Pacific Herring, *Clupea pallasi*, Studies and Fishery Management in Tomales Bay, 1993-94, with notes on Humboldt and Crescent City Area landings

by **Thomas O. Moore** *and* **John J. Mello**

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PACIFIC HERRING, *Clupea pallasi,* STUDIES AND FISHERY MANAGEMENT IN TOMALES BAY, 1993-94,

with notes on Humboldt and Crescent City Area landings.

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Abstract

The 1993-94 spawning biomass estimate for Pacific herring, *Clupea pallasi*, in Tomales Bay declined 40% from last season to 2,449 tons. Although this estimate is below the 20-year average of 4,700 tons, the spawning biomass estimate this year is close to the post 1982 El Niño 11-year average of 2,054 tons. The overall trend of increasing biomass since the 1989-90 season still continues. There were eight distinct spawns this season, the most in five years, with the largest spawn occurring in late January.

A total of 3.5 million m^2 of eelgrass, *Zostera marina*, was measured in Tomales Bay this season. Eelgrass density increased in the majority of the beds.

The commercial gillnet fleet in Tomales Bay caught a total of 219 tons of herring this season yielding an exploitation rate of 8.9%. Herring aged four, five, and six comprised 90% by number of this season's commercial gill net catch. Mean weight of herring ages three, six, and seven decreased slightly over last season while increases were seen for ages four, five, and eight. Mean length of commercial caught herring increased slightly over 1992-93.

Department variable-mesh gill nets caught a total of 455 herring of which 232 were aged. The dominant age class was four-yr-olds comprising 27% of the sample by number, followed by six-yr-olds representing the highly successful 1988 year class.

In Humboldt Bay, the 1993-94 commercial catch of 62.8 tons was about 5% over the 1993-94 season quota of 60 tons and was well above Humboldt Bay's 21-year average catch of 40.4 tons.

Crescent City area herring fishermen caught 32.5 tons, approximately 2% over the season quota for the Crescent City area. The 1993-94 season commercial catch is well above the 20-year average of 23.7 tons for this area.

Introduction

Since 1973, the California Department of Fish and Game (CDFG) has estimated the annual spawning biomass of Pacific herring, *Clupea pallasi*, in Tomales Bay as well as the age, length and sex composition of the herring catch for the area's roe fishery. Biomass estimates were derived from estimates of herring eggs deposited during the spawning season. California bays where herring spawn are relatively small and well suited for intensive spawning-ground surveys.

This report includes the spawning biomass estimate, biological characteristics, and landing statistics of the catch for the 1993-94 spawning season in Tomales Bay. Landing statistics are also reported for the Humboldt Bay and Crescent City area roe herring fisheries.

Description of Study Areas

Tomales Bay

Tomales Bay (Figure 1) lies in Marin County, north of San Francisco. It is 20 km (12.4 mi) long and averages 1.5 km (0.9 mi) wide. The predominant flora in the bay is eelgrass, *Zostera marina* (Hardwick 1973), which is surveyed annually for its distribution (Figure 1). Herring spawn primarily on eelgrass but other species of marine flora (*Gracilaria sp., Phylospadix sp., and Ulva sp.*), are utilized to a much lesser extent. Herring may also spawn on substrates other than plants in this bay including bare rocks and pier pilings in the intertidal and subtidal zones.

Humboldt Bay

Humboldt Bay is California's northernmost embayment, 129 km (80 mi) south of the Oregon border. Humboldt Bay has an unusual shape, with the northern and southern ends

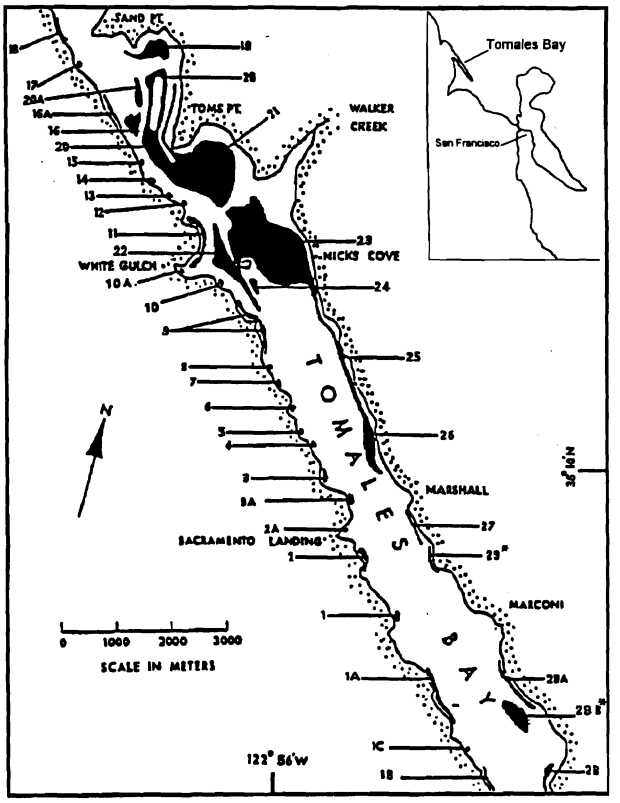

FIGURE 1. Tomales Bay, California with numbered vegetation beds. All beds are eelgrass except where (*) indicates *Gracilaria* spp.

broadened into shallow mud flats that are interspersed by tidal drainage channels. These mud flats, which are exposed on most minus tides, support vast areas of eelgrass covering an estimated 13 million m^2 (Harding and Butler 1979). The general distribution of eelgrass in north Humboldt Bay has not changed since 1979. Herring utilize both the north and south ends of the bay, but previous surveys found most spawning occurs in the northern end (Rabin and Barnhart 1986).

Crescent City Area

The Crescent City harbor breakwater and all rocky areas and kelp beds to the south near the harbor provide spawning habitat. Elk Creek discharges into the harbor embayment providing a source of freshwater and depresses

salinities during significant rainfall events. Most fishing takes place in the area around the commercial boat marina.

Methods

Tomales Bay

Spawning-Ground Surveys

Spawning-ground surveys were conducted from 5 November 1993 to 28 March 1994. As in the previous year, sampling was reduced from daily to 3-4 days per week due to project budget restrictions. We inspected eelgrass beds (Figure 1) for evidence of spawn from a 5.2 m (17 ft) boat. Spawn deposition area and density of spawn was determined by dragging a vegetation sampler (rake) through eelgrass beds to collect samples at random locations. The number of samples taken per bed (minimum of four) varied with the size of the bed, and at least 10 g of eelgrass with eggs were collected per sample. When the perimeter of the spawn deposition was found, the location was marked by dropping an anchored float as a reference point. Measuring between floats with an optical range finder provided linear measurements to calculate spawning area.

Processing of spawn samples was unchanged from previous seasons (Spratt 1981). Herring eggs were removed from the eelgrass blades and counted or estimated by weighing (ca. 750/g) to the nearest 0.1 g. The eelgrass was then reweighed to the nearest 0.1 g to obtain the number of eggs per unit weight of eelgrass.

Density of eelgrass for beds with 100% bottom cover was estimated using a multiple linear regression between eelgrass blade measurements and density (Spratt, 1989):

$$Y = a_l(\text{length}) + a_w(\text{width}) + B$$

where:

Y = kg eelgrass per m^2
a_l = slope of regression for length variable
a_w = slope of regression for width variable
B = Y intercept

During December and January, eelgrass blade length and width measurements were taken from eelgrass samples collected from the project's boat with a vegetation sampler. Between six and 15 sets of eelgrass blade lengths and widths were collected from 30 of the 37 eelgrass beds in the bay (Table 1). The 1993-94 eelgrass density values were computed by substituting these eelgrass data in the regression formula.

