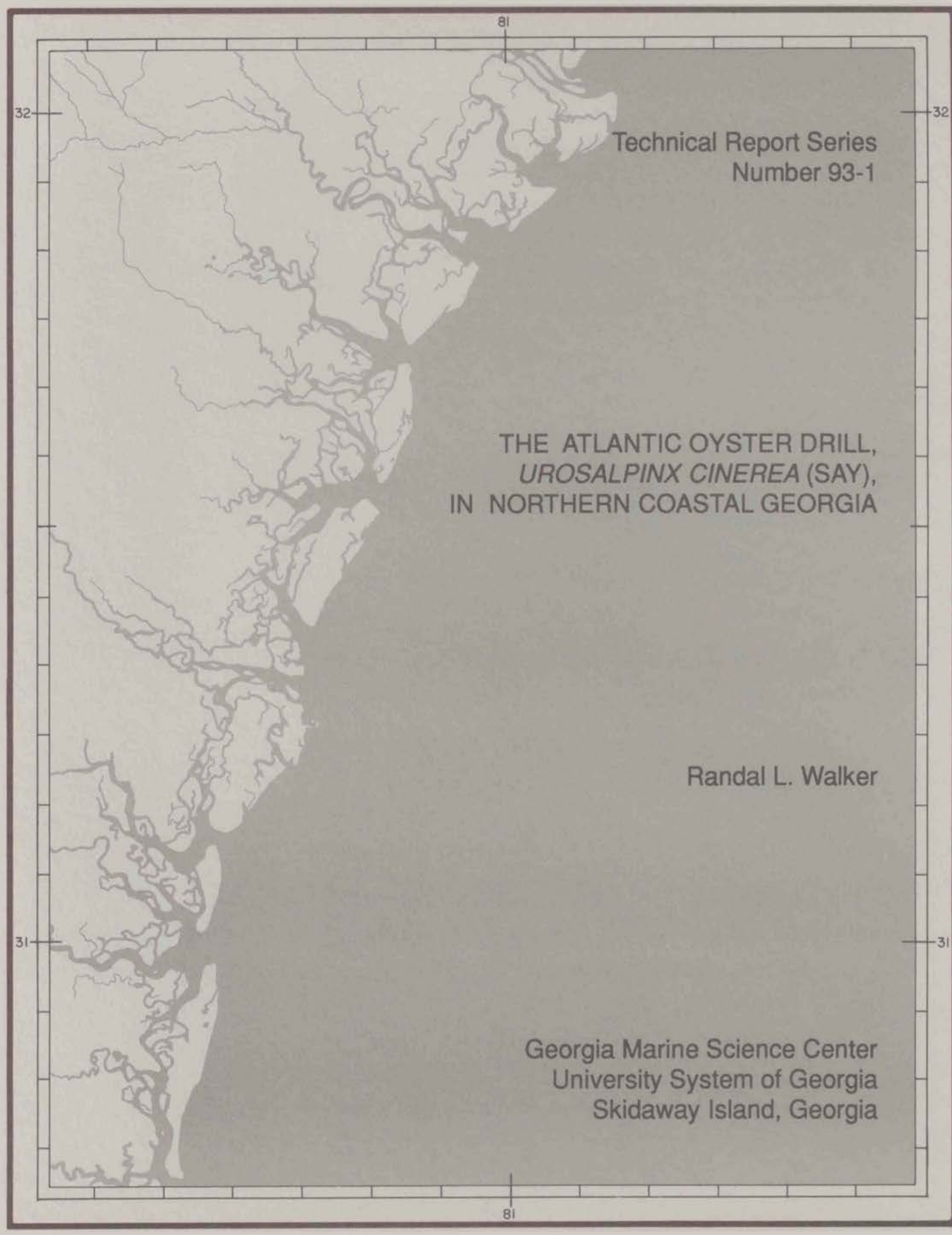

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THE ATLANTIC OYSTER DRILL, *UROSALPINX CINEREA* (SAY), IN NORTHERN COASTAL GEORGIA

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The Atlantic Oyster Drill,

Urosalpinx cinerea (Say),

in northern coastal Georgia

Technical Report 93-1

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ABSTRACT

A survey of the Sapelo Sound to Wassaw Sound area of coastal Georgia was conducted to determine the distribution and abundance of the Atlantic oyster drill, *Urosalpinx cinerea* (Say). Oyster drills were found to be abundant intertidally and widespread throughout the higher saline areas of this northern third of coastal Georgia. Drills occur at a larger size ($\bar{x}$ = 26.6 mm) in coastal Georgia than that reported for populations in more northern U.S. coastal areas, with the exception of those from the seaside of Virginia. All size classes ($\bar{x}$ = 15, 25, 35, 37, and 42 mm in shell height) of drills tested were capable of preying upon all sizes (mean sizes of 26 mm to 65 mm in shell length) of oysters, *Crassostrea virginica* (Gmelin). Oyster drills pose a serious threat to present oyster harvesting or oyster farming in the coastal waters of Georgia.

