodologies is presented in this section. The benefit-cost analyses presented include both those that exclude and those that include the effects of uncertainty on the model. Other studies provide information to be used in benefit-cost analysis (BCA) by estimating BCA model parameters using econometric techniques. Such methods as the travel cost method, contingent valuation, and willingness-to-pay studies, and economic impact assessments are also covered by some of the articles.

Finally, one of the articles provides a clear picture of how *not* to misuse economic arguments that relate to the valuation of commercial and recreational use of fisheries.

Although some of the articles are theoretical in nature, there are empirical studies of crab, perch, salmon, trout, scallop, and oysters fisheries.

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[1]For those articles directly concerned with the valuation of recreational fishing and fisheries, please see the Recreational Fisheries section.

Citation: Bishop, Richard C, Scott R. Milliman, Kevin J. Boyle, and Barry L. Johnson 1990 "Benefit-Cost Analysis of Fishery Rehabilitation Projects: A Great Lakes Case Study" Ocean and Shoreline Management (13): 253-274.

Fishery: Green Bay yellow perch

Management Issue: Potential economic gains from effort control

Technique: Benefit-cost analysis, uncertainty analysis

Summary: This paper provides estimates of the economic gains to be achieved from a planned reduction in effort resulting from a quota on commercial catch, a closed season on drop nets, and a daily bag limit on recreational participants. The gains to be achieved will only come after an initial period of reduced catch, and the rate at which the stock will recover is not known with certainty. Six potential growth patterns were postulated along with their estimated probability of occurrence, and changes in commercial industry profits and consumer surplus to recreational participants were estimated for each of the growth patterns. The expected net present value to each sector was calculated by summing the product of the probability of each of the patterns and the net present value of the benefits each would produce. The change in profits was calculated in a straightforward manner by comparing how revenues and costs would change with healthier stocks and higher CPUEs. The benefits to recreational participants were estimated using a contingent valuation procedure which showed that the consumer surplus for each perch fishing trip in 1986 was $26. Because it was not possible to estimate precisely how participation rates would vary with the different stock recovery patterns, conservative participation growth rates were assumed. The authors show that, while the expected gains to the commercial sector are small, there are significant potential gains for the recreational sector. More detail on the biological underpinnings of this analysis may be found in the following paper.

Milliman, Scott, Richard C. Bishop, and Barry L. Johnson 1987 "Economic Analysis of Fishery Rehabilitation Under Biological Uncertainty: A Conceptual Framework and Application" Canadian Journal of Fisheries and Aquatic Sciences 44(Supplement 2):289-297.

Keywords: Commercial, recreational, allocation, economic gains, Green Bay, yellow perch

Citation: Booth, Douglas E 1989 "Hydroelectric Dams and the Decline of Chinook Salmon in the Columbia River Basin" Marine Resource Economics 6(3):195-211.

Fishery: Chinook Salmon

Management Issue: Habitat loss

Technique: Econometric regression analysis

Summary: The decline of chinook salmon in the mouth of the Columbia River in recent decades is attributed, in part, to the construction and operation of hydroelectric dams. This paper estimates the magnitude of these losses using regression analysis where the return per spawner is regressed against loss rates for the dams (which consider both upstream and downstream survival rates), hatchery releases, and ocean troll effort. It is a good example of how data can be used to estimate the effects of habitat change on stock size. Problems such as multicollinearity are confronted, and the results are interpreted accordingly. While the results cannot be generalized to other problems, the methodology, which is appropriate for anadromous species only, is interesting and may be adapted for other similar problems. The results of this and similar studies provide necessary inputs for benefit cost analyses of habitat restoration or projects which will cause a decline in environmental conditions necessary for fish stocks.

Keywords: Mitigation, habitat loss, chinook salmon, Columbia River

Citation: Clark, Richard D. Jr., and Bin Huang 1985 "Conflict Between Sportfishing, Commercial Fishing, and Rehabilitation of Lake Trout in Lake Michigan" North American Journal of Fisheries Management 5:261-276.

Fishery: Lake trout, *Salvelinus namaycush*, U.S., Lake Michigan

Management Issue: Stock rehabilitation

Technique: Dynamic pool model

Summary: Since the mid-1950s extinction of native lake trout (*Salvelinus namaycush*) in Lake Michigan, both federal and state programs have had great difficulty in reestablishing trout. Despite supporting both sport and commercial fisheries, the planted trout have not been successfully reproducing to the point of self-sustainability.

Using a Beverton-Holt population dynamics model, the authors modify it to include: the impact of the two (sport and commercial) fisheries on the stock, the effects of variable cohort sizes as related to the numbers of fish planted, the effects of catch and release fishing of sublegally sized fish, the impact of fishing on egg production, and estimates of the effects of various size and effort regulations. Data for this study come from the Frankfort-Good Harbor Bay area of Lake Michigan, a region believed to be fairly representative of the entire lake. The simulation results show that, without simultaneous restrictions on the two fisheries, the trout restocking program will not be very successful. The sole successful management regime appears to be closure of both the sport and commercial fisheries.

Keywords: Rehabilitation, lake trout, *Salvelinus namaycush*, Lake Michigan, U.S., population dynamics, competition, dynamic pool

Citation: Edwards, Steven F. 1991 "A Critique of Three 'Economics" Arguments Commonly Used to Influence Fishery Allocations" North American Journal of Fisheries Management 11:121-130.

