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Canadian Atlantic Fisheries Scientific Advisory Committee

CAFSAC Research Document 83/70

Comité scientifique consultatif des pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 83/70

Herring Spawning Bed Survey in Miramichi Bay, N.B., in Spring 1983

by

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Abstract

A herring spawning bed was located by scuba diving in Escuminac, Miramichi Bay, N.B. on May 20, 1983. The bed extended 2200 m along the shoreline with mean offshore width of 400 m. Herring eggs were distributed over a depth range of 0.8 - 3.3 m. The substrate was rocky with sandy patches, and covered mostly with Irish Moss (Chondrus sp.) and to a lesser extent Rockweed (Fucus sp.). Mean bottom temperatures during spawning were 5.5 - 9.3 °C. Of all herring eggs collected, a mean of 3.9% were not viable.

Intensity of egg deposition was variable, ranging from a few scattered eggs to small clumps 4.5 layers deep. Mean egg deposition over the entire spawning bed was calculated as 24,666 eggs/m^2. Estimates of the number of herring required to produce the surveyed spawning bed were $7.20 \times 10^5 \pm 2.2 \times 10^5$ minimum and $4.40 \times 10^6 \pm 2.4 \times 10^6$ maximum. These numbers correspond to 151.3 ± 46.8 mt and 936.2 ± 510.6 mt, respectively. Herring catch in the vicinity of the spawning bed was estimated as 4800 mt.

The estimated size of herring spawning population in Miramichi Bay in the 1983 survey is much less than that of the Chaleur Bay survey in 1962 (Tibbo et. al. 1963). In 1962 herring catch in Chaleur Bay was only 998 mt representing an exploitation rate of 1-4%. In contrast, the exploitation rate in Miramichi Bay in 1983 ranged between 83.7 and 96.9%. In light of this very high rate of exploitation, it is obvious that the fishery is in a serious condition.

Résumé

Une frayère de hareng a été localisée par plongeurs autonomes près d'Escouminac, dans la baie Miramichi (N.-B.) le 20 mai 1983. Cette frayère s'étendait sur une longueur de 2 200 m le long de la ligne de rivage, la largeur moyenne étant de 400 m. Les oeufs étaient répartis à une profondeur de 0,8-3,3 m. Le substrat était rocheux avec plages sablonneuses, recouvert en grande partie de mousse d'Irlande (*Chondrus* sp.) et, à un degré moindre, de fucus (*Fucus* sp.). Au moment de la ponte, les températures moyennes du fond étaient de 5,5-9,3 °C. 3,9% en moyenne des oeufs de hareng recueillis n'étaient pas viables.

Les oeufs ont été déposés avec une intensité variable, allant de quelques oeufs éparpillés à de petites masses de 4,5 couches d'épaisseur. On a estimé à 24 666 oeufs/m^2 la déposition moyenne sur toute l'étendue de la frayère. Le nombre de harengs requis pour produire une telle frayère a été estimé à un minimum de $7,20 \times 10^5 \pm 2,2 \times 10^5$ à un maximum de $4,40 \times 10^6 \pm 2,4 \times 10^6$. Ces nombres correspondent à $151,3 \pm 46,8$ tm et $936,2 \pm 510,6$ tm respectivement. Les prises de hareng dans le voisinage de la frayère ont été estimées à 4 800 tm.

La taille estimée de la population de harengs reproducteurs dans la baie Miramichi lors du relevé de 1983 est de beaucoup inférieure à celle observée dans la baie des Chaleurs en 1962 (Tibbo *et al*. 1963). En 1962, les prises de hareng à ce dernier endroit n'avaient été que de 998 tm, soit un taux d'exploitation de 1-4%. Par contraste, le taux d'exploitation dans la baie Miramichi en 1983 a été de 83,7-96,9%. Avec un taux d'exploitation aussi élevé, il est évident que cette pêcherie est en mauvais état.

INTRODUCTION

Previous surveys of herring spawning beds in the Western Gulf of St. Lawrence have provided data on spawning habitat, incubation period, natural mortality of eggs, and intensity of spawning (Tibbo et al. 1963; Pottle et al.,1980; Messieh et al.,1981)

The 1983 survey was conducted to collect data on spawning bed habitat, size of the spawning area, and to estimate spawning stock biomass. It was uncertain whether significant spring spawning activity still occurred in the Escuminac area, given the recent decline in landings and the apparent absence of a spawning bed in the area in 1981. The last year of extensive egg deposition (observed but not quantified) was 1979 (Messieh et al., 1981). It was believed that there was a good chance for the 1979 year-class (4 year olds) entering the fishery as first recruit spawners in 1983.

MATERIALS AND METHODS

Search Area and Procedure

The search for herring spawning beds was restricted to the south shore of Miramichi Bay, between the junction of Fox and Huckleberry Islands and Herring Cove, about 5 km east of the Escuminac wharf (Fig. 1). Historical data and previous surveys have indicated that this was the major spring spawning area. A search grid with 200 m between stations was plotted on a hydrographic field sheet of the study area, extending up to 1.9 km offhsore and covering about 10 km of shoreline. LORAN C bearings were determined for each transect line parallel to shore and for each position on the search grid. LORAN C accuracy is approximately ± 20 m.

