

GROUND FISH RESOURCE SURVEY OF THE CONTINENTAL
SHELF OFF WASHINGTON, 1975

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Introduction

This report summarizes project progress in FY 1976 on the first phase of a survey on the continental shelf and upper continental slope off the coast of Washington. The second and final phase is a replicate survey scheduled for FY 1977.

Objectives of the survey were to obtain estimates of biomass of fishes occupying the continental shelf and upper slope, with particular emphasis on flatfish; to collect the necessary data for estimating age composition, growth and mortality; to determine fish distribution; and to index year class strength of flatfishes important to the commercial fishery prior to their recruitment to the fishery.

The survey was a cooperative effort between Oregon Department of Fish and Wildlife, Washington Department of Fisheries and U.S. National Marine Fisheries Service. The Washington Department of Fisheries supplied one man-month of support, and data collected on Pacific hake by us were supplied to the National Marine Fisheries Service as part of the 1975 synoptic survey on hake conducted by N.M.F.S.

METHODS

The survey area includes the coastal waters off the state of Washington from Cape Flattery (Lat. 48° 23' N.) to the Columbia River (Lat. 46° 16' N.) between 10-300 fathoms (fm). The northern offshore boundary was through the middle of Juan de Fuca canyon to the interception of the 300 fm contour. Duration of the survey was from September 12 to October 2, 1975. Stations were located 6 miles apart (beginning at Lat. 46° 16' N.).

The study area was 2,733 N mi² in area (trawlable area). Eighty stations were occupied on 20 tracklines (Figure 1). Seven additional stations were untrawlable and 12 tows were unoccupied due to a lack of charter time.

Tow locations were determined by loran (1L1, 1L0), radar and depth sounder. Length of tow was one nautical mile except tows 5-25 which were 30 minutes duration and were trawl calibration-tows made in cooperation with N.M.F.S.

Vessel and Gear Characteristics

The R/V *Commando* was chartered for the survey. It is a Pacific seiner-type trawler, 67-ft. overall in length and powered by a 325 h.p. engine. Otter boards supplied by the vessel were 5x7 ft. (1.5 x 2.1 m.) "V" type and weighed 1,050 lbs. each.

The trawl used was a 400 mesh eastern type constructed entirely of 3.5 in. mesh. Thirteen, 8-in floats were attached to the headrope. The footrope was 77-ft. in length constructed of 4.5-in diameter rubber-discs threaded over 3/8-in. chain. Sweep lines consist of 10 -fm bridles and 5-fm dandy lines. A 71-ft. 3/8-in. tickler chain was attached to each wing tip. In 10-fms (scope 8:1), the net fishes with a horizontal opening of 30-ft. and a vertical opening of about 5-ft. Average swept area (length of tow x horizontal opening) was 0.00494 N mi² (.172 a.).

