Assessment of the Status of Harbor Porpoise (*Phocoena phocoena*) in Oregon and Washington Waters

by
S. Osmek, J. Calambokidis, J. Laake, P. Gearin,
R. Delong, J. Scordino, S. Jeffries, and R. Brown

NOAA Technical Memorandum NMFS

The National Marine Fisheries Service's Alaska Fisheries Science Center uses the NOAA Technical Memorandum series to issue informal scientific and technical publications when complete formal review and editorial processing are not appropriate or feasible. Documents within this series reflect sound professional work and may be referenced in the formal scientific and technical literature.

The NMFS-AFSC Technical Memorandum series of the Alaska Fisheries Science Center continues the NMFS-F/NWC series established in 1970 by the Northwest Fisheries Center. The new NMFS-NWFSC series will be used by the Northwest Fisheries Science Center.

This document should be cited as follows:

Reference in this document to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Assessment of the Status of Harbor Porpoise (*Phocoena phocoena*) in Oregon and Washington Waters

by

S. Osmek[1], J. Calambokidis[2], J. Laake[1], P. Gearin[1], R. Delong[1], J. Scordino[3], S. Jeffries[4], and R. Brown[5]

[1] National Marine Mammal Laboratory
Alaska Fisheries Science Center
7600 Sand Point Way N.E., BIN C-15700
Seattle, WA 98115-0070

[2] Cascadia Research Collective
Waterstreet Building, Suite 201
218 1/2 West Fourth Avenue
Olympia, WA 98501

[3] Northwest Regional Office
National Marine Fisheries Service
7600 Sand Point Way NE
Seattle, WA 98115

[4] Washington Department of Fish and Wildlife
7801 Phillips Road
Tacoma, WA 98498

[5] Oregon Department of Fish and Wildlife
2040 SE Marine Science Drive
Newport, OR 97365

This document is available to the public through:

Notice to Users of this Document

ABSTRACT

The status of harbor porpoise, *Phocoena phocoena,* is reviewed for stocks in Oregon and Washington waters, and the adjacent transboundary waters of southern British Columbia, Canada, emphasizing the most recent data on their geographic range, population structure, distribution, population size, trends in abundance, and reproductive biology. This information is used to determine if the annual rate of incidental mortality and serious injury in gill-net fisheries from 1990-94 could be at a biologically significant level.

In the eastern North Pacific Ocean, harbor porpoise are found near the coast, generally in water depths of less than 200 m. Differences in harbor porpoise mitochondrial DNA and organochlorine pollutant ratios and concentrations indicate that porpoise movements and intrinsic rates of mixing are sufficiently restricted to form geographically distinct groups, but not specific stock boundaries. Two harbor porpoise transboundary management areas, the Inland Washington Stock and the Oregon/Washington Coast Stock, are recommended because incidental takes of harbor porpoise occur in commercial sockeye salmon gill-net fisheries of inland Washington waters.

The corrected 1990-91 best and minimum abundance estimates are $N = 3,352$ ($CV(N) = 0.270$) and $N_{min} = 2,680$ for inland Washington/southern British Columbia, and $N = 26,175$ ($CV(N) = 0.206$) and $N_{min} = 22,049$ for coastal Oregon/Washington. Except for Puget Sound, where a substantial decline in harbor porpoise abundance has occurred, there are no data to determine population trends in Oregon and Washington waters. The aerial survey data collected during the summer of 1990-91 for water depths less than 91 m (50 fathoms), indicated significant differences ($z = 6.9$, $P<0.001$) in harbor porpoise mean densities (1.7 animals/km^2 and 0.5

animals/km^2, respectively) between the waters of southern coastal Washington/Oregon and northern coastal and inland Washington (i.e., the U.S. and Canadian portions of the Strait of Juan de Fuca and San Juan Islands). Although incidental takes of this species in gill-net fisheries only occur in the regions of lowest harbor porpoise densities, other factors such as variations in habitat quality may be responsible for these observed density differences.

To determine if the annual number of incidental takes in gill-net fisheries was potentially significant for a particular stock, an average mortality rate was calculated for 1990-94 and compared to the stock's calculated potential biological removal (PBR) level (i.e., the product of the minimum population estimate, one-half the maximum theoretical productivity rate and a population recovery factor). For the Inland Washington Stock, an estimated total of 16 harbor porpoise are killed or seriously injured annually: 15 animals/year (90% C.I. = 2 - 58) are incidentally taken in the commercial and tribal sockeye salmon drift gill-net fishery and 1 is estimated to be taken annually in the tribal northwest Washington chinook salmon set gill-net fishery. This combined rate is less than the PBR, but it exceeds 10% of the calculated PBR (27 x 0.1 = 2.7 animals). This tribal chinook salmon fishery also operates in the waters of the Oregon/Washington Coast Stock. An average of 9 harbor porpoise (1990-93 data) are incidentally taken or seriously injured annually. The annual incidental mortality is less than 10% of the PBR (220 x 0.1 = 22) for the coastal stock.

CONTENTS

INTRODUCTION

In November 1988, the U.S. Congress passed a series of amendments to the Marine Mammal Protection Act (MMPA) that established the Marine Mammal Exemption Program (MMEP) and the Marine Mammal Assessment Program (MMAP). The MMEP was created to provide fisheries that incidentally took marine mammals in the U. S. Exclusive Economic Zone (EEZ) with limited exemptions from the MMPA regulations for 5 years. During that time, the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) were responsible for determining the level of human-induced marine mammal mortality and serious injury for fisheries suspected of incidentally taking marine mammals, and for gathering information on marine mammal populations, distribution, abundance, stock structure, and trends for those species that spend some portion of their time in the EEZ, These programs provided the requisite information for the NMFS to calculate potential biological removal (PBR) levels and to estimate the potential significance of human-caused impacts on marine mammal stocks. The PBR is defined as "the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population (OSP)" (Barlow et al. 1995). Barlow et al. (1995) defined a "stock" as "the fundamental [population] unit of legally mandated conservation efforts," unless some biologically significant data was available that would help delineate a specific stock boundary.

This document reviews information on the population status of harbor porpoise, *Phocoena phocoena,* occupying Oregon/Washington marine waters (Osmek et al. 1992, 1993, 1994, 1995), and recommends stocks for management purposes (i.e., stock boundaries do not necessarily represent stocks of biological significance). General information regarding harbor porpoise

geographic distribution along the west coast of North America and their reproductive biology is examined, while the subunits of this west coast population, abundance estimates, and regional density differences are discussed more specifically for Oregon/Washington waters. This information and the annual rates of incidental mortality and serious injury in commercial and tribal gill-net fisheries are used to determine PBR levels and the potential significance of human-induced impacts on two harbor porpoise stocks. The transboundary marine waters of southern British Columbia are considered an important biological component of inland Washington waters and are included in this stock (Fig. 1). The adjacent marine waters south of Oregon are divided into a Northern California Stock and a Central California Stock of harbor porpoise These stocks are discussed by Barlow and Hanan (1995).

RANGE AND STOCK STRUCTURE

Geographic Range and Seasonal Occurrence

In the eastern North Pacific Ocean, harbor porpoise are found coastally from north of Point Barrow, Alaska, south to Point Conception, California, and are typically seen in groups of less than 10 individuals. Harbor porpoise may occasionally frequent bays, the mouths of large rivers, and at times, they ascend freshwater streams (Leather-wood and Reeves 1983). Some of the earliest scientific observations of harbor porpoise in the northeast Pacific are from Lewis and Clark, who reported sighting harbor porpoise in the Columbia River near its mouth during their 1804-6 expedition (Twaites 1904-5). Aerial survey data, collected out to the 91 m (50 fathoms) isobath along coastal Oregon/Washing-ton (Calambokidis et al. 1992), suggests that the summer

1991 harbor porpoise distribution varied by depth with 65% of all group sightings (n=319) occurring in waters shallower than 37 m (20 fathoms). They found no meaningful relationship to water depth for the Strait of Juan de Fuca, but for the waters of the U.S./Canadian San Juan Islands, harbor porpoise were found more often at depths greater than 91 m. Distribution by depth in the five survey areas where harbor porpoise were observed was found to differ significantly from the expected effort-corrected uniform pattern. Although the sample size of sightings (n=88 animals) is small from a study by Green et al. (1992), their summer 1989-90 survey data indicate that most (68%) of the harbor porpoise individuals were found at water depths shallower than 100 m and were rarely observed at depths greater than 200 m.

Few reliable data are available on seasonal changes in distribution or abundance of harbor porpoise in the North Pacific Ocean. Catch per unit effort data from the 1988-89 northern Washington salmon set gill-net fishery indicate that seasonal changes in distribution may regularly occur around the Spike Rock fishing grounds (Fig. 2). Gear-in et al. (1994) reported that for gill nets fished less than 1.6 km from shore (11-30 m deep), more harbor porpoise were incidentally taken during July/August than during May/June. Both harbor porpoise and chinook salmon *(Uncorynchus tshawytscha)* were found to consume primarily Pacific herring *(Clupea pallasi),* market squid *(Loligo opalescens),* and smelts (Osmeridae). Harbor porpoise may follow prey into shallower waters during July/August. Taylor and Dawson (1984) observed that the harbor porpoise density (animals/km^2) in Sitakaday Narrows, Glacier Bay, Alaska, increased from 1.7 during summer to 5.9 during fall (P<O.OOl), and group size in this study area increased from about 1 in July to greater than 3 in February. Taylor and Dawson surmise that these changes in density and group size are related to changes in prey availability and feeding strategy

Harbor porpoise are present year-round in Oregon and Washington (Haley 1988,' Green et al. 1992). Observations of harbor porpoise on the east coast of North America indicate that a seasonal migration occurs, with the animals moving south and possibly offshore during winter (Gaskin 1977, Gaskin and Watson 1985). Annual migrations have also been described for harbor porpoise in Danish waters, where animals were driven into traps and captured (Heel 1962) and in British waters where seasonal differences in the number of harbor porpoise strandings have been documented (Easton et al. 1982). In the northeast Pacific, however, no strong seasonal migration has been documented.

Biological Subunits of the Population

Various methods have been used to determine population stock structure of harbor porpoise along North America. In the western North Atlantic, four major sub-populations of harbor porpoise are proposed (Gaskin 1984) based, in part, on differences in cranial morphology (Yurick and Gaskin 1987). Genetic and contaminant analyses have been used to investigate the stock structure of harbor porpoise in the northeast Pacific.

<u>Genetics</u>

Subunits of the population were analyzed using mitochondrial DNA (mtDNA) from samples collected along the west coast (Rose1 1992). Two distinct mtDNA groupings exist. One group is present in California, Washington, British Columbia, and Alaska. (No samples were available from Oregon.) A second group exists only in California and Washington waters. When an analysis of genetic variance was conducted with these data and **data** from additional samples from these regions, Rose1 et al. (1995) found significant differences for four of the six pair-wise comparisons.

These results demonstrate that harbor porpoise along the west coast of North America are not panmictic and genetic differences have evolved. Sample sizes were insufficient to determine whether genetic differences also exist between harbor porpoise of coastal Washington and the inland Washington waters of the Strait of Juan de Fuca, San Juan Islands, and Puget Sound (Fig. 1).

Contaminants

Geographic differences in organochlorine pollutant residue (OPR) ratios and concentrations have been used to assess harbor porpoise stock discreteness along the west coast of North America (Calambokidis and Barlow 1991, Osmek et al. 1994). Calambokidis and Barlow (1991) found decreasing concentrations of DDE in harbor porpoise blubber for those beach cast or incidentally caught individuals collected from coastal California north to coastal Washington waters. A similar decrease in DDE concentration with an increase in latitude was reported by Osmek et al. (1994) for samples collected in Oregon, Washington, and British Columbia waters, Calambokidis and Barlow (1991) showed that through discriminant analysis of OPR ratios, the state from which the harbor porpoise was collected from could be accurately predicted for 86% of the samples. These observed differences in OPR ratios illustrate that harbor porpoise movements are not coastwide. However, no specific boundaries can be identified from these genetic and contaminant data to determine biologically discrete subunits.