Fishery: General

Management Issue: Valuation of commercial and recreational fisheries

Technique: Theory, discussion

Summary: This article presents and dispels three arguments that are often heard in discussions of commercial versus recreational use of fisheries. These arguments are described here by the author as the "market value argument," the "revenues argument," and the "total value argument." The first argument claims that recreational fishing has no value unless it takes place in a market where the value is monetized as in sport/charter fishing. The second one tries to compare the result of two dissimilar forms of economic valuation--economic input and dockside revenues. The third argument is one which does not consider possible combinations of fishery exploitation by both commercial and recreational users.

The underlying economic explanations as to why these arguments are not correct are presented in a clear and direct manner, providing a very helpful reference for fishery managers and policy makers who may encounter them.

Keywords: Willingness-to-pay, contingent valuation, travel cost, economic impact, recreational, commercial, conflict, allocation

Citation: Grigalunas, Thomas A., James J. Opaluch, D. French, and M. Reed 1988 "Measuring Damages to Marine Natural Resources from Pollution Incidents under CERCLA" Marine Resource Economics 5(1): 1-22.

Fishery: General

Management Issue: Habitat, pollution damages

Technique: Simulation model, Ricker

Summary: The paper discusses a model which can be used to assess damages from spills of oil or hazardous substances in coastal and marine environments when individual site specific studies would be too expensive or would not likely provide superior results. Even when the model may not apply, the general procedure presented here provides an excellent framework for more detailed studies. To measure damages from a particular incident, linkage must be established from the incident to its effect on ambient conditions to biological and physical injuries to a measure of monetary damages. For fisheries, the output of a biological sub-model is a time series of lost catch for important species which is allocated to commercial and recreational users by participation rates. Exvessel prices are used to evaluate damages to commercially harvested fish, and estimates of marginal value per fish divided by average weight of fish were used to estimate the value of lost biomass of recreationally caught fish. Examples are provided, and it is shown that damages are sensitive to the shape of the relationship between damage and amount released as well and the location and time of the release. The full model is described in:

Grigalunas, T. A., J.J. Opaluch, D. French, and M. Reed 1987 Measuring Damages to Coastal and Marine Natural Resources: Concepts and Data Relevant for CERCLA Type A Damage Assessments Springfield, VA: National Technical Information Service.

Keywords: Habitat, pollution, damage

Citation: Kahn, James R., and W. Michael Kemp 1985 "Economic Losses Associated with the Degradation of an Ecosystem: The Case of Submerged Aquatic Vegetation in Chesapeake Bay" Journal of Environmental Economics and Management 12:246-263.

Fishery: Chesapeake Bay, U.S.

Management Issue: Economics of pollution damages

Technique: Econometrics

Summary: Pollution is known to have indirect consequences on the ecology of a region such as the Chesapeake Bay, but what is not well known is the value of such damage. This paper addresses this issue, and the authors estimate the value of the damages induced by waste discharge into the Chesapeake Bay by looking at changes in producer surplus (for commercial fisheries) and consumer surplus (for recreational fisheries). Waste discharge is used here because it can cause decreases in the amount of the submerged aquatic vegetation (SAV) that is a vital part of fish habitat.

Both a marginal damage and a total damage function are derived and estimated for the entire Chesapeake Bay. The results are subject, the authors caution, to the limitations and extrapolations of the (1969-1974) data.

Keywords: Marginal damage, indirect impacts, welfare, ecological degradation, pollution, submerged aquatic vegetation, Chesapeake Bay

Citation: Kahn, James R. 1987 "Measuring the Economic Damages Associated with Terrestrial Pollution of Marine Ecosystems" Marine Resource Economics 4(3):193-209.

Fishery: General

Management Issue: Pollution, habitat

Technique: Theoretical modeling

Summary: This paper studies the problem of evaluating the effects of environmental changes on the bioeconomic equilibrium of fisheries and shows that in order to measure damages it is necessary to have an understanding of the ecological and economic interconnections involved. For example, to better understand the implications of soil erosion on fisheries, it is necessary to know the relationship between soil erosion and turbidity, between turbidity and size and growth characteristics of the fish population, and between these stock effects and the valuation of commercial and recreational use. The author also shows how a model in which the equilibrium catch function is estimated directly as a function of environmental quality will be superior to a model which takes the stock effects from an independent ecosystem model. Models are also suggested for those cases in which only proxies for stock levels are available as well as for those cases in which no stock data is available.

Keywords: Pollution, habitat, damage

Citation: Kahn, James R., and Mark Rockel 1988 "Measuring the Economic Effects of Brown Tides" Journal of Shellfish Research 7(4):677-682.

Fishery: Bay scallops, U.S., New York

Management Issue: Economics of pollution damages

Technique: Econometrics

Summary: Although ecological changes can greatly affect a sector such as the fishing sector, there are few valuations of the extent to which something like a brown tide can, in dollars and cents terms, hurt the economy. This paper provides an explanation of the economic impacts of brown tides on recreational activities and on the bay scallop fishery in New York. After discussing the theoretical economic losses associated with brown tides, the authors derive the economic losses in commercial fishing for finfish and shellfish, but--due to a lack of data--only estimate the losses for the scallop fishery. The lack of data also prevented them from quantifying the losses in recreational activities, although such losses and a variety of methods that could be used to estimate them are discussed.