Estimated eelgrass densities had to be adjusted downward if bottom coverage was less than 100%. Percent cover estimates were determined using the paper traces from a Lowrance model LRG 1510 recording fathometer. Percent cover estimates were obtained by examining traces for each bed and determining what percentage of the trace exhibited eelgrass.

We remeasured the area of 23 eelgrass beds. The perimeter of smaller eelgrass beds was determined with a recording fathometer, then marked with anchored floats. An optical range finder was used to measure distance between floats, and these measurements were used to calculate area. Larger beds were measured by triangulation using known landmarks or plotting bed perimeters on navigation charts and calculating the area directly from the chart.

Spawning in intertidal areas was estimated by measuring the area of spawn and collecting eggs from random $100cm^2$ quadrants or by removing samples of cobble covered with eggs. In the laboratory, the density of eggs per $100cm^2$ was determined for rock, cobble, and gravel substrates by counting or estimating.

Biomass Computation In Tomales Bay, the estimated number of herring eggs spawned was converted to tons of spawning adult fish by incorporating sex ratio estimates for each spawning run. The sex ratio of spawning schools was determined from herring caught in multipanel research gill nets. However, we were not able to obtain the sex ratio of all schools due either to an inability to catch herring or because commercial fishing had altered the sex ratios. When sex ratio data were not available, an average sex ratio based on previous season's data for similar spawn dates was used. The following formula was used to calculate the conversion factor:

Conversion factor = 1/(F x f/p x K)

where:

F = fecundity (males and females combined)

f = percent females in a given spawning run.

P = percent females in population (assumed to be 50%)

K = 908,000 (grams/short ton)

A fecundity value of 113 eggs/g of body weight (males and females combined) (Hardwick 1973) was used in calculating 1993-94 biomass estimates.

Confidence Limits Confidence limits for herring spawning escapement estimates in Tomales Bay were calculated from variation in the density of egg deposits (Sokal and Rohlf 1969). Each spawning event usually encompassed several small spawning sites and total spawning escapement was the sum of the estimates for each site (Table 6). The confidence intervals were calculated for most spawn sites individually. In some cases where a large discrete variation in density of egg deposition occurred within an eelgrass bed, separate estimates of spawning within the bed were calculated.

Catch Sampling

Tomales Bay fishery samples were collected at an off-loading site at Marshall. Up to four samples (one per boat) were routinely taken per day from the commercial gill net catch when herring were available. Each sample, consisting of 20 randomly selected herring, was collected from bins or totes after vessels unloaded.

Tomales Bay samples were processed fresh when time permitted and remaining samples were frozen for later processing. Laboratory procedures have remained unchanged since the fishery began in 1973 (Spratt 1981). A 1.0 kg subsample was randomly selected for processing. Each fish in the subsample was weighed to the nearest 0.1 g, measured in body length (BL) to the nearest millimeter, and sex and maturity were determined. Body length was measured from the tip of the snout to the end of the silver pigmentation on the caudal peduncle. Otoliths were removed for age determination and stored in gelatin capsules. Ages were determined from otoliths by the authors using previously determined criteria (Spratt 1981).

Population Sampling

A variable-mesh monofilament nylon set gill net was used to collect fish for age and sex composition analysis. The gill net was constructed of five 10-ft. panels, each with a different mesh size (1.5, 1.75, 2.0, 2.25, and 2.5 in. mesh).

We determined the sex of all herring captured, measured their body length to the nearest millimeter, and removed otoliths for age analysis.

Length Corrections

This season some herring samples from Tomales Bay were frozen before processing. Reilly and Moore (1982) determined that herring shrink when they are frozen. They developed correction factors for thawed lengths. Based on these corrections, body lengths for frozen/thawed fish in four

categories were increased as follows: 125-155 mm BL, 4 mm; 156-189 mm, 5 mm; 190-224 mm, 6 mm; 225-250 mm, 7 mm.

Results

Tomales Bay

Spawning-Ground Surveys

This season 32 of the 37 total previously located eelgrass beds (Figure 1) were found in Tomales Bay. Twenty-four of the 32 eelgrass beds were remeasured this season (Table 1).

Vegetation Density Estimates The relationship between eelgrass density and blade length and width for the 1993-94 season was:

$$\text{Density (kg/m}^2) = 0.002177(l) + .0765(w) - 1.1810,\ r^2=.61$$

The majority of the beds increased in density (Table 2). However, over 90% of the 1993-94 herring spawning occurred in eelgrass beds that had decreased in density.

Spawning Biomass There were eight distinct periods of spawning this season, the most in five years. The first spawning occurred 19 November 1993 at eelgrass bed 1A (Figure 1 and Table 3). The season's second spawn took place on 14 December 1993, again utilizing eelgrass bed 1A as well as beds 1B, and 1C (Table 3). The December spawning biomass total of 370 tons is considerably less than last December's near record high monthly total of 1,346 tons.

Several small spawns occurred as the fishery proceeded in early and mid-January (Table 3). The largest spawn this season occurred on 27 January 1994 and covered five separate eelgrass beds (Figure 1 and Table 3). Three more spawns occurred in February, with the second largest spawn of the season covering a three-day period from 6 to 8 February. The season's last spawn occurred on 13 February 1993 (Table 3).

Spawning herring utilized only eight of the 32 eelgrass beds located in Tomales Bay this season. These beds are located in the inner portion of the bay most influenced by freshwater input from Lagunitas Creek, the bay's major source of freshwater inflow.

This season's spawning escapement estimate for Tomales Bay was 2,230 tons (Table 3). No hydroacoustic surveys were attempted in outer Bodega Bay during the 1993-94 season. Additionally, herring fishing in the outer Bodega Bay was closed again for the second consecutive season so the catch was composed entirely from fish caught in Tomales Bay (Table 4). The 1993-94 spawning biomass estimate of 2,449 tons in Tomales Bay was the second highest for the Bodega/Tomales Bay areas in the past seven seasons (Table 5).

Confidence Limits The 95% confidence intervals for the 1993-94 season were broad for smaller spawns due to the very light and patchy distribution of spawn (Table 6). In fact most of the spawns this season were relatively small with only four of the 24 separate spawns on individual eelgrass beds totaling more than 150 tons.

Confidence limits were narrower (<50%) for the four largest spawn sites, which accounted for over 65% of the spawn escapement.

Catch Sampling

A total of 729 herring from commercial catches was measured and sexed this season. Of that total, 237 herring from 24 samples were collected and processed for age determination and 704 were weighed.

Age Composition The dominant age groups this season were again four through six-yr-old herring, comprising 90% (92% last year) by number and 88% (91% last year) by

weight of the Tomales Bay commercial gill net catch (Table 7). Including seven-yr-old herring, these four age groups comprised over 98% (99% last year) of the catch by number. The number of four-yr-old herring, an indicator of recruitment, decreased slightly to 14% (15% last year) of the catch by number (Table 7).

Length Composition The average length of herring in the 1993-1994 commercial gill net catch was 197 mm, slightly larger than last season (Table 8). The length of four through six-yr-old herring increased an average of 2 mm from the 1992-93 season (Moore and Mello 1995)(Table 9).

Weight Composition Mean weights-at-age of the three dominant age groups in this season's catch from Tomales Bay ranged from 1 g below the long-term mean for six-yr-olds to 3 g above the long-term mean for five-yr-olds (Table 10). The mean weights-at-age for the two older age groups ranged from 1 g below the long-term mean for seven-year-olds to 8 g above the long-term mean for eight-yr-old fish. The large number of six and seven-yr-old herring (44% by number) dropped the 15-year combined unweighted mean to the fifth lowest value since the 1979-80 season (Table 10).

