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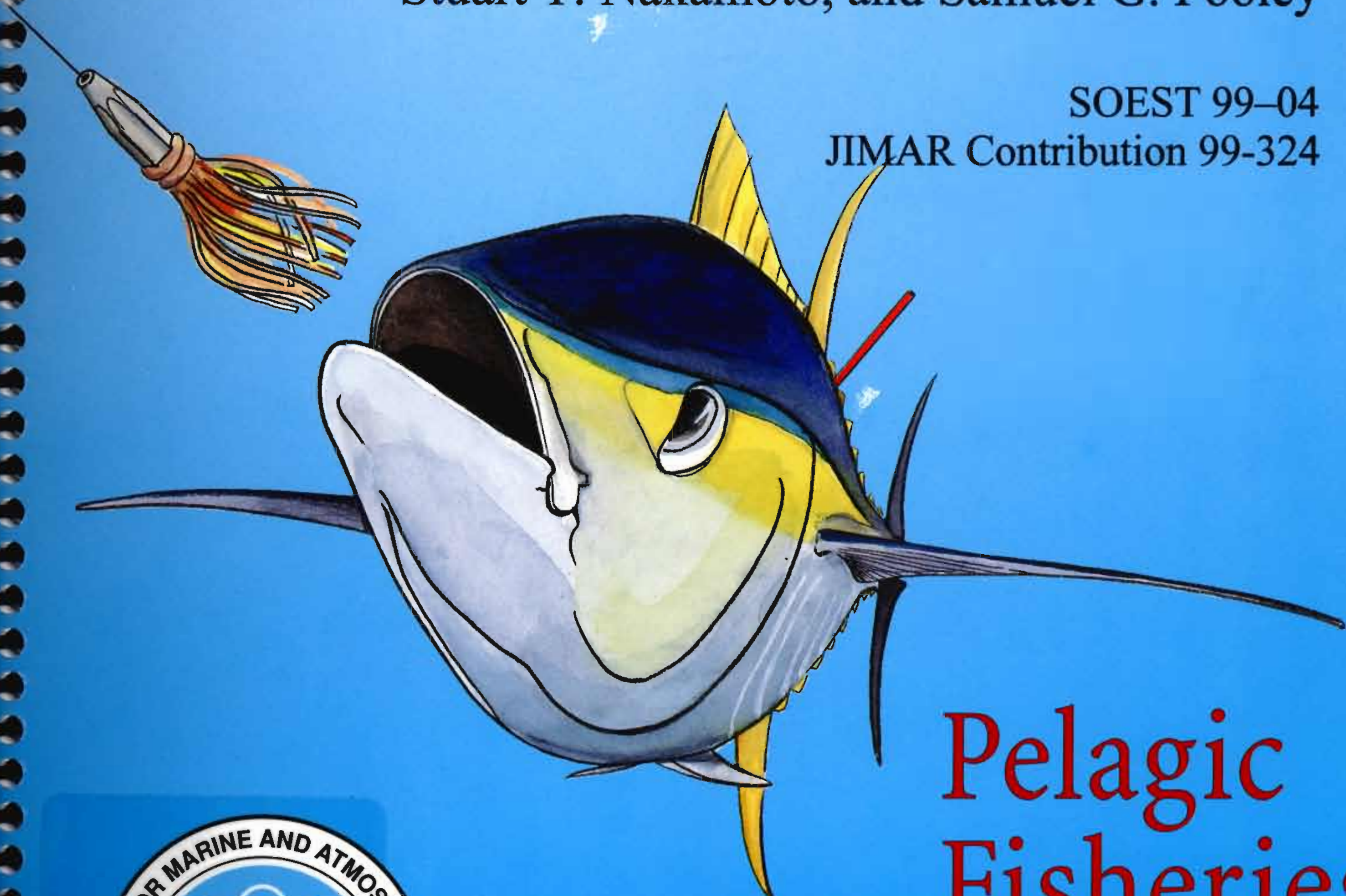
SOEST 99–04
JIMAR Contribution 99-324



JOINT INSTITUTE FOR MARINE AND ATMOSPHERIC RESEARCH
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Pelagic Fisheries Research Program

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ACKNOWLEDGMENTS

This research is funded by Cooperative Agreement Number NA37RJ0199 between the Joint Institute for Marine and Atmospheric Research (JIMAR) and National Oceanic and Atmospheric Administration (NOAA). We thank JIMAR for making the data available and for supporting this research. We also thank Marcia Hamilton, Kurt Kawamoto, and Rita E. Curtis for providing data and valuable comments.

ABSTRACT

Management of Hawaii's fisheries faces great challenges due to the rapid growth that has intensified competition among fisheries and users with different interests. This study develops and applies a multilevel and multiobjective programming model to assist decision-making in Hawaii's fishery. The multilevel aspect of the model incorporates objectives of both policy makers and fishermen. The use of a multiobjective model is essential in fisheries management since the typical fishery policy problem is characterized by more than one objective or goal that decision makers wish to optimize. The model covers nine fleet categories, five areas, four seasons, and 14 target species, of which 10 are target species. Catch per unit of effort (CPUE) includes targeted and bycatch species. A nonlinear relationship between CPUE and effort is incorporated into the model.

Under various objectives or policy options, the current model provides optimum solutions by fleet mix and its spatial and temporal distribution, as well as harvest level of fish resources. First, applications of the model indicate that economic efficiency of the Hawaii commercial fisheries can be improved if the number of handline vessels increases and the longline vessels would be more flexible in switching targets since the relative abundance of fish resources affects the choice on optimal fleet mix. Under profit maximization, optimal fleetwide profit could increase from the actual profit of $4.5 million to $17.96 million accompanied by 14% reduction in catch and 41% decrease in effort. Second, the multiobjective analyses showed that the degree of conflict between recreational and commercial fishing varies by effort level. At the current effort level, an increase of one recreational trip reduces commercial profit by $12.14 where at lower levels of commercial effort. Moreover, the study concludes that the area closure regime has reduced the conflict between commercial and recreational fishing; however, it caused profit loss to the longline fishery in a range of $0.70 to $0.44 million.

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1. INTRODUCTION

1.1 Brief Background of Hawaii's Marine Fisheries

Marine fisheries have a long history in Hawaii, and they have economic and cultural significance to the State. Hawaii's marine fisheries are important to the State's economy because they contribute to the local seafood supply, employment, and income. Hawaii's commercial fisheries industry generated $63 million ex-vessel revenue from 32 million pounds of commercial landings in 1996 (NMFS 1997). In addition, there are three other direct components, recreational fishing, subsistence fishing, and charter fishing, which contribute the economic value to the Hawaii's marine fisheries (Pooley 1993). Fishing and fish production not only have economic significance, but perhaps more importantly, also have cultural significance in Hawaii. Traditionally, fish was one of the main foods of native Hawaiians. Seafood consumption is also popular among Asian ethnic groups. As a result of cultural adoption by the rest of the population, per capita seafood consumption in Hawaii is much higher than the national average. The mild and tropical climate, as well as short distance from shore to deep sea, makes Hawaii one of the world's finest recreational fishing grounds year-round. Fishing activities attract tourists to Hawaii and they also provide Hawaii's residents an important release from urban culture and an opportunity for traditionally subsistence fishing practices.

Hawaii fishers harvested various species by different fishing methods, which included longline, handline, troll, pole-and-line (aku), and other miscellaneous methods used primarily for inshore fishing. The longline pelagic fishery is the largest commercial fishery in Hawaii, valued at $47 million ex-vessel revenue in 1996. The small-scale troll and handline fisheries for pelagic fish are next in value, at $9 million ex-vessel revenue, while lobster, *aku* (skipjack tuna), and bottomfish are the other major commercial fisheries.

1.2 Research Objectives

During the last two decades, Hawaii's commercial marine fishery has experienced rapid growth and structural change. The dramatic development of the longline fishery contributed most to the growth. The rapid development of Hawaii marine fisheries brought with it significant biological, economic, as well as social impacts. Competition among fisheries and/or user groups with different interests for the limited resources has intensified, and consequently fisheries management faces great challenges in trying to balance the needs and interest of different groups while protecting the fisheries resources at the same time (Pan 1998).

In general, the central political issue facing the Hawaii fisheries management is how to balance all of these interests and to allocate the uncertain quantities of fish between segments of the fishery (Pooley 1993). Unfortunately, research regarding distributive issues in Hawaii fisheries is inadequate to support fisheries management (Skillman *et al.* 1993). Lack of quantitative measurement and analysis tools on the relative benefits and costs related to the various human components of the fisheries increases the difficulty of the decision-making process; thus, each regulation is undertaken with a high degree of uncertainty concerning its effect on the participants in the fisheries (Pooley 1993). Therefore, to improve fisheries management, an analytic tool is needed to evaluate impacts of management actions from the perspectives of the entire fisheries as well as the various sectors of the fisheries. Research methodologies used to reveal tradeoffs in terms of costs and benefits to the entire fishery, as well as to each individual segment under different management objectives or under different policy options, can be useful in determining the optimal policy for the Hawaii fisheries management.

Mathematical programming is an attractive approach for fisheries management because it is capable of solving a system problem such as fisheries management that has many decision variables, within a multiobjective and multilevel environment. While the computational difficulties hinder the use of the optimal control theory in empirical research and simulation often results in an unlikely optimal solution for fisheries management, the mathematical programming approach operates at a highly disaggregated level providing insights into system behavior. Hence, mathematical programming techniques provide a particularly useful methodology to study distributive and operational issues facing fishery management (Önal 1996, and Gunn *et al.* 1991). Therefore, they have been applied to fisheries modeling and have addressed such issues as effort allocation, fishery industry structure, regulation scheme and impact, and harvest strategy for decades.

In one application of the mathematical programming techniques, a linear programming model was developed for the Northwestern Hawaiian Islands (NWHI) fisheries both as a directed bottomfish fishery and as a multipurpose fishery (E.R.G. Pacific Inc. 1986, and Kasaoka 1989). This model is referred to NMFS LP hereafter. The initial intent of the NMFS LP model was to analyze the potential impact of the limited-entry program on various Hawaii fisheries and on the economic performance of various fishing fleets. However, this effort was not particularly successful (Pooley 1993). First, the results of a baseline run of NMFS LP model did not realistically depict the actual fisheries situation in Hawaii (Miklius and Leung 1990). The model developer provided the following explanations for the unrealistic solution (E.R.G. Pacific Inc. 1986). First, relationships in the model may not be linear. Second, vessels within each fleet group may not be homogenous with respect to their costs, catch rates and fishing capacities. And third, incidental catches (bycatch) are not modeled. More importantly, Miklius and Leung (1990), in an evaluation of the NMFS LP model, concluded that the omission of microlevel decision-making by the fishermen and the omission of the decision makers' objectives other than profit maximization contributed to the unrealistic solutions from the model. In addition, the typical fishery policy problem is characterized by more than one objective or goal that the policy makers wish to optimize. It is obvious that in order for any models to be useful for policy analysis, a multiple objective approach has to be undertaken (Leung *et al.* 1999).

Therefore, an appropriate modeling technique, which includes multiobjective and multilevel analysis, is needed to model the Hawaii fisheries system in order to assist the decision making process for the Hawaii fisheries management. Research has been done recently to develop and test a multilevel and multiobjective programming model for the Hawaii fishery (Leung *et al.* 1999, and Pan 1998). To illustrate the uses of the current model, the study applied the current model to analyze several issues that are associated with the management of the Hawaii fisheries (Pan 1988). The specific objectives of the model applications in this study were to:

1. estimate the impact of stock conditions;
2. assess the impact of declining CPUE;
3. evaluate the tradeoffs between recreational fishing and commercial fishing; and
4. estimate impacts of the area-closure regime on commercial fisheries.

1.3 Overview of the Report

The main purpose of this report is to elaborate the proceeding paper, which was presented in the 1997 conference on Ocean-Scale Management of Pelagic Fisheries: Economic and Regulatory Issues (Leung *et al.* 1999), to provide detail description on the structure of the current model. This paper also highlights the results and findings from the empirical applications of the current model. More detail information about the model development and the empirical applications, as well as the data sources that used for the applications, can be found in the dissertation of Minling Pan (1998).

Section 2 presents the structure and scope of the multilevel and multiobjective programming model for the Hawaii fishery. A detailed description on how to use formulations to reflect the complex reality of the Hawaii fishery is given in this section. Data sources are briefly discussed in Section 3. Section 4 illustrates the model applications, which employed the current model to analyze several issues associated with the Hawaii fisheries management. Finally, Section 5 presents conclusions and the potential uses of the current model.

2. A MULTILEVEL AND MULTIOBJECTIVE MODEL

2.1 Model Outline

A two-level multiobjective nonlinear programming model was developed for the Hawaii fishery in this study. Figure 2.1 gives a simple representation of the model and its related inputs and outputs. The model formulation allows fishery management to consider the behavior of individual fishermen as well as fishery managers (fleetwide). It also considers the importance of other management objectives such as recreational fishing and employment opportunities in addition to the profit-seeking commercial fishing activities. Under various objectives (goals) and/or policy options facing Hawaii's fisheries, the current model not only provides optimal solutions of effort and catch and their spatial and temporal distributions, but also can be used to evaluate the tradeoff between policy goals. Optimal solutions from solving the model can be viewed as the outputs of the model, while policy goals and instruments, as well as the parameters that represent biological, technological and economic conditions of the fisheries, can be viewed as inputs to the model. The presentation of the model in this chapter includes the three components in a mathematical programming model, namely decision variables, constraints, and objectives. The nature of a mathematical programming model is to search for the values of the decision variables that result in optimal values for the defined objectives under the constraints.

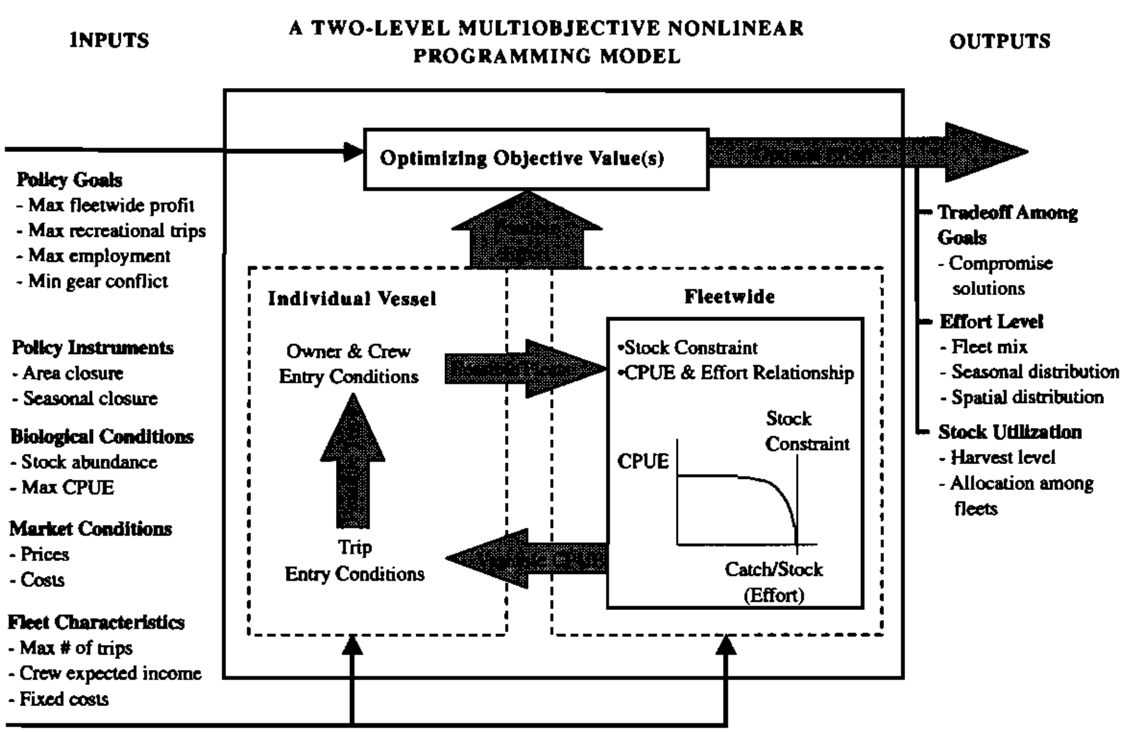


Figure 2.1 Model Structure and Mathematical Relationship Outline

2.2 Decision Variables

In accordance with traditional fishery economics research (Schaefer 1954, and Gulland 1968), fishing effort is specified as the decision variable in the current model. Fishing effort is an important decision variable in fishery management. In the United States, effort control—such as limited entry, seasonal or area closures, and effort quota—is a regular practice in fisheries management. Therefore, effort is an important decision variable in fisheries management.

In the current model, fishing effort is expressed in terms of the number of vessels in various fleets (fleet mix). The number of vessels in a specific fleet is associated with the number of trips taken by the fleet, because the number of trips taken by a vessel within a time period (year or season) is limited. Moreover, fishing effort is defined with four-dimensional variables encompassing fleet types, target species, area, and season, in order to reflect the variations in fishing activities of the Hawaii fisheries resulting from fishermen's motivation, vessel size, gear used, location of fishing grounds, and season. This model covers nine fleet categories, ten target types, five fishing areas, and four fishing seasons. In other words, fishing effort is disaggregated as a number of vessels (or trips) of a particular fleet targeting a specific species in a specific area during one specific season.

The following equations illustrate the relationship between number of trips and annual fleet size. The relationship between the number of trips and the number of vessels in four dimensions is represented by:

$$E_{ijkl} - \varepsilon_{ijkl} V_{ijkl} \leq 0 \tag{1}$$

Seasonal fleet size is represented by:

$$V_{il} - \sum_{j} \sum_{k} V_{ijkl} \geq 0 \tag{2}$$

Annual fleet size is represented by:

$$V_i - V_{il} \geq 0 \tag{3}$$

where:

Variable indices:

i = fleet, $i = 1, \ldots, 9$;
j = target species, $j = 1, \ldots, 10$;
k= area, $k = 1, \ldots, 5$;
l = season, $l = 1, \ldots 4$.

Variables:

E_{ijkl}: number of trips of fleet i targeting j in area k during season l (trip);
V_{ijkl}: number of vessels of fleet i targeting j in area k during season l (vessel);
V_{il}: number of vessels of fleet i during season l (vessel);
V_i: annual fleet size of fleet i (vessel).

Parameters:

ε_{ijkl}: maximum number of trips for a vessel in fleet i target species j in area k during season l (trip/vessel).

Equation $E_{ijkl} - \varepsilon_{ijkl}V_{ijkl}$ 0 represents the limitation of the maximum number trips a vessel takes in a season (ε_{ijkl}). The number of trips is limited due to the constraints of holding capacity of vessel, shelf life of the harvested species, distance to the fishing ground, and length of season. Therefore, the maximum-number-of-trips vary by fleet, target, fishing ground, and season.

The number of active vessels (fleet size) can be varied by season, in order to depict the seasonal variation of fishing activities of each individual fleet. The seasonal fleet size (V_{il}) is defined as the aggregated number of vessels over different target species (j) in various areas (k) during the season (l). This relationship is expressed mathematically in Equation (2) as: $V_{il} - \sum_j \sum_k V_{ijkl} \geq 0$.

The equation of $V_i - V_{il} \geq 0$ represents that annual fleet size (V_i) which is defined as the largest fleet size among the four seasons of fleet i. This formulation accounts for annual fixed costs as long as the vessel is active in any one season. This is one of the improvements that the current model offers over the NMFS LP model. The NMFS LP model charges vessel fixed cost by season and thus is unrealistic since the fishermen have to bear the annual fixed costs for the active seasons as well as the inactive ones.

2.2.1 Fleet Categories

Fleet classification is necessary because this study is involved with multiple fisheries and heterogeneous fishing fleets. The fishing fleets are classified into nine categories based on fishermen's motivation, gear type, and vessel size. Vessels within a fleet are assumed to be homogenous. Figure 2.2 illustrates the classification of the nine fleets and Table 2.1 summarizes their characteristics. This specification attempts to include the three major fisheries (pelagic, bottomfish, and lobster) and the different style fishermen including commercial, semi-commercial, and recreational fishermen in the Hawaii fishery. The actual numbers of vessels of these nine fleets in the Hawaii fishery are also presented this table.

The fleets are divided into two major groups, namely non-commercial and commercial fleets, based on whether or not fishing is an income source to the fishermen. Furthermore, the non-commercial group is divided into two fleets, namely recreational and *expense*, based on the disposition of catch. The commercial group is classified into seven fleets, which include charter boats, commercial handliners, commercial trollers, small multipurpose vessels, medium multipurpose vessels, large multipurpose vessels, and aku (pole-and-line) boats.

Recreational fleet refers to the fishing vessels involved in fishing activities without any catch sale. Among the 575 small-boat fishermen surveyed in 1996, about 28% fished for recreation and did not sell any catch (Hamilton and Huffman 1997). The other category of recreational fleets, named as *expense*, refers to a group of small-boat fishermen who sell at least part of their catch, but the revenue from fish sale does not cover all their expenses. In Hawaii, there were significant numbers of small-boat fishermen who sold at least part of their catch, but who do not consider themselves to be commercial fishermen. The current model considers the expense fishermen to be recreational users, as these vessels are not using the fisheries for strictly commercial purposes. According to the small-boat survey (Hamilton and Huffman 1997), earnings of expense fishermen were far less than break even.

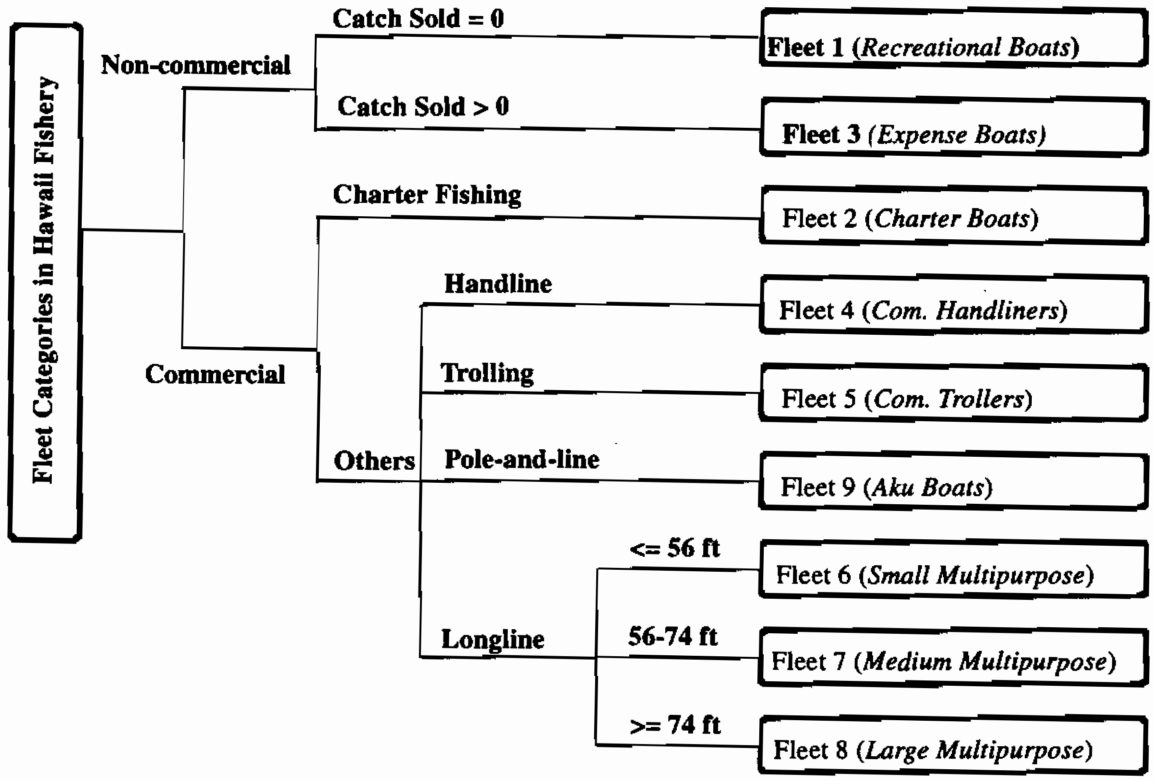


Figure 2.2 The Fleet Categories of the Hawaii Fishery

Table 2.1. Fleet Categories and their Main Characteristics

Fleet (*i*)	Main gear	Avg. vessel length (feet)	Catch disposition	Income source	No. of vessels 1993[a]	Catch 1993[a] (1000 lb)
Noncommercial						
1. Recreational boats	Troll or handline	20	Keep or share	No income	2,490	1,412
3. Expense boats	Troll or handline	23	Sell part	No income	952	3,185
Commercial						
2. Charter boats	Troll or handline	36	Sell part or all	Main source	99	1,105
4. Com. Handliners	Handline	25	Sell most or all	Main or part	149	4,756
5. Com. Trollers	Troll	25	Sell most or all	Main or part	232	3,060
6. Small Multipurpose	Longline	<54	Sell all	Main source	30	3,113
7. Medium Multipurpose	Longline	54-74	Sell all	Main source	48	7,538
8. Large Multipurpose	Longline	>74	Sell all	Main source	44	8,605
9. Aku Boats	Pole-and-line	60	Sell all	Main source	8	2,332

[a] Data sources for the actual number of vessels and catch for each fleet of the Hawaii fishery in 1993 are presented in Chapter 4.

Seven commercial fleets were identified in the current model. Fleet 2 refers to charter boats on which patrons pay to fish for recreational purpose, while the boat operators intend to make a living from patrons' payment and selling fish caught. Hence, charter boats were defined as a commercial fleet in the current study. Fleet 4 represents the commercial handline vessels where fishermen use handline gear and expect to earn a certain amount of their income from fishing activities. This fleet involves both pelagic and bottomfish fisheries. The commercial trolling fleet (Fleet 5) participates in pelagic fishery using trolling gear and the fishermen of this fleet expect at least positive income from their fishing activities. Fleet 9 represents aku boats or bait boats in the Hawaii fisheries, which use the pole-and-line method to target aku. Historically, the pole-and-line fishery was the largest commercial fishery in Hawaii. Despite the fact that it had substantially declined, aku boats still harvested 17.5% of the total tuna landed in Hawaii pelagic fishery in 1993 (the base year of this study) (WPRFMC 1994a). Fleets 6, 7, and 8, the small, medium, and large multipurpose fleets, respectively, represent the vessels equipped with longline gear and other gear types. They are multipurpose fleets because they are capable of adding other fishing gears without removing the main part of longline gear. For example, by removing part of the longline fishing equipment, such as floats, lines and hooks, a longline vessel can install the trap-haul equipment needed to catch lobsters within two to three weeks. The deepsea handline gear can be added to a longline vessel to target bottomfish. In fact, some vessels in the Hawaii fisheries have both a longline license and a bottomfish license, or a lobster license, and they may switch from one fishery to another fishery in different seasons. Fleets 6, 7, and 8 are classified based on their vessel length. The vessel size categories are consistent with the cost-earnings study of the Hawaii longline fleets conducted in 1993 (Hamilton *et al.* 1996).

2.2.2 Target Species (Trip Types)

Target is specified as one dimension of the decision variables, because choosing a species to target is a fishing strategy adopted by the fisherman. Target is associated with fishing behaviors, such as gear used, area, capture time, and depth fished, and it is also associated with outcomes such as CPUE and fish prices received (Boggs 1992a). In the Hawaii fishery, some species, such as yellowfin, are targeted by different fishing methods including handline, trolling, and longline gears. On the other hand, the same fishing method can target various species. Fishermen may switch targets during different seasons according to a change in fish abundance. Most of the fishermen do not change their targets during a trip. To simplify the model, this study assumes that each trip has only one target species or target type, and fishermen do not switch target during a trip.

A study by He *et al.* (1996) found that some longline fishermen appeared to switch fishing strategies (by set) within a trip if fishing efforts were identified into five types (clusters) based on catch composition. However He's study indicated that most of the longline trips appeared to reflect similar fishing strategies within a single trip. Trip type or trip target defined in the current study is a general concept that is not only evaluated by fish composition but also by fishing techniques. For example, longline trips are categorized by NMFS into only three categories, i.e., swordfish, tuna, and mixed, and fishermen identified the trip type for each trip in the NMFS logbook according to these three categories.

A fish species becomes the fishermen's target usually due to its high value and its abundant stock. Commercial fishermen and recreational fishermen may value a fish species in different ways. Commercial fishermen target species that bring higher profitability and income to their fishing operations, which may be a function of not only fish prices but also CPUE. Recreational fishermen may target fish species that bring greater sporting satisfaction without as much attention to marginal costs. For example, blue marlin is not a targeted species of the commercial fishermen because of its relatively low price in the Hawaii fish market. However it is a major targeted species of Hawaii's recreational fishermen. In the Hawaii fisheries, yellowfin, bigeye, skipjack (aku), swordfish, blue marlin, mahimahi, ono, bottomfish, and lobster are commonly targeted by different groups of fishermen. Some longliners practice a fishing method used to target both bigeye and swordfish, and that is referred to as the mixed target. The possible targets for each fleet are presented in Figure 2.5.

In Hawaii fisheries, it is common that fishermen catch not only the targeted species, but also significant amounts of untargeted species (bycatch) on each trip. Bycatch are sold to the market as soon as they have market value in Hawaii. Therefore, CPUE in this study is defined as a composite of the targeted species and bycatch. The detail definition of CPUE will be discussed in later part of this chapter.

2.2.3 Fishing Grounds (Areas)

The fishing grounds of Hawaii fisheries extend from just a mile offshore to over a thousand miles offshore. In Hawaii, small boats are scattered in all the Main Hawaiian Islands (MHI) fishing within 200 nmi, but mostly within 20 nmi. Longline fishing boats and lobster and bottomfish fishing boats can go beyond 200 nmi, and most of these vessels port in Honolulu.

The physical constraints of vessels, such as fuel capacity and vessel length, can limit the mobility of the fishermen. Fishermen's fishing motivation may also influence the areas that they prefer to fish in. The spatial variations in the abundance of fish resources have important impacts on catch composition. Also, the distance to fishing grounds will affect fishing costs and prices of fish caught. The current regulations for fisheries management in Hawaii are differentiated by fisheries as well as by areas. Therefore, to consider the spatial variations in Hawaii fisheries, for this model the fishing ground is divided into five areas based on the distance to the fishing ground. The distances between the five areas are shown in Table 2.2. Figure 2.3 shows Areas 1 to 3 that cover the areas originated from all of the MHI, while Figure 2.4 shows Areas 4 and 5 that cover the areas originated from the Oahu Island and Figure 2.5 shows the possible spatial distributions and the main targets of the nine fleets in the Hawaii fisheries.