Keywords: drills, *Urosalpinx*, abundance, distribution, predation, oysters, *Crassostrea*, *Thais*, *Eupleura*

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INTRODUCTION

The Atlantic oyster drill, *Urosalpinx cinerea* (Say), is considered a serious oyster, *Crassostrea virginica* (Gmelin), predator, especially in northern U.S. coastal waters (Federighi, 1931; Galtsolf *et al.*, 1937; Carriker, 1953; Galtsolf, 1964; Manzi, 1970; Huguenin, 1977), whereas oyster drills in coastal Georgia have not been considered a problem. Early reports indicated drills occur only sparingly in Georgia (Galtsolf *et al.*, 1937; Carriker, 1955). Although oyster drills were reported collected from Ossabaw, St. Catherines, Sapelo, and St. Simons Sound (Hoese, 1969), no data were provided pertaining to abundance or distribution of drills within those sounds. Drills were reported to be absent intertidally along the Duplin River on Sapelo Island (Bahr, 1974) and were reported not to occur in the creek systems about Sapelo Island, Georgia (Hoese and Durant, 1969). These early reports tend to indicate that oyster drills were absent or rare about Sapelo Island. In Wassaw Sound, the northernmost sound of coastal Georgia, oyster drills were reported abundant and widespread throughout the higher saline areas of the sound (Walker, 1981).

It is the purpose of this report to determine the abundance and distribution of oyster drills for the northern (Wassaw, Ossabaw, St. Catherines to Sapelo Sound) coastal waters of Georgia and to ascertain if current drill populations represent a threat to the development of oyster farming or harvesting.

METHODOLOGY

The data reported herein was collected by the author from 1977 to 1989 under several projects. Most of the drill data for Wassaw Sound was reported in Walker (1981), while that for the Harris Neck area was reported in Walker (1988). Drills were collected from the southern end of Wassaw Island (a National Wildlife Refuge) while sampling northern quahog, *Mercenaria mercenaria* (L.), populations to determine if there were sufficient clam stocks to warrant commercial fishing (unpublished data). Ossabaw and St. Catherines Islands were sampled for oyster drill populations to provide distributional data for the area between Wassaw Island and Harris Neck at the northwestern end of Sapelo Sound.

Drills were collected by taking six 0.1 m^2 or six 0.02 m^2 samples at different oyster beds. All oyster drill densities are reported as numbers per 0.1 m^2. A grid was placed on the oyster bed and oysters and shells within the grid were broken apart and inspected for the presence of oyster drills. Drills were collected, identified to species, counted, and measured to the nearest 0.5 mm with Vernier calipers. Measurements were recorded as shell height (i.e., from shell apex to the end of the siphonal canal).

To determine the potential predation effects that various size classes of drills have upon various size classes of oysters, the following experiment was set up on July 24, 1985. Three replicate trays of oyster drills (N = 20) of each mean size (15, 25, 35, 37, and 42 mm in shell height) were placed into trays containing 10 oysters of each of the following mean shell lengths (i.e., longest possible measurement): 26 mm, 35 mm, 45 mm, 55 mm, and 65 mm (Table 1). Each tray had a total of 50 oysters (10 of each size class) and 20

Table 1. The mean shell height of oyster drills, *Urosalpinx cinerea*, and mean shell length of oysters, *Crassostrea virginica*, placed into trays to determine prey size selection by various size classes of drills.

