OVERVIEW OF THE LOWER COOK INLET AREA COMMERCIAL HERRING FISHERY AND RECENT STOCK STATUS

A REPORT TO THE ALASKA BOARD OF FISHERIES

by
Lee F. Hammarstrom
and
Edward O. Otis

Regional Information Report[a] 2A01-17

Alaska Department of Fish and Game
Division of Commercial Fisheries
Central Region
333 Raspberry Road
Anchorage, Alaska 99518-1599

November 2001

[a] Contribution from the Homer area office. The Regional Information Report Series was established in 1987 to provide an information access system for all unpublished divisional reports. These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate timely reporting of recently collected information, reports in this series undergo only limited internal review and may contain preliminary data; this information may be subsequently finalized and published in the formal literature. Consequently, these reports should not be cited without prior approval of the author or the Division of Commercial Fisheries.

TABLE OF CONTENTS

LIST OF HERRING TABLES

LIST OF HERRING FIGURES

OVERVIEW OF THE LOWER COOK INLET AREA COMMERCIAL HERRING FISHERY

INTRODUCTION

The Lower Cook Inlet (LCI) management area is comprised of all waters west of the longitude of Cape Fairfield, north of the latitude of Cape Douglas, and south of the latitude of Anchor Point, and is divided into five fishing districts (Figure 1). Commercial herring fishing has historically occurred in four of the five management districts, with the Barren Islands District being the sole area where commercial herring fishing has not occurred. LCI herring fishing first occurred in the Southern District in 1914 with development of a gillnet fishery within Kachemak Bay (Figure 2). Eight saltries, six near Halibut Cove, were operating during the peak of the fishery. A purse seine fishery in Kachemak Bay began in 1923, but after three successive years of average annual harvests approaching 8,000 short tons (st; 1 short ton = 2,000 pounds), herring populations, and the fishery, collapsed.

The next LCI herring fishery began in 1939 and was centered in the Resurrection Bay and Day Harbor areas of the Eastern District (Figure 2). Product from this purse seine fishery was used exclusively for oil and meal reduction. Although the fishery continued through 1959, peak harvests occurred from 1944 to 1946 and averaged 16,000 st each of those years. After this time period, stocks sharply declined, apparently due to over-exploitation.

HISTORY AND DEVELOPMENT OF THE SAC ROE FISHERY

Introduction

Japanese market demand for salted herring roe resulted in development of a sac roe fishery in the 1960s. The relatively high prices paid to fishermen caused rapid expansion of the fishing fleet and harvest. In an effort to decrease the risk of a stock collapse and to sustain

the fishery, the department established conservative management strategies and guideline harvest levels. Following a period of suspected overexploitation, herring stocks throughout LCI generally declined after 1973. Concern over the declining trend led the Alaska Board of Fish and Game, prior to the start of the 1974 season, to establish a quota of 4,000 st for all of LCI.

The only allowable gear type in the LCI herring sac roe fishery is purse seine. The limited entry permit system for sac roe herring seining in Cook Inlet was implemented in 1977, and at the present time 74 permanent and two interim use permits are issued for the management area.

Outer/Eastern Districts

During the early years of sac roe herring fishing in LCI, seining occurred primarily in the Outer and Eastern Districts (Figure 2), with the majority of effort and harvest once again concentrated in Resurrection Bay of the Eastern District. The first major harvest occurred in 1969, when 760 st of herring were taken in the Eastern District (Table 1). The catch increased dramatically in 1970 to a record high of 2,100 st in this district, but the stocks, and resultant harvests, declined over the next three seasons. The Alaska Board of Fish and Game allocated 1,000 st from the total LCI quota of 4,000 st to each of the Outer and Eastern Districts beginning with the 1974 season. However, stock abundance continued to decline and these quotas were never achieved. As a result, the Outer and Eastern Districts were closed to herring fishing from 1975 to 1984.

In 1985, the sac roe fishery was allowed to resume in the Outer and Eastern Districts on a very conservative basis, even though no noticeable change in spawning biomass had been observed. Because of the stocks' reduced abundance and extreme vulnerability to fishing, guideline harvest levels were set at 150 to 200 st for each of the four fishing areas created within these two districts. Fishing effort in 1985 was minimal and the majority of the

harvest (216 st) once again occurred in Resurrection Bay. Only limited and sporadic harvests occurred in these two districts since 1985, with the majority of both the herring catch and the observed biomass comprised of fish age 4 and younger.

Despite considerable opportunity for exploratory fishing on a daily basis in the Outer and Eastern Districts during 1991 and 1992, the predominance of juvenile herring and the history of marginally acceptable roe recoveries from fish caught in these areas contributed to a lack of interest by fishermen and processors. These conditions prevailed from 1993 - 2001 and, consequently, the Outer and Eastern Districts were not opened to purse seining in any of the past nine seasons.

NOTE: Proposal #2 seeks to close the Outer and Eastern Districts to commercial herring fishing until a formal regulatory management plan with specific criteria is adopted. Proposal #3 seeks to repeal regulatory language allowing commercial herring fishing in the Outer and Eastern Districts.

Kamishak Bay District

Since 1973, most LCI sac roe harvests occurred within the Kamishak Bay District. Historical commercial harvests have ranged from a low of 240 st taken in 1973 to a high of 6,100 st taken in 1987 (Table 1), with estimated exvessel values ranging from $70,000 to $9.30 million (Table 2). After the initial harvest in 1973, Kamishak herring catches increased dramatically over the next three years, peaking at 4,800 st in 1976. Harvests dropped sharply during the ensuing three seasons, and by 1980 the stocks had declined to a point that the Kamishak Bay fishery was closed entirely beginning with the 1980 season.

Although the Kamishak Bay District herring season remained fairly constant during the 1970's, roughly from late April through June, a significant management change occurred

during this time. From 1973 through 1977, the fishery was basically “open season until closed”, but in 1978 it was changed to “closed season until opened by emergency (Table 5). This change required more active assessment of the herring stocks by the Department in order to determine appropriate opening times and harvest levels.

Herring stocks appeared to respond positively and rebuild rather quickly following the 5-year closure that began in 1980. The fishery was reopened in 1985, with a resulting harvest of 1,100 st (Table 1). Beginning in 1985, the commercial fishery in Kamishak Bay District was regulated to achieve a 10 - 20% exploitation rate mandated by the Board of Fisheries. By 1989, fishing efficiency had increased to a level where intensive regulatory management was required to maintain harvests within guideline levels, to direct the fishery at herring aggregations with high quality roe, and to protect younger age herring from harvest. From 1985 through 1989, harvests averaged about 3,900 st, with a peak catch of 6,100 st in 1987 (Table 1).

Management of the Kamishak Bay District between 1990 and 1997 stabilized the average harvest at roughly 40% of the 1987 record high catch. However, hindcast biomass estimates generated by an age-structured-assessment (ASA) model show that stocks were declining steadily throughout the decade (Table 3, Figure 4), and by 1998 the total commercial herring catch in the Kamishak Bay District totaled only 300 st despite several extended district-wide openings. The fishery has been closed beginning with the 1999 season due to low abundance levels.

The present Kamishak Bay District Herring Management Plan (KBDHMP) was formally adopted into regulation beginning with the 1993 season. Highlights of the plan include a minimum biomass threshold of 8,000 st, a maximum exploitation rate of 20% (scaled depending on the forecasted biomass), and a management strategy intended to limit the harvest of herring age 5 and younger. In addition, because the spawning stock of Kamishak Bay herring is believed to reside in waters of north Shelikof Strait in the Kodiak

Management Area for at least a part of the year, the KBDHMP dictates that 10% of the allowable harvest of Kamishak Bay herring be allocated to the Shelikof food/bait fishery.

NOTE: Staff proposal #1 seeks to adopt new regulatory language to amend the present Kamishak Bay District Herring Management Plan.

Southern District

Sac roe herring seining in the Southern District began in the early 1960's, but catches were sporadic and relatively insignificant until 1969. That year, over 550 st were taken, followed the next season by a district record high harvest of 2,700 st (Table 1). Although commercial harvests continued during the 1970's, albeit at much lower levels, observed low abundance of herring has virtually precluded commercial openings during the past 20 years in the Southern District. The only exception occurred in 1989, when 10 vessels in a single 2.5-hour opening harvested 170 st of herring averaging 8.9% roe recovery.