On April 27 divers started to determine the outer (seaward) boundary of algal cover along the designated area of shoreline and plotted areas of algal cover on the hydrographic charts. Searches for herring spawn were then confined to these areas as previous studies had indicated that substrate with abundant macrophytes is required for spawning (Pottle et al., 1980). Surface and bottom temperatures were recorded periodically throughout the survey. Regular searches for spawning beds were conducted from 30 April until 20 May, when a single spawning bed was located. During this period part of Bay du Vin was also searched (9 May). Particular attention was given to the 1980 spawning area off Huchkleberry Island. On May 19 fishermen reported that the herring schools had arrived, and a large spawning bed was located east of Escuminac wharf, the following day (Fig. 2).

Divers located and marked the perimeter of the spawning bed with buoys. Their positions were determined with LORAN C, and plotted on the hydrographic field sheet. Between 22 and 26 May the entire historical spawning area, plus Herring Cove and Escuminac were checked for additional spawning beds but none were found.

Quadrat Sample Collection

A 200 m interval sampling grid was plotted on the spawning bed with 35 stations within the bed and 18 stations outside the perimeter as a check on the accuracy of boundary determination. The three transect lines closest and parallel to shore were only 100 m apart (Figure 2). A 200 x 200 m section of the spawning bed was selected for intensive study, with 25 stations 1A-5E (Fig. 2) on a 50 m interval grid pattern. Quadrat sampling began at this site on May 26.

At each station the diver collected all algae and small rocks within a randomly placed 0.25 m^2 quadrat. A small airlift operated by compressed air from the diver's tank propelled loose material and algae scraped from the substrate into special bags. Large rocks with attached eggs were placed in separate bags. Sample bags were labelled and placed in containers of 5% formalin aboard the tender. The diver described the substrate type, algae cover, and intensity of egg deposition.

Sampling was completed on 30 May. A second set of quadrat samples was collected at stations 1A-5E on the small site on 01 June.

Quadrat Sample Analysis

Each 0.25 m^2 quadrat sample was partitioned into major macrophyte species with attached epiphytes, loose herring eggs and rocks. The sample bags were rinsed in large trays to remove adhering eggs and algae. Attached eggs were removed from algae or rock with blunt probes and the quantity obtained was determined by either direct count or, in case of large samples, by volumetric measurement referred to a previously caliberated standard of 295 loosely packed eggs /ml. Wet weight of algae was determined to the nearest 0.1 g after attached herring eggs were removed. Subsamples of about 20 ml of eggs were retained for staging and determination of natural mortality.

Quadrat sample data were transformed to equivalent values per m^2. Regressions of number of herring eggs /m^2 on total wet wt. of algae /m^2 were calculated for the two sets of samples from the small study site, and for the entire spawning bed. Regressions of number of herring eggs attached to algae (as opposed to total number) /m^2 were also calculated for these data sets. Additional regressions of number of eggs m^2 attached to Chondrus crispus on wet wt. of Chondrus/m^2 were calculated for the two data sets from the small site. There were insufficient quadrat samples containing Phyllophora sp. and Fucus sp. for regressions to be performed for egg attached to these species. Contour plots of total macrophytes /m^2 and total number of eggs /m^2 were generated from these data sets.

RESULTS

The single spawning bed located 0.8 km east of Escuminac wharf on 20 May, extended 2200 m along the shoreline with a maximum offshore width of about 650 m, mean offshore width of 400 m, and covered an area of about 0.88 km^2 (Fig. 2). Herring eggs were distributed over a depth range of 0.8 - 3.3 m (Table 1). The perimeter of the bed corresponded approximately to the offshore limit of algal cover.

The substrate can be described as rocky with sandy patches. Irish moss (Chondrus crispus) was the dominant macrophyte, constituting 81.9% of the total wet wt. of algae collected. Rockweed (Fucus sp.) accounted for 15.8% of the total wet wt. of algae. Macrophyte biomass for the entire bed and for the study site is detailed in Table 2.

Visual estimates of algal cover for the 35 stations within the spawning bed area averaged 26.5%. The mean estimate for 18 stations outside the perimeter was 14.7% with macrophytes absent at all but 6 stations. Mean estimates of algal cover for the two surveys of the small study site were 21.2% and 37.5%. Although there was considerable variation in figures for macrophyte biomass in the two data sets from the small study site, the two contour plots generated (Figure 3 A,B) show the same general pattern of macrophyte distribution.

Intensity of herring egg deposition varied, ranging from a few scattered eggs to small clumps 4-5 layers deep. Estimates of herring egg deposition are presented in Table 3. With regard to the estimate of egg abundance outside the spawning bed perimeter, two samples were omitted. These are believed to represent forced spawning sites (i.e. no algal cover and close to gill-nets, mean egg deposition of 13.0/m^2). The two contour plots for egg distribution at the study quadrat area (Figure 4 A,B) were markedly similar despite the considerable decrease in egg abundance between the two survey dates.

Developmental stages of Herring Eggs

Several samples of eggs were obtained for staging between the discovery of the spawning bed on 20 May and the start of quadrat sampling on 26 May. Data from these samples are presented in Table 4.

Data from the three quadrats collected between May 26 and June 1 are presented in Table 5. One week after discovery of the spawning bed 73.7% of the eggs were in stages 3 and 4 according to Baxter's (1971) scale. After 12 days 93.2% of the eggs were in stage 5. Hatching appeared to be complete by June 3. Water temperature data for the incubation period are presented in Table 6. Of about 3,500 eggs examined from the three quadrat sample collections, a mean of 3.9% were not viable (Table 5).

