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RESULTS OF DOVER SOLE TAGGING IN WATERS OFF NORTHERN CALIFORNIA, 1969 - 1971

by

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and
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ABSTRACT

Three seasonal trawl tagging cruises were undertaken by the California Department of Fish and Game between 1969 and 1971 to determine the distribution, abundance and stock identity of Dover sole (Microstomus pacificus) in the area between Cape Mendocino in northern California and Cape Blanco in southern Oregon. A total of 4730 Dover sole was tagged and released. Through 1984 26% (1235) were recovered. Recapture rates from the tagging cruises were 32% for the spring cruise, 28% for fall, and 15% for winter.

Only 13 of 1235 tags were recaptured outside of PMFC 2A and 1C areas (Cape Blanco to Cape Mendocino). The mean north-south dispersion of tagged Dover sole from point of release was 10.2 nautical miles (nm). The maximum distances moved from tagging sites were 215 nm southward and 211 nm northward. A stock unique for management purposes is indicated by the tag recoveries.

A seasonal migration by female Dover sole to deep-water grounds in fall and winter was demonstrated. Several estimates of total mortality (Z) were generated by regression of recoveries on time-at-liberty for all recoveries and for shallow- and deep-water returns, separately. Values were 0.41, 0.61, and 0.31, respectively.

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INTRODUCTION

Dover sole (Microstomus pacificus) has been a principal component in the northern California trawl fishery landings since the 1940's. Landings between 1960 and 1984 averaged 4475 metric tons (mt) in the Eureka-Crescent City area (PMFC Area 1C) (Figure 1) and comprised 63% of the state-wide total. Annual landings from this area remained relatively stable until 1969 when the catch increased sharply (Figure 2). Coincident with this increase was a shift in the fishery to a greater reliance on deep-water stocks (Figure 3). Between 1969 and 1984 an annual average of 5489 mt of Dover sole was landed with a range of 4012 to 7039 mt (Table 1).

Five trawl tagging cruises were undertaken by the California Department of Fish and Game during the period from 1969 to 1971 with the goal of determining the distribution, abundance, and stock identity of Dover sole in the area between Cape Mendocino in northern California and Cape Blanco in southern Oregon. Trawling stations were selected at random along seven transects from Cape Mendocino to Cape Blanco from shore to 1000 fms. Time limitation and inclement weather reduced the area covered by the surveys to four transects between Cape Mendocino and Pt. St. George and produced only three significant cruises. This report includes the results from spring (May) and fall (September) cruises in 1969 and a winter (February) cruise in 1971.

MATERIALS AND METHODS

Vessel and Transects

During 1969 and 1971 a total of 4,730 Dover sole was tagged and released over three bottom trawl cruises aboard the 30.5-m (100-ft) research vessel N.B. SCOFIELD. Trawling was conducted using a 400-mesh eastern trawl constructed of 1/2-in. webbing; a netliner constructed of 1/2-in. mesh was laced into the codend. The net was fished with steel 'V' doors and 45.7 m (25 fm) mud lines. Tows were of 10-30 min in duration.

Trawling stations were located along four transects at 20-min latitude lines between Cape Mendocino and Pt. St. George. The first station on each transect line was randomly selected between 9.1 and 45.7 m (5 and 25 fms) with the remaining stations spaced at 3-nm intervals to 1829 m (1000 fms) (Figure 4).

In May 1969, during the spring cruise, 1491 fish were tagged and released. Of this total 47% were from shallow-water trawls (0 - 199 fms). In September 1969, 2186 Dover sole were tagged and released with 56% of these from less than 200-fm trawls. The winter cruise was delayed until February 1971 when 1053 tagged Dover sole were released with only 1% coming from shallow water. Haul depths varied from 28 fms to 570 fms, with tagged releases ranging from zero to 549 per haul (Tables 2, 3, and 4).

Tagging Procedure

Dover sole captured during short 10- to 30-min tows were brought aboard and immediately placed into two portable tubs

which contained circulating sea water. Each fish was quickly examined for general condition and size. Only fish which were fully vulnerable to the commercial fishery, over 356 mm total length (TL) (14 in.), were dipped from the holding tubs, measured (to the nearest mm), tagged, and released while the vessel remained over the haul station.

All releases were tagged with a yellow vinyl-plastic spaghetti tag 27.9 cm (11 in.) in length and 1.8 mm in diameter. Each tag had an identity number. The tags were applied to the fish at mid-body, through the dorsal musculature about 1.9 cm (3/4 in.) below the base of the dorsal fin. A detachable stainless steel needle, which had been sterilized in alcohol, was used to thread the tag through the fish. The loose ends of the tag were secured by means of an overhand knot. Peterson disk tags were attached to 742 of the releases to estimate tag shedding rates. A Peterson disk tag consists of two laminated plastic disks, one on each side of the fish connected by a wire pin inserted through the dorsal musculature. One of the disks was imprinted with a serial number.

Onboard Biological Sampling

No attempt was made to assess short-term tagging mortality. However, the general condition of the tagged fish at the time of release was ranked and recorded based on a scale of 1 to 4 (1-moribund, 2-poor, 3-fair, 4-good). The occurrence of a jellied flesh condition, indicative of abnormally high moisture content (Patashnik and Groninger 1963), was also noted.

A portion of the Dover catch was retained for age-length-weight and shrinkage studies. The fish that were sampled included those brought aboard dead or injured and those less than 356 mm TL.

Recovery Procedure

Department biologists personally informed trawl fishermen and processors of the tagging program to stimulate interest and enlist cooperation. Fishermen were asked to return tagged fish with information on date, location (Loran or specific coastal landmarks), and depth of capture. A $1.00 reward and the release history of the tagged fish was provided to those returning tags. For each tagged fish returned, biological data were collected for sex, age (otoliths), gonad condition, flesh condition (jellied or non-jellied) total length (mm) and weight (kg).

Distance and direction traveled were calculated by plotting the release and return hauls on a nautical chart. The distance moved (in nautical miles) was determined from the midpoint of the release haul to the midpoint of the recovery haul. Direction of movement was categorized as "north", "south", "inshore", "off-shore", and "no movement". If the hauls overlapped at any point, the recovery was characterized as "no movement". Results were assigned to 10-min rectangular catch blocks, approximately 10 nm square (Clark 1935), to identify catch location (Figure 5).

The unsymmetrical depth contours off the coast made depth change a more accurate description of inshore-offshore movement than did an estimate of miles traveled. Tag and recovery depths were rounded off to the nearest fathom.

Dispersion from tagging point was analyzed as north/south or longitudinal dispersion from tagging point, and as bathymetric migration, especially as related to sex and time of year.

RESULTS

Tag Recovery Rates

There were 4730 Dover sole tagged and released over all three experiments with a recovery rate of 26% (1,235) through 1984. Recapturates for the three cruises were 32% for spring, 28% for fall, and 15% for the winter cruise.

Recovery rates for the four transect areas off Crescent City, Redding Rock, Trinidad, and the Eel River varied as 25% (301 out of 1206 tagged and released), 46% (201 out of 440), 21% (520 out of 2424) and 32% (213 out of 660), respectively. The highest recovery rate was for the lowest number of releases and vice versa (Table 5).

Recovery by Sex and Length

Males comprised 30% of measured recoveries over all experiments, females 69% and unknowns made up 1% (Table 6). The proportion of males in total recoveries varied by tagging cruise from a low of 22% for the spring cruise, to a high of 42% for the deeper water winter cruise (Tables 7 - 9). The proportion of males in total recoveries varied by tagging transect from a low of 7% for the Redding Rock transect to a high of 42% for the adjacent Trinidad transect.

Mean length at recovery by sex was relatively constant over cruises, with males and females tagged in the spring cruise exhibiting the highest average recovery length, though the modal interval of the winter cruise recoveries represents a one-interval increase for both sexes over the modes of the other cruises (Figures 6 and 7).

Mean length for males was 388 mm (SD 26 mm), and 425 mm (SD 42 mm) for females. Length frequency distributions were relatively unimodal, with the 360- to 379-mm interval representing the modal class for males, and the highest frequency of females represented in the 400- to 419-mm interval. Mean length at recovery was relatively constant; the Redding Rock tagging transect exhibited the highest average recovery length for both sexes (Tables 10 and 11).

Length at Release and Recapture

Lengths were recorded for 4711 released fish and 1223 recaptures. Mean length at tagging for all measured releases was 408 mm (SD 38 mm). Mean length at tagging for recaptures was 411 mm (SD 40 mm) (Table 12). Recovery rates by tagging length interval are uniform through the majority of intervals, with an overall rate of 26% (Figure 8). The length frequency distributions of releases and recoveries are almost identical with the 380- to 399-mm interval representing the greatest percentage of recoveries (Figure 9).

Recovery rates by cruise and tagging-length interval differed significantly as the winter cruise exhibited the lowest recovery rate (Table 13). Mean lengths at tagging for released Dover sole

ranged from 400 mm for the fall 1969 experiment to 421 mm for the spring cruise. Length frequency distributions of tagged and recovered fish for the three cruises are approximately unimodal, exhibiting a positive skewness indicative of gear selectivity (Figure 10).

Reliability of recovery lengths is affected by undocumented post-capture handling methods. Experiments on sacrificed fish taken during the cruises showed a range of shrinkage for fish frozen (or iced) after capture of 0 mm to 22 mm, with a mean of 5 mm. Harry (1956) concluded that a correction factor of 1.0 cm should be added to the observed length of iced Dover sole.

Recovery Rate by Condition at Tagging

The majority of tagged fish were in good condition (3355) and recovery rate was highest (32%) for fish rated in this category (Table 14). None of the 26 fish released in a moribund condition were recovered.

Jellied Dover sole represented 17% of the total released. Recovery rate for tagged jellied fish was only 10% over all cruises, compared to 26% for all fish.

Fish flesh quality is related to depth of capture as most of the Dover sole tagged in the jellied condition were captured at deep depths (Table 15). Often entire tows consisted of jellied fish which were judged to be in fair or good condition, despite their jellied flesh condition. Only 9 of the 785 tagged as jellied were from shallow-water tows; however, 11% of jellied

recoveries were made in less than 200 fms. Most (98%) of the fish considered to be in poor or moribund condition were deep-water fish.

Recovery Rate by Time-at-Liberty

Data from all experiments were used to examine recovery proportions by time-at-liberty over a 6-yr period (1970-1975). Depending on the analysis, one year at liberty is equivalent to either 365 d following release or the calendar year following tagging. The proportions of 862 tags recaptured, beginning in 1970, the year following release from the spring and fall cruises in 1969, are 43.7, 23.5, 13.0, 7.0, 6.0, and 1.4%, respectively. The 156 recaptures for the period 1972-1976 from the winter 1971 cruise had annual proportions as follows; 33.9, 19.5, 12.7, 13.6, and 5.1%. Data from all cruises were combined and the proportions are 42.6, 23.1, 13.0, 7.8, 5.9, and 1.8%, respectively.

The Kruskal Wallis one-way ANOVA non-parametric statistical test demonstrates a significant difference between cruises with regard to time-at-liberty for recoveries ($x2 = 295724$, $p < 0.01$), with the winter cruise tags exhibiting the greatest overall time-at-liberty (Table 16).

The longest times-at-liberty, through the end of 1984, for individual tags from each cruise are as follows:

CRUISE	TIME AT LIBERTY
Spring 1969	13 years 270 days
Fall 1969	10 years 265 days
Winter 1971	15 years 174 days.

Returns by Recovery Quarter

Of the 1235 recoveries, 552 (44.7%) occurred in the summer quarter (July, August and September), 453 were captured in the spring (April, May and June), and 159 (12.9%) were fall recoveries (October, November, December), with the remaining 71 (5.7%) winter recoveries. This trend parallels landing patterns. The heaviest fishing pressure and highest landings are consistently in the spring and summer quarter months; however, a chi-square test of frequency of recoveries by recovery quarter and recovery year shows these factors to be significantly interdependent ($x2 = 164.6912$, $p < 0.01$) (Table 17).

North-South Movement

Movement of Dover sole out of the study area was minimal. Only 13 of 1235 returned tags were from fish recaptured outside of the PMFC 2A and 1C areas (Cape Blanco to Cape Mendocino). The mean north/south dispersion of tagged Dover sole from point of release was 10.2 nm. Analysis of the recoveries shows that well over 50% did not move from point of tagging (Figure 11). The maximum distance moved by a tagged Dover sole was 215 nm southward from release point. The maximum northward movement was 211 nm. Tag returns by CDFG catch block reveal a "fingerprint" of longitudinal dispersion of tagged releases from east-west transect lines formed by the catch blocks (Figure 5). A comparison of the dispersal patterns of tags between block lines shows that the most northerly tag (block line 108) and southerly tag (block line 210) patterns are skewed to the south and north, respectively. There

seems to be no definite pattern to the interior block lines (Figures 12 and 13). A review of longitudinal movement from individual tagging block for each cruise transect parallels that of the tagging block lines. The most northerly (Crescent City) and southerly (Eel River) transect blocks indicate little movement across study area boundaries (Figures 14 and 15).

A linear regression of longitudinal dispersion on years at liberty shows no strong relationship of linearity ($r2 = 0.01$), for tags at liberty for at least 1 yr. Tags recovered between 1 and 2 yr at liberty averaged 9.1 nm of dispersion, compared to 6.4 nm for tags recovered within the first 90 d after release (Table 18). Almost half of the tags recovered after 5 or more years at large (36 out of 80) showed no movement.

A Kruskal Wallis test comparing longitudinal dispersion of Dover sole from tagging point by sex shows a highly significant difference between the sexes ($x2=1020609$, $p < 0.000$), with males ranking higher (Table 19).

Of those fish that moved north, males tended to move an average of almost 6 nm further northward than females from point of tagging, while females moved, on average, slightly further south than their male counterparts (23.1 nm to 19.6 nm) (Table 20). However, within respective sexes, a higher percentage of males moved south than did females (36.7 vs. 22.7), and a greater percentage of females migrated north as compared to males (22.0 to 14.5) (Table 21).

A statistical comparison of longitudinal dispersion of Dover sole by ranks amcng tagging cruises shows a highly significant difference ($x2=-194233$, $p < 0.000$), with the winter cruise ranked highest. The mean distance travelled between release and recapture point was 17.6 nm for those tagged on the winter cruise compared to the overall mean of 10.2 nm (Table 22).

Longitudinal dispersion by tagging cruise reveals some interesting anomalies. The percentage of a given cruise's recoveries that showed no north/south movement decreases from a high of 70% for the spring cruise to a low of 40% for the winter cruise. The proportion of the winter cruise recoveries that moved between 11 and 15 miles was equal to the no movement group (Figure 16).

Longitudinal movement by length groups (length at release) is fairly uniform through the classes with a trend toward less southerly movement with increasing size, possibly since males show a proclivity for southerly movement as demonstrated previously and because males average a shorter total length (Figure 17).

Dispersion Rates

Movement across catch block lines was further analyzed for characteristic dispersion rates. Recoveries by block line were summed according to distance (by 10-nm tag block line increments) from the corresponding original tag block line without regard to direction so that a dispersion rate could be calculated for each tag block line group. Recovered tags were weighted by commercial catches for the corresponding tag block line (tags/100 mt). Analysis was restricted to recoveries of the 1969 tagging cruises and to recoveries in PMFC area 1C for the period 1970 through 1975.

Recovery rate (ln [tags/100mt]) was regressed on longitudinal distance from tagging block line for each of the seven catch block lines. Distance was defined in terms of 10-nm catch block increments. The value of r2 varied from 0.92 for tag block line 132 down to 0.28 for the most southerly tag block line 210.

An annual dispersion rate was calculated after the method of Fargo et al. (1985). The highest annual rate was 2.2% for tag block line 120 (r2 = 0.89), the lowest was 0.6% for tag block line 210 and tag block line 108 (r2 = 0.72). The average annual rate of dispersion was 1.2%. The annual dispersion rate for Dover sole in PMFC area 5D was found to be 0.4% (Fargo et al. 1985).

Bathymetric movement

Dover sole were trawled from depths ranging from 12 to 650 fm. Tags were released from hauls ranging in depth from 20 to 510 fms.

Dover sole recoveries were profiled by recovery depth, sex and tagging cruise (Table 23). Females from the spring and fall cruises tended to be recovered in shallow (0 - 199 fm) depths (77% and 76%, respectively), while males were more evenly scattered through the depths. The winter cruise, where more deep tagging occurred, showed only 18% shallow-depth recoveries.

Recovery data from the three combined cruises reveal that shallow-water female recoveries dominated in the spring and summer quarters. Deep water females dominated in the winter and fall quarters. Over 90% of winter quarter recoveries were deep water males and females, with no males recovered in waters under 200 fm (Figure 18).

Releases in the 1969 cruises were almost evenly split between shallow (0-199 fm) and deep (200-599 fm) water. However, during the 1971 cruise only 1% of tag releases were from shallow water (Table 24). Recapture rate for shallow water tagging was 43% compared to only 14% for deeper water releases.

Recoveries through 1984 in the 0 - 199 fathom range (shallow) are disproportionately high (62.9%) compared to the small amount of landings in shallow water (33%) for the period of greatest recovery (1970 - 1975) (Table 25).

Mortality Rates

Instantaneous rates of total mortality (Z) were calculated based upon tag recoveries for the period 1970 through 1983 for all cruises combined, and for shallow- and deep-water recoveries. Recoveries for the two 1969 cruises and the 1971 cruise were combined, adjusting 1971 cruise recoveries to those of 1969, and dividing by the corresponding recovery year landings (100 mt) using a weighted mean ratio.

Adjusted recoveries (ln[recoveries/100 mt]) were regressed on time-at-liberty (12 yr) and the resulting formula was $y=1.51-0.41x$ ($r^2=0.94$). The estimate of Z (0.41) was obtained from the regression coefficient (Figure 19). Catch data limitations confined the shallow/deep-water analyses to the years 1970 to 1975. The regression formula of adjusted shallow water recoveries on time-at-liberty was $y=3.20-0.61x$ ($r^2=0.97$), with $Z=0.61$ (Figure 20). The deep-water regression formula was $y=1.24-0.31x$ ($r^2=0.95$) with $Z=0.31$ (Figure 21). Using a similar method to estimate Z, Fargo and Westerheim (1985) estimated a total mortality of 0.25 for the Northern Hecate Strait Dover sole fishery.