Tray No.	Mean Drill Size in mm ± SE	Mean Size ± SE of Oysters per Size Class in mm				
		26	35	45	55	65
1	14.9±0.66	27.1±1.3	35.6±0.8	45.0±0.8	55.0±1.0	65.3±1.2
2	15.0±0.72	27.5±0.7	35.5±0.9	44.9±1.0	54.9±1.1	65.3±1.9
3	15.0±0.75	25.5±1.7	35.5±1.0	44.8±0.9	55.3±1.2	65.0±2.4
4	24.9±0.66	27.8±0.8	35.1±1.4	44.9±0.8	55.2±0.9	65.6±1.3
5	25.0±0.61	27.5±0.4	35.3±0.7	44.9±0.8	55.0±0.9	64.9±0.9
6	25.0±0.64	25.1±1.0	35.5±0.9	45.2±0.9	55.1±1.3	65.0±1.6
7	34.0±0.59	26.0±1.2	34.2±1.2	44.3±0.8	55.3±0.8	65.7±1.9
8	35.0±0.60	25.8±2.0	35.3±0.9	45.0±1.2	55.3±0.9	64.8±1.5
9	35.0±0.57	24.7±1.9	35.3±1.4	45.2±1.0	54.9±0.8	65.2±1.6
10	36.8±0.45	25.7±0.9	35.6±1.0	44.9±0.8	55.0±0.9	65.3±1.5
11	37.0±0.58	27.5±0.5	35.6±1.0	44.5±0.8	55.0±1.0	64.9±1.5
12	37.1±0.55	24.3±2.0	35.9±1.1	45.3±1.0	55.5±0.7	65.3±1.0
13	41.7±0.33	26.3±1.6	34.9±0.9	45.1±0.9	54.2±0.9	64.9±1.0
14	41.7±0.31	27.3±0.5	34.6±0.9	45.0±0.7	55.4±0.9	64.7±1.5
15	41.9±0.30	24.4±1.1	34.8±0.9	45.5±0.8	54.0±1.0	64.7±1.2

drills of a single size class. Trays received a flow (0.3 l/min) of ambient seawater and aeration. Oyster drills were allowed to feed upon oysters until August 20, 1985. Trays were then terminated and the size-specific mortalities were determined for each tray.

RESULTS

With the exception of the northwest tip of Ossabaw Island (i.e., Bear Island, Queen Bess Creek, Florida Passage, and Buckhead Creek), oyster drills were found to be abundant and widespread throughout the northern third of the coastal waters of Georgia (See Appendix I). Drill absence from the northwest tip of Ossabaw Island is attributed to the lower salinity produced by the inflow of freshwater from the Ogeechee River. No other freshwater rivers empty into the survey area. Drill densities ranged from 0 to 210 drill m^{-2} (See Appendix II). Drill height ranged from 3.3 to 48.2 mm and averaged 26.6 ± 0.22 (SE) mm (N = 2367).

The results of the oyster drill size class feeding experiment are given in Table 2. All size classes of oyster drills successfully preyed upon all size classes of oysters to some degree (Table 2). In general, the 15 mm size class of drills preyed more successfully upon the two smaller oyster size classes, but clearly were able to consume oysters from the largest size class. The larger size class of oyster drill preyed more on the larger oysters, but did attack the smaller oysters as well. Egg laying within trays occurred for drills of the three largest size classes, but was not noted in trays containing the two smaller size classes of drills.

Table 2. The mean number ± SE of various sizes of oysters, *Crassostrea virginica*, consumed by various sizes of drills, *Urosalpinx cinerea*.

Drill Size in mm	Mean Number ± SE of Oysters Killed per Size Class 26 mm	35 mm	45 mm	55 mm	65 mm
15	8.0 ± 1.2	6.3 ± 0.9	2.0 ± 0.0	3.7 ± 1.8	1.0 ± 0.8
25	7.3 ± 1.9	7.3 ± 1.2	8.3 ± 0.3	4.7 ± 1.2	3.3 ± 0.7
35	8.6 ± 1.3	8.0 ± 0.6	9.3 ± 0.3	9.0 ± 0.6	7.3 ± 0.7
37	5.3 ± 0.7	8.0 ± 1.2	7.3 ± 1.8	9.7 ± 0.3	4.7 ± 1.3
42	3.0 ± 0.6	5.5 ± 0.3	5.0 ± 0.2	7.0 ± 1.2	6.0 ± 1.2

DISCUSSION

The data from this study clearly show that the Atlantic oyster drill, *Urosalpinx cinerea*, is widespread and poses a serious threat to oyster farming or harvesting in the northern third of coastal Georgia. A study on northern quahog, *Mercenaria mercenaria*, stock abundance (Walker and Stevens, 1988) in Christmas Creek, Little Cumberland and Cumberland Islands at the southern end of coastal Georgia reveals the presence of oyster drills, (Appendix III) and the author has observed drills throughout the Jointer Creek and Crooked River areas as well as the Cumberland dividing area. It is the opinion of the author that drills are fairly widespread throughout coastal Georgia with the possible exceptions of the Sapelo Island area and the Althamaha River (major freshwater river) area. The author is at a loss to explain the reported absence of drills about Sapelo Island (Bahr, 1974; Hoese and Durant, 1969), especially since this is an area of high salinity with abundant oyster populations. The author has collected drills from Wolf Island directly across Doboy Sound from southern end of Sapelo Island. Stevens (1983) observed no oyster mortalities in trays established within the Duplin River area of Sapelo Island, but observed heavy mortalities due to drills in oyster trays placed in Doboy Sound.