Recommended Stocks for Management

In the absence of evidence to define stocks of biological significance, management boundaries must be selected in a way to reasonably protect harbor porpoise so their populations

can be maintained within OSP, or if depleted, can be restored to OSP. It is recommended that a conservative approach be used to assign harbor porpoise stock boundaries in Oregon and Washington waters. The biological evidence indicates harbor porpoise movements are not range-wide in the northeast Pacific Ocean even though specific boundaries have not been empirically substantiated. The lack of a stock boundary within Oregon/Washington waters could result in an inappropriately large PBR being used for fisheries concentrated in northern Washington that may result in a local depletion of porpoise. Conversely, a harbor porpoise management plan that is too conservative is undesirable because a biologically significant stock could be repeatedly split which may result in commercial fishing activities being unnecessarily restricted.

It is recommended that Oregon and Washington waters be divided into two harbor porpoise stocks, Inland Washington and Oregon/Washington Coast, using a boundary located at the western end of the Strait of Juan de Fuca. This boundary extends north from Tatoosh Island, Washington, to Bonilla Point, British Columbia (approximately long. 124.43.5°W, Fig. 1). This boundary is also used by the Washington Department of Fish and Wildlife (WDFW) to manage commercial fisheries operating in Areas 4 and 4B (Fig. 2). A stock boundary at this location protects harbor porpoise in most areas where animal densities are relatively low and includes all non-tribal commercial gill net fisheries that are known to incidentally take harbor porpoise. This boundary, however, does not include all of the tribal gill-net fisheries that incidental take harbor porpoise along northern Washington of the Oregon/Washington Coast Stock.

ESTIMATES OF POPULATION SIZE AND REGIONAL DENSITY

Cooperative efforts between NMFS and various state and private organizations have focused on aerial and shipboard surveys and a correction factor to provide the best estimate of harbor porpoise abundance for Oregon, Washington, and southern British Columbia waters, Aerial line-transect surveys were flown during 1984-85 (Barlow et al. 1988) 1989 (Turnock et al In press.), 1990 (Calambokidis et al. 1991), 1991 (Calambokidis et al. 1992) and 1994 (Osmek et al. 1995). Vessel surveys were conducted during 1984-86 (Barlow 1988), 1988-89 (Calambokidis In press), and 1994 (Osmek et al. 1995). The aerial survey data collected by Calambokidis et al. (1992) are best suited for estimating harbor porpoise abundance for both stocks because these surveys had the most complete coverage of Oregon, coastal/inland Washington, and the transboundary waters of southern British Columbia.

Correction Factor

A correction factor for harbor porpoise aerial surveys was needed to compensate for the number of animals missed by observers on the survey trackline. Aerial-line transect theory assumes that animal sightability is 100% near the transect line ($g(0) = 1$), but decreases as a function of distance from the trackline. If factors such as animal submergence, sea state, cloud cover, water turbidity, and glare reduce visibility near the line ($g(0)<1$), abundance estimates will be negatively biased. To correct for these biases, a calibration experiment was conducted in August 1992 to estimate the probability that all porpoise groups are detected near the aerial trackline (Calambokidis et al. 1993a). Shore-based observers visually tracked porpoise groups

using theodolites and recorded locations, group sizes, and surfacing rates while the same twin-engine aircraft, used during the 1990-91 surveys, flew transects through the San Juan Islands study area. The shore and aerial sighting data were compared to determine whether a group at or near the surface was seen by aerial observers. Of the 92 groups located from shore within 100 m of the aerial trackline, 28 (30.4%) were seen by the aerial observers. With a point estimate of $g(0) = 0.324$ (SE = 0.056, var = 0.003), the correction factor was calculated at 3.1 $(1/g(O))$.

Best Estimate of Abundance

The summer 1991 surveys (Figs. 3b-d) provide the most recent abundance estimates and used aerial survey methods identical to the 1990 surveys (Fig. 3a). Therefore, these data were pooled by Calambokidis et al. (1993b) to estimate abundace. During these 1990-91 surveys, two side-window observers and one belly window observer reported harbor porpoise sightings to the data recorder while the aircraft flew a sawtooth configuration of line transects at an altitude of 183 m (600 ft) and a speed of 167 kmhr (90 knots). Along coastal Oregon/Washington, survey tracklines were primarily flown out to the 91 m isobath (50 fathoms). The exception was Heceta Bank, along coastal Oregon (Fig. 3b), where waters out to 182 m (100 fathoms) deep were sampled to provide complete coverage of the coastal waters where harbor porpoise commonly occur This survey design, however, excluded some harbor porpoise in Oregon/Washington coastal waters distributed at depths greater than 91 m (Green et al. 1992). All water depths were surveyed along inland Washington and southern British Columbia. Calambokidis et al. (1993b) estimated harbor porpoise abundance following the methods described by Buckland et al. (1993),

using the program DISTANCE (Laake et al. 1993). Only effort and group sightings from on-effort periods with optimal sighting conditions (Beaufort Wind Scale <_ Force 2 and cloud cover 5 25%) were used. The Hazard-rate model, with one cosine adjustment term, was used in the analysis to estimate the probability of detection with perpendicular distance from the track line (Fig. 4). The coefficient of variation (CV) for the corrected abundance estimates are below 0.30, an objective of Ferrero and Fowler (1992).

The estimate of harbor porpoise abundance for the Inland Washington Stock is 3,352 (CV = 0.270)(Table 1). It is important to note, however, that this may be a slight overestimate of abundance because the 1991 surveys were conducted before the Tatoosh-Bonilla harbor porpoise stock boundary was defined. Approximately 10% of the survey area was located outside (west) of this stock boundary and is part of the Coastal Oregon/Washington stock (Fig. 3c)(The amount of geographic area added to the coastal stock is 1% and is considered an inconsequential addition). Another important factor to consider is that an additional 20 % of the stock area lies in the waters of British Columbia outside the EEZ. Consequently, about 30% of the Inland Washington survey area lies either outside U.S. waters or the stock boundary line.

The best abundance estimate for the Oregon/Washington Coast Stock is 26,175 (CV = 0.206) harbor porpoise. No harbor porpoise were sighted in the mouth of the Columbia River, Grays Harbor, Willapa Bay, Hood Canal or Puget Sound in 1991 (Fig. 3d).

Minimum Population Estimate

The minimum population estimate (NG) is the 20th percentile of a log-normal distribution based on the estimate of the number of animals in a stock. N_{min} is calculated using Equation 1

from the 27-29 June 1994 PBR Workshop (see Barlow et al. 1995):

$$N_{min} = N/\exp(0.842*[\ln(1+[CV(N)]^2)]^{1/2})$$

where N is the abundance estimate. The minimum estimates of abundance are 2,680 for the Inland Washington Stock and 22,049 for the Oregon/Washington Coast Stock (Table 2).

Regional Differences in Density

We compared the density data from the five subregions that comprised the study area of Calambokidis et *al.* 1991 (Table 1). Harbor porpoise density in northern Washington (0.5 animals/km^2) is lower than the density in southern Washington (1.7 animals/km^2)(Z = 6.9, P<O.OOl). The aerial survey boundary separating these two water bodies occurs approximately one-quarter of the way down the Washington coast near the mouth of the Hoh River (Fig. 3b). Southern Washington had the highest density of porpoise with Oregon waters ranking second (Table 1). Barlow (1988) and Green et al. (1992) also reported a relatively high density in the waters off southern Washington and northern Oregon, (around the Columbia River mouth), with a much lower density occurring along the northern Washington coast. The only other dramatic difference was for the inland Washington waters of Hood Canal, and south Admiralty Inlet, in Puget Sound, where no harbor porpoise were observed.

The reasons for these disparities are unknown, but it may be related to differences in habitat or the location where incidental takes in gillnet fisheries occur. Fisheries-related incidental takes have only been reported from the waters of coastal northern Washington and the inland waters of Washington and British Columbia where densities are lowest.

POPULATION TRENDS AND GROWTH RATES

Population Trend

There are currently no reliable data on population trends of harbor porpoise for the waters of coastal Oregon/Washington, British Columbia, and most of inland Washington. In Puget Sound, however, it is known that a substantial decline in harbor porpoise abundance has occurred. During the 194Os, harbor porpoise were considered common in Puget Sound (Scheffer and Slipp 1948). Though quantitative data for this area are lacking, marine mammal survey effort (Everitt et al. 1980; Dale Rice, NMML, unpublished data), stranding records since the early 1970s (NW Marine Mammal Stranding Network, unpublished data) and the results of harbor porpoise surveys of 1991 (Calambokidis et al 1992) and 1994 (Osmek et al. 1995) indicate that harbor porpoise have become increasingly rare, Although declines in abundance have not been quantified elsewhere in inland Washington or British Columbia, anecdotal information suggests that abundance is declining in those areas (Flaherty and Stark 1984, Calambokidis and Baird 1994, T. Guenther, Marine Mammal Research Group, Box 6244, Victoria, BC, V8P 5L5, pers. commun., June 1995).

The cause(s) of the decline in Puget Sound are unidentified, but they are possibly related to several factors, including mortality associated with entanglement in gill-net fisheries, decreased reproductive output, immunosuppression, anthropogenic contaminants, human-generated noises, recreational and commercial sea-going vessel traffic, and possibly changes in prey availability and competition with Dall's porpoise *(Phocoenoides dalli),* a species that has likely increased in numbers within Puget Sound (Osmek et al. 1995).

Maximum Net Productivity

The maximum net productivity rate (R_{max}) has never been measured for free-ranging harbor porpoise. Barlow and Boveng (1991), using a female age at first birth of 4-years old, calculated a theoretical upper bound for R_{max} of 9.4% per year. Woodley and Read (1991) calculated a harbor porpoise R_{max} value of 5% per year, using the reproductive and survival rates of a Himalayan thar, *Hemitragus jemlahicus.* This terrestrial species is thought to exhibit a maximum reproductive potential similar to harbor porpoise because it also produces an average of one offspring annually, starting at age 4, and is not long-lived.

Barlow and Boveng (1991) recommended that their R_{max} value not be used for managing harbor porpoise populations because the objective of their study was to develop an exploratory model and not one for immediate application. It was decided the R_{max} value of Himalayan thars also should not be used to calculate PBR because the appropriateness of these data has not been fully evaluated. The default cetacean R_{max}, rate of 4% will be employed for Oregon/Washington harbor porpoise until additional data become available (Barlow et al. 1995).

CURRENT BIOLOGICAL REMOVALS

Incidental Mortality and Serious Injury

To maintain consistency with other MMAP documents that describe the status of marine mammal populations, the following estimates of incidental mortality and serious injury are based on observer data from five fishing seasons, 1990-94. For the set gill-net fishery along northwest

Washington, incidental mortality data since 1988, the year when this program was initiated, is provided to illustrate the dynamics of this tribal fishery in terms of annual variability in fishing effort and the number of annual incidental takes (Table 3). A description of the drift gillnets and set gillnets used in the salmon fisheries is provided in the Appendix.

Inland Washington Fisheries

In recent years, harbor porpoise have been incidentally taken from inland Washington waters in two gillnet fisheries: the Area 7/7A commercial/tribal San Juan Islands sockeye salmon *(Oncorynchs nerka),* drift gill-net fishery (Fig. 5) and the Area 4B/5 northwest Washington chinook salmon set gill-net fishery (Fig. 2). During August/September 1993-94, NMFS, in cooperation with the WDFW and the Northwest Tribes, conducted observer programs to monitor incidental takes of marine mammals in commercial drift gill-net and purse-seine activities within the U.S. waters of the Strait of Juan de Fuca and the San Juan Islands. One mortality was observed in Area 7 during the 1994 drift gillnet fishery near the San Juan Islands (Pierce et al. 1996). During this 1994 fishery, another harbor porpoise was observed entangled and released alive, presumably uninjured. Using one observed harbor porpoise mortality and over 600 observed gill-net sets in Areas 7 (almost 7% observer coverage), an incidental take estimate of 15 (90% C.I. = 2 - 58) harbor porpoise per year was calculated for an estimated total of 6,521 (SE=614) commercial sets and 2,824 (SE=286) tribal sets (Pierce et al. 1996).