Sex Ratio Male to female number and biomass (weight) ratios of the 1993-94 Tomales Bay commercial catch were nearly equal, at 1:0.96 and 1:0.99, respectively. The percent of females in the catch was 49% by number and 50% by weight.

Population Sampling

Herring held in Tomales Bay prior to spawning making them available for pre-spawning sampling. Spawning occurred in early December and early January. A few fish were caught in mid-January with the majority of sampled fish this season caught in late January (Table 11). Our final variable mesh gill net sample was obtained on 11 February prior to a small spawn.

Sex and Length Composition The mean body length for research gill net-caught herring was 192.5 mm; mean lengths were smallest in December 1993, and greatest in February 1994 (Table 11). Catches were heavily male dominated in December and January with February sex ratios still slightly male dominated. Reilly and Moore (1985) found that herring schools in San Francisco Bay were male dominated in November and December, sex ratios were about even by mid-January, and were female dominated in February and March. Additionally, body length was greatest for schools found during November and December and typically decreased throughout the rest of the spawning season.

Age Composition We captured a total of 455 herring, of which 232 herring between 158 mm and 240 mm were used for aging (Table 12). The four-yr-old age class was dominant and comprised 27% of the sample by number (Table 13). Age class six was the next most abundant reflecting the still strong 1988 year class. Age class three comprised a slightly lower percentage of the total age composition than was seen in the previous three seasons. Older age classes (eight and nine) were present in 1993-94 in similar numbers as the previous season and comprised 3% of the total number of herring aged (Table 13).

Fisheries

Tomales Bay

The season opened with an initial 300 ton quota at sunset on Sunday, 2 January 1994. A total of about 66 tons of herring were landed on 3 January 1994 (Table 14). Roe recovery averaged 11.2 % and ended fishers' concerns that initial landings would, as in the last season, be below the 10% dealer minimum. Fishing resumed on 16 January as herring

began to spawn and approximately 69 tons of herring were landed by 17 January. No herring were landed until fishing began again on 7 February. By 9 February an additional 75 tons had been landed. The last landings were made on 21 February when a little over nine tons were landed (Table 14).

A total of 219 tons, with an average roe count of 12.3%, was landed this season (Table 14). The 300 ton quota was never reached and 81 tons of the quota remained. Both the commercial catch and the average roe count for the season were below the 10-year average for the Tomales/Bodega Bay gillnet fleet (Table 15).

Humboldt Bay

The Humboldt Bay roe fishery opened on Sunday, 2 January 1994 with a 60 ton quota. The first landings were made on 3 January when a little over 100 pounds herring was landed (Table 16). A little over 5 tons were landed by one boat on 9 January and at this time all three vessels began fishing. By 11 January a total of about 22 tons was landed. An additional eight days were fished in January and on 27 January the fishery was closed. Almost 63 tons of herring were landed, exceeding the 60 ton quota by 3 tons, and exceeding the 21-year mean by more than 20 tons (Table 17).

Crescent City Area

The Crescent City area roe fishery opened on 15 January 1994 with a 30 ton quota. The first landings were on 19 January with about a half-ton of herring landed (Table 18). The bulk of the season total, a little over 30 tons, was landed on 6 and 7 February. The fishery closed on 7 February with a total of 32.5 tons landed, 2.5 tons over the quota (Table 18) and about 10 tons over the 22-year mean (Table 19).

Discussion

Spawning-Ground Surveys

Tomales Bay

The spawning escapement estimate for Tomales Bay decreased for the first time in the past five seasons (Table 5). The decrease in spawning escapement in Tomales Bay is consistent with the previously observed post-El Niño decreases. The possibility also exists that the trend of increasing escapement seen over the past five seasons has peaked. Additionally, the bay was closed to herring fishing for three spawning seasons prior to the 1992-93 peak in spawning escapement. Last season's fishing mortality could be a factor in reducing this season's escapement.

The full recovery of the Tomales Bay herring spawning stock will depend on either rebuilding the remaining population and/or attracting herring to Tomales Bay that may or may not have previously spawned there. The reduced spawning biomass in Tomales Bay from the 1986-87 to 1991-92 spawning seasons was most likely due to reduced freshwater inflow because of the 1987-92 drought. Rainfall in the Tomales Bay watershed during winter of 1993-94 was approximately 17.93 inches, about five inches below normal.

The major source of freshwater input to Tomales Bay is Lagunitas Creek at the upper end of the bay (Figure 1). Since the drought began in 1987, spawning has shifted to eelgrass beds near the upper end of the bay which become less saline with runoff from the upper bay watershed. Once again this season, spawning herring continued to use these more centrally located eelgrass beds in Tomales Bay coupled with below average rainfall and no overflow from Nicasio Dam into Lagunitas Creek (Figure 2).

Spawn events were examined in relation to high tides (tides greater than +5.0 ft), rainfall

greater than 0.1 in (significant rainfall), and lunar phase (within 4 days of a quarter moon). High tide before noon was the leading correlating factor in six out of eight recorded spawns (Figure 3). When significant rain was a factor (four out of eight spawns) it was associated with high tides. Spawning events correlated positively with the quarter moon in five of the eight spawns where tide and rainfall were not factors. In fact, these three

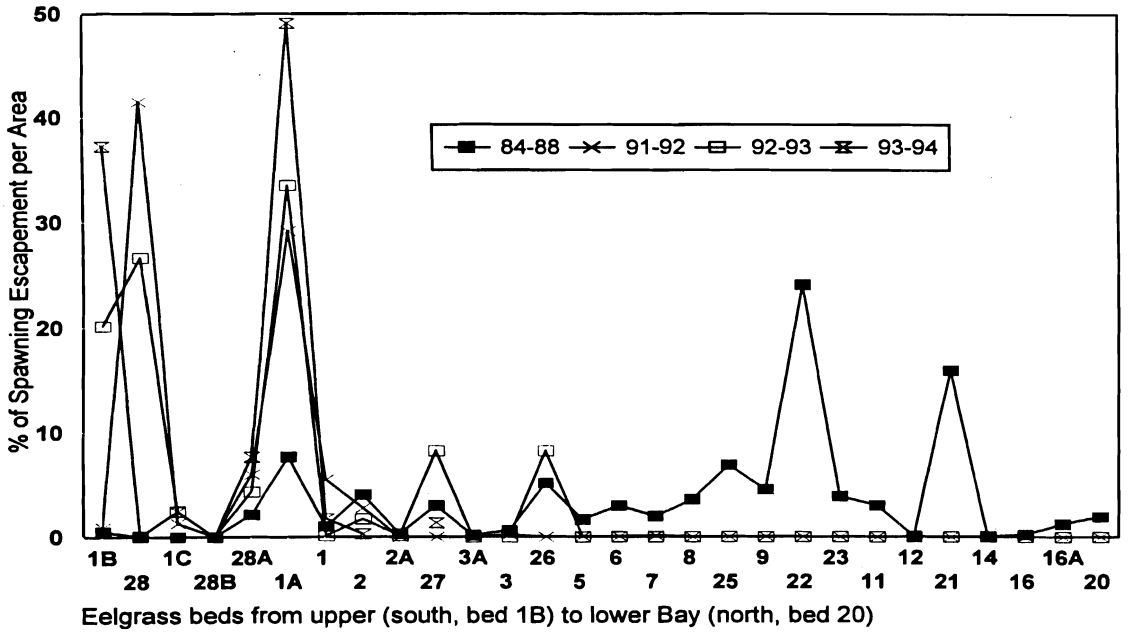

Figure 2. Average spawn escapement per eelgrass bed in Tomales Bay expressed as percent of season total.

