GROUNDFISH SURVEYS ON THE CONTINENTAL SHELF OFF OREGON, 1971-74

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INTRODUCTION

This report summarizes information obtained from groundfish surveys conducted by the Oregon Department of Fish and Wildlife from 1971 through 1974. The program was a comprehensive marine resource survey of the continental shelf and upper continental slope off Oregon between the Columbia River and Cape Blanco. Major goals were: (1) to obtain estimates of abundance or biomass for groundfish with emphasis on flatfish; (2) to develop ways of indexing year class (brood year) strength of flatfishes important to the commercial trawl fishery before they enter the fishery; and (3) to obtain estimates of age, growth and mortality rates of important flatfish. Such information, coupled with estimates of exploitation and fishing rates, provide a basis for estimating optimal levels of yield or catch.

Emphasis of the surveys was on flatfish because they were very important to the Oregon trawl fishery in 1971-75 and since the early 1940's. An additional reason for our stressing work on flatfish was that in the initial planning, it was hoped that the National Marine Fisheries Service (N.M.F.S.) might do the offshore work, especially on rockfish. However, since this did not occur, the surveys were extended seaward to include the upper continental slope in 1973-74.

Surveys provide information which is difficult to obtain from commercial fishery landing statistics. For example, it is difficult to obtain estimates of recruitment or the abundance of juveniles, because commercial trawls have larger mesh size and draggers also discard at sea the small and unmarketable fish; thus the data obtained are not influenced by market conditions, size limits or the economic need to fish mostly in areas of high abundance which commercial boats face. Simply put, survey trawl sets give a clearer picture of what comes up in the net.

The purpose of this report is to present the results obtained from the analysis of a great mass of data, obtained not only from the surveys, but also from landing statistics and fishermen's logbooks.

METHODS

The survey was conducted off the Oregon coast (Figure 1) between the Columbia River to just south of Cape Blanco. These limits were chosen because they were believed to be partial biological barriers as well as convenient geographical boundaries and included the bulk of the trawl fishery. Continuing the survey south of Cape Blanco would have required a survey to at least Point Saint George, California and probably further south to Cape Mendocino, more area than was possible to study with available funds and manpower. The survey period was from early September to early October each year, the best weather period off Oregon most years. Also, stocks of fish are relatively stable at this time of year because offshore spawning migrations for some species have not yet begun.

In 1971-72, depths surveyed were limited to the continental shelf between 10 and 110 fm. The offshore limit was extended to about 400 fm in 1973-74. As used here the area seaward of 110 fathoms out to 400 fathoms is called the upper continental slope or simply the upper slope. A survey of the upper slope area south of Heceta Bank was successfully completed in 1974. The total survey area was too large to adequately study in a single year; thus two years were required to obtain a single view of the groundfish resources, *i.e.*, 1971-72 and 1973-74. The northern half was surveyed in 1971 and 1973. The southern portion was surveyed in 1972 and 1974. An upper slope survey was tried in 1973-74 but was only partially successful.

Trawling locations (stations) were determined by use of a 5 x 5 N mi grid and located by loran, depth and ship's radar. Tow length on shelf station (less than 110 fm) was 0.75 N mi in 1971-72 and 1.0 N mi in 1973-74. Tow length was 1.5 N mi on slope stations in 1974. Nearly all tows were made to the south because prevailing winds were northerly and the skipper chose to trawl with the wind. All tows were made during daylight between 0700 and 1930 hours, and towing speeds were 2.0 to 2.5 knots.

The 67-ft. western seiner-type trawler R/V *Commando*, powered by a 358 hp engine, was used. The trawl used was a 400-mesh eastern type constructed entirely of 3.5-in mesh, stretched measure. Sweep lines (10-fm bridles, 5-fm dandy lines) were used to reduce herding of fish into the trawl mouth because we wanted to catch only those fish directly in front of the trawl mouth. This is important because if fish are herded by long sweeplines the estimates of biomass are too high, which would lead us to believe that there were more fish than there actually were. Divers measured the horizontal and vertical openings and appraised the workability of the trawl in Puget Sound, Washington. Horizontal and vertical openings were 32-ft and 3.5-ft, respectively, in 1971-72. A change from the rope-wrapped footrope (urged by some draggers in Charleston) supplied with the trawl, to a chain-disk footrope in 1973-74 reduced horizontal opening to 30-ft and increased vertical opening to nearly 6 ft. A further change in footropes was made in 1974. Tows on the upper slope were made with the trawl rigged with a roller-type (16-inch) footrope.

DEFINITION OF TERMINOLOGY

Before going any further it is important to define some words used in the report.

Biomass

The estimated weight of all fish or of a particular species occupying the grounds; it includes small fish of a size not suitable for market. Biomass is determined by dividing the area available to the trawl by the swept area (tow length x horizontal opening) and multiplying that result by the average catch of each species. For example we measured marine charts with a planimeter and found that between 60 and 70 fathoms the trawlable area was 523.2 square nautical miles. Since our trawl covered 0.00494 square nautical miles in a single average tow there would be 105,911 possible tows within the area (523.2 ÷ 0.00494 = 105,911). The average catch of Dover sole from 22 tows was 129.9 pounds, thus 129.9 x 105,911 = 13,757,839 pounds of Dover sole biomass. This value added to values calculated for other 10 fathom areas gives us the total Dover sole biomass.

Usable biomass

This word is used only for Dover, English, petrale and rex sole and sanddab. The term "biomass" again is weight. The term "usable" applies to the size of fish that would be landed and sold. Usable biomass is less than the total biomass because fish too small for market have been removed.

Exploitation rate

This is the fraction of the usable stock (usable biomass) that is caught and killed by fishing. This value is obtained by dividing landings by usable biomass. For some species the exploitation rate is underestimated because fish are caught but not landed, for example, sanddabs. Market limits have the effect of reducing the apparent exploitation rate, but the reduction is artificial because the exploitation still takes place.

Fishing mortality

Fishing mortality is used to define that portion of the stock that is caught and killed by man. It is related to exploitation rate but is not the same. Fishing mortality is under control by man (seasons, area closures, mesh size etc).

Natural mortality

Natural mortality is used to define death from natural causes such as being eaten by a predator, dying from old age or dying from disease.

The last two terms are not used further in this report but are introduced because they are essential elements when some form of management is considered.

ESTIMATES OF BIOMASS

The total biomass estimate (all species) for the shelf survey in 1971-72 was about 627 million pounds, and 519 million pounds in 1973-74 (Table 1). Pacific hake was the most abundant species (by weight). In 1971-72 they amounted to 292 million pounds and 150 million pounds in 1973-74. These estimates for hake are probably minimal, because hake are not fully vulnerable to the type of trawl we used.

Biomass of the flatfish group on the continental shelf amounted to about 188 million pounds in 1971-72, and 176 million pounds in 1973-74. Dover sole biomass declined 13% from 58 million pounds in 1971-72 to 50 million pounds in 1973-74. Other important flatfish showing a decrease from 1971-72 were petrale sole which declined by 31% to about 9 million pounds and rex sole which dropped 11% to 24 million pounds. Two important flatfish increased by 10% in biomass in 1973-74: English sole to 43 million pounds and Pacific sanddab to 26 million pounds.

The rockfish group in 1973-74 showed an 82% increase (to 67 million pounds) over 1971-72. The increase was mostly caused by one catch of canary rockfish in 1973-74 that accounted for about 90% of our total catch for this species and about 46% of our total catch of all rockfish species on the continental shelf. This one tow is a perfect example of why lots of tows are necessary for survey type work. It also points out that great care must be used in drawing conclusions from data that are highly variable, like rockfish catches tend to be. Biomass of off-bottom (like hake) and rockfish species were underestimated because our type of gear really was efficient only for catching flatfish and other bottom hugging species.

The 1974 survey also included the upper slope south of Heceta Bank (Figure 1)[1/].

1/ *The large untrawlable area near the center of the survey area.*

Table 1. Estimates of biomass (millions of pounds) of principal species, resource surveys off Oregon, 1971-74.

	Continental Shelf				Continental Slope	
	1971-72		1973-74		1974 only	
Species	Mid-point	Range	Mid-point	Range	Mid-point	Range
Spiny dogfish	8	4-13	28	18-38	T	-
Skates	37	30-45	38	33-42	T	-
Ratfish	28	21-36	27	20-35	T	-
Pacific cod	2	T-3	2	T-3	-	-
Pacific hake	292	192-393	150	106-195	5	2-8
Rockfish						
Pacific ocean perch	1	0-2	2	1-2	1	T-1
Yellowtail rockfish	5	T-9	5	1-8	-	-
Canary rockfish	6	3-9	37	0-103	-	-
Darkblotched rockfish	1	T-2	2	1-3	1	0-1
Other rockfish	24	7-40	21	8-35	4	2-6
Sablefish	25	9-41	22	15-29	20	12-29
Lingcod	10	7-12	9	5-13	T	-
Flatfish						
Dover sole	58	46-69	50	42-59	10	7-13
English sole	40	30-50	43	26-61	T	-
Petrale sole	13	8-18	9	6-11	T	-
Rex sole	27	22-32	24	19-29	2	1-2
Pacific sanddab	24	11-37	26	17-36	-	-
Arrowtooth flounder	17	13-21	16	13-19	1	T-1
Other flatfish	9	2-15	8	3-12	T	-
Total	627	405-847	519	334-733	44	24-61
Flatfish	188	132-242	176	126-227	13	8-16
Rockfish	37	10-62	67	11-151	6	2-8

T = trace = less than 250,000 pounds (¼ million)

This area supports a major fishery, primarily for Dover sole. Of the three most important species, Dover sole biomass was estimated at nearly 10 million pounds while petrale and rex sole amounted to 100 thousand pounds and two million pounds, respectively (Table 1). The upper slope estimates are not directly comparable with shelf estimates because roller gear, used only on the slope, allowed substantial escapement from the trawl. Based on six comparative tows the average catch rate of Dover sole with chain-disc footrope was nearly four times greater than the roller gear. However, no adjustments were made to adjust for the differences in catch rate because results of so few comparative tows could well be misleading.