Of the 2388 drills collected during this survey, 2367 (99.1%) were *Urosalpinx cinerea*, 19 (0.8%) were *Thais haemastoma*, and two (0.08%) were *Eurpleura caudata*. *Urosalpinx cinerea* is clearly the dominant oyster drill of the intertidal areas of Georgia. *Thais haemastoma* occurs sporadically and is not considered to be as serious a threat to the oyster industry (Walker, 1981) as it is in the Gulf of Mexico populations (Burkenroad, 1931; Van Sickle, 1976). *Eupleura caudata* is absent from the intertidal zone, although it is common subtidally (personal observations). Since oysters occur primarily intertidally in coastal Georgia (Harris, 1980), *Eupleura caudata* is not a threat to native oysters, but may be to oyster farming if oysters are planted in subtidal areas.

The densities of oyster drills collected during this study fall within the range of values reported from more northern areas of coastal United States (Table 3). Since drills are considered serious predators to oysters even at the lower reported densities (MacKenzie, 1970), drill populations in coastal Georgia pose a serious threat to natural harvesting as well as oyster farming.

Oyster drills collected during this study ranged in size to 48.2 mm and averaged 26.6 mm in shell height. Based on reported size data from other geographical areas (Table 4), oyster drills in Georgia tend to grow to a larger size than in other areas with the exception of the seaside of Virginia, where *Urosalpinx cinerea* form *follyensis* reach 60 mm in shell height. The presence of larger size drills combined with the fact that even small drills (< 20 mm) were able to consume some oysters > 60 mm in shell length (Table 2) show that drills are a serious threat to the oyster industry.

In conclusion, oyster drills were found to be abundant intertidally and widespread throughout the higher saline areas of the northern third of coastal Georgia. Drills occur at a larger size in the coastal waters of Georgia than that reported from populations in more northern U.S. coastal areas, with the exception of the seaside of Virginia. All size classes of drills were found to be capable of preying upon all sizes of oysters (mean sizes of 26 to 65 mm in length) tested. Thus, oyster drills pose a serious threat to present oyster harvesting or oyster farming in the coastal waters of Georgia.

Table 3. The range and mean densities of the Atlantic oyster drill, *Urosalpinx cinerea*, reported from different geographical areas.

Location	Habitat	Range No. m^{-2}	Mean Density No. m^{-2}	Source
England	Subtidal	237 to 947	---	Mistakidis 1951
Massachusetts		37 to 41	---	MacKenzie 1977
Rhode Island		---	6.5	MacKenzie 1977
New Hampshire	Subtidal	0 to 7	---	Turgeon and Fralick 1973
Connecticut		0.3 to 4.7	---	MacKenzie 1970
New York		0.9 to 6.3	---	MacKenzie 1970
New Jersey	Intertidal	---	29.0	Nelson 1922
New Jersey	Intertidal	---	5.0	Carriker 1955
Virginia	Subtidal	---	44.0	MacKenzie 1961
Virginia	Subtidal	0 to 1000	---	Wood 1968
N. Carolina	Intertidal	0 to 126	---	Chestnut 1955
Georgia	Intertidal	0 to 210	38.0	Walker *et al.* 1980
Georgia	Intertidal	0 to 210	41.2	This Study

Table 4. Comparison of shell heights of *Urosalpinx cinerea* from various geographical locations.

Location	Sex	Max. Height mm	Average Height	Source
England	Female	43	---	Cole 1942
	Male	39	---	
Great Bay, NH	Female	38.3	20.2	Turgeon & Fralick 1973
	Male	30.0	17.8	
Mystic River, CT	Mixed	35	---	Franz 1971
Woods Hole, MA	Mixed	29	---	Galtsolf 1964
Woods Hole, MA	Female	29	---	Federighi 1931a
	Male	26	---	
Delaware Bay, NJ	Mixed	37	---	Nelson 1931
Delaware Bay, NJ	Mixed	40	---	Carriker 1955
Seaside, VA	Mixed	61	---	Galtsolf *et al.* 1937
Hampton Roads, VA	Female	33	---	Federighi 1931b
	Male	29	---	
Virginia	Mixed	45	---	Griffith and Castagna 1962
	Female	---	28.0	
Seaside, VA	Female	44.6	29.8	Hargis & MacKenzie 1961
	Male	38.7	19.5	
York River, VA	Female	24.6	19.3	Hargis & MacKenzie 1961
	Male	21.1	19.5	
Beaufort, NC	Mixed	33	---	Federighi 1930
Wassaw Sound, GA	Mixed	48.2	24.7	This Study