Keywords: Economics, bay scallops, brown tides, recreation, commercial, welfare, U.S., New York

Citation: Lichtenberg, Erik, and David Zilberman 1987 "Regulation of Marine Contamination under Environmental Uncertainty: Shellfish Contamination in California" Marine Resource Economics 4(3):211:225.

Fishery: Shellfish, U.S., California

Management Issue: Habitat, pollution

Technique: Econometrics, simulation

Summary: This study analyzes the effects of manure run-off on the health safety of shellfish consumption and the ways of meeting various safety standards as efficiently as possible. Under normal conditions, runoff from manure disposal areas will have no ill effects, but during severe rainstorms manure will be washed into the watershed. Holding ponds of various sizes can be built to prevent this from occurring. Using probability estimates of precipitation and a formula for the risk of acute gastroenteritis from microbial shellfish contamination (as a function of water quality, microbial uptake by oysters, and human physiological response), it is possible to estimate the optimal pattern of holding pond construction. The authors argue that there is a great deal of uncertainty in environmental control analysis and that their methodology explicitly incorporates this uncertainty.

Keywords: Pollution, shellfish, U.S., California

Citation: Liston, Charles R., Charles Korson, and Milton H. Steinmueller 1982 "The Bioeconomic Impact of Impingement and Entrainment on Yellow Perch in Lake Erie" North American Journal of Fisheries Management 2:285-293.

Fishery: Yellow perch, *Perca flavescens*, U.S., Michigan, Lake Erie

Management Issue: Effects of power plants

Technique: Bioeconomic simulation model

Summary: Because of the intense angling for yellow perch *Perca flavescens* in western Lake Erie's waters, the biological and economic impacts of power plants have been of substantial concern. Using data from Monroe County, Michigan where the J.R. Whiting power plant is located, the authors first estimated the perch population and how it may have been affected by the plant, and then they derive an estimate of the value of the change.

Population estimates are derived using a logistic surplus production function and were then combined with impingement and entrainment data and a Leslie matrix model to determine the impacts on the fish population over the fifty year life expectancy of the power plant. Next, the authors derived the demand or willingness-to-pay curve for Michigan anglers to estimate the amount that anglers would be either willing-to-pay for the plant to not operate, or, conversely, the amount they would be willing to accept as compensation for those negative impacts of the power plant. Although the plant also provides an access site for anglers as well as a food source for bait and sport fish near the warm-water discharge plume, these benefits were not included in the calculations. If the 1.7% reduction in perch population estimated to be cause by the plant is perceived by perch anglers, then the annual economic loss to the fishery that can be attributed to the power plant is in the range of $25,000-$96,000 (1980 dollars).

Keywords: Logistic function, Leslie matrix, simulation, Michigan, U.S., Lake Erie, *Perca flavescens*, yellow perch, Monroe County, recreation, angling, economic value, impingement, entrainment

Citation: Loomis, John B. 1988 "The Bioeconomic Effects of Timber Harvesting on Recreational and Commercial Salmon and Steelhead Fishing: A Case Study of the Siuslaw National Forest" Marine Resource Economics 5(1):43-60.

Fishery: Pacific salmon, steelhead

Management Issue: Habitat

Technique: Econometrics, travel cost method

Summary: The economic effects of different harvest patterns on recreational and commercial salmon and steelhead harvests in a several rivers are estimated using a series of simple watershed, habitat, population and economic models. The approach uses a multi-site travel cost method and is able to estimate values for marginal catches, the measure that is especially critical for efficiency analysis. The results show that the marginal value per fish varies from river to river and from seaport to seaport. Commercial valuation is based upon the ex-vessel price of fish on the assumption that the changes considered will not affect price. The results show that adopting a minimum forest management program of using buffer strips and better road design will increase the net present value (NPV) (thirty years at 4%) of fishery related values by 28%. Also, a no harvesting policy would increase NPV over the same period by a further $1.67 million. The author points out, however, that the resultant decrease in the NPV of timber harvests would be greater than this.

Keywords: Habitat, multiple use, pacific salmon, steelhead

Citation: Lynne, Gary D., Patricia Conroy, and Frederick J. Prochaska 1981 "Economic Valuation of Marsh Areas for Marine Production Processes" Journal of Environmental Economics and Management 8:175-186.

Fishery: Blue crab, U.S., Florida

Management Issue: Habitat value

Technique: Bioeconomic modeling, econometrics

Summary: The focus of this paper is on an approach for quantifying and evaluating the marsh-estuarine area's contribution to the production of marketable marine life. Although this is a static look at the blue crab fishery in the Gulf coast of Florida, the use of a bioeconomic model and ordinary least squares for estimation of the derived demand value of marshes in blue crab production provides a first step towards quantitative, dynamic modeling.

The derived demand value of marshes was low (a present value of $3.00 per acre at the margin for blue crab production) and closely linked to the human effort applied to the marsh as well as to the availability of the marsh. This is completely plausible, but--as the authors point out--this raises the question of true model specification and form. In spite of these difficulties, the $3.00 present value estimate of the marginal acre of marsh used for blue crab production for human consumption does offer an idea of the marshes' economic contribution, and the quantification of such contributions will be increasingly important in making preservation versus development decisions in coastal areas.