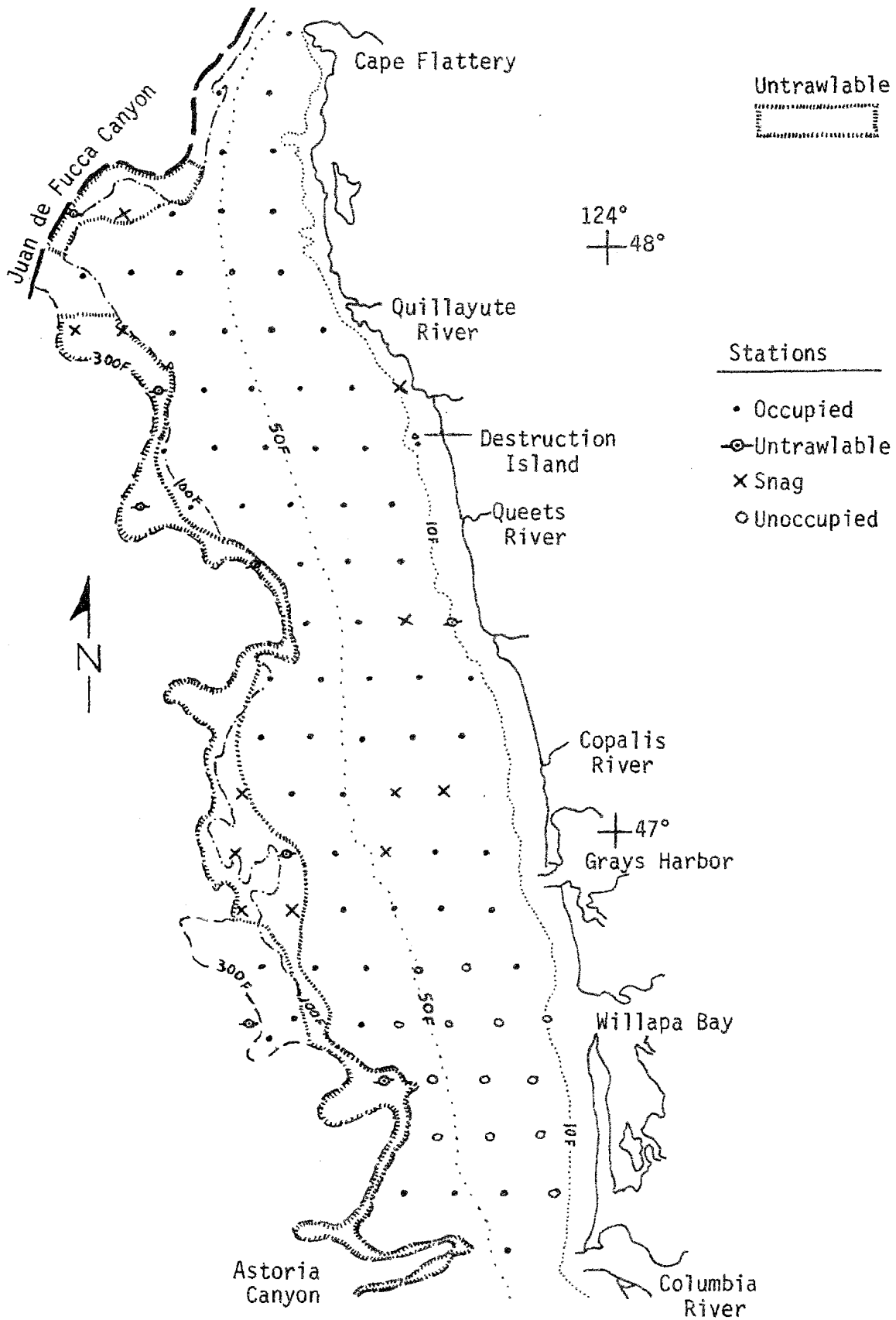


Figure 1. Location of stations for groundfish survey off Washington, 1975

Catch Processing

Catches were dumped onto a sorting table 6-ft² by 12 in. deep and 39-in. high. Catch was sorted by species and weighed. Each catch of Dungeness crab (*Cancer magister*) was recorded by number. Catch of Pacific hake (*Merluccius productus*) was determined by count and average weight.

Flatfish from each tow were sampled for age and sex composition. Sampling was systematic with rate of sampling ranging from 100% to 5% of the catch. Lengths by sex, of fish sampled for age were recorded on plastic measuring strips. Heads of flatfish sampled were removed to obtain otoliths or interopercles with the exception of Dover sole from which a fillet, with skin attached, was taken for scales. Heads and fillets by sex were placed in plastic bags, labeled and frozen for later processing ashore. Small catches of flatfishes were accumulated daily and sampled at days end. Age structures were examined later in the laboratory and assigned an age in accordance with accepted techniques. Expendable bathy thermograph (XBT) casts were completed on 22 tows to obtain water temperature profiles.

Growth

Length-weight constants were determined by $\text{Log } W = a + b \text{ Log } L$ (Appendix 1). Mean length at age was determined from visually-fitted age-length curves derived from 1975 survey data and supplemented by data collected from off the northern Oregon coast. (Appendix 2).

Estimates of Biomass, Usable Biomass, and Potential Yield

Estimates of biomass, usable biomass and potential yield were calculated by the method used by Demory, et.al. 1976.

RESULTS AND DISCUSSION

Estimates of Biomass

A total fish biomass of 143,000 metric tons (m.t.) was estimated for the survey area. English sole was the most abundant species at 18,443 m.t. followed by arrow-tooth flounder and Dover sole at 15,070 m.t. and 14,501 m.t. respectively (Table 1). Pacific hake was fourth in abundance at 11,400 m.t. Biomass for all rockfish species was 11,911 m.t. Biomass was underestimated for most off-bottom species, especially rockfish and hake. The trawl used was designed and considered efficient for flatfish only.

Usable Biomass and Potential Yield

Estimates of usable biomass in the survey area for commercial flatfish species ranged from 8,301 m.t. for Dover sole to 1,270 m.t. for petrale sole (Table 2). Usable biomass was 7,033 m.t. for English sole, 5,686 m.t. for rex sole and 2,529 m.t. for Pacific sanddab. Yield estimates ranged from 1,477 m.t. for English sole to 342 m.t. for petrale sole. Estimated yield was 1,245 m.t. for Dover sole, 1,194 m.t. for rex sole and 759 m.t. for Pacific sanddab.

Yield of Dover, English and rex soles and Pacific sanddab could probably double and remain well within estimated harvest limits. Pacific sanddab appear to be a relatively untapped resource.

Table 1. Biomass estimates of principle species from groundfish survey off Washington, 1975

Species ^{1/}	Catch (metric tons)	Confidence limits (± %)
Spiny dogfish	7,791	62
Skates (all species)	12,991	44
Ratfish	1,780	44
American shad	709	55
Pacific cod	1,977	81
Pacific hake	11,400	79
Rockfish		
Shortspine thornyhead	504	112
Pacific ocean perch	2,724	68
Yellowtail rockfish	2,616	127
Canary rockfish	1,976	91
Splitnose rockfish	1,909	186
Greenstriped rockfish	553	51
Darkblotched rockfish	549	54
Flag rockfish	374	87
Yelloweye rockfish	279	104
Rosethorn rockfish	107	43
Bocaccio	93	140
Rougheye rockfish	66	75
Black rockfish	50	142
Sharpchin rockfish	48	114
Stripetail rockfish	19	166
Redstripe rockfish	16	200
Silvergray rockfish	12	166
Quillback rockfish	10	200
Aurora rockfish	4	200
Widow rockfish	2	200
Sablefish	5,515	54
Lingcod	4,717	37
Flatfish		
English sole	18,443	60
Arrowtooth flounder	15,070	42
Dover sole	14,501	31
Rex sole	12,965	32
Pacific sanddab	8,442	69
Butter sole	8,021	105
Slender sole	2,345	47
Petrale sole	1,650	33
Starry flounder	1,557	117
Flathead sole	1,018	108
Sand sole	435	85
Pacific halibut	84	147
Rock sole	78	78
Curlfin sole	47	146

^{1/} Scientific and common names are shown in Appendix 4.