Table 2.2. Area Classifications

Area (k)	Distant from Origin (nmi)	Origins
1	<=20	Main Hawaiian Islands
2	21-75	Main Hawaiian Islands
3	76-200	Main Hawaiian Islands
4	200-900	Oahu Island
5	900-2000	Oahu Island

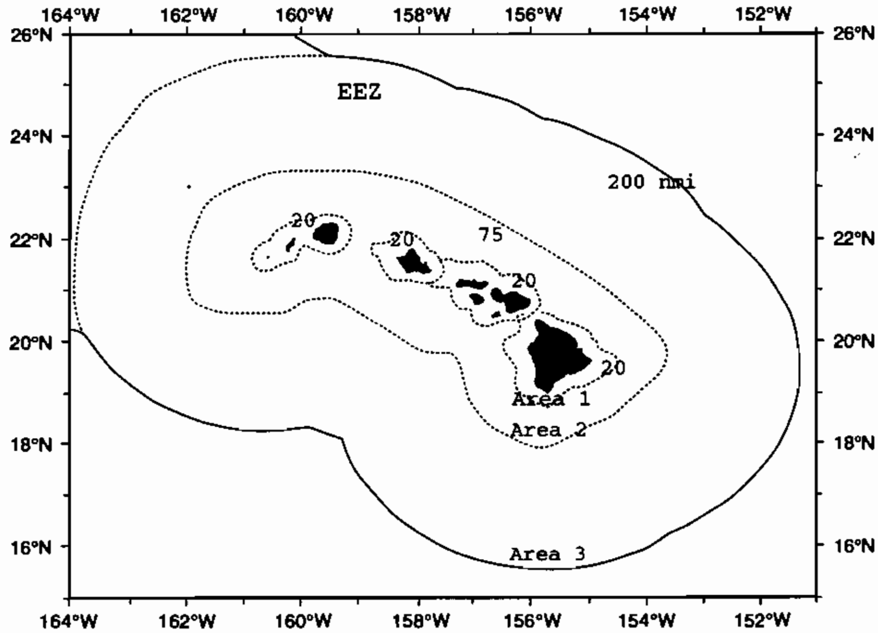


Figure 2.3 Map of the Areas 1, 2, and 3[1]

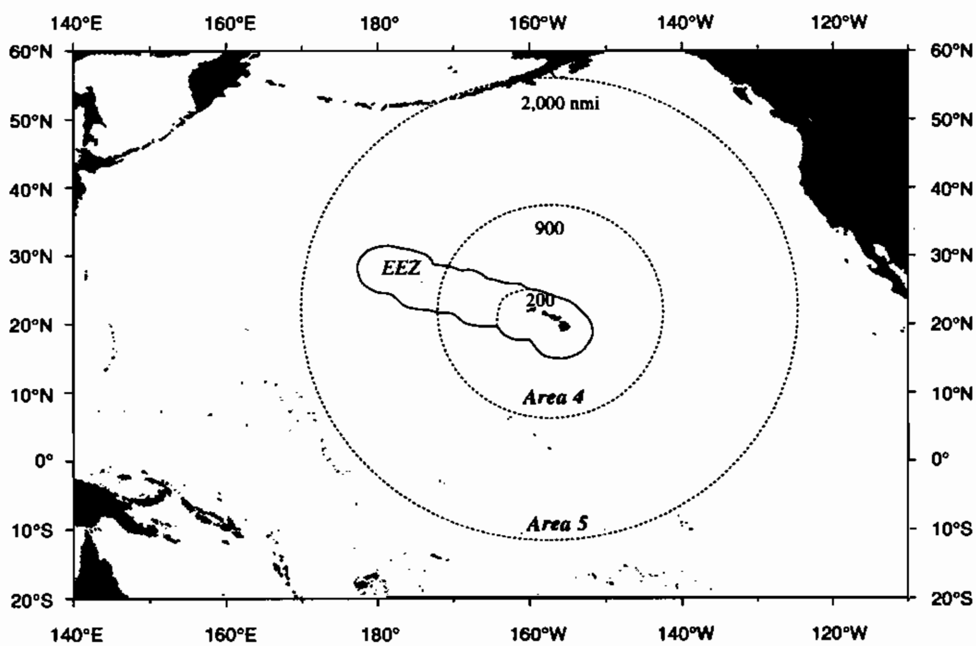


Figure 2.4 Map of the Areas 4 and 5

[1] Figures 2.3 and 3.4 are adapted from the maps provided by D.R. Kobayashi of the NMFS, Honolulu Laboratory.

2.2.4 Fishing Seasons

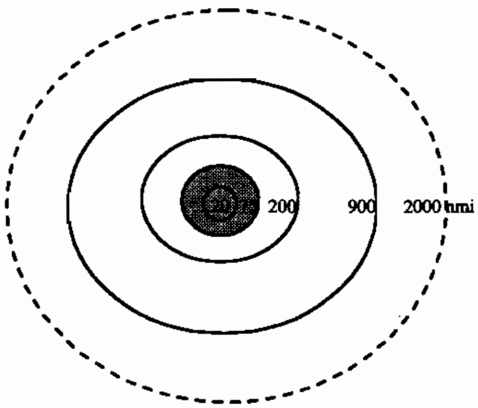
Four seasons are specified in the model (Table 2.3), in order to incorporate the seasonal variations of abundance of the important species and the seasonal variations of fishing activities in the Hawaii fishery.

Table 2.3. The Season Classifications

Season (l)	Period	Length (days)
1	Nov-Jan	90
2	Feb-May	120
3	Jun-Aug	90
4	Sept-Oct	60

POSSIBLE FISHING AREAS

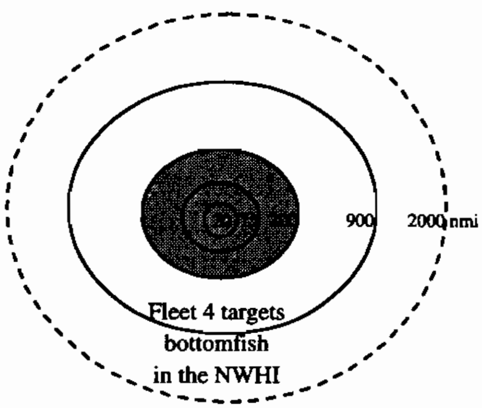
TARGETING SPECIES



<u>Fleet 1</u> (*Recreational Boats*)
1) mixed

<u>Fleet 2</u> (*Charter Boats*)
1) yellowfin 4) mahimahi 7) mixed
2) skipjack 5) ono
3) blue marlin 6) bottomfish

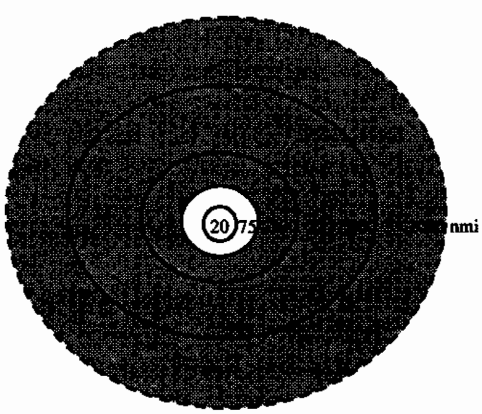
<u>Fleet 9</u> (*Aku Boats*)
1) skipjack



<u>Fleet 3</u> (*Expense Boats*)
1) mixed

<u>Fleet 4</u> (*Commercial Handliners*)
1) yellowfin 3) bottomfish (Area 1-5)
2) bigeye 4) mixed

<u>Fleet 5</u> (*Commercial Trollers*)
1) yellowfin 3) mahimahi 5) mixed
2) blue marlin 4) ono



<u>Fleet 6</u> (*Small Longliners*)
1) yellowfin 3) swordfish 5) lobster
2) bigeye 4) bottomfish 6) mixed

<u>Fleet 7</u> (*Medium Longliners*)
1) yellowfin 3) swordfish 5) mixed
2) bigeye 4) lobster

<u>Fleet 8</u> (*Large Longliners*)
1) yellowfin 3) swordfish
2) bigeye 4) mixed

Figure 2.5 Current Possible Fishing Areas and Target Species of the Fleets

The volumes of landings for most of pelagic species varied seasonally. Table 2.4 illustrates the average volumes of landings in the four seasons from 1990 to 1995 for the major species landed in Hawaii. The bolded number indicates the peak season for a species. Bigeye landings was peak in the season from September to October. Some species, such as yellowfin, albacore, aku, blue marlin, and lobster, had their peak season of landings from June to August, while some species, such swordfish, striped marlin, mahimahi, and ono, had their peak season of landings from February to May.

Table 2.4 The Average Seasonal Landings from 1990-1995[a]

	Nov-Jan		Feb-May		Jun-Aug		Sept-Oct		Annual
Species	pound (1,000)	%	pound (1,000)	%	pound (1,000)	%	pound (1,000)	%	Total (1,000)
Yellowfin	860	0.13	1,878	0.28	3,103	**0.46**	943	0.14	6,785
Bigeye	1,745	**0.39**	1,582	0.35	657	0.15	530	0.12	4,514
Albacore	317	0.22	324	0.22	553	**0.38**	250	0.17	1,445
Swordfish	563	0.09	3,770	**0.62**	1,517	0.25	239	0.04	6,089
Blue Marlin	468	0.17	658	0.23	1,095	**0.39**	600	0.21	2,822
Striped Marlin	478	0.31	561	**0.36**	329	0.21	194	0.12	1,561
Mahimahi	439	0.21	718	**0.34**	481	0.23	482	0.23	2,121
Ono	118	0.11	438	**0.42**	359	0.34	132	0.13	1,046
Aku	668	0.22	704	0.23	1,113	**0.36**	622	0.20	3,107
Shark	45	0.24	71	**0.38**	46	0.25	25	0.13	187
Other Pelagic	257	0.26	356	**0.37**	219	0.23	138	0.14	970
Bottomfish	380	0.29	406	**0.31**	276	0.21	235	0.18	1,298
Lobster	11	0.12	25	0.27	44	**0.48**	31	0.34	92

[a]The landings refer to the commercial and recreational landings. The commercial landings are based on the fishermen catch report from 1993 HDAR and 1993 NMFS logbook; recreational landings were estimated and included in this table. The estimation of the volumes of landings is discussed in Chapter 4.

2.3 CPUE and Catch Components

2.3.1 The Definition of CPUE

In this study, CPUE (catch per unit effort) refers to total catch of all species caught per fishing day. On line with the definition of fishing effort as a four-dimension variable in the current model, CPUE (including the volume and components) varies by fleet, target, area, and season.
First, CPUE is defined as a composite of targeted catch and bycatch, since Hawaii's pelagic fishery, bottomfish fishery, and lobster fishery are all multispecies fisheries. Except for the lobster fishery that harvested only two species, spiny lobster and slipper lobster, both the pelagic fishery and the bottomfish fishery land more than ten species each. These fisheries, especially the pelagic fishery, are technologically interdependent, which means the harvest of one species can lead to the harvest, intentional or not, of another species. When a fisherman targets one of these species, they usually catch the targeted species as well as the other species simultaneously. However, a species that is bycatch in one fishery can be the direct catch of another fishery. For example, blue marlin is a bycatch of the longline fishery, but it is a main target species of the

recreational fishing. Such technological interdependent fisheries may result in conflict between different fishing activities. Therefore, the definition of CPUE in this study allows the model not only to account for total catch from all the fishing activities, but also to consider the bycatch problems in the Hawaii fisheries. The model includes 14 species or species groups including all the species caught and landed by Hawaii based fishing vessels. Nine species are categorized individually and the others are grouped into five species groups as shown in Table 2.5. CPUE (total catch per fishing day in this study) can be any combination of the 14 species and it can be expressed by the following formulation:

$$CPUE_{ijkl} = \sum_{s=1}^{14} R_{ijkls}$$

where:

$CPUE_{ijkl}$: total catch per fishing day for effort E_{ijkl}
R_{ijkls}: catch per fishing day of species s for effort E_{ijkl}.

Table 2.5. Species or Species Groups Included in the Model

Species (*s*)	Common Name	Species Group	Targeted Species (*j*)
1	Yellowfin	Pelagic	Yes
2	Bigeye	Pelagic	Yes
3	Albacore	Pelagic	No[2]
4	Skipjack	Pelagic	Yes
5	Swordfish	Pelagic	Yes
6	Blue Marlin	Pelagic	Yes
7	Striped Marlin	Pelagic	No
8	Mahimahi	Pelagic	Yes
9	Ono	Pelagic	Yes
10	Sharks	Pelagic	No
11	Other pelagic	Pelagic	No
12	Bottomfish	Bottomfish	Yes
13	Lobster	Lobster	Yes
14	All others	Miscellaneous	No

The individual species include four tuna species (yellowfin, bigeye, albacore, and aku), three billfish species (blue marlin, striped marlin and swordfish) and two other species (mahimahi and ono). Bottomfish and lobster are also important species in Hawaii fisheries. Because bottomfish and lobster are localized resources and the fishing method and CPUE are similar within each species group, specific bottomfish and lobster are represented by an aggregated species group of bottomfish and lobster respectively.

Sharks are included in the model because sharks make up a large percentage of the catch of the longline (37% of the total number of fish caught in 1993), although, because most of the bulk of shark catch are discarded at sea, a very small portion of the total sharks caught was landed[3]. The other pelagic species, such as spearfish (*T. angustirostris*) and black marlin (*M. indica*), are aggregated into a single category referred to as 'other pelagic'. Other miscellaneous species are grouped as "other species". This species group is landed primarily by other miscellaneous gears and included in the study because there are bycatch species for some fishing practices considered in the model.

[2] A few vessels (longline and handline) occasionally target albacore.

[3] Most of the shark value in Hawaii is at-sea processed fins, with the rest of the shark discarded at sea. However information on the value of shark for landings is very limited.

2.3.2 The Constant vs. Variable Catch Rate

The current study assumes two possible relationships between CPUE and effort, which are constant catch rate (CCR) and variable catch rate (VCR), shown in Figure 2.6. If a nonlinear relationship between catch and effort is assumed, CPUE is a set of variables in the current model. Otherwise, CPUE is a set of parameters of the current model.

Many studies suggest that intensive local fishing pressure can reduce CPUE in a local area, without affecting abundance of the stock as a whole (Gulland 1968, Sathiendrakumar and Tisdell 1987, and Curran *et al.* 1996). It is possible that local CPUE declines for pelagic species while effort increases and the catch approaches the rates of fish immigration and recruitment in a limited area (Boggs 1992b). Sathiendrakumar and Tisdell (1987) define local CPUE as a function of total local catch, based on the assumption that local CPUE reduces as total catch increases. Unfortunately, no empirical estimation of the relationship for pelagic species between CPUE and catch has been established (Boggs 1992b). A time series study on the Hawaii pelagic fisheries from 1962 to 1992 reported that no statistically valid relationship between catch rates and expanded fishing effort exists (He and Boggs 1995), and the impact of further increase in fishing effort in Hawaii's fisheries is unknown. However, it is useful to consider such relationships. Therefore, the current study assumes two possible relationships (CCR and VCR) between CPUE and effort.

Overall, the CCR model contains about 508 decision variables, and the VCR model contains about 7,000 decision variables since CPUE becomes a set of variables.

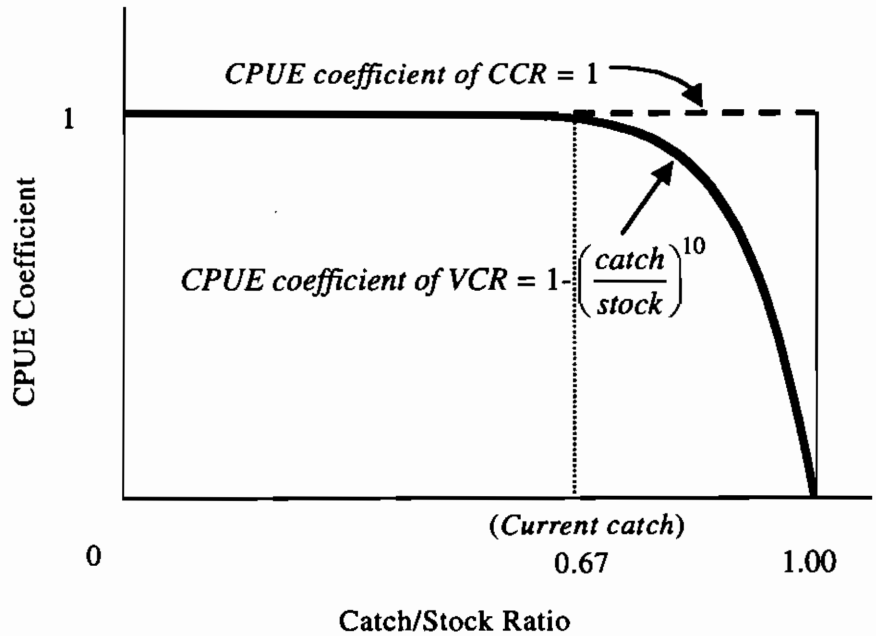


Figure 2.6 The Relationship between CPUE and Effort

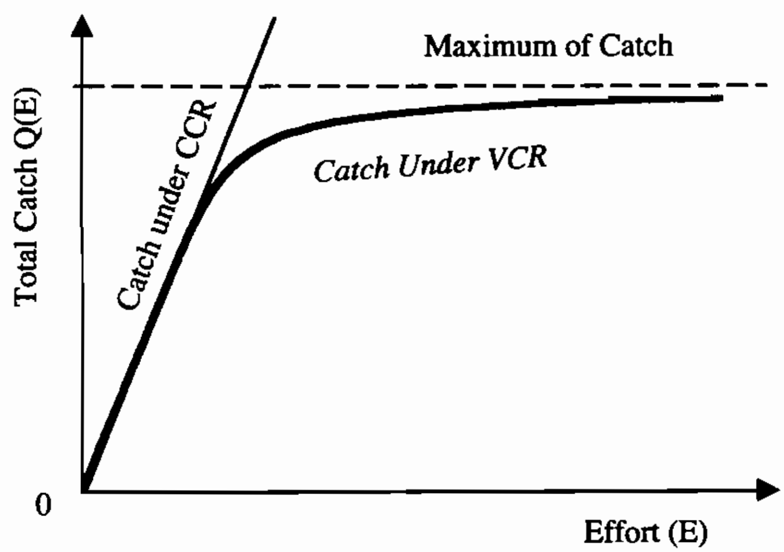


Figure 2.7 The Relationship between Catch and Effort

2.4 Fleetwide Constraints

2.4.1 Stock Constraints

During one season, the total catch in a limited area can not exceed the estimated fish stock in that area and for that season. The total catch of individual species is found by aggregating catch from targeted catch and bycatch over all fleets, to incorporate technological inter-dependence among stocks. The mathematical relationships of stock constraints are expressed in the equation below:

$$\sum_{i}\sum_{j} d^{f}_{ijkl} R_{ijkls} E_{ijkl} \leq s_{kls} \qquad (4)$$

where:

Variables:
R_{ijkls}: catch rate of species s for effort (trip type) E_{ijkl} (lbs/day);
E_{ijkl}: number of trips of fleet i target j in area k during season l (trips).

Parameters (constants):
d^{f}_{ijkl}: trip fishing days for effort E_{ijkl} (days/trip);
s_{kls}: stock for species s in area k during season l (lbs).

The stock of each species is specified as the total exploitable amount of fish (or total available catch) in the exploited areas of the Hawaii fisheries. However, the size of exploitable stocks of most species caught by Hawaii based vessels were difficult to determine. First, pelagic fish are highly migratory. Variations in the distribution and abundance of these pelagic species are often related to differences in their life history profiles, migration patterns, and habits that are affected by ever-changing environmental influences (WPRFMC 1995). Second, Hawaii fisheries have expanded both in size and in fishing grounds in the past two decades. Therefore, this study used the actual catch to estimate the total amount of exploitable catches for Hawaii fisheries. It was assumed that the exploitable stocks for the 14 species or species groups were at least as great as the actual catch.

The dynamic impacts of fish mortality are not considered in this model; thus it is a static model. For bottomfish and lobster fisheries, whose stocks are related to the reproduction and growth of resident fish, the current model represents short-run fishery behavior. However, for the Hawaii pelagic fisheries, the current model can represent short-run as well as long-run fishery behavior in terms of the biological concept. Because total pelagic catches by Hawaii fisheries comprise only a small fraction of Pacific-wide fisheries, catches from Hawaii fisheries are unlikely to cause a stock effect and the consequential reduction of pelagic fish abundance stock-wide. It would appear that the local fishing effort of the Hawaii fisheries is too small to have any significant effect on the size of stocks or their levels of production. For such a fishery, the local catch may increase with effort toward an asymptote (Skillman, *et al.* 1993, and Boggs 1992b).

2.4.2 The Effort and CPUE Relationship

These two different relationships between CPUE and effort result in different catch and effort relationships where catch increases as effort increases at various rates, as shown in Figure 2.7. The assumed function representing the possible relationship between CPUE and aggregated catch under VCR is expressed mathematically in the following equations:

$$A_{kls} = 1 - \left(\frac{Q_{kls}}{s_{kls}}\right)^n = 1 - \left(\frac{\sum_i \sum_j d^f_{ijkl} R_{ijkls} E_{ijkl}}{s_{kls}}\right)^n \qquad (5)$$

$$R_{ijkls} = A_{kls} \overline{R}_{ijkls} \qquad (6)$$

where:

Variables:

- A_{kls}: daily catch rate coefficient, whose value can be 1 to 0 depending on the ratio of total catch to stock s_{kls};
- Q_{ksl}: total catch of species s in area k and season l (lb);
- R_{ijkls}: daily catch per fishing day of species s for fleet i targeting species j in area k during season l (lb/day);
- E_{ijkl}: number of trips of fleet i target j in area k during season l (trips).

Parameters:

- s_{kls}: stock of species s in area k and season l (lb);
- $\overline{R}_{ijkls}$: the max catch per fishing day (lb/day);
- d^f_{ijkl}: number of fishing days per trip for effort E_{ijkl} (days/trip).

It is assumed that each type of effort is associated with a specific initial value of CPUE, and the initial (or maximum) CPUE for specific species ($\overline{R}_{ijkls}$) is determined by the stock-wide abundance condition. In this study, the initial value of CPUE was generated based on 1993 empirical data. Then, a coefficient (A_{kls}), whose value ranges from 1 to 0, is used to represent the degree of decline of CPUE. A coefficient of CPUE of 1 implies CPUE is at the maximum level, while a coefficient of CPUE of 0 implies CPUE reduces to zero. The actual CPUE value is determined by its initial value, which is associated with specific effort type (E_{ijkl}), and the coefficient value (Equation 6), which is associated with the total catch of a species.

The rate at which CPUE diminishes is dependent on the value of n in equation (5), given the fixed amount of stock s and total catch Q. The curve where n has a value of 10 represents that CPUE does not significantly decline until the point where the catch to stock ratio equals 0.667. Therefore, the curve where n equals 10 is chosen to represent a possible CPUE diminishing curve.

The CCR model assumes that the current effort has no negative effects on CPUE, and that a continuous increase in effort will not have any negative effects on CPUE. The coefficient of CPUE is equal to 1 and CPUE remains at the maximum for any effort level. Total catch increases proportionally to the effort increase. On the other hand, the VCR model presumes a nonlinear relationship between effect and total catch. Since no empirical estimation of the relationship between CPUE and catch has been established, nor has an estimate of local stock relationship between CPUE and catch has been established, nor has an estimate of local stock abundance been reported, the exploitable stock for Hawaii fisheries is assumed to be 50% more than the current catch, then the current catch (Q) to stock (s) ratio equals 0.667. As Figure 2.6 illustrates, from little effort up to the current effort level (where catch to stock ratio equals 0.667 if it is assumed that current catch is about 66.7% of the available stock), the crowding out effect may be too small to result in a significant decline of CPUE. However, when fishing effort exceeds the current level, CPUE declines at an increasing rate.

When the variable catch rate (VCR) is incorporated into the model, the model becomes a nonlinear programming model. As a result, fleetwide profit is nonlinear and it increases at the beginning when effort level is low, but eventually declines.

2.5 Mircolevel Entry Conditions

As discussed earlier, the NMFS model omitted microlevel decision-making by fishermen and consequently resulted in an unrealistic solution. First, fishery policy makers' objectives are typically not consistent with fishermen's objectives. For example, in fishery economic research, it is usually assumed that a commercial fisherman maximizes profit at the microlevel. However, at the macrolevel, improving economic efficiency of the fisheries is only one of the many objectives that fishery decision-makers try to achieve.

Second, maximizing fleet-wide profit does not necessarily imply maximizing individual fishermen's profit, especially when CPUE diminishes as effort increases. If CPUE declines as effort increases, an individual vessel's profit declines monotonically as total catch increases.
Third, in some fisheries, such as the Hawaii fisheries, there are diverse interest groups. As discussed earlier, Hawaii fishermen were categorized into nine fleets differentiated by motivation, vessel size, and fishing style. Different groups (fishermen) have various objectives or expectations from fishing.

Ideally, the two-level problem should be solved through the optimization at the fishermen's level nested within the optimization at the fishery managers' level. However, there is no practical solution algorithm for such a nested hierarchy model particularly given the nonlinear nature of the current model (Önal 1996). In order to keep the model manageable and solvable, the optimization at the fishermen's level is approximated by a set of entry conditions in this study. In other words, it was assumed that fishermen would make their decision to enter and continue fishing depending on certain conditions or expectations. These entry conditions include trip entry condition, crew entry condition, and owner entry conditions.

Due to lack of research on individual fishermen's behavior in the Hawaii fisheries, the parameters of these entry conditions were assumed to be varied by fleets and they were generated based on the empirical data of the Hawaii fisheries. The amount of trip costs and the percentage set as the entry conditions were generated based on recent cost-earnings studies on the Hawaii fishery. Thus, several micro-level entry conditions, which are used to approximate the decisions at the fishermen's level, are incorporated in the current model. The detailed discussions on the three sets of entry conditions are presented in the following paragraphs.

2.5.1 Trip Entry Condition

First, fishermen make the decision whether to enter into fishing operation for each production period. The appropriate time span for the short-run production process of fishing vessel is the length of a fishing trip (Doll 1988). Just as a farmer commits resources prior to and during a production cycle, a fisherman inputs resources and makes production decisions prior to and

Commercial fleets' trip entry condition. For commercial fleets, a trip is feasible if revenue gained at least covers operating costs. A trip entry condition was incorporated into the model to ensure that commercial fishermen at least cover trip expenses.

$$N_{ijkl}E_{ijkl} \geq 0 \qquad (7)$$
$$N_{ijkl} = \sum_s \left(p_{ils} d^f_{ijkl} R_{ijkls}\right) - c_{ijkl}$$

where:

Variables:
- N_{ijkl}: trip net revenue ($/trip);
- R_{ijkls}: catch per fishing day of species *s* for fleet *i* targeting species *j* in area *k* during season *l* (lb/trip);

Parameters:
- p_{ils}: fish price for species *s* caught by fleet *i* during season *l* ($/lb);
- d^f_{ijkl}: number of fishing days per trip for trip E_{ijkl} (days/trip);
- c_{ijkl}: variable costs (trip costs) per day for trip E_{ijkl} ($/trip);

Therefore, a trip (E_{ijkl}) is possible only if the trip net revenue (N_{ijkl}) is greater than or equal to zero. Equation (7) implies that positive E_{ijkl} requires a non-zero net revenue which implies the following condition:

$$E_{ijkl}\begin{cases} \geq 0 & if\, N_{ijkl} \geq 0 \\ = 0 & if\, N_{ijkl} < 0 \end{cases}$$

Net return of a trip is a variable related to total catch of a trip, fish prices, and the trip's variable costs. Total catch of a trip depends on CPUE (catch per fishing day of targeted species and bycatch R_{ijkls}) and the trip fishing days (d_{ijkl}). Because the major variables of fish prices in Hawaii's fresh-fish market depend on fish species, fish size, fish harvesting method, and fish quality grade (Bartram *et al.* 1996), fish prices (p_{ils}) were assumed to vary by fleet, season, and species. Excluding handling fees, prices received by fishermen (p_{ils}) were approximately 90% of ex-vessel value. In the equation of the trip net return (N_{ijkl}), prices that fishermen received were used to calculate trip revenues of fishermen.

Trip costs (c_{ijkl}) contain three components: operating costs, traveling costs, and turn-around (the time to unload catch and get supplies for another fishing trip) costs. Trip costs are computed as:

$$c_{ijkl} = c^t_i d^t_{ik} + c^f_{ij} d^f_{ijkl} + c^r_i d^r_{ij}$$

where:

- c^t_i: costs per traveling day, assumed to vary by fleet (*i*), refers mainly to fuel, oil, ice, and foods for crew.
- c^f_{ij}: costs per fishing day, assumed to vary by fleet (*i*) and target (*j*). refers mainly to travel costs and bait.

c_i^r: costs per turn around day, assumed to vary by fleet (i), refers mainly to mooring fee.

d_{ik}^t: number of trip traveling days, assumed to vary by fleet (i) and area (k), because different fleets may travel at different speed to different areas;

d_{ij}^r: necessary turn-around days between trips, assumed to vary by fleet (i) and target (j), refers to the time spent for unloading fish, replenishing for the next trips, and rests or breaks for the fishermen. For commercial fishermen, d_{ij}^r depends on trip length (days at sea). The longer the trip length, the longer the time for fishermen to unload fish, replenish goods and supplies and rest. For recreational fishermen who usually fish on weekend, the turn-around day (the break time between trips) is their work-time on weekdays.

d_{ik}^t: number of fishing days in a trip, assumed to vary by fleet (i), target (j), area (k), and season(l). Since the number of traveling days is relatively fixed, trip length primarily depends on the number of fishing days. The number of fishing days is generally affected by the shelf-life of fish, vessel capacity, and motivations of fishermen. In Hawaii, fishermen who target tuna for the 'sashimi' (raw fish) market fish less days than the fishermen who target swordfish, which usually is processed and sold as a frozen product, do. Recreational fishermen usually take shorter trips than commercial fishermen do (Hamm and Lum 1992). Small-boat fishermen who sell at least part of their catch usually had 42% longer trip length than that of fishermen who did not sell any of their catch.

Recreational trip entry condition. The number of trips is used to measure the recreational experiences in the current study. Even though the non-commercial fishermen of Fleets 1 and 3 are not seeking income or profit from fishing activities, they may have to meet certain conditions in order to continue their fishing practices. Recreational fishermen may expect a certain percentage of successful fishing trips or expect a certain level of CPUE. Expense fishermen may expect a certain amount of revenue from fish sold to cover a portion of their fishing expenses. Since information on the entry conditions or motivations of the non-commercial fishermen is limited, the entry condition for recreational boats (Fleet 1) is assumed to be at least 90% of the current catch rate of the desirable species. The lower bound of the coefficient of CPUE is arbitrarily defined as 90%, and the impact of the value of the coefficient of CPUE for the recreational fishing can be examined by conducting sensitivity analyses to the model. Expense fishermen were assumed to sell about 51% of their catch, and the revenue from fish sales will cover at least 30% of the trip expenses. The entry condition of the expense fleet was based on the actual practices as reported in a recent study by Hamilton and Huffman (1997).

The trip entry conditions of Fleet 1 and Fleet 3 are expressed mathematically as follows:

$$(A_{ils} - 0.9)E_{ijkl} \geq 0 \qquad i = 1 \qquad (8)$$

$$\left[0.51\sum_{s}\left(p_{ils}d_{ijkl}^{f}R_{ijkls}\right) - 0.3c_{ijkl}\right]E_{ijkl} \geq 0 \quad i = 3 \qquad (9)$$

where:

Variables:

A_{ils}: CPUE coefficients;
E_{ijkl}: number of trips of fleet i target j in area k during season l (trips).

Parameters:

p_{ils}: fish price for species s caught by fleet i during season l ($/lb);
d^f_{ijkl}: number of fishing days for trip E_{ijkl} (days/trip);
c_{ijkl}: trip costs for trip E_{ijkl} ($/trip).