Keywords: Marsh, estuary, blue crab, Florida, U.S., Gulf of Mexico, productivity, economic value, elasticity of substitution, elasticity of output, elasticity

Citation: Norgaard, Richard B. 1988 "The Oyster Beds of Ao Ban Don" Land Economics 64(1):83-85.

Fishery: Oysters, Thailand, Ao Ban Don

Management Issue: Habitat valuation

Technique: Cost accounting

Summary: Using estimates of revenues and capital costs, the rough value of the nutrients feeding the Ao Ban Don oyster beds is calculated using the residual return method. Despite the fact that it is the delivery of nutrients to these beds that makes them so valuable and that ecologists know almost nothing about how the nutrient system works is not a barrier to the analysis. Even without scientific knowledge, the monetary valuation provided here provides signals to the key participants about the critical nature of the larger process of resource management.

Keywords: Oysters, Thailand, Gulf of Siam, Ao Ban Don, nutrients, costs, revenues, valuation, residual return, monetary value

Economic Impact Studies

The seven articles in this section provide examples of economic impact studies done regarding the impact of commercial fishing activities of either the state or the regional level. Six of the articles are straightforward applications of economic impact studies. The seventh is a summary article that compares six input-output studies and examines the methodological differences as well as the differences in the derived economic impact estimates.

Two of the articles use the economic impact method to determine the potential effects of changes in jurisdiction. One study provides estimates of what the impact of Mexico's extended jurisdiction to 200 miles would be on the U.S. commercial shrimp fishery in the Gulf of Mexico. Another provides estimates of the economic impacts--in both the U.S. and Canada--of various maritime delimitation boundaries between the U.S. and Canada in the Gulf of Maine. Unfortunately, subsequent analyses of the actual impacts are not available to include here for comparison.

Although much of the data used in these studies is aggregate data that is not broken out on a species by species basis, a few of the studies were able to be use only partially aggregated data from crab, clam herring, menhaden, lobster, scallop, shrimp, and marine worm fisheries.

Additional articles that use economic impact analysis, at least in part, are found in the Recreational Fisheries and the Mitigation, Habitat, and Valuation sections of this bibliography.

Citation: Andrews, Margaret, and Daniel Rossi 1986 "The Economic Impact of Commercial Fisheries and Marine-Related Activities: A Critical Review of Northeastern Input-Output Studies" Coastal Zone Management Journal 13(3/4):335-367.

Fishery: General, U.S., Northeast

Management Issue: Comparison of economic impact estimates

Technique: Input-output

Summary: The authors of this paper provide an overview of six studies applying the input-output method to the commercial fishing and marine-related sectors in the northeastern U.S.. The comparisons of the size of the region studied, the sectors included--commercial fishing and marine-related as well as other regional sectors--and the procedures used for collecting data, permit the reader to see the advantages and shortcomings of each approach and of the method in general. The authors believe there is a tendency for these studies to provide economic impact estimates that are on the high side, and they call for a standardization of procedures when doing input-output analyses.

This paper cites others included in this bibliography:

- Briggs, Hugh, Ralph Townsend, and James Wilson 1982 "An Input-Output Analysis of Maine's Fisheries" Marine Fisheries Review 44(1):1-7.

- Callaghan, Dennis W., and Robert A. Comerford 1978 "The Economic Impact of Commercial Fishing on the State of Rhode Island, 1975" University of Rhode Island, Marine Technical Report 65, 32 pp.

Keywords: Input-output, regional, economic impact, coastal, U.S., Northeast

Citation: Briggs, Hugh, Ralph Townsend, and James Wilson 1982 "An Input-Output Analysis of Maine's Fisheries" Marine Fisheries Review 44(1):1-7.

Fishery: General, U.S., Maine

Management Issue: Economic impact of fisheries activities

Technique: Input-output model

Summary: This paper describes the conceptual basis for and empirical results of an input-output model for estimating the economic impact of 9 sectors of Maine's fishing industry. The nine sectors in the analysis included 5 harvesting sectors--clam harvesting; marine worm harvesting; herring and menhaden harvesting; lobster, crab, and scallop harvesting; and groundfish harvesting--as well as four processing sectors--clam and marine worm processing; herring and menhaden processing; lobster, crab, and scallop processing; and groundfish processing. The estimates generated here for Maine in 1980 showed that landings of $90 million ultimately generated $240 million in income.

Note: This study is one of two (the other is by Callaghan and Comerford, 1978) that are referenced in a third article included in this bibliography:

Andrews, Margaret, and Daniel Rossi 1986 "The Economic Impact of Commercial Fisheries and Marine-Related Activities: A Critical Review of Northeastern Input-Output Studies" Coastal Zone Management Journal 13(3/4):335-367.

Keywords: Input, output, economic impact, multipliers, income, U.S., Maine

Citation: Callaghan, Dennis W., and Robert A. Comerford 1978 "The Economic Impact of Commercial Fishing on the State of Rhode Island, 1975" University of Rhode Island, Marine Technical Report 65, 32 pp.