Catch curve analysis of PMFC area 3A Dover sole landings data revealed a Z value of 0.33 using a value of 0.15 for natural mortality (Demory et al 1984).

Age and Growth

The mean age of Dover sole recaptures using surface-aged otoliths was 10.2 yr, with a modal age of 9 yr. PMFC area 2B Dover sole showed ages from 9.5 to 11.7 yr, with 9 or 10 the most frequent modal age, on scale readings over the years since 1966 (Demory et al. 1984).

An analysis of ln (numbers at age) regressed on age using 1036 surface-aged otolith recoveries, aged 8 to 18, produced a linear relationship ($r2 = 0.94$) and a regression formula of $y=8.96-0.39x$.

Data from 171 Dover sole sacrificed during the cruises were used to plot a length-weight regression curve (Figure 22). Length-weight regression formulas for each sex were calculated. The regression coefficient 'b' for males is 2.70 (SE 0.139), for females 'b' = 3.24 (SE 0.105). Hagerman's (1952) study revealed a value of 2.95 for males and 2.97 for females.

Growth studies on recaptured fish were not performed due to the variability of the shrinkage factor and in many cases an undocumented storage method. Many fish exhibited shorter recapture lengths than release lengths.

Tag Shedding

The tag shedding rate for vinyl-spaghetti-tagged Dover sole was not significant, based upon double tagging with the Peterson disk tag. There were no recoveries consisting of a Peterson tag

without an accompanying spaghetti tag. Recovery rate for double tagged fish was 22% compared to 26% for all fish.

DISCUSSION

Stock Unity

Under ideal conditions a unit stock is defined as a single interbreeding population with homogeneous vital parameters of recruitment, growth and mortality. This condition, however, is rarely demonstrable, either because of scant data or the rarity of isolated interbreeding populations, so that stock must be more or less arbitrarily defined (Royce 1972).

Tagging experiments have been a traditional method of obtaining estimates of stock unity. The distribution of recoveries describes the area occupied by a stock during its migrations despite the fact that tag loss, non-reporting of tags and the distributions of fishing and recovery effort can be sources of bias. The extent to which different groups of tagged fish migrate and comingle has been used to determine unity, realizing that the drastic migrations of strays are less important than the general dispersion pattern of the main body of the stock (Cushing 1975).

Each stock may consist of subpopulations which are genetically self-sustaining. Our tagging study and others show little emigration from, nor movement into, PMFC management area 1C which suggests the existence of a manageable unit stock. Further, the lack of dispersion from tagging point suggests that there may be several subpopulations in the study area. If there is exchange with fishes from other areas, it may occur by displacement as larval drift.

Studies from other areas have shown little immigration into the study area. The deep-water canyons off Cape Mendocino appear to present a formidable barrier to migration; while no such physical obstacle appears to exist to the north, uneven oceanographic conditions (i.e. temperature and salinity) may act as a barrier there (Demory, 1986). Tagging studies off Oregon showed that some movement south out of area 2B does occur. Demory et al. (1984) report that 14% of fish tagged in area 2B were recaptured south of Cape Blanco, though only 2% of fish tagged in summer months were recovered south. This appears to corroborate our study results showing that winter cruise-tagged fish demonstrate the greatest propensity for north/south movement.

Bathymetric Movement and Sexual Maturity

Seasonal offshore movement, especially by female Dover sole, has been shown to be a coastwide phenomenon. Recent tagging studies by Fargo, Westrheim and Stocker (1985) demonstrate that northern Hecate Strait Dover sole move to deep-water wintering grounds. Trawl fishery data analysis by Hagerman (1952) showed a seasonal bathymetric migration off northern California. Similar studies off Oregon (Harry 1956) and Washington (Westrheim and Morgan 1963) also delineate this pattern of offshore migration to spawning grounds. These investigations show that males precede females to deep-water spawning grounds and then linger on after the females leave.

Study recoveries were analyzed by stage of sexual maturity. Fish were categorized using Hagerman's (1952) market and sea sample data. He found that at 320 mm TL about 50% of sampled

males were mature, and at 390 mm, almost all were mature. For females, 50% were mature at 350 mm, with 100% mature at 450 mm. Males and females were grouped by recovery length, according to the above criteria, as either immature (less than 50% mature), partially mature (between 50% and 100% mature), or mature.

Chi-square tests were run to determine the relationship between recovery depth and sexual maturity stage. Interestingly, recovery depth and sexual maturity stage were independent for the fall and winter recovery quarters ($p > 0.50$ for fall and $p > 0.80$ for winter), while sexual maturity stage and recovery depth were highly interdependent for the spring and summer quarters ($p < 0.000$ for both quarters), indicating a depth stratification by sex. The spring and summer quarter recoveries are characterized by having a high proportion of mature and partially mature females from shallow waters (Table 26). Fall and winter quarter recoveries are more uniformly distributed throughout depth ranges (Table 27). An examination of recoveries by depth, recovery quarter and sexual maturity becomes more meaningful in light of original tag and release depth data (Table 28). For example, partially mature females and mature females tagged in shallow depths and recovered in spring and summer quarters were primarily recovered in shallow depths (89%), while 70% of those recovered in fall and winter quarters were recovered in deep water. Conversely, those partially mature and mature females tagged in deep depths were primarily recaptured in deep water in all quarters. The same pattern held for males.

Recoveries were profiled by sex, tagging depth interval and length at time of tagging. Females showed no significant depth stratification for length, while males were highly significant ($p < 0.0000$) with larger males found at deeper depths. The mean male size at 0-99 fm was 383 mm vs. 394 mm at 300-399 fm. For females tagged in the spring cruise, 70% were tagged at 0-99 fm at a mean length of 437 mm, compared with only 10% at greater than 200 fm. Fall cruise females totalled 73% at the shallower depth, but averaged only 406 mm. Winter cruise females predominated (80%) at the 300-399 fm depth and averaged 417 nmm.

Recovery Rates

The proportions of our tags recovered during the first 5 yr following tagging are similar to the percentages recaptured from a 1979 Hecate Strait experiment (Fargo et al., 1985) where the recovery rates were 31.6, 33.7, 14.7, 6.4 and 13.3%, respectively, for the years 1980 - 1984. The 65.5% of total recoveries for 1980-81 compares with 67.3% of our 1969 experiment recoveries made in the years 1970-71, and 53.4% of the 1971 cruise recoveries made in the 2 yr following release (Table 29).

Sampling

All sacrificed fish from selected hauls on each cruise were summarized by length interval and sex (Table 30). Because principal collecting criteria were for fish under recruitment size (356 mm TL), a high proportion of these fish were males (68%). Hagerman (1952) reported male Dover sole grow at a slower rate than females and the maximum size is less. PMFC area 1C and 2A Dover sole market sample data is summarized for the years 1974 to 1983 (Table

31). Average total length of females was consistently greater than males. For example, mean total length for females for the years 1974 and 1975 was 419 mm compared to 388 mm for males.

SUMMARY

1. A total of 4730 Dover sole was tagged and released from three cruises during the spring and fall of 1969 and the winter of 1971. Overall recovery rate was 26% (1235) through 1984.
2. Recovery rates for the three cruises varied as 32% for the spring cruise, 28% for fall, and 15% for winter. Males comprised 30% of measured recoveries, females 69%, and unknowns 1%. Recovery rates for the four transect areas of Crescent City, Redding Rock, Trinidad, and the Eel River were 25%, 46%, 21%, and 32%, respectively.
3. Only 13 of the 1235 tags returned were recaptured outside of the PMFC 2A and 1C areas (Cape Blanco to Cape Mendocino). The mean north-south dispersion from point of release was 10.2 nm. An annual rate of dispersion within the study area was calculated as 1.2%.
4. Bathymetric movement analysis revealed a seasonal migration by females to deep-water spawning grounds during fall and winter quarters. Of females tagged in shallow depths and recovered in fall and winter quarters, 70% were recovered in deep water.
5. Several estimates of total mortality (Z) were generated by regressing recoveries on time-at-liberty for all recoveries and for shallow- and deep-water recoveries, separately. Values were 0.41, 0.61 and 0.31, respectively. Numbers at age analysis for aged recoveries showed a value for Z of 0.39.

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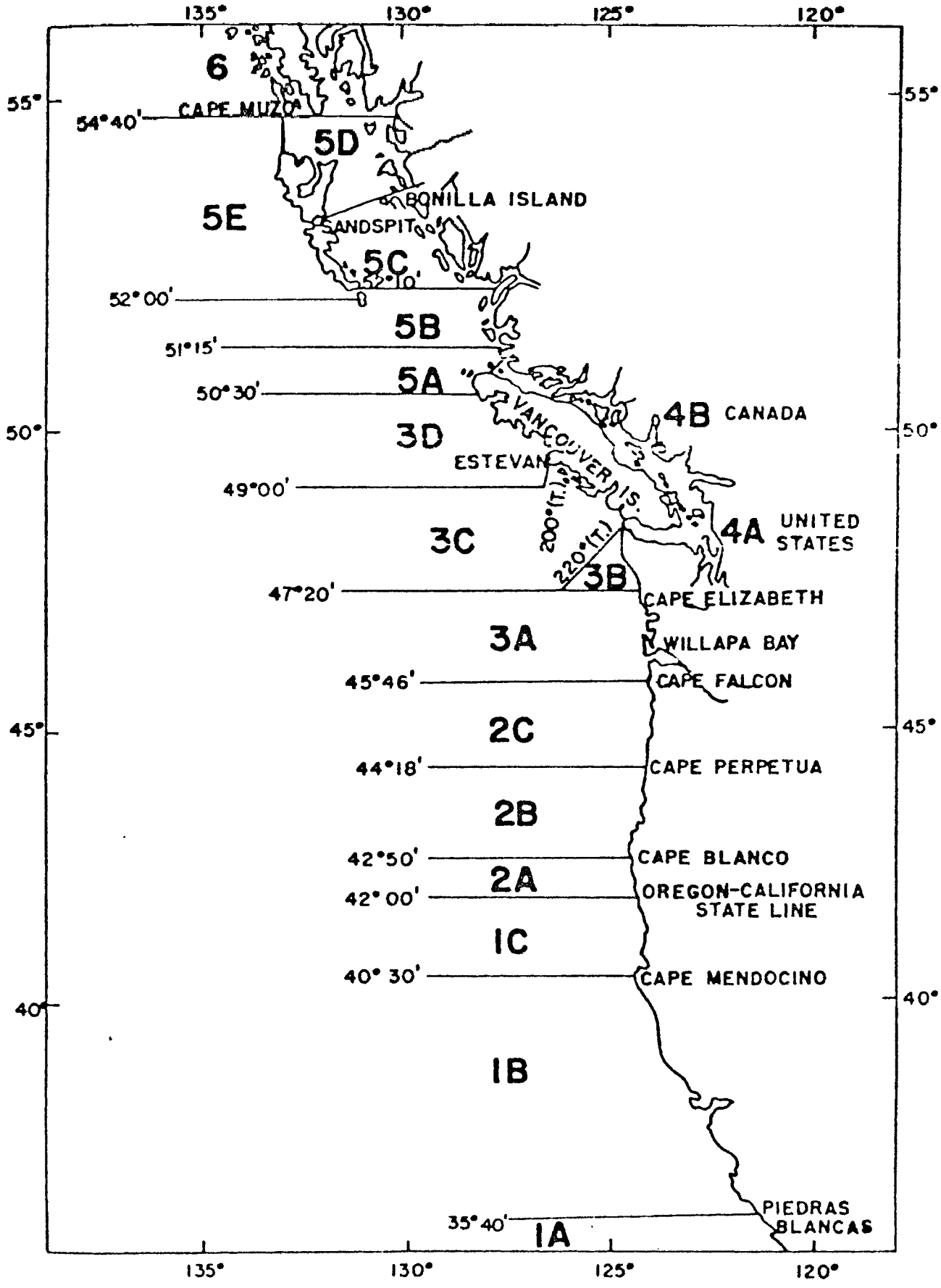


Figure 1. PMFC statistical areas, including Dover sole study site, PMFC area 1C.

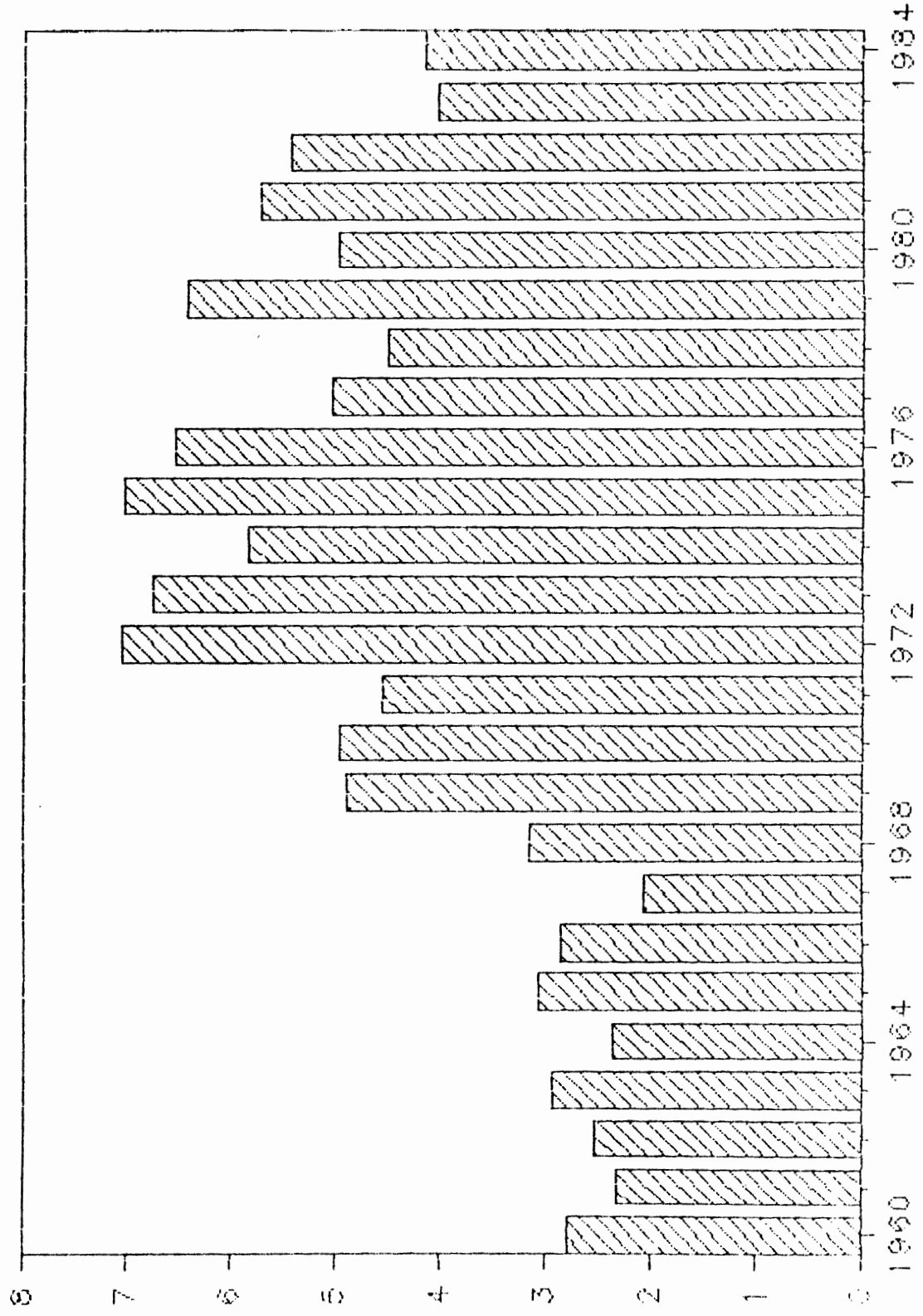


Figure 2. PMFC area 1C (Eureka-Crescent City) landings between 1960 and 1984 (metric tons).