ESTIMATES OF USABLE BIOMASS

Estimates of usable biomass for the five major species of flatfish ranged from about 51 million pounds of Dover sole (1973-74) to 6 million pounds of petrale sole (1973-74). Estimates were less in 1973-74 for English, petrale, and rex sole than in 1971-72 (Table 2). The estimate for Dover sole was greater in 1973-74, but this included fish from the upper slope, which was not surveyed in 1971-72.

Table 2. Estimates of usable biomass and potential yield (millions of pounds) compared to landings from survey area.

Species	Usable Biomass		Potential Annual Yield		Average Landings	
	1971-72 1/	1973-74 2/	1971-72 1/	1973-74 2/	1971-72 1/	1973-74 2/
Dover sole	49	51	7	8	4.3	3.9
English sole	16	14	3	3	1.4	1.0
Petrale sole	8	6	2	2	1.2	1.9
Rex sole	16	14	3	3	0.6	0.9
Pacific sanddab	7	9	2	3	0.6	0.2

1/ Continental shelf only
2/ Includes slope estimate south of Heceta Bank
3/ Includes slope landings south of Heceta Bank

EXPLOITATION RATE

Exploitation rate ranged from 0 for sanddabs off Newport to 37% for petrale sole off Coos Bay. In nearly all cases, exploitation rates were higher off Coos Bay than in other areas. The exception was off the Columbia River where rex sole were exploited at a higher rate than in other areas. When the survey area, for all species as a whole, was considered exploitation rates ranged from about 1% (sanddab) to 24% (petrale sole). It is important to note that even though sanddabs had a 0 exploitation rate the fish were still caught - they just were not landed. Market limits also have the effect of reducing the exploitation rate, since some usable fish might be discarded after a trip limit is met for that species.

Petrale sole may need protection off Coos Bay because the exploitation rate is quite high. In part, this is due to a spawning ground fishery when fish are concentrated. On the surface this appears to be a problem, but studies off British Columbia and Washington indicated that year class strength changes by natural causes (i.e. natural mortality) are more important than fishing in reducing (or expanding) stock size. Also the study off Washington pointed out that species like petrale sole (low abundance, high value) may well be kept at relatively low levels of abundance in the interest of optimizing yield from a multispecies trawl fishery where other less valuable (per fish) but more abundant species such as Dover sole dominate the catch. In fact in 1975 this was the case.

POTENTIAL YIELD

Estimates of potential annual yield ranged from nearly eight million pounds for Dover sole to about two million pounds for petrale sole (Table 2). Estimates for Dover, petrale and rex sole for 1973-74 are underestimated since these included catches made using the trawl rigged with the roller type footrope. When estimates of potential yield are compared to the survey area landings there is room for increasing the catch with the possible exception of petrale sole. The species offering the greatest potential were English sole, rex sole and sanddab. Increases in yield could be obtained with changes in market conditions. This would encourage use of species (or sizes) that are now mostly or entirely discarded. This would mean increasing exploitation rate. It is important to note here that these levels of potential yield are higher than optimum economic yield. To achieve the potential yield would mean large increases in effort.

DISTRIBUTION

Distribution of major species in September was very variable. The catch maps (Figures 2-13) show distribution of most species. Two prominent features are apparent: the area near the Columbia River and the area adjacent to Heceta Bank south to about Cape Blanco were high-catch regions. This pattern prevailed in both survey periods. On the other hand, the area north of Heceta Bank was usually sparsely populated.

If catch maps are compared with distribution of bottom types (Figure 1) it is apparent that English sole and sanddab occurred mostly inshore, over sand sediments, while Dover sole, arrowtooth flounder (turbot) and black cod were most abundant over mud sediments in deeper water.

Another view of distribution was obtained by plotting the biomass against sediment type and depth. Bottom types for the Oregon continental shelf were shown in a OSU Sea Grant pamphlet in 1972 by major sediment types. For our purpose only mud and sand were used. For the area south of Heceta Bank at depths greater than 200 fm bottom type was assumed to be mud although sand patches do occur. There is a sharp decline in the amount of sand with increasing depth and a sharp increase of mud with increasing depth (Figure 14, top left). When biomass of major species was compared to depth and sediment type, definite preferences were shown by some species while other species were less affected by bottom type or depth.

Dover sole, arrowtooth flounder and black cod were most abundant over mud bottom and depths greater than 60 fathoms. English sole, petrale sole and sanddab were more abundant at lesser depths where sand was dominant. Other species of flatfish, not show in Figure 14, but limited to shallow depths and sand sediments were butter sole, sand sole and starry flounder. The other species shown in Figure 14 were more widespread with depth, but ratfish were more abundant over sand bottom.

Although Figure 14 shows distribution by depth as well as abundance with depth and bottom type we still do not know which of the two factors control distribution. Since the amount of mud increases with depth, inversely to sand, it was not possible to separate the influence of depth from bottom type on species distribution. For example, do English sole respond to shallow depth or to sand bottom? We suspect that other factors such as temperature, or more importantly, food availability or preference have greater influence in determining distribution. The latter factors may not be independent of depth or bottom type either.

YEAR CLASS STRENGTH

A relative indicator of year class (brood year) strength was calculated by following year classes for the six most abundant species of flatfish over the four year survey period. A strong 1966 year class (born that year) was common for three of the six species. The 1968 year class showed well for English, petrale, and rex sole. For petrale sole the 1970 year class also appeared to be strong (Figure 15). The 1961 year class, even though 10-13 years old by 1971-74, was still noticeable in Dover, English, petrale and rex sole. This year class was the strongest for Dover sole off Oregon since the 1942 year class. For arrowtooth flounder, the 1967 and 1969 year classes appeared to be prominent.

COSTS

Costs of the program by fiscal year (FY) are shown below:

Budget Category	FY 1972	FY 1973	FY 1974	FY 1975
Personal Services	$43,552	$44,255	$43,634	$43,691
Contractual Services	25,205	23,994	22,136	21,282
Equipment & Supplies	5,762	2,324	8,499	3,399
Overhead	8,000	7,630	10,161	10,140
Miscellaneous	4,019	4,688	1,164	3,302
Total	$86,538	$82,891	$85,594	$81,814

SOME COMMENTS

As stated earlier, surveys provide a unique chance to obtain the necessary data for a rational management program. But surveys have limitations. An important limitation of the Oregon work was that it occurred only in September and because of this we do not have a picture of seasonal availability (distribution) which can have a major impact on calculations of abundance. Another problem was that we did not get complete coverage on the upper slope, thus our estimates of biomass are conservative.

There were also some gear limitations. Our trawl was good at catching flatfish (and improved with the addition of the chain-disc footrope) but not good for rockfish or other off bottom species.

We were satisfied with our survey design (the station pattern and number of stations). On the average we had one tow per 25 square miles of trawlable bottom. Compared to other U.S. and Canadian groundfish survey programs our trawling was extremely intense. For example, in the Bering Sea, coverage was about one tow per 600 square miles and off the east coast of the United States, 315 square miles.

Some criticized the survey because we could not show short term movements. This was certainly true and it is unlikely that any survey could, but we did show in a general way where fish were, at least in September. We did manage to detect shifts in distribution. And we obtained the best estimates of biomass available to date for the west coast.

Hopefully this study is not finished. Periodic surveys will be necessary to keep track of stock condition in future years. Also we need a complete seasonal picture of distribution. We also must find a way to put numbers beside the observations that fishermen make every time a set is made and hauled back. We also need to obtain more exact data on the extent and composition (by species and size) of fish discarded at sea. This can only be done by using working boats at sea through the course of a year.

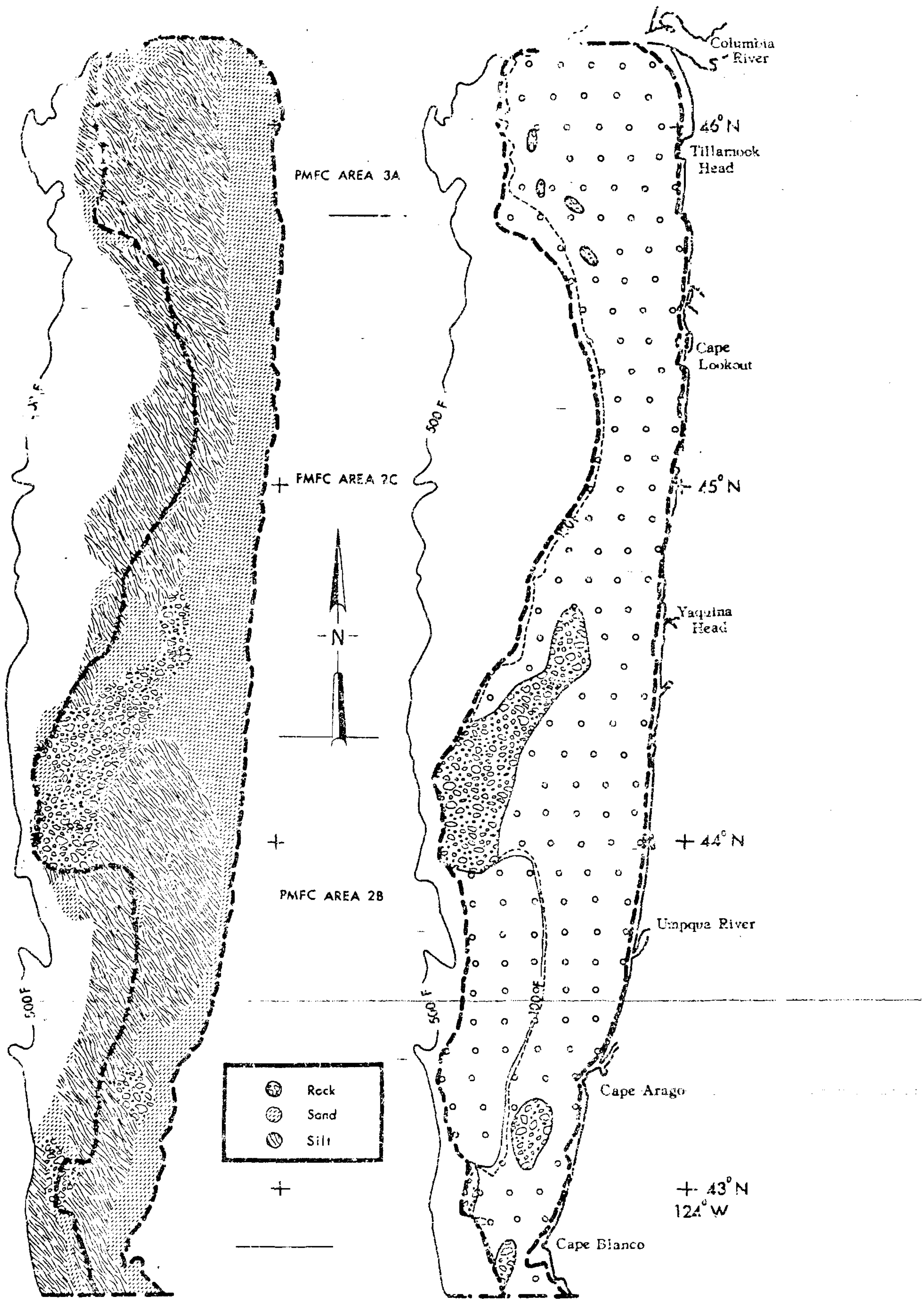

Figure 1. Location of trawl stations of groundfish surveys off Oregon, 1971-74. Heavy broken line defines survey limits (deep-water limit, lower portion, 1974 only). Sediment types after Byrne and Panshin (1972). PMFC statistical areas are indicated.