Fishery: Commercial, U.S., Rhode Island

Management Issue: Economic impact of commercial fishing activity

Technique: Input-output analysis (regional)

Summary: This economic impact study analyzes the impact of seventy-two firms involved in Rode Island's commercial fishing industry. The input-output framework used provides estimates of income multipliers for the commercial fishing industry's impact on the economy; the multipliers for fin fishermen, lobstermen, shell fishermen, processors, handlers, and packers, as well as those for non-Rhode Island vessels are also estimated. As might be expected, the fishing industry does not have as much total output as other economic sectors in Rhode Island. The study also provides a basis for comparing sectors' contributions to the economy using (their estimates of) interdependency coefficients.

Note: This study is one of two (the other is by Briggs, Townsend and Wilson, 1982) that are referenced in a third article included in this bibliography:

Andrews, Margaret, and Daniel Rossi 1986 "The Economic Impact of Commercial Fisheries and Marine-Related Activities: A Critical Review of Northeastern Input-Output Studies" Coastal Zone Management Journal 13(3/4):335-367.

Keywords: Economic impact, input, output, U.S., Rhode Island, commercial, industry, multiplier

Citation: Griffin, Wade L., and Bruce R. Beattie 1978 "Economic Impact of Mexico's 200-Mile Offshore Fishing Zone on the United States Gulf of Mexico Shrimp Fishery" Land Economics 54(1):27-38.

Fishery: Shrimp, U.S., Gulf of Mexico

Management Issue: Economic effects of Mexico's 200-mile limit

Technique: Regression

Summary: This paper looks at the economic ramifications on the U.S. Gulf of Mexico shrimp fleet of Mexico's extension of jurisdiction out to 200 miles. The impact of extended jurisdiction on the fishery's yield function as well as on the product's total value and cost is estimated using data from the period 1962 to 1974. Estimates of the net losses for the U.S. fleet are also provided. In order to gauge what sort of adjustment would need to occur in the U.S. fleet to make it more economically efficient, the authors also estimate break-even shrimp prices for different levels of effort. Because of relatively good product prices in 1976, it does not appear that the U.S. industry will suffer as a result of Mexico's action.

Keywords: Shrimp, U.S., Gulf of Mexico, extended jurisdiction, 200-mile limit, regression, break-even, Mexico

Citation: Jordan, Peter G., and Karen R. Polenske 1986 "A Multiplier Impact Study of Fishing Activities in New England and Nova Scotia" Resources for the Future, Discussion Paper Series No. RR86-02.

Fishery: Commercial, Gulf of Maine, U.S., Canada

Management Issue: Effects of the maritime delimitation between the U.S. and Canada

Technique: Input-output analysis

Summary: This paper was prepared for use by the U.S. State Department's litigation with Canada before the International Court of Justice (ICJ) regarding the Gulf of Maine boundary delimitation. The focus here is on the economic impact of various boundaries on New England (and especially on Massachusetts), the Atlantic Provinces and Nova Scotia. The analytical method used is that of economic impact studies. There are many analyses reviewed and discussed (seventeen multi-regional input-output, microsimulation and econometric models are mentioned just for the U.S.), and this provides a setting for the multi-regional input-output framework chosen here.

The comparison of the impacts on the primary and secondary sectors showed that both sectors would be affected by the decision. Regardless of whether it occurred in Nova Scotia or New England, a significant reduction in the fishery resources available to the primary sector would have a large impact in terms of output, employment, and income.

Keywords: International Court of Justice, Nova Scotia, New England, Canada, United States, Gulf of Maine, input-output, regional, boundary, dispute, impacts, multiplier

Citation: King, Dennis M., and Kenneth L. Shellhammer 1981 "The California Interindustry Fisheries (CIF) Model: An Input-Output Analysis of California Fisheries and Seafood Industries, Volume II," California Sea Grant College Program Working Paper No. P-T-6.

Fishery: General, U.S., California

Management Issue: Economic impact analysis

Technique: Input-output analysis

Summary: Information about input-output relationships, the distribution of costs, and the location of markets for specific industrial sectors can help show where and how fisheries fit into a state's overall economic framework. This paper (Volume II) is a non-technical description of the California Interindustry Fisheries (CIF) model--an input-output model that uses data from and provides results about the fisheries and seafood industry sectors in California during 1980 and 1981.

Output, income and employment multipliers are estimated for each of 19 fish harvesting sectors and 9 fish processing sectors. Guidelines are given on how to use the CIF model to forecast direct, indirect, and induced economic impacts of changes affecting California's fisheries and seafood industries.

Keywords: Economic impact, input-output, sector, multiplier, employment, processing, harvesting, U.S., California, fisheries, industries

Citation: Prochaska, Fred J., and R. Allen Morris 1978 "Primary Economic Impact of the Florida Commercial Fishing Sector" Florida Sea Grant Program, Report No. 25.

Fishery: Commercial, U.S., Florida

Management Issue: Economic impact of a commercial fishery

Technique: Economic impact

Summary: The lack of quantitative information about the benefits and costs of various uses of resources makes allocation decisions regarding resources difficult. This paper, in an effort to address this discrepancy, provides estimates of the value and impact of Florida's marine commercial fisheries. To do this, the value and quantity of commercial marine landings in the state are identified as are the direct expenditures and sales of the sector. The economic impact analysis of the commercial fishing sector is estimated for the state, with impacts estimated for the total fishery and on a species by species basis for the state's seven major fisheries. The primary economic impact of Florida's commercial fishing sector in 1975 was estimated to be $124.5 million, and the sector's 1975 output effect in the U.S. economy was estimated to be $163.7 million.