Egg Distribution in Relation to Algal Cover

Only 53.5% of the eggs collected were attached to macrophytes. Of the remainder, 0.2% were attached to bare substrate and 46.3% were loose. Whether the latter were disloged during collection and subsequent handling of samples or were unattached initially due to forced spawning by gillnet obstruction is unknown. Significant numbers of eggs on bare rock were recorded at only two sampling sites, both outside the plotted perimeter of the spawning bed as mentioned previously.

All regression of eggs attached to algae/m^2 on wet wt. of algae/m^2 were significant ($p < 0.01$; Table 7). There was also a significant association of total number of eggs /m^2 and algal biomass for both surveys of the small site and for the survey of the entire spawning bed.

Estimated numbers of Herring Eggs and Spawning Biomass

Given that the area covered by the Escuminac spawning bed was 0.88 km^2, mean egg depositions over the entire spawning bed (data from 35 stations in the 200 m interval survey grid) and in the small study site (1^{st} survey) were calculated as 24,666 eggs/m^2 and 155,398 eggs/m^2, respectively. This gives an estimate of 2.17×10^{10} eggs as a minimum total number and a maximum of 1.37×10^{11} eggs in the entire surveyed area (Table 8).

A mean fecundity of 6.1×10^4 eggs/female herring and 1:1 sex ratio in the spawning population were assumed. The resulting estimates of the number of herring of both sexes required to produce the surveyed spawning bed were $7.20 \times 10^5 \pm 2.2 \times 10^5$ minimum and $4.40 \times 10^6 \pm 2.40 \times 10^6$ maximum. These numbers correspond to 151.3 ± 46.8 mt and 936.2 ± 510.6 mt, respectively.

Herring catch from the spring fishery in this area was about 4000 mt (provisional estimate). This does not include an estimated 800 mt which were dumped because of poor markets.

DISCUSSION

The physical characteristics of the Escuminac spawning bed were similar to those of previously described Gulf of St. Lawrence sites at Huckleberry Island, Miramichi Bay (Pottle et al.,1981) and Blanchard Point, Chaleur Bay (Tibbo et al.,1963). All were located on substrates consisting primarily of rubble and bedrock, and with Chondrus as the principal macrophyte. Although maximum depth of Escuminac spawning bed was less than those recorded at the other sites, this was due to absence of significant algal cover at greater depths. The Escuminac bed was larger than those surveyed at Huckleberry Island and Blanchard Point.

As indicated in previous surveys there was a relationship between degree of algal cover and intensity of herring egg deposition. This relationship holds both for eggs attached to algae and for total eggs. "Natural" spawning beds can be distinguished from "Forced" spawning beds by the presence or absence respectively of a significant relationship between egg deposition and macrophyte biomass. Despite the variability in figures for macrophyte biomass from repeat sampling of the same stations at the small study site, there was a significant correlation between the two data sets ($p < 0.01$; $r = 0.57$, df = 23). This and the similarity of the contour plots (Figure 3 A,B) suggest that the general pattern of macrophyte distribution was correct. A significant correlation between data sets for egg distribuion was also obtained ($p < 0.01$, $r = 0.66$, df = 23), indicating that the repeatability of sampling was good.

Natural herring egg mortality was less than 5%. A 72.3% reduction in mean number of eggs/m^2 is apparent at the small study site between 27 May and 01 June. The decrease in mean number of eggs/m^2 can be largely attributed to hatching. As was the case in previous surveys hatching appeared complete within 17 days after spawning. This was the first occasion on which it was possible to determine the actual duration of incubation period, having found the spawning bed when the eggs were in stage I.

The size of the Miramichi Bay area surveyed for spawning in 1983 was larger than any previous spawning surveys in the Gulf of St. Lawrence. The intensity of egg deposition was much larger than those in 1980 and 1981, but far less than that reported by Tibbo et al., (1963) for the Chaleur Bay spawning in 1962. In 1982 no spawning survey was conducted in Miramichi Bay, but reports from the fishermen indicated a low spawning activity during that year. It is tempting to attribute the relatively large spawning bed in 1983 in part to the recruitment of the 1979 year class. Spawning activity was widespread in 1979 as observed by scuba divers although quantitative data on egg deposition are lacking (Messieh et al., 1981).

As expected, the egg intensity on the spawning bed varied largely between stations. On average, egg intensity and algal cover were higher in the small study site than in other stations on the spawning bed. Therefore, two estimates of egg intensity representing minimum and maximum values were calculated.

Estimates of the herring population size showed that the spawning population in Miramichi Bay in 1983 was much lower than that of Chaleur Bay in 1962 (Tibbo et al., 1963). The latter was estimated at 24,812 mt compared to only 151.3 - 936.2 mt in 1983. The large difference would raise concern about the status of herring stocks and the future of the fishery. This is particularly critical in view of the fact that exploitation rates differed drastically between the 1960's and the 1980's. In 1962 herring catch in Chaleur Bay was only 998 mt representing an exploitation rate of 1 - 4% (Tibbo et al., 1963). In contrast, herring catch in Miramichi Bay in spring 1983 was 4800 mt, representing exploitation rate of 83.7 - 96.9%. These rates of exploitation are alarmingly high.

In light of these findings, it is obvious that the herring fishery is in a serious condition. The level of exploitation is about 4 times higher than that required to stabilize the population, as recommended by CAFSAC and ICES for herring fisheries. The continuation of this high rate of exploitation will no doubt have a negative effect on rebuilding the herring stocks. This situation requires an immediate remedial action.