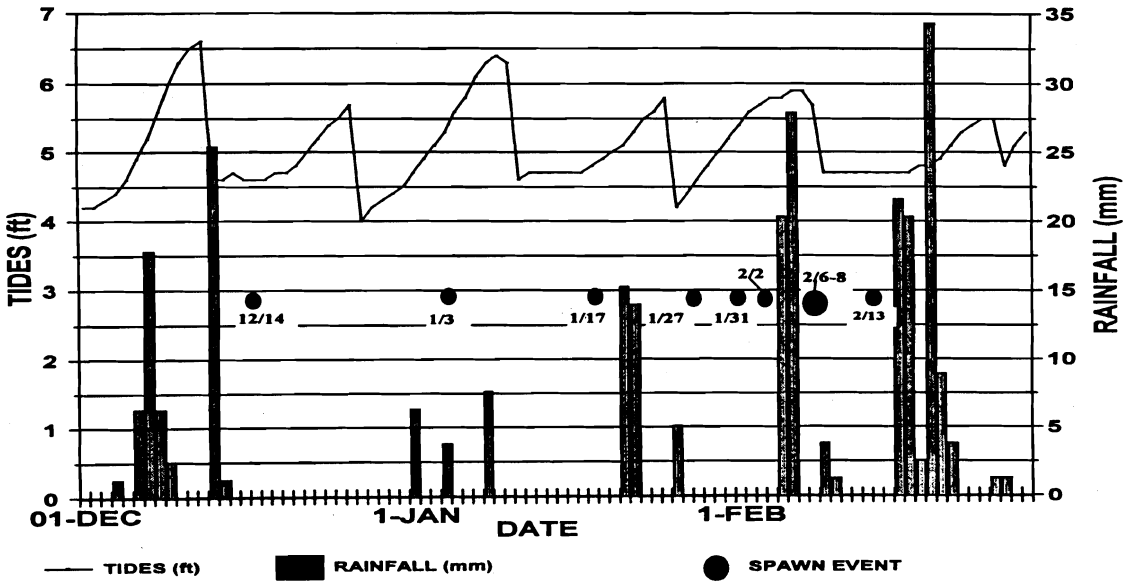

Figure 3. High tides, rainfall, and Pacific herring spawning events in Tomales Bay, 1993-94.

factors accounted for all spawn events this season. The apparent correlation of spawning events with high tide and rainfall was also seen in San Francisco Bay herring spawns (Reilly and Moore 1985). Also, in San Francisco Bay a close relationship between herring spawning and quarter phases of the moon has been observed, (Oda 1994).

This season's November spawning escapement total (19 tons) was the highest since surveys began in the 1973-74 season (Table 20). Although, this ranking may be partly due to historic November sampling efforts being lower than the present. Spawning in December this season accounted for 17% of the season's escapement and was almost double the long-term (1973-94) December average (Table 20). While not a record, it is the third highest percent of total spawn escapement for a December seen since surveys began in the 1973-74 season. Since the 1991-92 season, December spawning has been above both the long-term and the 11-year (post El Niño) average. Whether or not this is related to the recent (1991-92) El Niño, and will continue to be a trend, has yet to be determined.

The postulated post-El Niño biomass decrease seen after the 1976-77 and 1982-83 El Niños apparently occurred as the Tomales Bay biomass dropped to 2,449 tons from last season's 4,078 tons (Figure 4 and Table 5).

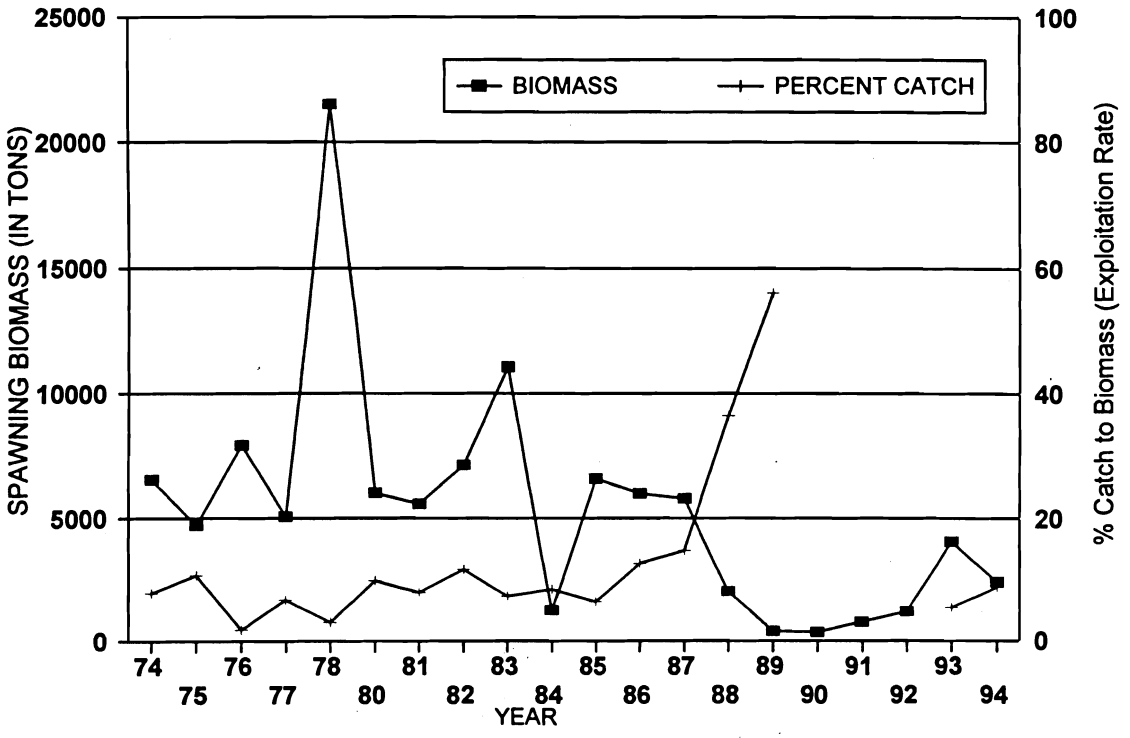

Figure 4. Pacific herring spawning biomass and exploitation rates, Tomales Bay, 1974-94.

Another possible explanation for the decrease in biomass would be that the recovering Tomales Bay spawning stock peaked and was stabilizing at some new short-term average biomass. The 1993-94 spawning escapement total is less than the 20-yr average spawning escapement of 4,704 tons and also less than the 11-yr (post 1982-83 El Niño) average of 2,054 tons (Table 5).

Fishery

Tomales Bay

No significant changes were made to the regulations concerning herring fishing for the 1993-94 season in Tomales Bay. Mesh size remained at 2-1/8 in., two permits may be fished from one vessel, and no permittee may possess more than one shackle of net (65 fm) unless two permits are fished, in which case two shackles of gear may be fished. Also, outer Bodega Bay remained closed in the 1993-94 season.

The commercial catch of 219 tons of herring represents an exploitation rate of 8.9%. Exploitation rates have averaged 12.8% since the 1973-74 season with only 3 years above this average (Table 5 and Figure 4). A 300 ton initial quota was set which yielded a 7.4% exploitation rate based on the previous season's biomass of 4,078 tons. This lower than average exploitation rate was chosen to allow for the postulated post-El Niño spawning escapement decrease. Additional quota increases were provided for if spawning escapement, as determined by the Department, reached or exceeded 3,000 tons prior to 15 February. The quota was to be increased as follows: 1) If spawning escapement is more than 3,000 tons, the total take of herring shall not exceed 400 tons for the season; 2) If the spawning escapement is more than 4,000 tons, the total take shall not exceed 500 tons for the season; 3) If spawning escapement is more than 5,000 tons, the total take shall not exceed 600 tons for the season.