Keywords: Expenditures, economic impact, Florida, U.S., commercial, economy

Politics, Political Science & Sociology

The theme found throughout the articles in this section is that fisheries management and policy involves more than just the stocks and industries. More explicitly, the articles focus on the need to consider the political and the institutional infrastructures within which management and policy are created--in addition to considering those biological and economic constraints that it has traditionally operated under.

Some of these articles provide characterizations or descriptions of fisheries from either a evolutionary perspective that describes the changes in a fishery or from a snapshot, this-is-it-now perspective. Still others take the approach of examining the socioeconomic impacts of fisheries policies and management.

The articles that examine the effects of policies and/or management on fisheries do not focus on the more standard measures of yield and effort. Instead, they concentrate on the issues related to the acceptability of policies (and subsequent compliance) as well as on those related the degree to which socio-economic factors and even geographical influences influence the success of management policies and strategies. Some of the authors have found, for instance, that ethnic and cultural characteristics have a great deal of influence on how and why fishery participants have reacted to policies as they have.

This section also includes an article describing the communication of health risks to the public. It addresses not only the need to effectively convey serious health concerns to the consumer, but also the need to avoid creating panic and subsequently harming the entire industry.

The examples of the institutional, political, and sociological influences on fisheries management are taken from herring, lobster, prawn, salmon, scale, shrimp, and groundfish fisheries.

Citation: Anderson, Lee G. 1987 "Expansion of the Fisheries Management Paradigm to Include Institutional Structure and Function" Transactions of the American Fisheries Society 116:396-404.

Fishery: General, commercial

Management Issue: The fisheries regulatory paradigm

Technique: Essay

Summary: This article examines the historical development of fisheries management and introduces a new approach which expands the management paradigm to include the fish stock and the industry as well as the institutional structure of contemporary management and regulation-making. The article begins with a description of the initial, biological approach to management before shifting to the bioeconomic approach that includes consideration of both the stock and the industry. After describing the new approach of bioregunomics, the author concludes with comments on how, given the low likelihood of change, to work for efficient fisheries regulations within the existing institutional framework.

Keywords: Regulation, management, policy, institution, bioregunomics, bioeconomics

Citation: Anderson, Lee G. 1987 "Bridging the Gap Between economic Theory and Fisheries Management: Can the MFCMA Produce Economically Rational Management?" Marine Fisheries Review 49(3):13-25.

Fishery: General, U.S.

Management Issue: The Magnuson Fishery Conservation and Management Act of 1976

Technique: Essay

Summary: This article examines the Magnuson Fishery Conservation and Management Act of 1976 (MFCMA) and raises the question of the act's potential to generate "good" fisheries management in the United States in terms of what economic theory would indicate. The importance of the effects of institutional structures in general and their effect on management are discussed to set the stage for the discussion of current management institutions under the MFCMA. The author then examines the potential for change under the MFCMA's reauthorization at ten years (in 1986) as well as the recommendations made by a "Blue Ribbon" panel that was commissioned by the National Oceanographic and Atmospheric Administration (NOAA). The conclusion describes both the potential (relatively high) and the likelihood (relatively low) for good fisheries management to result from such a flexible management framework as established by the MFCMA.

Keywords: Magnuson Fishery Conservation and Management Act of 1976, MFCMA, management, U.S.

Citation: Chatterton, Lynn and Brian 1981 "How Much Political Compromise Can Fisheries Management Stand?: Premiums and Politics in Closed Coastal Fisheries" Marine Policy April:114-134.

Fishery: Rock lobster, abalone, prawn, scale, Australia, South Australia

Management Issue: Politicization of fisheries management

Technique: Discussion

Summary: This paper traces the histories of license limitation programs in the South Australian rock lobster, abalone, prawn, and scale fisheries since the Fisheries Act Amendments of 1967. The authors recognize that the license limitation programs have helped conserve the resources' stocks, but they fail to recognize not only that the price increases of the respective licenses are a result of the improved resource condition, but also that new entrants must now face the true costs of entering the fishery. Despite the fact that some of the conclusions of the article are correct, not all are. The economic arguments presented are not fully accurate, either; however, the conclusion that fisheries management policies reflect the outcomes of political and not biological or economic processes can hold true in many instances.

Keywords: Politics, license limitation, management, rock lobster, abalone, prawn, scale, Australia, South Australia

Citation: Copes, Parzival 1980 "The Evolution of Marine Fisheries Policy in Canada" Journal of Business Administration 11(1).

Fishery: General, Canada

Management Issue: History of fisheries policy

Technique: Essay

Summary: Beginning with the Fisheries Act of 1868, this discussion paper traces Canadian fisheries policy. the author divides Canadian marine fisheries policy into three periods: prior to the mid-1960s, 1965-1976, and 1977 on. While the management during the first phase was largely reactive, the second phase saw the inclusion of economic considerations and active fishery regulation. The most recent phase, occurring after Canada's declaration of a 200-mile limit, has its own difficulties as well as opportunities for new techniques of economic management.

Keywords: Law, policy, Canada, 200-mile limit, management, economic efficiency, history

Citation: Crouch, Ben M. 1989 "Mexican Shrimp, Texas Shrimpers, and Maritime Conflict: The Creation of a White Collar Crime" Deviant Behavior 10:211-232.