Harbor porpoise are also known to be incidentally taken in the U.S. waters of the western Strait of Juan de Fuca in Area 4B/5 (Gearin et al. 1994, and NMFS, Northwest Region, unpublished data)(Fig. 2). This northwest Washington chinook salmon set gill-net fishery is exclusively tribal and is authorized by the Makah Tribe to operate annually from May through September. Most fishing activity, however, occurs from late May or early June through the middle

of August. From 1988 to 1993, 61.4% of the total fishing effort (5,429 net days) was expended in the western Strait of Juan de Fuca with the remainder spent along coastal northern Washington of the Oregon/Washington Coast Stock. One harbor porpoise was reported taken by a tribal fisherman during 1989 and one was observed taken by a NMFS fishery observer during 1991. That single take was used to extrapolate the mortality rate estimate of two for 1991 (Table 3). Excluding 1994, when no observer data was available for this fishery, the 1990-93 average annual take rate is one (2 kills/4 years = 0.5).

During October 1992, a harbor porpoise was incidentally killed in a tribal salmon gillnet in southern Puget Sound; the Tribe's reaction to the entanglement was one of surprise, probably indicating that such mortalities, like sightings of live animals, are infrequent (Osmek et al. 1995). Harbor porpoise incidental takes also occur in fisheries of inland British Columbia (Stacey et al. 1990, Baird et al. 1994a), but because observer programs are also lacking in these areas, no reliable annual take rates exist.

Oregon/Washington Coast Fisheries

Within the Oregon/Washington Coast Stock, harbor porpoise are incidentally taken in the Area 4/4A northwest Washington chinook salmon set gill-net fishery. Although much of the set gill-net fishing effort has recently been expended within the western Strait of Juan de Fuca, incidental take levels are much higher along the northern Washington coast. Since 1988, all but two harbor porpoise (n = 156) were incidentally taken from coastal Washington waters (Table 3). During 1988, 1989, 1990, and 1991, NMFS fishery observers saw 22, 14, 13, and 14 harbor porpoise incidentally taken, respectively. Fishing effort has decreased each year along coastal Washington from 1988 to 1993, when no effort was expended on the coast. This decline in fishing effort and incidental takes was primarily due to declining salmon runs. Though no observer

program was conducted during 1994; it is known that harbor porpoise were incidentally taken from the Oregon/Washington Coast Stock,

The total annual estimate of mortalities, using the percent observer coverage and the number of harbor porpoise observed taken by NMFS observers, was 33 (CV = 0.26), 16 (CV = 0.27), and 19 (CV = 0.29) for 1989, 1990, and 1991, respectively (Table 3). In 1988, no reasonable estimate of incidental mortality could be extrapolated because observer coverage was low and concentrated on one vessel that fished in the waters of Spike Rock, an area where incidental mortalities are highest (Gearin et al. 1994). It is known that 102 harbor porpoise were incidentally taken during 1988; the minimum estimate for 1992 and 1993 is 2 and 0, respectively. Because the 1994 data is currently unavailable, annual take estimates from 4 years (1990-93) were used to calculate the average incidental mortality rate of 9 harbor porpoise. Although gillnets are used in Oregon, the Columbia River, Willapa Bay, and Grays Harbor, no harbor porpoise incidental takes have been reported for these fisheries.

Sex and Age Distribution of Incidental Takes

Reproduction and population growth of harbor porpoise could be dramatically reduced if high numbers of adult females are removed from a population. Gearin et al. (1994) reported the sex and age structure of harbor porpoise recovered and necropsied from the tribal northwest Washington chinook salmon set gill-net fishery between 1988 and 1990 (Fig. 6). Of the 44 females examined, 3 1 (70.5%) were reproductively immature while 13 (29.5%) were mature. Of the 55 males sampled, 4 (7.3%) were calves, 28 (50.9%) were reproductively immature males and 23 (41.8%) mature males. It is not apparent from these data whether this fishery is removing harbor porpoise of each age and sex categories at proportions other than their relative occurrence

in the wild (Table 4). However, it does show that all sex and age classes are susceptible to entanglement in gillnets.

Other Human-Induced Mortality Causes

Subsistence Take

No directed subsistence takes of harbor porpoise presently occurs in Oregon or Washington waters. There are recent reports of fisherman in British Columbia (Stacey et al. 1990) and tribal fisherman in Washington who have eaten incidentally caught porpoise, but it appears this was done on an opportunistic basis and is probably uncommon. Historically, subsistence takes of harbor porpoise by harpooning along northwest Washington (Swan 1870) and shooting have occurred on the west coast (Scammon 1874, Scheffer and Slipp 1948). Because these methods of take are presumably difficult, relying on a porpoise to approach within shooting range, harvest levels of harbor porpoise by the northern tribes of the west coast were not thought to be great.

Illegal Killing and Intentional Harassment

Illegal takes of harbor porpoise are not known to occur and are considered unlikely because harbor porpoise are not known to feed on fish caught by fishing gear and therefore are not viewed as a menace by fisherman. This species currently does not provide products of commercial value which would encourage directed takes.

Live Capture

Free-ranging harbor porpoise are not easily live-captured using an active approach (Heel 1962, Silbers et al. 1990) and therefore have not been taken from the wild in large numbers. Only

live-stranded neonates, recovered from Oregon/Washington beaches and rehabilitated at the Point

Defiance Zoo and Aquarium, Tacoma, Washington, have been taken from the wild.

Unusual Mortality Events

Other causes of mortality that have the potential for affecting large numbers of harbor

porpoise have been noted in the waters of Washington and British Columbia. During October

1992, five dead harbor porpoise in fresh condition were found along several kilometers of

Washington's Long Beach Peninsula, near the mouth of the Columbia River (NMML,

unpublished data). The stomach contents from two of these harbor porpoise were tested for

paralytic shellfish poisoning (PSP), an assortment of biotoxins produced by dinoflagelates

(Alexandrium spp.) responsible for causing red-tides. Paralytic shellfish poisoning was found at

low concentrations (40 pg/lOO g and 41 pg/lOO g) below the U.S. Food and Drug Administration

regulatory closure level of 80 pg./100 g for seafood (J. Wekell, NMFS, Northwest Fisheries

Science Center, Utilization Research Division (URD), Seattle, WA, pers. commun January

1996). Northern anchovy, *Engraulis morahx,* was a common prey item found in both stomachs

and is thought to be the source of the PSP toxicity. During the same time period as the strandings,

a red-tide event was observed along the coast of Washington/Oregon and higher levels of PSP

were detected in mackerel (90 pg/lOO g) sampled 111 km (60 nm) offshore of Newport, Oregon,

and razor clams from southern Washington (M. Eklund, URD, pers. commun., May 1995). The

total number of porpoise affected (if they are affected at all by PSP) or the length of time these

animals were exposed to the low PSP levels is unknown. Additional analysis of stomach contents

for demoic acid, another biotoxin, and tissues selected for histopathological examinations, provided no information on the cause of these mortalities.

From April to May 1993, Baird et al. (1994b) collected the carcasses of 13 harbor porpoise, 10 Dall's porpoise and 1 unidentified porpoise along the beaches of Victoria, Vancouver Island, British Columbia (Fig. 1.). This number of stranded small cetaceans in this vicinity was relatively high compared to the average for an entire year (about 0 to 4 small cetaceans carcasses). Most of these porpoise had enlarged mesenteric lymph nodes, but the cause could not be investigated thoroughly, so the deaths could not be related to PSP or other disease agents. The total number of harbor porpoise affected by this event was undetermined.

POTENTIAL BIOLOGICAL REMOVALS AND STATUS OF STOCKS

PBR Calculations

Under the 1994 re-authorization of the MMPA, PBR is the product of the minimum population estimate (N_{min}), one-half the maximum theoretical net productivity (R_{max}) rate, and a recovery factor (F,):

$$PBR = N_{min} \times 0.5\ R_{max} \times F_r.$$

The F, for this stock is 0.50, the value for cetacean stocks with unknown population status (Barlow et al. 1995). Using an R_{max}, value of 0.04, the PBR is 27 for the Inland Washington Stock and 220 for the Oregon/Washington Coast Stock (Table 2).

Determination of Significance

Barlow et al. (1995) interpreted the zero-rate mortality goal of the MMPA to be met if the level of incidental mortality from commercial fishing operations is below 10% of PBR. If the level of incidental mortalities exceeds 10% of PBR, these takes cannot be considered an insignificant level. If the mortality level exceeds PBR then the number of takes are significant and the affected stock is defined as strategic.

For the Inland Washington Stock, total fishery mortality and serious injury, 16 (15+1), exceeds 10% of the calculated PBR (27 x 0.1 = 2.7) and, therefore, this take rate can not be considered insignificant. When the PBR is reduced by 30% (27 x (1.0 - 0.30) = 19), the amount of survey area outside the boundaries of this stock, stock status is unchanged because the take rate is still below 19. The incidental take level of 9 animals per year for the Oregon/Washington Coast Stock is insignificant because 9 is less than 10% of PBR (220 x 0.1 = 22).

Stock Status Relative to OSP and K

The status of these stocks relative to the OSP and carrying capacity (K) have not been determined because no reliable estimates of these parameters are available for comparison with the most recent (1991) abundance estimates for Oregon/Washington waters.

MANAGEMENT RECOMMENDATIONS AND CONSIDERATIONS

Future harbor porpoise studies should be conducted primarily in the transboundary waters of Washington and British Columbia, Canada where most fisheries incidental takes are known to occur and where harbor porpoise densities are low. It is recommended that NMFS and the Department of Fisheries and Oceans develop cooperative programs to assess harbor porpoise abundance and incidental take levels in those waters under their jurisdiction. For the next aerial surveys planned for inland Washington and coastal Oregon and Washington, the Tatoosh-Bonilla stock boundary and the international boundary should be used to define survey regions. Based on the results of these surveys, updated estimates of animal density, and ongoing studies of harbor porpoise stock structure, the best location(s) for a stock boundary should be reevaluated.

Inland Washington Stock

The potential effect of the sockeye salmon drift gill-net fishery takes on the status of this stock should be reviewed again when separate estimates of harbor porpoise abundance are available for both inland Washington and inland southern British Columbia. Until then, a conservative management approached for this stock is needed because:

1). The estimated mean level of incidental take can not be considered an insignificant annual mortality rate.

2). The upper 90% confidence interval for the incidental mortality estimate (n=58) exceeds twice the PBR (n=27).

3). The abundance estimate, and hence the PBR value, may be inappropriately large because approximately 30% of the 1991 survey area was inside British Columbia waters or west of the stock boundary line.

4). It is known that dramatic declines in harbor porpoise abundance have occurred in Puget Sound (Osmek et al. 1995).

Oregon/Washington Coast Stock

Emphasis should be placed on developing measures to mitigate incidental takes of harbor porpoise, particularly along coastal northwest Washington where monthly rates can exceed 0.7 mortalities per net day (Gearin et al. 1994). If the fishing effort increases to 1988-89 levels without mitigation, the annual number of harbor porpoise killed in this tribal fishery could rise to biologically significant levels (>lO% of PBR = 22). Such take levels could also negatively affect the status of the adjacent Inland Washington Stock because animals likely cross over the boundary that separates these two harbor porpoise management areas.

ACKNOWLEDGMENTS

.