Humboldt Bay

The commercial catch of 62.8 tons was about 5% over the 1993-94 season quota of 60 tons and was more than the 21-year average catch (40.4 tons) for Humboldt Bay (Table 17). The 60-ton quota for Humboldt Bay represents a 20% exploitation rate if the spawning biomass is approximately 300 tons. The long-term average catch would approximate a 13.5% exploitation rate.

Crescent City

The commercial catch of 32.5 tons was about 2% over the season quota for the Crescent City area and was also above the 20-year average (23.7 tons) for this area (Table 19). Spawns in the Crescent City harbor were sampled in 1977 and 1978 seasons, with conservative spawn escapement estimates of 139.4 tons and 127.2 tons, respectively (Patrick Collier, pers. comm.). A 30 ton quota, representing an approximate 20% exploitation rate, was set using the 133-ton average of the Crescent City harbor spawn escapement estimates.

Catch Sampling

This season's spawning biomass of 2,449 tons is well above this recent historic low; however, spawning biomass is down 40% from last year's 4,078 ton estimate. Tomales Bay was closed to herring fishing from 1989-90 through the 1991-92 season and catch data were obtained from the outer Bodega Bay herring fishery. It is possible that herring caught in outer Bodega Bay may be from a separate stock and catch data from the 1989-90 to 1991-92 seasons may not be representative of Tomales Bay herring. Tomales Bay was reopened for commercial herring fishing last season.

A strong year-class is very important to a fishery. This point is demonstrated by following the 1988 year-class. This year-class contributed a significant percent by number to the last three season's catches, making up 26%, 47%, and 36% respectively (Table 7). In contrast, for the second season in a row, four-yr-old herring were weakly represented in the commercial catch (14% by number) (Table 7) suggesting the years 1989 and 1990 are both poor year-classes and cannot be relied upon for good future recruitment. Spawning biomass estimates for the 1988-89 and 1989-

90 seasons were the two lowest ever recorded for Tomales Bay. The 1989 year-class (five-year-old fish) did, however, make a stronger than expected showing this season comprising 40% by number of sampled catch.

Population Sampling

A different picture of the Tomales Bay herring spawning population is seen when the variable mesh gill net catch is examined. A more balanced population structure is found in samples collected throughout a wider time range in the spawning season (Table 12). Fishing on each school prior to commercial effort, which removes larger and older fish from the total population, produces a more unbiased sample of the population. While the commercial catch is consistently dominated by five- and six-year-old fish, age data from research gill nets shows the actual population age structure is more influenced by the varying strength of each year-class (Table 13). In the 1990-92 season, three-yr-old fish were dominate in the variable-mesh gill net catch due to the strength of the 1988 year-class. This year-class composed the highest percentage by number for each season up to 1993-94 when four-yr-old fish of the 1990 year-class became prominent. Nearly all age classes were represented in 1993-94 population samples and in proportions suggesting good recruitment with the exception of three-yr-olds that comprised a lower percentage of the total age composition than was seen in the previous three seasons.

Conclusion

Tomales Bay

The spawning biomass of 2,449 tons for the 1993-94 season is down 40% from last season and remains below the 20-year average of 4,700 tons. This season's decline in biomass follows a pattern seen in the historical data when spawning biomass usually dropped in years following strong El Niño conditions with associated rainfall several inches above normal. Despite this, the spawning biomass estimate this year is close to the post 1982 El Niño 11-year average of 2,054 tons and the overall trend of increasing biomass since the 1989-90 season still continues.

Other factors that may have contributed to this season's decline in spawn escapement include: reduced freshwater flow, due to below average rainfall in the Tomales Bay watershed, resulting in less than optimal spawning conditions in the bay; weak year-classes coming from the drought years of 1989 and 1990, offering poor recruitment to the current stock; and the effects of 1991-92 season's fishing mortality. The fishery would most likely benefit from rainfall totals sufficient enough for water managers in Marin County to approve winter releases of freshwater from Nacasio Dam. Nacasio Dam has blocked freshwater input into Lagunitas Creek, the major source of freshwater in the upper end of the bay, every winter since 1987 with the exception of 1992-93. Improved recruitment could result from fish produced during the 1991-92 and 1992-93 seasons which had spawn escapement estimates well above the previous three seasons. Although the 1992 and 1993 year-classes will have little impact in the Tomales Bay commercial fishery next season, this potential recruitment pool suggests that continued recovery of herring stocks in Tomales Bay can be looked upon with cautious optimism.

The Department recommends continuation of the existing conservative management regime by proposing a 1994-1995 initial fishing quota of 250 tons of herring. However, the regulations would also contain provisions to increase the quota based on in-season estimates of spawning escapement. If escapement goals are achieved prior to 15 February 1995, then the quota would be

incrementally increased, as proposed. If spawning escapement does not exceed 2,500 tons prior to February 15, 1995, then no additional fishing quota would be provided for.

Humboldt Bay

The Humboldt Bay herring spawning biomass averaged over 300 tons in the 1990-91 and 1991-92 seasons and appears large enough to support the existing 60 ton fishery.

Crescent City

The Crescent City area herring biomass appears sufficient to support the existing small 30 ton fishery.

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Table 1. Tomales Bay eelgrass bed measurements, 1993-94 season.

Bed No.	Area m^2	Season Last Surveyed	Bed No.	Area m^2	Season Last Surveyed
1	5,268	1993-94	13	165	1992-93
1A	34,645	1993-94	14	745	1993-94
1B	20,758	1993-94	15	0	1989-90
1C	2,748	1993-94	16	4500	1990-91
2	6,865	1993-94	16A	7800	1989-90
2A	878	1993-94	17	2000	1989-90
3	1,064	1993-94	18	0	1989-90
3A	0	1992-93	19	38,000	1989-90
4	0	1992-93	20	135,500	1989-90
5	2,446	1993-94	20A	33,400	1989-90
6	10,254	1993-94	21	1,488,000	1990-91
7	6,838	1992-93	22	140,000	1990-91
8	5,697	1993-94	23	1,209,000	1990-91
9 North	7,968	1993-94	24	43,314	1993-94
9 South	14,409	1992-93	25	76,527	1993-94
10	2,696	1993-94	26	89,123	1993-94
10A	4,749	1993-94	27	12,816	1993-94
11 North	29,261	1993-94	28	35,170	1993-94
11 Middle	384	1993-94	28A	22,714	1993-94
11 South	1543	1993-94	30	not measured	-
12	1398	1993-94			
TOTAL AREA = 3,500,482 m^2					

Table 2. Eelgrass density estimates (kg/m^2) for most of Tomales Bay eelgrass beds, calculated from multiple regression.