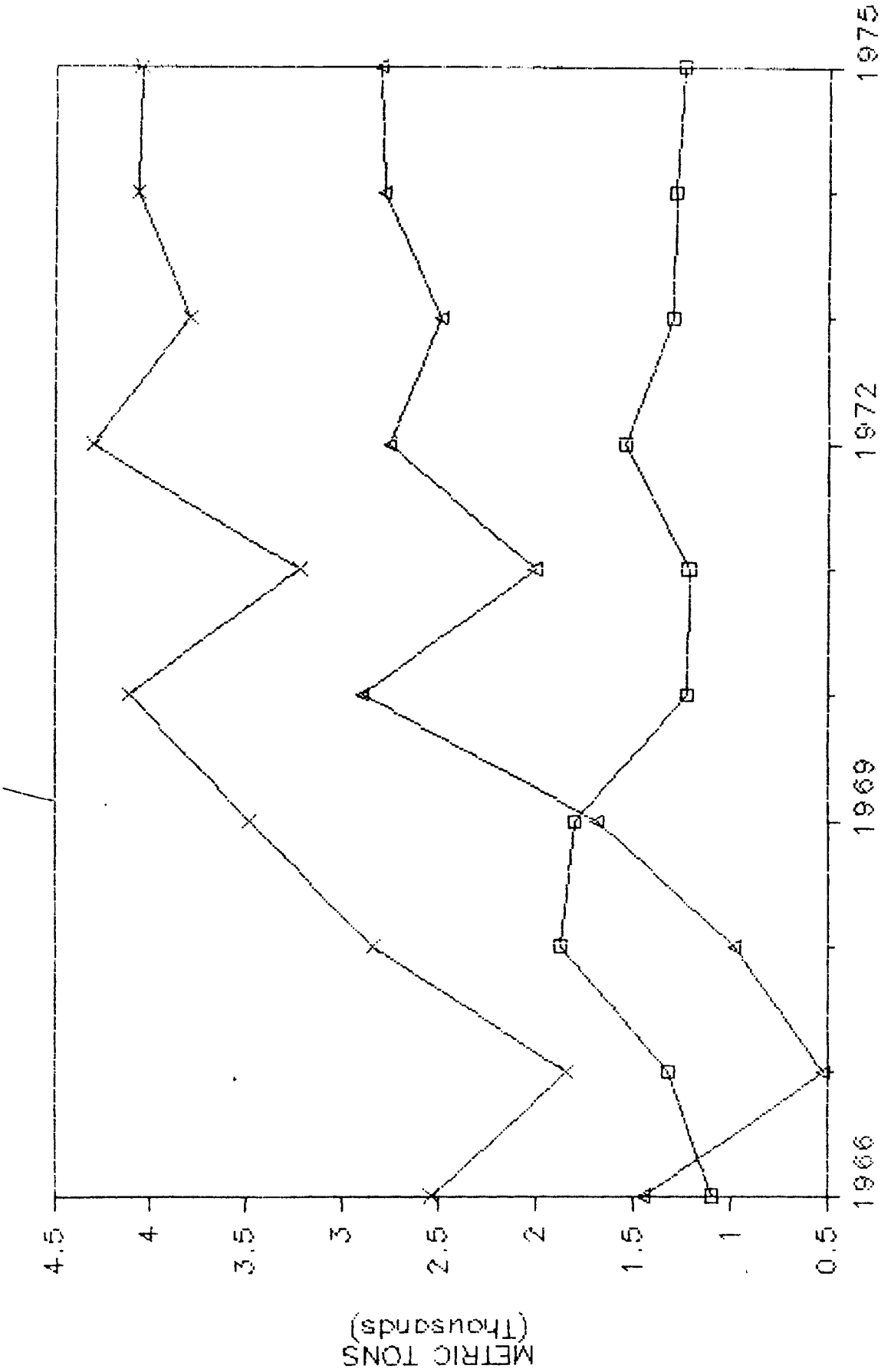


Figure 3. Shallow, deep water and total Dover sole landings (mt) between 1966 and 1975 to Crescent City-Eureka area ports (PMFC area 1C).

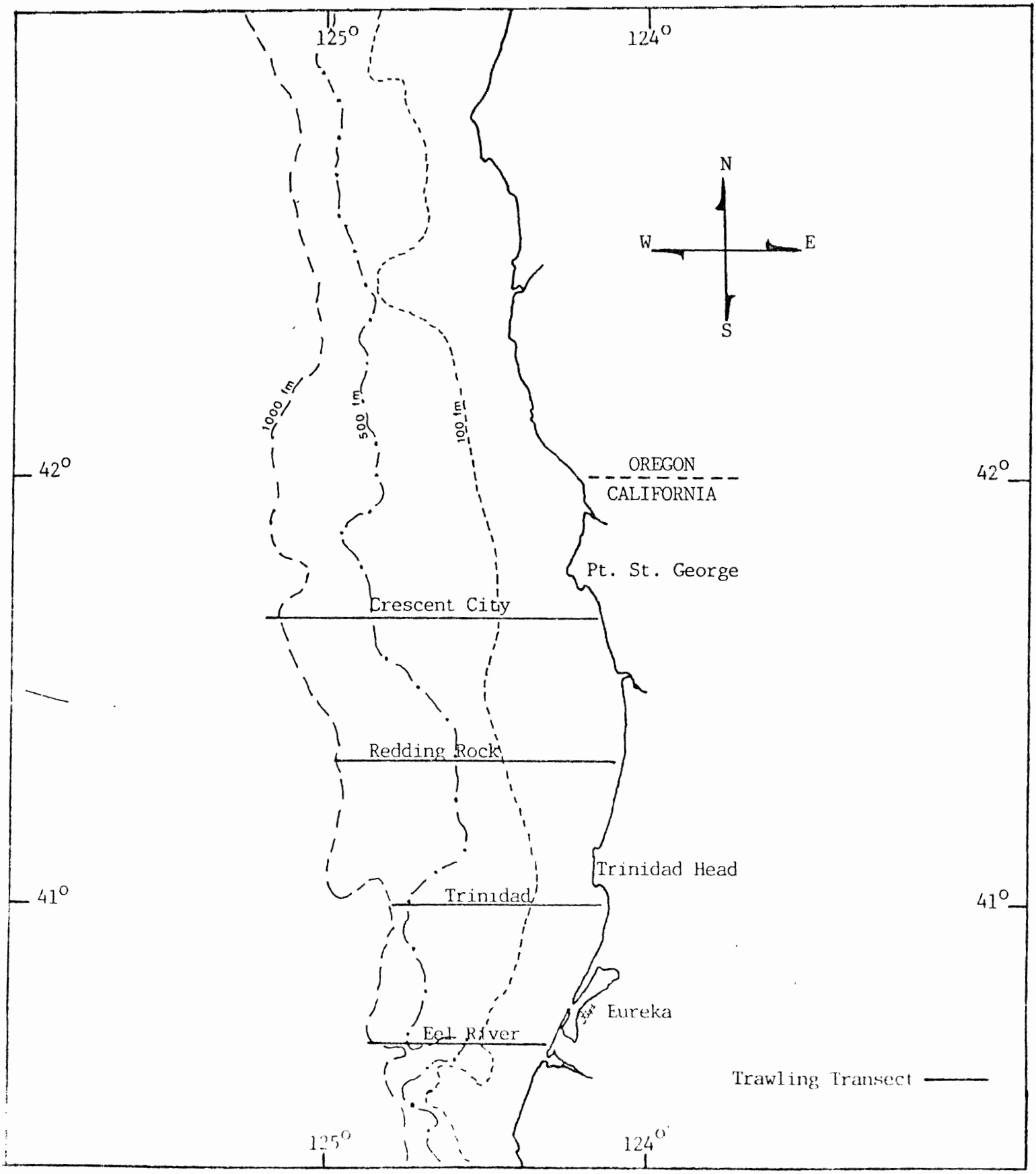


Figure 4. Location of trawling transect lines for Dover sole tagging cruises, 1969-1971.

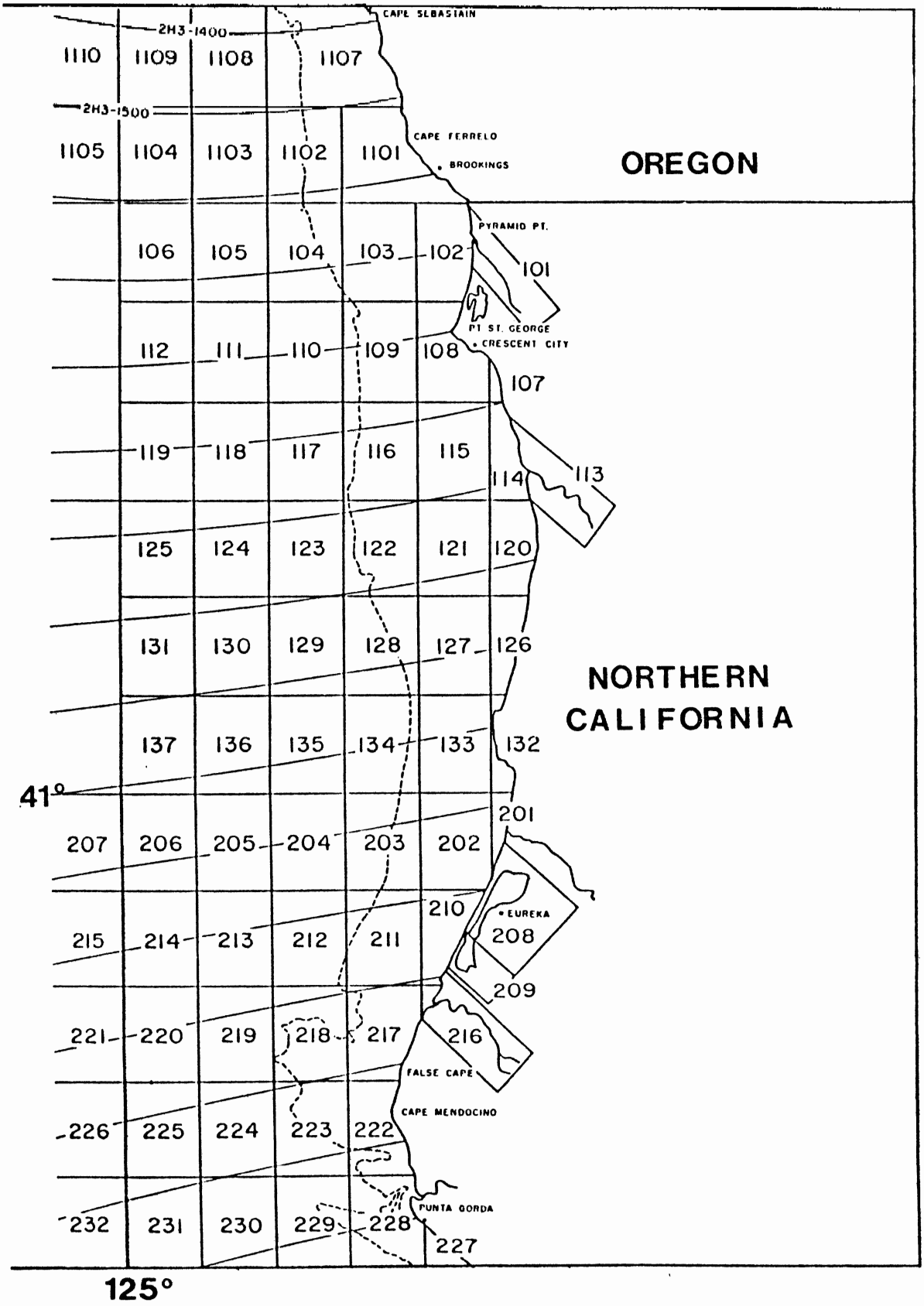


Figure 5. CDFG catch block locations, Cape Sebastian to Punta Gorda.

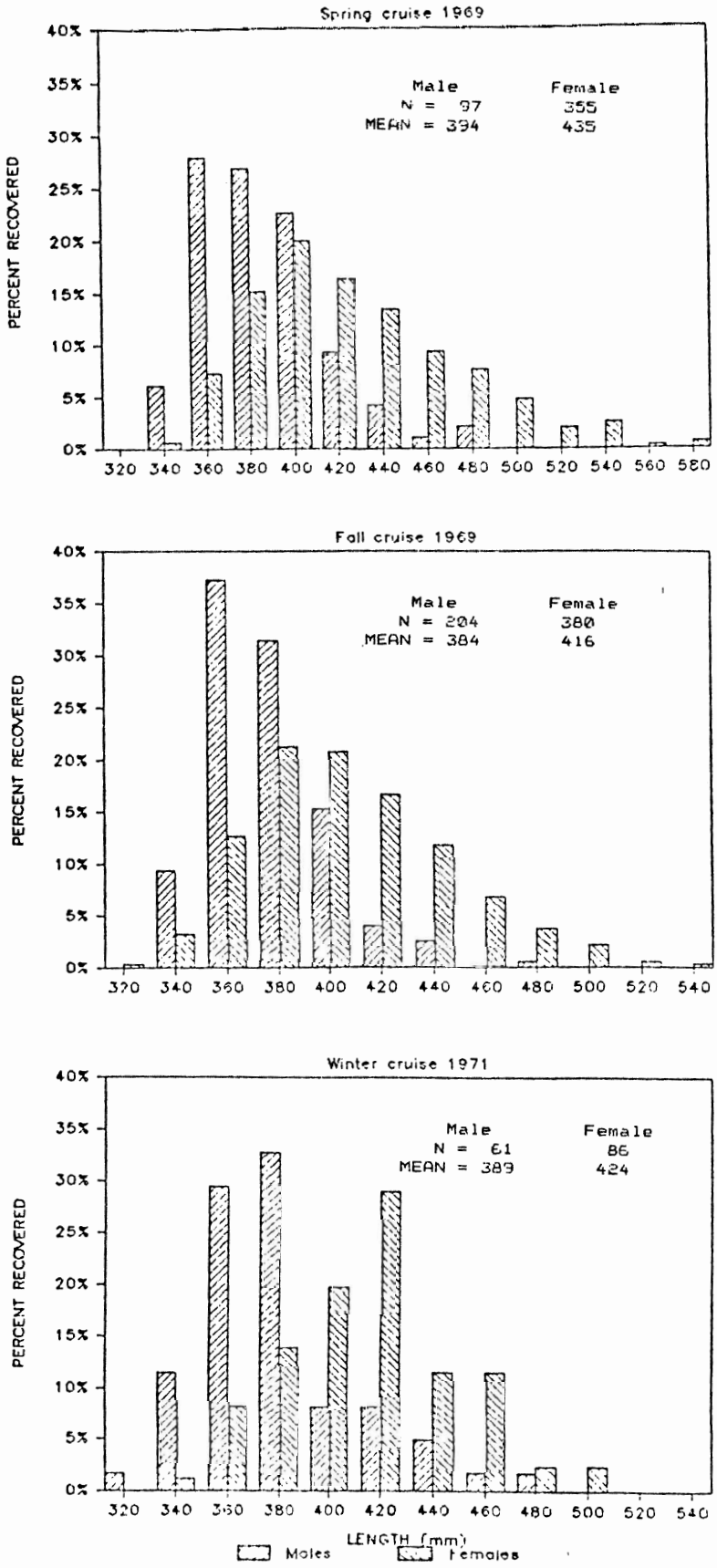


Figure 6. Length frequencies (%) of Dover sole by sex for each cruise.

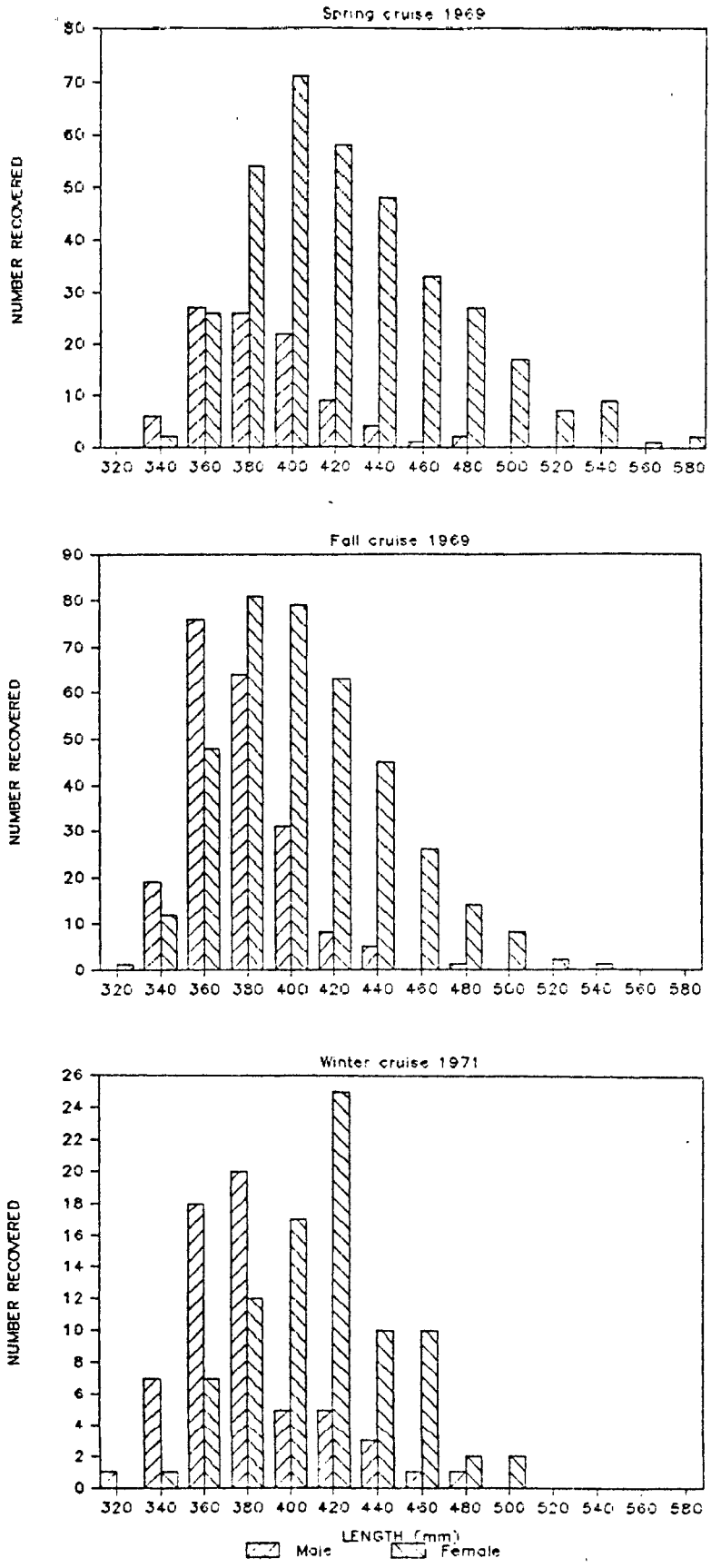


Figure 7. Length frequencies (number) of Dover sole by sex for each cruise.