CITATIONS

Baird, R.W., S.G. Wischniowski, T.J. Guenther, M.L. McAdie, and T.E. Cornish. 1994a. Strandings and fishing gear entanglements of cetaceans on the west coast of Canada in 1993. Int. Whal. Commn Doc. SC/46/05.

Baird, R.W., T. J. Guenther, R.R. Lewis, ML McAdie, and T.E. Cornish. 1994b. An investigation into the cause of an unusual porpoise, *Phocoena phocoena* and *Phocoenoides dalli,* mortality event in southern British Columbia. Contract Report to Dept. of Fish. and Oceans, British Columbia, Canada (available through NOAA, NMFS, NMML). 17 p.

Barlow, J. 1988. Harbor porpoise, *Phocoena phocoena,* abundance estimation for California, Oregon and Washington: I. Ship Surveys. Fish. Bull., U.S. 86:417-432.

Barlow, J., C.W. Oliver, T.D., Jackson, and B.L. Taylor. 1988. Harbor porpoise, *Phocoena phocoena,* abundance estimation for California, Oregon and Washington: II. Aerial Surveys, Fish. Bull., U.S. 86:433-444.

Barlow, J., and P. Boveng. 1991. Modeling age-specific mortality for marine mammal populations. Marine Mammal Sci. 7(1): 84-ll9.

Barlow, J., and D. Hanan. 1995. An assessment of the 1994 status of harbor porpoise in California. Pages 123-140. *In* A. Bjorge, G.P. Donovan, and J. Barlow (editors), Biology of the Phocoenids. Rep. Int. Whal. Commn. Special Issue 16

Barlow, J., S. Swartz, T.C. Eagle, and P.R. Wade. l995. U.S. marine mammal stock assessments: guidelines for preparation, background, and a summary to the 1995 assessments. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-6,73 p.

Buckland, S.T., D.R. Anderson, K.P. Bumham, and J.L. Laake. 1993. Distance sampling: estimating abundance of biological populations. Chapman & Hall, London. 446 p.

Calambokidis, J., and J. Barlow. 1991, Chlorinated hydrocarbon concentrations and their use for describing population discreteness in harbor porpoise from Washington, Oregon, and California. Pages 101-l10. *In* J.E. Reynolds III and D.K. Ode11 (editors), Proceedings of the Second Marine Mammal Stranding Workshop: 3-5 December 1987. Miami, FL. U.S. Dep. Commer., NOAA Tech. Rept. NMFS 98.

Calambokidis, J., J.C. Cubbage, S. J. Jeffries, P. J. Gearin, and R. Brown. 1991. Harbor porpoise distribution and abundance off Washington as determined from aerial surveys in 1990. Contract report available through the NMFS, AFSC, National Marine Mammal Lab. Seattle, WA, 35 p,

Calambokidis, J., J.R. Evenson, J.C. Cubbage, P. J. Gear-in, and S.D. Osmek. 1992. Harbor porpoise distribution and abundance off Oregon and Washington from aerial surveys in 1991. Contract report available through the NMFS, AFSC, National Marine Mammal Lab. Seattle, WA, 44 p,

Calambokidis, J., J. R. Evenson, J. C. Cubbage, S. D. Osmek, D. Rugh, and J. L. Laake. 1993a. Calibration of sighting rates of harbor porpoise from aerial surveys. Contract report available through the NMFS, AFSC, National Marine Mammal Lab. Seattle, WA, 41 p

Calambokidis, J., J.C. Cubbage, JR Evenson, S. Osmek, J.L. Laake, P. J. Gearin, B. J. Turnock, S.J. Jeffries, and R.F. Brown 1993b. Abundance estimates of harbor porpoise in Washington, and Oregon waters. Contract report available through the NMFS, AFSC, National Marine Mammal Lab, Seattle, WA, 55 p,

Calambokidis, J., and R.W. Baird. 1994. Status of marine mammals in the Strait of Georgia, Puget Sound and the Juan de Fuca Strait and potential human impacts. Pages 282-303. *In* R.C.H. Wilson, R.J. Beamish, F. Aitens, and J. Bell (editors), Review of the marine environment and biota of Strait of Georgia, Puget Sound and Juan de Fuca Strait. (Can. Tech. Rep. Fish. Aquat. Sci. 1948.) Can, Dep. Fish. Oceans, Ottawa, ON.

Calambokidis, J. In press. Vessel surveys for harbor porpoise off the Washington coast, *In* H. Kajimura (editor), Harbor porpoise interactions with the Makah salmon set net fishery in coastal Washington waters, 1988-89. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

DeMaster, D.P. 1978. Calculation of the average age of sexual maturity in marine mammals. J Fish. Res. Board Can. 35:912-5.

Easton, D.F., M. Klinowska, and M.C. Sheldrick. 1982. A preliminary analysis of the British stranding records of harbour porpoise *Phocoena phocoena.* Rep. Int. Whal. Commn. 32:423-*427.*

Everitt, R.D., C.H. Fiscus, and R.L. DeLong. 1980. Not-them Puget Sound marine mammals. DOC/EPA Interagency Energy Research and Development Program, EPA-600/7-80-l39, Washington D.C. 134 p.

Ferrero, R.C., and C. W. Fowler (editors). 1992. Survey designs for assessment of harbor porpoise and harbor seal populations in Oregon, Washington, and Alaska. AFSC Processed Rep. 92-03, 101 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115-0070.

Flaherty, C., and S. Stark. 1982. Harbor porpoise, *Phocoena phocoena,* assessment in

    Washington Sound. Contract report available through the NMFS, AFSC, National Marine

    Mammal Lab, Seattle, WA, 83 p.

Gaskin, D.E. 1977. Harbour porpoise *Phocoena phocoena* (L.) in the western approaches to the

    Bay of Fundy 1969-75. Rep. Int. Whal. Commn 27:487-492

Gaskin, D.E. 1984. The harbor porpoise, *Phocoena phocoena* (L.): Regional populations, status,

    and information on direct and indirect catches. Pages 569-586, *In* Fish Harbour, New

    Brunswick, Canada: Occupancy, Distribution, and Movements. Rep. Int. Whal. Commn 34

Gaskin, D.E., and A.P. Watson, 1985, The harbor porpoise, *Phocoena phocoena,* in Fish

    Harbour, New Brunswick, Canada: Occupancy, Distribution, and Movements. Fish. Bull,,

    U.S. 83:427-442.

Gearin, P., S.R. Melin, R.L. DeLong, H. Kajimura, and M.A. Johnson. 1994. Harbor porpoise

    interactions with a Chinook salmon set-net fishery in Washington State. Pages 427-438. *In*

    W.F. Perrin, GP Donovan, and J. Barlow (editors), Gillnets and cetaceans. Rep. Int. Whal

    Commn. Special Issue 15

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnel, and K. C. Balcomb. 1992. Cetacean distribution and abundance of Oregon and Washington, 1989-1990. Pages 1 - 100, *In* Brueggeman J. (editor), Oregon and Washington marine mammal and seabird surveys. Final Rep. OCS Study MMS 91-0093. 100 p,

Haley, D. (editor). 1988. A guide to marine mammals of greater Puget Sound. Island Publishers, Anacortes, WA, 191 p.

Heel, W.H.D. van 1962. Sound and cetaces. Neth. J. Sea Res. 1(4):407-507.

Laake, J.L., S.T. Buckland, D.R. Anderson, and K.P. Bumham. 1993, DISTANCE user's guide Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University, Fort Collins, CO 80523, USA. 84 p,

Leatherwood, S., and R.R. Reeves. 1983, Whales and dolphins. Sierra Club Handbook, San Francisco, CA. 302 p.

Osmek, S.D., P.J. Gearin, J. Calambokidis, and R.L. DeLong. 1992. Harbor porpoise *Phocoena phocoena* assessment studies for Oregon and Washington in 1991, Annual Marine Mammal Assessment Program report submitted to the NOAA, NMFS, Office of Protected Resources, Silver Spring, MD. Available through the NMFS, AFSC, National Marine Mammal Lab. Seattle, WA, 38 p.

Osmek, S.D., J.L. Laake, P.J. Gearin, and R.L. DeLong. 1993. Harbor porpoise (Phocoena

phocoena) population assessment studies for Oregon and Washington in 1992. Pages 1-13, *In*

H.W. Braham and D.P. DeMaster (editors), Marine Mammal Assessment Program: Status of

stocks and impacts of incidental takes, Annual report submitted to the NOAA, NMFS, Office

of Protected Resources, Silver Spring, MD. Available through the NMFS, AFSC, National

Marine Mammal Lab, Seattle, WA

Osmek, S.D., P. Rosel, A. Dizon, and R, DeLong. 1994. Harbor porpoise, *Phocoena phocoena,*

population assessment in Oregon and Washington, 1993. Pages l- 14, *In* H. W. Braham and

D.P. DeMaster (editors), Marine mammal assessment program: Status of stocks and impacts

of incidental take 1993. Annual report submitted to the NMFS, Office of Protected

Resources, Silver Spring, MD Available through the NMFS, AFSC, National Marine

Mammal Lab, Seattle, WA

Osmek, SD, M.B. Hanson, J.L. Laake, S. J. Jeffries, and R.L. DeLong. 1995. Harbor porpoise,

Phocoena phocoena, population assessment studies for Oregon and Washington in 1994.

Pages 141-172, In D.P. DeMaster, H.W. Braham and S.P. Hill, Marine mammal assessment

program: Status of stocks and impacts of incidental take 1994. Annual report submitted to the

NMFS, Office of Protected Resources, Silver Spring, MD Available through the NMFS,

AFSC, National Marine Mammal Lab, Seattle, WA

Pierce, J. D., M. Alexandersdottir, S.J. Jeffries, P. Erstad, W. Beattie, and A. Chapman 1996 Interactions of marbled mirrelets and marine mammals with the 1994 Puget Sound sockeye gill net fishery. Final Rep., Wash. Dept. Fish and Wildl., Olympia WA. 21p.

Rosel, P. E. 1992. Genetic population structure and systematic relationships of some small cetaceans inferred from mitochondrial DNA sequence variation. Ph.D. dissertation, University of California, San Diego. 19 1 p.

Rosel, P., A. Dizon, and M. Haygood. 1995. Variability of the mitochondrial control region in populations of harbour porpoise, *Phocoena phocoena,* on inter-oceanic and regional scales. Can. J. Fish Aquat. Sci. 52: 1210-1219.

Scammon, CM 1874. The marine mammals of the northwestern coast of North America. Republication by Dover Publications, Inc. (1968) NY 3 19 p.

Scheffer, V.B., and J.W. Slipp. 1948. The whales and dolphins of Washington State with a key to the cetaceans of the west coast of North America. Am Midl. Nat. 39(2):257-337.

Silber, G.K. ., R. S. Wells, and K.S. Norris. 1990. A preliminary assessment of techniques for catching and radio-tagging harbor porpoise. Rep. to U.S. Mar. Mamm Comm 29 p.

Stacey, P.J., R.W. Baird, and D.A. Duffus. 1990. A preliminary evaluation of incidental mortality
of small cetaceans, primarily Dall's porpoise, *Phocoenoides dalli,* harbour porpoise, *Phocoena
phocoena,* and Pacific white-sided dolphins, *Lugenorhynchus obliquidens,* in inshore fisheries
in British Columbia, Canada. Int. Whal. Commn Doc. SC/42/SM20. 14 p.

Swan, J.G. 1870. Indians of Cape Flattery, at the entrance to the Strait of Juan de Fuca,
Washington Territory. Smithsonian Contributions to Knowledge 220. Smithsonian Institution,
Washington City. 108 p.

Taylor, B.L., and P.K. Dawson. 1984. Seasonal changes in density and behavior of harbor
porpoise *(Phocoena phocoena)* affecting census methodology in Glacier Bay National Park,
Alaska. Rep Int. Whal. Comm 34:479-483.