BED NO.	DENSITY OF BED					% CHANGE
	1989-90	1990-91	1991-92	1992-93	1993-94	92-93 vs.93-94
1	1.67	0.88	1.39	1.17	1.62	38
1A	1.44	1.99	1.85	1.62	1.51	-7
1B	2.03	2.1	1.94	1.52	1.35	-11
1C	1.41	1.61	1.24	1.51	1.33	-12
2	1.61	1.46	1.63	1.46	1.62	11
2A	No data	No data	No data	1.25	.75	-40
3	1.23	1.11	0.93	1.21	1.35	10
3A	No data	0.77	No data	Not	Not	-
4	0.93	1.22	No data	Not	1.38	-
5	1.24	0.69	0.34	1.42	0.96	-32
6	1.04	1.08	0.6	0.84	0.76	-10
7	1.24	1.13	1.17	0.82	1.67	1
8	1.33	No data	0.48	0.94	0.69	-27
9 North	1.46	0.83	0.72	1.02	0.62	-39
9 South	1.18	0.83	0.92	0.58	0.61	5
10	2.06	1.45	1.09	0.76	1.14	0.5
10A	No data	0.94	1.19	Not	1.08	-
11	1.19	1.07	0.95	0.71	1.38	94
12	1.16	No data	1.03	1.01	1.24	23
13	No data	No data	No data	0.52	No data	-
14	0.68	No data	0.47	0.53	No data	-
15	No data	No data	0.44	Not	No data	-
16	1.76	1.09	No data	1.92	No data	-
16A	2.03	No data	0.83	2.07	No data	-
17	1.59	1.17	2.16	Not	1.92	-
18	0	No data	No data	Not	Not	-
19	1.79	No data	No data	Not	No data	-
20A	0.86	0.43	No data	Not	No data	-
21	2.78	0.96	1.18	1.84	2.08	13
22	1.98	1.99	2.08	1.58	1.89	20
23	1.75	0.98	1.35	1.53	1.56	2
24	1.28	1.83	1.86	2.01	1.49	-26
25	1.55	No data	0.14	0.59	0.93	58
26	1.47	0.63	0.3	0.96	1.47	53
27	1.11	2.07	0.72	1.81	1.47	-19
28	1.35	1.91	1.09	1.54	1.66	8
28A	1.83	2.08	1.17	1.51	1.57	4
30	No data	No data	No data	1.05	0.78	-26
AVERAGE PERCENT CHANGE:						+4

Table 3. Tomales Bay herring spawn data, 1993-94 season.

Date	Location	Area	Eggs/m^2	Millions of eggs	Conversion Factor X 10^{-8}	Tons
19 Nov	1A	34645	38214	1,320	1.38	18
23 Nov	1A	583	68,496	40	1.38	1
14 Dec	1A	34645	399,984	24,300	1.38	335
14 Dec-	1B	22333	27,394	612	1.38	8
14 Dec-	1C	1906	520,188	992	1.38	144
14 Dec	1C	2583	371,710	960	1.38	13
03 Jan 94	1B	22333	394,406	8,810	1.38	122
03 Jan 94	1	5268	393,944	2,080	1.38	29
03 Jan 94	2	2107	20,315	43	1.38	1
03 Jan 94	28A	22714	390,928	8,880	1.38	122
03 Jan 94	1A	34645	34,524	1,200	1.38	16
03 Jan 94	*	366	58,360	9	1.38	T
17 Jan 94	1A	31404	431,044	11,100	1.38	163
17 Jan 94	1A	3204	8,039	43	1.38	T
17 Jan 94	1B	2483	36,407	90	1.38	1
17 Jan 94	1C	2583	39,419	10	1.38	1
17 Jan 94	1C	1786	21,458	38	1.38	T
27 Jan 94	1A	34645	1,193,949	41,400	1.38	571
27 Jan 94	2	4091	81,761	33	1.38	5
27 Jan 94	2	2774	45,700	13	1.38	2
27 Jan 94	1	5268	137,815	73	1.38	10
31 Jan 94	1B	14592	554,707	8,090	1.38	112
31 Jan 94	1B	2332	489,967	1,140	1.38	16
31 Jan-94	1C	1786	193,285	345	1.38	5
31 Jan 94	1C	2,583	193,285	345	1.38	5
02 Feb 94	28A	2,887	838,520	2,420	1.07	26
02 Feb 94	28A	19,827	56,633	1,120	1.07	12
06 Feb 94	27	4,328	651,924	2,820	1.07	30
07 Feb 94	1B	14,592	6,724	98	1.07	1
08 Feb 94	1B	22,333	2,367,359	52,900	1.07	566
08 Feb 94	1C	1785	717,956	1,280	1.07	14
13 Feb 94	28A	16,275	56,151	904	0.96	9
13 Feb 94	28	3,746	60,079	225	0.96	2
					Total	2230

* Pier pilings in Marconi Cove.
T = Less than one ton.

Table 4. Tomales/Bodega Bay Area Herring Biomass Estimates.*

Season	Biomass Estimates		Catch (tons)	Total Tons
	Tomales Bay	Bodega Bay		
1988-89	167	NO SURVEY	213**	380
1989-90	345	350	95**	790
1990-91	779	NO SURVEY	86**	874
1991-92	1,214	NO SURVEY	24**	1,238
1992-93	3,856	NO SURVEY	222***	4,078
1993-94	2230	NO SURVEY	219***	2,449

* Biomass estimates are from spawning ground surveys in Tomales Bay and hydroacoustic surveys in Bodega Bay.
** Herring catch is from Bodega Bay.
*** Herring catch is from Tomales Bay.

Table 5. Pacific herring biomass estimates in Tomales Bay, 1973-74 through 1993-94 seasons.

Season	Spawn Escapement (tons)	Catch (tons)	Spawning biomass (tons)
1973-74	6,041	521	6,562
1974-75	4,210	518	4,728
1975-76	7,769	144	7,913
1976-77	4,739	344	5,083
1977-78	21,513	646	22,163
1978-79	--	448	--
1979-80	5,420	603	6,023
1980-81	5,128	448	5,576
1981-82	6,298	851	7,149
1982-83	10,218	822	11,040
1983-84	1,170	110	1,280
1984-85	6,156	430	6,586
1985-86	435	771	6,000*
1986-87	4,931	867	5,798
1987-88	1,311	750	2,061
1988-89	167	213	380
1989-90	345	--	345
1990-91	779	--	779
1991-92	1,214	--	1214
1992-93	3,856	222	4,078
1993-94	2,230	219	2,449

* Biomass estimated by cohort analysis; for all other years, biomass was estimated from spawning-ground surveys.

Table 6. Confidence limits for Tomales Bay herring spawn estimates, 1993-94 season.

Spawn Date	Location	Std. Error (eggs/m^2)	D.F. n - 1	Estimated Tons	95% Conf. Int.
19 Nov 93	1A	10	15	18	0.01
23Nov93	1A	63,035	5	1	0.5
14 Dec 93	1A	329,290	10	335	157
14 Dec 93	1B	17,041	7	8	5
14 Dec 93	1C	244,467	3	14	6
14 Dec 93	1C	759,078	3	13	27
3 Jan 94	1B	148,633	6	122	46
3 Jan 94	1	409,515	3	29	30
3 Jan 94	2	13,468	5	1	0.4
3 Jan 94	28A	238,107	8	122	75
3 Jan 94	1A	29,591	6	16	14
3 Jan 94	*	28,750	1	T	0.1
17 Jan 94	1A	269,940	17	163	117
17 Jan 94	1A	316,098	2	T	0.3
17 Jan 94	1B	33,854	3	1	1
17 Jan 94	1C	29,313	3	1	1
17 Jan 94	1C	20,466	3	T	0.5
17 Jan 94	1A	512,053	7	571	245
27 Jan 94	2	238,867	2	5	14
27 Jan 94	2	46,813	4	2	2
27 Jan 94	1	281,075	3	10	20
31 Jan 94	1B	429,512	7	112	86
31 Jan 94	1B	258,197	3	16	8
31 Jan 94	1C	202,772	3	5	5
31 Jan 94	1C	192,632	3	5	7
2 Feb 94	28A	977,121	2	26	30
2 Feb 94	28A	50,262	2	12	11
6 Feb 94	27	952,641	3	30	44
7 Feb 94	1B	2,189	5	1	0.3
8 Feb 94	1B	648,190	6	566	155
8 Feb 94	1C	199,658	2	14	4
13 Feb 94	28A	978,946	1	T	1.6
13 Feb 94	28A	83,988	4	9	13
13 Feb 94	28	47,875	3	2	2
TOTAL				2,230	

Table 7. Age and weight composition of the Tomales/Bodega Bay gill net catch, 1982-83 through 1993-94 seasons.