2.5.2 Owner's Entry Condition

The owner entry condition is specified only for commercial fleets and ensures that an owner's return adequately covers their investment in the long-run. Because most of the owner's expenses were fixed on an annual basis, the owner entry condition specifies that annual owner net income should be greater or equal to the fixed costs.

$$\left(\sum_j \sum_k \sum_k (1-\alpha_i) N_{ijkl} E_{ijkl} - fc_i V_i\right) V_i \geq 0 \qquad (10)$$

where

Variables:

N_{ijkl}: trip net revenue by fleet i target j in area k during season l ($/trip);
E_{ijkl}: number of trips of fleet i target j in area k during season l (trips);
V_i: number of vessels in fleet i (vessels);.

Parameters:

α_i: crew share of net revenue for fleet i;
$(1\text{-}\alpha_i)$: owner share of net revenue for fleet i;
fc_i: fixed costs, include opportunity costs of investment, depreciation, maintenance, and insurance ($/year).

Therefore, a fleet (V_i) is feasible only if the annual income to owner is greater than or equal to the annual fixed costs. Thus, equation (10) implies the following condition:

$$V_i \begin{cases} \geq 0 \ if \left(\sum_j \sum_k \sum_l (1-\alpha_i) N_{ijkl} E_{ijkl} - fc_i V_i\right) \geq 0 \\ = 0 \ if \left(\sum_j \sum_k \sum_l (1-\alpha_i) N_{ijkl} E_{ijkl} - fc_i V_i\right) < 0 \end{cases}$$

2.5.3 *Crew's Entry Condition*

The crew (including captain) expects certain income from fishery otherwise they may switch to other types of employment. Thus, the crew entry condition is included in the model to ensure that the crew income is sufficient to attract crew members to engage in the fishery. The crew entry conditions for commercial fleets are specified on an annual basis and is expressed mathematically in the following equation:

$$\left(\sum_{j}\sum_{k}\sum_{l}\alpha_i N_{ijkl}E_{ijkl} - \omega_i\left(d^f_{ijkl} + d^t_{ik}\right)E_{ijkl}\right)V_i \geq 0 \qquad (11)$$

where:

Variables:

N_{ijkl}: trip net revenue by fleet i target j in area k during season l (\$/trip);
E_{ijkl}: number of trips of fleet i target j in area k during season l (trips);
V_i: number of vessels in fleet i (vessels).

Parameters:

ω_i: expected wage per working day (day at sea) for all crew member of a vessel in fleet i (\$/day);
$d^f_{ijkl} + d^t_{ik}$: trip length (days at sea) for trip E_{ijkl} (days/trip);
α_i: crew share of net revenue for fleet i.

The crew's satisfaction with their income does not imply that the owner breaks even from the fishing operations. Therefore, a commercial fleet is economically feasible on an annual basis only if both crew and owner entry conditions are satisfied. With entry conditions, the optimal level of effort may not be consistent with the optimal level of effort without considering entry conditions (Pan 1998).

2.6 Objective Functions

Objective functions are essential components of mathematical programming models. They are based on the policy goals of decision-makers. A multiobjective programming model attempts to optimize two or more objective functions simultaneously to search for a *Pareto optimal* solution for a multiobjective optimizing problem. The number of objective functions incorporated into a multiobjective programming model depends on the needs of the research problem and the availability of the information on the specific problem. The choice of multiobjective programming techniques depends on the number of objective functions and the availability of relative preferences on the objective functions (Romero and Rehman 1989).

The policy goals for managing Hawaii's fisheries are designated primarily by a single entity: Western Pacific Regional Fishery Management Council (WPRFMC), the authority for managing EEZ (exclusive economic zone) fisheries in Hawaii. The main task of the Council is to protect fishery resources while maintaining opportunities for domestic commercial and recreational fishing at sustainable levels of effort and yield (WPRFMC 1998). Since fisheries management is typically characterized by multiple and often conflicting objectives, the analytic hierarchy process (AHP) was applied to evaluate and weigh the Council's management goals among a variety of Council groups (Leung *et al.* 1998). This study found that the biological criterion, among the four high-level goals: biological, economic, social, and political, had the highest priority (0.526). The economic and social criteria were of roughly equal weights (0.191 and priority (0.526). The economic and social criteria were of roughly equal weights (0.191 and 0.20). The AHP study also indicated the conservation goal (biological criterion) is a particularly important goal from the view of the Council members whose average weight on the biological criterion is 0.714. In addition, a series of sub-criteria for each of the four high-level goals (biological, economic, social, and political goals) was identified for the Hawaii fisheries management in the AHP study (Leung *et al.* 1998).

Conservation is an essential goal of the fisheries management in Hawaii (WPRFMC 1998, and Leung *et al.* 1998). In current model, the conservation goal (to protect fishery resources) is incorporated into the model by specifying the stock constraints (the total available catch constraints).

To evaluate the tradeoffs between commercial and non-commercial (including recreational and traditional subsistence) fishing, the study constructs a two-objective model. The two objectives considered in this study are stated as 1) maximizing fleetwide profit; and 2) maximizing recreational (or non-commercial) trips which includes the traditional fishing trips from both the recreational fleet and the expense fleet.

Profit maximization is a behavioral assumption underlying any commercial activities based on economic theory. Therefore, the value of commercial fishing is presented by fleet-wide profit in this study. The fleet-wide profit is defined here as the total annual fleet net revenue that is derived by subtracting trip variable costs, expected crew income (representing the shadow price of labor), and fixed charges from the gross annual fleet revenue. Thus, fleet-wide profit represents precisely the economic rents of the entire fishery if all their inputs are valued at their shadow costs and their outputs are valued at their margins. Since stock effect is not included in the current model, the shadow price of the foregone fish resource appears to zero in this case.

Placing a value on non-commercial fishing (recreational and traditional subsistence fishing) involves complicated theoretical and philosophical concerns. In this study, the value of non-commercial fishing is measured by the total amount of participation, that is the number of fishing trips taken by the recreational and traditional subsistence fishermen.

Several approaches are available to formulate and solve multiobjective programming models. Since only two objective functions are included in the current study, the tradeoff between these two objectives can be traced using the noninferior set estimation (NISE) method (Cohon *et al.* 1979). The NISE method is the most effective technique to solve two objective problems but it can be applied to two-objective models, while the other multiobjective programming techniques, such as goal programming and compromise programming, are capable of solving multiobjective models with more than two objectives (Romero and Rehman 1989). The two objectives are formulated in the mathematical equations below:

Maximize fleet-wide profit:

$$Max \sum_i \sum_j \sum_k \sum_l \sum_s N_{ijkl} E_{ijkl} - \sum_i \sum_j \sum_k \sum_l \omega_i (d^f_{ijkl} + d^t_{ik}) E_{ijkl} - \sum_i fc_i V_i$$

for i = 2, 4, to 9

Maximize number of recreational trips:

$$Max \sum_i \sum_j \sum_k \sum_l E_{ijkl} \qquad \text{for i = 1, 3}$$

where:

Variables:

N_{ijkl}: trip net revenue by fleet i target j in area k during season l ($/trip);
E_{ijkl}: number of trips of fleet i target j in area k during season l (trips);
V_i: number of vessels in fleet i (vessel).

Parameters:

ω_i: expected wage per day at sea for all crew member of a vessel of fleet i ($/day);
$d^f_{ijkl} + d^t_{ik}$: trip length (days at sea) for trip E_{ijkl} (days);
fc_i: fixed costs of fleet i ($).

In order to measure the total rent associated with the fisheries, this study chose the crew's expected income instead of the actual net revenue share as the labor costs in the profit maximizing objective function. This approach was taken since that crews in Hawaii usually obtain their shares, which are proportional to trip net revenue, after the fishing trips, and crews do not get paid if the trip revenue does not cover trip expenses. In other words, crew members share part of the rent from the fisheries. Traditional methods used in fisheries economic research that maximize rent to an open access resource have almost universally assumed all costs are directly proportional to effort. When crews receive a fixed share of gross returns, labor costs are proportional to catch. However, Griffin *et al.* (1976) indicated that the traditional analysis would result in management schemes that overtax vessels and ignore rent accruing to crews. To avoid this distortion, the fleet-wide profit used in this study accounts for the rent shared by crews.

2.7 Model Summary

The multiobjective and multilevel model provides an analytical framework to assist the decision-marking process for the Hawaii fisheries management. The current model covers nine fleet categories, five fishing areas, four fishing seasons, and 14 species or species groups, of which ten species or species groups are the possible targets in the Hawaii fishery. The current formulation allows for the inclusion of the three major fisheries (pelagic, bottomfish, and lobster) and the different types of fishermen, including commercial, semi-commercial, and recreational fishermen, in the Hawaii fishery. To better capture the reality of the Hawaii fisheries, the current model improves upon the previous NMFS LP model in the following aspects:

First, it incorporates multilevel and multiobjective into the model. The optimization of fishermen's level is approximated by three entry conditions. To evaluate the tradeoffs between commercial and recreational fishing, two management goals, represented by maximizing fleetwide profit and maximizing the number of recreational trips, are incorporated into the model as objective functions, while the 'core' management objective goal, the conservation goal, is included in the model as stock constraints.

Second, the structure of the model is better able to capture the reality of the operational and activity choices of the Hawaii fisheries through:

- increasing the dimensions of decision variables;
- including bycatch in CPUE;
- incorporating a nonlinear catch-effort relationship; and
- allowing seasonal variation of fleet sizes, while fixed costs are charged in annual base.

Under various objectives or policy options facing Hawaii's fisheries, the current model provides the optimal solution in terms of fleet mix, harvest levels of the different species, fish resource allocation among the different effort groups (fleets), and spatial and seasonal distribution of effort.

There are total 508 decision variables in the CCR model and approximately 7,000 decision variables in the VCR model. The current model was solved on a personal computer with GAMS software that was developed by GAMS Development Corporation (1996). The GAMS program for the current model, as well as the mathematical formulations, is presented in Appendix 1.

3. DATA

This section provides a brief summary about the sources and procedures used in generating data for the model validation and application. Model parameters were calibrated such that for each fleet, Total catch = (CPUE per trip)*(fleet size)*(number of trips per vessel). While there is no guarantee that such a process provides 'real' parameters and constants for the model, it provides at least internal consistency among all the parameters and constants. In addition, consistency checks for all parameters of the model are necessary especially in our case where data came from three independent sources (HDAR, cost-earning surveys, and NMFS longline logbook) as described as follows.

The model uses five categories of parameters: CPUE, exploitable stock size (total available catch), output prices, trip days, and costs (operating costs and fixed costs). Most of the parameters are generated based on actual operations of the Hawaii fisheries in 1993. 1993 was chosen because detailed cost-earning data about the longline fishery were available for that year. The five categories of parameters were generated primarily from three sources of information: 1993 Hawaii Division of Aquatic Resources (HDAR) data, 1993 NMFS longline logbooks, and the 1993 cost-earning studies conducted by the Joint Institute for Marine and Atmospheric Research (JIMFR) and NMFS. If necessary data were not available from these three sources, or not available for 1993, other sources such as the annual reports of the NMFS or a different time period's information were utilized. Table 2.1 summarizes the data sources for each category of parameters.

HDAR data refer to the commercial catch reports submitted by licensed commercial fishermen. Since 1945 the State of Hawaii has collected these commercial catch reports (HDAR 1984). The State of Hawaii requires commercial fishermen, who sold at least one fish during a calendar year, to submit a monthly report recording the catch and sales information for each day fished. The information includes a license number, the date and area fished, gear type, species, counts and weight caught, pounds sold, value of sales, and port of landing.

Table 3.1. Major Data Sources for the Parameters

Parameters	Main Sources
CPUE (*i,j,k,l,s*)	
Multipurpose fleets (*i*=6-8)	NMFS longline logbook (1993) & HDAR data (1993)
All other fleets (*i*=1-5, 9)	HDAR data (1993) & the NMFS cost-earnings survey of small boats (1997)
Total Available Catch (*s,k,l*)	HDAR (1993), NMFS longline logbook 1993, and
Actual 1993 catches	NMFS cost-earnings survey of small boats (1997)
Prices (*i,l,s*)	
Multipurpose fleets (*i*=6-8)	NMFS longline logbook (1993) & HDAR data (1993)
All other fleets (*i*=1-5, 9)	HDAR data (1993)
Costs (*i,j,k,l*)	
Multipurpose fleets (*i*=6-8)	NMFS cost-earnings survey of longliners (1994)
Charter boat fleet (*i*=2)	NMFS cost-earnings survey of charter boats (1997)
Aku boat fleet (*i*=9)	Boggs and Pooley (1987)
All other fleets (*i*=1, 3-5)	NMFS cost-earning survey of small boats (1997)
Trip length & number of trips (*i,j,k,l*)	
Multipurpose fleets (*i*=6-8)	NMFS longline logbook (1993) & HDAR data (1993)
All other fleets (*i*=1-5, 9)	Estimated by K. Kawamoto and S.G. Pooley

Federal regulation placed on the Hawaii longline fishery that became effective on November 27, 1990 (WPRFMC 1991) requires the fishermen to fill out the NMFS longline logbooks. NMFS longline logbooks contain daily information on longline fishing effort and catch including target species, bait used, number of hooks used, set time and location, and number of fish caught by species. The logbooks must be submitted to the NMFS within 72 hours of returning to port after each trip.

A number of detailed cost-earning studies for the Hawaii's fisheries were conducted by JIMAR and NMFS in recent years. These studies included cost-earnings studies of bottomfish vessels in the NWHI in 1993, longline vessels in 1994, small boats in 1996-1997, and an ongoing study of charter boats that began in 1997. They have provided detailed information about costs and earnings for various fishing sectors of Hawaii's fisheries.

The detailed procedures of the data processing for each group of parameters were elaborated in the Pan's dissertation (1998). The values of the parameters are presented in the appendices: CPUE in Appendix 2, prices of fish sold in Appendix 3, the exploitable stocks from 1990, 1993, and 1995 in Appendices 4-6, the number of recreational trips for these years, which were used as the lower bounds of the recreational activities in Appendix 7, fixed costs and the crew and owner entry conditions in Appendix 8, variable costs in Appendix 9, the maximum number of trips in Appendix 10.

4. A BASELINE MODEL AND APPLICATION RESULTS

4.1 The Baseline Model and the Optimal Solution

The baseline model, a single objective of profit maximizing with a fixed number of recreational trips and constant CPUE (CCR) model, is constructed to test the model. Unlike simulation models where one can adjust model parameters so as to reproduce as accurately as possible the situations being modeled, mathematical programming models are normative and prescriptive in nature and are not expected to reproduce the actual situation, particularly under the assumption that the actual situation is sub-optimal. The base line model is performed to assess the reasonableness of the current model. Sensitivity analyses on the impacts of total available catches using the CCR model and evaluation of the declining CPUE using the VCR model are also presented in this Section.

A baseline model is defined under an objective of maximizing commercial profit subject to fixed recreational activities, and was run with a constant catch rate (CCR). The parameters generated from the 1993 data that were described in the previous section were applied to the baseline model. This process was used to test if the output of the single objective profit maximizing model conforms to the reality of the Hawaii fisheries in 1993, the base year. The basic features of the baseline model are summarized as follows:

- Maximizing fleetwide profit (rent);
- Constant catch rate (CCR);
- 100% of 1993 actual catch as total available catch;
- 100% of 1993 estimated recreational trips as lower bounds of recreational participation; and
- Areas 1 and 2 (within 75 nmi) closed to longliners with exception of 3 small longline vessels, that are allowed to fish in their customary waters.

The optimal solution of the baseline model is presented in Appendices 11.1 to 11.3. Appendix 11.1 summarizes the fishing operation and performance for both fleetwide and individual fleet. Appendix 11.2 presents the effort (number of vessels and number of fishing trips) and effort distributions by fleet, target, area, and season. Appendixes 11.3 presents the total available catch and harvest rates by species, area, season, and also total catch and catch distribution among fleets.

In general, the optimal result from the baseline model seems plausible. Although there are differences between the outcome of the base line model and the actual situation of the Hawaii fisheries, these differences were expected and explicable.

4.1.1 Harvest Level and Catch Distribution

The spatial and seasonal distribution of the optimal catch from the baseline model is consistent with the actual distribution. Figure 4.1 presents total catch distributions over the four seasons, and Figure 4.2 presents total catch distributions over the five areas. Total optimal catch is 30.9 million pounds, which is 4.2 million pounds less than the total available catch, however, the difference between the optimal and the actual catch was evenly distributed among each season or area.

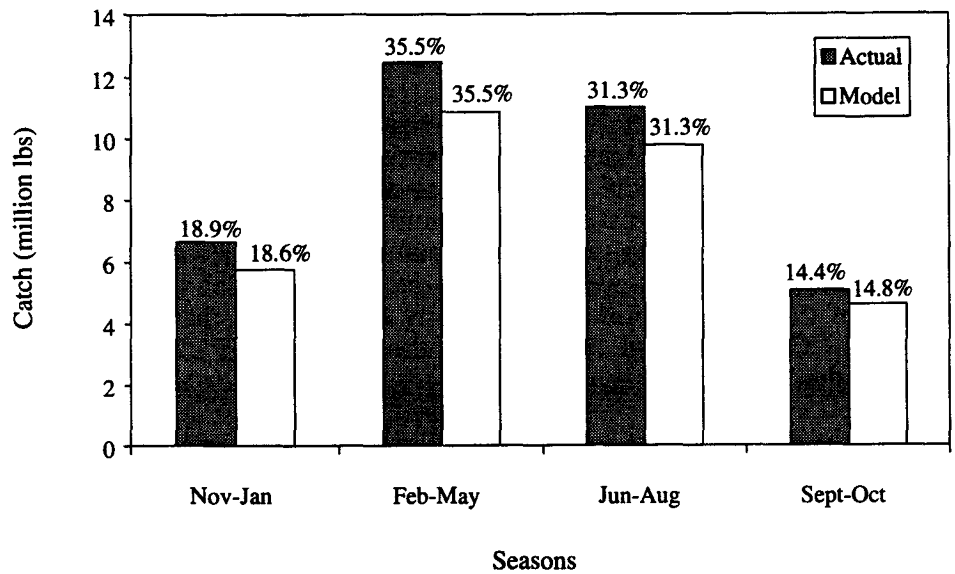


Figure 4.1 Catch Distribution by Season—the Baseline Model vs. Actual

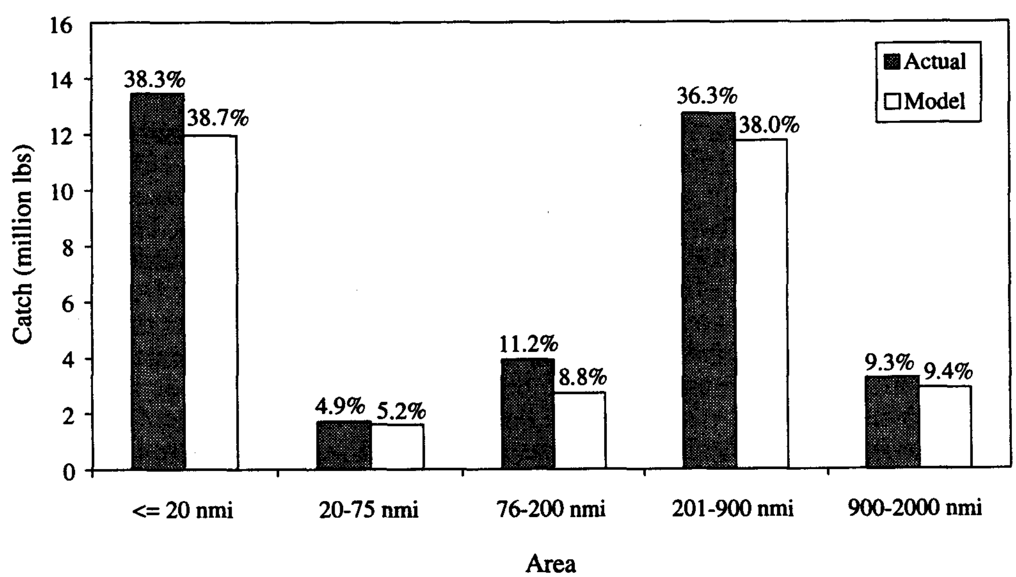


Figure 4.2 Catch Distribution by Area—the Baseline Model vs. Actual

The optimal harvest levels for different species are varied, with total optimal catch at 88% of actual level. Some species, such as yellowfin and bigeye tuna, in specific areas and seasons were 100% harvested, while some other species, such as albacore and shark, were harvested at relatively lower percentages (59%-53%) of the given available catch. It can be observed that the targeted species are harvested at a higher ratio to the given available catch than that of the untargeted species (Table 4.1).

Table 4.1. The Optimal Harvest Rates by Species

Species	1,000 Pounds		%
	Total Available Catch	Caught	Caught
Yellowfin	6,162	6,059	98
Bigeye	5,110	4,704	92
Albacore	1,264	750	59
Swordfish	9,697	9,320	96
Blue marlin	2,690	2,051	76
Striped marlin	1,758	1,285	73
Mahimahi	1,679	1,123	67
Ono	1,028	616	60
Aku	3,517	3,495	99
Shark	154	82	53
Other Pelagic	887	370	42
Bottomfish	1,115	1,020	91
All others	47	44	94
Total targeted	*30,998*	*28,388*	*92*
Total untargeted	*4,110*	*2,531*	*62*
Total	**35,108**	**30,919**	**88**

An average of 92% of given available catch of the targeted species were caught, while an average of 62% of the available catch of the untargeted species were harvested. Fish prices of the targeted species prices are usually higher than that of the untargeted species (the average price of the targeted species is $2.55 while the untargeted species is $1.35). Since higher fish price leads higher revenue, in turn, catching higher value fish may contribute to greater profit. The reduction in overall catch from the actual level comes mostly from a lower catch of the low value species. This result is based on the assumption of fixed fish prices since there is no demand relation incorporated into the current model.

4.1.2 Effort and Distribution

Under the assumption of profit maximization, the optimal solution of the baseline model suggests that total effort in terms of the total number of commercial vessels active during the year was 41% less than the actual effort (Table 4.2), since the number of commercial vessels could be reduced from 610 to 358. Along with that reduction of the number of commercial vessels, gross profits of the commercial sector could be improved from $4.54 million to $17.96 million as efficiency increases. However, profit maximization leads to a decline of 4.2 million pounds of catch and $12.6 million revenue.

The decrease in the number of vessels primarily affected two fleets, charter boats and commercial trollers, which showed negative profits in 1993. Optimal fleet size of charter boats is found to be 45 vessels, which is about 50% of the actual level in 1993, and commercial trollers could be reduced from 232 actual vessels to 64 vessels, which is 27.5% of the actual level. On the other hand, the results from the baseline model show that the optimal sizes of two fleets, the commercial handliners and the large multipurpose longliners, are greater than their actual fleet sizes, while the total number of fleet-wide vessels reduces.

In addition, the optimal solution of the baseline model suggests that less variation of effort over the four seasons results in a higher profit achievement. Moreover, the baseline model suggests that longline fishing can be more efficient if the mixed target strategy is practiced the most while swordfish target strategy is practiced the least among the three types of longline fishing targets. This finding is also consistent with the NMFS cost-earnings study which reported that the large and medium vessels using the mixed target strategy obtain the highest returns in 1993.

Table 4.2. Effort, Profit and Revenue Distribution—Model vs. Actual

Fleet	No. of vessels		Profit ($1,000)		Revenue ($1,000)	
	Model	Actual	Model	Actual	Model	Actual
Recreational						
Recreational boats	2,490	2,490				
Expense boats	952	952			2,811	2,890
Commercial						
Charter boats	45	99	641	(2,203)	7,273	9,109
Commercial handliners	163	149	3,256	533	11,694	11,419
Commercial Trollers	64	232	1,081	(1,085)	4,277	5,970
Small multipurpose	14	30	1,273	180	5,221	7,313
Medium multipurpose	6	48	856	1,789	3,454	20,813
Large multipurpose	52	44	9,470	4,218	36,640	27,213
Aku boats	14	8	1,380	1,106	3,461	2,820
Total recreational	3,442	3,442	-	-	2,811	2,890
Total commercial	358	610	17,957	4,538	72,020	84,657

In general, the optimal solution suggests a flexible target schedule (strategies) for each fleet over the four seasons, in order to optimize profit. The optimal solution suggests that most of the commercial fleets switch their targets in different seasons, except aku boats that target only one species (skipjack tuna) in all seasons. For example, the optimal solution suggests that the commercial handliners mainly target bottomfish from November to January, while a large portion of commercial handliners trips targets yellowfin from June to August. Similarly, the large multipurpose vessels—whose number increases from the actual to the model solution—use longline gear mainly to target mixed species in Seasons 2 and 3 (February to August), while in Season 1 (November to January) they use longline mainly to target bigeye (Appendix 11.2).

4.2. The Model Applications and Results

This section illustrates the applications of the current model in analyzing several issues associated with the Hawaii fisheries management as a quantitative tool in assisting the decision-making process in the Hawaii fisheries management. The applications of the model presented include 1) evaluation of impacts of change in total available catch, 2) evaluation of impacts of declining CPUE, 3) evaluation of the tradeoffs between recreational fishing and commercial fishing, and 4) estimation of policy impacts by the area-closure regime that was designed to reduce gear conflict between longline vessels and the small-boat fleets (troll, handline, charter boating, expense, and recreation).

4.2.1 The Impacts of Total Available Catch

The first application is to evaluate the impact of stock conditions (total available catch) on the optimal solution. The application indicates that a proportional change in fish stock for every species results in same optimal fleet mix, while the optimal fleet mix will change if the relative abundance of different species changes. This implies that the number of fishing vessels and the available fishing days are not a constraints in expanding catch for any fleet.

Using 150% of 1993 actual catch as the total available catch constraint of the CCR model, the optimal fleetwide profit increases by exactly 50% and total catch increases also by 50%, compared to the optimal solution when 100% of 1993 actual catch as the total available catch constraints (Table 4.3). The optimal number of vessels of each fleet increases proportionally as the total available catch for each species increase proportionally; thus, the structure of the fleets (fleet mix) did not change[1].

Table 4.3. Optimal Fleet Structure under Different Stock Conditions

Stock Conditions	1993 Catch	150% of 1993 Catch	*Change Ratio*	1995 Catch	*Change Ratio*
Total Available Catch (million lb)	***35.1***	***52.7***	***1.5***	***37.9***	***1.1***
No. of Recreational Trips (1,000)	87	131	1.5	97	1.1
No. of Commercial Vessels	358	537	1.5	325	0.9
Charter boats	45	68	1.5	20	0.4
Commercial handliners	163	245	1.5	147	0.9
Commercial trollers	64	96	1.5	89	1.4
Small multipurpose	14	21	1.5	28	2.0
Medium multipurpose	6	9	1.5	17	2.8
Large multipurpose	52	78	1.5	18	0.3
Aku boats	14	21	1.5	6	0.4
Fleetwide Profit ($million)	*30.3*	*45.4*	*1.5*	*28.6*	*0.9*

However, when the actual catch in different years is applied to the CCR model as the stock constraints, the amount of total available catch for each species was not proportional to the amount of total available catch in 1993. The optimal fleet structure changes, as does the optimal profit. Table 4.3 also presents the optimal fleet structure resulted from the run where 1995 actual catch was used as total available catch in the model. It can be observed that the optimal fleet structure (fleet mix) changes under these different stock conditions. For example, the optimal fleet size of the large multipurpose fleet in 1993 scenario is 52 vessels, and it is a dominate fleet for the three longline fleets. However, in 1995 scenario, the optimal fleet size reduces to 18 vessels, while other two longline fleets more than double their optimal fleet sizes, compared to the 1993 scenario. Further, for those years with higher swordfish stock, the optimal solution

[1] The implies that the number of fishing vessels and the available fishing days are not a constraint in expanding catch for one fleet.

suggests that the large multipurpose fleet should comprise the principal fleet. However, if tuna are relatively abundant, small and medium vessels are more profitable for the Hawaii fisheries[2].

4.2.2 The Impacts of Declining CPUE (VCR Model)

If CPUE declines as effort increases, the nonlinear relationship between catch and effort is modeled by equations (5) and (6) in Section 2. These two equations indicate that the CPUE of a specific species is associated with the aggregated catch including direct catch and indirect catch. Applying 150% actual catch as stock constraints, the optimal fleet structure yielded by the VCR model is summarized in Table 4.4. The optimal solution of the CCR model is presented in the same table for comparison.

In terms of effort, the VCR model suggests that the optimal number of commercial vessels is 382, while the optimal number resulting from the CCR model under the same stock constraints is 537. In other words, if CPUE declines as effort increases, optimal effort in terms of number of vessels is only 71% and total catch is about 74% of what it is when the CPUE is constant. Furthermore, the impact between the tow formulations (CCR vs. VCR) is not uniform among fleets and ranges from 33% to 122%. Thus, the optimal fleet structure resulting from these two models is different. Optimal fleetwide profit yielded from the VCR model is about $22.8 million, which is 85% of the CCR results, while the optimal number of vessels was only 71% of the CCR results.

Table 4.4. The Optimal Fleet Mix and Rent Distribution (VCR vs. CCR Model)

Fleet	No. of Vessels			Profit ($1,000)		
	VCR	CCR	Ratio	VCR	CCR	Ratio
Recreational						
Recreational boats	2,490	2,490	1.00			
Expense boats	952	952	1.00			
Commercial						
Charter boats	43	68	0.64	617	962	0.64
Commercial handliners	169	245	0.69	2,530	4,884	0.52
Commercial trollers	77	96	0.80	1,398	1,622	0.86
Small multipurpose	7	21	0.33	805	1,910	0.42
Medium multipurpose	11	9	1.22	1,386	1,284	1.08
Large multipurpose	60	78	0.77	14,560	14,205	1.02
Aku boats	15	21	0.71	1,562	2,070	0.75
Total recreational	3,442	3,442	1.00	-	-	
Total commercial	382	537	0.71	22,858	26,936	0.85

The VCR model dictates that no a single species can be fully utilized under an optimality scenario, unlike the CCR model that results in fully utilization of the total available catch for many species. The optimal catch resulted from the VCR model is 33.5 million pounds, which is about 71% of the CCR model.

Table 4.5 shows the optimal harvest rates from the CCR and VCR models. The first column lists the actual catch for each species in the 1993. Assuming that there are 50% more fish than the actual catch, the total available catch used as the stock constraint is 150% of the 1993 catch. When CPUE is constant, the CCR model suggested the optimal catch could increase to 37%

[2] Note that this application emphasizes the impact of the profitability objective, rather than the recreational objective, because this application of the model was run to maximize profit under fixed recreational trips.

more than the actual catch for the targeted species. For some species, such as yellowfin, we could harvest 47% more than the actual catch. However, if CPUE declines as effort increases, it is very limited to increase optimal catch for the same species, even though there are 50% more fish in the ocean that not being used. For example, we could only harvest 6% more yellowfin, 3% more of bigeye, 13% more of aku, and 3% more of bottomfish. Among all these species, swordfish is very sensitive to the CPUE decline. The optimal catch of swordfish under the VCR model is almost the same as the actual catch, while under the CCR model optimal swordfish catch could be 44% more than the actual catch. This implies that profit margin of swordfish fishing is very limited under the current CPUE level and that any decline in CPUE (as suggested by VCR model) precludes increases in fishing effort.