Turnock, B.J., S.J. Jeffries, and R.F. Brown In press. Population abundance of harbor porpoise
Phocoena phocoena from aerial surveys off the coast of Oregon, Washington, Strait of Juan
de Fuca, and Vancouver Island. *In* H. Kajimura (editor), Harbor porpoise abundance and
interactions with the Makah salmon set-net fishery in coastal Washington waters, 1988-89.
U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

Twaites, R. G. (editor). 1904-5, Original journals of the Lewis and Clark expedition, 1804- 1806.
New York, Dodd, Mead & Co., 7 Vols. and atlas, illus.

Woodley, T.H., and Read, A. J. 1991. Potential growth of a harbour porpoise, *Phocoena phocoena,* population subjected to incidental mortality. Int. Whal. Comm Doc. SC/42/SM22.

Yurick, D.B., and D.E. Gaskin. 1987. Morphometric and meristic comparisons of skulls of harbor porpoise *Phocoena phocoena* (L.) from the North Atlantic and North Pacific. Ophelia 27: 53-*75.*

Table 1.--Harbor porpoise abundance estimates by survey area and stock for Oregon/Washington waters (Calambokidis et al. 1993b). Aerial surveys were conducted during summer 1990-9 1 off the coast to a minimum depth of 9 1 m (50 fins). All inland water depths were surveyed.

| | OREGON/WASHINGTON COAST | | | INLAND WASHINGTON | |
	Oregon	Southern Washington	Northern Washington	Strait of Juan de Fuca*	San Juan Islands*
ABUNDANCE ESTIMATE					
Effort - km	1750	756	693	845	698
Replicates (lines)	91	35	46	43	21
Sightings	220	146	31	34	25
Number	357	220	43	49	37
f(0) - km	16.92	16.92	16.92	16.92	16.92
Density (groups)	0.31	0.48	0.11	0.10	0.09
Group size	1.53	1.53	1.53	1.53	1.53
Density (animals)	0.47	0.73	0.17	0.15	0.14
Area (km²)	9,844	4,870	1,300	5,076	2,291
Uncorrected abundance	4,671	3,552	220	771	310
Correction factor	3.1	3.1	3.1	3.1	3.1
Corrected density (animals/km²)	1.47**	2.26**	0.52	0.47	0.42
Corrected abundance	14,480	11,014	681	2,392	960
COEFFICIENT OF VARIATION CALCULATION					
cv f(0)	0.067	0.067	0.067	0.067	0.067
cv N (replicate lines)	0.114	0.154	0.220	0.259	0.242
cv Group size	0.021	0.021	0.021	0.021	0.021
cv Density (replicate lines)	0.134	0.169	0.231	0.268	0.252
cv Correction factor	0.171	0.171	0.171	0.171	0.171
cv Abundance	0.217	0.241	0.287	0.318	0.305

STOCK ESTIMATES

	OREGON/WASHINGTON COAST	INLAND WASHINGTON
Corrected abundance	N = 26,175 (CV = 0.206)	N = 3,352 (CV = 0.270)

* = Includes the inland waters of southern British Columbia, Canada.

** = The combined mean density of Oregon/southern Washington waters (1.7) was significantly different than northern coastal Washington and inland Washington/southern British Columbia combined (0.5; $z = 6.9$).

Table 2.-- Corrected abundance estimates (1990-91), PBRs, and annual incidental take rates for two Washington harbor porpoises stocks. The PBRs were calculated using R_{max} and F_r values of 0.04 and 0.5, respectively

Area	Area in km^2	N	CV(N)	N_{min}	PBR	Average no. takes/year
Inland Washington Stock*	7,367	3,352	0.270	2,680	27	16**
Puget Sound	1,238	rare				
Oregon/Washington Coast Stock	16,015	26,175	0.206	22,049	220	9***

*Includes approximately 30% of the survey area located outside the Stock boundary.

**Incidental takes were only observed in the 1994 commercial drift gill-net fishery for sockeye salmon. The number of takes is significant because it exceeds 10% of the PBR (3).

***The number of incidental takes in the 1990-93 Tribal salmon set gill-net fishery may be an insignificant level.

Table 3.-- The NMFS observer program results by Fishery Management Area for the northwest Washington chinook salmon set gill-net fishery. During 1994, several harbor porpoises were known to be incidentally taken, but the final results are unavailable. (Source: NOAA, NMFS, Northwest Region and NMML, Seattle, WA, unpublished data.)

Description/ Year	1988	1989	1990	1991	1992	1993	1990-93 Mean
Areas 4B and 5 (Inland Washington Stock)							
Total net days fished	1216	859	469	251	327	215	316
Percent net days observed	3.4	22.7	41.8	61.9	79.9	60.5	51.0
Number of discrete vessels	8	8	5	4	4	7	5
Observed animals taken	0	0	0	1	0	0	0
Not observed but recovered	0	0	0	0	0	0	0
Reported but not recovered	0	1	0	0	0	0	0
Observed, recovered and reported	0	1	0	1	0	0	0
Total estimate from observed takes	0	0	0	2	0	0	1
Area 4 and 4A (Oregon/Washington Coast Stock)							
Total net days fished	1384	483	91	131	4	0	76*
Percent net days observed	5.5	42.6	74.7	71.0	69.5	0	72.5*
Number of discrete vessels	4	2	2	2	1	0	1
Observed animals taken	22	14	13	13	0	0	7
Not observed but recovered	48	3	0	1	2	0	1
Reported but not recovered	32	5	0	1	0	0	0
Observed, recovered or reported	102	22	13	15	2	0	8
Total estimate from observed takes	**	33	16	19	0	0	9

*1990-92 mean. No fishery was conducted in Area 4/4A during 1993.
**Not estimated. For 1988, an incidental take estimate would be invalid because observer coverage was low and concentrated on one vessel that fished Spike Rock waters where catch per unit effort was highest.

35

Table 4 --Mean total lengths, body weights, and ranges for 99 harbor porpoise incidentally caught in the Tribal northwest chinook salmon set gill-net fishery, July 1988 through August 1990 (Gearin et al. 1994).