Table 2. Estimated usable biomass, potential yield and commercial landing (m.t.) of Principle Species of flatfish for Washington Coast, 1975

Species	Usable biomass m.t.	F ₁ ^{1/}	Potential Yield m.t.	Commercial landings m.t.
Dover sole	8,302	0.15	1,245	578
English sole	7,033	0.21	1,477	697
Petrale sole	1,268	0.27	342	854
Rex sole	5,686	0.21	1,194	317
Pacific sanddab	2,529	0.30	759	22
Arrowtooth flounder	14,452	0.25 ^{2/}	3,613	32

^{1/} After Demory, et. al., 1976.

^{2/} Arbitrary

Our yield estimate for petrale sole is far below the actual harvest level. According to Mark Pedersen, Washington Department of Fisheries, our survey stations straddled the petrale fishing grounds. He also stated that petrale sole move to deep-water spawning areas near the end of September. A total of 145 m.t. of petrale sole were landed in Washington from PMFC area 3B in September 1975 (Pedersen, 1976). This was the best month for production (33% of the years total catch from the area). In October 1975, catch of petrale sole from this area dropped to 23 m.t., 5% of the areas total catch.

Distribution

Butter sole were found primarily shallower than 30 fms. English Sole and Pacific sanddab were generally taken shallower than 60 fms. Dover and rex sole were caught throughout most survey depths (Figure 2). Other flatfish species were caught in mid-depth tows and generally not in either shallow nor deep tows.

A bimodal depth distribution was observed for Dover sole and lingcod. A large population of young Dover sole, with an average age of 5.5 years was located in 30-50 fms, 60% of which were females. In 90-110 fms a second concentration was found. These were older fish with an average age of 8 yrs. of which 45% were females.

A large number of small lingcod (mean wt. 7.9 lbs.) were found at about 40 fms. A second area of slightly larger lingcod (mean wt. 9.2 lbs.) was found in about 70 fms.

Several species show an increase in mean weight with increasing depth, especially English and petrale sole and sablefish (Table 3). Flathead and butter sole showed increasing weight with increasing depth to a lesser degree. Rex sole, slender sole, Pacific sanddabs and most rockfish species displayed little change in mean weight with depth.

Sediment type distribution is grossly illustrated in Figure 3 which summarizes published accounts of marine sediment studies off Washington (Roberts 1974, Vendathnam and McManus 1973, and Gross et.al. 1967). Sediment type inside of 50 fms. is almost entirely sand. Two exceptions are gravel areas found off Cape Elizabeth and Grays Harbor. Most sediments outside the 50 fm contour are coarse silt.

Distribution of some species suggested sediment type preference. English sole, Pacific sanddabs and butter sole were usually found over sand. Arrowtooth flounder were found almost exclusively over silt bottom while petrale, Dover and flathead sole distribution tended to show a preference for silt bottom. A bottom type preference was not apparent for rex sole. Our trawl generally performed poorly over gravel bottom; therefore, no species preference could be established for gravel.

There was no apparent difference in distribution by depth between the sexes. Large sex ratio differences were observed between individual tows, but no general trend was evident.

Flatfish were most abundant in the area west of Destruction Island between the Quillayute and Queets River in 18-40 fms. Largest catches per standard tow were 962 lb. English sole, 879 lbs. Pacific sanddab, 870 lbs. butter sole and 465 lbs. rex sole. Other areas where large catches were made were: Southwest of Cape Flattery in 100 fms. where Dover sole were caught at 526 lbs. per standard tow, and Northwest of Quillayute River where arrowtooth flounder were caught at a rate of 670 lbs. per standard tow.