Table 4.5. Optimal Harvest Rates Results from VCR and CCR Models

Species	1993 Actual Catch	Stock Constraints (Ratio to 1993 catch)	Optimal Catch/Stock	
			CCR model	VCR model
Targeted Species	***30,997***	***1.50***	***1.37***	***0.99***
Yellowfin	6,162	1.50	1.47	1.06
Bigeye	5,110	1.50	1.38	1.03
Swordfish	9,697	1.50	1.44	1.00
Aku (Skipjack)	3,517	1.50	1.49	1.13
Bottomfish	1,115	1.50	1.37	1.03
Blue marlin	2,689	1.50	1.14	0.79
Mahimahi	1,679	1.50	1.00	0.68
Ono	1,028	1.50	0.90	0.66
Nontargeted Species	**4,111**	**1.50**	**0.92**	**0.70**
Albacore	1,265	1.50	0.89	0.61
Striped marlin	1,758	1.50	1.10	0.85
Shark	154	1.50	0.80	0.68
Other Pelagic	887	1.50	0.63	0.53
All others	47	1.50	1.39	0.97
Total	***66,105***	***1.50***	***1.35***	***0.97***

4.2.3 Tradeoff between Recreational and Commercial Fishing

Allocation of fish resources between recreational and commercial segments has become one of the central issues facing Hawaii fisheries management as discussed earlier. Therefore, this study examines the tradeoffs between the management objectives of the recreational and commercial fishing in Hawaii.

The recreational objective is evaluated by recreational fishing participation as measured by the number of recreational trips, while the commercial objective is evaluated by profit generated from the commercial fleets. The Non-Inferior Set Estimation (NISE) method, developed by Cohon *et al.* (1979), is used to map out the tradeoffs of the two management goals. The detailed procedures of mapping the tradeoff curve were discussed in Pan (1998).

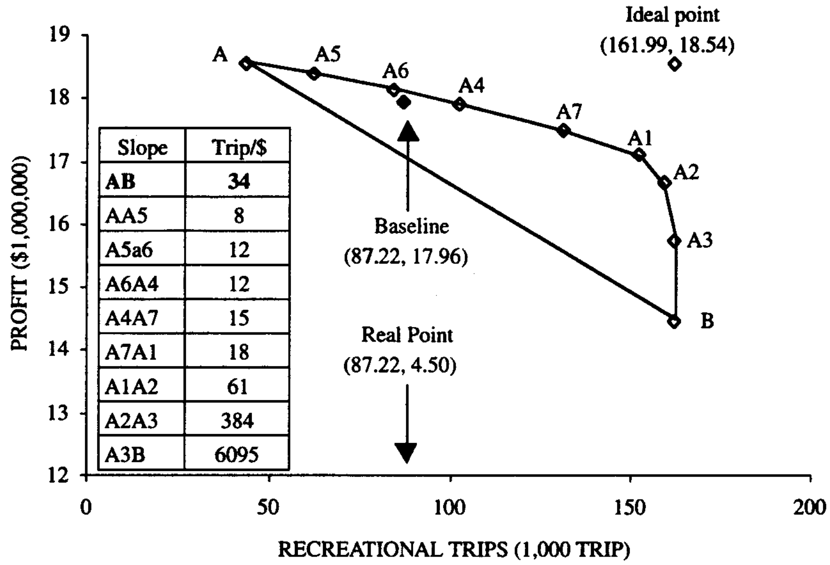
The pay-off matrix for recreational trips and commercial profit of Hawaii fisheries is presented in Table 4.6. The payoff matrix displays the degree of conflict between the two objectives. Maximum commercial profit is $18.54 million, when the number of recreational trips is limited by its lower bound, 43,610 trips. This tradeoff refers to Point A in Figure 4.3a or Figure 4.3b. However, the maximum recreational trips can be as many as 161,990 trips, but to do so, commercial profit drops from $18.54 million to $14.47 million (Point B). Thus, computed from the two extreme points, the average tradeoff of one recreational trip to commercial profit is $34.25. In other words, increasing one recreational trip may lead to a reduction of $34.25 profit in commercial fishing.

Table 4.6. The Payoff Matrix of Recreational and Commercial Fishing

Objective	Commercial Objective (Z_c) $million	Recreational Objective (Z_r) 1,000 trips
Maximize Z_c (Point A)	18.54	43.61
Maximize Z_r (Point B)	14.47	161.99

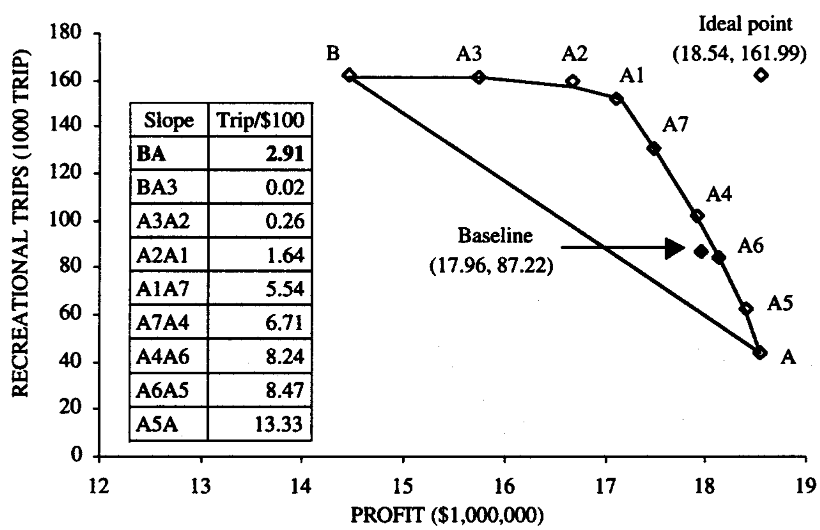
However, the tradeoff curve is not necessarily a straight (linear) line between the two extreme points (AB), because the degree of conflict between the two objectives can vary in different parts of the feasible region. The NISE method employs a weighted objective function to generate the tradeoff curve that represents the set of noninferior solutions toward the ideal point, assuming that the feasible region in the decision space (and therefore the objective space) is a convex set. Figures 4.3a and 4.3b present the tradeoff curve between number of recreational trips and fleetwide profit for the Hawaii fisheries generated by the NISE method. Figure 4.3a illustrates the tradeoff curve in term of recreational trips to commercial profit, while Figure 4.3b illustrates the tradeoff curve in term of commercial profit to recreational trips.

As illustrated in Figure 4.3a, the tradeoff curve in the section between point A to point A1 is flatter than the average tradeoff represented by the segment AB, while another section of the tradeoff curve, segments between point A1 to point B, is steeper than the average tradeoff. This implies the tradeoff between recreational trips to commercial rent in the range from 43,610 trips (Point A) to 152,300 trips (Point A1) is lower than the average tradeoff. In this range, an increase of one recreational trip will cause a commercial profit reduction of $13.16, while the average reduction in profit per recreational trip for the entire tradeoff curve is $34.25. On the other hand, further increases in recreational trips beyond point A1 can cause much higher marginal profit loss. The slope of points A1 and B is -$272.45/trip, which means that on the average, an increase of one recreational trip in the range from 152,300 to 161,990 causes $272.45 in profit reduction. The tradeoffs can be evaluated in terms of the number of trips to one unit of profit (Figure 4.3b). For example, the tradeoff values for the increase of commercial profit to the reduce of number of trips are low in the range Point B to Point A1, where commercial effort is low and recreational effort is high. An increase $100 commercial profit in the range from $14.5 million to $17.0 million will cause less than one trip (0.37) reduce of recreational fishing between Point B and A1. However, an increase $100 commercial profit in the range from $17.0 million to $18.5 million will cause 7.6 recreational trips.



Slope	Trip/$
AB	**34**
AA5	8
A5a6	12
A6A4	12
A4A7	15
A7A1	18
A1A2	61
A2A3	384
A3B	6095

Figure 4.3a The Tradeoff Curve of a Recreational Trip to Commercial Profit



Slope	Trip/$100
BA	**2.91**
BA3	0.02
A3A2	0.26
A2A1	1.64
A1A7	5.54
A7A4	6.71
A4A6	8.24
A6A5	8.47
A5A	13.33

Figure 4.3b The Tradeoff Curve of Commercial Profit to Recreational Trip

The technological interdependence (the interaction on stocks by different fishing operations) between recreational and commercial fishing leads to the various tradeoff values along the tradeoff curve as effort level changes. When fishing effort is low, many fish species are abundant, and then, only a few species face catch competition between the two groups of fishermen. In this situation, an increase of one unit of recreational catch requires a tradeoff of less than one unit of commercial catch. However, when recreational and/or commercial fishing effort increases, more and more species are caught under competition. Then, an increase in recreational catch may require offsetting a greater amount of commercial catch. According to the NISE analysis, when recreational participation falls in the range between 43,610 trips (Point A) to 152,300 trips (Point A1), it only needs to offset 27 pounds of commercial catch for every recreational trip, which yields 47 pounds of fish on average, in the Hawaii fisheries. However, if the number of recreational trips exceeds 152,300 trips and approaches the maximum (Point B), an increase of one recreational trip leads to reduction of about 571 pounds of commercial catch.

Currently, the recreational participation in Hawaii is about 87,220 trips, based on 1993's estimates. This point is located in the range between the points A6 and A4 of the tradeoff curve. At this range, the marginal tradeoff to commercial fishing of one recreational trip, which yields 47 pounds of fish on average, is $12.14 in terms of commercial fishing profit, or 22 pounds in terms of commercial catch. This implies that, in the Hawaii current effort level, the tradeoff to commercial fishing of one recreational trip is less than the average tradeoff.

4.2.4 The Impacts of Area Closure

The area closure regulation was imposed on Hawaii longliners in 1991. The purpose of the area closure is to eliminate the physical gear conflict between the longline fishery and the other fisheries. To investigate the costs of this policy, this study applied the model under two scenarios (the open access and area closure scenarios). The same analyses are conducted using the actual catch figures from 1990, the year before the area closure regime was implemented, and from 1993, the year after the area closure regime was implemented, as the stock constraints, respectively, to estimate the possible range of the cost.

Table 4.7 presents the summaries of these analyses. When the actual catch of 1990 was used as the stock constraint, the optimal commercial profit under area closure scenario is $6.99 million, which is $0.70 million less than the open access scenario, and total optimal catch under area closure scenario is 0.94 million pounds less than the open access scenario. When the actual catch of 1993 was used as stock constraint, the differences in catch and profit between these two scenarios are less than that when the actual catch of 1990 was used as the stock constraint. The commercial profit under area closure scenario is $0.44 million less than the open access, and total catch under area closure scenario is 0.07 million pounds less than the open access.

Table 4.7. The Optimal Profit and Catch under Different Scenarios

Policy Option	1990 Stock		1993 Stock	
	Profit ($million)	Catch (million lbs)	Profit ($million)	Catch (million lbs)
Open Access	7.69	12	18.4	26.42
Area Closure	6.99	11	17.96	26.35
Difference	***-0.70***	***-0.94***	***-0.44***	***-0.07***

Since the actual catch in 1993 after the area closure is greater than the actual catch in 1990 before area closure, and since the pelagic fish are highly migratory, it is unknown whether longline fishermen could catch those fish before they move into the closure areas, or whether these fish could simply pass by the islands with no one able to catch them due to the area closure. Therefore, the loss of $0.70 million profit under area closure based on the 1990 catch as stock constraint can be viewed as the upper bound of commercial loss for reducing gear conflict, while the loss of $0.44 million profit under the area closure resulting based on the 1993 catch as the stock constraint can be viewed as the lower bound of the cost for reducing gear conflict.

5. CONCLUSIONS AND DISCUSSION

5.1 Conclusions

This study has significant potential for the Hawaii fisheries management. The applications of the model suggest that the current model provides a good quantitative tool for the decision-makers of the Hawaii fisheries management. The information obtained is summarized as follows:

- The longline area closure apparently results a decline of profit to the commercial fleets in a range of $0.70 to $0.44 million if the recreational fishing is fixed in the current effort level.
- The tradeoff between recreational and commercial fishing varies by effort level. At the current level, an increase of one recreational trip reduces commercial profit by $12 or reduces commercial catch by 22 pounds. This study suggests that if total recreational trips exceed 152,300 trips (about double of the current levels), the cost of each additional recreational trip in terms of commercial profit would increase dramatically (from $13.16/trip to $272.45/trip).
- The economic efficiency of the Hawaii commercial fisheries could improve if the number of handline vessels increased and longline vessels were more flexible in switching targets since the relative abundance of fish resources affects the choices on optimal fleet mix (fleet structure).

5.2 Potential Uses and Extensions of Current Model

The current model has been applied to several issues associated with fisheries management in Hawaii. This model can also be extended and applied to examine other current issues of concern in Hawaii fisheries management and to evaluate the impact of policy options associated with these issues.

The catch and sale of blue marlin caught by the longliners as bycatch has lately been an issue facing the WPRFM Council. Some recreational and charter boat fishermen have requested the WPRFM Council ban blue marlin sales in Hawaii, presumably by all types of vessels[3]. The Council needs to know the impact of this ban on the longline fishery in order to determine if it should be considered as a regulatory policy. The current model, by setting the price of blue marlin at zero, may be applied to evaluate the economic impact of banning blue marlin sales on the longline fishery and the other fisheries in Hawaii.

The interaction between longline vessels and protected species, initially turtles but more lately seabirds (albatrosses), has been one of the major management problems facing fisheries managers in the WPRFM Council. A number of technical and operational measures, as well as other regulation regimes such as area closure, might be introduced within the Hawaii longline fishery to attempt to reduce or eliminate this incidental mortality of seabirds. However, these measures may lead to the fisheries bearing different degrees of losses, because technical measures may result in an increase in operating costs, operational measures may actually reduce catchability of targeted species, and regulatory regimes such as area closures may reduce total available catch. To assist the decision maker in choosing the suitable or acceptable policy option for the Hawaii longline fishery, the current model can be applied to evaluate the benefits and

[3] The small boat fleet catches approximately 45% of the blue marlin landed in Hawaii.

costs of the longline fishery resulting from these various options by modifying the parameters of CPUE and costs in the model.

5.3 Model Limitations

Like other models, the current model is just a simplification of the real world. Thus, the generated results should be treated as indicative of reality rather than an exact representation of real effects. The results are only as good as the data and the assumptions used in constructing the model. There are several potential areas, such as an alternative to the approximation of bilevel optimization, the consideration of dynamic stock effect, and incorporation of some parameters in the form of stochastic elements, for further development of the model (Pan 1998).

While the next generation of models will improve as our knowledge of the Hawaii fishery increases, it is important to make the current model easily accessible by potential users (the decision makers) and to gain more experience on the working of the model. It is in this spirit that the current model has been implemented as a decision support system to facilitate easy experimentation of the model for policy evaluations (El-Gayar and Ji 1998). This decision support system is developed under Microsoft's Windows environment using GAMS (1996) as the model solver, Microsoft FoxPro as the database manager, and Microsoft Excel as the solution viewer.

Appendix 1. The GAMS Program for the Baseline Model

Part I. The GAMS Program

```
***********************************************************************
*          GAMS Program for the Baseline Model of A Multilevel        *
*                 and Multiobjective Programming Model                *
*       Solver: CONOPT                                                *
***********************************************************************

***************************************
*              Data Section           *
***************************************
$INCLUDE "DATA.INC"

PARAMETERS
W1  weight of the 1nd goal (maximum number of recreational trips)
W2  weight of the 2th goal (maximum profit from commercial fleets)
;
W1 = 0;
W2 = 100;

PARAMETER
AL(L)   parameter for switching between seasons;
AL('001') = 1;
AL('002') = 1;
AL('003') = 1;
AL('004') = 1;

PARAMETER
SL(L)   seasonal distribution of fixed cost;
SL('001') = 90;
SL('002') = 120;
SL('003') = 90;
SL('004') = 60;

PARAMETER
FCS    share of fixed cost in the considered seasons;
FCS = SUM(L,AL(L)*SL(L))/360;

PARAMETER
SCOEFF   stock coefficient;
SCOEFF = 1.0;

***************************************
*         Variables                   *
***************************************

VARIABLES
   GOAL     weighted net revenue and number of recreational boats
   TP       total net revenue from commercial fleet fisheries in $1E6
   TR       total revenue from commercial fleet fisheries in $1E6
   RQ       total catch from recreational fleets (FLEET 1 and 2 and 3)
   RT       the sum of recreational trips (1000 trips)
   P        the sum of profit from commercial fleet fisheries in $1E6
```

Appendix 1. (Continued) The GAMS Program for the Baseline Model

```
TRIP(FLEET,TSPECIES,AREA,SEASON)          # of trips in fleet I targeting
                                          species J in area K during L
VESSEL1(FLEET,TSPECIES,AREA,SEASON)       # of vessels in fleet I
                                          targeting species J in area K
                                          during season L
VESSEL2(FLEET,SEASON)                     # of vessels by season
VESSEL3(FLEET)                            # of vessels (fleet size)
CQ(FLEET,TSPECIES,AREA,SEASON,            catch quantity per trip by
SPECIES)                                  species and area and season
                                          (1000 lbs)
TQ(AREA,SEASON,SPECIES)                   total catch quantity by species
                                          and area and season (1000 lbs)
REVENUE(FLEET,TSPECIES,AREA,SEASON)       revenue per trip ($1000 per
                                          trip)
TNR(FLEET,TSPECIES,AREA,SEASON)           net revenue per trip ($1000 per
                                          trip)
VCRATE(FLEET,TSPECIES,AREA,SEASON,        variable catch rate (lbs per
SPECIES)                                  fishing day)
A(AREA,SEASON,SPECIES)                    catch rate coefficient
                                          (decimal)
CQSR(AREA,SEASON,SPECIES)                 catch quantity saturation ratio
                                          (decimal)
TROFLEET(FLEET)                           revenue for owner ($1000000)
TEROFLEET(FLEET)                          expected revenue for owner
                                          (fixed costs) ($1000000)
NRODIFF(FLEET)                            net revenue for owner after
                                          accounting for fixed cost
                                          ($1000000)
FRCREW(FLEET)                             revenue for crew ($1000000)
EFRCREW(FLEET)                            expected revenue for crew
                                          ($1000000)
NRCDIFF(FLEET)                            over expected revenue for crew
                                          ($1000000)    ;

POSITIVE VARIABLES TRIP, VESSEL1, VESSEL2, VESSEL3 VCRATE, CQ, TQ,
   REVENUE;
POSITIVE VARIABLES TROFLEET, TEROFLEET, FRCREW, EFRCREW;

**************************************
*        Equation Declarations       *
**************************************
EQUATIONS
*     goals
      GOAL1       weighted objective function

*     objective function
      RTRIPS      total recreational trips for Fleet 1 and Fleet 3
      PROFIT      total profit from commercial fleets
```

Appendix 1. (Continued) The GAMS Program for the Baseline Model

```
*   constraints on trips and vessels
TRIPSCI(FLEET,TSPECIES,AREA,SEASON)          constraint on trips for
                                             commercial fleets
TRIPSNCI(FLEET,TSPECIES,AREA,SEASON)         constraint on trips for
                                             recreational fleets
VSEASON(FLEET,SEASON)                        vessels in fleet by seasons
VYEAR(FLEET,SEASON)                          annual vessels in fleet
SCQ(FLEET,TSPECIES,AREA,SEASON,SPECIES)      catch quantity per trip
TCATCH(AREA,SEASON,SPECIES)                  total catch
UPTC(AREA,SEASON,SPECIES)                    upper bound on total catch
TRIPR(FLEET,TSPECIES,AREA,SEASON)            trip revenue
TNREV(FLEET,TSPECIES,AREA,SEASON)            trip net revenue

*   equations for specifying catch rate as a function of total catch
ACRATE(FLEET,TSPECIES,AREA,SEASON,SPECIES)  actual catch rate per day
QTSATUR(AREA,SEASON,SPECIES)                define the total catch
                                            sat. ratio
CRATECOE(AREA,SEASON,SPECIES)               the catch rate coefficient

*   equations for trip entry condition (commercial fleets)
ENTRY1(FLEET,TSPECIES,AREA,SEASON)  trip entry condition for MC<=MR

*   equations for trip entry condition (recreational fleets)
REENTRY1(NCI,J,K,L,S)   trip entry condition for recreational fleet 1
REENTRY2(NCI,J,K,L,S)   trip entry condition for recreational fleet 3

*   equations for owner entry condition
TROWNER(FLEET)    total returns to owner
TEROWNER(FLEET)   total expected returns to owner
ONR(FLEET)        difference between returns and expected returns
OWNER1(FLEET)     owner entry condition

*   equations for crew entry condition
FLRCREW(FLEET)    actual returns to crew for whole fleet
EFLRCREW(FLEET)   expected returns to crew for whole fleet
CRDIFF(FLEET)     difference between the actual and expected returns to
                  crews
CREW1(FLEET)      crew entry condition

*$ONTEXT
* Constraints on rec trips for Fleet 1 and Fleet 3 over four seasons
     RTRIPS1     total recreational trips for Fleet 1
     RTRIPS3     total recreational trips for Fleet 3
* Constraints on recreational trips for Fleets 1 3 over four seasons
     RTRIPS11    minimum recreational trips for Fleet 1 in Season 1
     RTRIPS12    minimum recreational trips for Fleet 1 in Season 2
     RTRIPS13    minimum recreational trips for Fleet 1 in Season 3
     RTRIPS14    minimum recreational trips for Fleet 1 in Season 4
     RTRIPS31    minimum recreational trips for Fleet 3 in Season 1
     RTRIPS32    minimum recreational trips for Fleet 3 in Season 2
     RTRIPS33    minimum recreational trips for Fleet 3 in Season 3
     RTRIPS34    minimum recreational trips for Fleet 3 in Season 4
*$OFFTEXT     ;
```

Appendix 1. (Continued) The GAMS Program for the Baseline Model

```
***************************************
*        Equation  Definitions        *
***************************************
* weighted goal
     GOAL1..
          GOAL =E= W1*TR + W2*P                                        ;
* Objective function
     NETREV..
          TP =E= (SUM((CI,J,K,L)$(FTAEFG(CI,J,K,L) AND AL(L)),
          TNR(CI,J,K,L)*TRIP(CI,J,K,L)) - SUM(CI,
          FCS*FC(CI)*VESSEL3(CI))/1000)/1000  ;
     PROFIT..
          P =E= TP - SUM(CI, EFRCREW(CI))                              ;
     RTRIPS..
          RT =E= SUM((NCI,J,L)$(FTAEFG(NCI,J,'001',L) AND AL(L)),
                 TRIP(NCI,J,'001',L)/1000)                             ;

* Constraints on trips and vessels
TRIPSCI(CI,J,K,L)$(FTAEFG(CI,J,K,L) AND AL(L))..
     TRIP(CI,J,K,L) =L= VESSEL1(CI,J,K,L)*MAXTRIP(CI,J,K,L)            ;
TRIPSNCI(NCI,J,'001',L)$(FTAEFG(NCI,J,'001',L) AND AL(L))..
     TRIP(NCI,J,'001',L) =E=
VESSEL1(NCI,J,'001',L)*MAXTRIP(NCI,J,'001',L)                          ;
VSEASON(I,L)$(FEDT(I,L,'Seasln') AND AL(L))..
     VESSEL2(I,L) =E= SUM((J,K)$FTAEFG(I,J,K,L), VESSEL1(I,J,K,L))     ;
VYEAR(I,L)$(FEDT(I,L,'Seasln') AND AL(L))..
     VESSEL3(I) =G= VESSEL2(I,L)                                       ;

* Catch quantity per trip
SCQ(I,J,K,L,S)$(FTAESFG(I,J,K,L,S) AND AL(L))..
     CQ(I,J,K,L,S) =E= FTAEDT(I,J,K,L,'Fd')*VCRATE(I,J,K,L,S)/1000     ;
* Catch quantity of species S in area K during season L
TCATCH(K,L,S)$(AESDT(K,L,S,'LcStock') AND AL(L))..
     TQ(K,L,S) =E= SUM((I,J)$(FTAESFG(I,J,K,L,S) AND AL(L)),
     CQ(I,J,K,L,S)*TRIP(I,J,K,L))                                      ;
UPTC(K,L,S)$(AESDT(K,L,S,'LcStock') AND AL(L))..
     TQ(K,L,S) =L= (SCOEFF/1.5)*AESDT(K,L,S,'LcStock')/1000            ;

* Net revenue per trip
TRIPR(I,J,K,L)$(FTAEFG(I,J,K,L) AND AL(L))..
     REVENUE(I,J,K,L) =E= SUM(S$(FTAESFG(I,J,K,L,S) AND AL(L)),
     (1-0.1)*CQ(I,J,K,L,S)*FESDT(I,L,S,'P'))
          +  (550$((FLT(I) GT 0.5) AND (TPS(J) GT 0.5))
          +  470$((FLT(I) GT 0.5) AND (TPS(J) LT 0.5)))/1000           ;
TNREV(I,J,K,L)$(FTAEFG(I,J,K,L) AND AL(L))..
     TNR(I,J,K,L) =E= REVENUE(I,J,K,L)-COST(I,J,K,L)/1000              ;

* Equations for specifying catch rate as a function of total catch
ACRATE(I,J,K,L,S)$(FTAESFG(I,J,K,L,S) AND AL(L))..
     VCRATE(I,J,K,L,S) =E= (A(K,L,S)*FTAESDT(I,J,K,L,S,'Catch'))
     $(AESDT(K,L,S,'LcStock') AND AL(L))                               ;
```

```
QTSATUR(K,L,S)$(AESDT(K,L,S,'LcStock') AND AL(L))..
      CQSR(K,L,S)*(SCOEFF/1.5)*AESDT(K,L,S,'LcStock')/1000
      =E= TQ(K,L,S)                                                    ;
CRATECOE(K,L,S)$(AESDT(K,L,S,'LcStock') AND AL(L))..
      A(K,L,S) =E= 1
      - (CQSR(K,L,S))**10                                              ;

* Equations for trip entry condition (commercial fleets)
ENTRY1(CI,J,K,L)$(FTAEFG(CI,J,K,L) AND AL(L))..
      TNR(CI,J,K,L)*TRIP(CI,J,K,L) =G= 0                               ;

* Equations for trip entry condition (recreational fleets)
REENTRY1('001',J,'001',L,S)$(AESDT('001',L,S,'LcStock') AND
      FTAEFG('001',J,'001',L) AND AL(L))(A('001',L,S) -
      0.9)*TRIP('001',J,'001',L) =G= 0                                 ;
   REENTRY2('003',J,K,L,S)$(AESDT(K,L,S,'LcStock') AND
      FTAEFG('003',J,K,L) AND AL(L))(0.51*REVENUE('003',J,'001',L)-
      0.30*COST('003',J,'001',L)/1000)*TRIP('003',J,'001',L) =G= 0     ;

* Equations for owner entry condition
TROWNER(CI)..
      TROFLEET(CI) =E= (SUM((J,K,L)$(FTAEFG(CI,J,K,L) AND AL(L)),
      1-FLTMST(CI,'Cc'))*TNR(CI,J,K,L)*TRIP(CI,J,K,L)))/1000           ;
TEROWNER(CI)..
      TEROFLEET(CI) =E= FCS*FC(CI)*VESSEL3(CI)/1000000                 ;
ONR(CI)..
      NRODIFF(CI) =E= TROFLEET(CI)-TEROFLEET(CI)                       ;
OWNER1(CI)..
      NRODIFF(CI)*VESSEL3(CI) =G= 0                                    ;

* Equations for crew entry condition
FLRCREW(CI)..
      FRCREW(CI) =E= (SUM((J,K,L)$(FTAEFG(CI,J,K,L) AND AL(L)),
      FLTMST(CI,'Cc')*TNR(CI,J,K,L)*TRIP(CI,J,K,L)))/1000              ;
EFLRCREW(CI)..
      EFRCREW(CI) =E= SUM((J,K,L)$(FTAEFG(CI,J,K,L) AND AL(L)),
      FLTMST(CI,'Erc')*(FAEDT(CI,K,L,'Td')
      +FTAEDT(CI,J,K,L,'Fd'))*TRIP(CI,J,K,L))/1000000                  ;
CRDIFF(CI)..
      NRCDIFF(CI) =E= FRCREW(CI)-EFRCREW(CI                            ;
CREW1(CI)..
      NRCDIFF(CI)*VESSEL3(CI) =G= 0                                    ;

*$ONTEXT
*Constraints on annually recreational trips for Fleets 1 and 3
RTRIPS1..
      34.859 =E= SUM((J,L)$(FTAEFG('001',J,'001',L) AND
      AL(L)),TRIP('001',J,'001',L)/1000)                               ;
RTRIPS3..
      52.359 =E= SUM((J,L)$(FTAEFG('003',J,'001',L) AND
      AL(L)),TRIP('003',J,'001',L)/1000)                               ;
```

Appendix 1. (Continued) The GAMS Program for the Baseline Model

```
* Constraints on recreational trips for Fleets 1 and 3 in four seasons
RTRIPS11..
     SUM((J)$(FTAEFG('001',J,'001','001') AND
     AL('001')),TRIP('001',J,'001','001')/1000) =E=  6.381          ;
RTRIPS12..
     SUM((J)$(FTAEFG('001',J,'001','002') AND
     AL('002')),TRIP('001',J,'001','002')/1000) =E= 11.180          ;
RTRIPS13..
     SUM((J)$(FTAEFG('001',J,'001','003') AND
     AL('003')),TRIP('001',J,'001','003')/1000) =E= 12.288          ;
RTRIPS14..
     SUM((J)$(FTAEFG('001',J,'001','004') AND
     AL('004')),TRIP('001',J,'001','004')/1000) =E=  5.010          ;
RTRIPS31..
     SUM((J)$(FTAEFG('003',J,'001','001') AND
     AL('001')),TRIP('003',J,'001','001')/1000) =E= 10.668          ;
RTRIPS32..
     SUM((J)$(FTAEFG('003',J,'001','002') AND
     AL('002')),TRIP('003',J,'001','002')/1000) =E= 14.185          ;
RTRIPS33..
     SUM((J)$(FTAEFG('003',J,'001','003') AND
     AL('003')),TRIP('003',J,'001','003')/1000) =E= 18.550          ;
RTRIPS34..
     SUM((J)$(FTAEFG('003',J,'001','004') AND
     AL('004')),TRIP('003',J,'001','004')/1000) =E=  8.956          ;
*$OFFTEXT

****************************************
*  Lower/Upper Bounds & Fixed Variables  *
****************************************
A.UP(K,L,S) = 1;
CQSR.UP(K,L,S) = 1;

* fixed sizes of fleets 1 and 3
*Vessel2.FX('001',L) = 2000;
*VESSEL2.FX('003',L) = 900;

* exclude the activities of recreational fleets in areas 2 to 5
VESSEL1.FX('001',J,'002',L) = 0;
VESSEL1.FX('001',J,'003',L) = 0;
VESSEL1.FX('001',J,'004',L) = 0;
VESSEL1.FX('001',J,'005',L) = 0;
VESSEL1.FX('003',J,'002',L) = 0;
VESSEL1.FX('003',J,'003',L) = 0;
VESSEL1.FX('003',J,'004',L) = 0;
VESSEL1.FX('003',J,'005',L) = 0;

* exclude the activities of commercial fleets in area 1
*VESSEL1.FX(CI,J,'001',L) = 0;

*$ONTEXT
* area closure ( fleets 6 and 7 and 8 are excluded from areas 1 and 2)
```