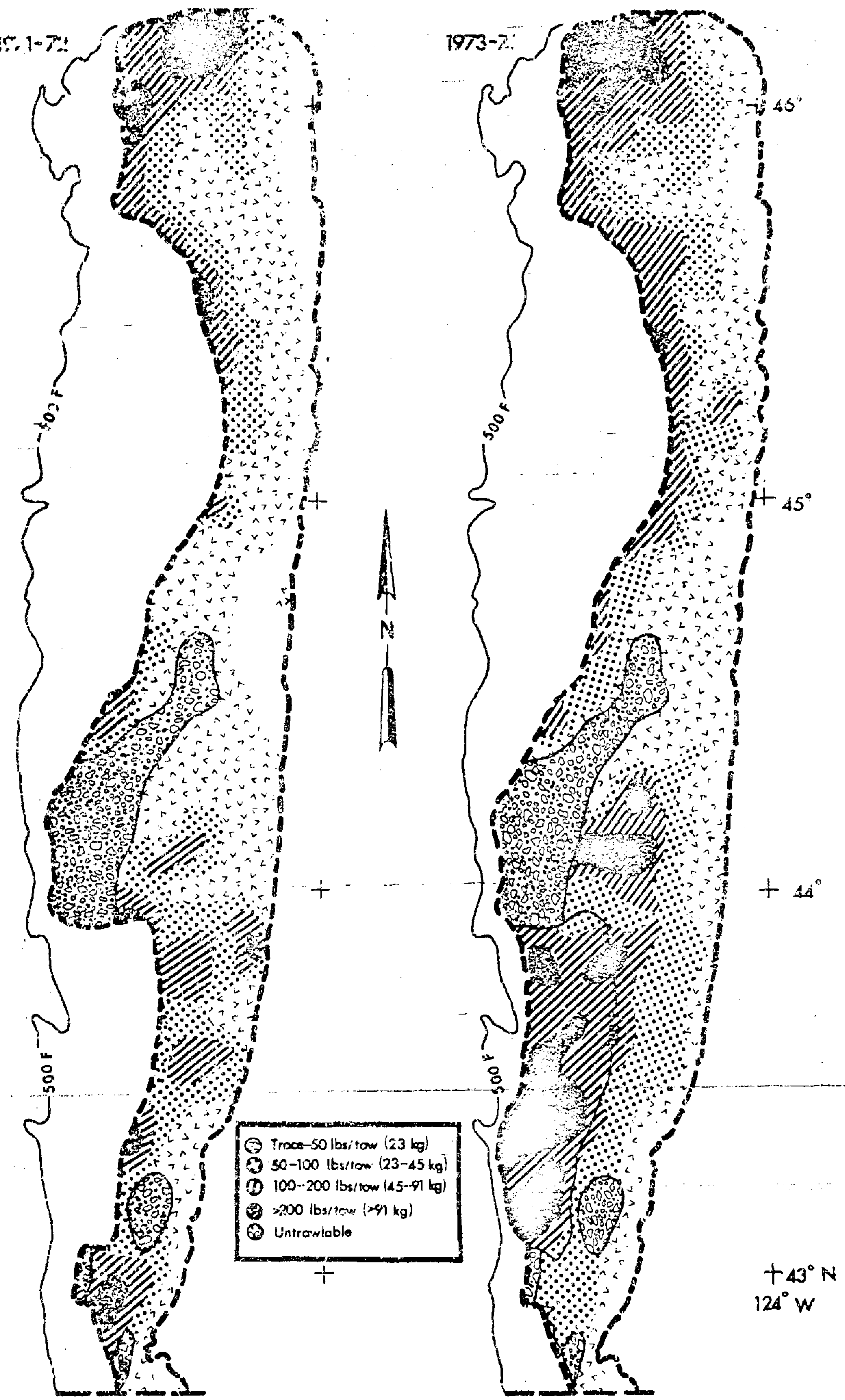

Figure 2. Distribution and relative abundance (weight) of Dover sole in September 1971-72 and 1973-74 off Oregon as determined by groundfish surveys. Heavy broken line is limit of survey.

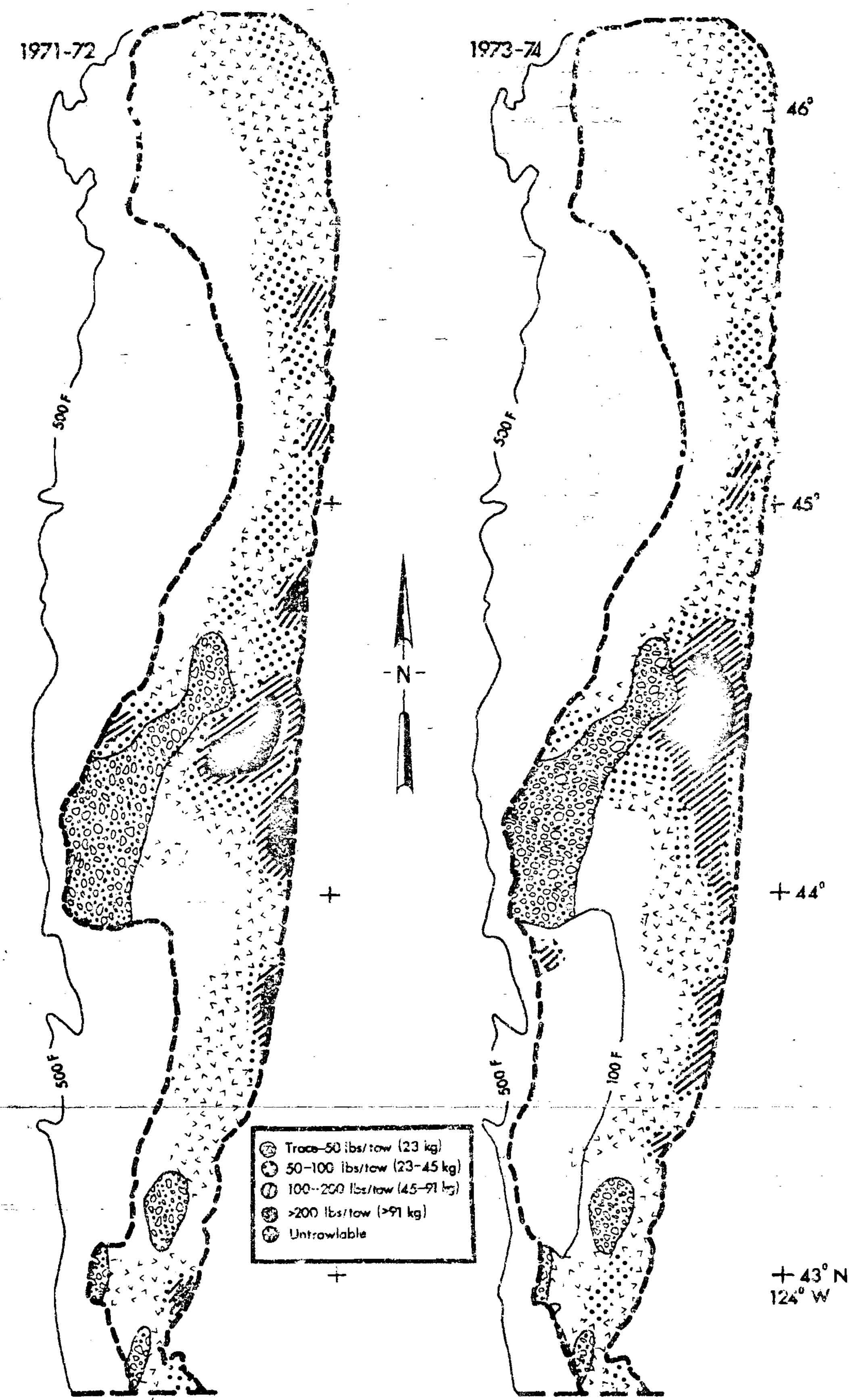

Figure 3. Distribution and relative abundance (weight) of English sole in September 1971-72 and 1973-74 off Oregon as determined by groundfish surveys. Heavy broken line is limit of survey.