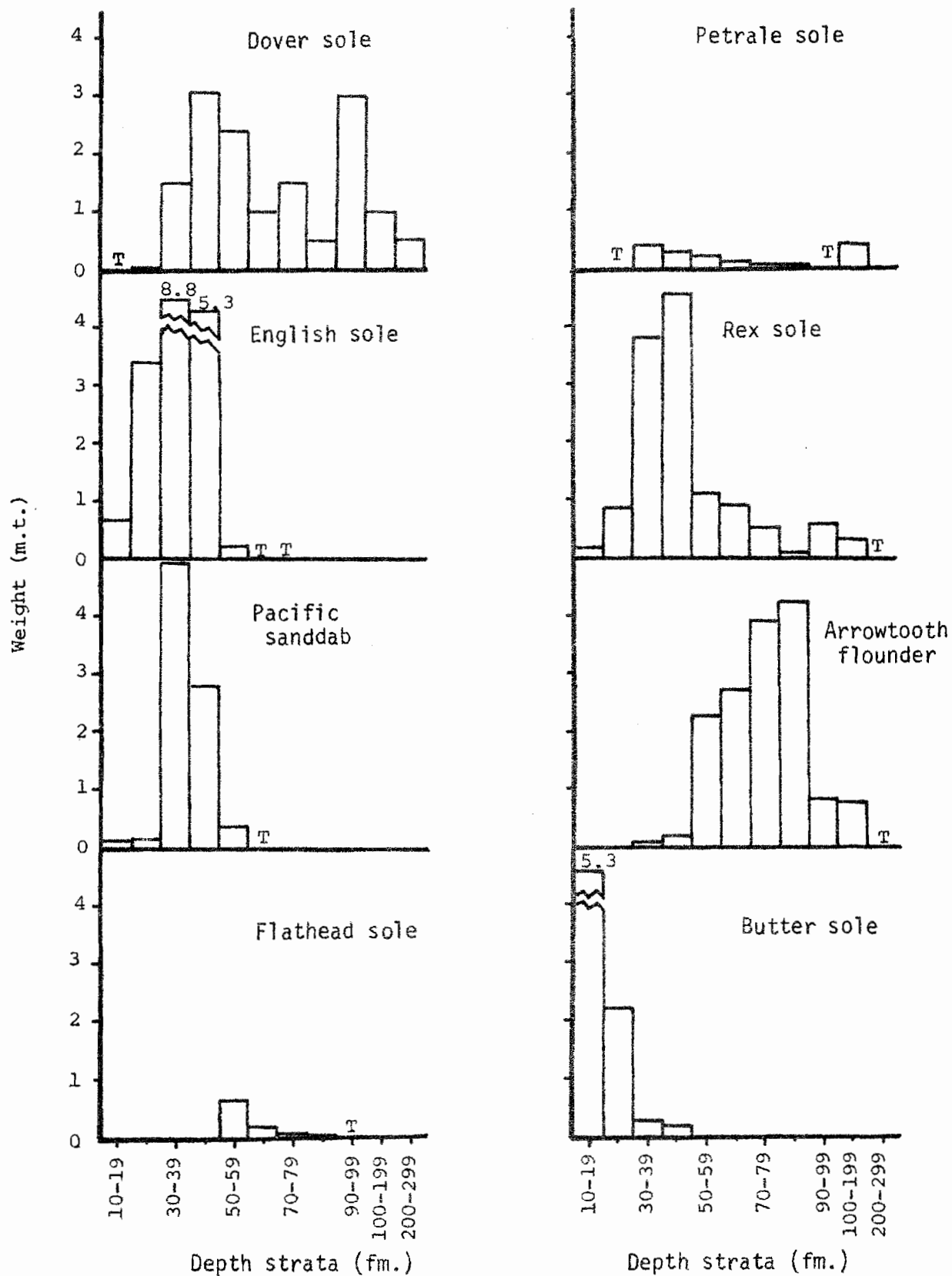


Figure 2. Distribution of selected species by depth as determined from groundfish survey off Washington, 1975. T = <0.05 m.t.

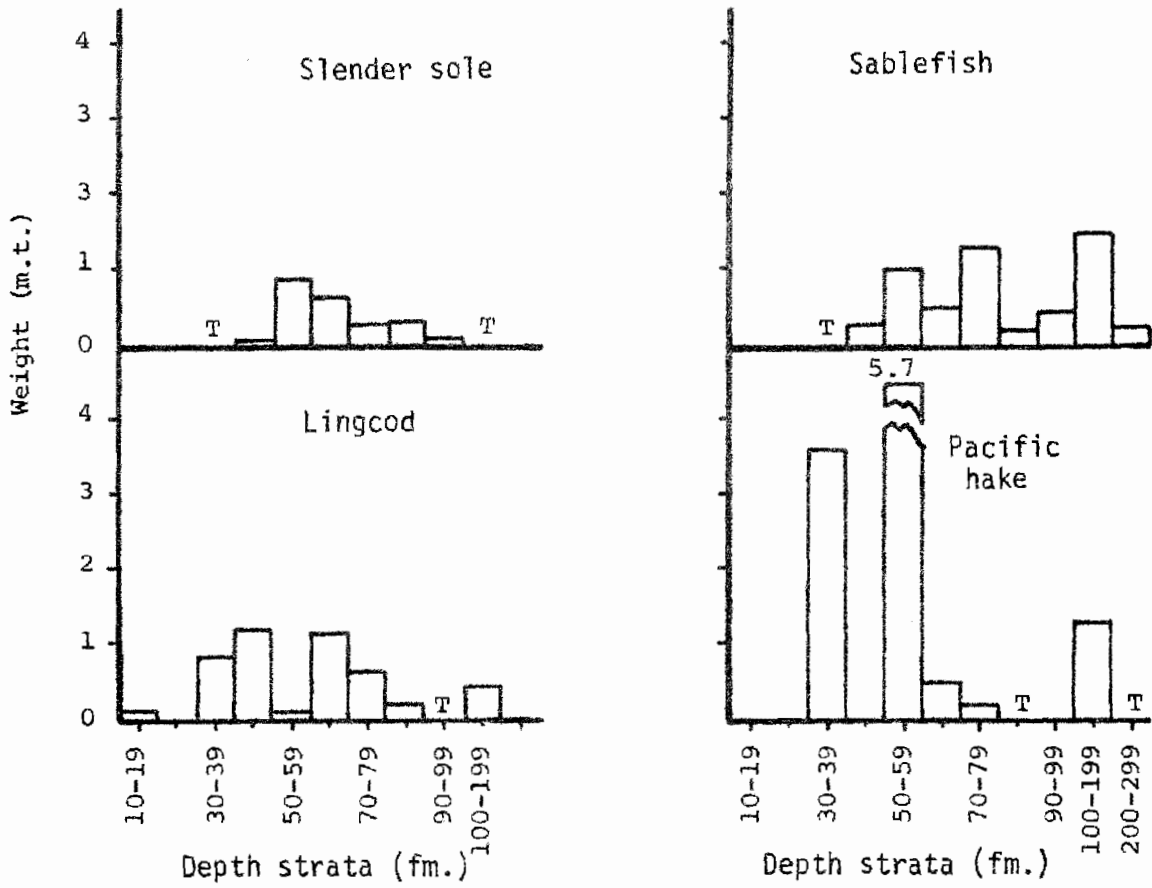


Figure 2. (Continued)

Table 3. Mean weight (lbs) of selected species by depth strata as determined from groundfish survey off Washington, 1975