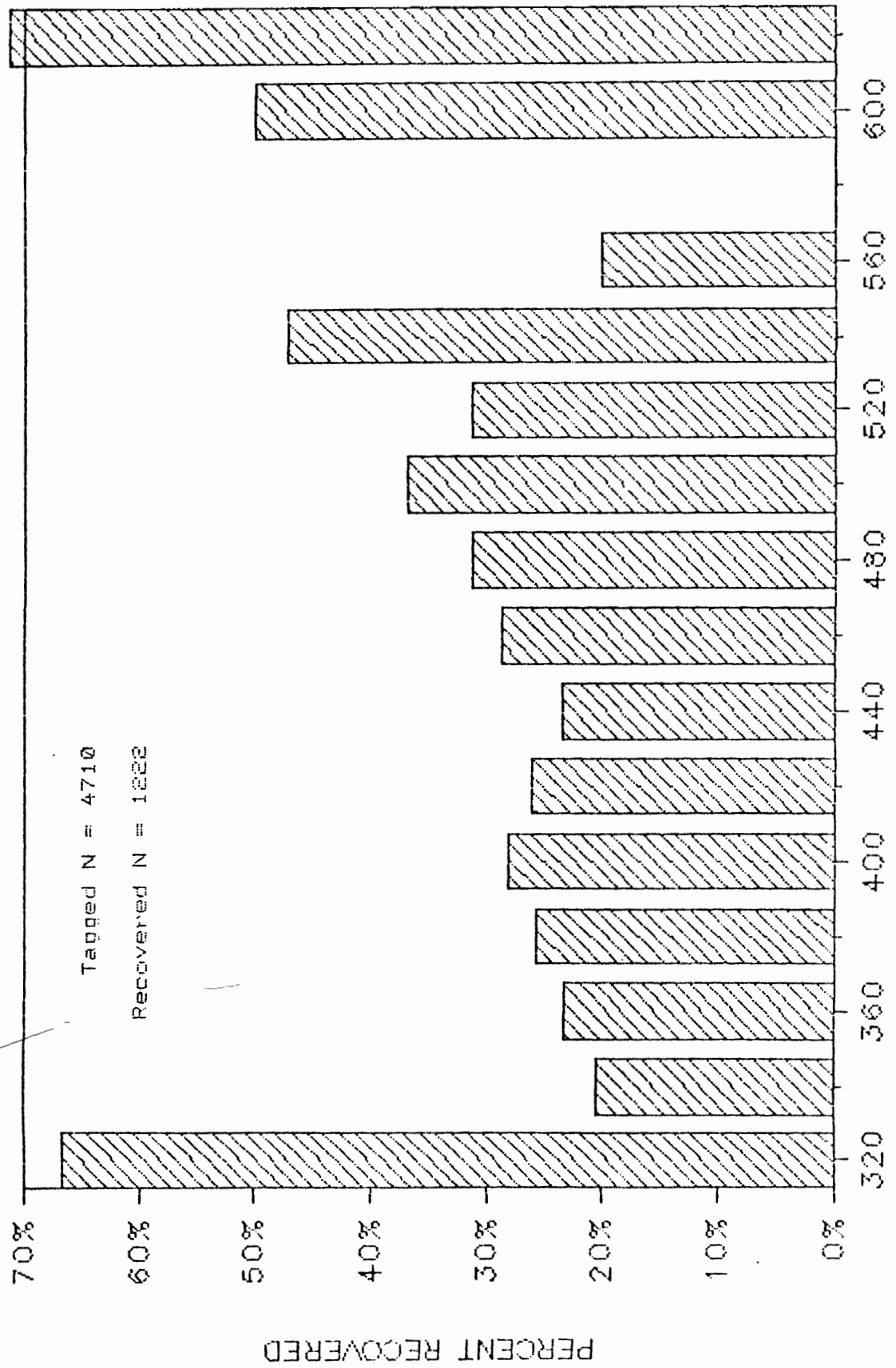


Figure 8. Dover sole tag recovery rate by length group.

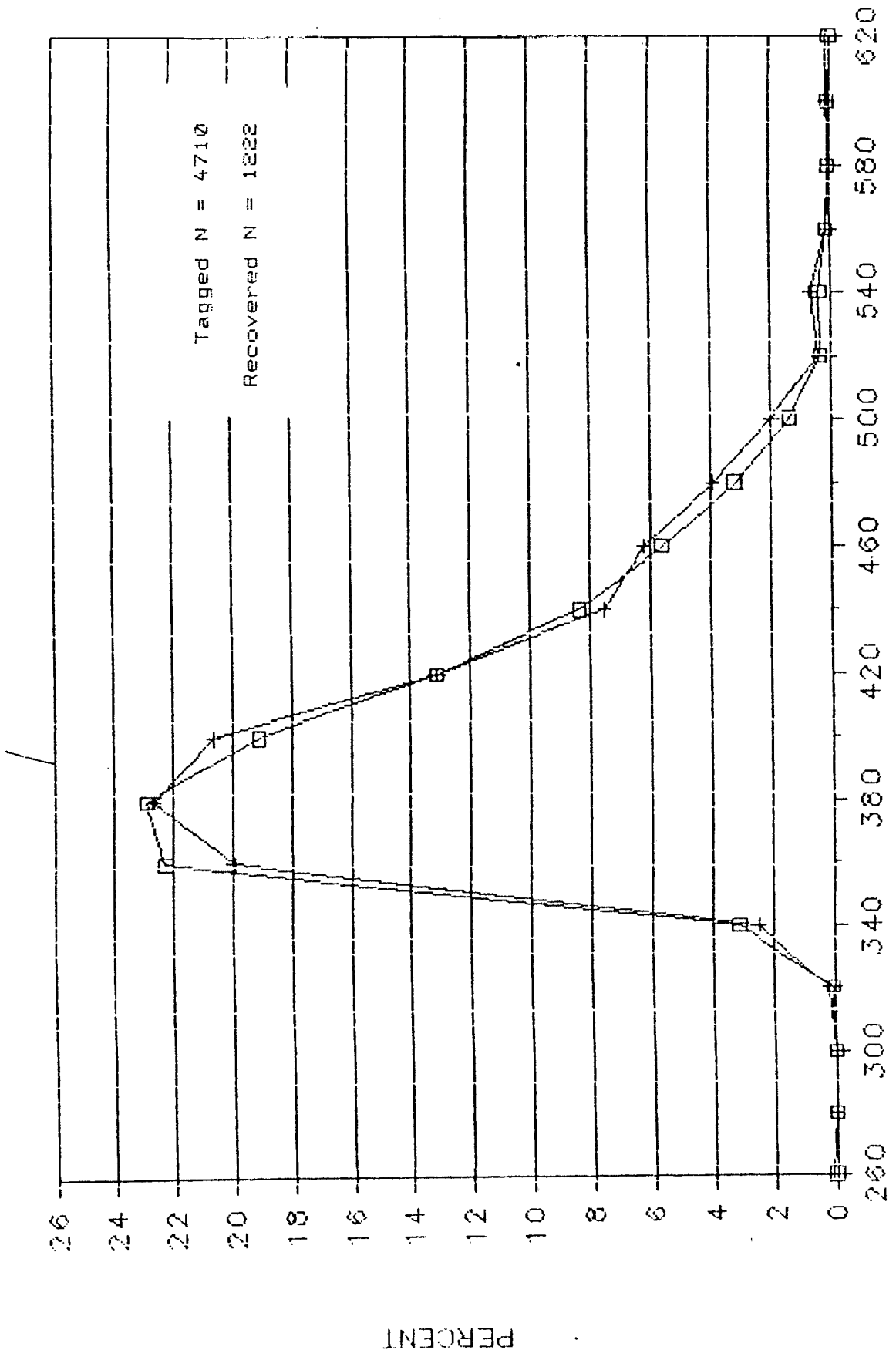


Figure 9. Length frequencies (%) of Dover sole tagged and recovered for all cruises.

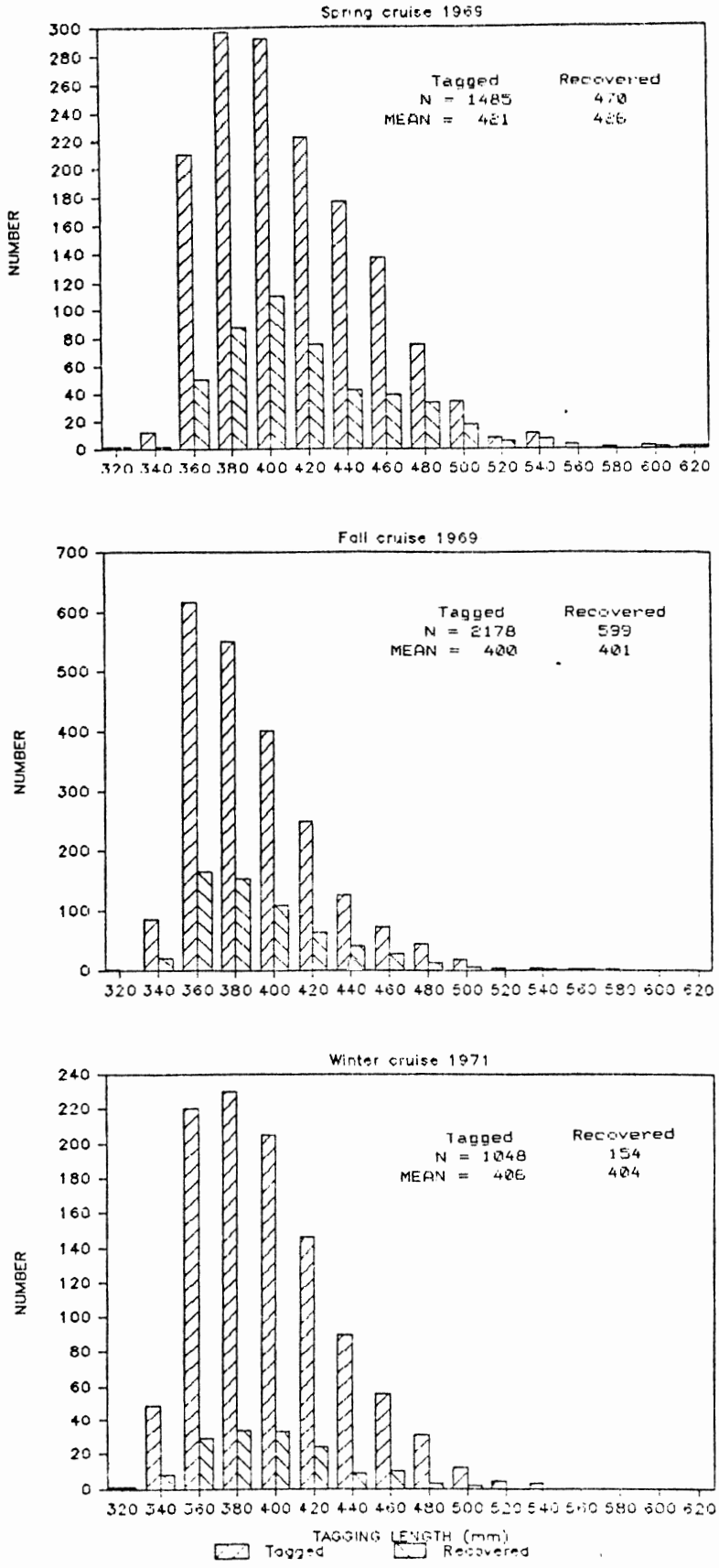


Figure 10. Length frequencies (number) of Dover sole tagged and recovered by cruise.

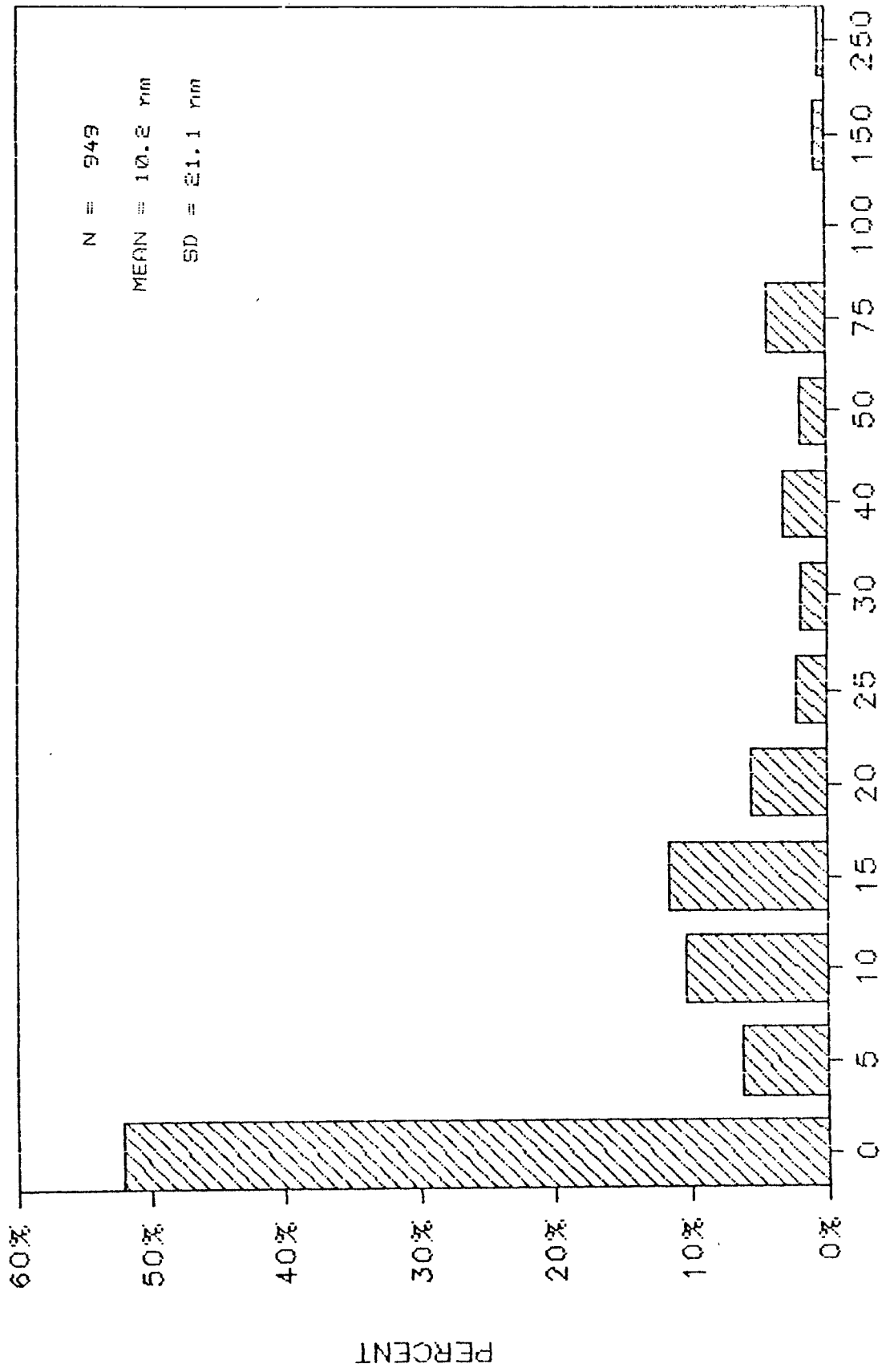


Figure 11. Dispersion of Dover sole in nautical miles from tagging point.

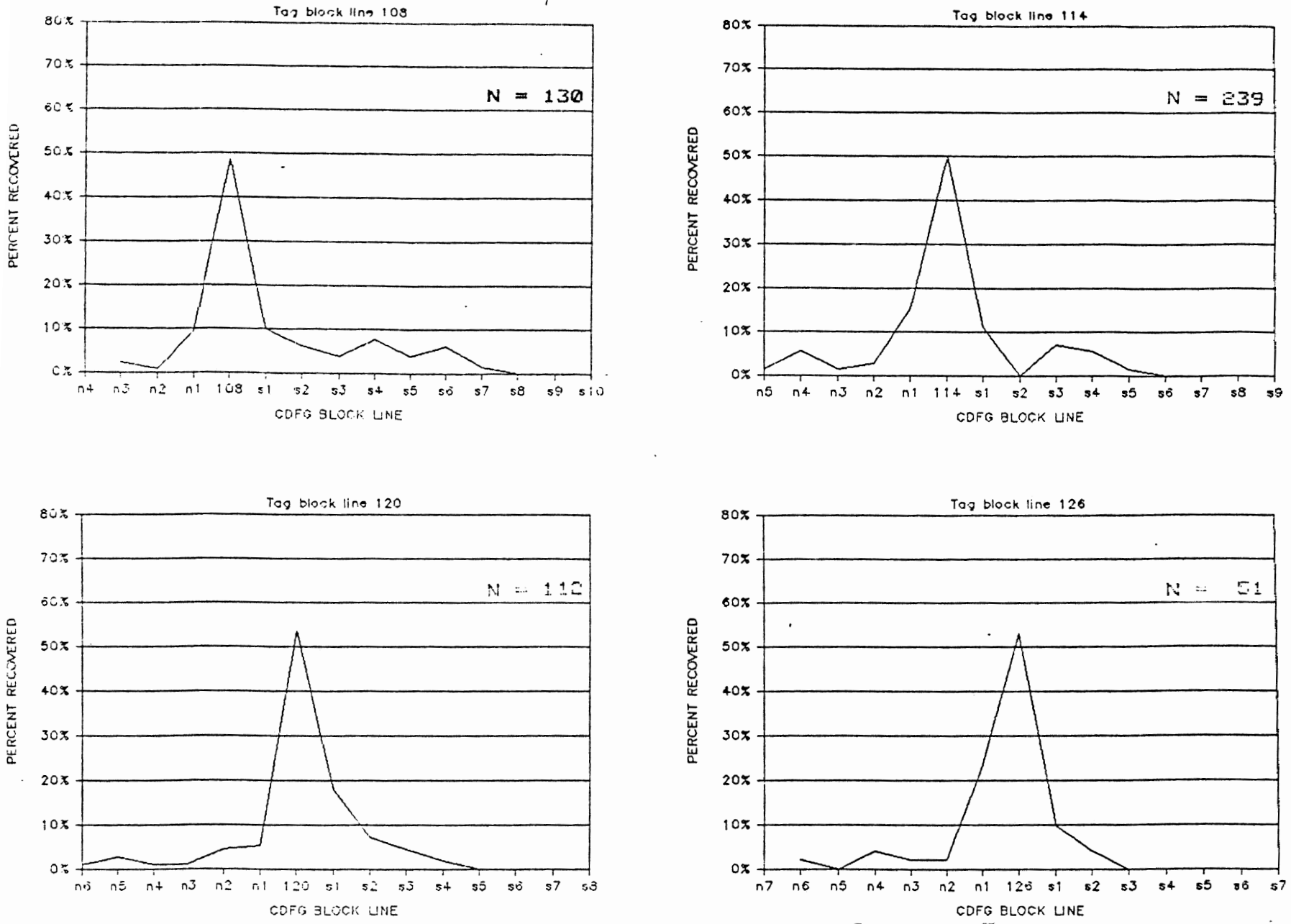
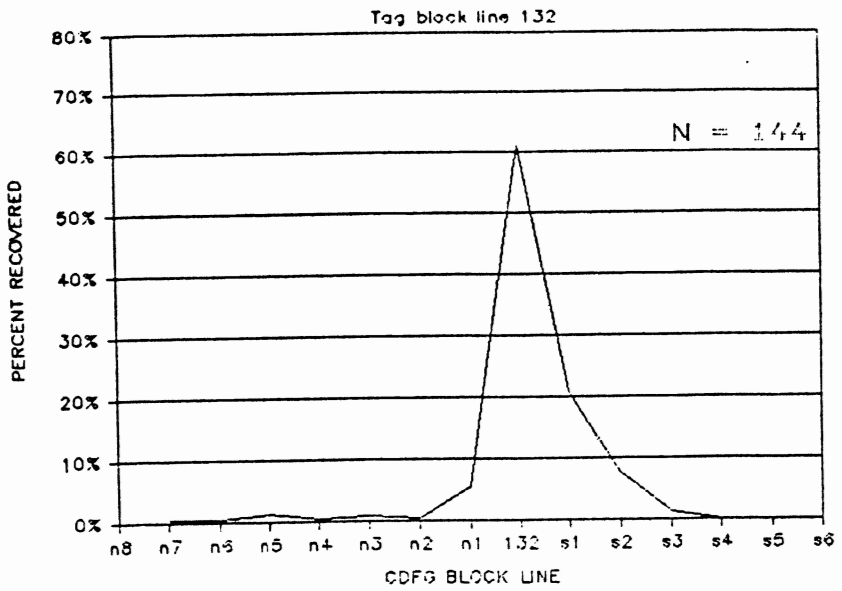
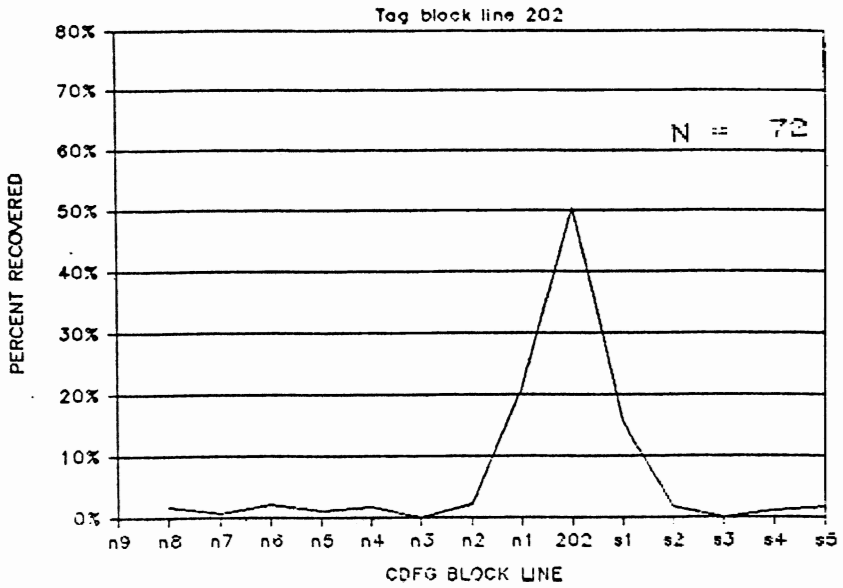