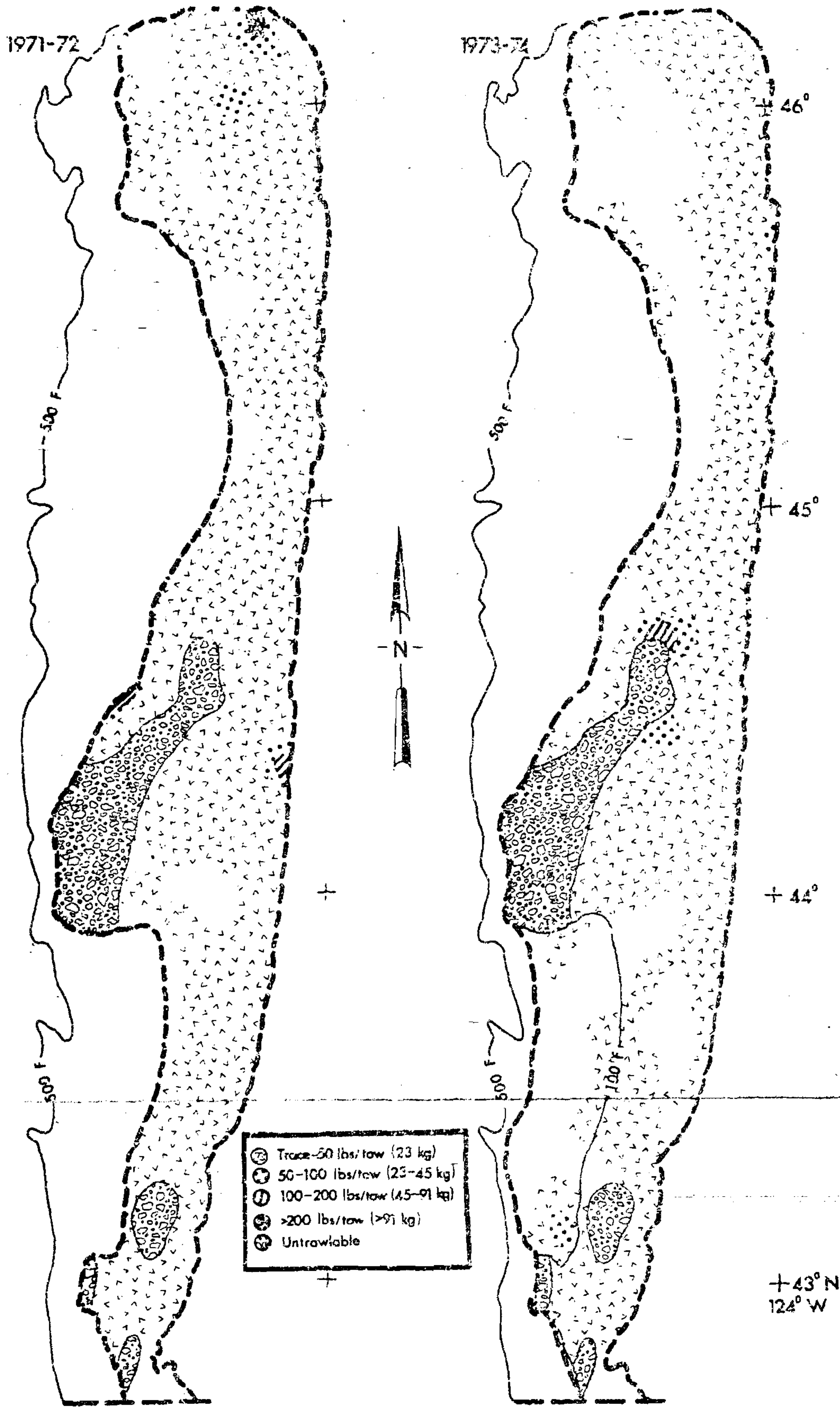

Figure 4. Distribution and relative abundance (weight) of petrale sole in September 1971-72 and 1973-74 off Oregon as determined by groundfish surveys. Heavy broken line is limit of survey.

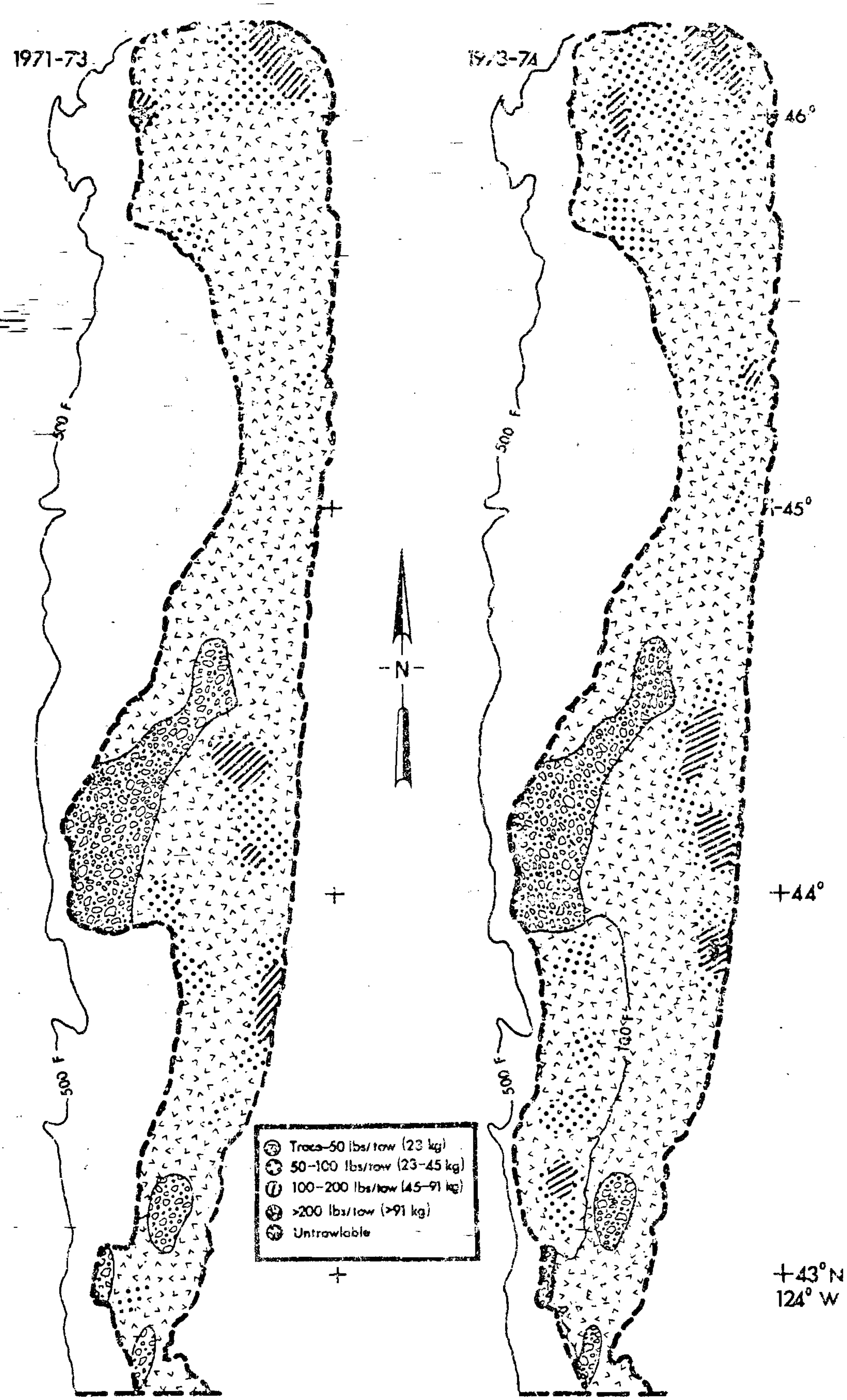

Figure 5. Distribution and relative abundance (weight) of Rex sole in September 1971-72 and 1973-74 off Oregon as determined by groundfish surveys. Heavy broken line is limit of survey.

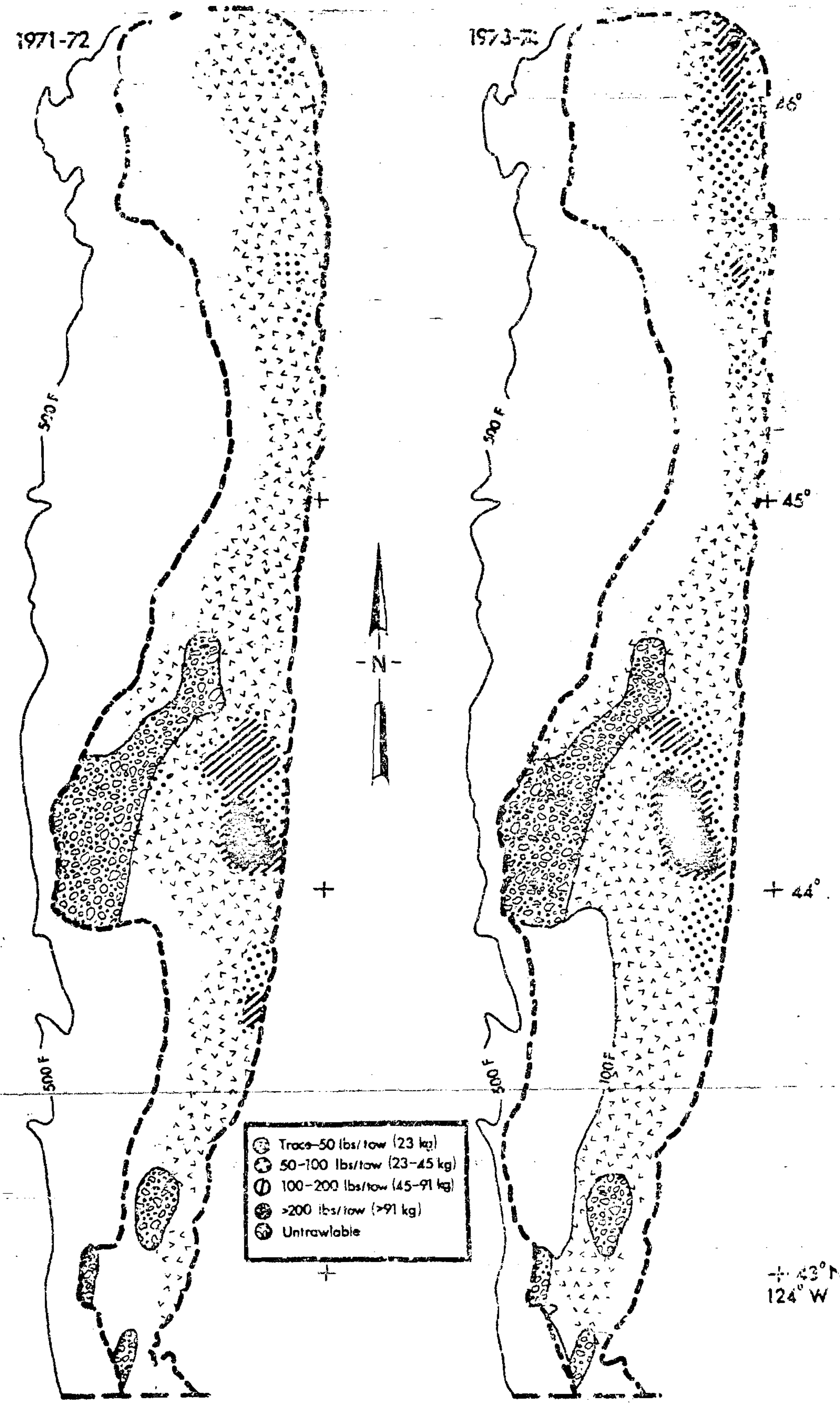

Figure 6. Distribution and relative abundance (weight) of Pacific sanddab in September 1971-72 and 1973-74 off Oregon as determined by groundfish surveys. Heavy broken line is limit of survey.