Species	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-199	200-299
Dover sole	1.00	0.77	0.71	0.61	1.10	1.56	1.17	1.42	1.14	1.06	1.30
English sole	0.33	0.43	0.56	0.62	0.79	2.00	0.30	-	-	-	-
Petrale sole	-	0.66	1.30	1.88	1.61	2.77	2.14	3.13	3.75	3.47	
Rex sole	0.50	0.37	0.43	0.37	0.40	0.44	0.43	0.37	0.41	0.48	0.52
Pacific sanddab	0.54	0.48	0.48	0.46	0.49	0.50	-	-	-	-	-
Arrowtooth flounder	-	-	2.33	2.52	1.72	1.99	2.01	1.77	1.88	2.43	5.25
Flathead sole	-	-	-	-	0.34	0.40	0.50	0.79	0.55	-	-
Slender sole	-	-	0.22	0.33	0.34	0.34	0.38	0.32	0.31	0.33	0.20
Butter sole	0.38	0.41	0.43	0.44	-	-	-	-	-	-	-
Sablefish	-	-	1.07	1.22	2.06	2.84	2.80	2.67	2.66	2.79	5.78
Lingcod	13.75	-	7.54	8.12	4.57	9.17	9.09	10.10	3.90	11.63	-
Pacific hake	-	-	2.92	-	2.88	3.04	2.80	2.33	-	2.91	2.11

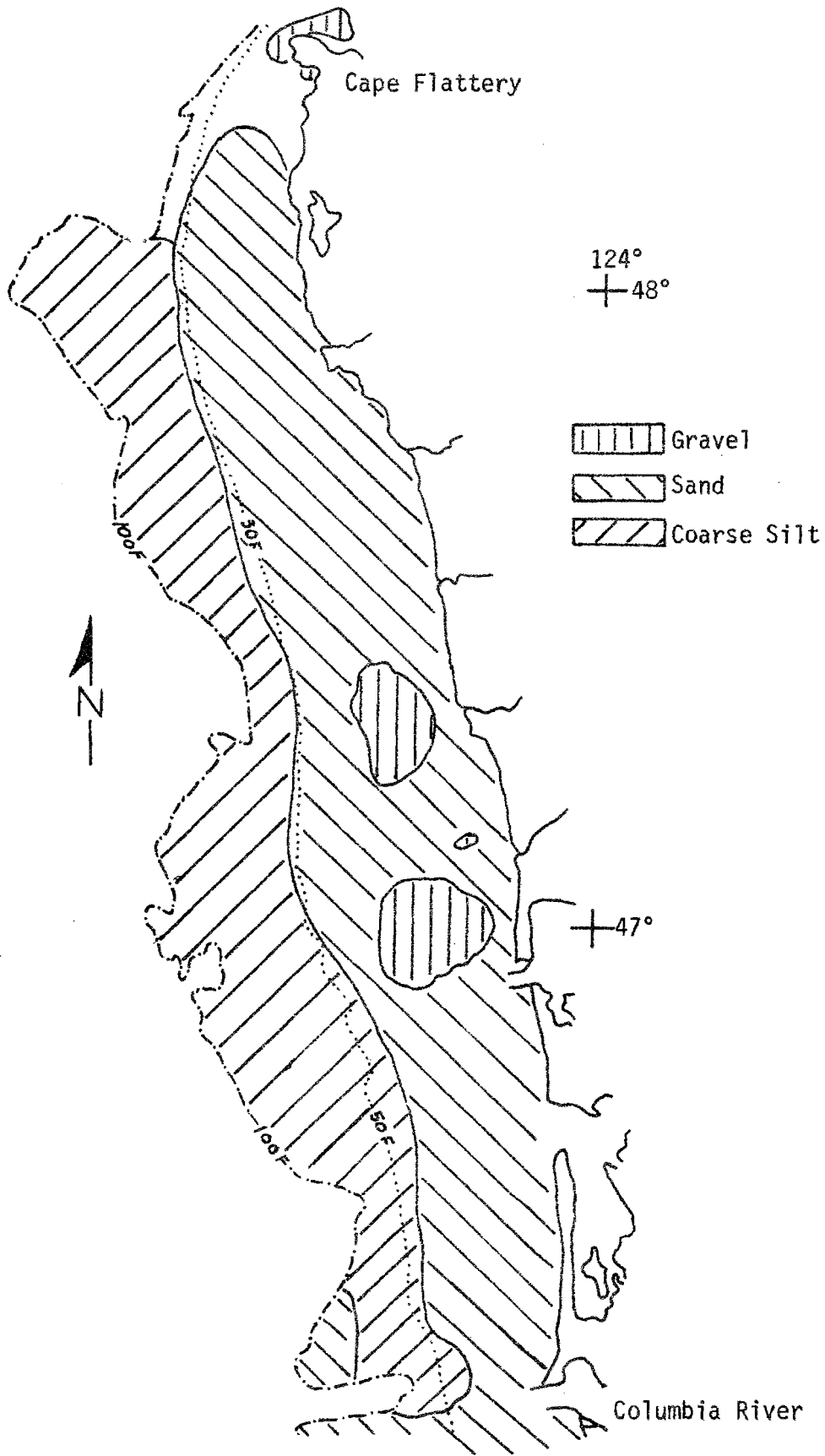


Figure 3. Distribution of sediment type on the continental shelf off Washington

Temperature

XBT temperature profiles were made at 22 stations, primarily from the Copalis River to Willapa Bay in 25-258 fms. Too little data were collected to indicate definite temperature preferences. Bottom temperature ranged from 6.4C in 100 fms. to 8.3C in 70 fms.