Figure 12. Movement of Dover sole across block lines for tag block lines 108 to 126. Direction represented in catch block increments as n1, s1, etc.





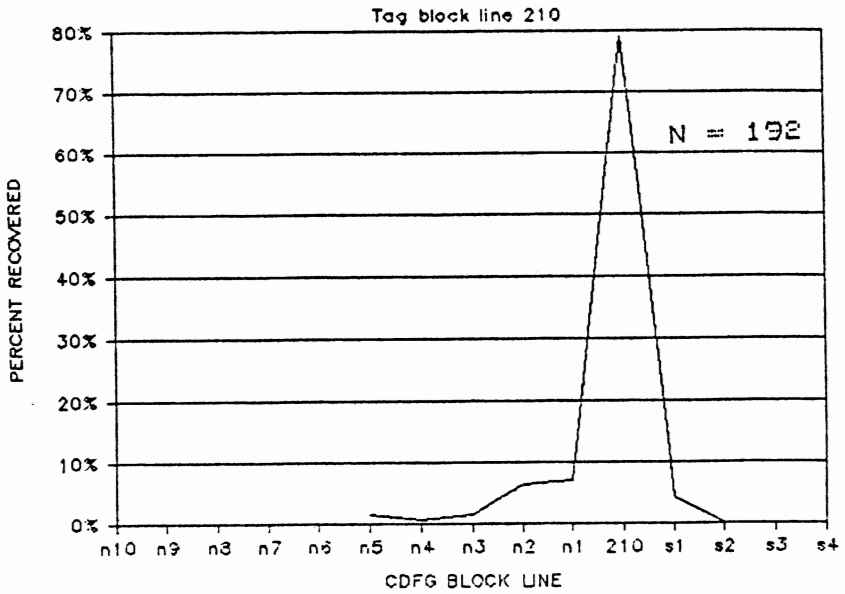


Figure 13. Movement of Dover sole across block lines for tag block lines 132 to 210. Direction represented in catch block increments as n1, s1, etc.

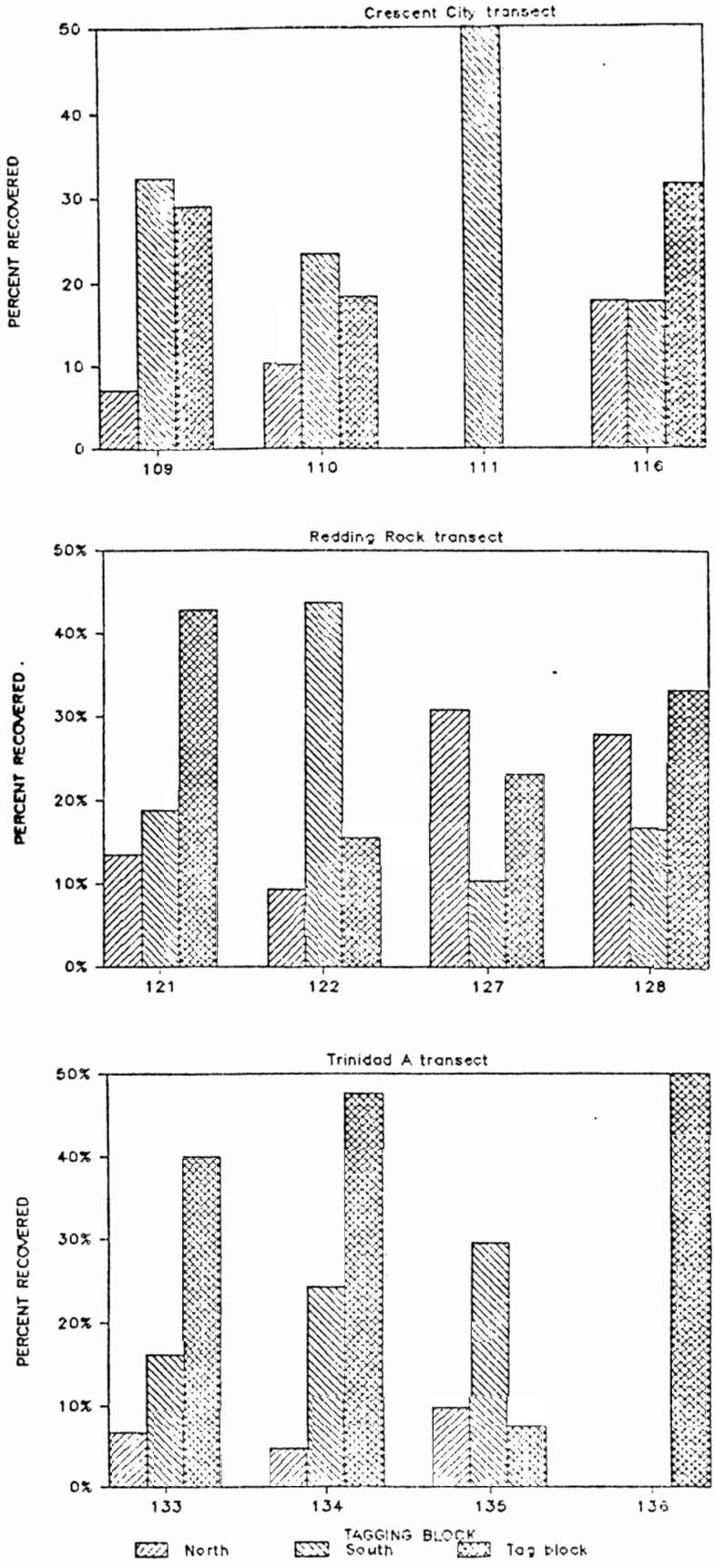


Figure 14. North, south or no movement (as percent of total recovered) from tag block within each transect for Crescent City, Redding Rock and Trinidad A.

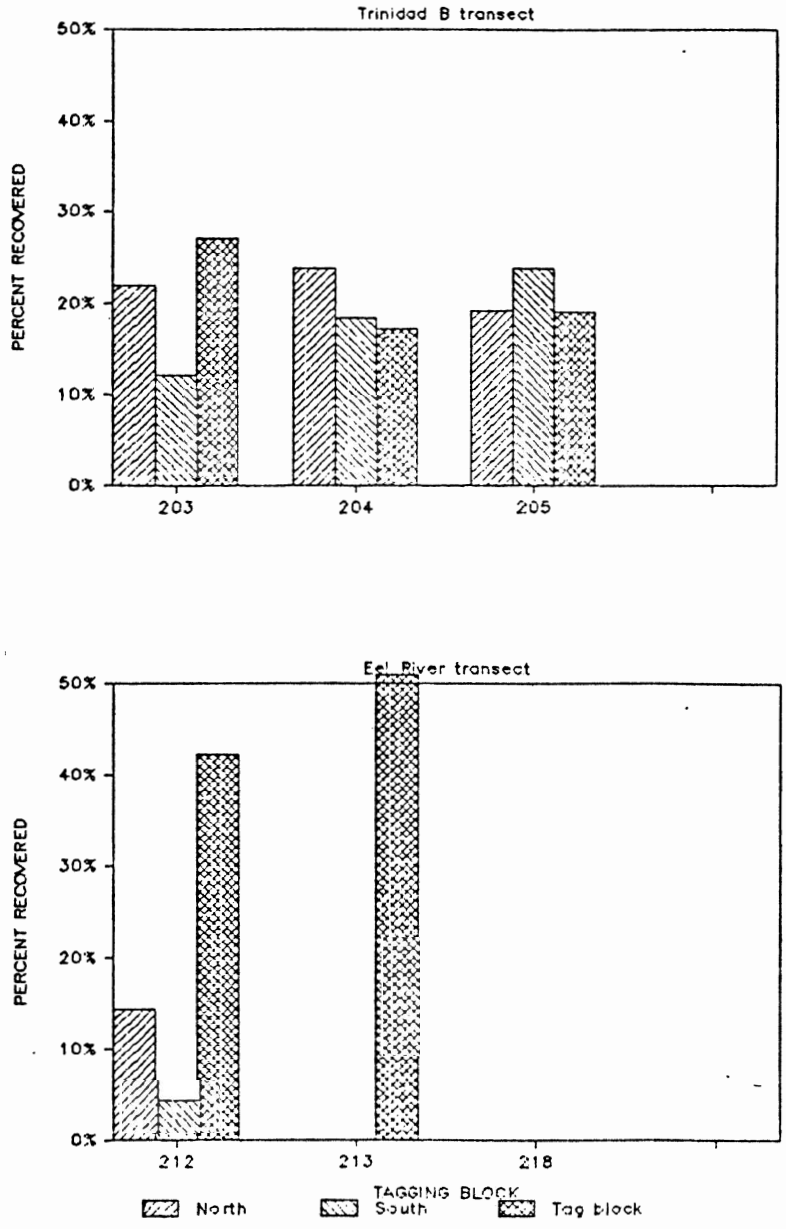


Figure 15. North, south or no movement (as percent of total recovered) from tag block within each transect for Trinidad B and Eel River transects.

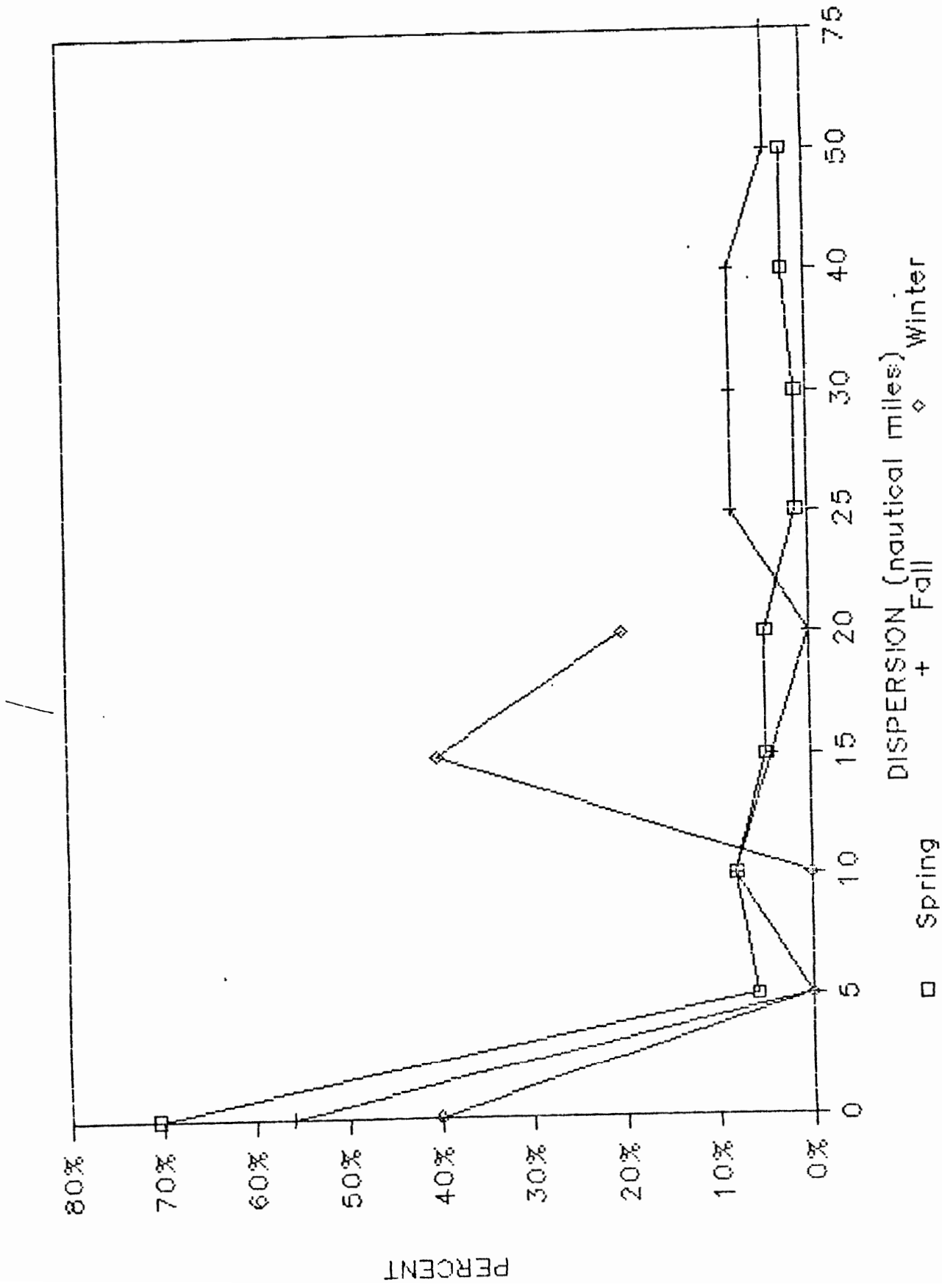


Figure 16. Longitudinal dispersion in nautical miles (as percent of total recovered) by cruise.

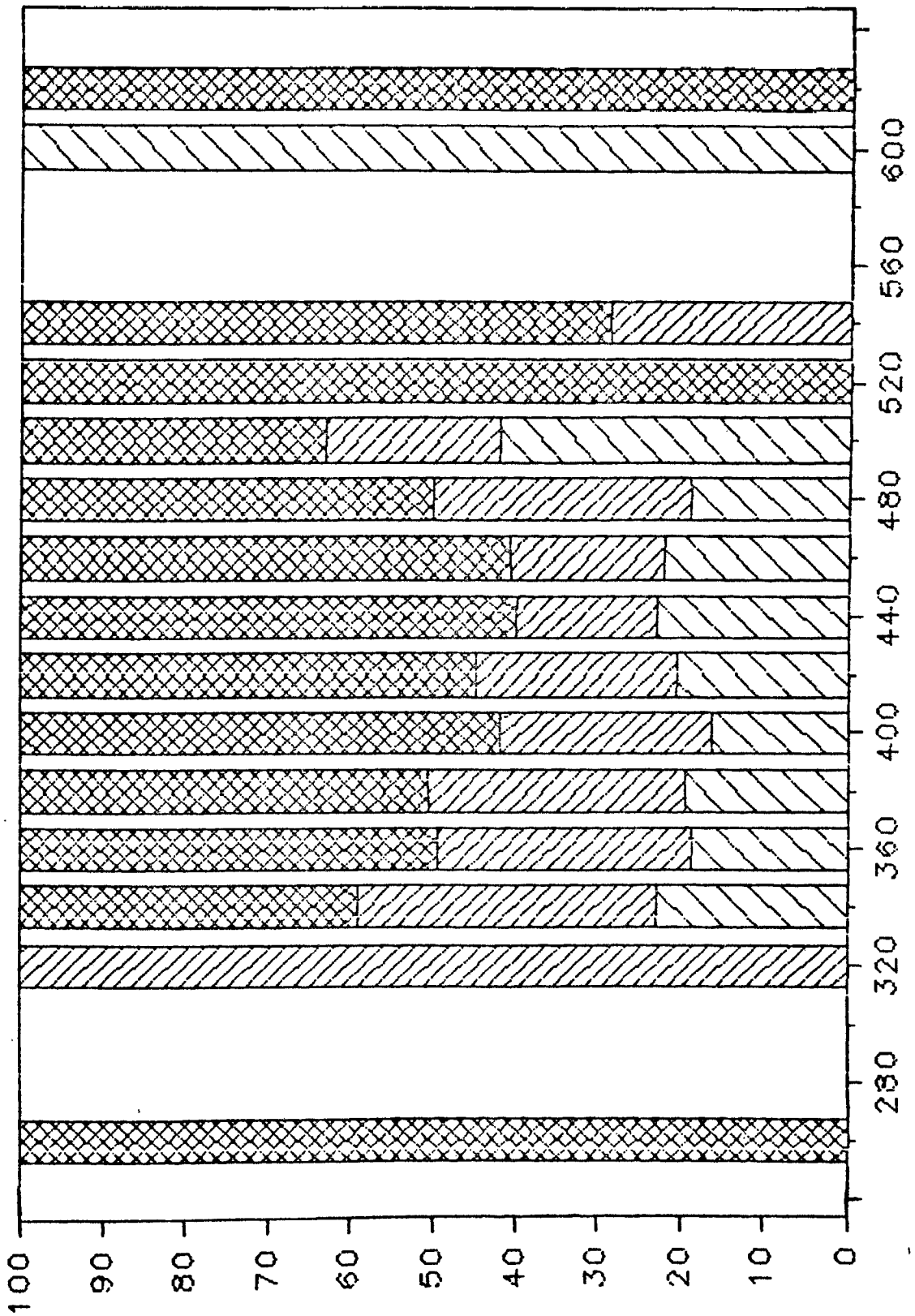


Figure 17. Longitudinal movement of Dover sole from tagging point by length class.