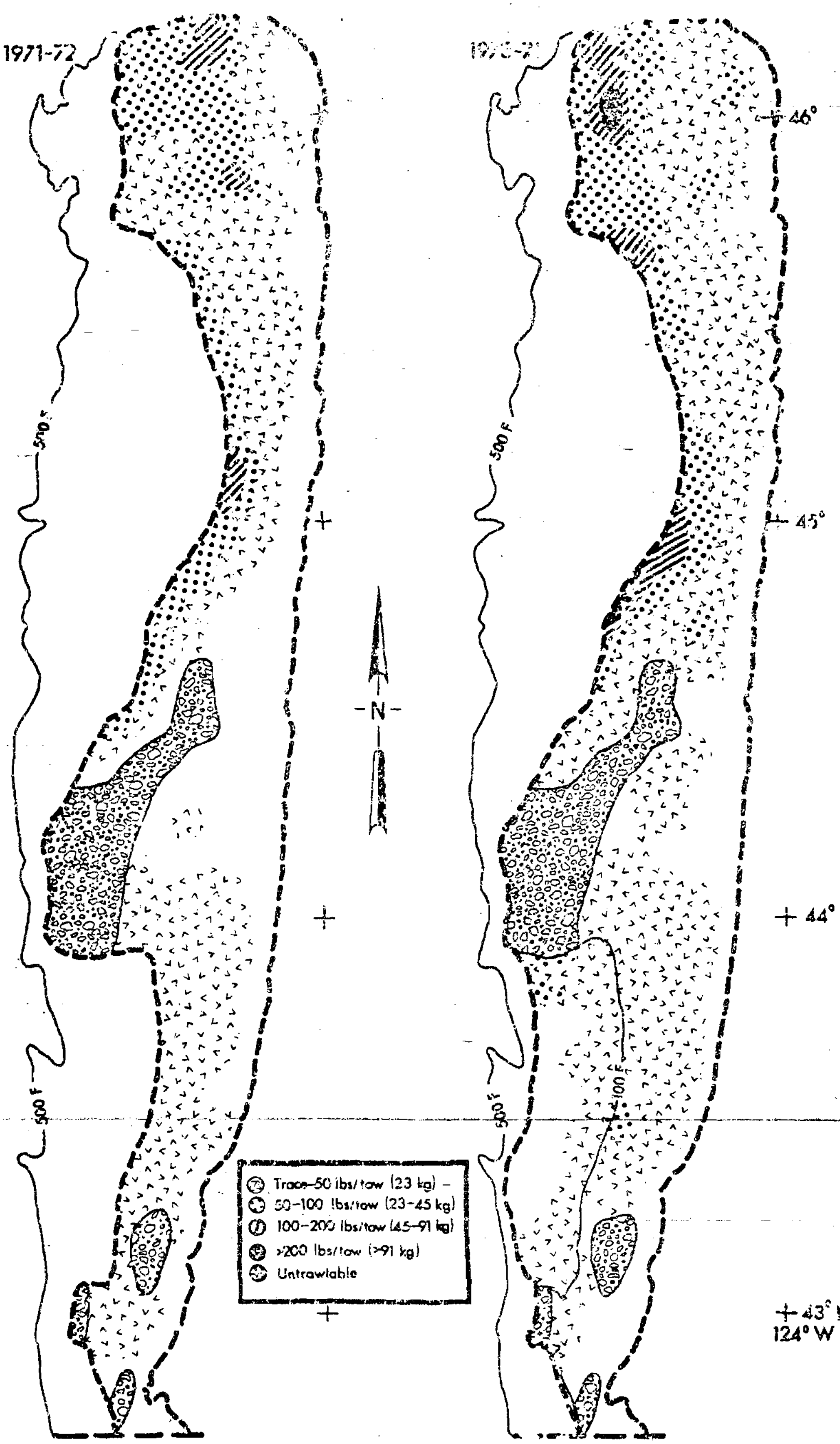

Figure 7. Distribution and relative abundance (weight) of arrowtooth flounder in September 1971-72 and 1973-74 off Oregon as determined by groundfish surveys. Heavy broken line is limit of survey.

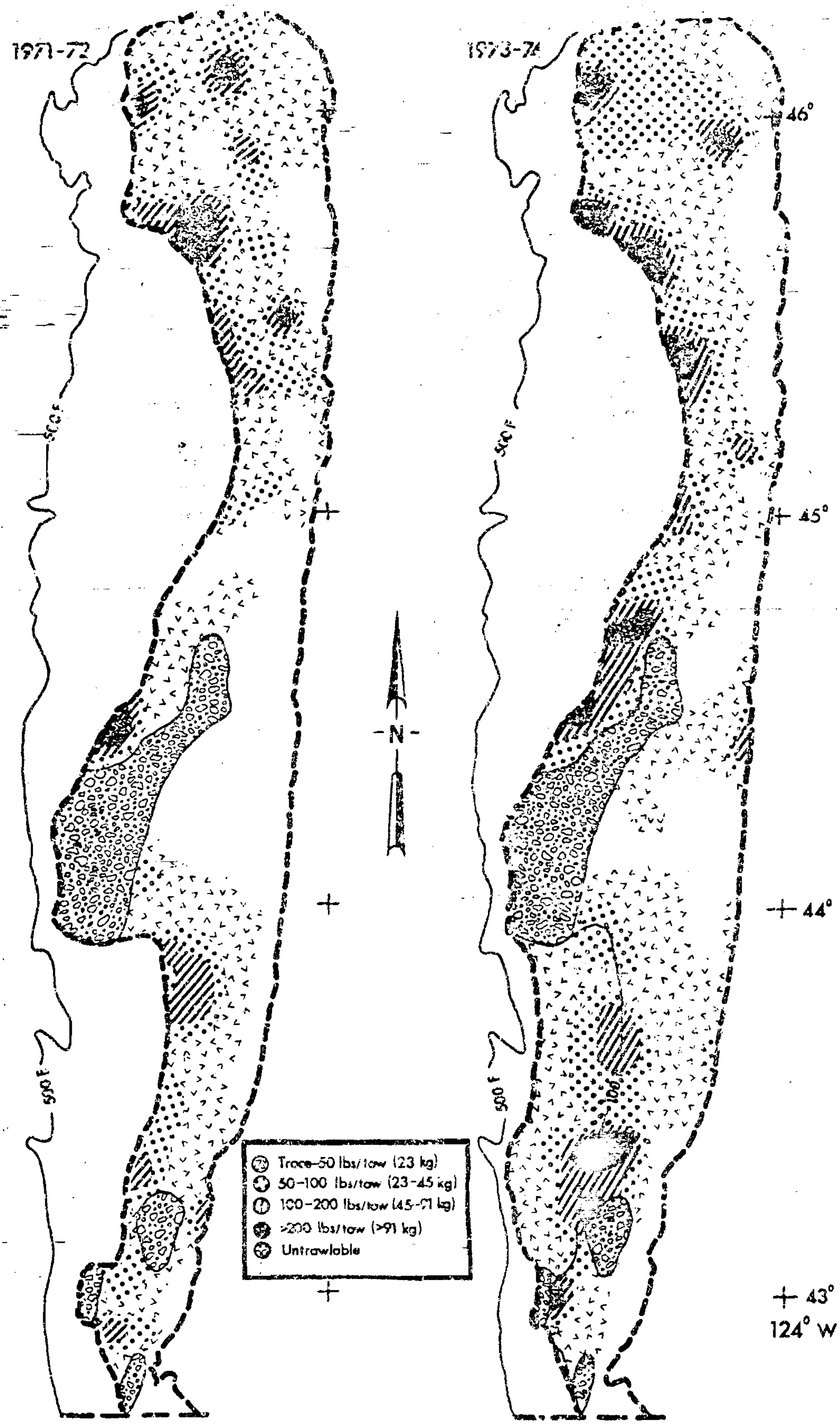

Figure 8. Distribution and relative abundance (weight) of rockfish in September 1971-72 and 1973-74 off Oregon as determined by groundfish surveys. Heavy broken line is limit of survey.