Year Class Strength

Age composition was analyzed for seven flatfish species by comparing relative age frequencies (Figure 4). These species are compared to recent northern Oregon survey age frequencies. Age frequencies were weighted to catch by using sampling rate.

A strong 1972 year class was indicated for English sole by the high incidence of 3-yr. old fish off Washington. This conclusion is supported by findings from larval surveys conducted off Oregon by the Oregon State University, School of Oceanography. Their survey, March 1973, showed an exceptionally large number of English sole larvae compared to like surveys conducted in 1972 and 1974 (personal communications, Joanne Laroche, School of Oceanography, O.S.U.).

The 1972 year class was also strong for butter sole and arrowtooth flounder off Washington. The 1970 year class appeared to be good for Dover, English, petrale, rex, slender and butter sole, as was found for petrale sole off Oregon. The exceptionally strong 1961 year class noted in stocks off Oregon was still evident for Washington Dover sole.

The dominance of five year old Dover sole in survey catches off Washington contrasts greatly with northern Oregon survey data (1971, 1973) where eight year old Dover sole were dominant. This difference cannot be attributed entirely to an exceptionally strong year class, because it should have shown in other species but did not (Figure 4). Therefore separate stocks of Dover sole north and south of the Columbia river are suggested. This conclusion is supported by a tagging study off Washington. Westheim and Morgan (1963) reported that of 2,406 tagged Dover sole released off Willapa Bay, only two of the 251 recoveries were taken south of the Astoria Canyon.

The age distributions of arrowtooth flounder indicated another possible separation of stocks. An older population was seen off Washington with seven year old fish dominating the stock. Younger fish of the 1967 year class, four and six years old, dominated the arrowtooth flounder survey catches off Oregon in 1971 and 1973.

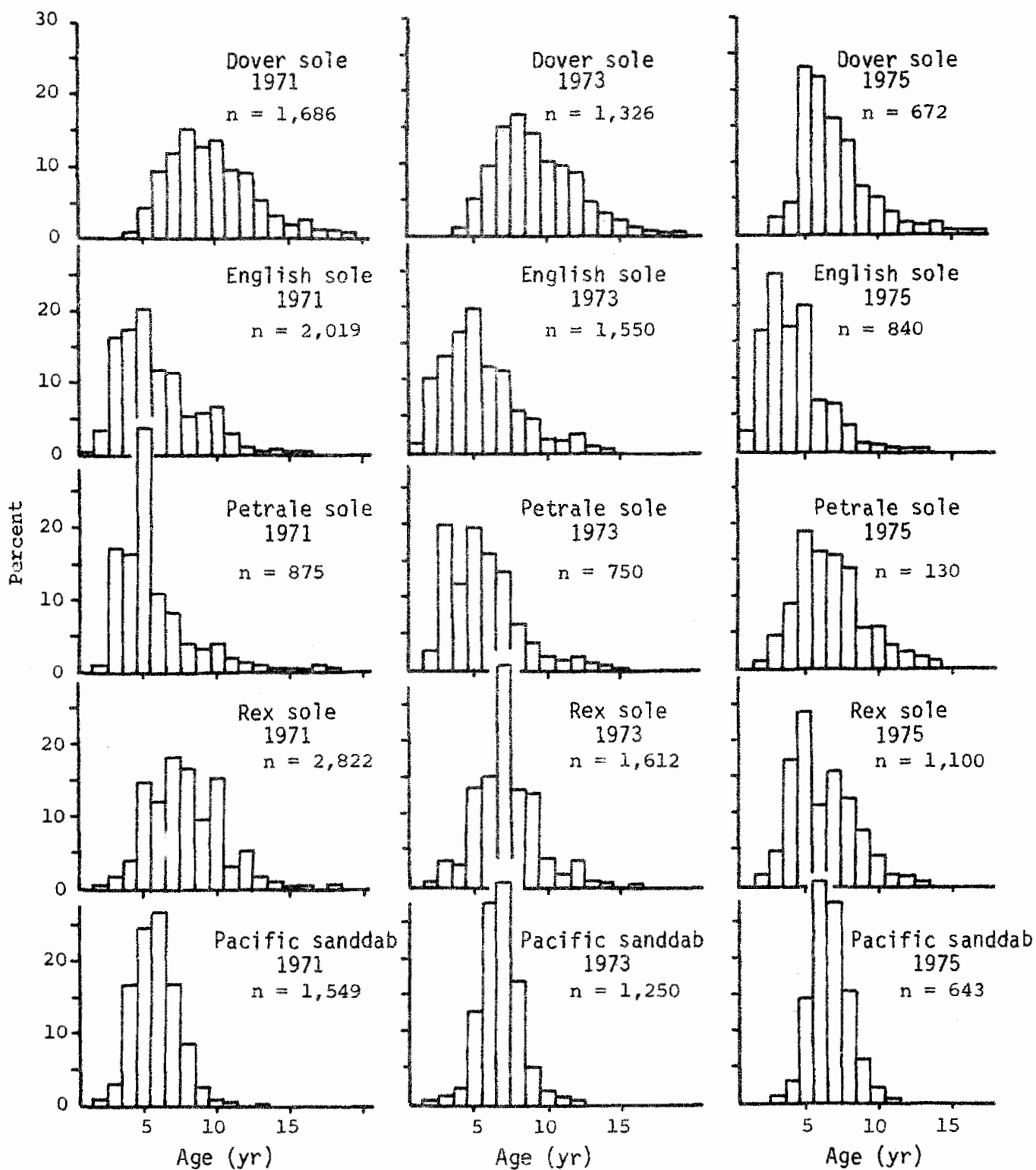


Figure 4. Year class strength, relative frequency as determined from groundfish surveys off northern Oregon (1971, 1973) and Washington (1975)