NOTE: Proposal #2 seeks to close the Southern District to commercial herring fishing until a formal regulatory management plan with specific criteria is adopted. Proposal #3 seeks to repeal regulatory language allowing commercial herring fishing in the Southern District.

2001 SEASON OVERVIEW

Assessment Methods

The primary method of herring biomass assessment in LCI is the aerial survey. Aerial surveys are conducted annually throughout the herring-spawning season in the Kamishak Bay and Southern Districts, from late April through early June, to determine relative abundance and distribution of herring. Aerial surveys of the Outer and Eastern Districts are not normally conducted due to the size of the area and the characteristically poor weather in the Gulf of Alaska, which precludes surveys on a regular basis and makes aerial biomass estimation in these districts impractical. Data collection methods in the Kamishak Bay and Southern Districts are consistent between seasons, with numbers and distribution of herring schools, location and extent of milt, and visibility factors affecting survey results recorded on index maps for each survey. Three standard conversion factors are used to estimate herring biomass based on each 538 ft^2 (50 m^2) of school surface area sighted and water depth: 1) 1.52 st for water depths of 16 ft or less); 2) 2.56 st for water depths between 16 and 26 ft; and 3) 2.83 st for water depths greater than 26 ft (Lebida and Whitmore 1985).

Due to invariably poor weather and water clarity, aerial surveys rarely provide reliable estimates of total biomass returning to Kamishak District Bay waters (Otis et al. 1998). As a result, an age-structured-assessment (ASA) model has been used for the past eight years to forecast herring abundance for Kamishak Bay, as well as to "hindcast" previous years' total abundance. This dynamic model incorporates a variety of heterogeneous data sources including: times series of commercial catch age composition; total run age composition; and aerial survey biomass estimates from years with adequate survey conditions and coverage. The model simultaneously minimizes the differences between expected and observed return data for each of its components, updates hindcasts of previous years' abundance, and returns a forecasted estimate of the following year's return.

Another tool the Department annually utilizes to aid in herring assessment in the Kamishak Bay District, and opportunistically in the Southern District, is a chartered commercial seine vessel. In years when a commercial fishery does not occur, the Department is unable to utilize the fleet to collect samples for age composition analysis. The chartered commercial purse seine vessel is able to collect such samples and related information to further aid in understanding the dynamics of the herring stocks. As long as sufficient funding is available, separate sampling charters are conducted to sample different portions of the spawning migration (early and late). In years when a fishery occurs, traditionally in the early part of the migration, a single "late season" sampling charter is employed to obtain a more complete picture of the overall return. Hydroacoustic observations and water temperature/depth parameters are concurrently accumulated during the charters. The information gathered during these sampling efforts provides age class data that: 1) allow the staff to generate an age composition estimate of the overall biomass observed by aerial surveyors throughout the entire duration of the spawning migration; and 2) facilitates the evaluation of the relative strength of recruiting year classes. This is critical in generating the annual herring forecast. The charters further serve to informally verify the relative magnitude of herring biomass observed by aerial surveyors.

Kamishak Bay District 2001 Season Summary

Aerial survey coverage for Kamishak Bay in 2001 was considered good to excellent, while overall observation conditions were considered only fair. A single 7-day period in early May represented the longest time period during which no surveys were flown due to poor weather. A total of 15 surveys were completed in the Kamishak Bay District. Despite the good coverage, Department aerial surveyors actually observed only about 3,400 tons of herring in the Kamishak Bay District this season, in sharp contrast to the 2000 season's observed total of around 8,100 tons. The 2001 observation was somewhat discouraging in that the Department had been guardedly optimistic about the Kamishak herring stocks prior

to the season and was expecting to see a significant increase in the biomass resulting from a relatively strong showing of age-3 recruit fish in 2000.

Good weather contributed to the success of the Department's two 10-day vessel charters to collect age composition samples during the periods April 24 – May 2 and May 14 - 23. During the 20 days spent in the district, the contracted vessel made a cumulative total of 13 sets, resulting in the collection of nearly 4,600 fish for age/weight/length (AWL) analysis. The second charter, to collect age composition samples during the latter portion of the return in 2001, was particularly crucial in documenting the unexpected weakness in the recruit component within the population. Information and samples collected during the Department's two charters indicated that the predicted influx of young, newly recruited fish did not materialize to the extent suggested by the previous year's information.

Although herring biomass had been declining in Kamishak Bay through 1998, that trend now appears to have reversed and has been slowly increasing since that time. The ASA model estimated the total 2001 return at 7,730 st (Otis *in preparation*; Tables 3 and 4, Figure 4), a modest increase over the 2000 hindcast estimate of 6,320 st. Recruitment into the spawning population did occur in 2001, but the magnitude of this recruitment does not appear to be as great as was anticipated. The overall return this season was dominated by fish age 4 and 5 at 24% and 30% of the biomass by weight, respectively (Table 4, Figure 5). While the 1993 and 1994 cohorts appeared relatively strong at 12-13% each of the forecasted biomass, they were estimated to be only about one-quarter the size of the very strong 1988 cohort that supported the commercial fishery throughout most of the 1990's.

Southern District 2001 Season Summary

A total of seven aerial surveys of the Southern District were flown between April 24 and May 23 in 2001, all conducted under relatively good conditions. The 2001 run biomass, estimated as the sum of all daily biomass estimates, totaled only 1,380 st, a sharp decrease from the previous year's estimate of 7,200 st, which was the highest in many years. The peak 2001 individual biomass survey (791 st) occurred on April 30, with the majority of herring observed in Tutka Bay. Peak surveys in areas where herring historically have been observed were as follows: Mallard Bay, 80 st on May 14; east of the Homer Spit/Mud Bay, 180 st on April 30; Glacier Spit/Halibut Cove, 150 st on May 10; and Tutka Bay, 610 st on April 30. A chartered seine vessel opportunistically collected 1,200 herring for AWL analysis during two sets in the Southern District this season, one set near Glacier Spit and the other by Rusty's Lagoon. Age-3, -4, and -5 fish dominated the combined results from these samples at 29%, 20%, and 18%, respectively. As has been the persistent trend over the past two decades, low abundance levels in the Southern District precluded any commercial fishing during the 2001 season.

Outer/Eastern District 2001 Season Summary

As in previous recent seasons, no herring assessment occurred in the Outer and Eastern Districts during 2001. Unlike the Southern and Kamishak Bay Districts, historical samples from the Outer and Eastern Districts have contained up to 14% age-2 (sexually immature) herring. Although formal sampling has not occurred in recent years and was very limited in previous years, two small, informal samples of herring from two separate schools observed aerially in Day Harbor (Eastern District, late June) and Port Dick (Outer District, early July) were obtained by handline jigging during the 2000 season. Scales were not collected for age composition analysis, but size of all fish caught suggested that they were age-2 juveniles. No discernible shift to older age herring has ever been observed in this area, suggesting the

possibility that the Outer and Eastern Districts may be feeding and rearing grounds for juvenile fish from another area.

New Research

Two additional research projects were recently undertaken to better understand Kamishak Bay herring stock structure and it's relationship to other North Gulf of Alaska herring stocks. The KBDHMP dictates that 10% of the allowable harvest for Kamishak Bay be allocated to the Shelikof food/bait fishery because it appears these two stocks mix during part of the year around the north end of Shelikof Strait (Johnson et. al. 1988; unpublished data). The extent to which these stocks intermix is poorly understood, however, the ramifications of their mixing greatly complicate the assessment and management of each stock. Therefore, the department successfully applied for a grant from the Exxon Valdez Trustee Council (EVOS-TC) to investigate the feasibility of using two relatively new stock identification techniques, fatty acid composition of heart tissue and elemental composition of otoliths, to distinguish between several Alaska herring stocks. Representative samples were collected from Sitka, Prince William Sound, Kamishak, Kodiak, and Togiak spawning aggregations during the spring of 2001. Chemical analysis of those samples is underway and results should become available during 2002.

The second recent research project undertaken by the Department also stems from outside funding. The Department successfully applied for funding from the National Marine Fisheries Service to synthesize all of the historical Kamishak Bay herring stock assessment and commercial fishery data into a geo-referenced database (ArcView). Much of this historical information, dating back to 1973, exists only in hard copy form on aerial survey maps. During the next year, the department plans to capture those data into electronic maps, making them available for a variety of more in-depth analyses.