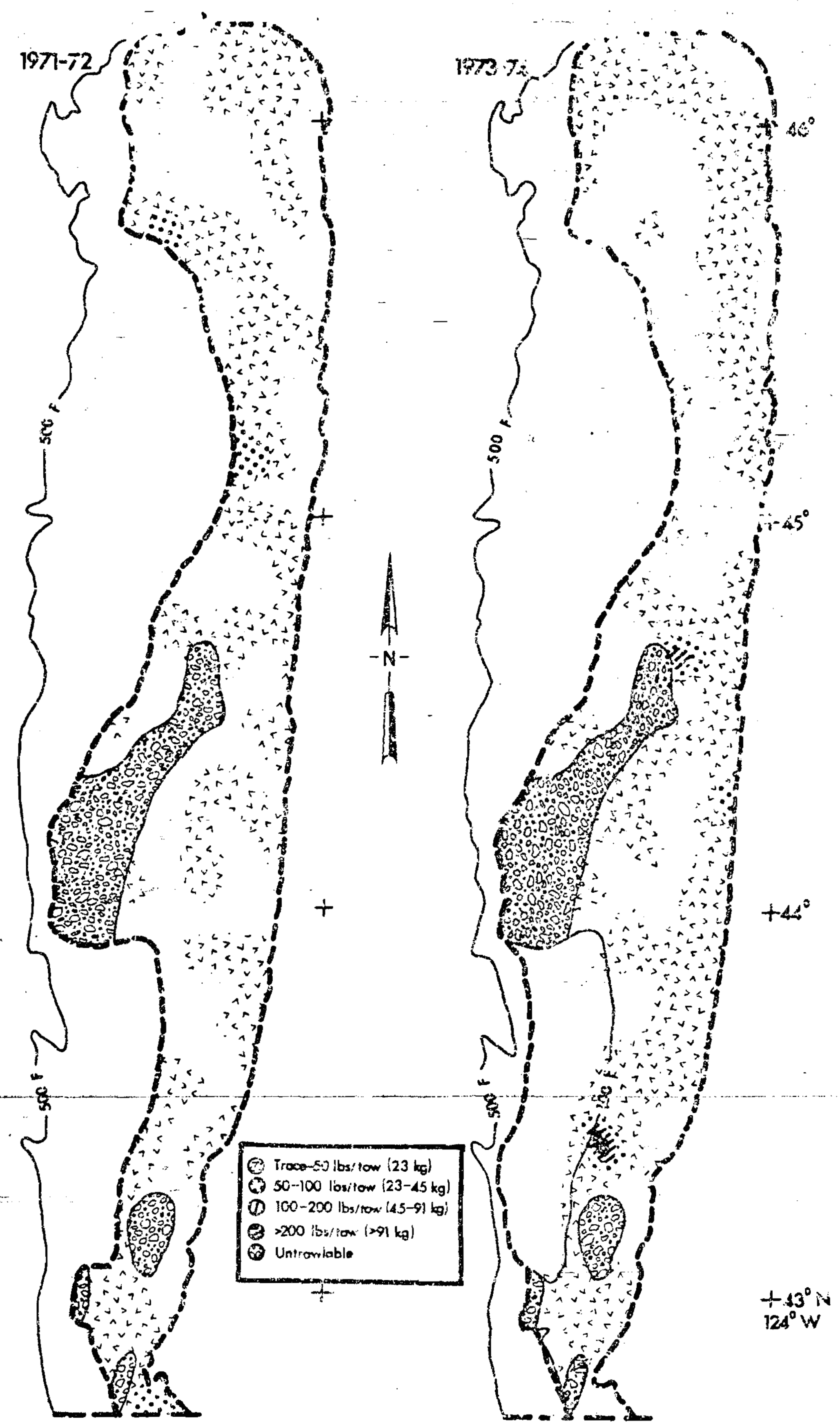

Figure 9. Distribution and relative abundance (weight) of lingcod in September 1971-72 and 1973-74 off Oregon as determined by groundfish surveys. Heavy broken line is limit of survey.

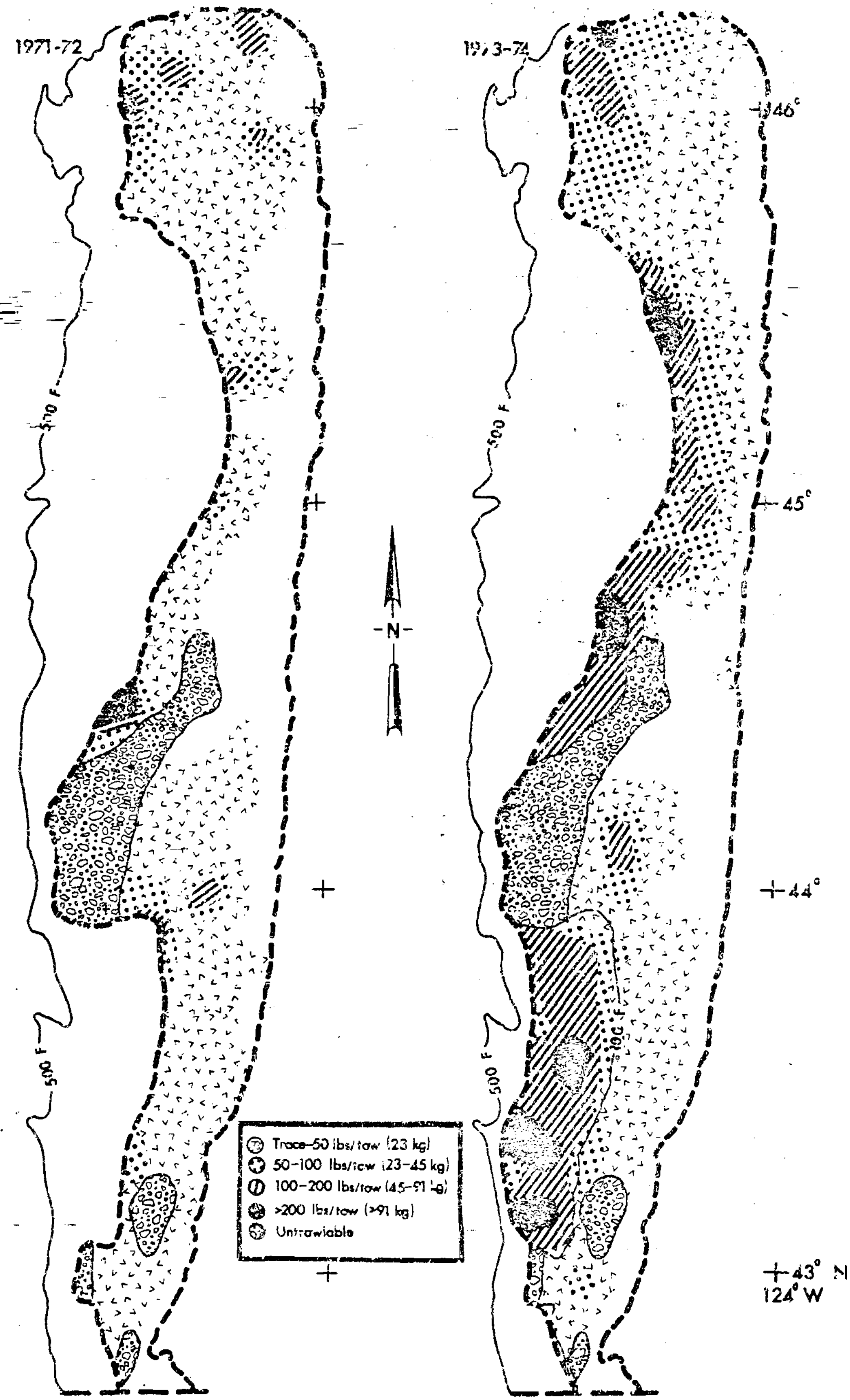

Figure 10. Distribution and relative abundance (weight) of sablefish in September 1971-72 and 1973-74 off Oregon as determined by groundfish surveys. Heavy broken line is limit of survey.

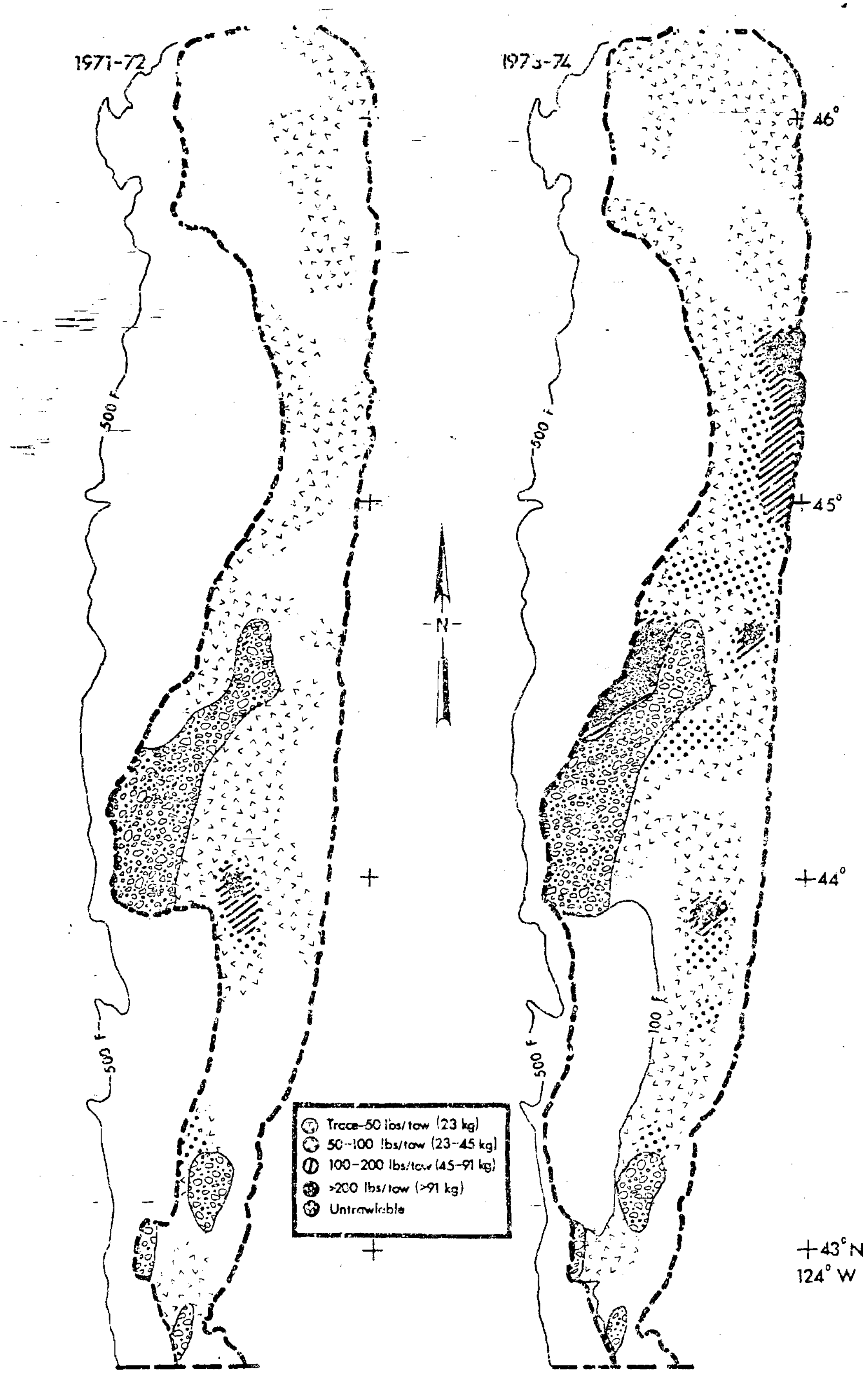

Figure 11. Distribution and relative abundance (weight) of spiny dogfish in September 1971-72 and 1973-74 off Oregon as determined by groundfish surveys. Heavy broken line is limit of survey.