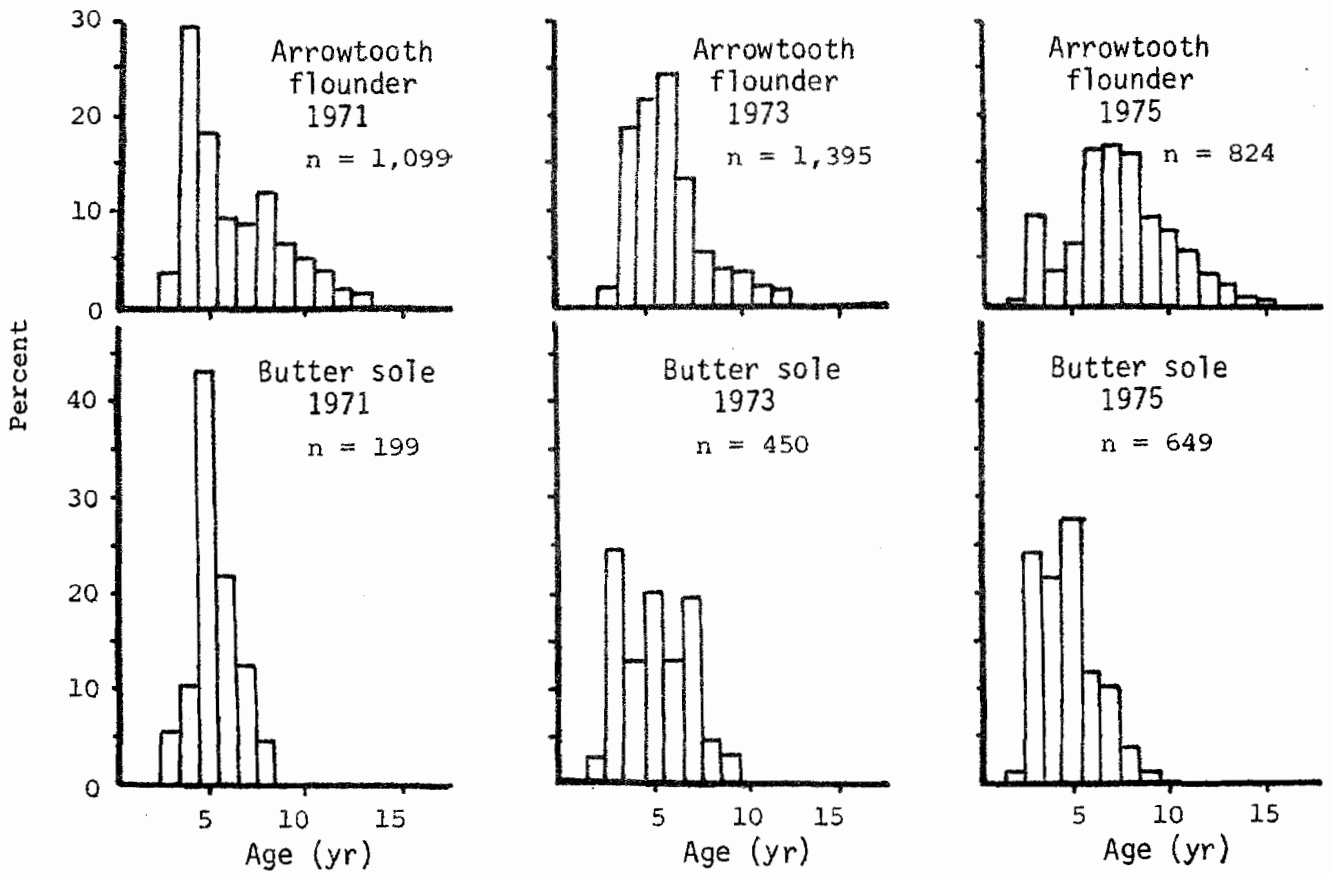


Figure 4. (Continued)

ACKNOWLEDGMENTS

The efforts of Mark Pedersen, Jim Beam, and Steve Axtell, Washington Dept. of Fisheries, were much appreciated as were those of Dr. A.V. Tyler, Larry Six and Robert Haymen, Oregon State University. Steve Klug and Tim Rymer of the O.D.F.W. also ably assisted. Our gratitude is expressed to Lou Fredd for his statistical assistance. The University of Washington research vessel, R/V *Commando* and crew provided outstanding support throughout the survey.

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Appendix 1. Length-weight constants for selected flatfish species from groundfish survey off Washington, 1975.

	Length-Weight Constants			
	Males		Females	
	a	b	a	b
Dover sole	-196514	2.95833	-2.12630	3.06697
English sole	-1.81046	2.83217	-2.09881	3.04795
Petrale sole ^{1/}	-2.11289	3.135	-2.4437	3.348
Rex sole	-3.00881	3.51367	-3.09201	3.57285
Arrowtooth flounder	-2.49291	3.26895	-2.46547	3.26485
Pacific sanddab	-2.26826	3.17960	-2.38859	3.29136
Butter sole	-2.22167	3.12243	-2.10104	3.05275
Flathead sole	-2.43440	3.28206	-2.53236	3.35309
Slender sole	-2.50958	3.20714	-3.00625	3.59390

^{1/} From Petersen, 1975.