Reproductive class	n	Mean total length (cm)	Range (cm)	Mean body weight (kg)	Range (kg)
Calves	4	89.8	82.0-98.0	12.0	9.5-16.0
Immature females	31	134.9	115.2-152.9	39.9	24.0-59.0
Immature males	28	125.9	107.4-140.0	34.6	26.2-48.0
Mature females	13	163.6	154.8-177.7	63.5	50.5-86.5
Mature males	23	143.0	131.8-155.4	48.3	35.0-61.0
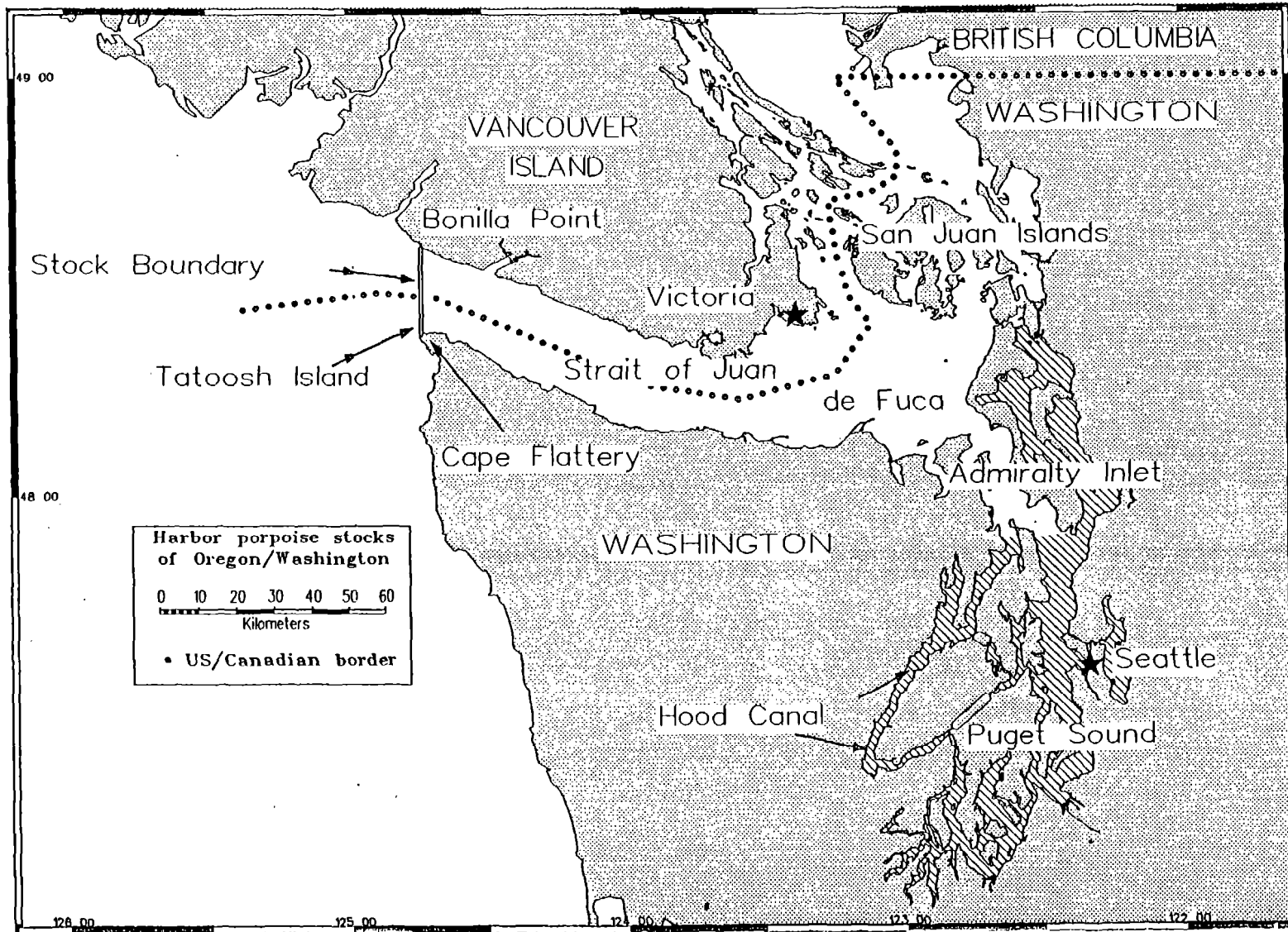
Figure 1 .--The Oregon/Washington Coast Stock and the Inland Washington Stock are separated
by the Tatoosh Island-Bonnila Point line located off Cape Flattery, Washington. The
cross-hatching represents the waters where harbor porpoise rarely occur.
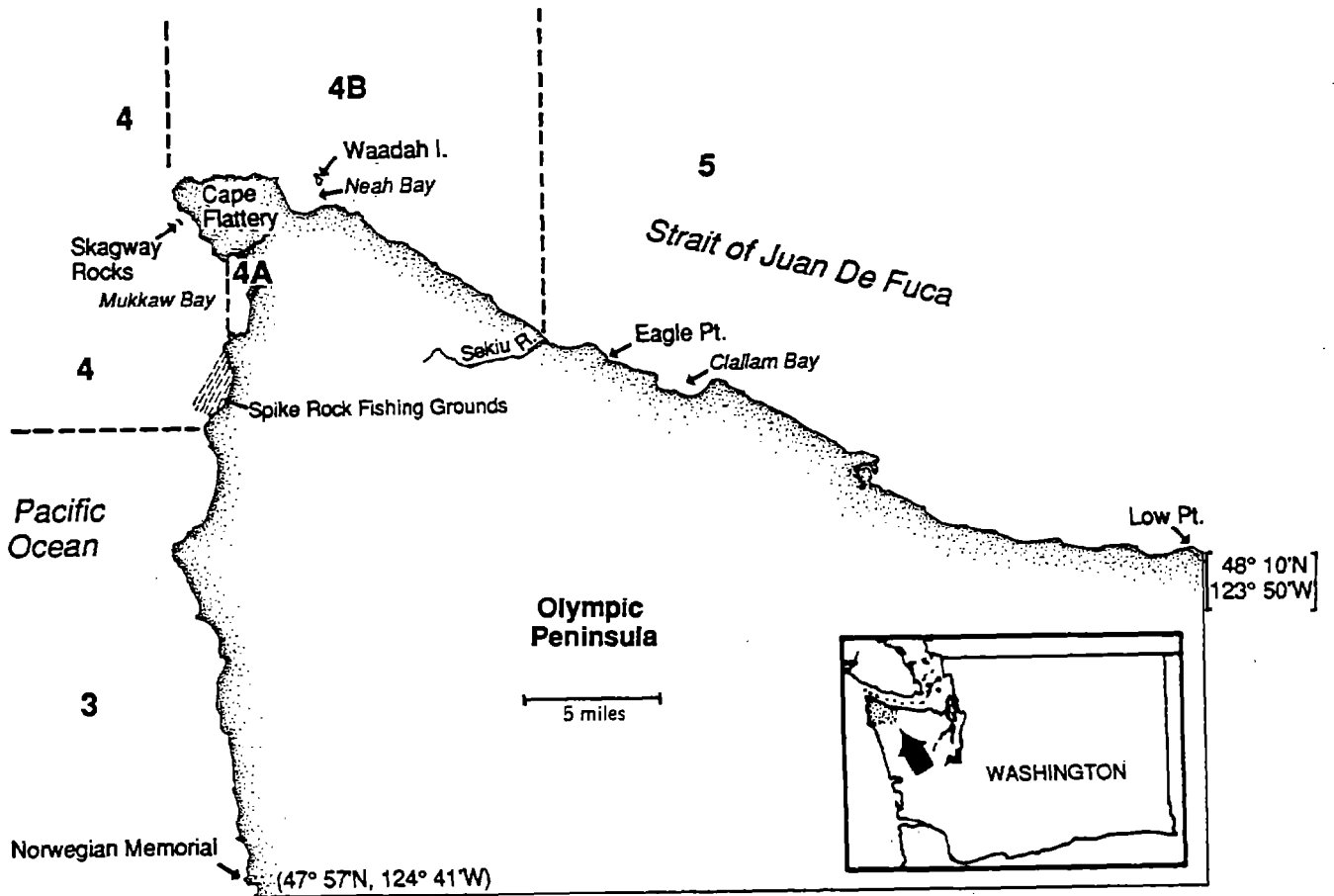
Figure 2.-- The Tribal northwest Washington chinook salmon set gill-net fishery operates in the waters of both the Oregon/Washington Coast Stock (Area 4/4A) and the Inland Washington Stock (Area 4B/5)(Fig. 1 from Gearin et al. 1995).
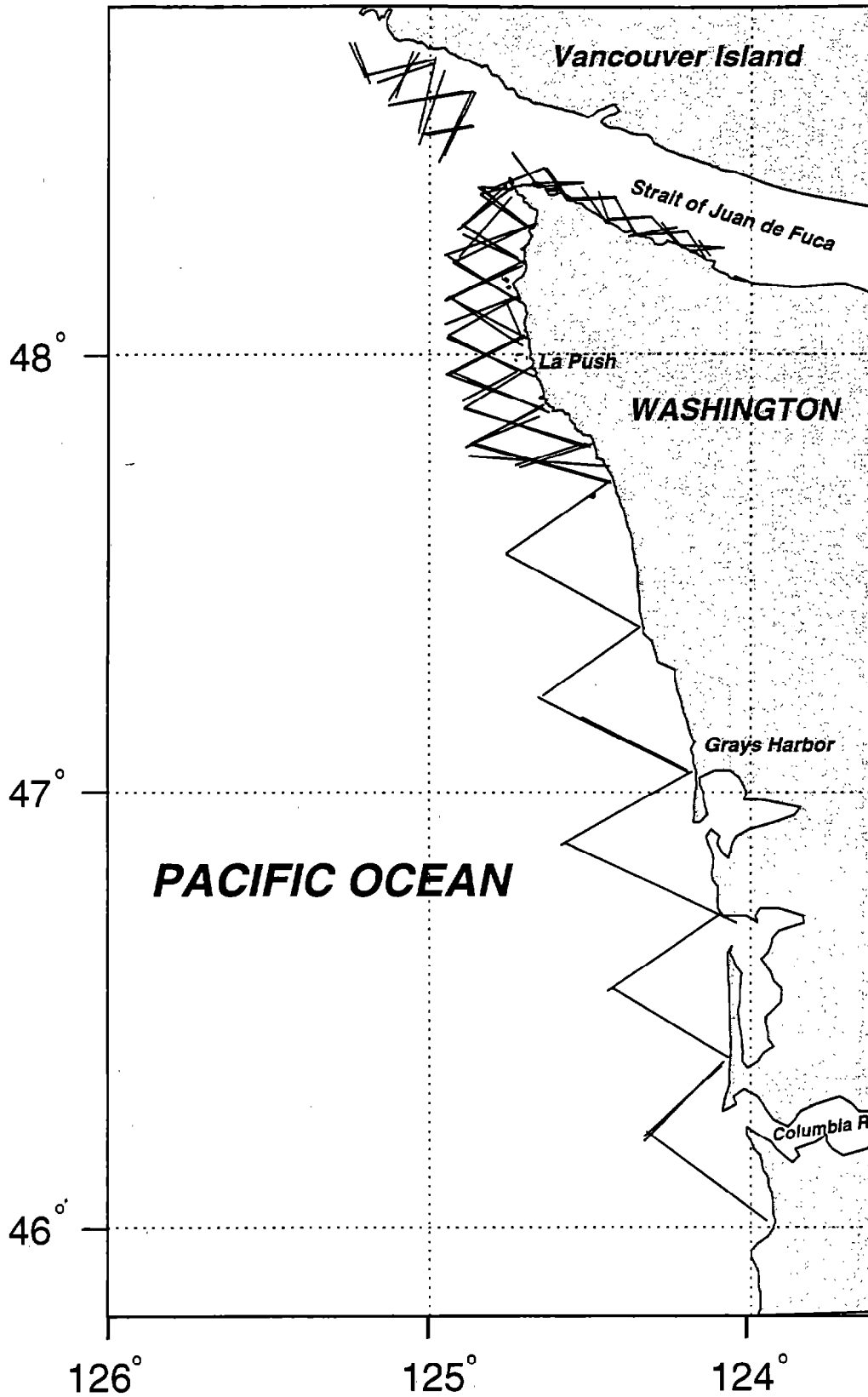
Figure 3a.-- 1990 survey tracklines flown along coastal Washington to determine harbor porpoise abundance (Fig. 11 from Calambokidis et al. 1993b).
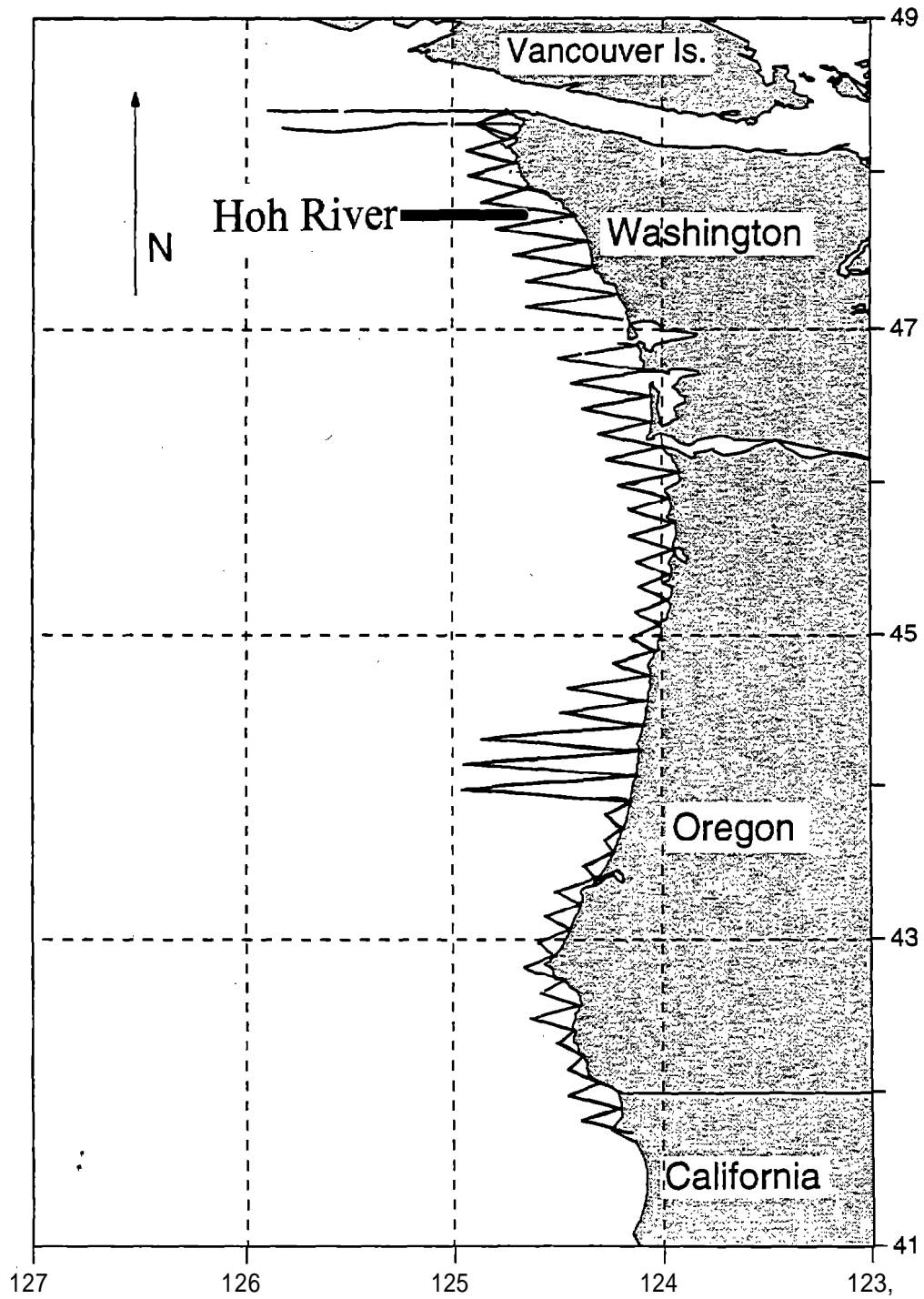
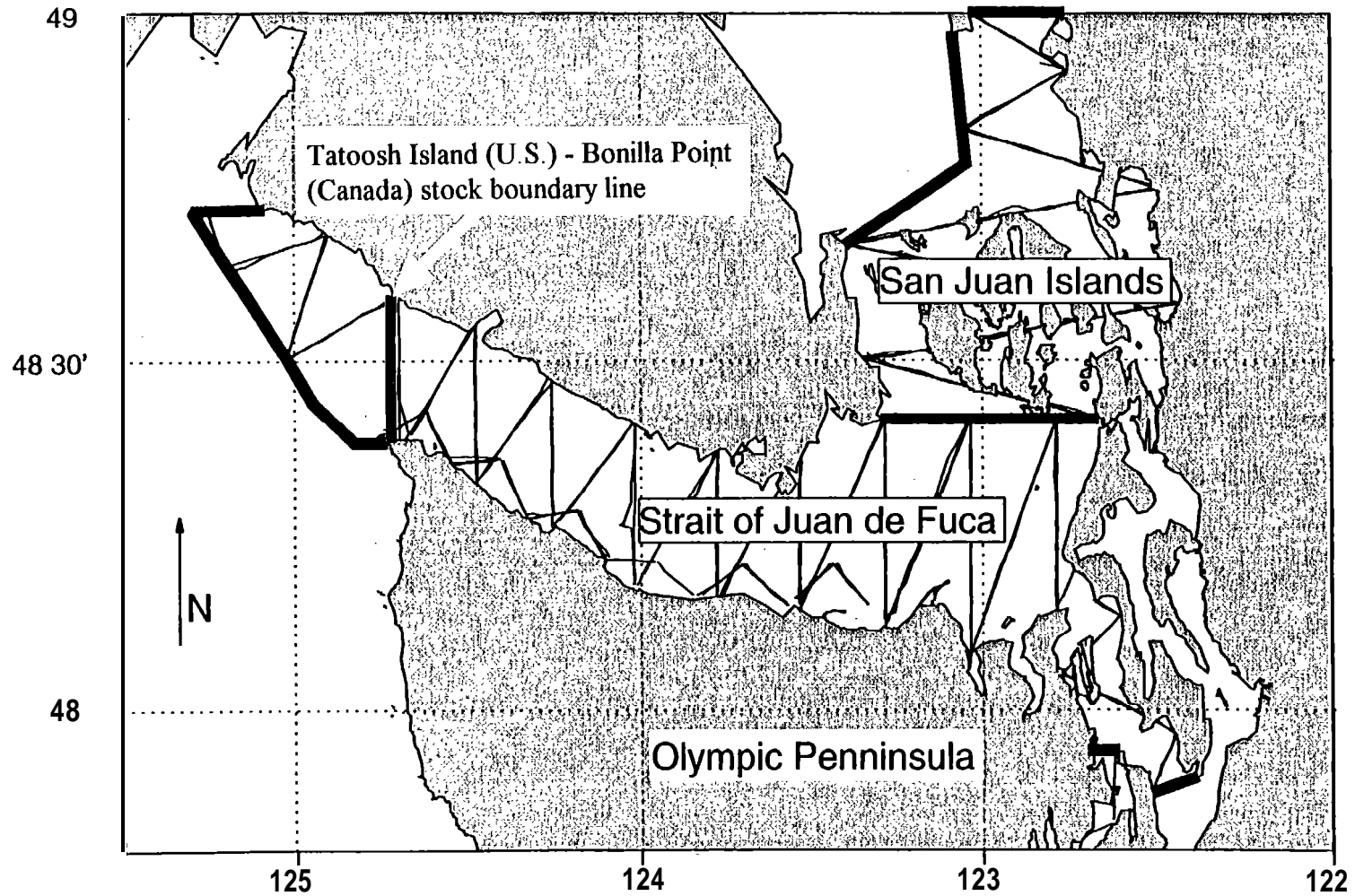Figure 3b.- 1991 survey tracklines flown along coastal Oregon and Washington to determine harbor porpoise abundance (Fig. 13 from Calambokidis et al. 1993b).