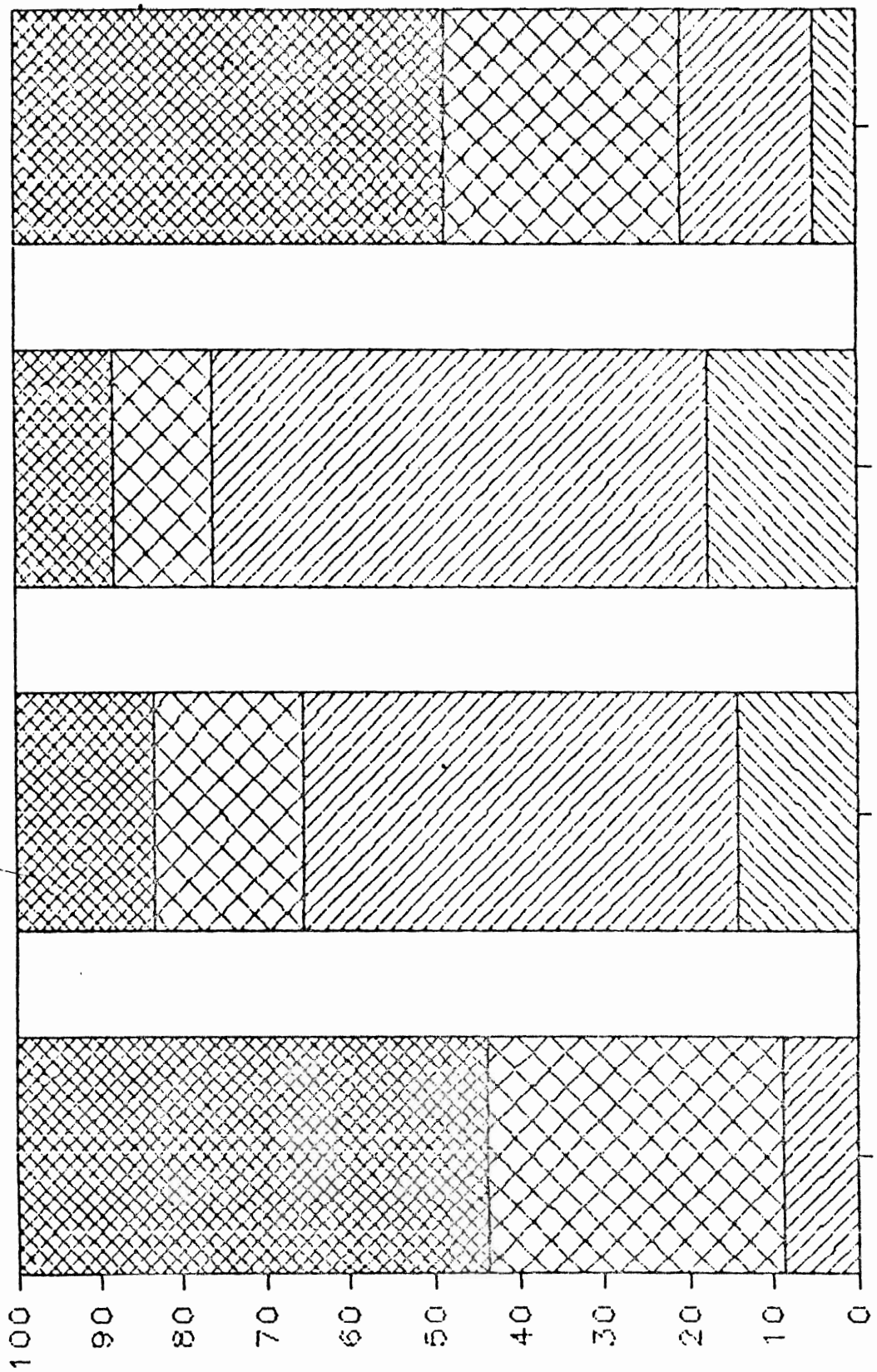


Figure 18. Dover sole recoveries (%) by quarter, sex (M and F) and depth (shallow, <200 fm and deep, > 200 fm) for all cruises.

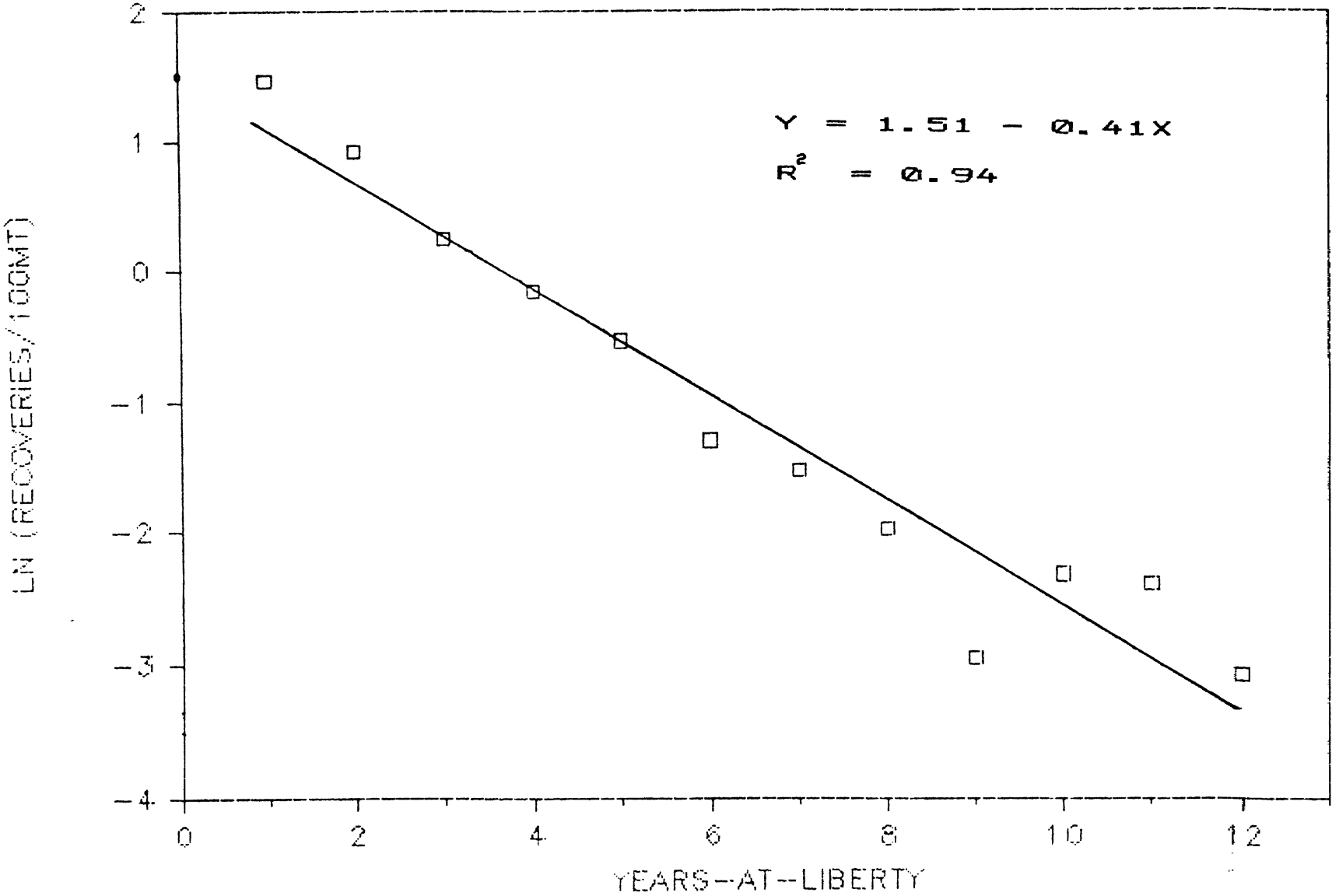


Figure 19. Regression of ln (recoveries/100mt) on years-at-liberty for Dover sole recovered on all cruises. 1971 cruise recoveries adjusted to 1969 cruise recoveries using landings and recoveries from the years between 1970 and 1983.

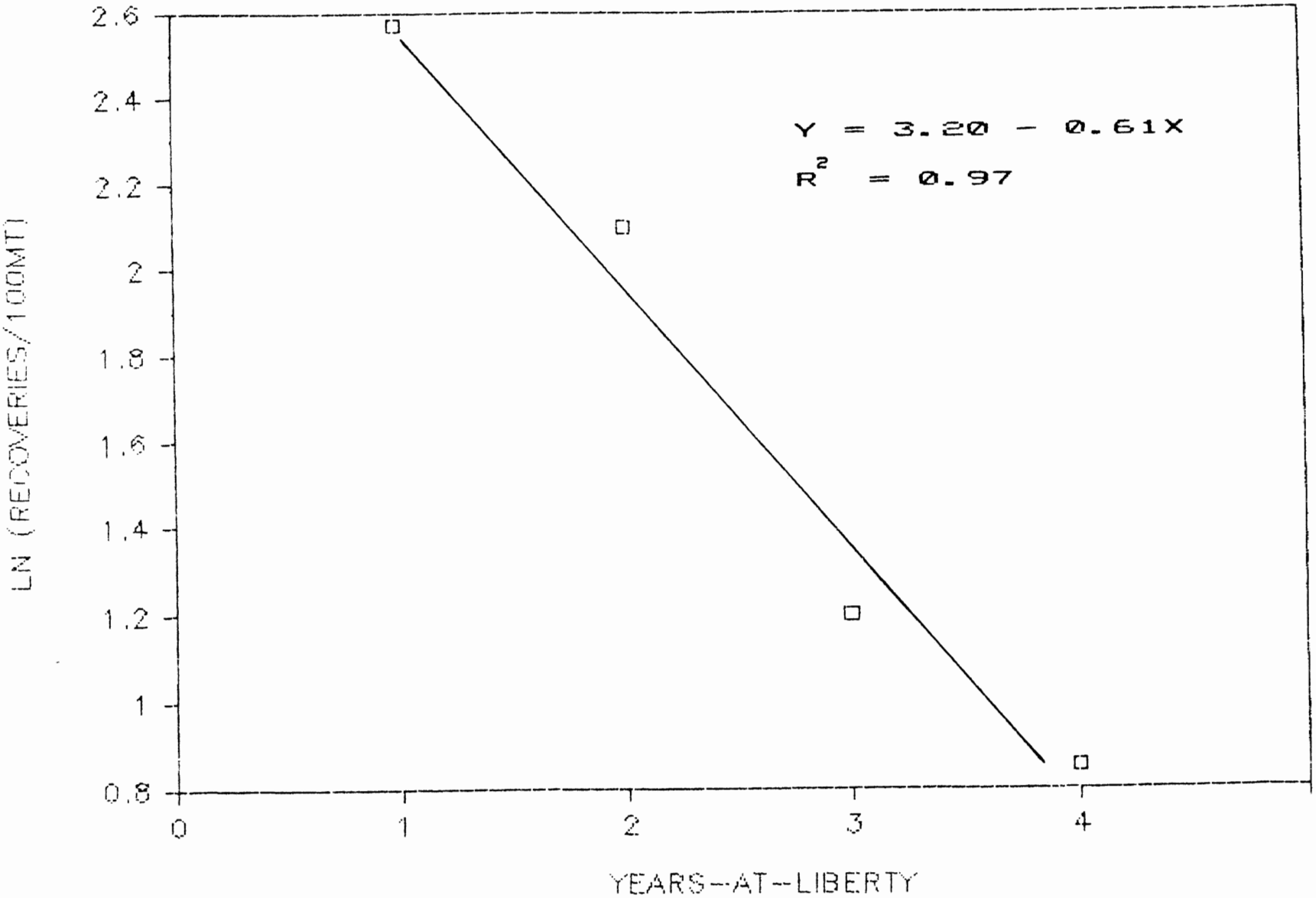


Figure 20. Regression of ln (recoveries/100mt) on years-at-liberty for Dover sole recovered in shallow water (0-199 fm). 1971 cruise recoveries adjusted to 1969 cruise recoveries using landings and recoveries from the years 1970 to 1975.

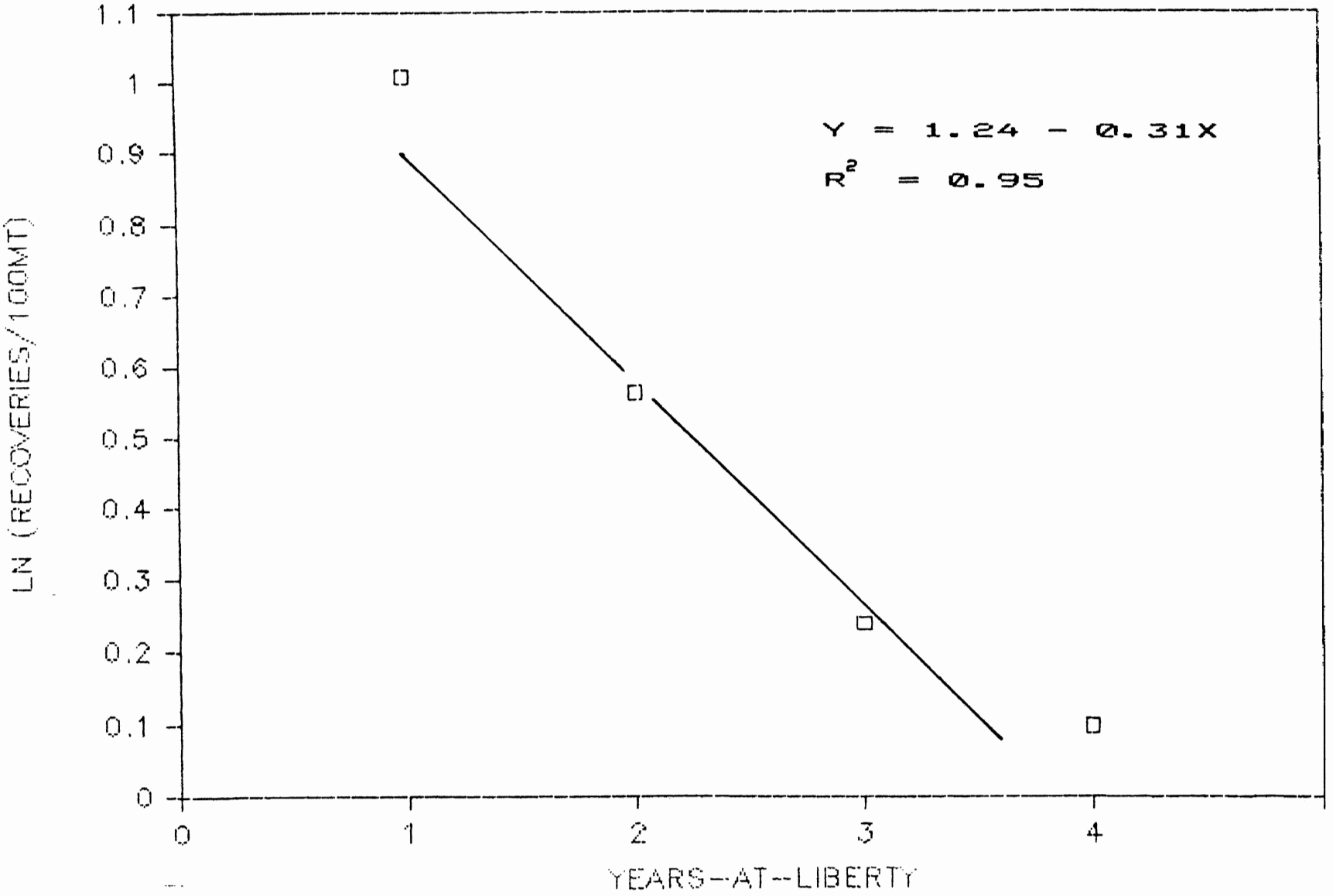


Figure 21. Regression of ln (recoveries/100mt) on years-at-liberty for Dover sole recovered in deep water (0-199 fm). 1971 cruise recoveries adjusted to 1969 cruise recoveries using landings and recoveries from the years 1970 to 1975.