2002 SEASON OUTLOOK

Kamishak Bay District

The forecasted herring biomass generated by the ASA model for 2002 in the Kamishak Bay District is 9,020 st (Table 4, Figure 4). Although this total exceeds the current regulatory threshold of 8,000 st for which a commercial harvest can occur, nearly 40% of the predicted return in 2002 will be comprised of fish age 5 and younger, with the single age-5 year class projected to make up over one-fourth of the overall return (Table 4, Figure 5). Since the KBDHMP directs the Department to limit the harvest of fish age-5 and younger, the sac roe fishery in the Kamishak Bay district will remain closed for the 2002 season. The resource, and hence the commercial fishery, is best served by protecting the remaining spawning population in order to rebuild it to a harvestable level.

Without a commercial fishery in 2002, the Department's ability to collect age composition information will be greatly reduced. The Department expects to once again obtain samples with a chartered commercial seine vessel throughout the duration of the 2002 run, with sufficient funding expected for both an early and a late season charter. The Department will also attempt to conduct comprehensive aerial surveys throughout the spawning season, from mid-April to early June, as conditions permit.

Other Districts

Based on the persistent trend of low herring abundance in the Southern District and a historical preponderance of juvenile herring in the Outer and Eastern Districts, no commercial herring harvests are anticipated during 2002 in any of these areas. Monitoring of the Southern District herring stocks will occur as in the past through the use of aerial surveys in conjunction with test fishing samples collected on an opportunistic basis.

KAMISHAK BAY DISTRICT HERRING BIOMASS THRESHOLD ANALYSIS

INTRODUCTION

Threshold management policy is a relatively recent concept (Quinn et. al. 1990). Two general types of thresholds are commonly referenced in fisheries management - conservation thresholds and productivity thresholds. A *conservation threshold* is intended to represent the stock abundance below which full recovery is uncertain due to reproductive failure. A firm understanding of the stock-recruitment relationship is necessary to establish a conservation threshold. More commonly used in the management of exploited fish populations is the *productivity threshold*. Productivity thresholds represent the lowest level from which a population can quickly rebound to commercial viability and are intended to facilitate sustained annual yields.

Quantitative methods for establishing productivity thresholds were only recently standardized. In the past decade, these methods have been used to set productivity thresholds for most of Alaska's major herring stocks (Zheng et. al. 1993; Funk and Rowell 1995; Carlile 1998). Productivity thresholds are generally set at 25% of the average unfished biomass (AUB), a theoretical value derived from a simple population simulation model. While complete knowledge of the stock-recruitment relationship is not required to estimate the AUB and establish a productivity threshold, estimates of some basic population parameters are needed, such as age-at-maturity, survival, and weight-at-age.

Prior to the development of standard quantitative approaches, herring managers sometimes set productivity thresholds based on their knowledge of the herring stock and its exploitation history. This was the case in the 1980's when the Department established a threshold of 8,000 st for the Kamishak District sac roe herring fishery (Schroeder 1989). As part of a

process to reevaluate the KBDHMP following the second fishery closure in the 29-year history of the fishery, the department recently conducted a threshold analysis of the Kamishak Bay herring stock.

THRESHOLD ANALYSIS METHODS

Standard quantitative techniques were used to simulate Kamishak Bay herring biomass trends over a period of 1,000 years. Only simulation years 251-1000 were used to estimate the AUB to allow the model to stabilize (Figure 6). Estimates for various population parameters were derived from the ASA model the Department uses to forecast the Kamishak Bay herring stock and establish the coming years' harvest guideline (Table 6). Three different recruit models were evaluated to determine their effect on the population simulation results. Because herring recruitment success in Kamishak Bay appears be related more to environmental factors than spawning stock level (Figure 7), an empirical, density-independent recruit model, based on ASA-model hindcast estimates of recruit abundance over the past 24 years, was chosen.

Because the simulation model randomly selected a recruit abundance from the pool of empirical observations at the start of each simulation year, each run of the model yielded slightly different results. Accordingly, ten iterations of the simulation model were run to calculate the mean AUB before establishing the threshold. The same model was then rerun ten times while simulating an average exploitation rate of 15%, the maximum level proposed by the Department in it's revised KBDHMP (see Proposal #1). This evaluated the effect the threshold would have on average yield and closures to the fishery.

THRESHOLD RESULTS AND DISCUSSION

The mean AUB from the ten population simulations was 22,760 st (range: 21,670 - 24,100 st; Table 7). Applying the standard 25% to this value yielded a recommended

productivity threshold of 5,690 st. The average minimum and maximum biomass level in the simulations was 8,940 st and 40,390 st, respectively. The Department recommends rounding the 5,690 st threshold up to 6,000 st for two reasons: (1) it introduces more conservatism to a fishery that has experienced two multi-year closures during its 29-year history; and (2) 6,000 st is still less than the lowest minimum biomass (6,070 st) projected during the ten simulations that included 15% exploitation. Thus, it is unlikely that this slight increase in the threshold would preclude future fishing opportunities.

When a 15% exploitation rate was included, the average yield over the 750-year simulation was 1,960 st (Table 8). That value is 29% lower than the actual, overall average yield from the Kamishak Bay sac roe herring fishery, and 38% lower than the average yield when excluding the three low-harvest years that immediately preceded the fishery closures. The average minimum and maximum yield indicated by the simulation model was 720 st and 3,600 st, respectively. It is informative to note that the actual maximum yield during the 29-year history of the Kamishak fishery was 6,130 st, 70% higher than the maximum harvest projected by the simulation model. Of further interest is the fact that that during all simulations, the stock biomass remained above the threshold, avoiding the need to close the fishery. A more detailed review of the methods and results associated with this threshold analysis will be provided in an oral report and committee deliberation materials.

REFERENCES

Carlile, D. 1998. Estimation and evaluation of a harvest threshold for management of the Sitka herring sac roe fishery based on a percentage of average unfished biomass. Alaska Department of Fish and Game, Regional Information Report No. 1J98-18. 21 p.

Funk, F., and K.A. Rowell. 1995. Population model suggests new threshold for managing Alaska's Togiak fishery for Pacific herring in Bristol Bay. Alaska Fisheries Research Bulletin 2:125-136.

Johnson, B.A., C. Burkey, and D. Gaudet. 1988. Stock identification of Pacific herring in the bait fishery in Shelikof Strait, Alaska, 1985-86. Alaska Department of Fish and Game, unpublished report. 28 p.

Lebida, R.C., and D.C. Whitmore. 1985. Bering Sea Aerial Survey Manual. Alaska Department of Fish and Game, Bristol Bay Data Report No. 85-2. 31 p.

Quinn, T.J., II, R. Fagen, and J. Zheng. 1990. Threshold management policies for exploited populations. Canadian Journal of Fisheries and Aquatic Sciences 47:2016-2029.

Otis, E.O., W.R. Bechtol, and W.A. Bucher. 1998. Coping with a challenging stock assessment situation: the Kamishak Bay sac-roe herring fishery. Pages 557-573 In Fishery Stock Assessment Models: Proceedings of the International Symposium on Fishery Stock Assessment Models for the 21st Century, October 8-11, 1997, Anchorage, Alaska. Eds. F. Funk, T.J. Quinn, J. Heifetz, J.N. Ianelli, J.E. Powers, J.F. Schweigert, P.J. Sullivan, and C.-I. Zhang. University of Alaska Sea Grant College Program AK-SG-98-01.

Otis, E.O. *In preparation.* Forecast of the Kamishak herring stock in 2002. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report, Anchorage.

Schroeder, T.R. 1989. A summary of historical data for the Lower Cook Inlet, Alaska, Pacific herring sac roe fishery. Alaska Department of Fish and Game Fishery Research Bulletin 89-04. 116 p.

Zheng, J., F. Funk, G.H. Kruse, and R. Fagen. 1993. Evaluation of threshold management strategies for Pacific herring in Alaska. Pages 141-165 *in* G. Kruse, D.M. Eggers, R.J. Marasco, C. Pautzke, and T.J. Quinn II (Editors), Proceedings of the International Symposium on Management Strategies for Exploited Fish

Populations. Alaska Sea Grant College Program Report No. 93-02, University of Alaska Fairbanks.

Table 1. Commercial catch of Pacific herring (*Clupea pallasi*) in short tons and effort in number of permits by district in the commercial sac roe seine fishery, Lower Cook Inlet, 1961 – 2001[a].