	Age (years)							
Season	2	3	4	5	6	7	8	9
1982-83								
% by number	-	-	4	24	34	24	11	3
% by weight	-	-	3	21	33	25	13	5
1983-84								
% by number	-	-	13	36	35	11	2	3
% by weight	-	-	10	34	36	13	3	4
1984-85								
% by number	1	6	13	27	33	15	4	1
% by weight	1	5	11	25	35	17	5	1
1985-86								
% by number	-	14	25	27	18	10	5	1
% by weight	-	11	23	27	20	12	6	1
1986-87								
% by number	-	4	20	38	27	6	3	2
% by weight	-	3	17	37	29	7	4	3
1987-88								
% by number	-	<1	11	31	34	18	4	<2
% by weight	-	<1	9	28	34	21	5	2
1988-89 *								
% by number	-	4	22	33	28	9	3	1
% by weight	-	3	18	30	31	12	4	2
1989-90 *								
% by number	-	2	9	18	37	26	8	-
% by weight	-	2	7	16	36	31	10	-
1990-91 *								
% by number	-	4	21	32	26	12	4	1
% by weight	-	3	17	29	28	15	6	2
1991-92								
% by number	-	10	26	37	21	6	-	-
% by weight	-	8	23	38	24	7	-	-
1992-93								
% by number	-	1	15	47	30	7	-	-
1993-94								
% by number	-	<1	14	40	36	8	2	-
% by weight	-	<1	12	38	38	9	2	-

* The Tomales Bay fishery was closed three seasons and the samples were collected from the outer Bodega Bay catch.

Table 8. Mean length of herring from Tomales/Bodega Bay roe fisheries, 1972-73 through 1993-94.

YEAR	MEAN LENGTH (mm BL)	SIZE RANGE	YEAR	MEAN LENGTH (mm BL)	SIZE RANGE
1972-73	186	150-234	1983-84	199	174-242
1973-74	190	146-248	1984-85	202	164-232
1974-75	189	142-236	1985-86	198	166-226
1975-76	184	150-230	1986-87	197	174-236
1976-77	169	140-216	1987-88	201	170-234
1977-78	217	194-248	1988-89	197	170-236
1978-79	*	*	1989-90	204	172-222
1979-80	214	196-236	1990-91	197	174-232
1980-81	208	172-234	1991-92	194	168-214
1981-82	211	176-236	1992-93**	196	166-226
1982-83	208	184-236	1993-94**	197	170-234

* No field work this season. ** Tomales Bay fishery only, outer Bodega Bay closed.

Table 9. Length frequency of the 1993-94 Tomales Bay commercial gill net catch of Pacific herring.

Body Length (mm)	Age 3	4	5	6	7	8
232	0	0	0	0	0	1
230	0	0	0	0	0	0
228	0	0	0	0	0	0
226	0	0	0	0	0	0
224	0	0	0	0	1	1
222	0	0	0	0	0	0
220	0	0	0	0	0	1
218	0	0	0	0	0	0
216	0	0	0	0	0	1
214	0	0	0	3	3	1
212	0	0	0	3	2	0
210	0	0	0	6	1	0
208	0	0	0	8	3	0
206	0	0	3	9	4	0
204	0	0	2	9	1	0
202	0	0	1	9	1	0
200	0	0	14	16	2	0
198	0	0	16	4	0	0
196	0	1	16	11	1	0
194	0	3	8	4	0	0
192	0	3	12	2	0	0
190	0	7	6	1	0	0
188	0	1	5	0	0	0
186	0	7	8	0	0	0
184	0	4	3	0	0	0
182	0	1	0	0	0	0
180	0	2	0	0	0	0
178	0	2	0	0	0	0
176	0	0	0	0	0	0
174	0	1	0	0	0	0
172	0	1	0	0	0	0
170	1	0	0	0	0	0
n	1	33	94	85	19	5
Mean	170	186.9	195.3	203.0	208.3	222.2
s.d.	0	5.7	5.3	5.7	6.1	6.9

Table 10. Mean weight (g) at age of Tomales/Bodega Bay herring in the commercial gill net catch by area and season.

Season	Age 2	3	4	5	6	7	8	9	Unwted. mean*
1979-80	-	-	130	135	137	145	188	-	147
1980-81	-	92	113	131	141	153	161	177	138
1981-82	-	83	116	121	147	158	160	172	137
1982-83	-	-	100	120	132	150	169	172	141
1983-84	-	-	91	106	114	131	141	150	122
1984-85	76	102	109	117	135	151	161	172	128
1985-86	73	94	106	121	137	150	148	162	124
1986-87	-	89	98	113	127	150	165	186	133
1987-88	-	78	94	110	125	146	162	166	126
1988-89	-	88	101	114	134	147	171	192	128
1989-90**	-	88	101	120	133	154	173	-	128
1990-91**	-	85	99	110	129	152	177	191	135
1991-92**	-	87	103	122	135	147	-	-	118
1992-93***	-	83	99	117	130	143	-	-	122
1993-94***	-	79	105	121	132	147	173	-	126
Unwted. mean	74	88	104	118	133	148	165	174	130

* Calculated for ages 4 through 8; they comprise 95% of the samples.
** Catch from outer Bodega Bay only, Tomales Bay closed.
*** Catch from Tomales Bay only, outer Bodega Bay closed.

Table 11. Pacific herring mean body lengths and sex ratios from variable mesh gill net catches in Tomales Bay, 1993-94 season.

Date	Mean length(BL mm)	Sex ratio (F/M)
12/06/93	184.7	11/11 (50%M)
12/15/93	196.3	3/6 (67%M)
12/22/93	192.5	1/1 (50%M)
12/28/93	182.9	18/36 (67%M)
12/29/93	200.6	11/15 (58%M)
12/93	185.9	19/28 (60%M)
December total	**187.7**	**63/99 (61%M)**
1/24/94	189.5	3/1 (25%M)
1/27/94	195.5	87/169 (66%M)
January total	**195.3**	**90/170 (65%M)**
2/11/94	195.8	16/17 (52%M)
Total	192.5	169/286 (63%M)

Table 12. Length frequency of Pacific herring from the 1993-94 Tomales Bay variable-mesh gill net catch.

Body Length (mm)	Age 2	3	4	5	6	7	8	9
240								1
218							1	1
216						2		
214					2	4	1	
212				1		2	1	
210				2	1	3		
208					6	1		
206				2	7	2		
204				1	14			
202			1	2	3			
200				6	4	1	1	
198				2	3			
196				5	5			
194			1	6	5			
192			6	7	4			
190			6	6	1			
188			5	2				
186		1	15	3				
184			5	1				
182			6	1				
180		3	5					
178		2	4					
176		7	2					
174		5	5					
172	1	4	1					
170		7						
168	2	6						
166	1	3						
164	1	1						
162		1						
160	1							
158	1							
n	7	40	62	47	55	15	4	2
Mean	165.6	173.0	184.9	195.9	202.1	211.1	211.8	230
s.d.	4.62	4.89	5.89	6.80	5.83	4.22	6.46	14.8

Table 13. Pacific herring age composition from variable-mesh gill net catches in Tomales Bay, 1990-91 through 1993-94 seasons.