Figure 3c.-- 1991 survey tracklines flown along inland Washington and southern British Columbia to determine harbor porpoise abundance (Fig. 14 from Calambokidis et al. 1993b).
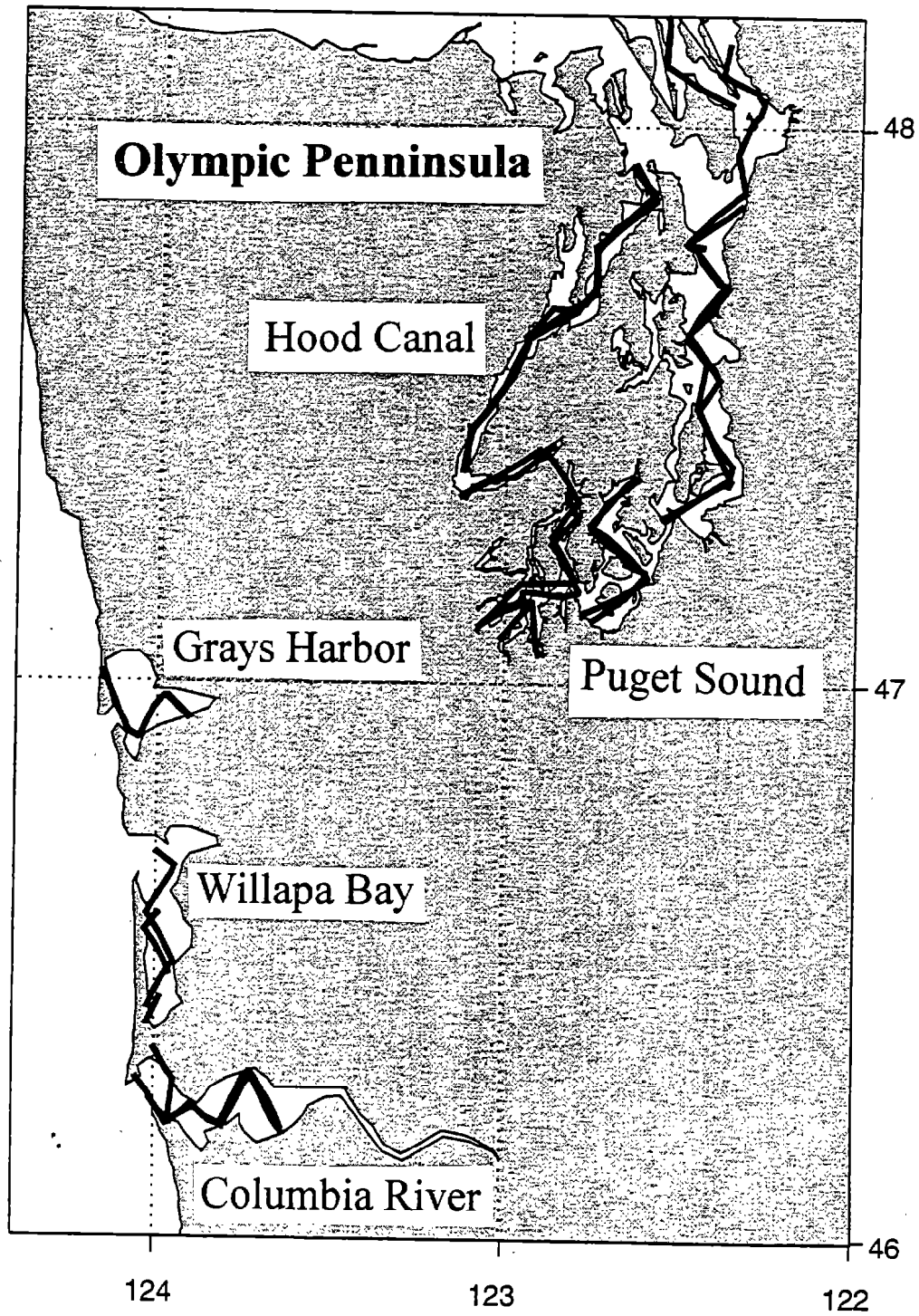
Figure 3d.-- 1991 aerial survey tracklines for the waters of Grays Harbor, Willapa Bay and the Columbia River (Fig. 3 from Calambokidis et al. 1992). No harbor porpoises were seen in these waters.
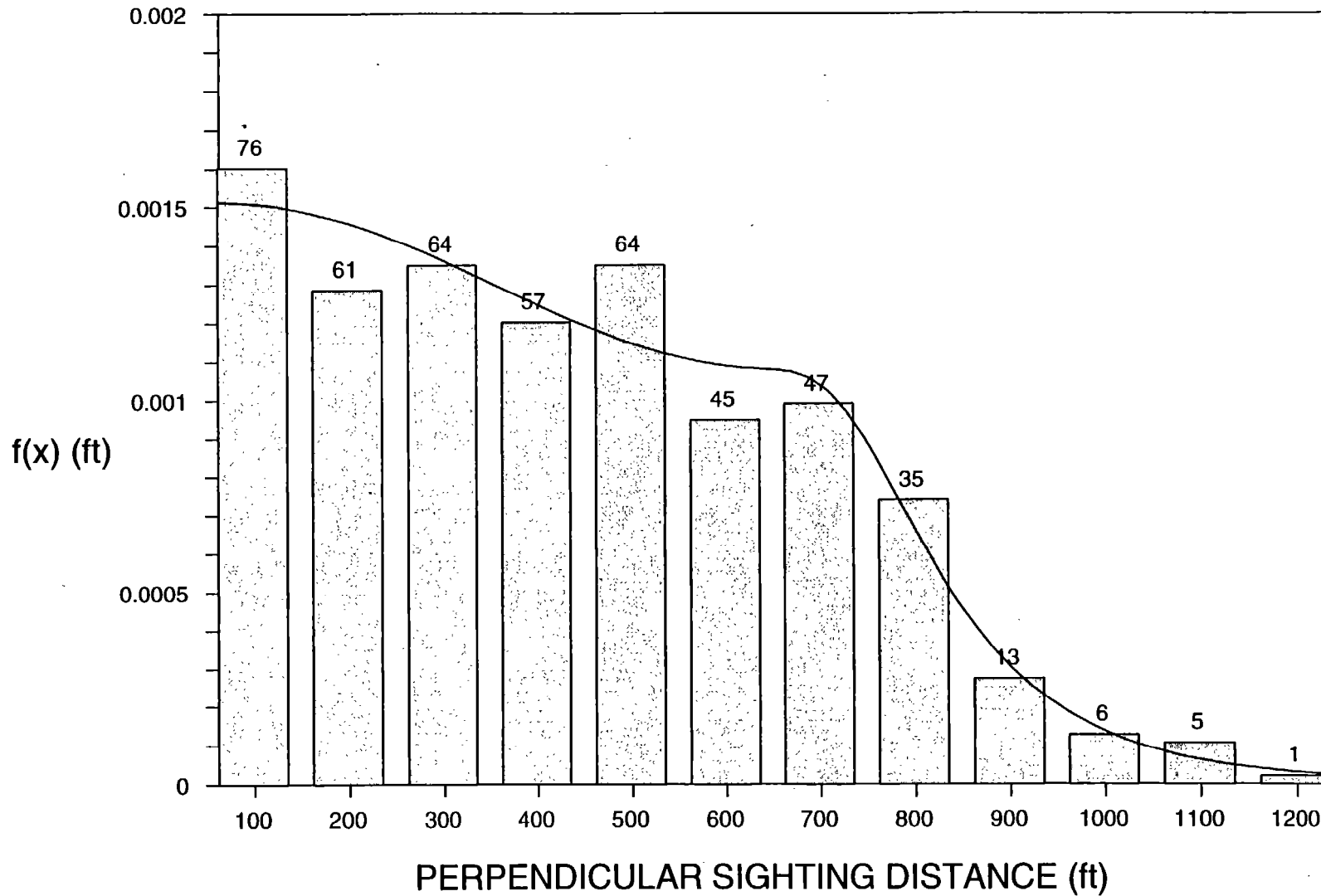
Figure 4.-- Perpendicular sighting distances for pooled 1990-91 aerial survey data (Fig. 3 from Calambokidis et al. 1993b). Fitted hazard rate model with one cosine adjustment term is shown. The number of sightings are above the bars.
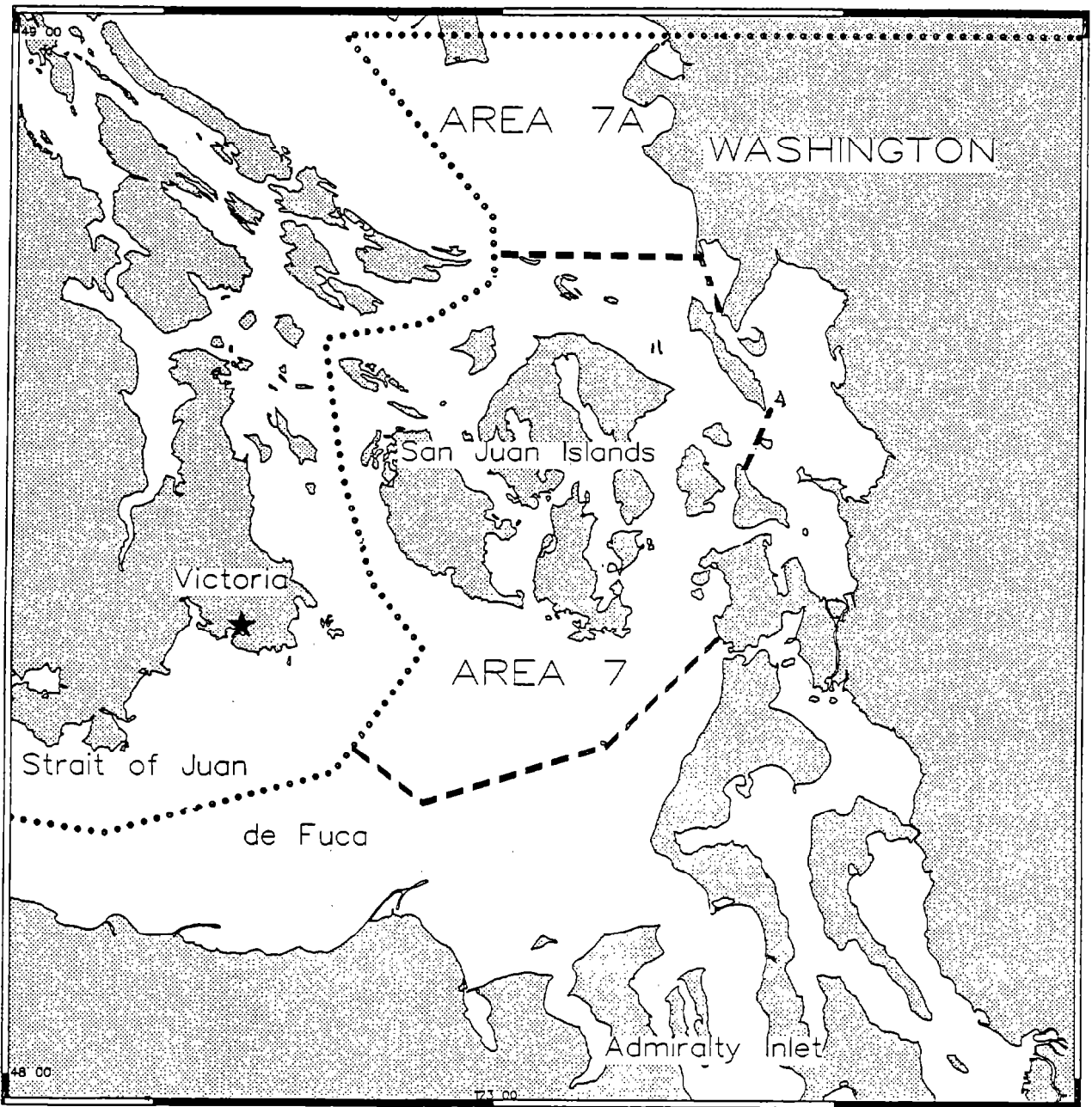
Figure 5.-- Location of the 7/7A drift gill-net sockeye salmon fishery within Inland Washington.
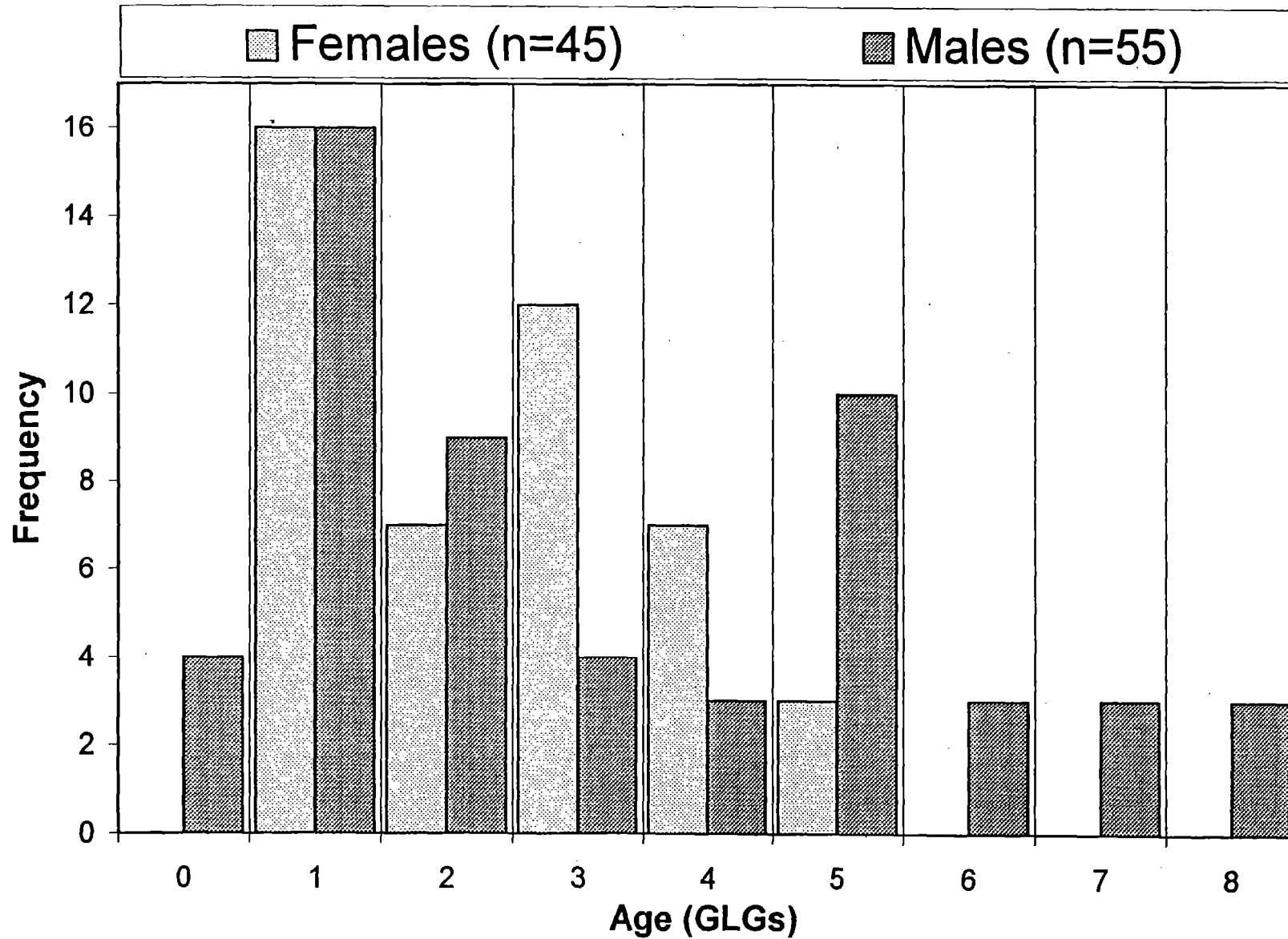
Figure 6.-- Age and sex distribution of harbor porpoises recovered from the Tribal northwest
Washington chinook salmon set gill-net fishery during 1988-90. DeMaster (1978)
calculated the mean age of reproductive maturity for harbor porpoises at 3.9 for
females and 3.5 for males.