	Southern		Kamishak		Eastern		Outer		Total	
Year	Tons	Permits	Tons	Permits	Tons	Permits	Tons	Permits	Tons	Permits
1961	0		0		1		0		1	
1962	0		0		0		0		0	
1963	1		0		0		0		1	
1964	0		0		0		0		0	
1965	2		0		0		0		2	
1966	0		0		7		0			7
1967	0		0		0		0			0
1968	20		0		0		0			20
1969	551		0		758		38			1,347
1970	2,709		0		2,100		0			4,809
1971	13	2			831	22			844	24
1972	1	1			30	1			31	2
1973	204	16	243	14	831	25	301	12	1,579	37
1974	110	7	2,114	26	47	5	384	26	2,655	45
1975	24	5	4,119	40					4,143	41
1976	0		4,842	66					4,842	66
1977	291	13	2,908	57					3,199	58
1978	17	7	402	44					419	44
1979	13	3	415	35					428	36
1980										
1981	---		---		---		---		---	
1982	---		---		---		---		---	
1983	---		---		---		---		---	
1984	---		---		---		---		---	
1985	---		1,132	23	204	7	12	2	1,348	29
1986	---		1,959	54	167	4	28	3	2,154	57
1987	---		6,132	63	584	4	202	9	6,918	69
1988	---		5,548	75	0	0	0	0	5,548	75
1989	170	6	4,801	75	0	0	0	0	4,971	75
1990	---		2,264	75	---		---		2,264	75
1991	---		1,992	58	0	0	0	0	1,992	58
1992	---		2,282	56	0	0	0	0	2,282	56
1993	---		3,570	60	---		---		3,570	60
1994	---		2,167	61	---		---		2,167	61
1995	---		3,378	60	---		---		3,378	60
1996	---		2,984	62	---		---		2,984	62
1997	---		1,746[b]	45[b]	---		---		1,746	45
1998	---		331[b]	20[b]	---		---		331	20
1999	---		100[c]	1[c]	---		---		100	1
2000	---		---		---		---		---	
2001	---		---		---		---		---	
Averages:										
1971-80	75	7	1,671	40	435	13	171	10	2,016	39
1981-90	170	6	3,639	61	191	3	48	3	3,867	63
1991-2000			2,061	53					2,061	53
1981-2000			2,692	56	136	2	35	2	2,784	57

[a] Data source: ADF&G fish ticket database.

[b] Includes both commercial harvest and ADF&G test fish harvest.

[c] Commercial fishery closed, ADF&G test fish harvest only.

Table 2. Preseason estimates of biomass and projected commercial sac roe seine harvests, and actual harvests, for Pacific herring (*Clupea pallasi*) in short tons, average roe recovery, numbers of permits making landings, and exvessel value in millions of dollars, Kamishak Bay District, Lower Cook Inlet, 1981 - 2001.

Year	PRESEASON Forecasted Biomass (st)	PRESEASON Projected Harvest (st)[a]	Actual Commercial Harvest (st)[a]	Average Roe %	No. of Permits w/Landings	Exvessel Value[b] ($$ millions)
1981	[c]	---	CLOSED	---	---	---
1982	[c]	---	CLOSED	---	---	---
1983	[c]	---	CLOSED	---	---	---
1984	[c]	---	CLOSED	---	---	---
1985	[c]	[d]	1,132	11.3	23	1.00
1986	[c]	[d]	1,959	10.4	54	2.20
1987	[c]	3,833	6,132	11.3	63	8.40
1988	[c]	5,190	5,548	11.1	74	9.30
1989	37,785	5,000	4,801	9.5	74	3.50[e]
1990	28,658	2,292	2,264	10.8	75	1.80
1991	17,256	1,554	1,992	11.3	58	1.30
1992	16,431	1,479	2,282	9.7	56	1.40
1993	28,805	2,592	3,570	10.2	60	2.20
1994	25,300	3,421	2,167	10.6	61	1.50
1995	21,998	2,970	3,378	9.8	60	4.00
1996	20,925	2,250	2,984	10.1	62	6.00[f]
1997	25,300	3,420	1,746	9.3	45	0.40
1998	19,800	1,780	331	8.5	20	0.07
1999	[f]	---	CLOSED	---	---	---
2000	6,330	---	CLOSED	---	---	---
2001	11,352	---	CLOSED	---	---	---
1981-2000 Average	22,887	2,982	2,878	10.3	56	3.08

[a] Kamishak Bay allocation only, does not include Shelikof Strait food/bait allocation.
[b] Exvessel values exclude any postseason retroactive adjustments (except where noted).
[c] Prior to 1989, preseason forecasts of biomass were not generated.
[d] Prior to 1987, preseason harvest projections were not generated.
[e] Includes retroactive adjustment.
[f] 1999 preseason biomass calculated as a range of 6,000 to 13,000 st.

Table 3. Estimates of Pacific herring (*Clupea pallasi*) total biomass in short tons using two different methods, actual commercial sac roe seine harvest in short tons, and percent exploitation, Kamishak Bay District, Lower Cook Inlet, 1981 - 2001.

Year	Aerial Survey Total Biomass Estimate (st)[a]	ASA Model Total Biomass Estimate (st)[b,c]	Actual Commercial Harvest (st)	Estimated Exploitation Rate (%)[b]
1981	5,130	12,590	CLOSED	----
1982	4,835	20,356	CLOSED	----
1983	4,750	24,552	CLOSED	----
1984	6,500	26,237	CLOSED	----
1985	13,320	30,093	1,132	3.8
1986	26,001	29,843	1,959	6.6
1987	35,332	32,473	6,132	18.9
1988	29,548	26,869	5,548	20.6
1989	35,701	23,450	4,801	20.5
1990	19,664	17,534	2,264	12.9
1991	18,163[e]	16,356	1,992	12.2
1992	24,077	16,228	2,282	14.1
1993	32,439	17,914	3,570	19.9
1994	25,344[e]	14,929	2,167	14.5
1995	25,115	13,920	3,378	24.3
1996	21,121	10,080	2,984	29.6
1997	--------	6,431	1,746	27.1
1998	--------	4,736	331	7.0
1999	--------	5,165	CLOSED	----
2000	--------	6,231	CLOSED	----
2001	--------	7,773	CLOSED	----
1981-2000 Average	20,214	17,799	2,878	16.2

[a] Diverse methods have been used to generate historical aerial survey biomass estimates; after 1989, see LCI herring forecast report or statewide herring forecast document to determine specific method for individual year.

[b] Figures are based on the best available data at the time of publishing and are subject to change; therefore all figures herein supercede those previously reported.

[c] ASA model integrates heterogeneous data sources and simultaneously minimizes differences between observed and expected return data to forecast the following year's biomass as well as hindcast previous years' biomass.

[d] No data available.

[e] Due to poor aerial survey conditions, biomass was calculated from the preseason estimate of abundance, adjusted to match observed age composition samples in the commercial catch.

Table 4. Total biomass estimates and commercial catch of Pacific herring (*Clupea pallasi*) in short tons by age class, Kamishak Bay District, Lower Cook Inlet, 2001, and 2002 forecast.

Age	2001 Est. Spawning Biomass	Percent by Weight	2001 Commercial Harvest[a]	Percent by Weight	2001 Total Biomass	Percent by Weight	2002 Forecast Biomass	Percent by Weight
1								
2								
3	413	5.3			413	5.3	406	4.5
4	1,825	23.6			1,825	23.6	545	6.1
5	2,319	30.0			2,319	30.0	2,363	26.2
6	740	9.6			740	9.6	2,692	29.9
7	948	12.3			948	12.3	714	7.9
8	999	12.9			999	12.9	904	10.0
9	277	3.6			277	3.6	940	10.4
10	64	0.8			64	0.8	288	3.2
11	54	0.7			54	0.7	75	0.8
12	28	0.4			28	0.4	58	0.6
13+	66	0.9			66	0.9	36	0.4
TOTALS	7,733	100.1	0		7,733	100.1	9,020	100.00

[a] Due to the low forecasted biomass, the commercial herring fishery in Kamishak Bay was not opened in 2001.

Table 5. Summary of herring sac roe seine fishery openings and commercial harvests in the Kamishak Bay District of Lower Cook Inlet, 1969 - 2001.