Fishery: Shrimp, U.S., Mexico

Management Issue: Federal-local interactions

Technique: Interpretive essay

Summary: This paper is a case study of the category of white collar crime arising from regulations that are intended to alter traditional work patterns. The setting is that of the Gulf of Mexico shrimp fishery exploited by Texas; the regulation is the Lacey Act of 1981; the crime is that of U.S. fishermen harvesting shrimp in Mexico's waters. Although the prevention of fishing in Mexican waters was minimally enforced before 1981, the Lacey Act forced both U.S. and Mexican authorities to become law enforcers and to prevent further fishing--via arrest, if need be. This study characterizes and examines the relationships between shrimpers and federal authorities using information from official documents and from personal interviews. The analysis of the interactions is framed using Turk's theory of normative-legal conflict. The author concludes that, although overt conflict decreased in the late 1980s, white collar crime of this sort has not been eliminated.

Keywords: Lacey Act, shrimp, Texas, U.S., Mexico, Gulf of Mexico, enforcement, compliance, conflict

Citation: Davis, Anthony, and Victor Thiessen 1986 "Making Sense of the Dollars: Income Distribution Among Atlantic Canadian Fishermen and Public Policy" Marine Policy 10(3):201-214.

Fishery: General, Atlantic, Canada

Management Issue: Sectoral definition, organization

Technique: Essay

Summary: Although motivated by and agreeing with the gross conclusions of a study concluding that the Atlantic Canadian fishermen face a difficult life, this study disagrees with the level of generality imposed on the fishing sector by the aforementioned study. By reanalyzing demographic and financial data according to whether or not a fisherman was an inshore or offshore fishery participant, the authors show that the pattern of income distribution reflects both occupational and economic conditions and that the Atlantic Canadian fishing industry is organized affects the participants' income distribution. If the government intends to develop and implement public policies in a particular sector, the results of this study illustrate that it is vital to consider the socio-economic organization of the fishing sector.

Keywords: Socio-economic, income distribution, welfare, Canada, industry, sectors, characterization, public policy, Atlantic

Citation: Harris, Craig K. 1982 "A Profile of the Michigan Commercial Fisherman" Michigan Sea Grant, Michigan Agricultural Experiment Station Publication No. 8443, MICHU-SG-82-205.

Fishery: Commercial, U.S., Michigan

Management Issue: Characterization of commercial fishermen

Technique: Interview, Interpretive essay

Summary: The impetus for the study came from the Michigan Department of Natural Resources in an effort to better understand the Michigan commercial fishing industry and how a ban on gill nets might affect it. Using the results from interview done in 1975 of 96% of license holding commercial fishermen in Michigan, this report creates a statistical profile of fishermen licensed by the State of Michigan to fish in Lakes Michigan and Superior and northern Lake Huron. The report also compares Michigan fishermen with fishermen in other areas as well as fishermen in general with men having other occupations in Michigan. Although the profile described here may have changed somewhat, the author concludes that it still presents an accurate picture of the Michigan commercial Great Lakes fisherman in 1975 that can be used for both interfishery and intertemporal comparisons.

Keywords: Sociology, income, technology, demographics, Lake Michigan, Lake Superior, Lake Huron, Michigan

Citation: Healey, M. C. 1985 "Influence of Fishermen's Preferences on the Success of Commercial Fishery Management Regimes" North American Journal of Fisheries Management 5:173-180.

Fishery: Herring, *Clupea harengus*, Gulf of Maine

Management Issue: Fishermen's choice of management goals

Technique: Decision analysis

Summary: Accurate anticipation of fishermen's behavior/reactions to regulatory schemes is very important when trying to determine the success of proposed management regimes. If their behavior and preferences are consistent, then multi-attribute fishery models will have a higher likelihood of being accurate. To address this issue of consistency, the author uses a multi-attribute utility model to examine changes in fishermen's behavior between bad and good years in the Gulf of Maine herring fishery when fishermen had somewhat alternatively support long-term conservation efforts and the reaping of short-term windfall gains. This case study is used because the fishery has both good and bad years and also has a relatively good data set. The author concludes that what may appear to be illogical behavior can, in fact, be perfectly logical behavior--in the context of the fishermen's preferences for certain aspects of a problem.

Keywords: Management, goals, Gulf of Maine, herring, *Clupea harengus*, utility

Citation: McGuire, Thomas R. 1983 "The Political Economy of Shrimping in the Gulf of California" Human Organization 42(2):132-145.

Fishery: Shrimp, Mexico

Management Issue: Cooperative management

Technique: Interpretive essay

Summary: The prognosis for Mexico's shrimp cooperatives along the Gulf of California is not, in general, a good one; the inshore shrimping cooperatives are basically headed for failure because they cannot withstand the many (internal) pressures of conflict and population growth and because they are typically unable to compete with capital intensive offshore shrimpers. This paper focuses on why one cooperative--the Yaqui Indian shrimp cooperative in the northern end of the Gulf of California--is successful. The author traces the cooperative's history and the way this indigenous group has managed its political power in order to become a force that the government of Mexico listens to. The author concludes that a fortuitous combination of several biological, sociological, locational, and historical factors--i.e., largely exogenous factors--has led to this outcome.