Appendix 1. (Continued) The GAMS Program for the Baseline Model

```
EQUATION
     SLLINERS(J,L)  partial area closure for Fleet 6                      ;
     SLLINERS(J,L)..
          VESSEL1('006',J,'001',L) + VESSEL1('006',J,'002',L) =L= 3  ;

VESSEL1.FX('007',J,'001',L) = 0;
TRIP.FX('007',J,'001',L) = 0;
VESSEL1.FX('007',J,'002',L) = 0;
TRIP.FX('007',J,'002',L) = 0;

VESSEL1.FX('008',J,'001',L) = 0;
TRIP.FX('008',J,'001',L) = 0;
VESSEL1.FX('008',J,'002',L) = 0;
TRIP.FX('008',J,'002',L) = 0;
*$OFFTEXT

****************************************
*     Declaration of the 1st Model     *
****************************************
MODEL HFMMA /ALL/;

***************************************
*          Option Definition          *
***************************************
OPTION ITERLIM = 100000;
OPTION RESLIM = 2000000;
OPTION DOMLIM = 1000000;
OPTION LIMROW = 1000;
HFMMA.OPTFILE = 1;
*HFMMA.SCALEOPT = 1;
HFMMA.WORKSPACE = 40.0;

***************************************
*           Initial Values            *
***************************************
VESSEL3.L(CI) = 1;
*A.L(K,L,S) = 0.9;
*TRIP.L(I,J,K,L) = 1;
*VESSEL1.L(I,J,K,L) = 1;
*CQ.L(I,J,K,L,S) = 1;
*TNR.L(I,J,K,L) = 1;
Y.L(CI,J,K,L) = 0;
OWNER.L(CI) = 0;
CREW.L(CI) = 0;

***************************************
*    Solve Statement (the 1st Run)    *
***************************************
SOLVE HFMMA USING NLP MAXIMIZING GOAL;
```

Appendix 1. (Continued) The GAMS Program for the Baseline Model

```
***************************************
*              Result Export          *
***************************************
* Define temporary parameter for eliminating values of TRIP
* when corresponding VESSEL1 is zero;
PARAMETER
TTT(I,J,K,L)    temporary parameter;
TTT(I,J,K,L) = TRIP.L(I,J,K,L);
TRIP.L(I,J,K,L) = TTT(I,J,K,L)$(VESSEL1.L(I,J,K,L)*FTAEFG(I,J,K,L));

FILE RESULTA /HFMM2A.TXT/;
PUT RESULTA;
RESULTA.PC = 5;

$INCLUDE "EXPORT.INC"

$ONTEXT
**************************************
*  Data Preparation for the 2nd Run  *
**************************************
VESSEL2.FX(I,L) = FLOOR(VESSEL2.L(I,L));
VESSEL2.UP(I,L) = FLOOR(VESSEL2.L(I,L));
VESSEL3.UP(I) = SMAX(L,FLOOR(VESSEL2.L(I,L)));

***************************************
*    Solve Statement (the 2nd Run)    *
***************************************
SOLVE HFMMA USING NLP MAXIMIZING GOAL;
***************************************
*              Result Export          *
***************************************
TTT(I,J,K,L) = TRIP.L(I,J,K,L);
TRIP.L(I,J,K,L) = TTT(I,J,K,L)$(VESSEL1.L(I,J,K,L)*FTAEFG(I,J,K,L));

FILE RESULTB /HFMM2B.TXT/;
PUT RESULTB;
RESULTB.PC = 5;

$INCLUDE "EXPORT.INC"
$OFFTEXT
```

Part II. Mathematical Formulations

Objectives:

$$Max\sum_i\sum_j\sum_k\sum_l\sum_s N_{ijkl}E_{ijkl} - \sum_i\sum_j\sum_k\sum_l \omega_i(d^f_{ijkl} + d^t_{ik})E_{ijkl} - \sum_i fc_iV_i$$

$$N_{ijkl} = \sum_s\left(p_{ils}d^f_{ijkl}R_{ijkls}\right) - c_{ijkl} \qquad \text{for } i = 2,\ 4 \text{ to } 9$$

$$Max\sum_i\sum_j\sum_k\sum_l E_{ijkl} \qquad \text{for } i = 1,\ 3$$

Appendix 1. (Continued) The GAMS Program for the Baseline Model

Subject to:

$$E_{ijkl} - \varepsilon_{ijkl} V_{ijkl} \le 0 \qquad (1)$$

$$V_{il} \sum_j \sum_k V_{ijkl} = 0 \qquad (2)$$

$$V_i - V_{il} \ge 0 \qquad (3)$$

$$\sum_i \sum_j d^f_{ijkl} R_{ijkls} E_{ijkl} \le s_{kls} \qquad (4)$$

$$A_{kls} = 1 - \left(\frac{Q_{kls}}{s_{kls}} \right)^{10} = 1 - \left(\frac{\sum_i \sum_j d^f_{ijkl} R_{ijkls} E_{ijkl}}{s_{kls}} \right)^{10} \qquad (5)$$

$$R_{ijkls} = A_{kls} \overline{R}_{ijkls} \qquad (6)$$

$$(A_{kls} - 0.9) E_{ijkl} \ge 0 \qquad i = 1 \qquad (7)$$

$$\left[0.51 \sum_s \left(p_{ils} d^f_{ijkl} R_{ijkls} \right) - 0.3 c_{ijkl} \right] E_{ijkl} \ge 0 \qquad i = 3 \qquad (8)$$

$$N_{ijkl} E_{ijkl} \ge 0 \qquad i = 2,\ 4 \text{ to } 9 \qquad (9)$$

$$\left(\sum_j \sum_k \sum_l (1 - \alpha_i) N_{ijkl} E_{ijkl} - fc_i V_i \right) V_i \ge 0 \qquad i = 2,\ 4 \text{ to } 9 \qquad (10)$$

$$\left(\sum_j \sum_k \sum_l \alpha_i N_{ijkl} E_{ijkl} - \omega_i \left(d^f_{ijkl} + d^t_{ik} \right) E_{ijkl} \right) V_i \ge 0 \qquad (11)$$

Variable indices:

- i = fleet, i = 1, ..., 9;
- j = target species, j = 1, ..., 10;
- k = area, k = 1, ..., 5;
- l = season, l = 1, ..., 4;
- s = species, s = 1, ..., 14

Variables:

- E_{ijkl}: number of trips of fleet i targeting j in area k during season l (trip);
- V_{ijkl}: number of vessels of fleet i targeting j in area k during season l (vessel);
- V_{il}: number of vessels of fleet i during season l (vessel);
- V_i: annual fleet size of fleet i (vessel);
- N_{ijkl}: trip net revenue by fleet i target j in area k during season l ($/trip);
- A_{ils}: CPUE coefficients;
- Q_{ksl}: total catch of species s in area k and season l (lb);
- R_{ijkls}: daily catch per fishing day of species s for fleet i targeting species j in area k during season l (lb/day);

Appendix 1. (Continued) The GAMS Program for the Baseline Model

Parameters:

c_{ijkl}:	trip costs for trip E_{ijkl} ($/trip);
d^f_{ijkl}:	number of fishing days for trip E_{ijkl} (days/trip);
d^t_{ik}:	number of traveling days for trip E_{ijkl} (days/trip);
$d^f_{ijkl} + d^t_{ik}$:	trip length (days at sea) for trip E_{ijkl} (days/trip);
fc_i:	fixed costs, include opportunity costs of investment, depreciation, maintenance, and insurance ($/year);
p_{ils}:	fish price for species *s* caught by fleet *i* during season *l* ($/lb);
s_{kls}:	stock of species *s* in area *k* and season *l* (lb);
ε_{ijkl}:	maximum number of trips for a vessel in fleet *i* target species *j* in area *k* during season *l* (trip/vessel);
α_i:	crew share of net revenue for fleet *i* ;
$(1-\alpha_i)$:	owner share of net revenue for fleet *i*;
ω_i:	expected wage per working day (day at sea) for all crew member of a vessel in fleet *i* ($/day);
$\overline{R}_{ijkls}$:	the max catch per fishing day (lb/day).

Appendix 2. Catch per Fishing Days (CPUE) by Fleet, Area, Target, and Season

Fleet Area	Target	Season	Total	fin	Big-eye	Alba-core	fish	Blue marlin	marlin	Mahi-mahi	Ono	Aku	Shark	Other pelagic	fish	Lob-ster	All others
				Catch per Fishing Day (lb)													
Fleet 1 (Recreational): possible fishing areas are 1 and 2																	
	Mixed	1 Nov-Jan	**51**	8				16	5	10	2	5		2	4		0.2
		2 Feb-May	**31**	4		0.1		4	2	4	5	9	1	1	1		0.1
		3 Jun-Aug	**43**	14				9	2	2	3	10		1	1		
		4 Sept-Oct	**44**	3				23	2	5	2	7		1	2		0.1
	Mixed	1 Nov-Jan															
		2 Feb-May	**23**						17	6							
		3 Jun-Aug	**10**									10					
		4 Sept-Oct	**94**					94									
Fleet 2 (Charter boat): Possible fishing areas are area 1 and 2																	
	Yellowfin	1 Nov-Jan	**96**	79				1	4	5	0.4	6		0.1			
		2 Feb-May	**98**	82				1	4	4	3	4		1			
		3 Jun-Aug	**145**	130				5	2	1	4	2	2	1	0.1		
		4 Sept-Oct	**162**	128						33							
	Blue Marlin	1 Nov-Jan	**114**	2				70	40	1		1		1	0.2		
		2 Feb-May	**111**	1				57	47	2	1	1	0.3	1			
		3 Jun-Aug	**152**	4				115	25	2	2	1		2			0.4
		4 Sept-Oct	**188**					134	28	25	1						
		1 Nov-Jan	**59**	1				3	1	53	1	1		0.2			
		2 Feb-May	**45**	1					1	39	2	2		1			
		3 Jun-Aug	**58**	3						48	5	2		1			
		4 Sept-Oct	**138**					12	3	122		2		0			
	Ono	1 Nov-Jan	**45**							1	43				1		
		2 Feb-May	**38**	0.3	0.1				0.1	4	31	1		1	0.1		
		3 Jun-Aug	**30**	0.2						1	27	1		0.3			0.1
		4 Sept-Oct	**35**								35						
	Aku	1 Nov-Jan	**52**	5					1	1	1	44					
		2 Feb-May	**51**	2					2	2	2	42		0.4			
		3 Jun-Aug	**27**	1							1	26		0.1			
		4 Sept-Oct	**112**	8				12		16		76					
	Bottom-fish	1 Nov-Jan	**17**												17		
		2 Feb-May	**26**								3			0.4	23		0.3
		3 Jun-Aug	**27**							1	2			0.2	23		
		4 Sept-Oct	**87**							7					80		
	Mixed	1 Nov-Jan	**31**									0.1	10	21			0.3
		2 Feb-May	**39**	0.3					2	1	1	0.3	3	33			0.1
		3 Jun-Aug	**53**							1	2	0.2	10	40			
		4 Sept-Oct	**94**										94				
	Yellowfin	1 Nov-Jan	**80**	80													
		2 Feb-May	**341**	236							106						
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Blue Marlin	1 Nov-Jan	**0**														
		2 Feb-May	**87**						79	5		3					
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Mahi	1 Nov-Jan	**191**							130	62						
		2 Feb-May	**16**							16							
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Ono	1 Nov-Jan	**0**														
		2 Feb-May	**221**	8						23	191						
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Aku	1 Nov-Jan	**16**									16					
		2 Feb-May	**73**							27		45					
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Bottom fish	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Mixed	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														

Appendix 2. (Continued) CPUE by Fleet, Area, Target, and Season

Fleet Area	Target	Season	Total	Catch per Fishing Day (lb) fin	Big-eye	Alba-core	fish	Blue	marlin	Mahi-mahi	Ono	Aku	Shark	Other pelagic	fish	Lob-ster	All others
Fleet 3 (Expense): possible fishing areas: Area 1, 2, and 3																	
Area 1	Mixed	1 Nov-Jan	**56**	7	0.1			17	7	6	2	7	0.3	1	8		0.3
		2 Feb-May	**44**	7	0.3	0.1	0.1	4	4	8	9	7	0.1	2	3		0.2
		3 Jun-Aug	**73**	28	0.1	1	0.1	19	1	4	7	9	0.4	1	1		0.1
		4 Sept-Oct	**65**	8	0.2	0.1		29	2	9	4	6	0.1	1	5		0.3
	Mixed	1 Nov-Jan	**91**	5				20	5	34	2	21		3	1		
		2 Feb-May	**62**	1				3	4	34	6	11		1	2		0.2
		3 Jun-Aug	**100**	45				27	2	5	4	16		1	1		
		4 Sept-Oct	**78**	6				19	5	27	4	17		0.1			
Area 3	Mixed	1 Nov-Jan	**118**	114					2	2							
		2 Feb-May	**43**	22	12					9							
		3 Jun-Aug	**0**														
		4 Sept-Oct	**22**	18								2		2			2
Fleet 4 (Commercial handline): possible fishing areas: Area 1, 2, 3, 4, and 5))																	
Area 1	Yellowfin	1 Nov-Jan	**186**	174					1	4	2	5		1			
		2 Feb-May	**262**	240		11	2		0.3	2	5	0.4	0.3	1			0.2
		3 Jun-Aug	**368**	329		32	2	0.1	0.1	2	1	1	1	0.1			0.1
		4 Sept-Oct	**310**	226		76	0.1			4	1	2	0.2	1	0.1		0.3
	Bigeye	1 Nov-Jan	**0**														
		2 Feb-May	**94**			90	1				3						
		3 Jun-Aug	**134**	2	6	121	1		1	1	0.2	1	1				0.4
		4 Sept-Oct	**131**		10	118				2	1						
	Bottom-fish	1 Nov-Jan	**83**											0.1	79		4
		2 Feb-May	**81**											0.3	77		4
		3 Jun-Aug	**120**											0.2	116		4
		4 Sept-Oct	**93**											0.2	89		4
	Mixed	1 Nov-Jan	**55**	9				10	2	14	6	15					
		2 Feb-May	**70**	8		2	0.2	3		15	33	7		3			0.1
		3 Jun-Aug	**73**	4		2		16	1	32	10	6	2	1			0.3
		4 Sept-Oct	**81**	13		1	1	23	1	22	9	8	1	2			0.3
Area 2	Yellowfin	1 Nov-Jan	**0**														
		2 Feb-May	**645**	476		166					3						
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Bigeye	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Bottom-fish	1 Nov-Jan	**0**														
		2 Feb-May	**485**											4	474		7
		3 Jun-Aug	**36**												36		
		4 Sept-Oct	**49**												48		1
	Mixed	1 Nov-Jan	**0**														
		2 Feb-May	**63**							63							
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
Area 3	Yellowfin	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Bigeye	1 Nov-Jan	**1256**	209	987			30		26	4						
		2 Feb-May	**667**	114	540					12	0.4						
		3 Jun-Aug	**981**	159	748			47		6		22					
		4 Sept-Oct	**621**	109	512												
	Bottom-fish	1 Nov-Jan	**138**												137		1
		2 Feb-May	**90**												88		2
		3 Jun-Aug	**160**												158		2
		4 Sept-Oct	**0**														
	Mixed	1 Nov-Jan	**91**	20						28	34	1		8			
		2 Feb-May	**109**	15						19	69	6		1			1
		3 Jun-Aug	**161**					161									
		4 Sept-Oct	**18**									8		5			5
Area 4	Bottom-fish	1 Nov-Jan	**59**												58		1
		2 Feb-May	**328**												325		3
		3 Jun-Aug	**161**												160		2
		4 Sept-Oct	**508**												502		5

Appendix 2. (Continued) CPUE by Fleet, Area, Target, and Season

				Catch per Fishing Day (lb)													
Fleet	Target	Season	Total		Big-	Alba-		Blue		Mahi-	Ono	Aku	Shark	Other		Lob-	All
Area				fin	eye	core	fish		marlin	mahi				pelagic	fish	ster	others
Fleet 4																	
Area 5	Bottom-fish	1 Nov-Jan	**437**												435		2
		2 Feb-May	**0**														
		3 Jun-Aug	**0**														
		4 Sept-Oct	**468**												461		7
Fleet 5 (Commercial trolling; possible fishing area 1, 2, 3, 4, and 5)																	
Area 1	Yellowfin	1 Nov-Jan	**184**	161				4	2	6	5	6		1			
		2 Feb-May	**203**	174				2	3	5	12	5		2	0.3		
		3 Jun-Aug	**198**	180		1		3	1	2	5	6		1			
		4 Sept-Oct	**187**	162				9	0.3	9	2	3		1	0.3		
	Blue Marlin	1 Nov-Jan	**156**	4				116	26	5	1	3	1	1			
		2 Feb-May	**124**	2				63	42	5	3	8		2			
		3 Jun-Aug	**186**	6				161	7	5	3	3	0.2	1	0.1		
		4 Sept-Oct	**183**	3				156	9	10	1	3	0.3	1	0.1		
	Mahimahi	1 Nov-Jan	**121**	9				1	2	101	1	7		0.4			
		2 Feb-May	**115**	2				0.1	2	99	7	5		0.4			
		3 Jun-Aug	**110**	1				4	1	93	7	4		0.2			
		4 Sept-Oct	**133**	4				3	2	118	3	2	0.2	1			0.1
	Ono	1 Nov-Jan	**68**	2					1	3	62			0.4			0.2
		2 Feb-May	**102**	5				0.1	0.1	10	87	1		0.2	0.2		
		3 Jun-Aug	**47**	2		0.1		1	1	3	40	1		0.1			
		4 Sept-Oct	**54**	3						3	46	2		0.3			0.1
	Mixed	1 Nov-Jan	**114**	3				2	3	8	0.4	91	2	5			
		2 Feb-May	**76**	3				0.2	1	6	2	59		5			
		3 Jun-Aug	**92**	3				2	0.1	5	3	70	2	7			
		4 Sept-Oct	**129**	6				6	2	11	1	88	8	8	0.1		0.1
	Yellowfin	1 Nov-Jan	**80**	59						5		16					
		2 Feb-May	**167**	150						17							
		4 Sept-Oct	**371**	11				218	27	116							
	Blue Marlin	1 Nov-Jan	**165**	27				36	74	9	20						
		2 Feb-May	**228**					170	34		6	19					
		3 Jun-Aug	**199**					131	16	45		7					
		4 Sept-Oct	**269**	8	9					233	2	17					
	Mahimahi	1 Nov-Jan	**138**	5						117	12	4					
		2 Feb-May	**159**	5						138	16						
		3 Jun-Aug	**157**							149	3	5					
		4 Sept-Oct	**885**	15						46	824						
	Ono	1 Nov-Jan	**77**								69			8			
		2 Feb-May	**31**							6	21	5					
		3 Jun-Aug	**193**								193						
		4 Sept-Oct	**148**							6		141					
	Mixed	1 Nov-Jan	**34**									20		14			
		2 Feb-May	**224**					13		25		185					
		3 Jun-Aug	**281**	1				18		28	1	232					
		4 Sept-Oct	**361**	2				23		36	2	298					
Area 3	Yellowfin	1 Nov-Jan	**111**	111													
		2 Feb-May	**948**	701						59	150			7	27		5
		3 Jun-Aug	**252**	252													
		4 Sept-Oct	**439**	361				10		62		6					
	Blue marlin	1 Nov-Jan	**0**														
		2 Feb-May	**105**					105									
		3 Jun-Aug	**39**					39									
		4 Sept-Oct	**0**														
	Mahimahi	1 Nov-Jan	**391**							373	4	15					
		2 Feb-May	**0**														
		3 Jun-Aug	**39**							39							
		4 Sept-Oct	**123**							123							
	Ono	1 Nov-Jan	**139**	33						14	93						
		2 Feb-May	**0**														
		3 Jun-Aug	**113**							7	104				2		
		4 Sept-Oct	**414**							8	404	2					
	Mixed	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**11**									9		3			
		4 Sept-Oct	**4**									4					

Appendix 2. (Continued) CPUE by Fleet, Area, Target, and Season

Fleet Area	Target	Season	Total	Catch per Fishing Day (lb): Yellowfin	Bigeye	Albacore	Swordfish	Blue marlin	Striped marlin	Mahimahi	Ono	Aku	Shark	Other pelagic	Bottomfish	Lobster	All others
Fleet 6 (Small Multipurpose0): possible fishing areas: 3,4, and 5 (after area closure)																	
Area 1	Yellowfin	1 Nov-Jan	**0**														
		2 Feb-May	**84**	32	20				27	5							
		3 Jun-Aug	**741**	476		38	27	165	15	5	10			6			
		4 Sept-Oct	**92**	87		4					1						
	Bigeye	1 Nov-Jan	**734**	48	418	14	3	21	147	13	8	1	4	53			5
		2 Feb-May	**876**	101	422	8	4		169	53	2	13		86			17
		3 Jun-Aug	**1622**		486	539			246	6	53	37	14	195			47
		4 Sept-Oct	**1502**	100	532	233	5	44	244	70	15	4		246			11
	Swordfish	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**722**	124	215			318		38	26						1
		4 Sept-Oct	**0**														
	Bottom-fish	1 Nov-Jan	**131**												130		1
		2 Feb-May	**127**												126		1
		3 Jun-Aug	**192**												191		1
		4 Sept-Oct	**146**												145		1
	Lobster	1 Nov-Jan	**70**													70	
		2 Feb-May	**90**													90	
		3 Jun-Aug	**1**													1	
		4 Sept-Oct	**90**													90	
	Mixed	1 Nov-Jan	**416**	36	132	18		46	150	4	2			23			6
		2 Feb-May	**667**	68	29	11	483	16	31	17	3			10			
		3 Jun-Aug	**0**														
		4 Sept-Oct	**11**			3				8							
Area 2	Yellowfin	1 Nov-Jan	**0**														
		2 Feb-May	**427**	64		167			121		8		10	53			5
		3 Jun-Aug	**1229**	504	71	128	142	199	50	9	32	11	10	65			8
	Bigeye	1 Nov-Jan	**1102**	111	586	50	14	46	161	10	11	1	12	94			8
		2 Feb-May	**1286**	198	512	105	35	14	177	39	13	13	11	154			16
		3 Jun-Aug	**943**		387	251	3		143	9	24			94			33
		4 Sept-Oct	**1799**	154	936	131	28	93	192	69	4		8	171			13
	Swordfish	1 Nov-Jan	**1234**	10	44		956	29	141	26	9		7	10			1
		2 Feb-May	**1546**	166	149	151	702	78	189	13	15	0.4	14	68			1
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Bottomfish	1 Nov-Jan	**0**														
		2 Feb-May	**785**											7	777		1
		3 Jun-Aug	**60**												60		
		4 Sept-Oct	**80**												79		2
	Lobster	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Mixed	1 Nov-Jan	**1111**	82	332	160			353	27	10	9	11	112			15
		2 Feb-May	**1048**	35	84	52	643	4	143	16	11		19	40			1
		3 Jun-Aug	**2045**	104	178	245	887	95	161	9	17	12	12	278			48
		4 Sept-Oct	**1261**	71	256		325	212	217	161			12	6			
Area 3	Yellowfin	1 Nov-Jan	**612**	264	123	4	34	47	81	51	1			7			1
		2 Feb-May	**990**	403	342		4		102	25	23			93			
		3 Jun-Aug	**1008**	510	42	149	17	150	43	5	21	5	11	55			2
		4 Sept-Oct	**1033**	363	111	166	1	218	15	21	24	3	11	99			2
	Bigeye	1 Nov-Jan	**1150**	74	645	38	1	38	200	17	13	2	8	113			1
		2 Feb-May	**1162**	117	511	105	11	8	168	33	20	11	8	169			1
		3 Jun-Aug	**1067**	134	294	240	17	71	96	5	43	34	7	124			
		4 Sept-Oct	**752**	169	215	92	1	76	75	28	9	1	3	82			
	Swordfish	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**631**	108	188			278		33	23						1
		4 Sept-Oct	**0**														
	Bottomfish	1 Nov-Jan	**225**												224		2
		2 Feb-May	**147**												144		3
		3 Jun-Aug	**262**												259		3
		4 Sept-Oct	**0**														

Appendix 2. (Continued) CPUE by Fleet, Area, Target, and Season11

Fleet	Target	Season	Total	Catch per Fishing Day (lb)												
					Big-	Alba-		Blue		Mahi-	Ono	Aku	Shark	Other		Lob-	All
Area				fin	eye	core	fish		marlin	mahi				pelagic	fish	ster	others
Fleet 6																	
Area 3	Lobster	1 Nov-Jan	**522**													522	
		2 Feb-May	**522**													522	
		3 Jun-Aug	**522**													522	
		4 Sept-Oct	**522**													522	
	Mixed	1 Nov-Jan	**642**	51	284		217							90			1
		2 Feb-May	**986**	118	409	19	150	48	160	63	10		3	7			1
		3 Jun-Aug	**1250**	909	16	4	25	265	16	4	1		5	4			1
Area 4	Yellowfin	1 Nov-Jan	**1558**	744	266	48	437	6	45		2		7	4			
		2 Feb-May	**0**														
		3 Jun-Aug	**1178**	554	69	72	149	192	16	15	11	2	3	94			2
		4 Sept-Oct	**1234**	409	232	169	14	203	53	52	21	1	3	75			1
	Bigeye	1 Nov-Jan	**929**	60	451	39	4	57	202	8	7	2	6	95			
		2 Feb-May	**1083**	144	518	76	3	13	143	28	27	14	6	112			
		3 Jun-Aug	**1067**	134	294	240	17	71	96	5	43	34	7	124			
		4 Sept-Oct	**752**	169	215	92	1	76	75	28	9	1	3	82			
	Swordfish	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**1391**	62	156		881		269	11				12			
		4 Sept-Oct	**0**														
		1 Nov-Jan	**97**												96		1
		2 Feb-May	**538**												533		5
		3 Jun-Aug	**265**												262		3
		4 Sept-Oct	**829**												824		5
	Lobster	1 Nov-Jan	**522**													522	
		2 Feb-May	**522**													522	
		3 Jun-Aug	**522**													522	
		4 Sept-Oct	**522**													522	
	Mixed	1 Nov-Jan	**719**	20	393	37	218		50								
		2 Feb-May	**965**	110	177	51	533	4	35	23	10		3	19			
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
Area 5	Yellowfin	1 Nov-Jan	**1394**	729	256		406			3							
		2 Feb-May	**0**														
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Bigeye	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Swordfish	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**1041**	63	242		645		80	7			5				
		4 Sept-Oct	**1340**				1340										
		1 Nov-Jan	**716**												712		3
		2 Feb-May	**0**														
		3 Jun-Aug	**0**														
		4 Sept-Oct	**759**												757		2
	Lobster	1 Nov-Jan	**522**													522	
		2 Feb-May	**522**													522	
		3 Jun-Aug	**522**													522	
		4 Sept-Oct	**522**													522	
	Mixed	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														

Appendix 2. (Continued) CPUE by Fleet, Area, Target, and Season11

Fleet Area	Target	Season	Total	Yellowfin	Bigeye	Albacore	Swordfish	Blue marlin	Striped marlin	Mahi-mahi	Ono	Aku	Shark	Other pelagic	Bottomfish	Lobster	All others
				Catch per Fishing Day (lb)													
Fleet 7 (Medium Multipurpose0): possible fishing areas: 3,4, and 5 (after area closure)																	
Area 1	Yellowfin	1 Nov-Jan	**0**														
		2 Feb-May	**84**	32	20				27	5							
		3 Jun-Aug	**741**	476		38	27	165	15	5	10			6			
		4 Sept-Oct	**92**	87		4					1						
	Bigeye	1 Nov-Jan	**734**	48	418	14	3	21	147	13	8	1	4	53			5
		2 Feb-May	**876**	101	422	8	4		169	53	2	13		86			17
		3 Jun-Aug	**1622**		486	539			246	6	53	37	14	195			47
		4 Sept-Oct	**1502**	100	532	233	5	44	244	70	15	4		246			11
	Swordfish	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**722**	124	215			318		38	26						1
		4 Sept-Oct	**0**														
	Lobster	1 Nov-Jan	**70**													70	
		2 Feb-May	**90**													90	
		3 Jun-Aug	**1**													1	
		4 Sept-Oct	**90**													90	
	Mixed	1 Nov-Jan	**416**	36	132	18		46	150	4	2			23			6
		2 Feb-May	**667**	68	29	11	483	16	31	17	3			10			
		3 Jun-Aug	**0**														
		4 Sept-Oct	**11**			3				8							
Area 2	Yellowfin	1 Nov-Jan	**0**														
		2 Feb-May	**427**	64		167			121		8		10	53			5
		3 Jun-Aug	**1229**	504	71	128	142	199	50	9	32	11	10	65			8
		4 Sept-Oct	**0**														
	Bigeye	1 Nov-Jan	**1102**	111	586	50	14	46	161	10	11	1	12	94			8
		3 Jun-Aug	**943**		387	251	3		143	9	24			94			33
		4 Sept-Oct	**1799**	154	936	131	28	93	192	69	4		8	171			13
	Swordfish	1 Nov-Jan	**0**														
		2 Feb-May	**1234**	10	44		956	29	141	26	9		7	10			1
		3 Jun-Aug	**1546**	166	149	151	702	78	189	13	15	0	14	68			1
		4 Sept-Oct	**0**														
	Lobster	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Mixed	1 Nov-Jan	**1111**	82	332	160			353	27	10	9	11	112			15
		2 Feb-May	**1048**	35	84	52	643	4	143	16	11		19	40			1
		3 Jun-Aug	**2045**	104	178	245	887	95	161	9	17	12	12	278			48
		4 Sept-Oct	**1261**	71	256		325	212	217	161			12	6			
Area 3	Yellowfin	1 Nov-Jan	**0**														
		2 Feb-May	**990**	403	342		4		102	25	23			93			
		3 Jun-Aug	**1173**	458	154	120	10	203	45	6	18	6	4	148			1
		4 Sept-Oct	**1696**	890	82	53		123	498	25	12		5	8			1
	Bigeye	1 Nov-Jan	**1280**	105	722	26	3	35	193	14	21	2	35	124			1
		2 Feb-May	**1033**	92	329	136	5	19	190	25	39	3	17	177			1
		3 Jun-Aug	**1043**	80	354	235	13	78	68	9	36	15	7	150			
		4 Sept-Oct	**1072**	56	444	160	8	33	159	47	8	3	7	149			
	Swordfish	1 Nov-Jan	**0**														
		2 Feb-May	**1340**	11	48		1038	32	153	29	10		8	11			1
		3 Jun-Aug	**1502**	161	145	147	682	76	184	12	15	0	14	66			1
		4 Sept-Oct	**0**														
	Lobster	1 Nov-Jan	**522**													522	
		2 Feb-May	**522**													522	
		3 Jun-Aug	**522**													522	
		4 Sept-Oct	**522**													522	
	Mixed	1 Nov-Jan	**1057**	166	555	19	162	16	89	27	1	1	20	2			1
		2 Feb-May	**1113**	107	528	31	252	10	137	25	1	1	14	6			1
		3 Jun-Aug	**1269**	474	105	29	376	162	69	15	13		16	10			1
		4 Sept-Oct	**729**	39	326	4	44	137	94	62			16	7			1