Year	Dates of Openings	Total Hrs. Open	Harvest (short tons)	Catch Rate (short tons/ hour open)	Number of Permits w/Landings
1969-73	No closed periods				
1974	1/1 - 5/20		2,114		26
1975	1/1 - 6/6	(Closed Iniskin Bay 5/17)	4,119		40
1976	1/1 - 5/21	(Closed Iniskin Bay 5/17; reopened Kamishak 6/2)	4,824		66
1977	1/1 - 5/31	(Closed Kamishak Dist. 5/12; reopened 5/14 - 5/17; reopened 5/29 - 5/31)	2,908		57
1978[a]	4/16 - 5/31	96	402	4.2	44
1979	5/12 - 5/15	72	415	5.8	36
1980 through 1984	CLOSED	0	0		
1985	4/20 - 6/15	1,350 (56.2 days)	1,132	0.8	23
1986	4/20 - 6/13	1,303 (54.3 days)	1,959	1.5	54
1987	4/21 - 4/23	65	6,132	94.3	63
1988	4/22 - 4/29	42	5,548	132.1	74
1989	4/17 - 4/30	24.5	4,801	196.0	74
1990	4/22 - 4/23	8	2,264	283.0	75
1991	4/26	1	1,922	1,922.0	58
1992	4/24	0.5	2,282	4,564.0	56
1993	4/21	0.75	3,570	4,760.0	60
1994	4/25 4/29	0.5 1.0	778 1,338	1,556.0 1,338.0	35 53
1995	4/27 4/28	0.5 1.0	1,685 1,693	3,370.0 1,693.0	45 44
1996	4/24	0.5	2,984	5,968.0	62
1997	4/25[b] 4/29 4/30 5/1 5/22[d]	0.5 1.5 8.0 12.0 [d]	0 1,580 61 51 54	0 1,053.3 7.6 4.3 [d]	0 42 [c] 4 -
1998	4/21 4/22 5/14[d] 5/22[d]	0.5 2.0 [d] [d]	160 136 10 23	320.0 68.0 [d] [d]	12 11 - -
1999	CLOSED	CLOSED	100[d]	[d]	-

- continued -

Table 5. (page 2 of 2)

Year	Dates of Openings	Total Hrs. Open	Harvest (short tons)	Catch Rate (short tons/ hour open)	Number of Permits w/Landings
2000	CLOSED	CLOSED	0		
2001	CLOSED	CLOSED	0		

[a] Management by emergency order began.
[b] Despite the open fishing period, the entire fleet collectively agreed not to fish due to ongoing price negotiations with processors.
[c] To comply with **AS 16.05.815 CONFIDENTIAL NATURE OF CERTAIN REPORTS AND RECORDS**, effort data has been masked where fewer than four vessels fished in a given area.
[d] ADF&G test fishing harvest.

Table 6. Population parameter estimates derived from the ASA model that were used to simulate Kamishak Bay herring biomass trends.

	Age										
Population Parameters	3	4	5	6	7	8	9	10	11	12	13+
Survival:	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%
Maturity:	0.23	0.48	0.74	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Seine Selectivity:	0.04	0.15	0.40	0.72	0.91	1.00	1.00	1.00	1.00	1.00	1.00
Weight:	83	125	158	190	213	235	249	269	278	282	316

Table 7. Average unfished biomass (AUB) and productivity threshold estimated by running 10 iterations of a Kamishak Bay herring population simulation model, based on an empirical, density independent recruit model.

Simulation Number	Threshold % of AUB	Threshold (st)	MILLIONS OF RECRUITS				BIOMASS (st)			
			Mean	Max.	Min.	Med.	Average	Median	Minimum	Maximum
1	25%	5,416	74	223	11	48	21,666	21,669	10,336	36,543
2	25%	5,810	76	223	11	61	23,240	23,031	8,464	44,343
3	25%	5,714	76	223	11	48	22,856	22,342	9,743	39,305
4	25%	6,025	78	223	11	61	24,099	23,783	8,673	44,371
5	25%	5,710	77	223	11	61	22,838	22,598	7,655	40,014
6	25%	5,466	75	223	11	48	21,866	21,678	6,977	40,806
7	25%	5,579	74	223	11	48	22,317	21,750	12,182	41,052
8	25%	5,608	75	223	11	61	22,434	21,982	8,063	38,362
9	25%	5,765	76	223	11	48	23,062	22,620	9,089	40,787
10	25%	5,800	76	223	11	48	23,199	23,096	8,167	38,314
Avg. for last 10 simulations		**5,689**	**76**	**223**	**11**	**53**	**22,757**	**22,455**	**8,935**	**40,390**

Table 8. Average yield estimated by running 10 iterations of a Kamishak Bay herring population simulation model based on an empirical, density dependent recruit model.

Simulation Number	Target Exploitation Rate	MILLIONS OF RECRUITS				BIOMASS (st)				YIELD (st)			% of Years Closed
		Mean	Max.	Min.	Med.	Average	Median	Min.	Max.	Average	Min.	Max.	
1	15%	75	223	11	48	18,209	17,828	6,071	34,286	1,905	635	3,587	0%
2	15%	77	223	11	61	18,442	18,165	6,387	31,597	1,930	668	3,306	0%
3	15%	80	223	11	67	19,544	19,441	6,663	32,536	2,045	697	3,634	0%
4	15%	76	223	11	48	18,066	17,733	7,016	35,775	1,890	734	3,743	0%
5	15%	79	223	11	61	19,344	18,686	6,754	36,213	2,024	673	3,789	0%
6	15%	72	223	11	48	17,564	17,017	7,348	32,013	1,838	769	3,528	0%
7	15%	77	223	11	61	19,350	19,387	6,492	32,106	2,024	679	3,359	0%
8	15%	76	223	11	48	18,590	18,408	6,543	35,043	1,945	685	3,709	0%
9	15%	75	223	11	48	18,541	18,102	7,981	34,566	1,940	822	3,617	0%
10	15%	79	223	11	61	19,616	19,456	8,206	35,904	2,052	859	3,756	0%
Avg. for last 10 simulations		**77**	**223**	**11**	**55**	**18,727**	**18,423**	**6,946**	**34,004**	**1,959**	**722**	**3603**	**0%**