Keywords: Management, cooperative, Mexico, Gulf of California, shrimp, Yaqui, penaeid, sociology

Citation: Miller, Marc L., and Jeffrey C. Johnson 1981 "Hard Work and Competition in the Bristol Bay Salmon Fishery" Human Organization 40(2):131-139.

Fishery: Salmon, U.S., Alaska, Bristol Bay

Management Issue: Workforce characterization

Technique: Essay

Summary: Although fishery management can be considered as management of one industry, doing so overlooks the diversity and dynamics that occur within the industry. This paper explicitly looks at the composition of the Bristol Bay, Alaska salmon fishery, from its basic nature to its multiple networks and cross-networks between its constituents. The authors describe the kinds of fishermen, their ethnic affiliation, their time in the fishery, and the ways in which they interact--both cooperatively and antagonistically. The authors conclude with a note about the increasing ability of the fishermen to act together when dealing with their processing adversary.

Keywords: Organization, salmon, U.S., Alaska, Bristol Bay, culture, sociology, allocation

Citation: Miller, Marc L., and John Van Maanen 1979 "Boats Don't Fish, People Do" Human Organization 38(4):377-385.

Fishery: General, U.S., Gloucester, Massachusetts

Management Issue: Federal management

Technique: Interpretive essay

Summary: Having to live with uncertainty is by no means enjoyable, and people will typically act to reduce the uncertainty in their lives. The authors of this paper describe a situation in which the fishermen of Gloucester, Massachusetts have responded to uncertainties regarding their livelihoods--their fisheries--as a result of government policies that were not explicitly designed to offer short term solutions. The paper describes the social organization of the Gloucester fishing community before launching into a discussion of the various federal management regimes (quotas and closures) imposed on the fishery and of how these regimes affected the fishing community.

Keywords: Organization, anthropology, culture, organization, collusion, community, Gloucester, Massachusetts, U.S., management, compliance

Citation: Raizin, Myles, and G. M. Meaburn 1989 "The Economic Costs of Informing the Public on Seafood Safety Matters" NOAA Technical Memorandum NMFS-SEFC-225.

Fishery: General

Management Issue: Economics of health risk information

Technique: Essay

Summary: Because health risks are a vary important facet of seafood safety programs, this memorandum provides a discussion of how such risks can be communicated to the public and of how the public may respond to various communications. How the information is framed, how (a) risk is assessed, and what sort of information is provided can greatly influence or bias the public's risk perception, as well as the degree of cognitive dissonance that is generated. The authors also note that social attitudes should also be considered in light of how they may affect the public's reaction. They conclude with the comment that the art of risk communication involves balancing the health benefits of such information, the economic costs of providing information, and the avoidance costs that may result from such information.

Keywords: Management, risk, health, perception, avoidance costs, cognitive dissonance

Citation: Rugman, Alan M., and Andrew Anderson 1987 "A Fishy Business: The Abuse of American Trade Law in the Atlantic Groundfish Case of 1985-1986" Canadian Public Policy 13(2):152-164.

Fishery: General, Atlantic, Canada

Management Issue: Use of trade sanctions

Technique: Essay

Summary: This essay describes--as the authors put it--yet another example of U.S. producers trying to use U.S. trade law as a way to limit Canadian fish exporters' access to U.S. markets. The authors describe the events leading up to and the 1985-1986 countervailing duty case that was brought against the Atlantic Canadian fishing industry. They conclude that the U.S. International Trade Commission (ITC) did not follow due process and did not have sufficient evidence to supports its actions.

Keywords: Countervailing duty, U.S. International Trade Commission, ITC, trade, law, exports, imports, General Agreement on Tariffs and Trade, GATT, Atlantic, groundfish, Canada

Citation: Van Maanen, John, Marc Miller, and Jeffrey Johnson 1982 "An Occupation in Transition: Traditional and Modern Forms of Commercial Fishing" Work and Occupations 9(2):193-216.

Fishery: Commercial, U.S., Alaska

Management Issue: Social variation and occupational change

Technique: Essay

Summary: This paper looks at how changes in the technology of, management of, and rationale for fishing are affecting the industry and its participants. A comparison between traditional and modern fishing is made using the Bristol Bay, Alaska fishery as an example. Participants, the organization of the fishery, and the patterns of participation in the fishery are described. The authors conclude that the occupation of fishing will become increasingly similar to other corporate and industrial activities.

Keywords: Ethnography, Bristol Bay, Alaska, U.S., commercial, sociology, economics, traditional, salmon, canneries, community

Citation: Welch, W. P. 1983 "The Political Feasibility of Full Ownership Property Rights: The Cases of Pollution and Fisheries" Policy Sciences 16:165-180.

Fishery: General, Pollution

Management Issue: Political feasibility of assigning ownership rights

Technique: Essay

Summary: This paper looks at the (lack of) ownership rights in a variety of common property resource situations, including fisheries. Of the three schemes the authors present for assigning property rights--grandfathering, charging for use, or charging for use above a certain level--historical participation is noted as being the most politically feasible. The discussion then focuses on the sorts of conditions that facilitate property rights development. The authors conclude that simpler policies that do not involve radical changes are more likely to succeed because of the familiarity with and the level of information about them.

Keywords: Management, pollution, common property, externality, entry limitation, allocation, transferability, ownership, rights