Appendix 2. (Continued) CPUE by Fleet, Area, Target, and Season11

Fleet Area	Target	Season	Total	fin	Big- eye	Alba- core	fish	Blue	marlin	Mahi- mahi	Ono	Aku	Shark	Other pelagic	fish	Lob- ster	All others
				Catch per Fishing Day (lb)													
Fleet 7																	
Area 4	Yellowfin	1 Nov-Jan	**1558**	744	266	48	437	6	45		2		7	4			
		2 Feb-May	**0**														
		3 Jun-Aug	**1178**	554	69	72	149	192	16	15	11	2	3	94			1.5
		4 Sept-Oct	**1234**	409	232	169	14	203	53	52	21	1	3	75			1.0
	Bigeye	1 Nov-Jan	**940**	88	500	43	14	36	135	16	4	4	11	89			
		2 Feb-May	**1166**	120	565	97	4	18	131	26	19	9	17	160			
		3 Jun-Aug	**1043**	80	354	235	13	78	68	9	36	15	7	150			
		4 Sept-Oct	**1072**	56	444	160	8	33	159	47	8	3	7	149			
	Swordfish	1 Nov-Jan	**809**	26	169	137	354	28	46	11	6		7	25			
		2 Feb-May	**1432**	75	148	14	1111	8	53	14	3		5	1			
		3 Jun-Aug	**1366**	77	105	45	938	32	138	10	5	0.2	7	9			
		4 Sept-Oct	**0**														
	Lobster	1 Nov-Jan	**522**													522	
		2 Feb-May	**522**													522	
		3 Jun-Aug	**522**													522	
		4 Sept-Oct	**522**													522	
	Mixed	1 Nov-Jan	**1202**	118	298	160	568	14	28	7	2	0	4	3			
		2 Feb-May	**1619**	100	231	43	1129	5	65	32	4	1	6	3			
		3 Jun-Aug	**1758**	262	415	101	611	92	143	21	12	10	9	83			
		4 Sept-Oct	**695**	61	251	5	122	103	71	74	1		6	3			
	Yellowfin	1 Nov-Jan	**1394**	729	256		406			3							
		2 Feb-May	**0**														
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Swordfish	1 Nov-Jan	**607**	6	64	113	399		15	3			5	2			
		2 Feb-May	**1444**	42	85	2	1281		33				1				
		3 Jun-Aug	**796**	6	92	6	651	2	20	8	0.3		9	2			
		4 Sept-Oct	**1370**	4	20	16	1308	7	8	5	0.4		3				
	Lobster	1 Nov-Jan	**522**													522	
		2 Feb-May	**522**													522	
		3 Jun-Aug	**522**													522	
		4 Sept-Oct	**522**													522	
	Mixed	1 Nov-Jan	**915**	101	163	137	441	11	51	4	1	1	2	6			
		2 Feb-May	**0**														
		3 Jun-Aug	**1939**	26	825		1038	11	23	16							
		4 Sept-Oct	**976**	29	158	17	737	3	17	14							
Fleet 8 (Large longline): possible fishing areas: longline vessle only can go to 3,4, and 5																	
Area 1	Yellowfin	1 Nov-Jan	**0**														
		2 Feb-May	**84**	32	20				27	5							
		3 Jun-Aug	**741**	476		38	27	165	15	5	10			6			
		4 Sept-Oct	**92**	87		4					1						
	Bigeye	1 Nov-Jan	**734**	48	418	14	3	21	147	13	8	1	4	53			5
		2 Feb-May	**876**	101	422	8	4		169	53	2	13		86			17
		3 Jun-Aug	**1622**		486	539			246	6	53	37	14	195			47
		4 Sept-Oct	**1502**	100	532	233	5	44	244	70	15	4		246			11
	Swordfish	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**722**	124	215			318		38	26						1
		4 Sept-Oct	**0**														
	Mixed	1 Nov-Jan	**416**	36	132	18		46	150	4	2			23			6
		2 Feb-May	**667**	68	29	11	483	16	31	17	3			10			
		3 Jun-Aug	**0**														
		4 Sept-Oct	**11**			3				8							

Appendix 2. (Continued) CPUE by Fleet, Area, Target, and Season

Catch per Fishing Day (lb)

Fleet Area	Target	Season	Total	Yellow-fin	Big-eye	Alba-core	Sword-fish	Blue marlin	Striped marlin	Mahi-mahi	Ono	Aku	Shark	Other pelagic	Bottom-fish	Lob-ster	All others
Fleet 7																	
Area 4	Yellowfin	1 Nov-Jan	**1558**	744	266	48	437	6	45		2		7	4			
		2 Feb-May	**0**														
		3 Jun-Aug	**1178**	554	69	72	149	192	16	15	11	2	3	94			1.5
		4 Sept-Oct	**1234**	409	232	169	14	203	53	52	21	1	3	75			1.0
	Bigeye	1 Nov-Jan	**940**	88	500	43	14	36	135	16	4	4	11	89			
		2 Feb-May	**1166**	120	565	97	4	18	131	26	19	9	17	160			
		3 Jun-Aug	**1043**	80	354	235	13	78	68	9	36	15	7	150			
		4 Sept-Oct	**1072**	56	444	160	8	33	159	47	8	3	7	149			
	Swordfish	1 Nov-Jan	**809**	26	169	137	354	28	46	11	6		7	25			
		2 Feb-May	**1432**	75	148	14	1111	8	53	14	3		5	1			
		3 Jun-Aug	**1366**	77	105	45	938	32	138	10	5	0.2	7	9			
		4 Sept-Oct	**0**														
	Lobster	1 Nov-Jan	**522**													522	
		2 Feb-May	**522**													522	
		3 Jun-Aug	**522**													522	
		4 Sept-Oct	**522**													522	
	Mixed	1 Nov-Jan	**1202**	118	298	160	568	14	28	7	2	0	4	3			
		2 Feb-May	**1619**	100	231	43	1129	5	65	32	4	1	6	3			
		3 Jun-Aug	**1758**	262	415	101	611	92	143	21	12	10	9	83			
		4 Sept-Oct	**695**	61	251	5	122	103	71	74	1		6	3			
Area 5	Yellowfin	1 Nov-Jan	**1394**	729	256		406			3							
		2 Feb-May	**0**														
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Bigeye	1 Nov-Jan	**670**	34	157	107	261	14	41	2			6	49			
		2 Feb-May	**0**														
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Swordfish	1 Nov-Jan	**607**	6	64	113	399		15	3			5	2			
		2 Feb-May	**1444**	42	85	2	1281		33				1				
		3 Jun-Aug	**796**	6	92	6	651	2	20	8	0.3		9	2			
		4 Sept-Oct	**1370**	4	20	16	1308	7	8	5	0.4		3				
	Lobster	1 Nov-Jan	**522**													522	
		2 Feb-May	**522**													522	
		3 Jun-Aug	**522**													522	
		4 Sept-Oct	**522**													522	
	Mixed	1 Nov-Jan	**915**	101	163	137	441	11	51	4	1	1	2	6			
		2 Feb-May	**0**														
		3 Jun-Aug	**1939**	26	825		1038	11	23	16							
		4 Sept-Oct	**976**	29	158	17	737	3	17	14							
Fleet 8 (Large Multipurpose): possible fishing areas: 3,4, and 5 (after area closure)																	
Area 1	Yellowfin	1 Nov-Jan	**0**														
		2 Feb-May	**84**	32	20				27	5							
		3 Jun-Aug	**741**	476		38	27	165	15	5	10			6			
		4 Sept-Oct	**92**	87		4					1						
	Bigeye	1 Nov-Jan	**734**	48	418	14	3	21	147	13	8	1	4	53			5
		2 Feb-May	**876**	101	422	8	4		169	53	2	13		86			17
		3 Jun-Aug	**1622**		486	539			246	6	53	37	14	195			47
		4 Sept-Oct	**1502**	100	532	233	5	44	244	70	15	4		246			11
	Swordfish	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**722**	124	215			318		38	26						1
		4 Sept-Oct	**0**														
	Mixed	1 Nov-Jan	**416**	36	132	18		46	150	4	2			23			6
		2 Feb-May	**667**	68	29	11	483	16	31	17	3			10			
		3 Jun-Aug	**0**														
		4 Sept-Oct	**11**			3				8							
Area 2	Yellowfin	1 Nov-Jan	**0**														
		2 Feb-May	**427**	64		167			121		8		10	53			5
		3 Jun-Aug	**1229**	504	71	128	142	199	50	9	32	11	10	65			8
		4 Sept-Oct	**0**														

Appendix 2. (Continued) CPUE by Fleet, Area, Target, and Season

Fleet Area	Target	Season	Total	Catch per Fishing Day (lb) fin	Big- eye	Alba- core	fish	Blue	marlin	Mahi- mahi	Ono	Aku	Shark	Other pelagic	fish	Lob- ster	All others
Fleet 8																	
Area 2	Bigeye	1 Nov-Jan	**1102**	111	586	50	14	46	161	10	11	1	12	94			8
		2 Feb-May	**1286**	198	512	105	35	14	177	39	13	13	11	154			16
		3 Jun-Aug	**943**		387	251	3		143	9	24			94			33
		4 Sept-Oct	**1799**	154	936	131	28	93	192	69	4		8	171			13
	Swordfish	1 Nov-Jan	**0**														
		2 Feb-May	**1234**	10	44		956	29	141	26	9		7	10			1
		3 Jun-Aug	**1546**	166	149	151	702	78	189	13	15	0.4	14	68			1
		4 Sept-Oct	**0**														
	Mixed	1 Nov-Jan	**1111**	82	332	160			353	27	10	9	11	112			15
		2 Feb-May	**1048**	35	84	52	643	4	143	16	11		19	40			1
		3 Jun-Aug	**2045**	104	178	245	887	95	161	9	17	12	12	278			48
		4 Sept-Oct	**1261**	71	256		325	212	217	161			12	6			
Area 3	Yellowfin	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**0**														
		4 Sept-Oct	**1023**	246	190	56	4	321	91	19	5	0.3	10	81			1
	Bigeye	1 Nov-Jan	**1125**	158	658	12	6	77	119	50	2		10	33			1
		2 Feb-May	**987**	144	380	72		12	171	23	29	9		146			1
		3 Jun-Aug	**0**														
		4 Sept-Oct	**0**														
	Swordfish	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**1367**	21	113	24	1039	19	113	26			11				1
		4 Sept-Oct	**0**														
	Mixed	1 Nov-Jan	**0**														
		2 Feb-May	**0**														
		3 Jun-Aug	**1292**	52	255	13	734	15	205	8	6			3			1
Area 4	Yellowfin	1 Nov-Jan															
		2 Feb-May															
		3 Jun-Aug															
		4 Sept-Oct	**955**	230	163	66	5	247	131	47	1		2	62			
	Bigeye	1 Nov-Jan	**1251**		830	18	5		299	9	36	2	19	33			
		2 Feb-May	**1218**	94	298	147	382	38	120	19	47	5	4	63			
		3 Jun-Aug															
		4 Sept-Oct															
	Swordfish	1 Nov-Jan	**1099**	33	241	91	712	1	10	1	1		8	1			
		2 Feb-May	**1746**	79	147	14	1436	4	37	17	3	0.1	5	3			
		3 Jun-Aug	**1215**	59	241	17	763	22	73	32	2	0.3	3	3			
		4 Sept-Oct	**440**	19	168		94	41	42	57			17	2			
	Mixed	1 Nov-Jan	**1118**	55	324	44	668	6	13	2	0.2		5	1			
		2 Feb-May	**1980**	88	252	32	1548	3	40	9	2		5	1			
		3 Jun-Aug	**2022**	58	703	14	1054	42	117	24	3		3	4			
		4 Sept-Oct	**867**	71	421	9	119	114	56	61	2		9	6			
	Bigeye	1 Nov-Jan															
		2 Feb-May															
		3 Jun-Aug															
		4 Sept-Oct															
	Swordfish	1 Nov-Jan	**1179**	35	128	159	819		22	1	0.2		9	5			
		2 Feb-May	**1323**	30	189	15	1068		14	4		0.2	4				
		3 Jun-Aug	**1079**	25	116	1	844	20	31	31	2		8	3			
		4 Sept-Oct	**1832**	7	26	41	1753		4	0			1	0.2			
	Mixed	1 Nov-Jan	**1151**	52	210	199	644	6	30	6	1		2	1			
		2 Feb-May															
		3 Jun-Aug	**1516**	35	639	4	681	84	41	26	1		4	2			
		4 Sept-Oct	**1108**	50	354	92	392	139	49	24	1		4	5			
Fleet 9 (Aku boat): possible fishing areas: 1, and 2.																	
Area 1	Aku	1 Nov-Jan	**1823**	18								1806					
		2 Feb-May	**824**	26						6		792					
		3 Jun-Aug	**2258**	18								2224		16			
		4 Sept-Oct	**2374**	1						0.3		2369		4			
Area 2	Aku	1 Nov-Jan	**3091**							6		3085					
		2 Feb-May	**1168**									1169					
		3 Jun-Aug	**2612**									2612					
		4 Sept-Oct	**3638**	1						11		3627					

Appendix 3. Fish Prices by Fleet, Season, Species

Fleet Season	Yellow-fin ($)	Big-eye ($)	Alba-core ($)	Sword-fish ($)	Blue marlin ($)	Striped marlin ($)	Mahi-mahi ($)	Ono ($)	Aku ($)	Shark ($)	Other pelagic ($)	Bottom-fish ($)	Lob-ster ($)	All other ($)
Fleet 1 (Recreational)														
1 Nov-Jan	2.21	2.37	1.35	1.63	1.00	1.31	2.53	3.51	1.67	0.82	1.36	3.57	5.13	2.23
2 Feb-May	2.27	2.21	1.68	2.31	1.37	1.50	2.37	2.23	2.05	1.00	1.34	3.44	4.20	2.47
3 Jun-Aug	1.85	1.86	1.02	2.11	0.88	1.08	2.76	2.36	1.47	0.77	1.17	3.37	6.59	2.59
4 Sept-Oct	2.54	1.68	1.17	2.00	1.01	1.31	2.35	3.07	1.40	1.10	1.41	3.16	5.29	2.10
Fleet 2 (Charter boat)														
1 Nov-Jan	2.56	3.35	1.35	1.00	1.01	1.37	2.55	3.48	1.84	1.04	1.36	3.45	5.13	1.48
2 Feb-May	2.29	2.76	1.09	2.56	1.07	1.30	2.38	2.29	2.12	0.80	1.29	3.37	4.20	2.50
3 Jun-Aug	1.71	2.13	1.13	1.59	0.87	0.97	2.94	2.07	1.44	0.83	1.11	2.70	6.59	2.05
4 Sept-Oct	2.72	1.68	1.23	2.00	1.18	1.06	2.27	3.10	1.55	1.10	1.45	3.68	5.29	2.10
Fleet 3 (Expence)														
1 Nov-Jan	1.99	2.04	1.02	1.63	0.92	1.25	2.48	3.53	1.73	0.71	1.34	4.00	5.13	2.79
2 Feb-May	2.12	1.85	1.70	2.15	1.24	1.45	2.36	2.22	1.89	1.25	1.37	4.01	4.20	2.94
3 Jun-Aug	1.80	1.29	0.96	2.45	0.85	1.11	2.72	2.35	1.41	0.49	1.10	3.50	6.59	2.60
4 Sept-Oct	2.28	2.08	1.06	2.00	0.85	1.26	2.33	3.00	1.33	1.10	1.41	3.53	5.29	2.68
Fleet 4 (Commercial Handline)														
1 Nov-Jan	1.96	1.82	1.35	2.25	0.98	1.32	2.68	3.31	1.44	0.71	1.35	4.58	5.13	2.99
2 Feb-May	2.29	2.01	1.38	2.22	1.81	1.65	2.40	2.12	2.03	0.96	1.45	4.50	4.20	2.95
4 Sept-Oct	2.68	1.28	1.22	2.00	0.96	1.50	2.37	3.09	1.37	1.20	1.36	3.99	5.29	2.66
Fleet 5 (Commercial Trolling)														
1 Nov-Jan	2.33	2.26	3.00	1.63	1.09	1.30	2.42	3.71	1.68	0.82	1.39	2.25	5.13	1.67
2 Feb-May	2.38	2.21	2.55	2.31	1.36	1.59	2.35	2.28	2.15	1.00	1.26	1.88	4.20	1.50
3 Jun-Aug	1.97	1.86	0.96	2.11	1.01	1.33	2.94	2.63	1.56	1.00	1.26	2.31	6.59	1.38
4 Sept-Oct	2.46	1.68	1.17	2.00	1.05	1.42	2.44	3.08	1.34	1.00	1.42	1.45	5.29	0.97
Fleet 6 (Small multipurpose)														
1 Nov-Jan	3.10	3.56	1.42	2.28	1.16	1.25	1.61	2.96	1.17	0.88	1.02	3.55	5.13	1.62
2 Feb-May	2.96	3.63	1.82	2.87	1.66	1.57	1.69	2.04	1.29	1.22	1.08	3.00	4.20	1.21
3 Jun-Aug	2.48	3.03	1.15	3.18	0.96	1.13	2.48	2.21	0.86	0.78	1.11	3.29	6.59	1.35
4 Sept-Oct	3.06	3.63	1.58	2.25	0.78	1.37	1.82	2.35	0.78	0.87	1.12	2.89	5.29	1.97
Fleet 7 (Medium multipurpose)														
1 Nov-Jan	2.99	4.62	1.45	2.95	0.92	1.32	1.48	2.69	1.13	1.01	0.97	3.55	5.13	1.62
2 Feb-May	3.05	3.49	1.36	2.81	1.37	1.51	1.44	1.73	1.11	1.14	0.98	3.00	4.20	1.21
3 Jun-Aug	2.34	2.87	1.00	3.29	0.91	0.94	2.33	1.60	0.88	0.66	0.82	3.29	6.59	1.35
4 Sept-Oct	2.95	3.78	1.33	2.30	0.75	1.10	1.53	2.25	0.90	0.87	1.06	2.89	5.29	1.97
Fleet 8 (Large multipurpose)														
1 Nov-Jan	2.84	6.69	1.00	3.07	1.02	1.33	1.02	2.46	1.50	0.74	0.95	3.55	5.13	1.62
2 Feb-May	2.94	3.49	1.18	3.08	1.39	1.57	1.16	1.58	1.01	0.99	0.95	3.00	4.20	1.21
3 Jun-Aug	1.92	2.63	0.78	3.26	0.86	0.89	1.54	0.89	0.75	0.79	0.74	3.29	6.59	1.35
4 Sept-Oct	2.75	4.54	0.95	2.36	0.63	1.25	1.18	1.49	0.50	0.84	0.86	2.89	5.29	1.97
Fleet 9 (Aku boat)														
1 Nov-Jan	1.68	2.37	1.35	1.63	1.00	1.31	1.88	3.51	1.62	0.82	1.36	3.57	5.13	2.23
2 Feb-May	1.41	2.21	1.68	2.31	1.37	1.50	1.60	2.23	2.12	1.00	1.34	3.44	4.20	2.47
3 Jun-Aug	0.97	1.86	1.02	2.11	0.88	1.08	2.76	2.36	1.20	0.77	0.91	3.37	6.59	2.59
4 Sept-Oct	0.95	1.68	1.17	2.00	1.01	1.31	1.69	3.07	0.86	1.10	1.08	3.16	5.29	2.10

Appendix 4. Estimated Actual Catch 1993 by Species, Area, and Season

Total = **35.1** millions

SPECIES	AREA (nmi)	SEASON Nov-Jan 1	Feb-May 2	Jun-Aug 3	Sept-Oct 4	TOTAL BY AREA Amount	%
Yellowfin	1 <=20	379,386	774,816	2,950,345	470,656	*4,575,203*	0.74
	2 21-75	17,379	28,680	30,454	3,303	*79,815*	0.01
	3 76-200	164,627	147,555	246,711	92,350	*651,243*	0.11
	4 201-900	96,482	455,969	184,389	49,319	*786,159*	0.13
	5 >900	33,881	10,272	17,013	8,553	*69,720*	0.01
	Subtotal	*691,755*	*1,417,293*	*3,428,911*	*624,181*	*6,162,140*	
		0.11	0.23	0.56	0.10	*1*	
Bigeye	1 <=20	66,499	18,453	7,243	14,295	*106,491*	0.02
	2 21-75	84,190	47,680	8,789	14,065	*154,725*	0.03
	3 76-200	862,471	589,955	176,065	141,437	*1,769,929*	0.35
	4 201-900	502,737	1,304,327	763,127	150,105	*2,720,296*	0.53
	5 >900	134,017	39,697	138,961	45,620	*358,295*	0.07
	Subtotal	*1,649,914*	*2,000,113*	*1,094,185*	*365,523*	*5,109,735*	
		0.32	0.39	0.21	0.07	*1*	
Albacore	1 <=20	2,651	27,795	230,591	101,854	*362,891*	0.29
	2 21-75	7,943	14,356	10,657	1,704	*34,661*	0.03
	3 76-200	27,654	71,765	71,217	17,129	*187,765*	0.15
	4 201-900	109,937	207,829	153,091	36,643	*507,500*	0.40
	5 >900	138,675	3,048	1,638	28,155	*171,516*	0.14
	Subtotal	*286,861*	*324,792*	*467,194*	*185,485*	*1,264,332*	
		0.23	0.26	0.37	0.15	1	
Swordfish	1 <=20	391	17,565	11,679	385	*30,021*	0.00
	2 21-75	1,919	23,394	18,394	2,762	*46,469*	0.00
	3 76-200	25,701	79,618	168,147	3,529	*276,995*	0.03
	4 201-900	596,190	4,847,388	1,462,861	19,888	*6,926,327*	0.71
	5 >900	566,782	313,777	590,178	946,035	*2,416,772*	0.25
	Subtotal	*1,190,983*	*5,281,741*	*2,251,260*	*972,600*	*9,696,585*	
		0.12	0.54	0.23	0.10	*1*	
Blue marlin	1 <=20	520,489	289,795	777,814	623,091	*2,211,189*	0.82
	2 21-75	10,127	2,557	15,909	12,803	*41,396*	0.02
	3 76-200	38,141	13,597	92,294	49,060	*193,091*	0.07
	4 201-900	25,670	36,055	98,162	51,773	*211,661*	0.08
	5 >900	2,962	-	16,237	12,998	*32,197*	0.01
	Subtotal	*597,389*	*342,003*	*1,000,415*	*749,725*	*2,689,533*	
		0.22	0.13	0.37	0.28	*1*	
Striped marlin	1 <=20	202,031	242,777	82,298	54,624	*581,730*	0.33
	2 21-75	25,325	26,540	6,343	4,882	*63,090*	0.04
	3 76-200	145,685	139,754	48,277	15,204	*348,921*	0.20
	4 201-900	103,529	315,322	234,401	50,419	*703,672*	0.40
	5 >900	22,783	5,113	23,323	9,412	*60,631*	0.03
	Subtotal	*499,355*	*729,505*	*394,643*	*134,541*	*1,758,044*	
		0.28	0.41	0.22	0.08	*1*	
Mahimahi	1 <=20	275,733	459,576	259,077	342,717	*1,337,103*	0.80
	2 21-75	15,599	17,637	10,423	16,331	*59,990*	0.04
	3 76-200	33,773	34,244	6,802	13,275	*88,095*	0.05
	4 201-900	8,733	89,980	43,970	24,047	*166,730*	0.10
	5 >900	2,697	837	18,363	4,867	*26,765*	0.02
	Subtotal	*336,536*	*602,275*	*338,635*	*401,237*	*1,678,683*	
		0.20	0.36	0.20	0.24	*1*	

Appendix 4. (Continued) Estimated Actual Catch 1993 by Species, Area, and Season

SPECIES	AREA (nmi)	SEASON Nov-Jan 1	Feb-May 2	Jun-Aug 3	Sept-Oct 4	TOTAL BY AREA Amount (lb)	%
Ono	1 <=20	70,403	436,860	282,065	74,703	*864,031*	0.84
	2 21-75	4,724	8,005	3,579	1,137	*17,445*	0.02
	3 76-200	15,439	26,348	11,942	18,895	*72,623*	0.07
	4 201-900	4,227	40,649	24,763	2,689	*72,328*	0.07
	5 >900	349	-	863	175	*1,387*	0.00
	Subtotal	*95,143*	*511,862*	*323,211*	*97,598*	*1,027,814*	
		0.09	0.50	0.31	0.09	*1*	
Aku	1 <=20	437,749	479,783	886,429	518,991	*2,322,951*	0.66
	2 21-75	203,486	37,435	321,418	591,053	*1,153,391*	0.33
	3 76-200	1,413	6,242	5,384	543	*13,583*	0.00
	4 201-900	985	14,369	11,298	612	*27,264*	0.01
	5 >900	72	47	-	-	*119*	0.00
	Subtotal	*643,705*	*537,875*	*1,224,529*	*1,111,199*	*3,517,307*	
		0.18	0.15	0.35	0.32	*1*	
Shark	1 <=20	7,900	14,057	17,635	7,285	*46,877*	0.30
	2 21-75	1,728	1,695	547	197	*4,168*	0.03
	3 76-200	15,393	8,285	4,970	2,548	*31,196*	0.20
	4 201-900	10,255	33,010	11,436	3,290	*57,991*	0.38
	5 >900	5,221	1,041	6,199	1,627	*14,087*	0.09
		0.26	0.38	0.26	0.10	*1*	
Other pelagic	1 <=20	43,493	87,572	66,231	25,397	*222,693*	0.25
	2 21-75	14,115	15,675	7,562	2,279	*39,630*	0.04
	3 76-200	82,633	105,137	67,725	20,920	*276,415*	0.31
	4 201-900	41,487	183,279	79,280	35,546	*339,592*	0.38
	5 >900	5,754	-	2,028	571	*8,353*	0.01
	Subtotal	*187,482*	*391,662*	*222,826*	*84,713*	*886,683*	
		0.21	0.44	0.25	0.10	*1*	
Bottomfish	1 <=20	276,275	170,024	150,297	163,290	*759,886*	0.68
	2 21-75	87	4,336	392	383	*5,198*	0.00
	3 76-200	9,006	12,417	3,524	-	*24,947*	0.02
	4 201-900	41,386	55,317	27,159	85,400	*209,262*	0.19
	5 >900	67,786	-	-	47,987	*115,773*	0.10
	Subtotal	*394,540*	*242,093*	*181,372*	*297,061*	*1,115,066*	
		0.35	0.22	0.16	0.27	*1*	
Lobster	1 <=20	-	-	-	-	-	
	2 21-75	-	-	-	-	-	
	3 76-200	-	-	-	-	-	
	4 201-900	-	-	-	-	-	
	5 >900	-	-	-	-	-	
	Subtotal	-	-	-	-	-	
All others	1 <=20	13,195	10,237	7,267	8,493	*39,193*	0.83
	2 21-75	1,171	1,611	1,289	181	*4,253*	0.09
	3 76-200	66	377	42	60	*545*	0.01
	4 201-900	505	515	265	923	*2,209*	0.05
	5 >900	307	-	-	720	*1,027*	0.02
	Subtotal	*15,245*	*12,741*	*8,864*	*10,378*	*47,227*	
		0.32	*0.27*	*0.19*	*0.22*	*1*	

Appendix 5. Estimated Actual Catch 1990 by Species, Area, and Season

Total = 22.5 millions

SPECIES	AREA (nmi)	SEASON Nov-Jan 1	Feb-May 2	Jun-Aug 3	Sept-Oct 4	TOTAL BY AREA Amount	%
Yellowfin	1 <=20	594,831	1,659,998	2,407,614	574,759	5,237,202	0.77
	2 21-75	110,619	161,064	491,905	195,607	959,195	0.14
	3 76-200	73,418	12,285	103,112	46,991	235,807	0.03
	4 201-900	78,948	44,869	100,777	126,021	350,615	0.05
	5 >900	1,771	-	-	-	1,771	0.00
		859,587	1,878,217	3,103,408	943,378	6,784,590	
		0.13	0.28	0.46	0.14	1	
Bigeye	1 <=20	116,718	125,829	30,867	29,315	302,729	0.14
	2 21-75	422,634	298,384	105,303	134,707	961,029	0.44
	3 76-200	239,492	45,986	57,395	132,847	475,720	0.22
	4 201-900	209,021	33,201	49,975	116,999	409,196	0.19
	5 >900	12,970	-	-	-	12,970	0.01
		1,000,835	503,401	243,539	413,869	2,161,643	
		0.46	0.23	0.11	0.19	1	
Albacore	1 <=20	8,559	15,121	75,165	16,196	115,041	0.36
	2 21-75	26,058	29,197	42,412	14,331	111,999	0.35
	3 76-200	9,762	3,597	13,939	11,453	38,750	0.12
	4 201-900	17,933	6,881	6,607	19,873	51,293	0.16
	5 >900	-	-	-	-	-	0.00
		62,312	54,796	138,122	61,853	317,083	
Swordfish	1 <=20	10,736	122,229	187,347	4,789	325,102	0.18
	2 21-75	42,616	402,423	371,487	17,271	833,798	0.47
	3 76-200	25,023	26,944	168,084	10,334	230,385	0.13
	4 201-900	41,239	126,475	151,275	32,380	351,368	0.20
	5 >900	43,809	-	-	-	43,809	0.02
		163,423	678,071	878,193	64,775	1,784,463	
		0.09	0.38	0.49	0.04	1	
Blue marlin	1 <=20	337,088	744,787	844,351	347,163	2,273,390	0.80
	2 21-75	35,738	74,228	131,695	115,524	357,185	0.13
	3 76-200	8,780	3,022	33,498	38,041	83,341	0.03
	4 201-900	9,289	2,868	50,777	56,010	118,944	0.04
	5 >900	-	-	-	-	-	0.00
		390,895	824,905	1,060,322	556,738	2,832,860	
		0.14	0.29	0.37	0.20	1	
Striped marlin	1 <=20	160,414	239,105	141,353	18,682	559,554	0.53
	2 21-75	102,261	137,881	65,356	16,227	321,725	0.31
	3 76-200	41,433	13,651	14,479	14,757	84,320	0.08
	4 201-900	29,101	16,053	18,379	20,314	83,847	0.08
	5 >900	1,516	-	-	-	1,516	0.00
		334,726	406,690	239,566	69,980	1,050,962	
		0.32	0.39	0.23	0.07	1	
Mahimahi	1 <=20	371,711	633,997	233,371	339,434	1,578,513	0.80
	2 21-75	137,522	75,733	23,503	57,858	294,617	0.15
	3 76-200	19,635	1,872	3,988	12,947	38,442	0.02
	4 201-900	21,519	2,299	6,409	29,858	60,085	0.03
	5 >900	2,355	-	-	707	3,062	0.00
		552,743	713,901	267,272	440,803	1,974,719	
		0.28	0.36	0.14	0.22	1	