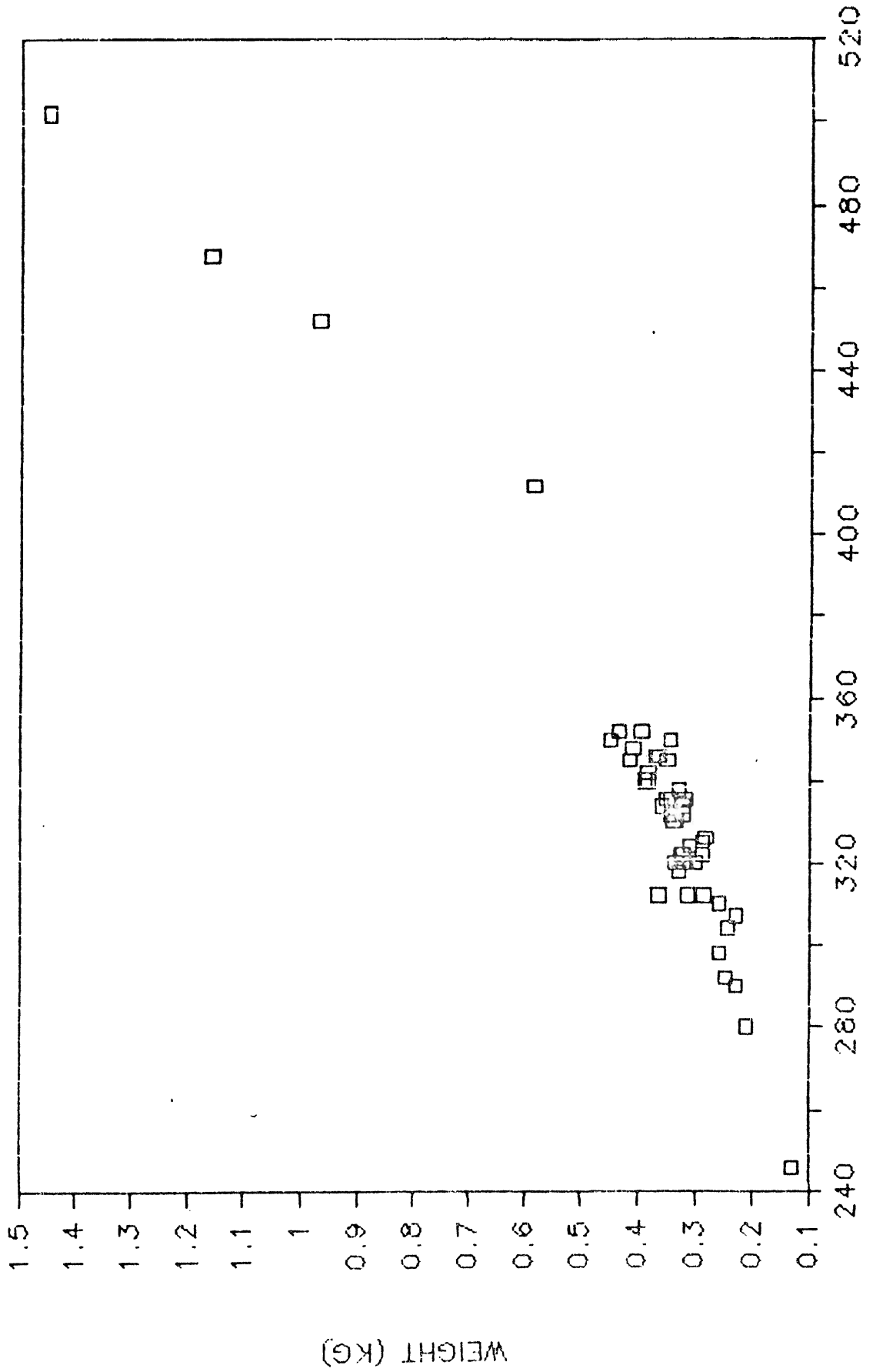


Figure 22. Weight-length relationship for 171 Dover sole from selected tagging cruise hauls, 1969-71.

TABLE 1. Dover sole Landings in Pounds and Metric Tons to Eureka-Crescent City Area Ports, 1960 - 1984.

Year	Pounds (thousands)	Metric Tons	Percent tate otal
1960	6160	2794	67%
1961	5093	2310	65%
1962	5569	2526	65%
1963	6487	2943	66%
1964	5221	2368	56%
1965	6733	3054	63%
1966	6297	2856	61%
1967	4542	2060	64%
1968	6926	3142	81%
1969	10,783	4891	84%
1970	10,940	4962	70%
1971	10,018	4544	70%
1972	15,519	7039	70%
1973	14,889	6754	66%
1974	12,853	5830	67%
1975	15,464	7015	68%
1976	14,405	6534	63%
1977	11,101	5036	51%
1978	9956	4516	48%
1979	14,169	6427	61%
1980	10,975	4978	61%
1981	12,617	5723	62%
1982	11,976	5432	55%
1983	8844	4012	48%
1984	9123	4138	42%
MEAN	9866	4475	
SD	3550	1610	

TABLE 2. Dover Sole Releases and Recoveries by Transect and haul for Spring Cruise, 1969.

Cruise	Transect	Haul	Depth-fm	Tagged	Recovered	% Recovered
Spring	Crescent	27	33	1	0	0%
		28	54	134	79	59%
		29	74	58	34	59%
		30	172	106	52	49%
		31	330	103	9	9%
		36	399	14	0	0%
		37	405	28	2	7%
	Redding R	21	39	74	36	49%
		22	47	46	22	48%
		23	56	59	39	66%
		24	81	38	18	47%
		25	570	10	0	0%
	Trinidad	11	49	22	8	36%
		12	96	32	16	50%
		13	155	89	52	58%
		14	222	20	5	25%
		15	295	59	17	29%
		16	380	69	2	3%
		17	380	297	43	14%
		18	442	51	0	0%
	Eel River	4	85	57	34	51%
		5	300	7	0	0%
		7	455	107	9	8%

TABLE 3. Dover Sole Releases and Recoveried by Transect and Haul for Fall Cruise, 1969.

Cruise	Transect	Haul	Depth-fm	Tagged	Recovered	% Recovered
Fall	Crescent	8	54	26	11	42%
		9	90	31	18	58%
		10	172	146	57	39%
		11	317	52	12	23%
		26	410	115	2	2%
		27	401	147	5	3%
		30	465	22	0	0%
	Redding R	23	40	48	20	42%
		24	47	38	19	50%
		25	54	40	17	43%
		32	79	87	32	37%
	Trinidad	2	28	1	0	0%
		3	44	124	67	54%
		4	85	59	30	51%
		13	159	283	60	21%
		14	220	175	59	34%
		15	295	43	8	19%
		16	372	160	8	5%
		17	380	110	7	6%
	Eel River	21	88	342	131	38%
		22	310	137	39	28%

TABLE 4. Dover Sole Releases and Recoveries by Transect and Haul for Winter Cruise, 1971.

Cruise	Transect	Haul	Depth-fm	Tagged	Recovered	% Recovered
Winter	Crescent	12	342	47	10	21%
		13	480	77	5	6%
		14	440	42	1	2%
		15	425	46	1	2%
		16	188	11	3	27%
	Redding R	2	440	143	3	2%
		3	397	92	18	20%
		4	377	549	97	18%
		5	318	38	16	42%
		6	291	8	2	25%

TABLE 5. Numbers of Tagged and Released Dover Sole by Cruise and Transect, and Recoveries by Tagging Transect.

Tagging Transect	Cruise			Total	Recovrd	Recovrd
	Spring	Fall	Winter			
Crescent City	444	539	223	1206	301	25.0%
Redding Rock	227	213	0	440	201	45.7%
Trinidad	639	955	830	2424	520	21.5%
Eel River	181	479	0	660	213	32.3%
Total	1491	2186	1053	4730	1235	26.1%

TABLE 6. Length Frequencies of Recovered Dover Sole by Sex for All Cruises, 1969 - 71.

Total Length* (mm)	Sex: Male R	Male % R	Female R	Female % R	Unknown R	Unknown % R	Total R	Total % R
320	1	0.3%	1	0.1%	0	0.0%	2	0.2%
40	32	8.8%	15	1.8%	2	12.5%	49	4.1%
60	121	33.4%	81	9.9%	3	18.8%	205	17.1%
80	110	30.4%	147	17.9%	2	12.5%	259	21.6%
400	58	16.0%	167	20.3%	3	18.8%	228	19.0%
20	22	6.1%	146	17.8%	2	12.5%	170	14.2%
40	12	3.3%	103	12.5%	2	12.5%	117	9.8%
60	2	0.6%	69	8.4%	2	12.5%	73	6.1%
80	4	1.1%	43	5.2%	0	0.0%	47	3.9%
500	0	0.0%	27	3.3%	0	0.0%	27	2.3%
20	0	0.0%	9	1.1%	0	0.0%	9	0.8%
40	0	0.0%	10	1.2%	0	0.0%	10	0.8%
60	0	0.0%	1	0.1%	0	0.0%	1	0.1%
80	0	0.0%	2	0.2%	0	0.0%	2	0.2%
N	362	30.2%	821	68.5%	16	1.3%	1199	
MEAN	388		425		409			
SD	26		42		39			

* Length at recovery

TABLE 7. Length Frequencies of Recovered (R) Dover Sole by Sex for Spring Cruise 1969.

Total Length* (mm)	Male R	Male % R	Female R	Female % R	Total R	Total % R
320	0	0.0%	0	0.0%	0	0.0%
40	6	6.2%	2	0.6%	8	1.8%
60	27	27.8%	26	7.3%	53	11.7%
80	26	26.8%	54	15.2%	80	17.7%
400	22	22.7%	71	20.0%	93	20.6%
20	9	9.3%	58	16.3%	67	14.8%
40	4	4.1%	48	13.5%	52	11.5%
60	1	1.0%	33	9.3%	34	7.5%
80	2	2.1%	27	7.6%	29	6.4%
500	0	0.0%	17	4.8%	17	3.8%
20	0	0.0%	7	2.0%	7	1.5%
40	0	0.0%	9	2.5%	9	2.0%
60	0	0.0%	1	0.3%	1	0.2%
80	0	0.0%	2	0.6%	2	0.4%
N	97	21.5%	355	78.5%	452	
MEAN	394		435			
SD	29		46			

* Length at recovery

TABLE 8. Length Frequencies of Recovered (R) Dover Sole by Sex for Fall Cruise 1969.

Total Length* (mm)	Male R	Male % R	Female R	Female % R	Total R	Total % R
320	0	0.0%	1	0.3%	1	0.2%
40	19	9.3%	12	3.2%	31	5.3%
60	76	37.3%	48	12.6%	124	21.2%
80	64	31.4%	81	21.3%	145	24.8%
400	31	15.2%	79	20.8%	110	18.8%
20	8	3.9%	63	16.6%	71	12.2%
40	5	2.5%	45	11.8%	50	8.6%
60	0	0.0%	26	6.8%	26	4.5%
80	1	0.5%	14	3.7%	15	2.6%
500	0	0.0%	8	2.1%	8	1.4%
20	0	0.0%	2	0.5%	2	0.3%
40	0	0.0%	1	0.3%	1	0.2%
60	0	0.0%	0	0.0%	0	0.0%
80	0	0.0%	0	0.0%	0	0.0%
N	204	34.9%	380	65.1%	584	
MEAN	384		416			
SD	23		38			

* Length at recovery

TABLE 9. Length Frequencies of Recovered (R) Dover Sole by Sex for Winter Cruise 1971.

Total Length* (mm)	Male R	Male % R	Female R	Female % R	Total R	Total % R
320	1	1.6%	0	0.0%	1	0.7%
40	7	11.5%	1	1.2%	8	5.4%
60	18	29.5%	7	8.1%	25	17.0%
80	20	32.8%	12	14.0%	32	21.8%
400	5	8.2%	17	19.8%	22	15.0%
20	5	8.2%	25	29.1%	30	20.4%
40	3	4.9%	10	11.6%	13	8.8%
60	1	1.6%	10	11.6%	11	7.5%
80	1	1.6%	2	2.3%	3	2.0%
500	0	0.0%	2	2.3%	2	1.4%
20	0	0.0%	0	0.0%	0	0.0%
40	0	0.0%	0	0.0%	0	0.0%
60	0	0.0%	0	0.0%	0	0.0%
80	0	0.0%	0	0.0%	0	0.0%
N	61	41.5%	86	58.5%	147	
MEAN	389		424			
SD	30		34			

* Length at recovery

TABLE 10a. Length Frequencies of Recovered (R) Dover Sole by Sex for Crescent City Transect, All Cruises.

Total Length* (mm)	Male R	Male % R	Female R	Female % R	Total R	Total % R
320	0	0.0%	0	0.0%	0	0.0%
40	8	14.5%	4	1.8%	12	4.2%
60	15	27.3%	30	13.2%	45	15.9%
80	16	29.1%	47	20.6%	63	22.3%
400	10	18.2%	43	18.9%	53	18.7%
20	3	5.5%	30	13.2%	33	11.7%
40	0	0.0%	27	11.8%	27	9.5%
60	0	0.0%	23	10.1%	23	8.1%
80	3	5.5%	14	6.1%	17	6.0%
500	0	0.0%	5	2.2%	5	1.8%
20	0	0.0%	1	0.4%	1	0.4%
40	0	0.0%	3	1.3%	3	1.1%
60	0	0.0%	0	0.0%	0	0.0%
80	0	0.0%	1	0.4%	1	0.4%
N	55	19.4%	228	80.6%	283	
MEAN	389		423			
SD	31		43			

* Length at recovery

TABLE 10b. Length Frequencies of Recovered (R) Dover Sole by Sex for Redding Rock Transect, All Cruises.

Total Length* (mm)	Male R	Male % R	Female R	Female % R	Total R	Total % R
320	0	0.0%	0	0.0%	0	0.0%
40	0	0.0%	5	2.9%	5	2.6%
60	2	14.3%	9	5.1%	11	5.8%
80	5	35.7%	20	11.4%	25	13.2%
400	5	35.7%	37	21.1%	42	22.2%
20	1	7.1%	30	17.1%	31	16.4%
40	1	7.1%	30	17.1%	31	16.4%
60	0	0.0%	11	6.3%	11	5.8%
80	0	0.0%	9	5.1%	9	4.8%
500	0	0.0%	13	7.4%	13	6.9%
20	0	0.0%	5	2.9%	5	2.6%
40	0	0.0%	5	2.9%	5	2.6%
60	0	0.0%	0	0.0%	0	0.0%
80	0	0.0%	1	0.6%	1	0.5%
N	14	7.4%	175	92.6%	189	
MEAN	400		436			
SD	24		48			

* Length at recovery

TABLE 11a. Length Frequencies of Recovered (R) dover Sole by Sex for Trinidad Transect, all Cruises.

Total Length* (mm)	Male R	Male % R	Female R	Female % R	Total R	Total % R
320	1	0.4%	0	0.0%	1	0.2%
40	22	9.0%	5	1.9%	27	5.4%
60	82	33.6%	30	11.7%	112	22.4%
80	74	30.3%	51	19.8%	125	25.0%
400	36	14.8%	49	19.1%	85	17.0%
20	17	7.0%	57	22.2%	74	14.8%
40	9	3.7%	28	10.9%	37	7.4%
60	2	0.8%	23	8.9%	25	5.0%
80	1	0.4%	9	3.5%	10	2.0%
500	0	0.0%	3	1.2%	3	0.6%
20	0	0.0%	0	0.0%	0	0.0%
40	0	0.0%	1	0.4%	1	0.2%
60	0	0.0%	1	0.4%	1	0.2%
80	0	0.0%	0	0.0%	0	0.0%
N	244	48.7%	257	51.3%	501	
MEAN	388		418			
SD	25		37			

* Length at recovery

TABLE 11b. Length Frequencies of Recovered (R) Dover Sole by Sex for Eel River Transect, all Cruises

Total Length* (mm)	Male R	Male % R	Female R	Female % R	Total R	Total % R
320	0	0.0%	1	0.6%	1	0.5%
40	2	4.1%	1	0.6%	3	1.4%
60	22	44.9%	12	7.5%	34	16.2%
80	15	30.6%	29	18.0%	44	21.0%
400	7	14.3%	38	23.6%	45	21.4%
20	1	2.0%	29	18.0%	30	14.3%
40	2	4.1%	18	11.2%	20	9.5%
60	0	0.0%	12	7.5%	12	5.7%
80	0	0.0%	11	6.8%	11	5.2%
500	0	0.0%	6	3.7%	6	2.9%
20	0	0.0%	3	1.9%	3	1.4%
40	0	0.0%	1	0.6%	1	0.5%
60	0	0.0%	0	0.0%	0	0.0%
80	0	0.0%	0	0.0%	0	0.0%
N	49	23.3%	161	76.7%	210	
MEAN	384		426			
SD	23		40			

* Length at recovery

TABLE 12. Length Frequencies of Tagged and Recovered Dover Sole for All Cruises, 1969 - 1971.

Total Length* (mm)	Tagged	Recovered	Percent Recovered
260	1	1	100%
80	0	-	-
300	0	-	-
20	3	2	67%
40	147	30	20%
60	1048	244	23%
80	1078	277	26%
400	899	252	28%
20	618	161	26%
40	393	92	23%
60	265	76	29%
80	151	48	32%
500	65	24	37%
20	16	5	31%
40	17	8	47%
60	5	1	20%
80	2	0	0%
600	2	1	50%
20	1	1	100%
N	4711	1223	26%
MEAN	408	411	
SD	38	40	

* Length at tagging

TABLE 13. Length Frequencies of Tagged (T) and Recovered (R) Dover Sole by Cruise, 1969-1971.