Appendix 2. Mean length at age of selected species from eye fitted curve^{1/}

Age	Mean Length Species, cm															
	Dover sole ^{2/}		English sole		Rex sole		Pacific sanddab		Arrowtooth flounder		Slender sole		Flathead sole		Butter sole	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
1	10.0	10.5	15.3	15.1	16.0	15.0	8.7	10.0	14.0	11.0	-	-	-	12.0	-	-
2	15.7	16.0	21.3	23.3	21.5	21.8	13.3	15.7	22.0	21.0	12.5	16.0	21.0	21.0	15.0	-
3	20.5	21.2	24.5	28.3	23.3	25.3	17.4	20.2	27.8	29.0	19.5	21.5	25.8	25.6	20.7	21.5
4	24.6	26.0	26.5	31.3	24.8	27.5	20.5	22.7	32.0	34.3	21.5	24.3	28.0	29.1	23.1	23.7
5	28.4	29.7	27.7	33.5	25.9	28.9	22.8	24.6	35.1	38.6	23.2	25.4	29.4	31.8	24.0	25.6
6	31.0	32.8	28.7	35.5	27.0	29.7	23.7	26.0	38.0	41.8	24.5	26.1	-	34.3	24.7	27.2
7	33.8	35.6	29.3	37.3	27.9	30.5	24.5	27.4	40.0	44.5	25.6	26.8	-	36.6	25.0	28.8
8	35.7	37.7	29.8	38.2	28.9	31.2	25.0	28.5	41.6	47.2	26.5	27.5	-	38.8	25.1	30.3
9	37.5	39.8	30.2	40.0	29.6	31.8	25.5	29.5	42.8	49.7	27.2	28.3	-	41.0	-	-
10	38.9	41.6	30.4	40.8	30.2	32.5	26.0	30.1	43.7	52.0	27.8	28.8	-	-	-	-
11	40.0	43.0	30.6	41.4	30.9	33.2	-	30.5	44.1	54.5	28.4	29.3	-	-	-	-
12	40.8	44.2	30.7	41.7	31.5	33.8	-	-	44.5	56.9	-	29.7	-	-	-	-
13	-	-	-	-	-	34.3	-	-	-	-	-	30.0	-	-	-	-
14	-	-	-	-	-	34.7	-	-	-	-	-	-	-	-	-	-

^{1/} Petrale sole mean length at age may be obtained from Petersen, 1975.

^{2/} Includes data from Oregon survey work and 1975 Astoria market samples.

Appendix 3. Instantaneous mortality rate Z for selected species of flatfish off Washington, 1975. Age range in parentheses.

Species	Z	
	Males	Females
Dover sole	0.50 (6-15)	0.35 (5-17)
English sole	0.43 (3-12)	0.49 (3-13)
Petrable sole	0.65 (6-11)	0.27 (5-17)
Rex sole	0.41 (5-18)	0.43 (5-14)
Pacific sanddab	0.84 (6-10)	0.79 (7-11)
Arrowtooth flounder	0.35 (6-17)	0.42 (7-17)

Appendix 4. Common and scientific names of species on groundfish survey off Washington, 1975

Spiny dogfish	<i>Squalus acanthias</i>
Skates	<i>Rajidae</i>
Ratfish	<i>Hydralagus colliei</i>
American shad	<i>Alosa sapidissima</i>
Pacific cod	<i>Gadus macrocephalus</i>
Pacific hake	<i>Merluccius productus</i>
Shortspine thornyhead	<i>Sebastolobus alascanus</i>
Rougheye rockfish	<i>Sebastes aleutianus</i>
Pacific ocean perch	<i>Sebastes alutus</i>
Aurora rockfish	<i>Sebastes aurora</i>
Silvergray rockfish	<i>Sebastes brevispinis</i>
Darkblotched rockfish	<i>Sebastes crameri</i>
Splitnose rockfish	<i>Sebastes diploproa</i>
Greenstriped rockfish	<i>Sebastes elongatus</i>
Widow rockfish	<i>Sebastes entomelas</i>
Yellowtail rockfish	<i>Sebastes flavidus</i>
Rosethorn rockfish	<i>Sebastes helvomaculatus</i>
Quillback rockfish	<i>Sebastes maliger</i>
Black rockfish	<i>Sebastes melanops</i>
Bocaccio	<i>Sebastes paucispinis</i>
Canary rockfish	<i>Sebastes pinniger</i>
Redstripe rockfish	<i>Sebastes proriger</i>
Yelloweye rockfish	<i>Sebastes ruberrimus</i>
Flag rockfish	<i>Sebastes rubrivinctus</i>
Stripetail rockfish	<i>Sebastes saxicola</i>
Sharpchin rockfish	<i>Sebastes zacentrus</i>
Sablefish	<i>Anoplopoma fimbria</i>
Lingcod	<i>Ophiodon elongatus</i>
Pacific sanddab	<i>Citharichthys sordidus</i>
Arrowtooth flounder	<i>Artheresthes stamias</i>
Petrable sole	<i>Eopsetta jordani</i>
Rex sole	<i>Glyptocephalus zachirus</i>
Flathead sole	<i>Hippoglossoides elassondon</i>
Pacific halibut	<i>Hippoglossus stenolepis</i>
Butter sole	<i>Isopsetta isolepis</i>
Rock sole	<i>Lepidopsetta bilineata</i>
Slender sole	<i>Lyopsetta exilis</i>
Dover sole	<i>Microstomus pacificus</i>
English sole	<i>Parophrys vetulus</i>
Starry flounder	<i>Platichthys stellatus</i>
Curlfin sole	<i>Pleuronichthys decurrens</i>
Sand sole	<i>Psettichthys melanostictus</i>