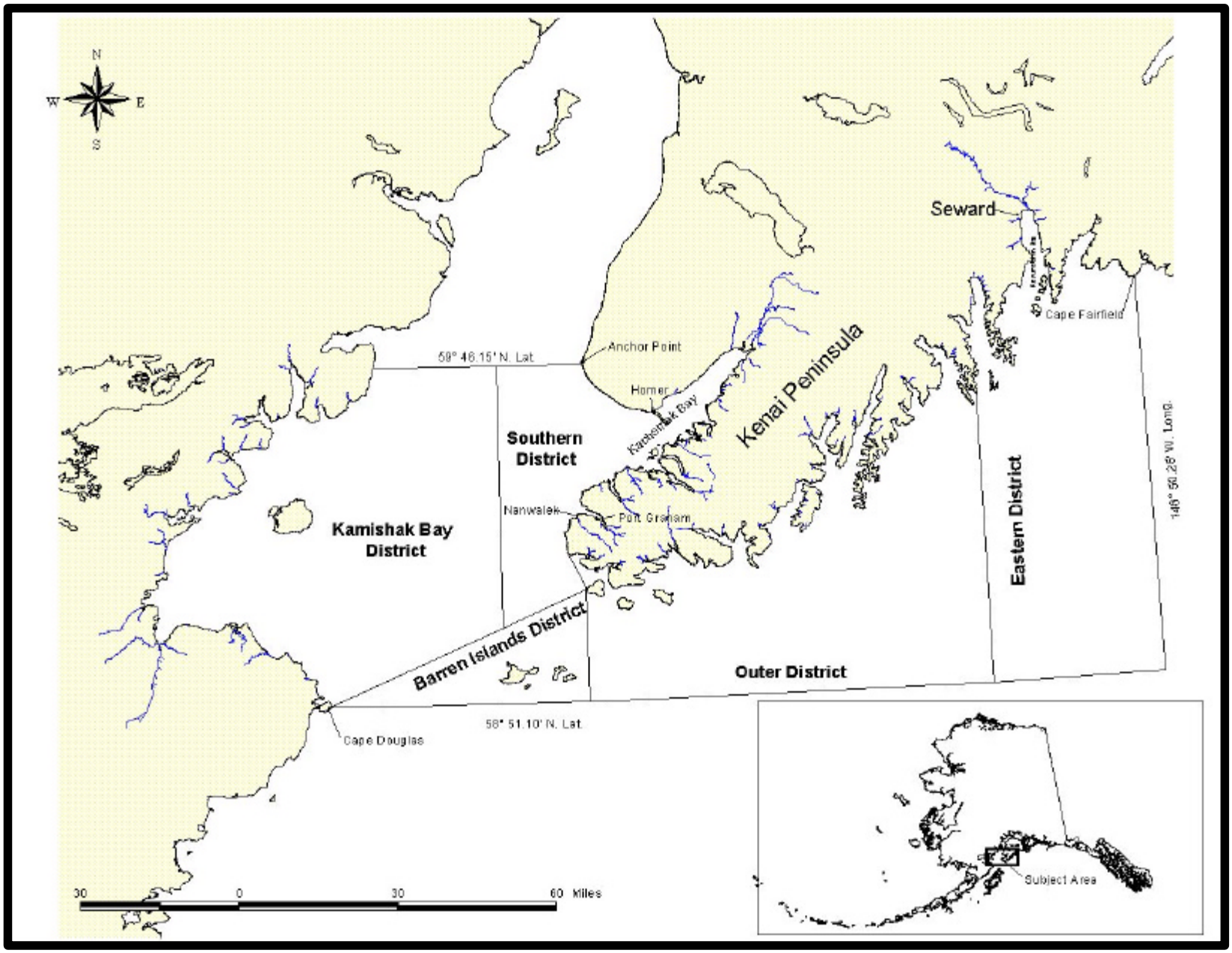

Figure 1. Lower Cook Inlet salmon and herring management area.

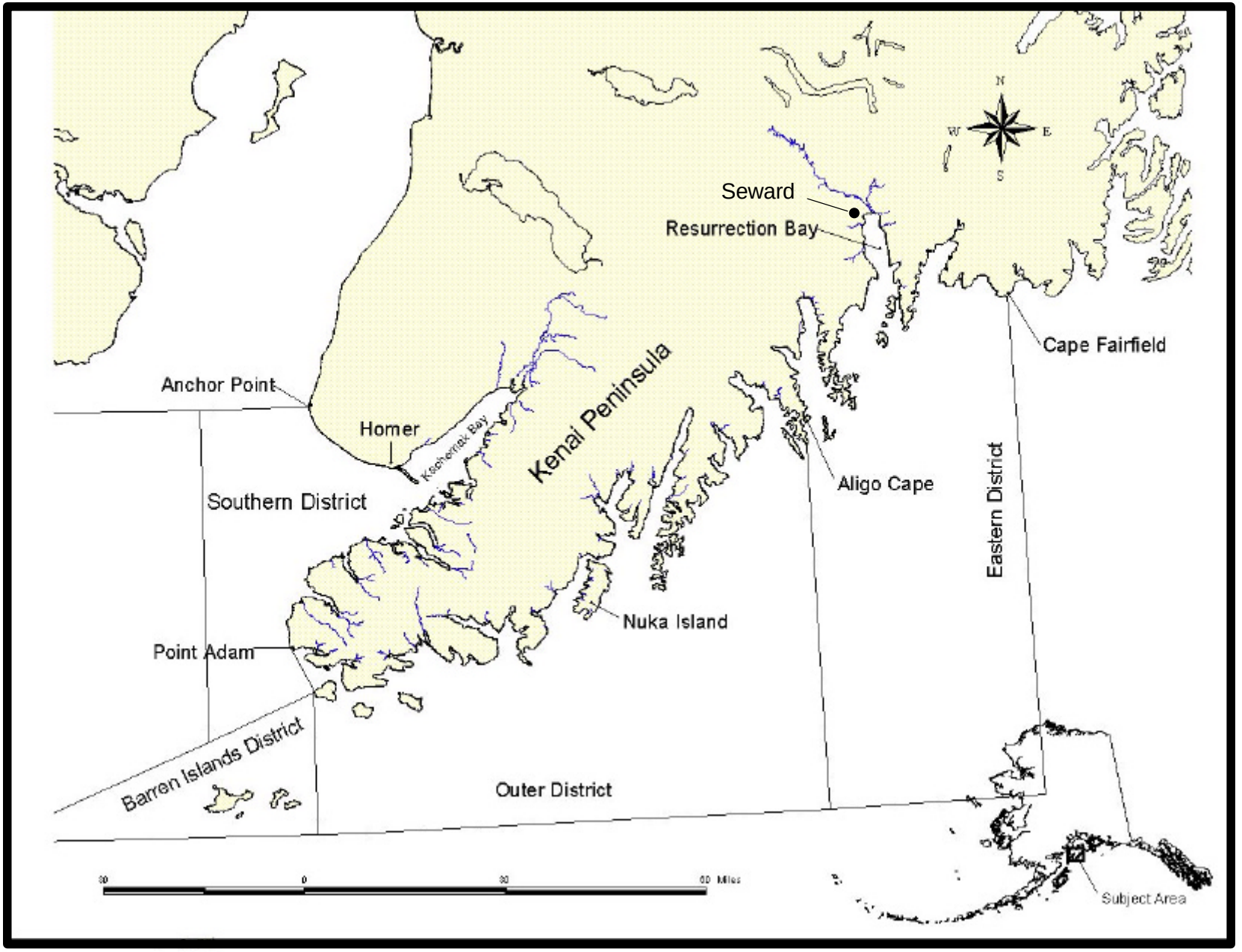

Figure 2. Southern, Outer, and Eastern Districts in Lower Cook Inlet.

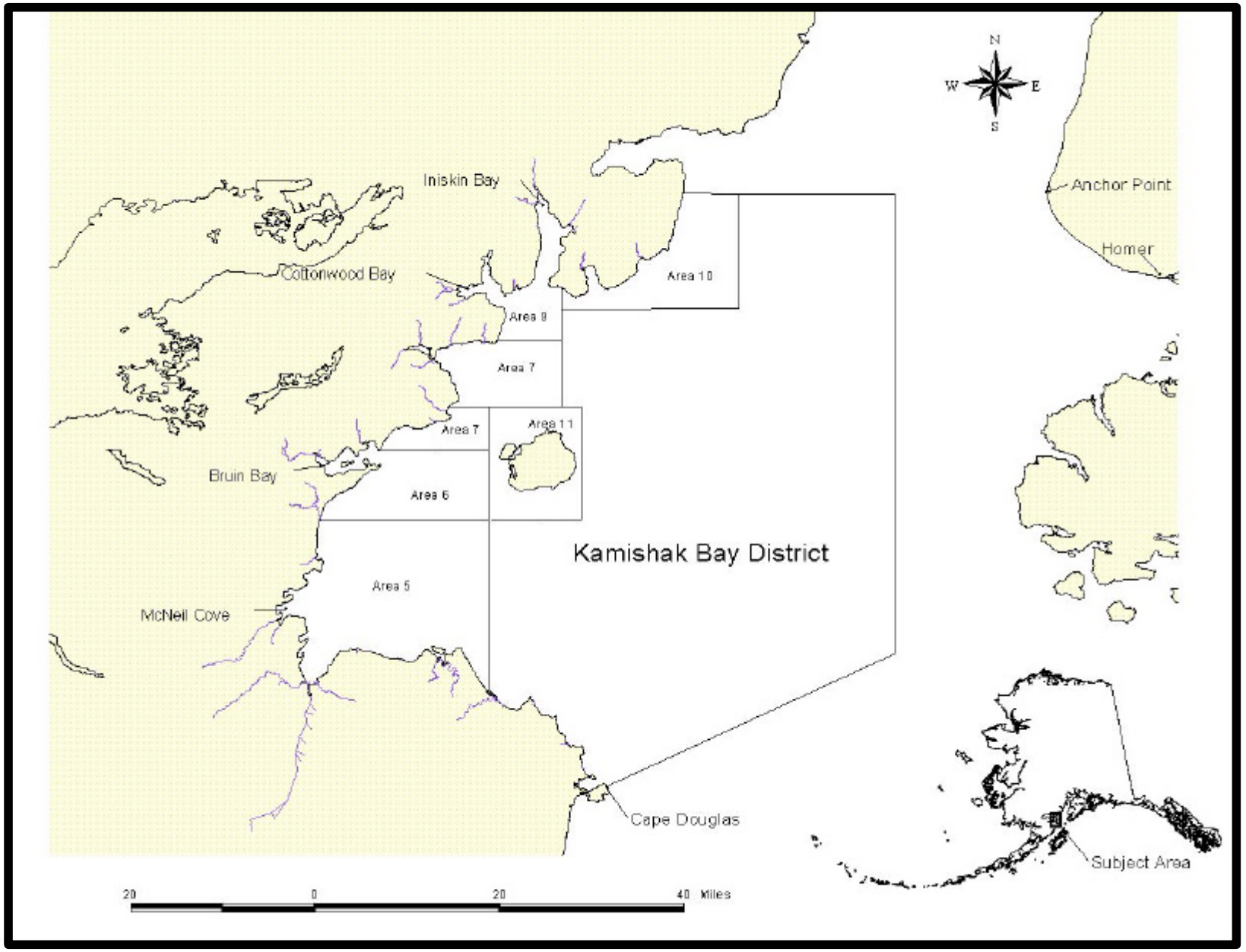

Figure 3. Kamishak Bay District herring management areas in Lower Cook Inlet.