Total Length* (mm)	Cruise: Spring T	Spring R	Spring % R	Fall T	Fall R	Fall % R	Winter T	Winter R	Winter % R
260	0	–	–	0	–	–	1	1	100%
80	0	–	–	0	–	–	0	–	–
300	0	–	–	0	–	–	0	–	–
20	1	1	100%	1	0	0%	1	1	100%
40	12	1	8%	86	21	24%	49	8	16%
60	211	50	24%	617	165	27%	220	29	13%
80	297	88	30%	551	155	28%	230	34	15%
400	292	110	38%	402	109	27%	205	33	16%
20	223	75	34%	249	62	25%	146	24	16%
40	177	42	24%	126	41	33%	90	9	10%
60	137	39	28%	72	27	38%	56	10	18%
80	75	33	44%	45	12	27%	31	3	10%
500	34	17	50%	19	5	26%	12	2	17%
20	8	5	63%	4	0	0%	4	0	0%
40	11	7	64%	3	1	33%	3	0	0%
60	3	0	0%	2	1	50%	0	–	–
80	1	0	0%	1	0	0%	0	–	–
600	2	1	50%	0	–	–	0	–	–
20	1	1	100%	0	–	–	0	–	–
N	1485	470	32%	2178	599	28%	1048	154	15%
Mean	421	426		400	401		406	404	
SD		44			34			36	

* Length at tagging

TABLE 14. Tagging Depth Frequency Distributions of Tagged (T) and Recovered (R) Dover Sole by Condition at Tagging.

Tagging Depth (fathoms)	Condition: Moribund T	Moribund R	Moribund % R	Poor T	Poor R	Poor % R	Fair T	Fair R	Fair % R	Good T	Good R	Good % R
0 - 99	1	0	0%	11	0	0%	8	0	0%	1323	629	48%
100 - 199	1	0	0%	1	0	0%	107	52	49%	546	172	32%
200 - 299	1	0	0%	1	0	0%	79	22	28%	224	69	31%
300 - 399	0	-	-	477	54	11%	352	27	8%	823	182	22%
400 - 499	23	0	0%	160	9	6%	150	5	3%	419	14	3%
500 - 599	0	-	-	0	-	-	0	-	-	20	0	0%
N	26	0	0%	650	63	10%	696	106	15%	3355	1066	32%
MEAN	430	-		384	385		334	251		216	147	

TABLE 15. Depth Frequency Distributions of Tagged (T) and Recovered (R) Jellied Dover Sole by Sex, 1969 - 71.

Depth (fathoms)	Male		Female		Unknwn		Total	
	T	R	T	R	T	R	T	R
0 - 99	0	5	0	0	9	0	[illegible]	[illegible]
100 - 199	0	1	0	2	0	0	2	3
200 - 299	0	4	0	5	0	1	0	10
300 - 399	39	14	25	9	411	0	475	23
400 - 499	5	5	3	2	293	1	301	8
500 - 599	0	15	0	10	0	2	0	27
N	44	44	28	28	713	4	785	76

% Tagged jellied Dover sole of total tagged = 17%
% Recovered jellied Dover of total recovered = 6%
% Recovered jellied Dover of tagged jellied = 10%

TABLE 16. Kruskal Wallis 1-Way ANOVA by Ranks for Years at Large by Cruise.

Cruise	Avg Rank	Cases
Spring	541.060	477
Fall	646.886	602
Winter	741.788	156

Valid Cases = 1235 Chi Square = 295723 Df = 2

Corrected Chi Square for 249 sets of ties = 295724

PROB = 0.0000 **

TABLE 17. Chi-square Test of Yearly Dover Sole Recoveries by Recovery Quarter.

Recovery Year	Recovery Quarter: Win Recovrd	Win Row%	Spr Recovrd	Spr Row%	Sum Recovrd	Sum Row%	Fal Recov	Fal Row%	Total Recovered
1969	0	0.0%	36	16.6%	124	57.1%	57	26.3%	217
1970	19	5.0%	171	45.4%	164	43.5%	23	6.1%	377
1971	11	4.6%	93	38.6%	117	48.5%	20	8.3%	241
1972	11	7.2%	67	44.1%	55	36.2%	19	12.5%	152
1973	11	12.9%	33	38.8%	33	38.8%	8	9.4%	85
1974	7	10.4%	25	37.3%	23	34.3%	12	17.9%	67
1975	3	10.7%	8	28.6%	13	46.4%	4	14.3%	28
1976	2	8.7%	8	34.8%	7	30.4%	6	26.1%	23
1977	2	13.3%	3	20.0%	7	46.7%	3	20.0%	15
1978	1	14.3%	2	28.6%	3	42.9%	1	14.3%	7
1979	1	14.3%	2	28.6%	1	14.3%	3	42.9%	7
1980	0	0.0%	4	66.7%	1	16.7%	1	16.7%	6
1981	1	33.3%	1	33.3%	1	33.3%	0	0.0%	3
1982	0	0.0%	0	0.0%	1	100.0%	0	0.0%	1
1983	0	0.0%	0	0.0%	1	100.0%	0	0.0%	1
1984	2	40.0%	0	0.0%	1	20.0%	2	40.0%	5
N	71	5.7%	453	36.7%	552	44.7%	159	12.9%	1235

Chi-square = 164.691 Df = 45 Prob. = 0.0000 **

TABLE 18. Dispersion of Dover Sole from Point of Tagging by Time-at-liberty.

Dispersion (nautical miles)	Time at Large: Days 0-89	Days 90-179	Days 180-365	Years 1	Years 2 - 5	Years > 5
0	78	26	125	112	130	36
1 - 5	5	6	11	17	17	3
6 - 10	9	5	22	28	22	11
11 - 15	7	5	19	31	30	8
16 - 20	5	3	9	11	20	4
21 - 25	3	2	2	5	8	1
26 - 30	3	2	4	4	3	3
31 - 40	4	3	6	8	8	3
41 - 50	3	2	2	3	5	4
51 - 75	1	2	7	9	10	5
76 - 100			0		0	0
101 - 150			0		3	2
151 - 250			1		3	
N	118	56	208	228	259	80
Mean (n. miles)	6.4	10.5	8.1	9.1	13	14.9
SD	12	15.1	19.3	14.1	29.2	23.3

TABLE 19. Kruskal Wallis 1-Way ANOVA by Ranks for Dispersion of Dover Sole from Tagging Point (in Nautical Miles) by Sea.

Sex	Avg Rank	Cases
Males	485.699	289
Females	451.942	635

Valid Cases = 924 Chi Square = 866372 Df = 1

Corrected Chi Square for 53 sets of ties = 1020609

Prob. = 0.0000 **

Table 20. Longitudinal movement (in nautical miles) of recovered Dover sole from tagging point by sex.

Movement (n. miles)		Sex			Total
		Male	Female	Unknwn	
North	N	42	140	4	186
	MEAN	26.3	20.6	31.0	22.1
	SD	19.9	25	23.2	
South	N	106	144	6	256
	MEAN	19.6	23.1	25	21.7
	SD	22.2	32	21.3	
None	N	141	351	15	507
	MEAN	-	-	-	
	SD	-	-	-	

TABLE 21. Chi-square Test of Longitudinal Movement of Tagged Dover Sole by Sex.

Movement		Male	Female	Total
North	N	42	140	182
	Row%	23.1	76.9	
	Col%	14.5	22.0	
South	N	106	144	250
	Row%	42.4	57.6	
	Col%	36.7	22.7	
None	N	141	351	492
	Row%	28.7	71.3	
	Col%	48.8	55.3	
Total		289	635	924

Chi-square = 21.6527 Df = 2 Prob. = 0.0000 **

TABLE 22. Kruskal Wallis 1-Way ANOVA by Ranks for Dispersion of Dover Sole from Tagging Point (in Nautical Miles) by Cruise.

Cruise	Avg Rank	Cases	Mean	SD
Spring	468.342	380	8.19	13.04
Fall	459.742	455	10.02	20.37
Winter	558.092	114	17.56	37.62

Valid Cases = 949 Chi Square = -164586 Df = 2

Corrected Chi Square for 53 sets of ties = -194233

Prob. = 0.0000 **

TABLE 23. Dover Sole Recoveries (R) by Recovery Depth, Sex and Tagging Cruise.

Cruise	Recovery Depth (fathoms)	Male R	Male % R	Female R	Female % R	Totals R	Totals % R
Spring							
	0 - 99	26	33%	179	62%	205	56%
	100 - 199	17	22%	44	15%	61	17%
	200 - 299	6	8%	26	9%	32	9%
	300 - 399	20	26%	29	10%	49	13%
	400 - 499	8	10%	7	2%	15	4%
	500 - 599	1	1%	3	1%	4	1%
	Totals	78	21%	288	79%	366	100%
Fall							
	0 - 99	45	27%	153	53%	198	44%
	100 - 199	31	19%	65	23%	96	21%
	200 - 299	36	22%	30	10%	66	15%
	300 - 399	40	24%	33	11%	73	16%
	400 - 499	9	5%	6	2%	15	3%
	500 - 599	3	2%	0	0%	3	1%
	Totals	164	36%	287	64%	451	100%
Winter							
	0 - 99	6	13%	4	6%	10	9%
	100 - 199	5	11%	8	12%	13	12%
	200 - 299	7	15%	14	22%	21	19%
	300 - 399	16	35%	19	29%	35	32%
	400 - 499	9	20%	14	22%	23	21%
	500 - 599	3	7%	6	9%	9	8%
	Totals	46	41%	65	59%	111	100%

TABLE 24. Tagging Depth Frequency Distributions of Released Dover Sole by Cruise, 1969-71.

Tagging Depth (fathoms)	Cruise: Spring Tagged	Spring %	Fall Tagged	Fall %	Winter Tagged	Winter %	Total Tagged	Total %
0 - 99	503	34%	796	36%	0	0%	1299	27%
100 - 199	195	13%	429	20%	11	1%	635	13%
200 - 299	86	6%	218	10%	8	1%	312	7%
300 - 399	483	32%	459	21%	726	69%	1668	35%
400 - 499	186	12%	284	13%	308	29%	778	16%
500 - 599	38	3%	0	0%	0	0%	38	1%
N	1491	32%	2186	46%	1053	22%	4730	

TABLE 25. Dover Sole Catch by Depth Strata for PMFC Area 1C for the Years 1966 - 1975.

YEAR	Pounds (thousands)			Metric Tons		
	0 - 199 fm	>= 200 fm	Total	0 - 199 fm	>= 200 fm	Total
1966	2405	3187	5592	1091	1446	2537
1967	2913	1145	4057	1321	519	1840
1968	4119	2151	6269	1868	976	2844
1969	3961	3716	7677	1797	1685	3482
1970	2692	6371	9063	1221	2890	4111
1971	2678	4419	7097	1215	2004	3219
1972	3392	6077	9469	1539	2756	4295
1973	2856	5490	8346	1295	2490	3786
1974	2830	6140	8970	1283	2785	4069
1975	2731	6196	8926	1239	2810	4049
Mean	3058	4489	7547	1387	2036	3423

TABLE 26. Chi-square Test of Sexual Maturity Stage by Recovery Depth for Tagged Dover Sole for Spring and Summer Recovery Quarters.

Spring Qtr

Recovery Depth (fm)	Males*		Females			Total
	50%	Mature	Immature	50%	Mature	
Under 100	17	8	0	97	30	152
100 - 199	21	3	1	46	6	77
200 - 299	9	7	1	19	4	40
300 - 399	16	16	0	21	4	57
400 - 499	5	10	0	4	5	24
Over 499	0	0	0	0	0	0
Totals	68	44	2	187	49	350

Chi-Square = 75.554 Df = 16 Prob. = 0.0000 **

Summer Qtr

Recovery Depth (fm)	Males*		Females			Total
	50%	Mature	Immature	50%	Mature	
Under 100	30	21	1	143	57	252
100 - 199	19	5	0	32	19	75
200 - 299	15	4	0	16	3	38
300 - 399	14	10	0	14	3	41
400 - 499	4	1	0	7	2	14
Over 499	2	1	0	3	3	9
Totals	84	42	1	215	87	429

Chi-Square = 47.663 Df = 20 Prob. = 0.0005 **

* Immature males category contained no releases

TABLE 27. Chi-square Test of Sexual Maturity Stage by Recovery Depth for Tagged Dover Sole for Fall and Winter Recovery Quarters.

Fall Qtr

Recovery Depth (fm)	Males*		Females			
	50%	Mature	Immature	50%	Mature	Total
Under 100	1	0	0	3	3	7
100 - 199	2	2	0	7	3	14
200 - 299	8	2	0	15	6	31
300 - 399	5	6	0	18	8	37
400 - 499	2	1	0	2	1	6
Over 499	1	3	0	1	1	6
Totals	19	14	0	46	22	101

Chi-Square = 13.467 Df = 15 Prob. = 0.5663 ns

Winter Qtr

Recovery Depth (fm)	Males*		Females			
	50%	Mature	Immature	50%	Mature	Total
Under 100	0	0	0	1	0	1
100 - 199	0	0	0	3	0	3
200 - 299	2	2	0	4	2	10
300 - 399	4	5	0	9	4	22
400 - 499	3	0	0	5	1	9
Over 499	0	0	0	1	0	1
Totals	9	7	0	23	7	46

Chi-Square = 9.226 Df = 15 Prob. = 0.8654 ns

* Immature males category contained no releases

TABLE 28. Dover Sole Recoveries by Recovery Depth, Recovery Quarter and Tagging Depth for Stages of Sexual Maturity.

Tagging Depth (fm)	Recovery Quarter	Recovery Depth (fm)	Sexual Maturity: Males 50%	Males Mature	Males Immature	Females 50%	Females Mature	Totals
0 - 199	Winter	0 - 199	0	0	0	1	0	1
		over 199	3	1	0	9	2	15
	Spring	0 - 199	33	8	1	140	36	218
		over 199	12	2	1	29	5	49
	Summer	0 - 199	40	16	1	169	72	298
		over 199	7	2	0	11	5	25
	Fall	0 - 199	3	1	0	9	6	19
		over 199	2	3	0	20	7	32
Over 199	Winter	0 - 199	0	0	0	3	0	3
		over 199	6	6	0	10	5	27
	Spring	0 - 199	5	3	0	3	0	11
		over 199	18	31	0	15	8	72
	Summer	0 - 199	9	10	0	6	4	29
		over 199	28	14	0	29	6	77
	Fall	0 - 199	0	1	0	1	0	2
		over 199	14	9	0	16	9	48
Totals			180	107	3	471	165	926

TABLE 29. Dover Sole Recoveries (R) by Tagging Cruise and Recovery Year.

	Cruise							
	Spring		Fall		Winter		Total	
Recovery Year	R	% R	R	% R	R	% R	R	% R
1969	170	35.6%	47	7.8%	-	-	217	17.6%
1970	138	28.9%	239	39.7%	-	-	377	30.5%
1971	75	15.7%	128	21.3%	38	24.4%	241	19.5%
1972	48	10.1%	64	10.6%	40	25.6%	152	12.3%
1973	16	3.4%	46	7.6%	23	14.7%	85	6.9%
1974	14	2.9%	38	6.3%	15	9.6%	67	5.4%
1975	3	0.6%	9	1.5%	16	10.3%	28	2.3%
1976	3	0.6%	14	2.3%	6	3.8%	23	1.9%
1977	2	0.4%	7	1.2%	6	3.8%	15	1.2%
1978	1	0.2%	4	0.7%	2	1.3%	7	0.6%
1979	1	0.2%	4	0.7%	2	1.3%	7	0.6%
1980	4	0.8%	2	0.3%	0	0.0%	6	0.5%
1981	1	0.2%	0	0.0%	2	1.3%	3	0.2%
1982	0	0.0%	0	0.0%	1	0.6%	1	0.1%
1983	0	0.0%	0	0.0%	1	0.6%	1	0.1%
1984	1	0.2%	0	0.0%	4	2.6%	5	0.4%
N	477	38.6%	602	48.7%	156	12.6%	1235	

TABLE 30. Length Frequencies of Dover Sole by Sex from Biological Samples of Selected Hauls from All Cruises, 1969 - 71.

Total Length (mm)	Male No.	Male %	Female No.	Female %	Total No.	Total %
160			1	1%	1	0%
80			1	1%	1	0%
200			0	0%	0	0%
20	1	1%	2	2%	3	1%
40	1	1%	1	1%	2	1%
60	1	1%	0	0%	1	0%
80	10	5%	7	8%	17	6%
300	29	15%	8	9%	37	13%
320	58	30%	31	35%	89	32%
40	80	42%	31	35%	111	40%
60	4	2%	1	1%	5	2%
80	3	2%	1	1%	4	1%
400	2	1%	1	1%	3	1%
20	1	1%	0	0%	1	0%
40	1	1%	1	1%	2	1%
60			1	1%	1	0%
80			0	0%	0	0%
500			1	1%	1	0%
N	191	68%	88	32%	279	100%
MEAN	335		330		333	
SD	25		44		33	

TABLE 31. PMFC Area 1C and 2A Dover Sole Sample Data by Year, Quarter Year and Sex.

	Quarter Year											
	I			II			III			IV		
Year	Females	Males	%Males	Females	Males	%Males	Females	Males	%Males	Females	Males	%Males
1974												
Numbers	134	315	62	361	365	50	376	299	44	83	92	53
Ave Len (mm)	439	401		417	393		414	387		449	406	
1975												
Numbers	63	86	58	193	307	61	203	196	49	119	81	41
Ave Len	419	338		424	384		421	383		380	387	
1976												
Numbers	88	60	41	219	131	37	203	97	32	88	62	41
Ave Len	397	391		405	371		409	380		432	379	
1977												
Numbers	23	27	54	213	187	47	405	245	38	102	98	49
Ave Len	411	366		405	378		405	370		428	386	
1978												
Numbers	78	122	68	320	280	46	339	114	25	118	82	41
Ave Len	432	392		422	385		410	383		397	376	
1979												
Numbers	63	237	79	109	41	27	191	59	24	-	-	-
Ave Len	444	398		412	370		418	382		-	-	
1980												
Numbers	-	-	-	578	565	50	617	533	46	253	347	58
Ave Len	-	-		400	373		402	375		401	371	
1981												
Numbers	151	199	57	322	428	57	542	660	55	441	359	45
Ave Len	414	379		411	386		408	376		403	396	
1982												
Numbers	206	243	54	119	281	70	138	113	45	104	146	58
Ave Len	402	374		427	381		409	383		425	381	
1983												
Numbers	87	163	65	597	478	44	344	156	31	188	166	47
Ave Len	398	379		402	378		397	381		427	388	