ACKNOWLEDGMENTS

The herring spawning bed survey was carried out under D.S.S. Contract No. 07SC FP 630-3-8003, by Murdoch, Pottle and MacPherson Marine Services. The diving tender "Mysis" was on loan from the St. Andrews Biological Station. P. MacPherson, T. Hurlbut, C. Bourque, J. Stairs and B. Gill conducted the diving operation.

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TABLE 1 Depth (MLW) at selected stations on the perimeter of and within the spawning bed. See fig. 2 for the locations of these stations.

Station	Depth(m)	Station	Depth(m)
7	2.6	30	1.4
14	2.4	33	2.1
18	2.1	36	1.1
21	3.3	39	0.8
23	2.7	41	0.8

TABLE 2 Details of the macrophyte biomass in the spawning area (g/m^2)

Sample Area	Stations	$\overline{X}$	S.E.	Range
Entire Bed	35	436.4	81.8	0.0 -1,969.9
Outside Perimeter	18	198.0	96.5	0.0 -1,475.0
Small Site (1st survey)	25	518.1	112.8	6.7 -2,422.9
Small Site (2nd survey)	25	661.6	95.5	61.9 -2,264.0

TABLE 3 Details of herring egg deposition in the spawning area in number of eggs/m^2.

Sample Area	Stations	$\overline{X}$	S.E.	Range
Entire Bed	35	24,666.0	7,448.1	0.0-170,583.9
Outside Perimeter	18	5,159.3	3,571.2	0.0-52,813.8
Small site (1st survey)	25	155,397.7	85,643.5	696.0-2,174,60
Small site (2nd survey)	25	43,030.0	9,894.0	40.0-184,176.4

TABLE 4 Developmental stages of eggs examined before commencement of quadrat sampling.

Date	Stage of Development 1	2	3	4	5	Non-fertile
20 May	364	0	0	0	0	33
20 May*	232	0	0	0	0	2
21 May	0	0	0	0	0	100
23 May	14	1	131	0	0	6
25 May	0	0	1	172	0	3

* forced spawning site

TABLE 5 Developmental stages of herring (*Clupea harengus* L.) eggs collected on the spawning bed between May 26 and June 1,1983. Data are from 50-60 egg subsamples of quadrat samples.

	Date	Stage of Development 1	2	3	4	5	Non-fertile
A. Relative Frequency							
	May 26,27	0	22	450	487	272	42
	May 29,30	4	7	16	30	1027	55
	June 1	1	4	7	22	1026	41
B. % of Total	Date	1	2	3	4	5	Non-fertile
	May 16,27	0.0	1.7	35.4	38.3	21.4	3.3
	May 29,30	0.4	0.6	1.4	2.6	90.2	4.8
	June 1	0.1	0.4	0.6	2.0	93.2	3.7

TABLE 6 Surface and bottom temperatures in the Miramichi Bay search area (07 - 19 May) and at the Escuminac spawning site (20 May - 04 June)

Date	Surface Temp. (°C)	Bottom Temp. (°C)
07 May	6.0	0.0
11 May	-	4.0
15 May	7.0	5.1
16 May	7.3	7.2
18 May	7.0	4.0
19 May	7.3	6.0
20 May	7.0	6.5
21 May	6.5	6.5
23 May	7.0	7.0
24 May	5.5	5.5
26 May	8.5	7.5
27 May	8.5	8.5
01 June	9.0	7.5
04 June	9.7	9.3

TABLE 7 Results of regressions of number of herring eggs/m^2 on wet weight of algae/m^2.

Regression	r	df	p
Entire Spawning Bed			
1) Total Eggs on Total Algae	0.48	39	<0.01
2) Attached Eggs on Total Algae	0.45	39	<0.01
Small Site 1st Survey			
1) Total Eggs on Total Algae	0.48	23	<0.05
2) Attached Eggs on Total Algae	0.56	23	<0.01
3) Eggs on *Chondrus* on Wt. of *Chondrus*	0.58	23	<0.01
Small Site - 2nd Survey			
1) Total Eggs on Total Algae	0.53	23	<0.01
2) Attached Eggs on Total Algae	0.56	23	<0.01
3) Eggs on *Chrondus* on Wt. of *Chondrus*	0.62	23	<0.01

Table 8. Estimates of spawning herring biomass in Miramichi Bay based on the spawning bed survey, 1983.

	Number of eggs		Number of fish		Spawning biomass(mt)	
	$\bar{X}$	S.E.	$\bar{X}$	S.E.	$\bar{X}$	S.E.
Sample Area						
Entire Bed	2.17×10^{10}	$.65 \times 10^{10}$	7.20×10^{5}	2.20×10^{5}	151.3	46.8
Small Site (1st survey)	1.37×10^{11}	$.75 \times 10^{11}$	4.40×10^{6}	2.40×10^{6}	936.2	510.6