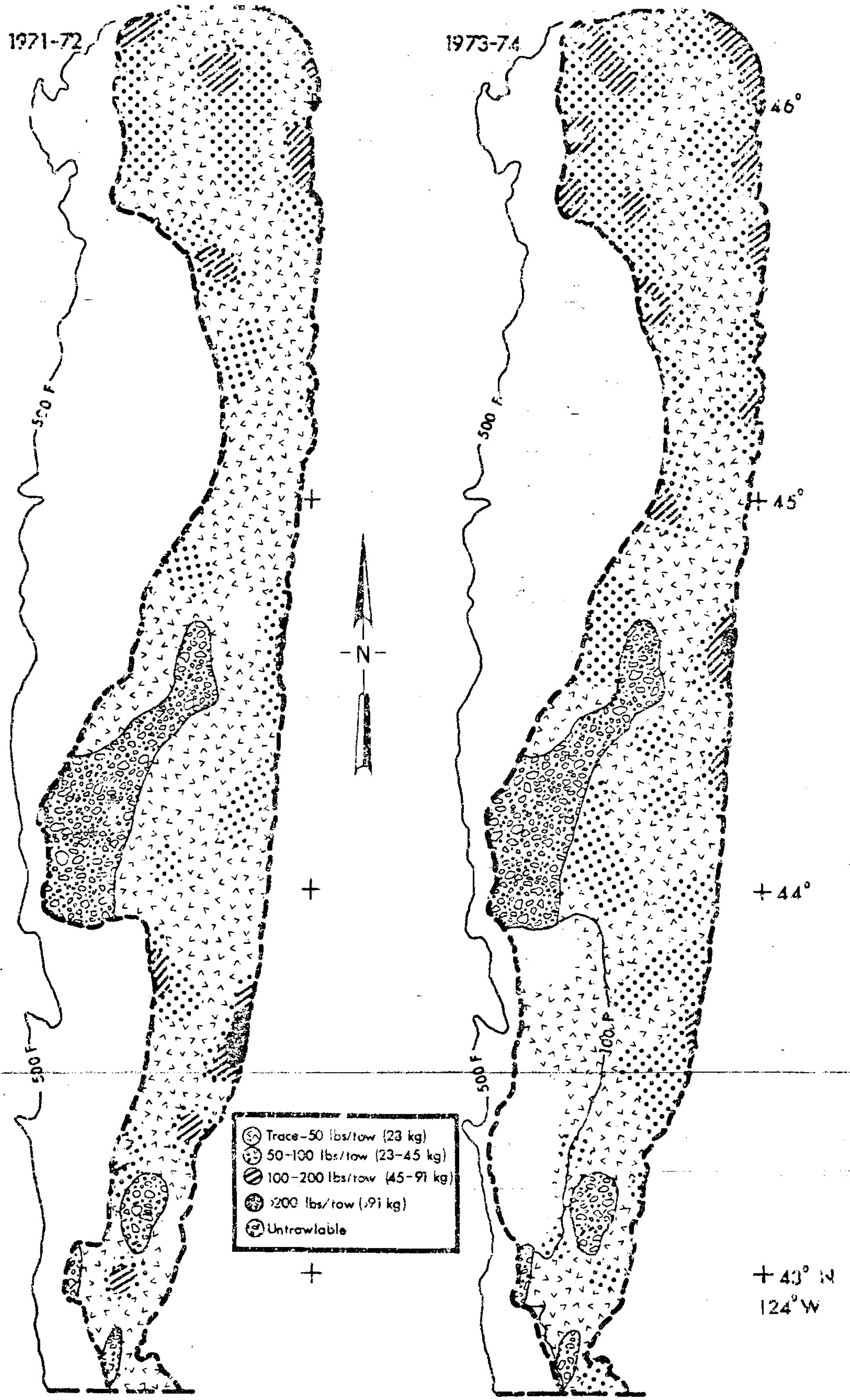

Figure 12. Distribution and relative abundance (weight) of skates in September 1971-72 and 1973-74 off Oregon as determined by groundfish surveys. Heavy broken line is limit of survey.

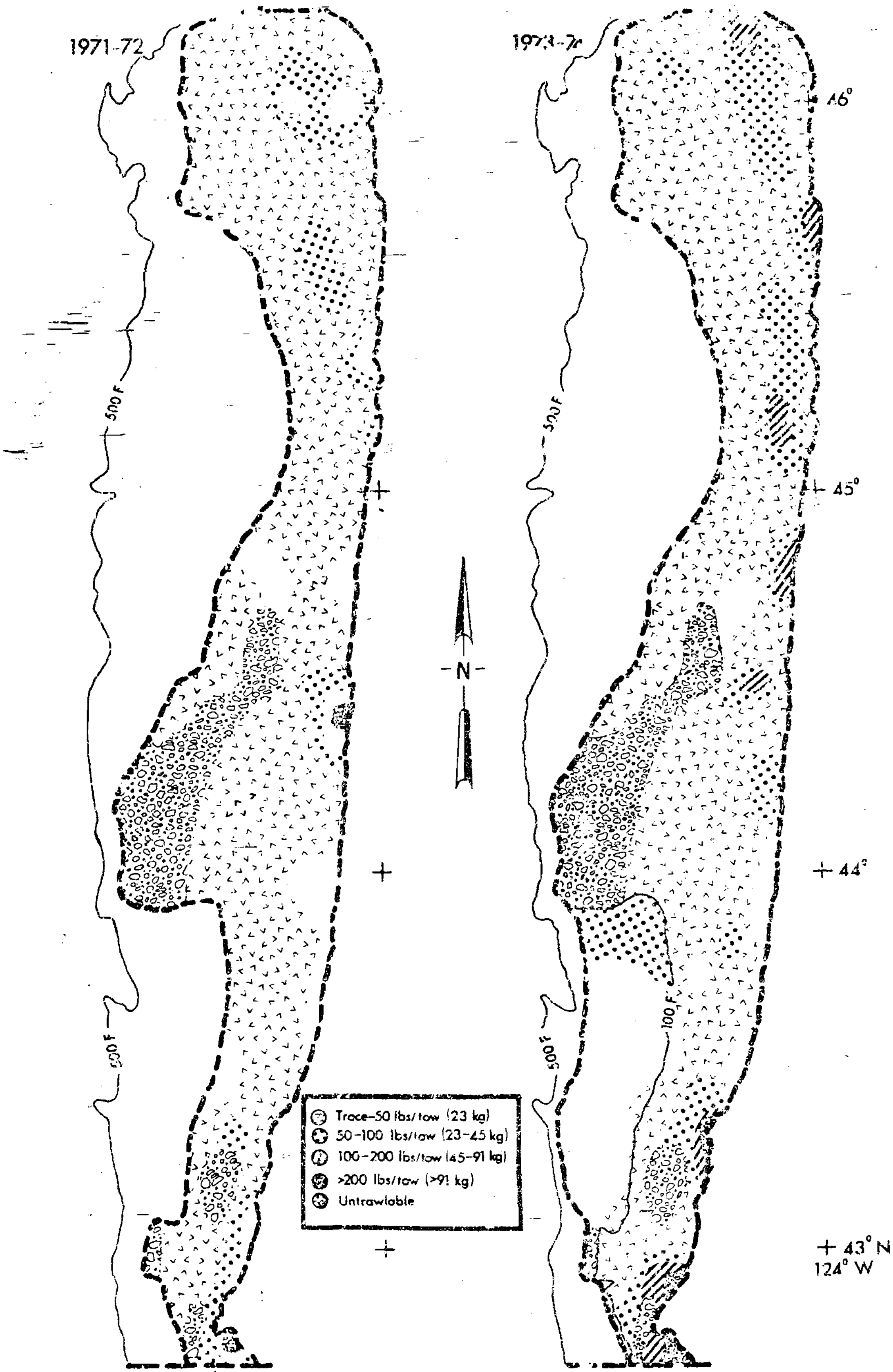

Figure 13. Distribution and relative abundance (weight) of ratfish in September 1971-72 and 1973-74 off Oregon as determined by groundfish surveys. Heavy broken line is limit of survey.