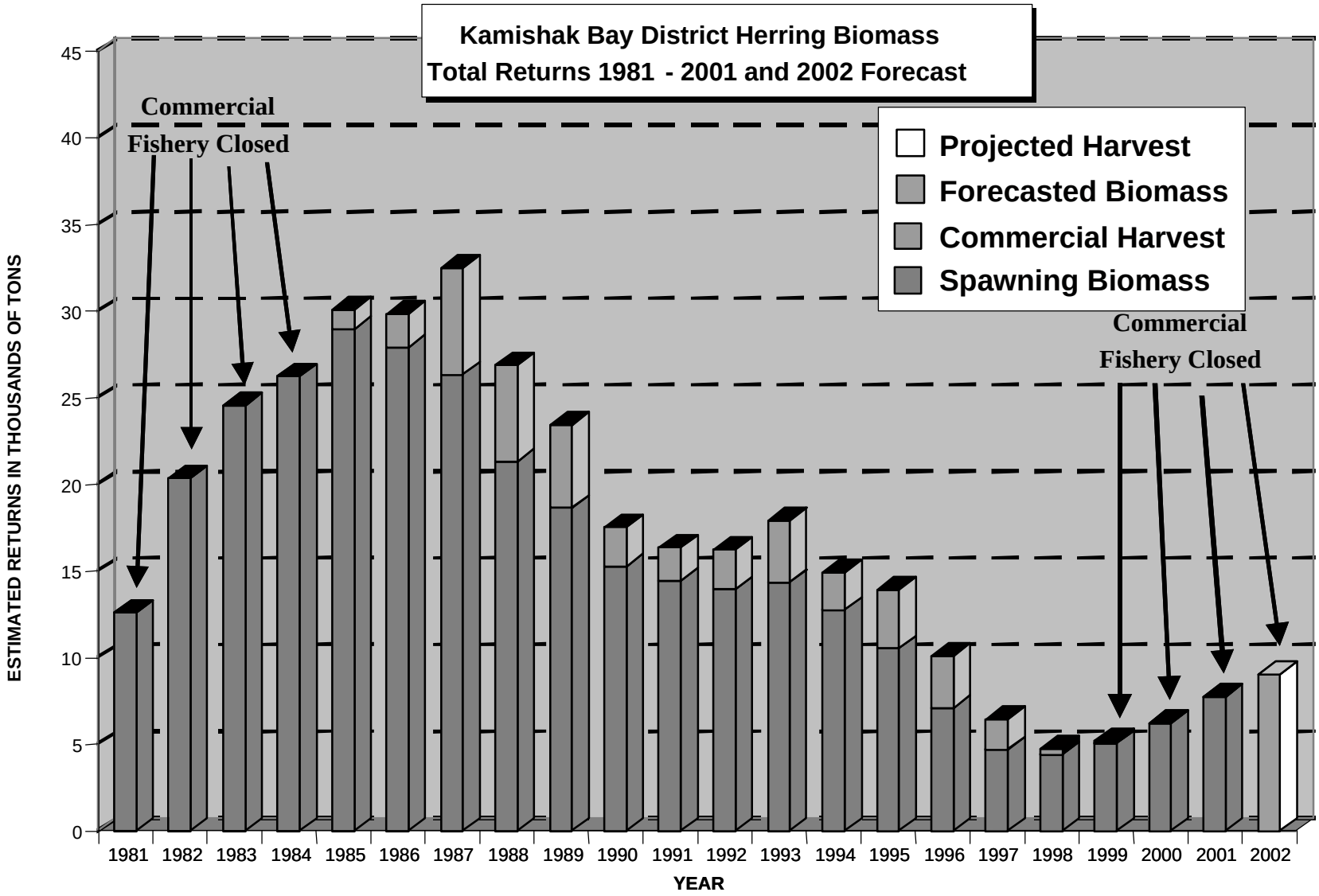

Figure 4. Biomass estimates and commercial harvests of Pacific herring in the sac roe seine fishery, Kamishak Bay District, Lower Cook Inlet, 1981 – 2001, and 2002 projection.

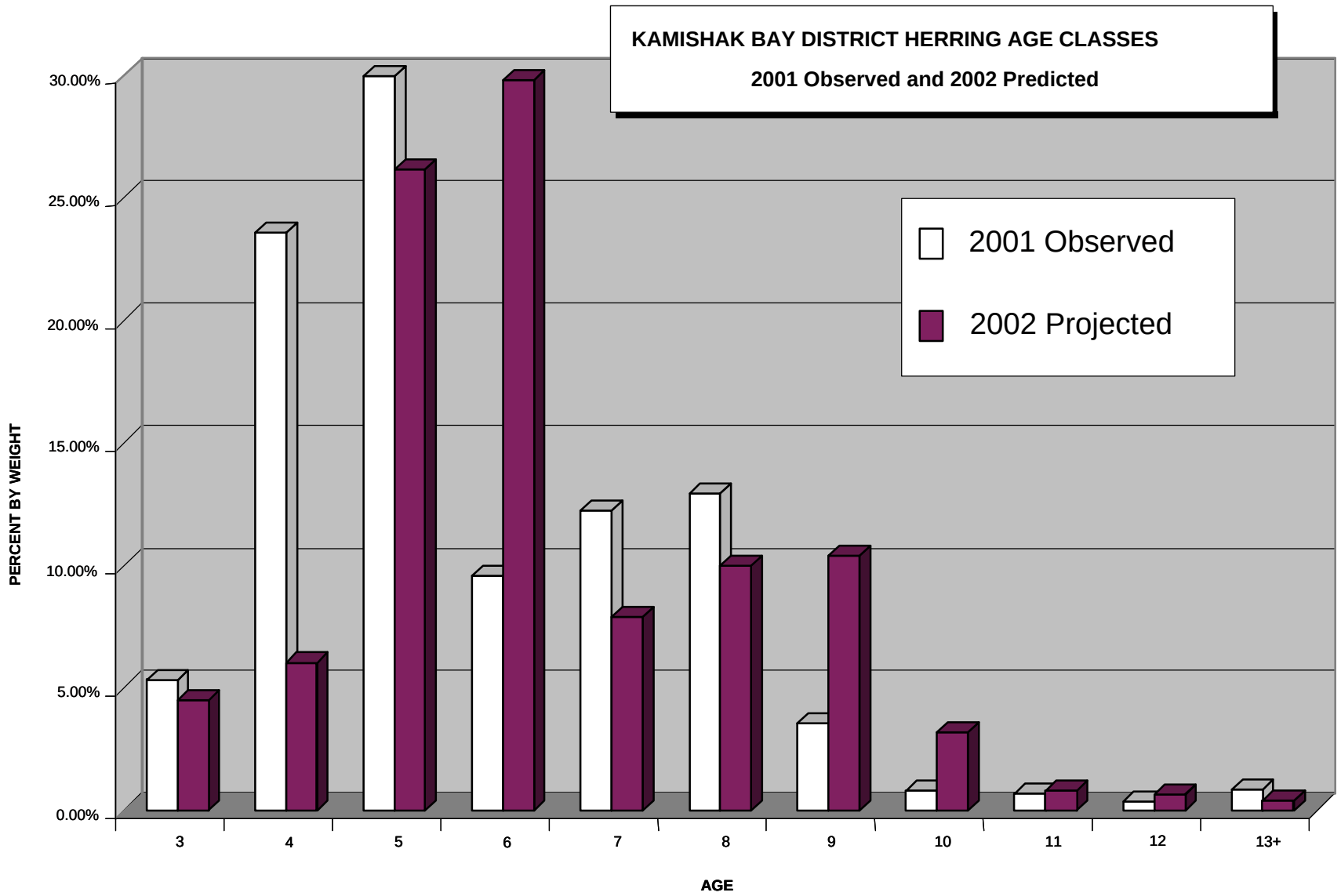

Figure 5. Herring age composition from samples collected in Kamishak Bay District, Lower Cook Inlet, 2001, and 2002 forecast.