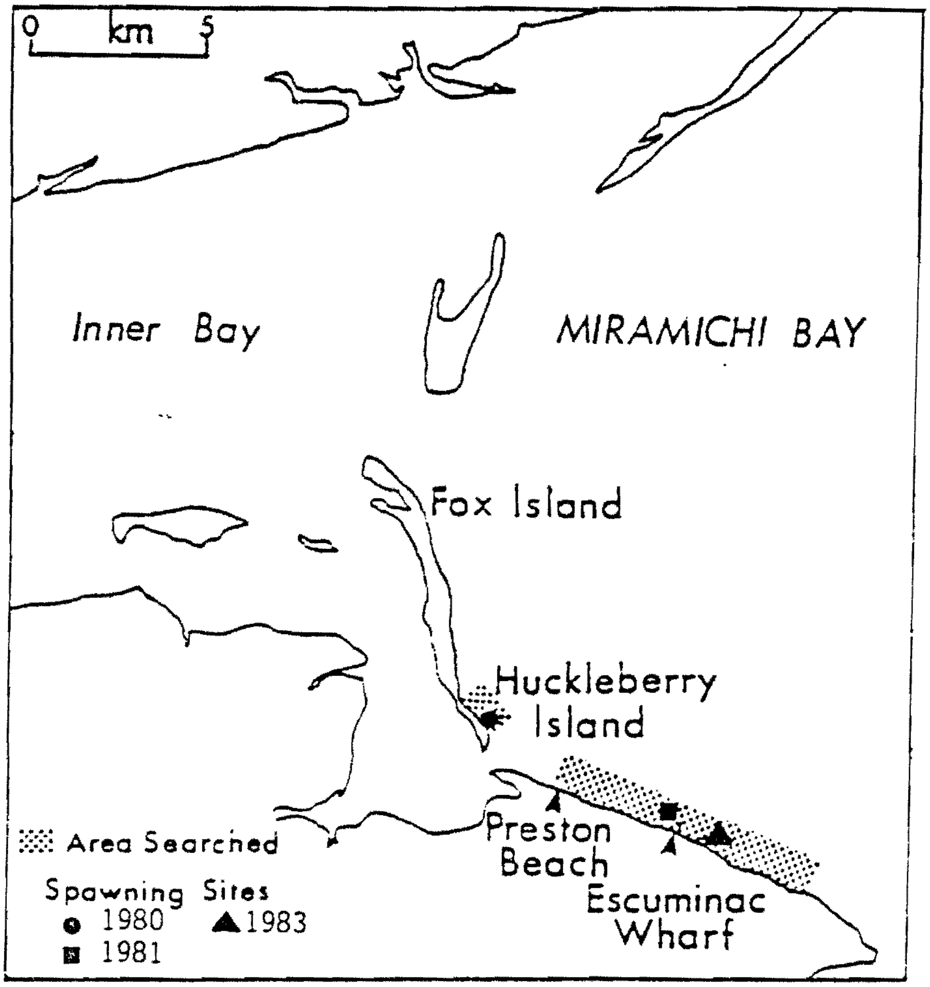


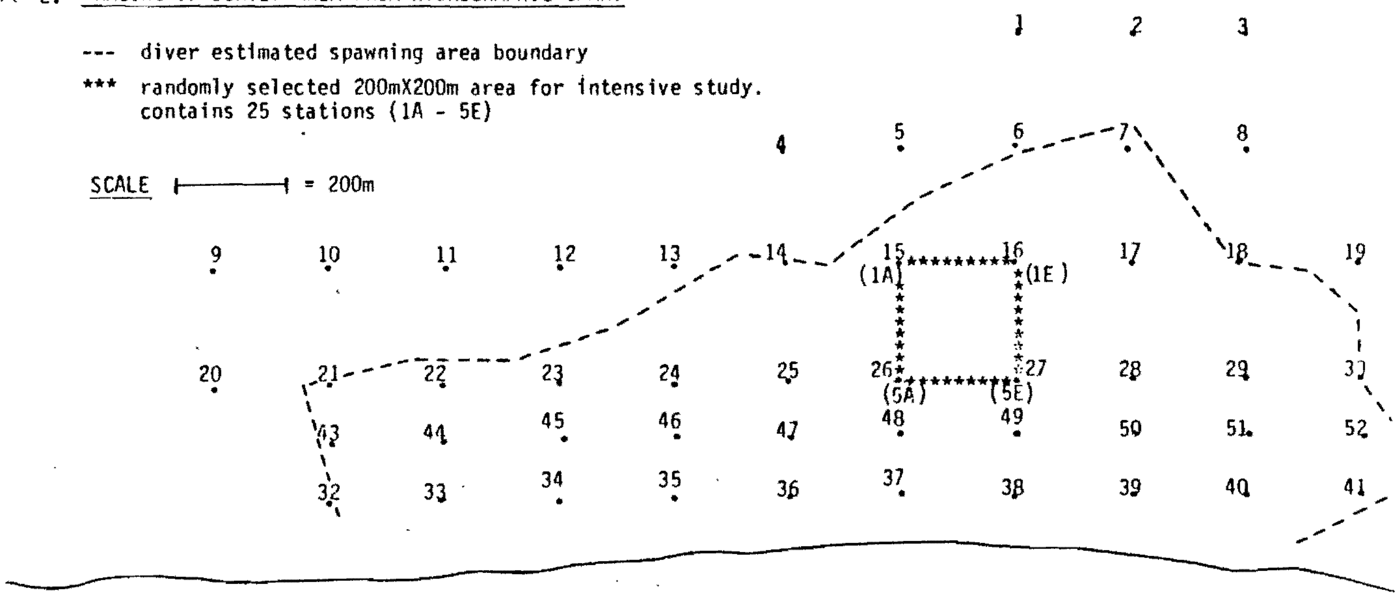
Figure 1. Map of the 1983 search areas in Miramichi Bay, N.B. and locations of areas of herring egg deposition surveyed in 1980, 1981 and 1983.