Appendix 5. (Continued) Estimated Actual Catch 1990 by Species, Area, and Season

SPECIES	AREA (nmi)	SEASON Nov-Jan 1	Feb-May 2	Jun-Aug 3	Sept-Oct 4	TOTAL BY AREA Amount (lb)	%
Ono	1 <=20	50,651	246,367	381,097	98,851	*776,967*	0.91
	2 21-75	6,628	11,569	18,511	6,269	*42,978*	0.05
	3 76-200	2,987	273	2,879	3,735	*9,875*	0.01
	4 201-900	2,789	6,445	6,517	5,645	*21,396*	0.03
	5 >900	-	-	-	430	*430*	0.00
		63,055	*264,655*	*409,005*	*114,931*	*851,646*	
		0.07	0.31	0.48	0.13	*1*	
Aku	1 <=20	490,513	552,652	789,949	181,958	*2,015,073*	0.88
	2 21-75	2,979	71,257	196,598	7,362	*278,196*	0.12
	3 76-200	1,208	-	146	84	*1,438*	0.00
	4 201-900	259	566	-	-	*825*	0.00
	5 >900	-	-	-	-	-	0.00
		494,959	*624,475*	*986,693*	*189,404*	*2,295,531*	
		0.22	0.27	0.43	0.08	*1*	
Shark	1 <=20	19,033	37,025	16,263	13,549	*85,871*	0.57
	2 21-75	12,138	9,299	4,677	4,190	*30,305*	0.20
	3 76-200	4,833	299	2,989	1,906	*10,027*	0.07
	4 201-900	6,021	1,358	4,143	10,862	*22,384*	0.15
	5 >900	2,458	-	-	-	*2,458*	0.02
		0.29	0.32	0.19	0.20	*1*	
Other pelagic	1 <=20	64,555	123,150	69,574	32,366	*289,645*	0.56
	2 21-75	43,321	54,840	19,651	23,223	*141,036*	0.27
	3 76-200	20,531	5,698	9,863	12,567	*48,659*	0.09
	4 201-900	9,341	9,425	7,615	13,745	*40,127*	0.08
	5 >900	880	-	-	247	*1,127*	0.00
		138,628	*193,113*	*106,703*	*82,149*	*520,593*	
		0.27	0.37	0.20	0.16	*1*	
Bottomfish	1 <=20	267,021	352,943	282,830	172,615	*1,075,409*	0.76
	2 21-75	1,424	3,210	4,632	4,665	*13,931*	0.01
	3 76-200	5,243	13	21,744	11,266	*38,267*	0.03
	4 201-900	48,420	59,354	63,892	68,363	*240,029*	0.17
	5 >900	8,435	-	-	39,882	*48,317*	0.03
		330,543	*415,521*	*373,098*	*296,792*	*1,415,953*	
		0.23	0.29	0.26	0.21	*1*	
Lobster	1 <=20	1,604	1,307	-	1,446	*4,357*	0.02
	2 21-75	-	-	-	-	-	0.00
	3 76-200	-	-	-	-	-	0.00
	4 201-900	15,245	57,442	112,365	59,315	*244,368*	0.96
	5 >900	-	-	4,185	1,115	*5,301*	0.02
		16,849	*58,749*	*116,551*	*61,877*	*254,026*	
		0.07	0.23	0.46	0.24	*1*	
All others	1 <=20	13,225	24,821	19,725	14,241	*72,012*	0.63
	2 21-75	175	1,733	24,061	1,274	*27,243*	0.24
	3 76-200	108	194	317	208	*827*	0.01
	4 201-900	154	6,393	5,782	1,248	*13,577*	0.12
	5 >900	27	-	-	17	*45*	0.00
		13,689	*33,141*	*49,885*	*16,989*	*113,704*	
		0.12	*0.29*	*0.44*	*0.15*	*1*	

Appendix 6. Estimated Actual Catch 1995 by Species, Area, and Season

Total = **37.9** millions

SPECIES	AREA (nmi)	SEASON Nov-Jan 1	Feb-May 2	Jun-Aug 3	Sept-Oct 4	TOTAL BY AREA Amount (lb)	%
Yellowfin	1 <=20	890,516	918,862	2,765,256	773,767	*5,348,401*	0.64
	2 21-75	47,437	18,004	96,232	8,686	*170,359*	0.02
	3 76-200	342,727	529,397	536,860	121,870	*1,530,855*	0.18
	4 201-900	173,899	507,864	430,915	144,036	*1,256,714*	0.15
	5 >900	205	15,969	25,709	5,269	*47,151*	0.01
	Subtotal	*1,454,784*	*1,990,096*	*3,854,971*	*1,053,628*	*8,353,479*	
		0.17	*0.24*	*0.46*	*0.13*	*1.00*	
Bigeye	1 <=20	94,923	11,701	6,263	38,358	*151,245*	0.02
	2 21-75	124,989	47,006	11,368	31,868	*215,231*	0.03
	3 76-200	1,257,655	1,149,423	155,571	430,727	*2,993,376*	0.44
	4 201-900	684,659	1,707,118	619,785	317,622	*3,329,184*	0.49
	5 >900	0	25,827	42,473	29,573	*97,872*	0.01
	Subtotal	*2,162,227*	*2,941,074*	*835,460*	*848,147*	*6,786,908*	
		0.32	*0.43*	*0.12*	*0.12*	*1.00*	
Albacore	1 <=20	190,279	19,402	283,876	423,145	*916,701*	0.26
	2 21-75	36,056	6,843	48,605	30,081	*121,586*	0.03
	3 76-200	252,019	127,488	297,789	180,591	*857,886*	0.24
	4 201-900	151,560	498,477	842,115	185,168	*1,677,321*	0.47
	5 >900	0	7,918	4,897	1,611	*14,427*	0.00
	Subtotal	*629,913*	*660,129*	*1,477,283*	*820,596*	*3,587,921*	
Swordfish	1 <=20	4,715	1,814	12,632	1,912	*21,073*	0.01
	2 21-75	5,394	1,521	7,737	327	*14,980*	0.00
	3 76-200	17,802	242,081	262,285	4,731	*526,899*	0.13
	4 201-900	72,045	1,661,034	820,764	36,115	*2,589,957*	0.66
	5 >900	0	324,409	451,461	2,875	*778,746*	0.20
	Subtotal	*99,956*	*2,230,860*	*1,554,880*	*45,960*	*3,931,656*	
		0.03	*0.57*	*0.40*	*0.01*	*1.00*	
Blue marlin	1 <=20	472,207	324,436	1,002,829	487,677	*2,287,150*	0.71
	2 21-75	22,621	2,486	27,230	6,453	*58,789*	0.02
	3 76-200	107,517	54,248	185,097	102,018	*448,880*	0.14
	4 201-900	39,907	135,989	172,173	62,607	*410,676*	0.13
	5 >900	0	0	4,025	6,271	*10,297*	0.00
	Subtotal	*642,252*	*517,159*	*1,391,355*	*665,026*	*3,215,792*	
		0.20	*0.16*	*0.43*	*0.21*	*1.00*	
Striped marlin	1 <=20	224,579	116,462	49,081	83,507	*473,630*	0.20
	2 21-75	43,227	7,580	1,076	13,971	*65,855*	0.03
	3 76-200	334,383	186,351	64,241	170,359	*755,335*	0.32
	4 201-900	224,861	349,673	272,047	208,162	*1,054,743*	0.44
	5 >900	0	9,851	11,755	6,383	*27,988*	0.01
	Subtotal	*827,051*	*669,916*	*398,200*	*482,383*	*2,377,550*	
		0.35	*0.28*	*0.17*	*0.20*	*1.00*	
Mahimahi	1 <=20	264,985	489,722	342,472	233,929	*1,331,109*	0.65
	2 21-75	25,555	19,583	5,743	12,336	*63,216*	0.03
	3 76-200	59,887	136,981	13,232	18,192	*228,291*	0.11
	4 201-900	49,747	281,126	27,227	45,059	*403,158*	0.20
	5 >900	0	4,512	4,953	3,408	*12,873*	0.01
	Subtotal	*400,173*	*931,923*	*393,626*	*312,924*	*2,038,647*	
		0.20	*0.46*	*0.19*	*0.15*	*1.00*	

Appendix 6. (Continued) Estimated Actual Catch 1995 by Species, Area, and Season

SPECIES	AREA (nmi)	SEASON Nov-Jan 1	Feb-May 2	Jun-Aug 3	Sept-Oct 4	TOTAL BY AREA Amount (lb)	%
Ono	1 <=20	124,346	537,700	361,038	114,225	*1,137,309*	0.76
	2 21-75	13,447	5,035	3,349	9,692	*31,523*	0.02
	3 76-200	32,435	42,562	23,079	35,761	*133,837*	0.09
	4 201-900	19,255	84,447	54,167	25,537	*183,406*	0.12
	5 >900	0	579	217	23	*819*	0.00
	Subtotal	*189,482*	*670,323*	*441,850*	*185,239*	*1,486,894*	
		0.13	*0.45*	*0.30*	*0.12*	*1.00*	
Aku	1 <=20	598,497	594,893	851,917	452,087	*2,497,394*	0.86
	2 21-75	40,799	11,916	12,924	62,888	*128,527*	0.04
	3 76-200	40,710	36,104	3,758	1,035	*81,607*	0.03
	4 201-900	96,577	76,907	11,323	1,409	*186,216*	0.06
	5 >900	*0*	*1,401*	*0*	*0*	*1,401*	0.00
	Subtotal	*776,584*	*721,221*	*879,921*	*517,419*	*2,895,146*	
		0.27	*0.25*	*0.30*	*0.18*	*1.00*	
Shark	1 <=20	12,359	7,095	9,693	5,633	*34,781*	0.20
	2 21-75	5,341	2,037	550	300	*8,229*	0.05
	3 76-200	26,037	19,839	7,159	4,624	*57,660*	0.33
	4 201-900	*8,867*	*39,131*	*15,329*	*9,281*	*72,609*	0.42
	5 >900	0.00	0.00	0.00	0.00	*0.00*	0.00
	Subtotal	*52,605*	*68,103*	*32,732*	*19,839*	*173,278*	
		0.30	*0.39*	*0.19*	*0.11*	*1.00*	
pelagic	2 21-75	26,241	23,869	4,347	9,699	*64,157*	0.04
	3 76-200	*210,015*	*222,719*	*66,163*	*88,584*	*587,481*	0.37
	4 201-900	120,713	279,808	210,145	83,926	*694,593*	0.43
	5 >900	0	549	1,109	0	*1,657*	0.00
	Subtotal	*459,436*	*595,966*	*334,965*	*217,303*	*1,607,670*	
		0.29	*0.37*	*0.21*	*0.14*	*1.00*	
Bottomfish	1 <=20	318,149	306,381	136,266	119,080	*879,875*	0.66
	2 21-75	*4,743*	*14,767*	*6,277*	*467*	*26,253*	0.02
	3 76-200	27773.33	46953.33	31728.00	6325.33	*112780.00*	0.08
	4 201-900	53,128	52,308	36,360	25,256	*167,052*	0.13
	5 >900	16,861	73,838	39,839	18,985	*149,524*	0.11
	Subtotal	*420,654*	*494,247*	*250,471*	*170,113*	*1,335,485*	
		0.31	*0.37*	*0.19*	*0.13*	*1.00*	
Lobster	1 <=20	*2,514*	*1,392*	*2,627*	*0*	*6,533*	0.25
	2 21-75	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	0.00
	3 76-200	0	0	0	0	*0*	0.00
	4 201-900	0	0	0	19,859	*19,859*	0.75
	5 >900	0	0	0	0	*0*	0.00
	Subtotal	*2,514*	*1,392*	*2,627*	*19,859*	*26,393*	
		0.10	*0.05*	*0.10*	*0.75*	*1.00*	
All others	1 <=20	17,521	24,581	15,418	13,090	*70,609*	0.74
	2 21-75	189	1,189	800	55	*2,233*	0.02
	3 76-200	813	2,640	4,124	689	*8,267*	0.09
	4 201-900	1,861	4,950	7,047	169	*14,028*	0.15
	5 >900	1	7	18	0	*27*	0.00
	Subtotal	*20,386*	*33,367*	*27,407*	*14,003*	*95,163*	
		0.21	*0.35*	*0.29*	*0.15*	*1.00*	

Appendix 7. Estimated Recreational Trips for 1990-1995[a]

	1 Nov-Jan	2 Feb-May	3 Jan-Aug	4 Sept-Oct	Total
1990 Recreational Trips					
Fleet 1	6,439	16,413	12,446	3,783	39,082
Fleet 3	10,766	20,825	18,789	6,763	57,142
1991 Recreational Trips					
Fleet 1	7,611	15,374	14,466	5,547	42,999
Fleet 3	12,725	19,507	21,838	9,917	63,986
1992 Recreational Trips					
Fleet 1	6,222	13,102	10,389	3,822	33,534
Fleet 3	10,402	16,623	15,683	6,832	49,540
1993 Recreational Trips					
Fleet 1	6,381	11,180	12,288	5,010	34,859
Fleet 3	10,668	14,185	18,550	8,956	52,359
1994 Recreational Trips					
Fleet 1	5,252	12,453	13,008	4,312	35,025
1995 Recreational Trips					
Fleet 1	8,221	12,751	13,204	4,788	38,964
Fleet 3	13,745	16,179	19,932	8,559	58,414

[a]This table presents the estimated number of recreational trips, which were used as a constraint of the actual level of recreational effort for the year that was analyzed by the model.

Appendix 8. Fixed Costs 1993 and Entry Conditions

Owner's Entry Condition							Crew's Entry Condition			
Annual fixed costs					Owner's share	Expected Net rev.	Crew share	Expected income		
Vessel prices ($)	Vessel life (year)	Expected return to invest	Mainten-ance ($)	Fixed costs ($)		($)		$/day ($)	Annual work days (day)	Annual exp. income ($)
26,185	30		1,308				0.50	0	14	0
187,364	30	0.06	30,626	48,113	0.40	72,170	0.60	258	149	38,442
49,832	30	0.06	3,629	8,280	0.28	21,291	0.72	139	127	17,653
55,436	30	0.06	3,254	8,428	0.39	13,182	0.61	79	96	7,584
275,000	40	0.06	46,000	69,375	0.60	46,250	0.40	431	181	78,011
339,000	40	0.06	62,000	90,815	0.60	60,543	0.40	434	213	92,442
473,000	40	0.06	68,600	108,805	0.65	58,587	0.35	530	199	105,470
50,000	30	0.06	8,000	12,667	0.60	8,444	0.40	623	130	80,990

Appendix 9. Variable Costs per Day

Fleet	Target	Cost per Fishing Day ($)	Costs per Travel Day ($)	Costs per Turn-around Day ($)
1. Recreational				
	mix pelagic	118	45	0
2. Charter Boats				
	yellowfin	320	60	0
	blue marlin	320	60	0
	mahimahi	320	60	0
	ono	320	60	0
	aku	320	60	0
	bottomfish	320	60	0
	mixed	320	60	0
3. Expense				
	mixed	121	50	0
4. Commercial Handliners				
	yellowfin	190	60	0
	bigeye	677	60	0
	bottomfish	152	60	0
	mixed species	190	60	0
5. Commercial Trollers				
	blue marlin	140	60	0
	mahimahi	140	60	0
	ono	140	60	0
	mixed	140	60	0
6. Small Multi-purpose				
	yellowfin	810	326	17
	bigeye	810	326	17
	swordfish	1277	326	17
	bottomfish	729	326	17
	lobster	1283	326	17
	mixed	1521	326	17
7. Medium Multi-purpose				
	yellowfin	730	730	20
	bigeye	730	730	20
	swordfish	1277	730	20
	lobster	1283	730	20
	mixed	1521	730	20
8. Large Multi-purpose				
	yellowfin	730	838	27
	bigeye	730	838	27
	swordfish	1476	838	27
	mixed	1521	838	27
9. Aku Boats				
	aku	475	100	20

Appendix 10. Trips Days and the Maximum Number of Trips by Fleet, Target, Season, and Area

Fleet	Target	Season 1 (11 - 1) Turn-aroud Days	Season 1 Travel Days	Season 1 Fishing Days	Season 1 No. of Trips	Season 2 (2 - 4) Turn-aroud Days	Season 2 Travel Days	Season 2 Days	Season 2 No. of Trips	Season 3 (5 - 8) Turn-aroud Days	Season 3 Travel Days	Season 3 Days	Season 3 No. of Trips	Season 4 (9 - 10) Turn-aroud Days	Season 4 Travel Days	Season 4 Days	Season 4 No. of Trips	Annual Trips
Fleet 1 (Rec. Boats)																		
Area 1	Mixed	23.0	0.0	1.0	4	23.0	0.0	1.0	5	23.0	0.0	1.0	4	23.0	0.0	1.0	2	**14**
Area 2	Mixed	23.0	0.0	1.0	4	23.0	0.0	1.0	5	23.0	0.0	1.0	4	23.0	0.0	1.0	2	**14**
Fleet 2 (Charter Boats)																		
Area 1	Yellowfin	0.5	0.0	1.0	56	0.5	0.0	1.0	75	0.5	0.0	1.0	37	0.5	0.0	1.0	56	**224**
	Blue Marlin	0.5	0.0	1.0	56	0.5	0.0	1.0	75	0.5	0.0	1.0	37	0.5	0.0	1.0	56	**224**
	Mahimahi	0.5	0.0	1.0	56	0.5	0.0	1.0	75	0.5	0.0	1.0	37	0.5	0.0	1.0	56	**224**
	Ono	0.5	0.0	1.0	56	0.5	0.0	1.0	75	0.5	0.0	1.0	37	0.5	0.0	1.0	56	**224**
	Aku	0.5	0.0	1.0	56	0.5	0.0	1.0	75	0.5	0.0	1.0	37	0.5	0.0	1.0	56	**224**
	Bottomfish	0.5	0.0	1.0	56	0.5	0.0	1.0	75	0.5	0.0	1.0	37	0.5	0.0	1.0	56	**224**
	Mixed	0.5	0.0	1.0	56	0.5	0.0	1.0	75	0.5	0.0	1.0	37	0.5	0.0	1.0	56	**224**
	Blue Marlin	0.5	0.0	1.0	56	0.5	0.0	1.0	75	0.5	0.0	1.0	37	0.5	0.0	1.0	56	**224**
	Mahimahi	0.5	0.0	1.0	56	0.5	0.0	1.0	75	0.5	0.0	1.0	37	0.5	0.0	1.0	56	**224**
	Ono	0.5	0.0	1.0	56	0.5	0.0	1.0	75	0.5	0.0	1.0	37	0.5	0.0	1.0	56	**224**
	Aku	0.5	0.0	1.0	56	0.5	0.0	1.0	75	0.5	0.0	1.0	37	0.5	0.0	1.0	56	**224**
	Bottomfish	0.5	0.0	1.0	56	0.5	0.0	1.0	75	0.5	0.0	1.0	37	0.5	0.0	1.0	56	**224**
	Mixed	0.5	0.0	1.0	56	0.5	0.0	1.0	75	0.5	0.0	1.0	37	0.5	0.0	1.0	56	**224**
Fleet 3 (Expense)																		
Area 1	Mixed	5.1	0.0	1.0	14	5.1	0.0	1.0	18	5.1	0.0	1.0	14	5.1	0.0	1.0	9	**55**
Area 2	Mixed	5.1	0.0	1.0	14	5.1	0.0	1.0	18	5.1	0.0	1.0	14	5.1	0.0	1.0	9	**55**
Area 3	Mixed	6.0	0.5	3.0	9	6.0	0.5	3.0	12	6.0	0.5	3.0	9	6.0	0.5	3.0	6	**35**
Fleet 4 (Com. Handliners)																		
Area 1	Yellowfin	1.0	0.0	1.0	42	1.0	0.0	1.0	56	1.0	0.0	1.0	42	1.0	0.0	1.0	28	**168**
	Bigeye	1.0	0.0	1.0	42	1.0	0.0	1.0	56	1.0	0.0	1.0	42	1.0	0.0	1.0	28	**168**
	Bottomfish	1.0	0.0	1.0	42	1.0	0.0	1.0	56	1.0	0.0	1.0	42	1.0	0.0	1.0	28	**168**
	Mixed	1.0	0.0	1.0	42	1.0	0.0	1.0	56	1.0	0.0	1.0	42	1.0	0.0	1.0	28	**168**
Area 2	Yellowfin	2.0	0.2	1.0	26	2.0	0.2	1.0	35	2.0	0.2	1.0	26	2.0	0.2	1.0	18	**105**
	Bigeye	2.0	0.2	1.0	26	2.0	0.2	1.0	35	2.0	0.2	1.0	26	2.0	0.2	1.0	18	**105**
	Bottomfish	2.0	0.2	2.0	20	2.0	0.2	2.0	27	2.0	0.2	2.0	20	2.0	0.2	2.0	13	**80**
	Mixed	2.0	0.2	1.0	26	2.0	0.2	1.0	35	2.0	0.2	1.0	26	2.0	0.2	1.0	18	**105**
Area 3	Yellowfin	4.0	0.5	3.5	11	4.0	0.5	3.5	14	4.0	0.5	3.5	11	4.0	0.5	3.5	7	**42**
	Bigeye	4.0	0.5	4.5	9	4.0	0.5	4.5	12	4.0	0.5	4.5	9	4.0	0.5	4.5	6	**37**
	Bottomfish	4.0	0.5	5.5	8	4.0	0.5	5.5	11	4.0	0.5	5.5	8	4.0	0.5	5.5	6	**34**
	Mixed	4.0	0.5	2.0	13	4.0	0.5	2.0	17	4.0	0.5	2.0	13	4.0	0.5	2.0	9	**52**

Appendix 10. (Continued) Trips Days and the Maximum Number of Trips by Fleet, Target, Season, and Area

Fleet	Target	Season 1 (11 - 1)				Season 2 (2 - 4)				Season 3 (5 - 8)				Season 4 (9 - 10)				Annual Trips
		Turn-aroud Days	Travel Days	Fishing Days	No. of Trips	Turn-aroud Days	Travel Days	Days	No. of Trips	Turn-aroud Days	Travel Days	Days	No. of Trips	Turn-aroud Days	Travel Days	Days	No. of Trips	
Fleet 4																		
Area 4	Bottomfish	7.0	1.5	10.0	5	7.0	1.5	10.0	6	7.0	1.5	10.0	5	7.0	1.5	10.0	3	**18**
Area 5	Bottomfish	7.0	5.0	13.0	3	7.0	5.0	13.0	4	7.0	5.0	13.0	3	7.0	5.0	13.0	2	**13**
Fleet 5 (Com. Trollers)	**Area 1 (<= 20 nml)**																	
Area 1	Yellowfin	1.0	0.0	1.0	42	1.0	0.0	1.0	56	1.0	0.0	1.0	42	1.0	0.0	1.0	28	**168**
	Blue Marlin	1.0	0.0	1.0	42	1.0	0.0	1.0	56	1.0	0.0	1.0	42	1.0	0.0	1.0	28	**168**
	Mahimahi	1.0	0.0	1.0	42	1.0	0.0	1.0	56	1.0	0.0	1.0	42	1.0	0.0	1.0	28	**168**
	Ono	1.0	0.0	1.0	42	1.0	0.0	1.0	56	1.0	0.0	1.0	42	1.0	0.0	1.0	28	**168**
	Mixed	1.0	0.0	1.0	42	1.0	0.0	1.0	56	1.0	0.0	1.0	42	1.0	0.0	1.0	28	**168**
Area 2	Yellowfin	2.0	0.2	1.0	26	2.0	0.2	1.0	35	2.0	0.2	1.0	26	2.0	0.2	1.0	18	**105**
	Blue Marlin	2.0	0.2	1.0	26	2.0	0.2	1.0	35	2.0	0.2	1.0	26	2.0	0.2	1.0	18	**105**
	Ono	2.0	0.2	1.0	26	2.0	0.2	1.0	35	2.0	0.2	1.0	26	2.0	0.2	1.0	18	**105**
	Mixed	2.0	0.2	1.0	26	2.0	0.2	1.0	35	2.0	0.2	1.0	26	2.0	0.2	1.0	18	**105**
Area 3	Yellowfin	4.0	0.5	2.0	13	4.0	0.5	2.0	17	4.0	0.5	2.0	13	4.0	0.5	2.0	9	**52**
	Blue Marlin	4.0	0.5	2.0	13	4.0	0.5	2.0	17	4.0	0.5	2.0	13	4.0	0.5	2.0	9	**52**
	Mahimahi	4.0	0.5	2.0	13	4.0	0.5	2.0	17	4.0	0.5	2.0	13	4.0	0.5	2.0	9	**52**
	Ono	4.0	0.5	2.0	13	4.0	0.5	2.0	17	4.0	0.5	2.0	13	4.0	0.5	2.0	9	**52**
	Mixed	4.0	0.5	2.0	13	4.0	0.5	2.0	17	4.0	0.5	2.0	13	4.0	0.5	2.0	9	**52**
Fleet 6 (S. Multi-purpose)	**Area 1 (<= 20 nml)**																	
Area 1	Yellowfin	7.6	0.1	9.7	5	7.6	0.1	7.7	7	7.6	0.1	8.2	5	7.6	0.1	5.5	4	**22**
	Bigeye	7.6	0.1	9.7	5	7.6	0.1	7.7	7	7.6	0.1	8.2	5	7.6	0.1	5.5	4	**22**
	Swordfish	9.5	0.1	17.0	3	9.5	0.1	17.0	4	9.5	0.1	18.0	3	9.5	0.1	16.5	2	**13**
	Bottomfish	4.0	0.1	4.5	10	4.0	0.1	4.5	13	4.0	0.1	4.5	10	4.0	0.1	4.5	7	**39**
	Lobster	20.0	0.1	31.0	2	20.0	0.1	31.0	2	20.0	0.1	31.0	2	20.0	0.1	31.0	1	**7**
	Mixed	9.0	0.1	5.0	6	9.0	0.1	6.9	7	9.0	0.1	6.4	5	9.0	0.1	6.4	4	**22**
Area 2	Yellowfin	7.6	0.2	10.8	5	7.6	0.2	8.8	7	7.6	0.2	9.2	5	7.6	0.2	6.5	4	**20**
	Bigeye	7.6	0.2	10.8	5	7.6	0.2	8.8	7	7.6	0.2	9.2	5	7.6	0.2	6.5	4	**20**
	Swordfish	9.5	0.2	18.0	3	9.5	0.2	18.0	4	9.5	0.2	19.0	3	9.5	0.2	17.5	2	**12**
	Bottomfish	4.0	0.2	5.5	9	4.0	0.2	5.5	12	4.0	0.2	5.5	9	4.0	0.2	5.5	6	**35**
	Lobster	20.0	0.2	32.0	2	20.0	0.2	32.0	2	20.0	0.2	32.0	2	20.0	0.2	32.0	1	**6**
	Mixed	9.0	0.2	6.0	6	9.0	0.2	7.9	7	9.0	0.2	7.4	5	9.0	0.2	7.4	3	**21**

Appendix 10. (Continued) Trips Days and the Maximum Number of Trips by Fleet, Target, Season, and Area

Fleet	Target	Season 1 (11 - 1)				Season 2 (2 - 4)				Season 3 (5 - 8)				Season 4 (9 - 10)				Annual Trips
		Turn-aroud Days	Travel Days	Fishing Days	No. of Trips	Turn-aroud Days	Travel Days	Days	No. of Trips	Turn-aroud Days	Travel Days	Days	No. of Trips	Turn-aroud Days	Travel Days	Days	No. of Trips	
Fleet 6																		
Area 3	Yellowfin	7.6	1.0	10.8	4	7.6	1.2	8.8	6	7.6	1.1	9.2	5	7.6	1.1	6.5	4	**19**
	Bigeye	7.6	1.0	10.8	4	7.6	1.2	8.8	6	7.6	1.1	9.2	5	7.6	1.1	6.5	4	**19**
	Swordfish	9.5	1.0	18.0	3	9.5	1.2	18.0	4	9.5	1.1	19.0	3	9.5	1.1	17.5	2	**12**
	Bottomfish	4.0	1.0	5.5	8	4.0	1.2	5.5	10	4.0	1.1	5.5	8	4.0	1.1	5.5	5	**32**
	Lobster	20.0	1.0	32.0	2	20.0	1.2	32.0	2	20.0	1.1	32.0	2	20.0	1.1	32.0	1	**6**
	Mixed	9.0	1.0	6.0	5	9.0	1.2	7.9	6	9.0	1.1	7.4	5	9.0	1.1	7.4	3	**19**
Area 4	Yellowfin	7.6	1.9	7.4	5	7.6	2.2	9.5	6	7.6	1.7	11.7	4	7.6	1.8	10.4	3	**18**
	Bigeye	7.6	1.9	7.4	5	7.6	2.2	9.5	6	7.6	1.7	11.7	4	7.6	1.8	10.4	3	**18**
	Broadbill	9.5	1.9	18.0	3	9.5	2.2	18.0	4	9.5	1.7	19.0	3	9.5	1.8	17.5	2	**11**
	Bottomfish	7.0	1.9	10.0	4	7.0	2.2	10.0	6	7.0	1.7	10.0	4	7.0	1.8	10.0	3	**18**
	Mixed	9.0	1.9	6.0	5	9.0	2.2	7.9	6	9.0	1.7	7.0	5	9.0	1.8	7.0	3	**19**
Area 5	Yellowfin	7.6	8.0	10.4	3	7.6	8.0	10.4	4	7.6	8.5	11.7	3	7.6	14.1	10.4	2	**12**
	Bigeye	7.6	8.0	11.7	3	7.6	8.0	11.7	4	7.6	8.5	11.7	3	7.6	14.1	10.4	2	**12**
	Broadbill	9.5	8.0	18.0	2	9.5	8.0	18.0	3	9.5	8.5	19.0	2	9.5	14.1	17.5	1	**9**
	Bottomfish	7.0	8.0	13.0	3	7.0	8.0	13.0	4	7.0	8.5	13.0	3	7.0	14.1	13.0	2	**12**
	Lobster	20.0	8.0	32.0	1	20.0	8.0	32.0	2	20.0	8.5	32.0	1	20.0	14.1	32.0	1	**6**
	Mixed	9.0	8.0	7.0	4	9.0	8.0	7.9	5	9.0	8.5	7.0	3	9.0	14.1	7.0	2	**13**
Fleet 7 (M. Multi-purpose)																		
Area 1	Yellowfin	6.8	0.1	8.6	5	6.8	0.1	9.5	7	6.8	0.1	10.0	5	6.8	0.1	4.7	5	**22**
	Bigeye	6.8	0.1	8.6	5	6.8	0.1	9.5	7	6.8	0.1	10.0	5	6.8	0.1	4.7	5	**22**
	Broadbill	9.9	0.1	9.7	4	9.9	0.1	11.0	5	9.9	0.1	8.5	5	9.9	0.1	9.7	3	**17**
	Lobster	20.0	0.1	31.0	2	20.0	0.1	31.0	2	20.0	0.1	31.0	2	20.0	0.1	31.0	1	**7**
	Mixed	10.8	0.1	8.0	4	10.8	0.1	5.6	7	10.8	0.1	7.5	5	10.8	0.1	9.4	3	**19**
Area 2	Yellowfin	6.8	0.2	9.6	5	6.8	0.2	10.5	6	6.8	0.2	11.0	5	6.8	0.2	4.7	5	**21**
	Bigeye	6.8	0.2	9.6	5	6.8	0.2	10.5	6	6.8	0.2	11.0	5	6.8	0.2	4.7	5	**21**
	Broadbill	9.9	0.2	10.8	4	9.9	0.2	12.0	5	9.9	0.2	9.5	4	9.9	0.2	10.8	3	**16**
	Lobster	20.0	0.2	32.0	2	20.0	0.2	32.0	2	20.0	0.2	32.0	2	20.0	0.2	32.0	1	**6**
	Mix Pelagic	10.8	0.2	9.0	4	10.8	0.2	6.6	6	10.8	0.2	8.5	4	10.8	0.2	10.4	3	**17**
Area 3	Yellowfin	6.8	1.0	9.6	5	6.8	1.2	10.5	6	6.8	1.1	11.0	4	6.8	1.1	4.7	4	**20**
	Bigeye	6.8	1.0	9.6	5	6.8	1.2	10.5	6	6.8	1.1	11.0	4	6.8	1.1	4.7	4	**20**
	Broadbill	9.9	1.0	10.8	4	9.9	1.2	12.0	5	9.9	1.1	9.5	4	9.9	1.1	10.8	3	**15**
	Lobster	20.0	1.0	32.0	2	20.0	1.2	32.0	2	20.0	1.1	32.0	2	20.0	1.1	32.0	1	**6**
	Mixed	10.8	1.0	9.0	4	10.8	1.2	6.6	6	10.8	1.1	8.5	4	10.8	1.1	10.4	3	**17**