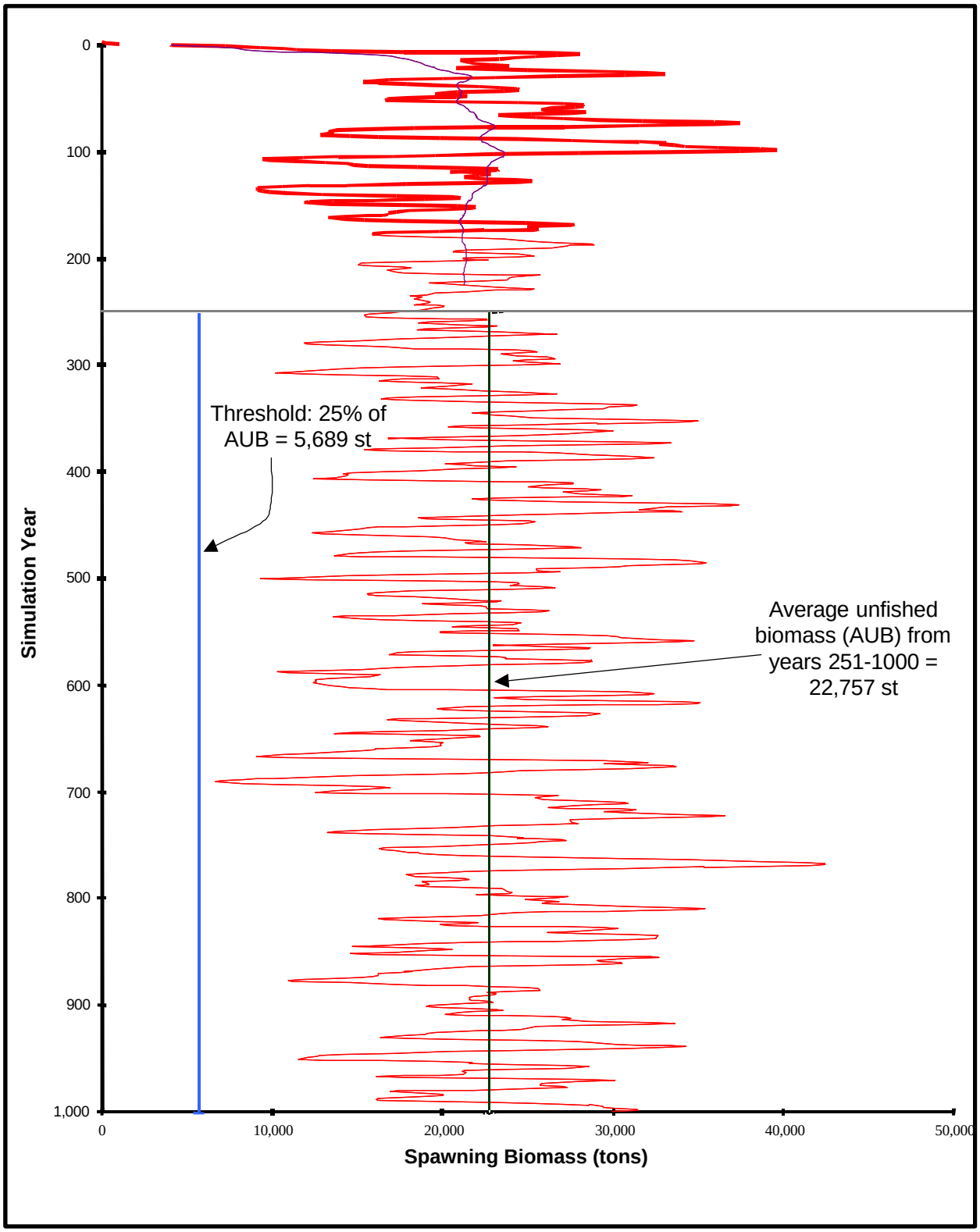

Figure 6. Kamishak Bay herring biomass trend over 1000-year simulation, illustrating the average unfished biomass (AUB) and productivity threshold level.

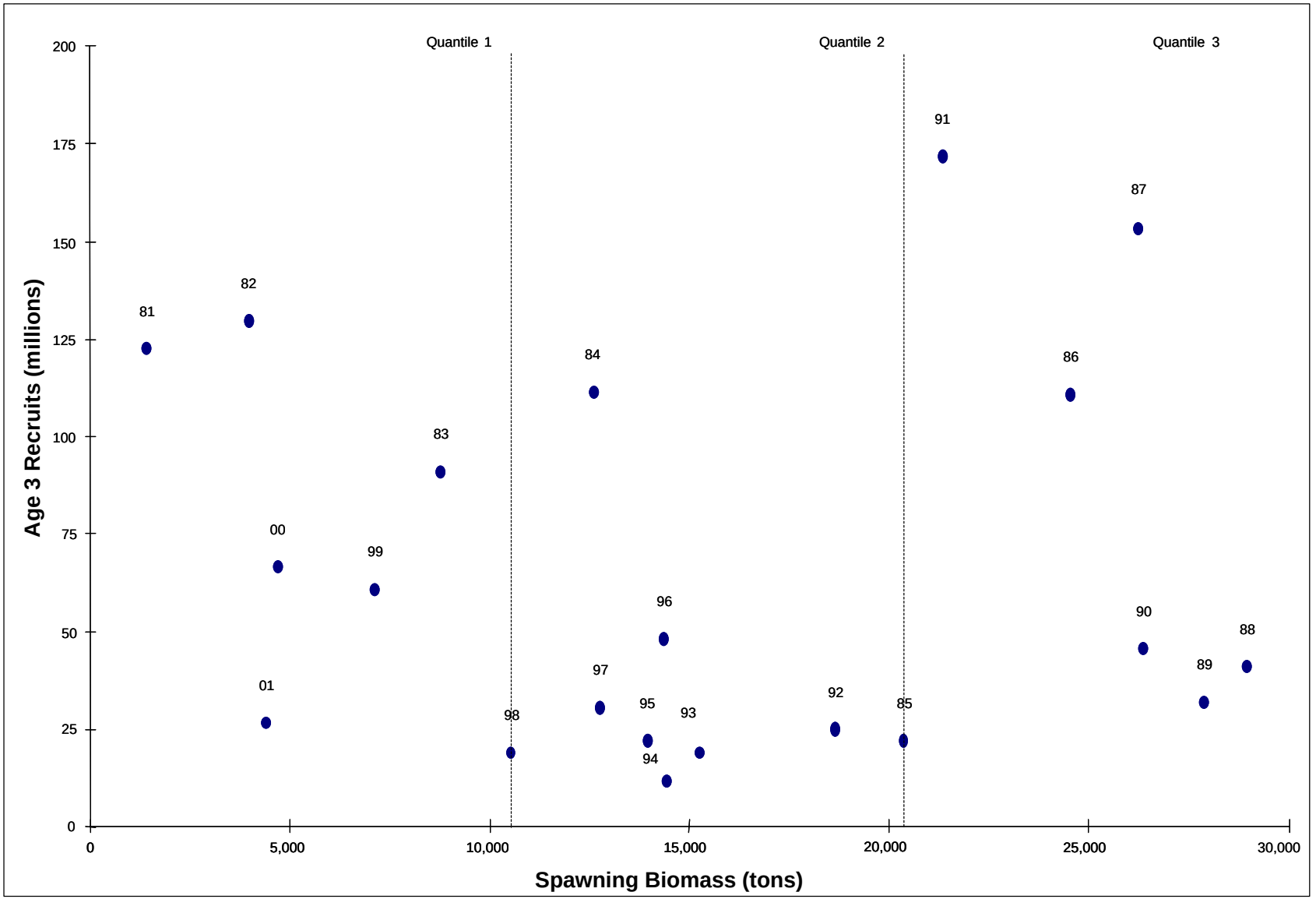

Figure 7. Stock-recruit relationship for Kamishak Bay herring, 1981-2001. Note the lack of any relationship between spawning biomass and abundance of age-3 recruit, and also the trend for consistently poor recruitments during the 1990's.