Figure 2. TRACING OF SURVEY AREA FROM HYDROGRAPHIC CHART

--- diver estimated spawning area boundary

*** randomly selected 200mX200m area for intensive study. contains 25 stations (1A - 5E)

SCALE |———| = 200m



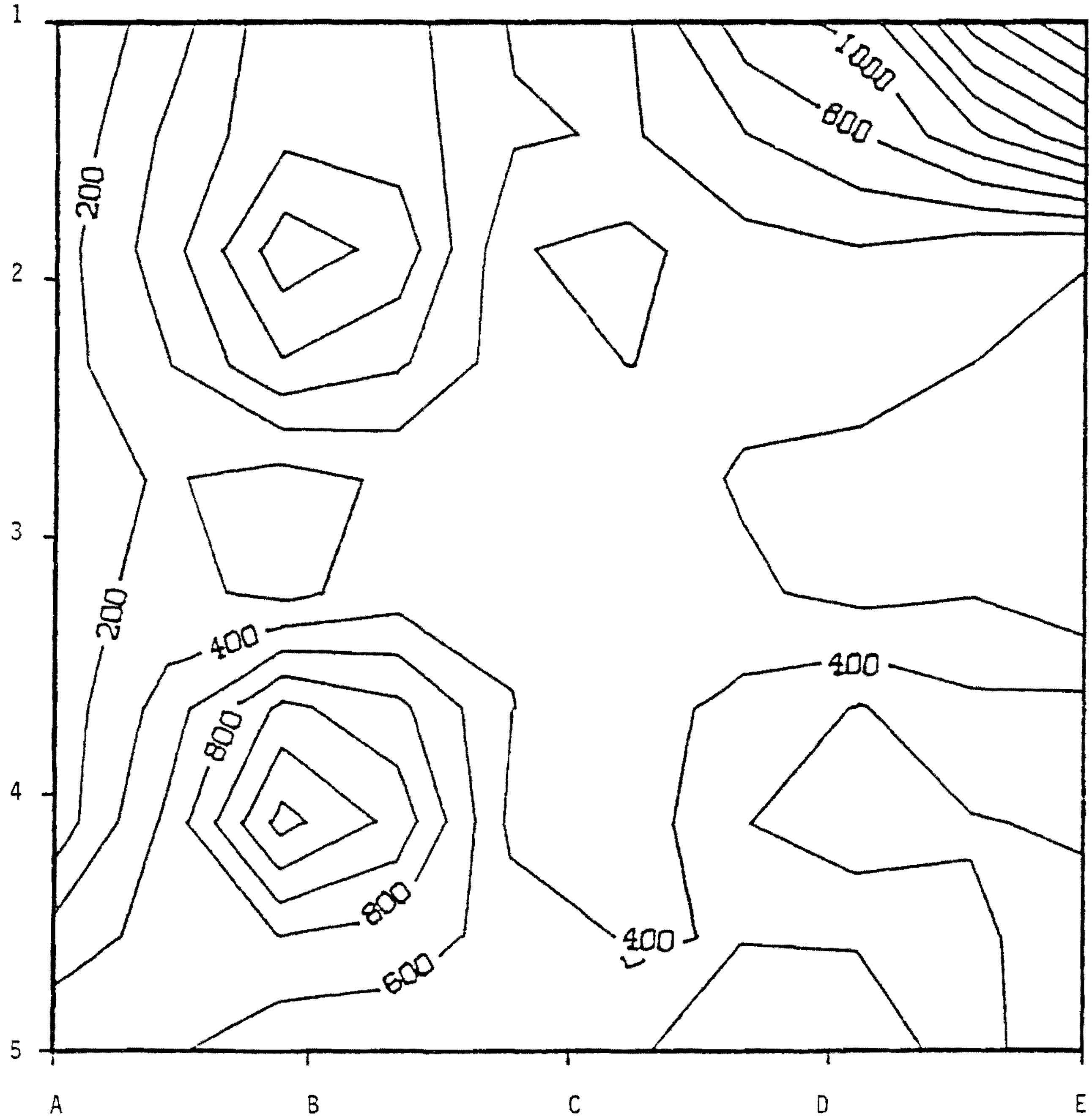
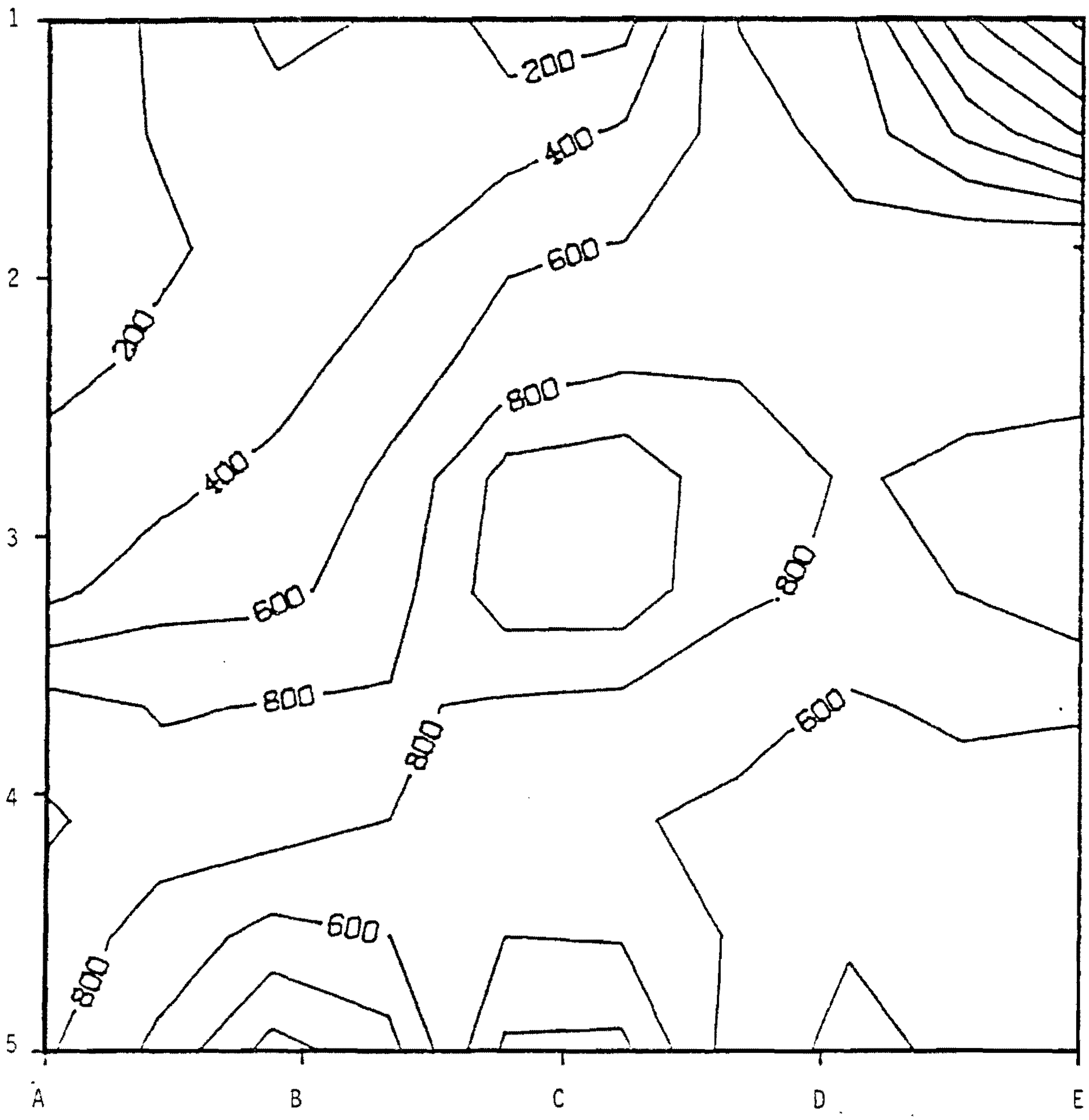