Appendix 10. (Continued) Trips Days and the Maximum Number of Trips by Fleet, Target, Season, and Area

Fleet	Target	Season 1 (11 - 1)				Season 2 (2 - 4)				Season 3 (5 - 8)				Season 4 (9 - 10)				Annual
		Turn-aroud Days	Travel Days	Fishing Days	No. of Trips	Turn-aroud Days	Travel Days	Days	No. of Trips	Turn-aroud Days	Travel Days	Days	No. of Trips	Turn-aroud Days	Travel Days	Days	No. of Trips	Trips
Fleet 7																		
Area 4	Yellowfin	6.8	3.0	11.0	4	6.8	3.3	11.5	5	6.8	2.8	11.9	4	6.8	2.4	11.3	3	**16**
	Bigeye	6.8	3.0	11.0	4	6.8	3.3	11.5	5	6.8	2.8	11.9	4	6.8	2.4	11.3	3	**16**
	Broadbill	9.9	3.0	15.0	3	9.9	3.3	16.3	4	9.9	2.8	12.6	3	9.9	2.4	14.6	2	**12**
	Lobster	20.0	3.0	32.0	2	20.0	3.3	32.0	2	20.0	2.8	32.0	2	20.0	2.4	32.0	1	**6**
	Mixed	10.8	3.0	12.3	3	10.8	3.3	10.0	5	10.8	2.8	10.4	4	10.8	2.4	10.4	2	**14**
Area 5	Yellowfin	6.8	7.4	12.0	3	6.8	7.4	12.0	4	6.8	8.2	12.0	3	6.8	12.4	12.0	2	**12**
	Bigeye	6.8	7.4	12.0	3	6.8	7.4	12.0	4	6.8	8.2	12.0	3	6.8	12.4	12.0	2	**12**
	Broadbill	9.9	7.4	24.0	2	9.9	7.4	25.2	3	9.9	8.2	24.4	2	9.9	12.4	20.2	1	**8**
	Lobster	20.0	7.4	32.0	1	20.0	7.4	32.0	2	20.0	8.2	32.0	1	20.0	12.4	32.0	1	**6**
	Mixed	10.8	7.4	14.7	3	10.8	7.4	11.0	4	10.8	8.2	10.0	3	10.8	12.4	19.0	1	**11**
Area 1	Yellowfin	7.0	0.1	9.5	5	7.0	0.1	7.3	8	7.0	0.1	9.5	5	7.0	0.1	11.7	3	**21**
	Bigeye	7.0	0.1	9.5	5	7.0	0.1	7.3	8	7.0	0.1	9.5	5	7.0	0.1	11.7	3	**21**
	Broadbill	8.9	0.1	18.4	3	8.9	0.1	16.3	4	8.9	0.1	16.2	3	8.9	0.1	19.0	2	**13**
	Mixed	7.9	0.1	15.4	4	7.9	0.1	13.6	5	7.9	0.1	12.5	4	7.9	0.1	19.5	2	**15**
Area 2	Yellowfin	7.0	0.2	10.5	5	7.0	0.2	8.3	7	7.0	0.2	10.5	5	7.0	0.2	12.7	3	**20**
	Bigeye	7.0	0.2	10.5	5	7.0	0.2	8.3	7	7.0	0.2	10.5	5	7.0	0.2	12.7	3	**20**
	Broadbill	8.9	0.2	19.4	3	8.9	0.2	17.3	4	8.9	0.2	17.2	3	8.9	0.2	20.0	2	**12**
	Mixed	7.9	0.2	16.4	3	7.9	0.2	14.7	5	7.9	0.2	13.5	4	7.9	0.2	20.5	2	**14**
Area 3	Yellowfin	7.0	1.0	10.5	5	7.0	1.3	8.3	7	7.0	1.0	10.5	5	7.0	1.1	12.7	3	**19**
	Bigeye	7.0	1.0	10.5	5	7.0	1.3	8.3	7	7.0	1.0	10.5	5	7.0	1.1	12.7	3	**19**
	Broadbill	8.9	1.0	19.4	3	8.9	1.3	17.3	4	8.9	1.0	17.2	3	8.9	1.1	20.0	2	**12**
	Mixed	7.9	1.0	16.4	3	7.9	1.3	14.7	5	7.9	1.0	13.5	4	7.9	1.1	20.5	2	**14**
Area 4	Yellowfin	7.0	5.3	11.8	3	7.0	4.7	9.5	5	7.0	4.4	11.1	4	7.0	2.8	12.0	3	**15**
	Bigeye	7.0	5.3	11.8	3	7.0	4.7	9.5	5	7.0	4.4	11.1	4	7.0	2.8	12.0	3	**15**
	Broadbill	8.9	5.3	19.4	3	8.9	4.7	17.3	4	8.9	4.4	17.2	3	8.9	2.8	20.0	2	**11**
	Mixed	7.9	5.3	16.4	3	7.9	4.7	14.7	4	7.9	4.4	13.5	3	7.9	2.8	20.5	2	**12**
Area 5	Yellowfin	7.0	7.9	12.0	3	7.0	6.9	12.0	4	7.0	8.6	12.0	3	7.0	11.9	12.0	2	**12**
	Bigeye	7.0	7.9	12.0	3	7.0	6.9	12.0	4	7.0	8.6	12.0	3	7.0	11.9	12.0	2	**12**
	Broadbill	8.9	7.9	20.9	2	8.9	6.9	26.0	3	8.9	8.6	25.0	2	8.9	11.9	24.5	1	**8**
	Mixed	7.9	7.9	16.4	3	7.9	6.9	14.6	4	7.9	8.6	13.5	3	7.9	11.9	20.5	1	**11**
Fleet 9 (Aku Boat)																		
Area 1	Aku	2.0	0.1	2.0	20	2.0	0.1	2.0	27	2.0	0.1	2.0	20	2.0	0.1	2.0	14	**82**
Area 2	Aku	3.0	0.2	2.0	16	3.0	0.2	2.0	22	3.0	0.2	2.0	16	3.0	0.2	2.0	11	**65**

Appendix 11.1 Optimal Fleet Activities and Performance from the Baseline Model

Fleet-wide Solution

Goals	Goal Description	Total Rev. ($ million)	Total Net Rev. ($ million)	Total Profit ($ million)	Catch (million lb.) Rec.		Com.	Total
1	Maximize total profit from commercial fleets	**69.90**	**29.82**	**17.43**	**5.05**	**1.17**	**24.37**	**30.58**

Individual Fleet $1000

Fleet	Vessels or Trips	Trips /Vessel	Work Day (%)	Vessels or Trips 11-1	2-5	6-8	9-10	Rev.	Cost V. cost	F. cost	Total	Profit Total		Owner entry condition NR	Exp. NR	Diff.	Crew entry conditions NR	Exp. NR	Diff.
Rec. Boat (1,000 trip)	95	8	60	18	14	37	26	6894	11912	42465	54377	-47483	-499	0	0	0	0	0	0
Charter Boats	40	224	100	40	40	40	40	6529	1721	1923	3645	575	14	1923	1923	0	2885	2310	575
Expense (1,000 trip)	22	18	33	0	22	0	0	2066	2887	6123	9010	-6944	-313	0	0	0	0	0	0
Com. Handliners	174	78	55	81	45	174	97	12206	5116	1441	6557	3370	19	1985	1441	544	5105	2279	2826
Com. Trollers	57	146	100	57	57	57	57	3825	1637	481	2118	986	17	853	481	372	1335	721	613
S. Multipurpose	12	9	61	0	12	12	2	4085	1744	823	2567	859	72	1405	823	582	937	659	277
M. Multipurpose	6	14	96	6	6	5	6	3454	1519	532	2051	856	146	1161	532	629	774	547	227
L. Multipurpose	52	9	76	39	52	33	25	36640	16419	5654	22073	9470	182	13144	5654	7490	7078	5098	1980
Aku Boats	13	46	61	6	5	9	13	3161	908	162	1071	1311	102	1352	162	1189	901	779	122
Total	354			230	217	330	240	69901	29064	11017	40081	17426		21823	11017	10807	19013	12394	6620

Note: The recreational fleets are not counted in the numbers in Total

Appendix 11.2 Optimal No. of Vessels and Trips from the Baseline Model

Area	Target Species	Season 1 (11-1) Vessels	Season 1 (11-1) Trips	Season 2 (2-5) Vessels	Season 2 (2-5) Trips	Season 3 (6-8) Vessels	Season 3 (6-8) Trips	Season 4 (9-10) Vessels	Season 4 (9-10) Trips
FLEET 1 (RECREATIONAL)									
AREA 1	Mixed	5214.7	18251	2964.9	13836	10460.1	36610	11318.2	26409
AREA 2	Mixed								
TOTAL		**5214.7**	**18251**	**2964.9**	**13836**	**10460.1**	**36610**	**11318.2**	**26409**
FLEET 2 (CHARTER)									
AREA 1	Yellowfin					40.0	2238	29.8	1111
	Blue Marlin	38.6	2163	34.5	2574			4.0	148
	Mahimahi							6.2	233
	Ono								
	Aku								
	Bottomfish								
	Mix Pelagic								
	Subtotal	*38.6*	*2163*	*34.5*	*2574*	*40.0*	*2238*	*40.0*	*1492*
	Blue Marlin			4.5	335				
	Mahimahi	1.4	76						
	Ono								
	Aku								
	Bottomfish								
	Mix Pelagic								
	Subtotal	*1.4*	*76*	*5.5*	*410*				
TOTAL		**40.0**	**2238**	**40.0**	**2984**	**40.0**	**2238**	**40.0**	**1492**
FLEET 3 (EXPENSE)									
AREA 1	Mixed			1206.6	22153				
AREA 2	Mixed								
AREA 3	Mixed								
TOTAL		**0.0**	**0**	**1206.6**	**22153**	**0.0**	**0**	**0.0**	**0**

Appendix 11.2 (Continued) Optimal No. of Vessels & Trips from the Baseline Model

Area	Target Species	Season 1(11-1) Vessels	Season 1(11-1) Trips	Season 2 (2-5) Vessels	Season 2 (2-5) Trips	Season 3 (6-8) Vessels	Season 3 (6-8) Trips	Season 4 (9-10) Vessels	Season 4 (9-10) Trips
FLEET 4 (COM. HANDLINERS)									
AREA 1	Yellowfin					144.0	6048	36.7	1029
	Bigeye								
	Bottomfish	61.4	2580	20.5	1150	24.8	1039	43.4	1216
	Mix Pelagic								
	Subtotal	*61.4*	*2580*	*20.5*	*1150*	*168.8*	*7087*	*80.2*	*2245*
AREA 2	Yellowfin			0.7	23				
	Bigeye								
	Bottomfish			0.2	5				
	Mix Pelagic								
	Subtotal			*0.8*	*28*				
AREA 3	Yellowfin								
	Bigeye	16.4	153	19.4	241	5.3	49	8.4	52
	Bottomfish			1.2	14				
	Mix Pelagic								
	Subtotal	*16.4*	*153*	*20.6*	*255*	*5.3*	*49*	*8.4*	*52*
AREA 5	Bottomfish	3.5	12					3.6	8
TOTAL		**81.3**	**2744**	**44.8**	**1450**	**174.1**	**7137**	**97.4**	**2321**
FLEET 5 (COM. TROLLERS)									
AREA 1	Yellowfin	33.1	1391	56.1	3143	22.2	931		
	Blue Marlin								
	Mahimahi	21.2	890					45.8	1283
	Ono								
	Mix Pelagic								
	Subtotal	*54.3*	*2281*	*56.1*	*3143*	*22.2*	*931*	*45.8*	*1283*
AREA 2	Yellowfin								
	Blue Marlin	1.8	47						
	Mahimahi					2.9	76	4.6	81
	Ono		0					0.3	5
	Mix Pelagic								
	Subtotal	*1.8*	*47*			*2.9*	*76*	*4.9*	*86*
AREA 3	Yellowfin			0.9	16	32.0	414	3.7	32
	Blue Marlin								
	Mahimahi	1.0	12						
	Ono							2.6	23
	Mix Pelagic								
	Subtotal	*1.0*	*12*	*0.9*	*16*	*32.0*	*414*	*6.3*	*55*
TOTAL		**57.0**	**2340**	**57.1**	**3159**	**57.1**	**1420**	**57.0**	**1423**

Appendix 11.2 (Continued) Optimal No. of Vessels & Trips from the Baseline Model

Area	Target Species	Season 1(11-1) Vessels	Season 1(11-1) Trips	Season 2 (2-5) Vessels	Season 2 (2-5) Trips	Season 3 (6-8) Vessels	Season 3 (6-8) Trips	Season 4 (9-10) Vessels	Season 4 (9-10) Trips
AREA 1	Yellowfin								
	Bigeye								
	Swordfish								
	Bottom fish								
	Lobster								
	Mix Pelagic								
	Subtotal								
AREA 2	Yellowfin								
	Bigeye								
	Swordfish								
	Bottom fish								
	Lobster								
	Mix Pelagic								
	Subtotal								
AREA 3	Yellowfin								
	Bigeye					0.4	2		
	Swordfish								
	Bottom fish								
	Lobster								
	Mix Pelagic								
	Subtotal					*0.4*	*2*		
AREA 4	Yellowfin					3.8	15	1.7	5
	Bigeye			11.9	69				
	Swordfish					7.7	21		
	Bottom fish								
	Lobster								
	Mix Pelagic								
	Subtotal			*11.9*	*69*	*11.5*	*37*	*1.7*	*5*
AREA 5	Yellowfin								
	Bigeye								
	Swordfish								
	Bottom fish								
	Lobster								
	Mix Pelagic								
	Subtotal								
TOTAL		**0.0**	**0**	**11.9**	**69**	**11.9**	**38**	**1.7**	**5**

Appendix 11.2 (Continued) Optimal No. of Vessels & Trips from the Baseline Model

Area	Target Species	Season 1(11-1) Vessels	Season 1(11-1) Trips	Season 2 (2-5) Vessels	Season 2 (2-5) Trips	Season 3 (6-8) Vessels	Season 3 (6-8) Trips	Season 4 (9-10) Vessels	Season 4 (9-10) Trips
FLEET 7 (MEDIUM MULTIPURPOSERS)									
AREA 1	Yellowfin								
	Bigeye								
	Swordfish								
	Lobster								
	Mix Pelagic								
	Subtotal								
AREA 2	Yellowfin								
	Bigeye								
	Swordfish								
	Lobster								
	Mix Pelagic								
	Subtotal								
AREA 3	Yellowfin							0.5	2
	Bigeye								
	Swordfish			1.3	6				
	Mix Pelagic								
	Subtotal			*1.3*	*6*			*0.5*	*2*
AREA 4	Yellowfin	0.9	4						
	Bigeye	4.7	19	2.2	12			5.4	15
	Swordfish					1.4	5		
	Lobster								
	Mix Pelagic					0.1	0		
	Subtotal	*5.7*	*23*	*2.2*	*12*	*1.5*	*5*	*5.4*	*15*
AREA 5	Yellowfin	0.2	1						
	Bigeye								
	Swordfish			2.3	6				
	Lobster								
	Mix Pelagic					3.5	10		
	Subtotal	*0.2*	*1*	*2.3*	*6*	*3.5*	*10*		
TOTAL		**5.9**	**23**	**5.9**	**24**	**5.0**	**15**	**5.9**	**17**

Appendix 14.2 (Continued) Optimal No. of Vessels & Trips from the Baseline Model

Area	Target Species	Season 1(11-1) Vessels	Season 1(11-1) Trips	Season 2 (2-5) Vessels	Season 2 (2-5) Trips	Season 3 (6-8) Vessels	Season 3 (6-8) Trips	Season 4 (9-10) Vessels	Season 4 (9-10) Trips
AREA 1	Yellowfin								
	Bigeye								
	Swordfish								
	Mix Pelagic								
	Subtotal								
AREA 2	Yellowfin								
	Bigeye								
	Swordfish								
	Mix Pelagic								
	Subtotal								
AREA 3	Yellowfin							3.2	9
	Bigeye	2.8	13						
	Swordfish					0.8	2		
	Mix Pelagic								
	Subtotal	*2.8*	*13*			*0.8*	*2*	*3.2*	*9*
	Bigeye	2.1	7						
	Swordfish								
	Mix Pelagic	18.5	52	52.0	214	22.0	72	4.1	7
	Subtotal	*20.6*	*60*	*52.0*	*214*	*22.0*	*72*	*4.3*	*8*
AREA 5	Yellowfin								
	Bigeye								
	Swordfish	11.7	26			9.7	19	17.8	22
	Mix Pelagic	4.0	10						
	Subtotal	*15.7*	*37*			*9.7*	*19*	*17.8*	*22*
TOTAL		**39.1**	**109**	**52.0**	**214**	**32.5**	**93**	**25.3**	**38**
FLEET 9 (AKU BOATS)									
AREA 1	Aku	4.5	91	4.3	118	5.6	115	5.3	72
AREA 2	Aku	2.0	33	0.7	16	3.8	62	7.6	81
TOTAL		**6.5**	**124**	**5.0**	**133**	**9.4**	**176**	**12.8**	**153**

Appendix 11.3 Optimal Resources Uses and Allocation from the Baseline Model

Species	Area	Stock	Stock by Seasons (%)				Catch		Stock Use in Seasons (%)				Catch by Fleet (%)								
		1000 lb	11-1	2-5	6-8	9-10	Amount	%	11-1	2-5	6-8	9-10	Rec.	Char-ter	Exp-ense	Com. HL	Com. TL	S. MP	M. MP	L. MP	Aku Boat
Yellowfin	1	4,575	8.3	16.9	64.5	10.3	4,575	100.0	100.0	100.0	100.0	100.0	17.1	9.6	3.6	48.6	20.8				0.3
	2	80	21.8	35.9	38.2	4.1	30	37.1	2.8	100.0	1.3	2.5		59.6		37.1	3.0				0.3
	3	651	25.3	22.7	37.9	14.2	644	98.8	100.0	100.0	100.0	91.8				51.1	39.5	0.3	1.6	7.6	
	4	786	12.3	58.0	23.5	6.3	709	90.1	100.0	84.6	100.0	85.0						33.7	11.3	55.1	
	5	70	48.6	14.7	24.4	12.3	58	83.6	100.0	63.3	84.4	41.6							25.6	74.5	
Subtotal		6,162	11.2	23.0	55.6	10.1	6,015	97.6	11.0	21.8	55.1	9.8	13.0	7.6	2.7	42.6	20.0	4.0	1.6	7.8	0.2
Bigeye	1	106	62.5	17.3	6.8	13.4	7	6.2	0.0	36.0	0.0	0.0			100.0						
	2	155	54.4	30.8	5.7	9.1	0	0.0	0.0	0.0	0.0	0.0									
	3	1,770	48.7	33.3	10.0	8.0	1,672	94.5	88.7	100.0	100.0	100.0				92.7		0.3	0.3	6.7	
	4	2,720	18.5	48.0	28.1	5.5	2,580	94.9	92.7	92.2	100.0	99.2						16.5	10.5	73.0	
	5	358	37.4	11.1	38.8	12.7	274	76.5	80.6	32.9	100.0	30.4							36.0	64.0	
Subtotal		5,110	32.3	39.1	21.4	7.2	4,533	88.7	26.2	35.5	21.1	6.0	0.0	0.0	0.1	34.2	0.0	9.5	6.7	48.4	0.0
Albacore	1	363	0.7	7.7	63.5	28.1	277	76.3	0.0	13.0	84.8	76.4	0.5		0.8	98.4	0.3				
	2	35	22.9	41.4	30.8	4.9	4	11.1	0.0	26.8	0.0	0.0				100.0					
	3	188	14.7	38.2	37.9	9.1	13	7.0	5.8	0.0	6.8	38.8						29.5	4.3	66.2	
	4	508	21.7	41.0	30.2	7.2	278	54.7	46.2	77.6	18.8	100.0						25.7	19.2	55.2	
	5	172	80.9	1.8	1.0	16.4	144	83.9	87.1	8.1	32.2	79.4							0.2	99.8	
Subtotal		1,264	22.7	25.7	37.0	14.7	715	56.6	13.7	13.4	18.2	11.3	0.2	0.0	0.3	38.6	0.1	10.5	11.4	33.7	0.0
Swordfish	1	30	1.3	58.5	38.9	1.3	13	42.0	0.0	12.6	88.0	26.7			17.6	82.4					
	2	46	4.1	50.3	39.6	5.9	0	0.0	0.0	0.0	0.0	0.0									
	3	277	9.3	28.7	60.7	1.3	125	45.0	2.9	100.0	26.1	12.4						0.2	63.8	35.9	
	4	6,926	8.6	70.0	21.1	0.3	6,926	100.0	100.0	100.0	100.0	100.0						5.6	1.2	93.2	
	5	2,417	23.5	13.0	24.4	39.1	2,214	91.6	99.0	62.9	86.3	100.0							13.8	86.2	
Subtotal		9,697	12.3	54.5	23.2	10.0	9,278	95.7	11.9	52.9	20.9	10.0	0.0	0.0	0.0	0.1	0.0	4.2	2.0	92.3	0.0
Blue Marlin	1	2,211	23.5	13.1	35.2	28.2	1,721	77.8	86.4	100.0	46.1	100.0	74.9	19.3	4.8	0.0	1.0				
	2	41	24.5	6.2	38.4	30.9	10	24.5	100.0	0.0	0.0	0.0					100.0				
	3	193	19.8	7.0	47.8	25.4	83	42.8	80.7	17.8	13.4	75.5				37.6	0.8	1.4	4.5	55.8	
	4	212	12.1	17.0	46.4	24.5	145	68.6	49.8	58.5	78.5	66.2						36.2	12.1	51.6	
	5	32	9.2	0.0	50.4	40.4	12	36.6	31.9	0.0	66.8	0.0							9.0	91.0	
Overall		2,690	22.2	12.7	37.2	27.9	1,971	73.3	18.8	11.7	17.0	25.8	65.4	16.9	4.2	1.6	1.4	2.7	1.2	6.5	0.0

Appendix 11.3 (Continued) Optimal Resources Uses and Allocation from the Baseline Model

Species	Area	Stock 1000 lb	Stock by Seasons (%) 11-1	2-5	6-8	9-10	Catch Amount	Catch %	Stock Use in Seasons (%) 11-1	2-5	6-8	9-10
Striped Marlin	1	582	34.7	41.7	14.2	9.4	547	94.1	85.1	98.2	100.0	100.0
	2	63	40.1	42.1	10.1	7.7	28	44.0	4.9	100.0	0.0	0.0
	3	349	41.8	40.1	13.8	4.4	49	14.0	10.8	8.4	13.0	100.0
	4	704	14.7	44.8	33.3	7.2	577	82.0	64.9	75.2	100.0	75.3
	5	61	37.6	8.4	38.5	15.5	42	68.5	76.5	100.0	72.6	21.8
Subtotal		1,758	28.4	41.5	22.5	7.7	1,242	70.7	15.6	29.5	19.3	6.3
Mahimahi	1	1,337	20.6	34.4	19.4	25.6	972	72.7	100.0	54.7	39.4	100.0
	2	60	26.0	29.4	17.4	27.2	41	69.0	100.0	8.9	100.0	84.6
	3	88	38.3	38.9	7.7	15.1	60	68.2	100.0	50.3	35.3	50.3
	4	167	5.2	54.0	26.4	14.4	107	64.0	63.2	56.5	69.6	82.3
Subtotal		1,679	20.1	35.9	20.2	23.9	1,198	71.4	19.8	19.1	9.6	22.8
Ono	1	864	8.2	50.6	32.7	8.7	558	64.5	65.1	72.9	50.0	69.9
	2	17	27.1	45.9	20.5	6.5	15	86.5	100.0	100.0	34.2	100.0
	3	73	21.3	36.3	16.4	26.0	28	39.2	18.6	22.7	5.8	100.0
	4	72	5.8	56.2	34.2	3.7	38	53.1	100.0	64.3	21.6	100.0
	5	1	25.2	0.0	62.2	12.6	1	87.1	100.0	0.0	100.0	0.0
Subtotal		1,028	9.3	49.8	31.5	9.5	641	62.3	5.6	34.9	14.5	7.3
Aku	1	2,323	18.8	20.7	38.2	22.3	2,323	100.0	100.0	100.0	100.0	100.0
	2	1,153	17.6	3.3	27.9	51.2	1,153	100.0	100.0	100.0	100.0	100.0
	3	14	10.4	46.0	39.6	4.0	6	46.3	25.9	0.0	100.0	100.0
	4	27	3.6	52.7	41.4	2.2	12	45.2	100.0	72.7	3.5	82.7
	5	0	60.7	39.3	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
Subtotal		3,517	18.3	15.3	34.8	31.6	3,495	99.4	18.3	15.0	34.5	31.6
Shark	1	47	16.9	30.0	37.6	15.5	21	45.1	0.0	100.0	37.5	6.4
	2	4	41.5	40.7	13.1	4.7	0	0.0	0.0	0.0	0.0	0.0
	3	31	49.3	26.6	15.9	8.2	4	11.6	8.7	7.3	11.4	43.6
	4	58	17.7	56.9	19.7	5.7	37	63.4	86.2	64.3	35.6	79.4
	5	14	37.1	7.4	44.0	11.6	10	70.8	100.0	20.7	61.9	43.1
Subtotal		154	26.2	37.6	26.4	9.7	71	46.3	10.0	23.4	9.8	3.2

Species	Area	Catch by Fleet (%) Rec.	Char-ter	Exp-ense	Com. HL	Com. TL	S. MP	M. MP	L. MP	Aku Boat
Striped Marlin	1	41.8	39.5	15.4	0.1	3.3				
	2		95.5			4.5				
	3						3.1	34.8	62.1	
	4						36.1	14.3	49.6	
	5							17.9	82.1	
Subtotal		18.4	19.5	6.8	0.0	1.6	16.9	8.5	27.1	0.0
Mahimahi	1	45.1	8.0	17.8	1.5	27.4				0.2
	2		27.4			67.3				5.3
	3				53.7	25.8	0.1	4.1	16.3	
	4						26.0	14.3	59.6	
Subtotal		36.6	7.4	14.4	3.9	25.9	2.3	1.7	7.0	0.3
Ono	1	50.5	2.1	36.6	1.6	9.3				
	2		83.4		0.5	16.1				
	3				10.5	81.4	2.5	3.0	2.7	
	4						53.1	13.4	33.5	
	5								100.0	
Subtotal		43.9	3.8	31.8	1.8	12.1	3.3	0.9	2.2	0.0
Aku	1	32.4	0.4	6.6	0.2	1.7				58.8
	2		0.1			0.0				99.9
	3				76.8	13.9	8.8		0.5	
	4						78.6	19.9	1.5	
	5									
Subtotal		21.5	0.3	4.4	0.3	1.1	0.3	0.1	0.0	72.0
Shark	1	52.4	20.6	10.5	15.3	1.2				
	2									
	3						3.3	18.1	78.6	
	4						12.7	17.3	70.1	
	5							2.2	97.8	
Subtotal		15.5	6.1	3.1	4.5	0.4	6.7	12.2	49.8	0.0

Appendix 11.3 (Continued) Optimal Resources Uses and Allocation from the Baseline Model

Species	Area	Stock	Stock by Seasons (%)				Stock Use in Seasons						Catch by Fleet (%)								
							Catch		(%)				Rec.	Char-ter	Exp-ense	Com. HL	Com. TL	S. MP	M. MP	L. MP	Aku Boat
		1000 lb	11-1	2-5	6-8	9-10	Amount	%	11-1	2-5	6-8	9-10									
Other	1	223	19.5	39.3	29.7	11.4	169	75.9	84.4	68.0	77.3	84.5	63.8	3.5	22.3	1.8	6.2				2.4
Pelagic	2	40	35.6	39.6	19.1	5.8	0	0.1	0.0	0.2	0.0	0.0				100.0					
	3	276	29.9	38.0	24.5	7.6	16	5.9	5.3	1.0	3.0	42.5					1.4	12.2	5.5	80.8	
	4	340	12.2	54.0	23.4	10.5	176	51.7	54.2	52.9	33.6	82.9						56.0	37.2	6.8	
	5	8	68.9	0.0	24.3	6.8	4	50.1	48.3	0.0	63.8	18.9								100.0	
Subtotal		**887**	**21.1**	**44.2**	**25.1**	**9.6**	**365**	**41.2**	**7.5**	**17.8**	**9.2**	**6.8**	**29.5**	**1.6**	**10.3**	**0.9**	**2.9**	**27.5**	**18.1**	**7.0**	**1.1**
Bottom	1	760	36.4	22.4	19.8	21.5	755	99.3	98.1	100.0	100.0	100.0	22.1	0.1	8.5	69.1	0.1				
Fish	2	5	1.7	83.4	7.5	7.4	4	83.5	0.0	100.0	0.0	0.0				100.0					
	3	25	36.1	49.8	14.1	0.0	7	29.7	0.0	59.8	0.0	0.0				88.4	11.6				
	5	116	58.6	0.0	0.0	41.5	115	99.1	98.5	0.0	0.0	100.0				100.0					
Subtotal		**1,115**	**35.4**	**21.7**	**16.3**	**26.6**	**1,018**	**91.3**	**30.3**	**21.3**	**13.5**	**26.2**	**16.4**	**0.1**	**6.3**	**77.0**	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**
Lobster	1	0	0.0	0.0	0.0	0.0	0		0.0	0.0	0.0	0.0									
	2	0	0.0	0.0	0.0	0.0	0		0.0	0.0	0.0	0.0									
	3	0	0.0	0.0	0.0	0.0	0		0.0	0.0	0.0	0.0									
	4	0	0.0	0.0	0.0	0.0	0		0.0	0.0	0.0	0.0									
	5	0	0.0	0.0	0.0	0.0	0		0.0	0.0	0.0	0.0									
Subtotal		**0**	**0.0**	**0.0**	**0.0**	**0.0**	**0**		**0.0**	**0.0**	**0.0**	**0.0**									
All others	1	39	33.7	26.1	18.5	21.7	36	90.9	100.0	97.3	65.5	90.6	21.6		12.4	65.7	0.4				
	2	4	27.5	37.9	30.3	4.3	0	1.6	0.0	4.1	0.0	0.0				100.0					
	3	1	12.1	69.2	7.7	11.0	1	100.0	100.0	100.0	100.0	100.0				26.1	29.0		15.1	29.9	
	4	2	22.9	23.3	12.0	41.8	2	76.9	0.0	99.0	100.0	100.0				81.4		18.6			
	5	1	29.9	0.0	0.0	70.1	1	99.0	100.0	0.0	0.0	99.7				100.0					
Subtotal		**47**	**32.3**	**27.0**	**18.8**	**22.0**	**39**	**82.5**	**28.7**	**23.1**	**10.7**	**19.9**	**19.7**	**0.0**	**11.4**	**66.3**	**0.7**	**0.8**	**0.2**	**0.4**	**0.0**

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