Season	Age (yrs) 2	3	4	5	6	7	8	9
1990-91 % by number	10	32	19	17	17	4	<1	<1
1991-92 % by number	3	31	37	20	6	3	-	-
1992-93 % by number	3	25	15	26	19	10	2	<1
1993-94 % by number	3	17	27	20	24	6	2	1

Table 14. Daily landings of Tomales Bay gill net fleet, 1993-94 season.

Date	Pounds	Tons	Trips	Lbs/Trip	Roe count
03 Jan 94	131,592	65.9	22	5,998	11.2
17 Jan 94	137,887	68.9	25	5,515	11.7
07 Feb 94	24,083	12.0	13	1,852	13.0
08-09 Feb 94	125,613	62.8	39	3,221	13.6
21 Feb 94	18,692	9.3	17	1,100	13.7
Total	437,867	218.9	116	3,775	12.3

Table 15. Annual landings by the Tomales/Bodega Bay gill net fleet.

Year	Pounds	Tons	Trips	Lbs/Trip	Roe count
84-85	844,472	422.24	215	3,928	12.8
85-86	1,542,676	771.34	512	3,013	12.5
86-87	1,732,428	866.21	429	4,038	12.5
87-88	1,499,402	749.52	484	3,097	12.4
88-89	426,163	213.08	291	1,465	12.7
89-90	190,409	95.23	61	42	13.5
90-91	173,103	86.55	72	2,404	13.7
91-92	47,125	23.56	30	1,571	14.6
92-93*	444,312	222.31	66	6,737	11.1
93-94*	437,867	218.9	116	3,775	12.8

* Catch from Tomales Bay, outer Bodega Bay closed to fishing.

Table 16. Daily landings of Pacific herring by the Humboldt Bay gill net fleet, 1993-94 season.

Date	Pounds	Tons	Trips	Lbs/Trip	Roe Count
3-Jan-1994	136	0.07	1	136	
5-Jan-1994	259	0.13	1	259	
7-Jan-1994	1,870	0.94	1	1,870	
9-Jan-1994	10,368	5.2	1	10,368	
10-Jan-1994	10,303	5.2	3	3,434	
11-Jan-1994	20,242	10.1	3	6,747	
12-Jan-1994	52	0.03	1	52	
13-Jan-1994	5,960	3.0	2	2,980	
14-Jan-1994	19,037	9.5	3	6,346	
15-Jan-1994	14,710	7.4	3	4,903	
16-Jan-1994	10,865	5.4	3	3,622	
17-Jan-1994	8,591	4.3	3	2,864	
18-Jan-1994	17,348	8.7	3	5,782	
27-Jan-1994	5,761	2.9	1	5,761	
Total	125,502	62.8	29	4,328	

*roe count was not obtained on most landing dates.

Table 17. Humboldt Bay commercial gill net landings, 1974 to 1994.

Season	Pounds	Tons
1974	4,478	2.2
1975	2,000	1.0
1976	23,134	11.6
1977	42,949	21.5
1978	23,417	11.7
1979	98,831	49.4
1980	98,981	49.5
1981	85,920	43.0
1982	103,280	51.6
1983	18,980	9.5
1984	110,384	55.2
1985	118,734	59.4
1986	119,884	59.9
1987	143,202	71.6
1988	62,480	31.2
1989	87,143	43.6
1990	121,873	60.9
1991	126,769	63.4
1992	123,735	61.9
1993	57,191	28.6
1994	125,502	62.8
Total	1,698,867	849.5
Average	80,898	40.4

Table 18. Daily landings of Pacific herring by the Crescent City gill net fleet, 1993-94 season (roe count not obtained).

Date	Pounds	Tons	Trips	Lbs/Trip
19-Jan-1994	1,006	0.5	1	1,006
20-Jan-1994	1,072	0.5	1	1,072
29-Jan-1994	2,265	1.1	2	1,133
6-Feb-1994	41,427	20.7	8	5,178
7-Feb-1994	19,406	9.7	3	6,469
Total	65,176	32.5	15	4,345

Table 19. Crescent City commercial gill net landings of Pacific herring, 1974 to 1994.

Season	Pounds	Tons
1973	24,155	12.1
1974	119,043	59.5
1975	25,514	12.8
1976	2,100	1.1
1977	0	0
1978	25,516	12.8
1979	24,772	12.4
1980	52,228	26.1
1981	18,566	9.3
1982	7,772	3.9
1983	50,481	25.2
1984	37,206	18.6
1985	70,979	35.5
1986	70,606	35.3
1987	0	0.0
1988	99,254	49.6
1989	60,357	30.0
1990	66,411	33.2
1991	72,002	36.0
1992	64,601	32.3
1993	56,922	28.5
1994	65,176	32.5
Total	1,013,661	506.7
Average	46,076	23

Table 20. Pacific herring spawn escapement (tons) and percent of total spawn escapement in Tomales Bay, 1973 to 1994.

Season	Dec	Jan 1-15	Jan 16-31	Feb 1-15	Feb 16-28	Mar	Total
73-74	551	0	2,186	3,052	250	2	6,041
	9%	0%	36%	51%	4%	1%	
74-75	421	357	2,361	769	168	134	4,211
	10%	9%	56%	18%	4%	3%	
75-76	452	4,557	717	1,929	Trace	117	7,769
	6%	59%	9%	25%	0%	2%	
76-77	2,004	2,031	245	212	41	204	4,739
	42%	43%	5%	4%	1%	4%	
77-78	1,072	2,711	17,243	405	88	0	21,517
	5%	13%	80%	2%	1%	0%	
78-79	NO	FIELD	WORK	THIS	SEASON		
79-80	659	1,164	3,497	100	0	0	5,420
	12%	22%	64%	2%	0%	0%	
80-81	192	1,803	2,300	Trace	20	0	5,135
	4%	35%	45%	0%	1%	0%	
81-82	216	1,161	4,528	39	354	0	6,298
	3%	18%	72%	1%	6%	0%	
82-83	159	1,756	2,807	1,777	3,310	553	10,362
	2%	17%	27%	17%	32%	5%	
83-84	51	308	771	40	0	0	1,170
	4%	26%	66%	3%	0%	0%	
84-85	120	190	5,411	590	45	0	6,156
	2%	3%	88%	10%	1%	0%	
85-86	0	5	195	41	193	0	435
	0%	1%	45%	9%	44%	0%	
86-87	0	130	1,350	1,170	2,281	0	4,931
		3%	27%	24%	46%		
87-88	160	195	956	0	0	0	1,311
	12%	15%	73%	0%	0%	0%	
88-89	2	18	146	0	0	0	167
	1%	12%	87%	0%	0%	0%	
89-90	0	0	345	0	0	0	345
			100%				

Table 20 (continued). Pacific herring spawn escapement (tons) and percent of total spawn escapement in Tomales Bay, 1973 to 1993.

Season	Dec	Jan 1-15	Jan 16-31	Feb 1-15	Feb 16-28	Mar	Total
90-91	0	54	671	0	50	3	779
	0%	7%	86%	0%	6%	1%	
91-92	150	0	890	163	8	2	1,214
	12%	0%	74%	13%	1%	0%	
92-93	1,346	345	0	2,140	18	0	3,857
	35%	9%	0%	55%	1%	0%	
93-94	389	290	891	660	0	0	2230
	17%	13%	40%	30%	0%	0%	
AVG 73-94	397	854	2376	654	341	51	4704
AVG%	8%	18%	50%	14%	7%	1%	
CUM%	8%	27%	77%	91%	98%	100%	
AVG 83-94	202	140	1057	437	236	0	2054
AVG%	10%	7%	51%	21%	11%	0%	
CUM%	10%	17%	68%	89%	100%	100%	