Figure 3(A). A contour plot showing algal intensity on the herring spawning bed during the first survey.



Figre 3(B). A contour plot showing algal intensity on the herring spawning bed during the second survey.

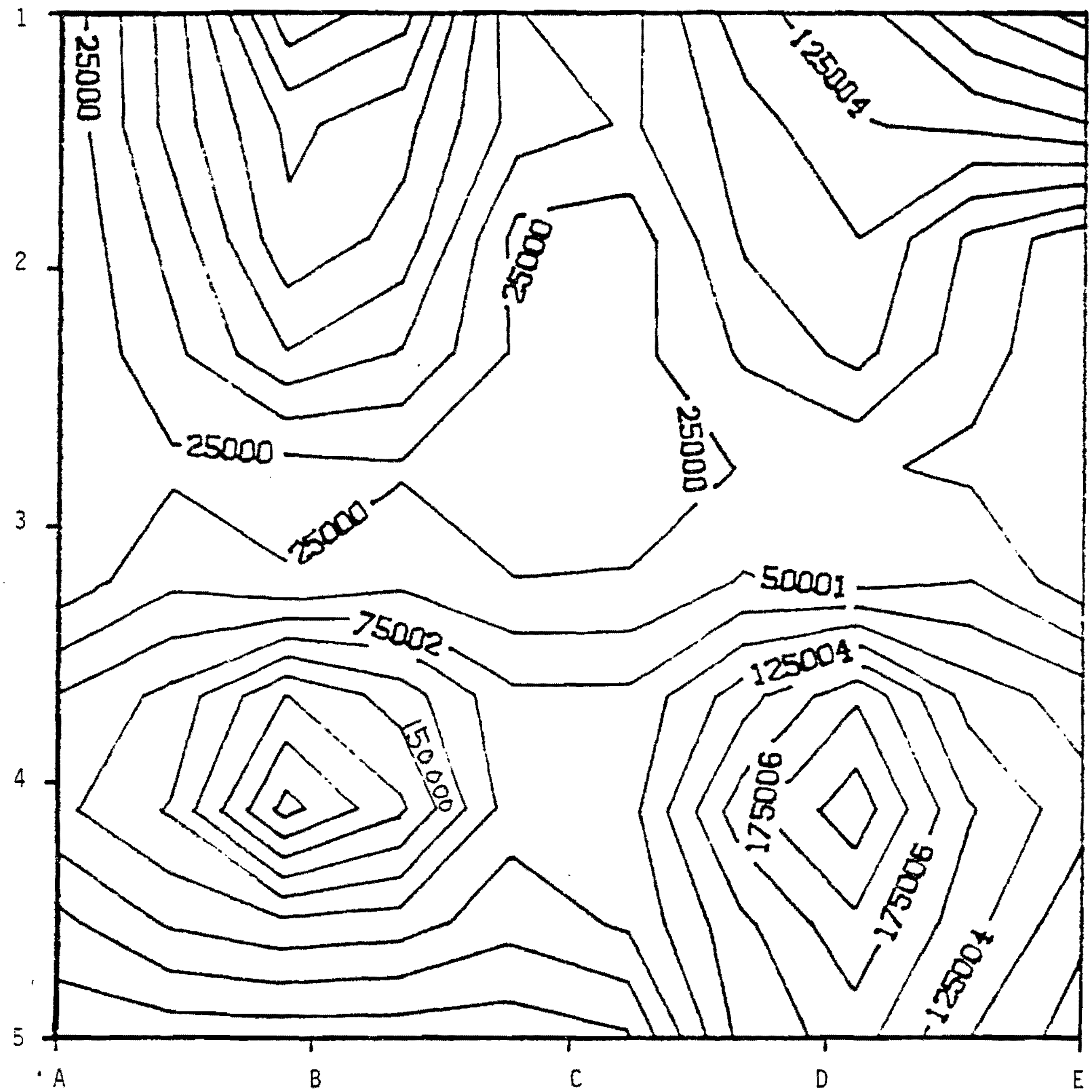


Figure 4(A). A contour plot showing intensity of herring egg deposition in the first survey.

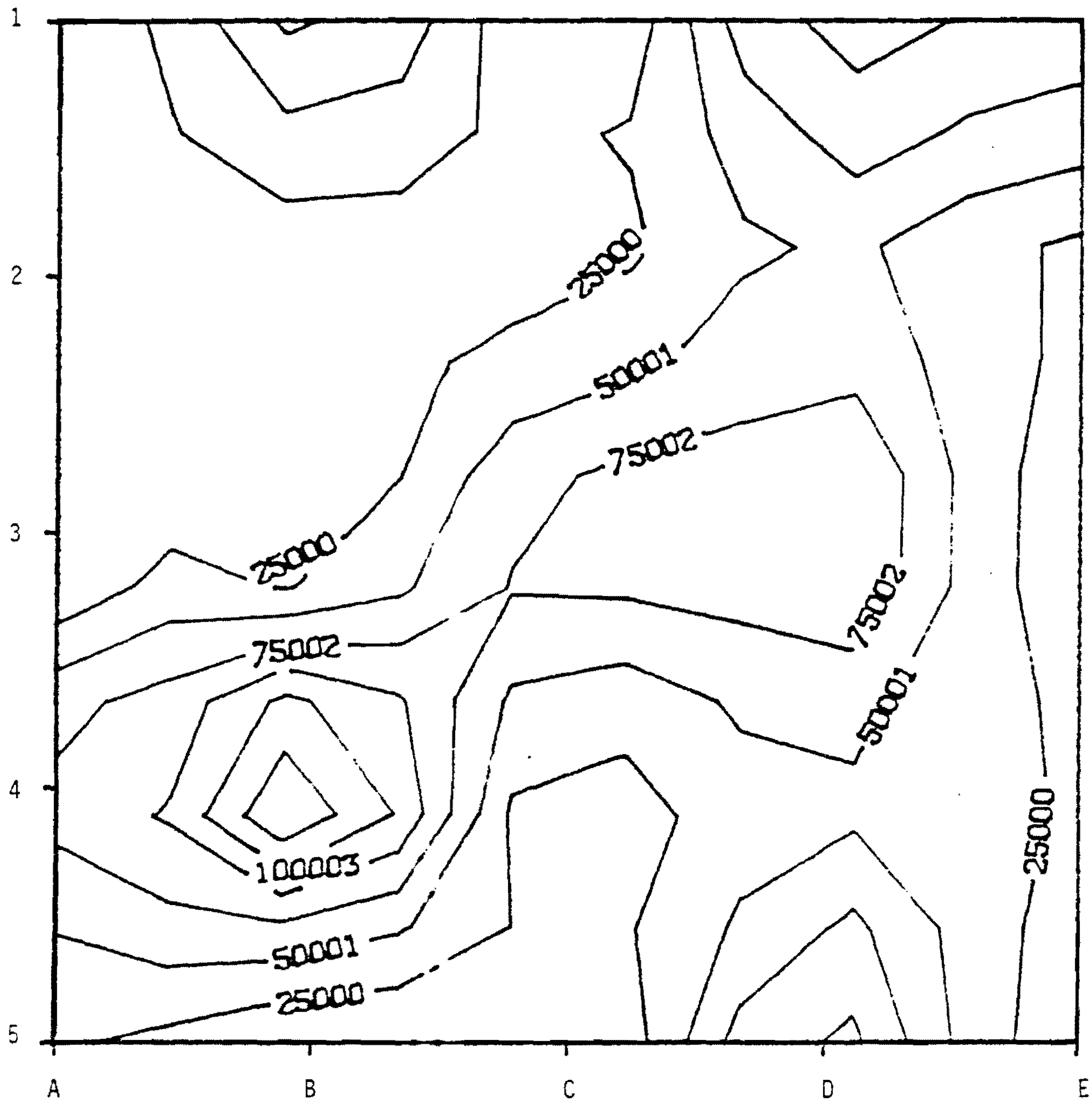


Figure 4(B). A contour plot showing intensity of herring egg deposition in the second survey.