APPENDIX

Description of Drift and Set Gillnets

The drift and set gillnets used for fishing salmon in Oregon and Washington waters are similar to one another, but vary somewhat because of how and where they are fished. The drift gillnets used within inland Washington waters are made of a 12.7 cm (5 inch) stretched-mesh, multi-strand, monofilament with a maximum net length of 549 m (300 fathoms). Drift nets hang down from the corkline in the water column to a depth of 19.1-25.4 m (150-200 meshes) as it moves with the fishing vessel in the current. Drift-nets are frequently fished at night and are checked for fish after several hours of fishing. Over 1,000 vessels are licensed by the State to fish drift gillnets in these waters, and about 500-600 actually fish each year. The tribal set gillnets, fished along coastal and inland Washington waters, are constructed of a 17.8-20.3 cm (7-8 inch) stretched-mesh, multi-strand, monofilament with a maximum net length of 183 m (100 fathoms). These set nets are fished 7.1-18.3 m (40-90 meshes) above a heavy lead-line (0.25-0.50 kg/m (1-2 lb/fathom) which is anchored to the bottom, usually near shore, at a water depth ranging from 4 to 30 m deep. Weather permitting, set nets are checked for fish daily.

RECENT TECHNICAL MEMORANDUMS

Copies of this and other NOAA Technical Memorandums are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22167. Paper copies vary in price. Microfiche copies cost $3.50.

AFSC-

75 WING, B. L., C. W. DERRAH, and V. M. O'CONNELL. 1997. Ichthyoplankton in the eastern Gulf of Alaska, May 1990,42 p. NTIS No. PB97-174379.

74 WILSON, C. D., and M. A. GUTTORMSEN. 1997. Echo integration-trawl survey of Pacific whiting, Merluccius productus, off the west coasts of the United States and Canada during July-September 1995, 70 p. NTIS No. PB97-174387.

73 CELEWYCZ, A. G., and A. C. WERTHEIMER. 1997. Suitability of Dry Bay, southeastern Alaska, as rearing habitat for juvenile salmon, 19 p. NTIS No. PB97-161343.

72 KINOSHITA, R. K., A. GREIG, D. COLPO, and J.M. TERRY. 1997. Economic status of the groundfish fisheries off Alaska, 1995, 91 p. NTIS No. PB97-161269.

71 STRICK, J. M., L. W. FRITZ, and J. P. LEWIS. 1997. Aerial and ship-based surveys of Steller sea lions (Eumetopias jubatus in Southeast Alaska, the Gulf of Alaska, and Aleutian Islands during June and July, 55 p. NTIS No. PB97-144026.

70 EBBERTS, B. D., and B. L. WING. 1997. Diversity and abundance of neustonic zooplankton in the north Pacific subarctic frontal zone, 34 p. NTIS No. PB97-138218.

69 SINCLAIR, E.H. (editor). 1996. Fur seal investigations, 1994, 144 p. NTIS No. PB97-129456.

68 MERRICK, R. L., T. R. LOUGHLIN, and D. G. CALKINS. 1996. Hot branding: A technique for long-term marking of pinnipeds, 21 p. NTIS No. PB97-124226.

67 LANG, G M., and P. A. LIVINGSTON. 1996. Food habits of key groundfish species in the eastern Bering Sea slope region, 111 p. NTIS No. PB97-124010.

66 KINOSHITA, R. K., and J. M. TERRY. 1996. Oregon, Washington, and Alaska exports of edible fishery products, 1995,48 p. NTIS No. PB96-214663.

65 HONKALEHTO T., and N. WILLIAMSON. 1996. Echo integration-trawl survey of walleye pollock (Theragra chalcogramma) in the Southeastern Aleutian Basin during February and March 1995, 57 p. NTIS No. PB96-202726.

64 TYNAN, C. 1996. Characterization of oceanographic habitat of cetaceans in the Southern Indian Ocean between 82° - 115° E: Cruise report from World Ocean Circulation Experiment (WOCE) 18S and l9S, 53 p. NTIS No. PB96-192786.

63 KINOSHITA, R. K., and J. M. TERRY. 1996. Oregon, Washington, and Alaska exports of edible fishery products, 1994, 49 p. NTIS No. PB96-183553.

62 KINOSHITA, R. K., A. GRIEG, and J. M. TERRY. 1996. Economic status of the groundfish fisheries off Alaska, 1994, 108 p. NTIS No. PB96-178595.

61 PELLA, J., M. MASUDA, and S. NELSON. 1996. Search algorithms for computing stock composition of a mixture from traits of individuals by maximum likelihood, 68 p. NTIS No. PB96-154653.

60 YANG, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991, 105 p. NTIS No. PB96-147582.