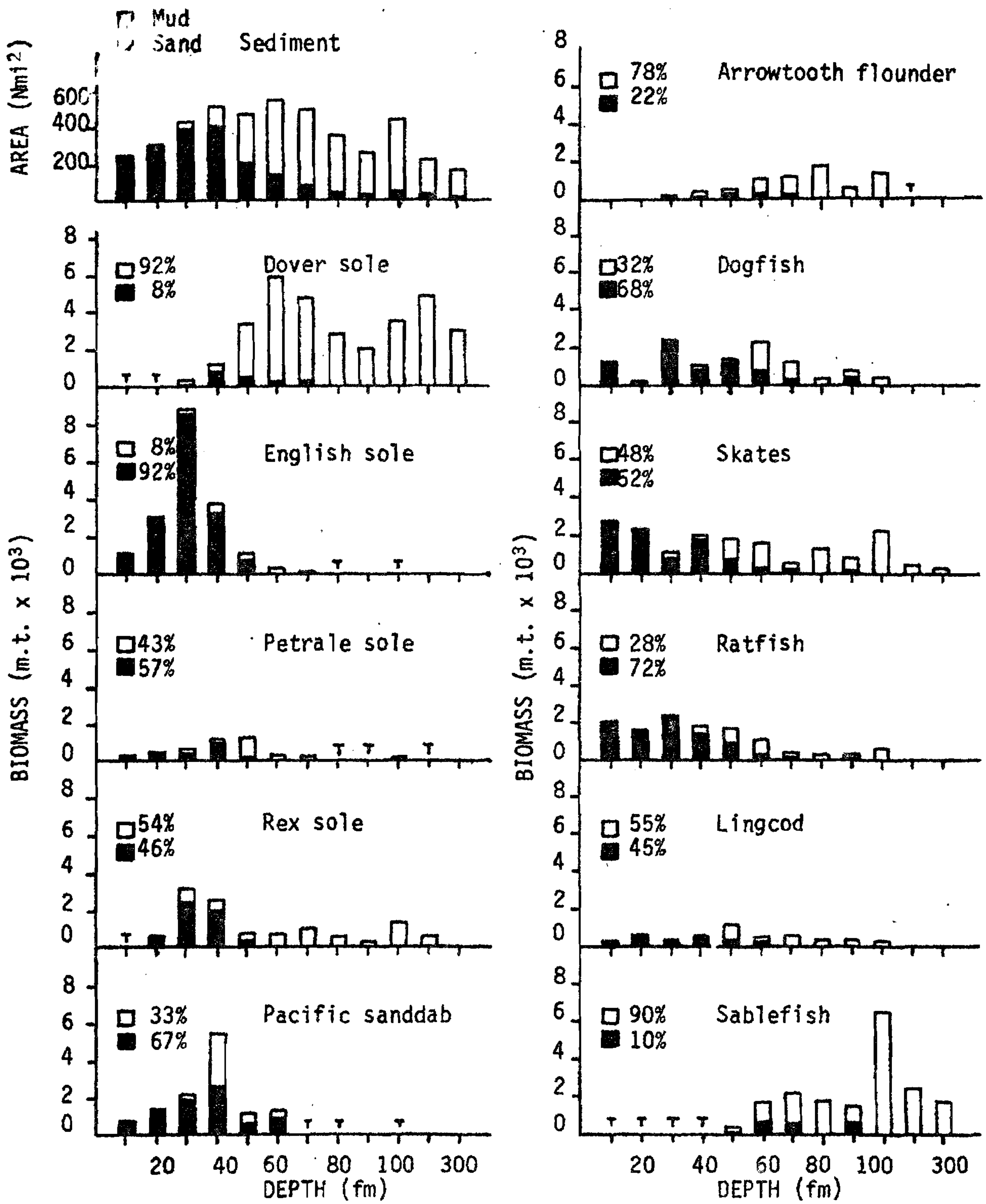

Figure 14. Correlation of abundance of selected species with depth and sediment type within depth 1973-74. Percent shows abundance related to sediment type. Note change in strata at 100 fm. T = <100 m.t.

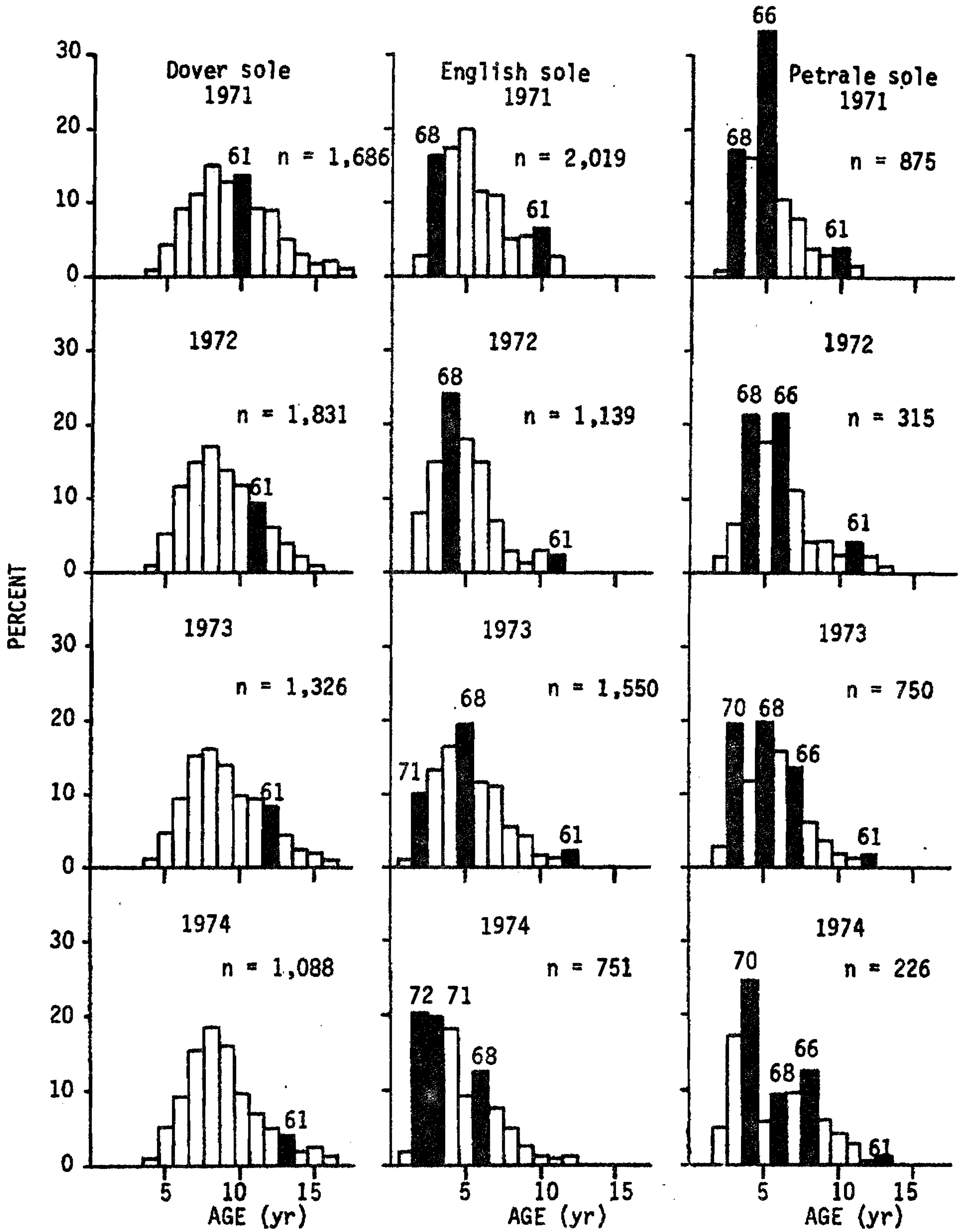

Figure 15. Year class strength (of ten flatfish species), as indicated by relative frequency 1971-1974. Age frequencies of <1 percent are not shown. Data applies only to continental shelf stations.

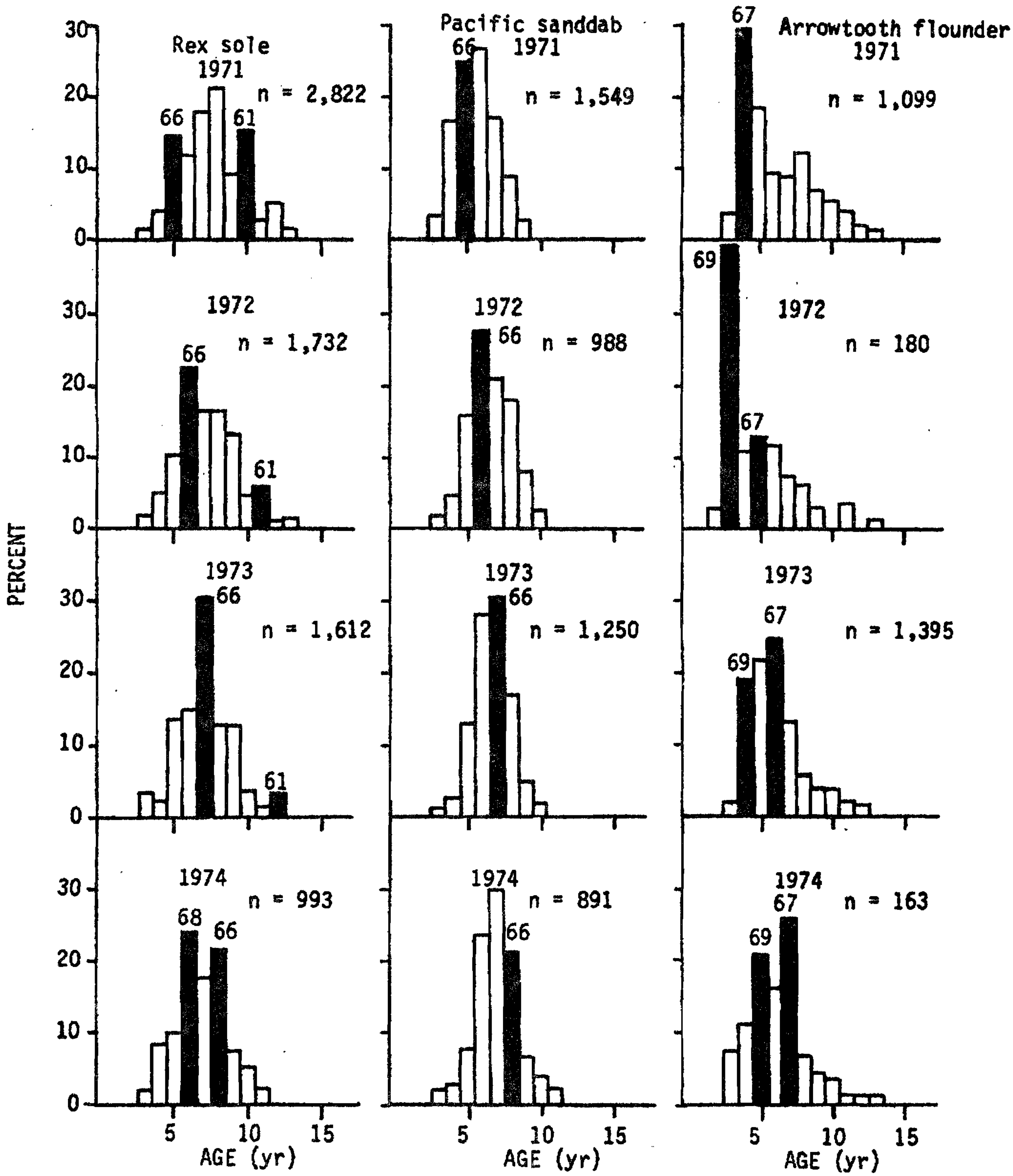

Figure 15. Continued.