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Appendix I

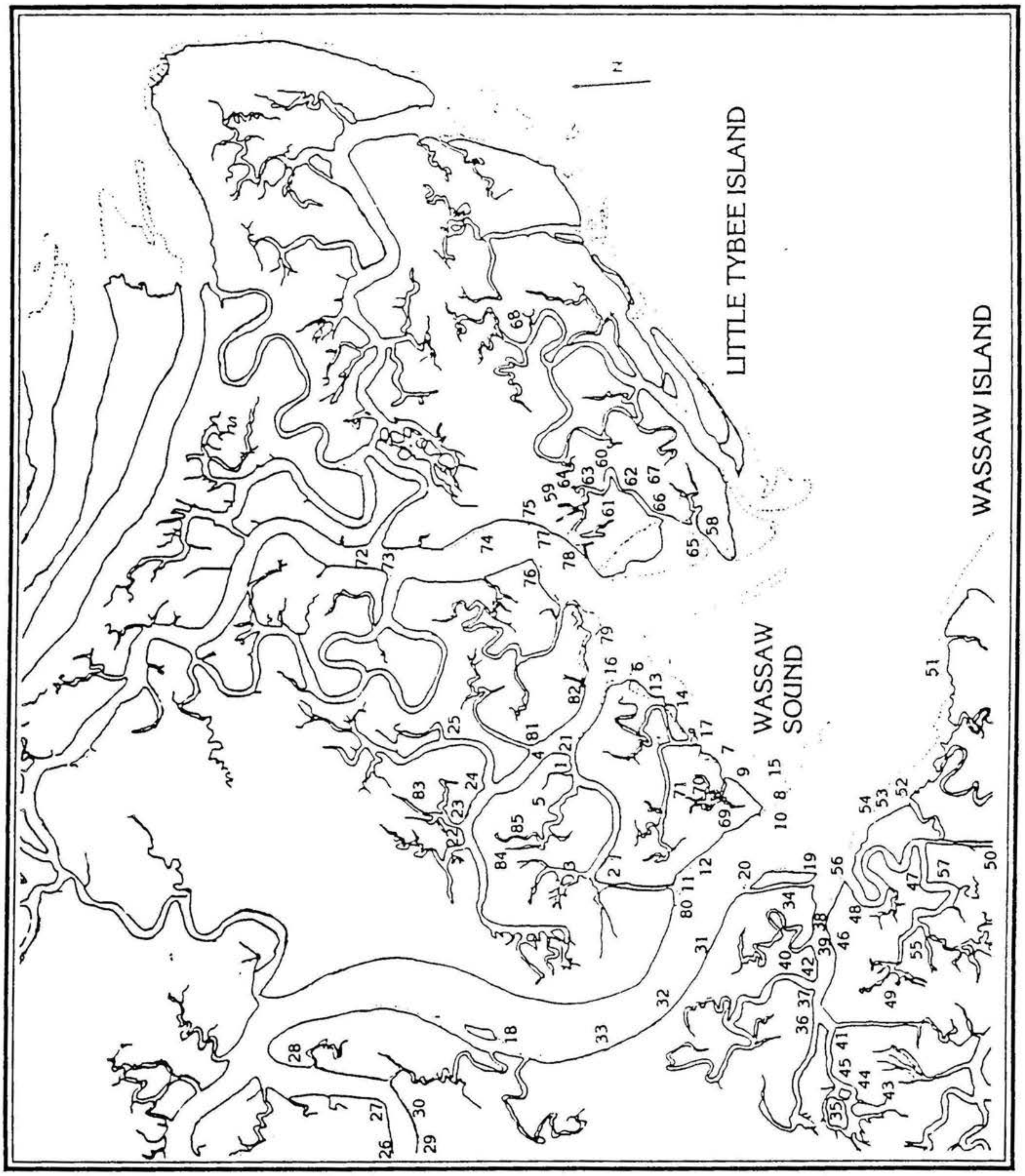

Figure A1. Oyster drill, Urosalpinx cinerea, collection stations for Wassaw Sound, Georgia.

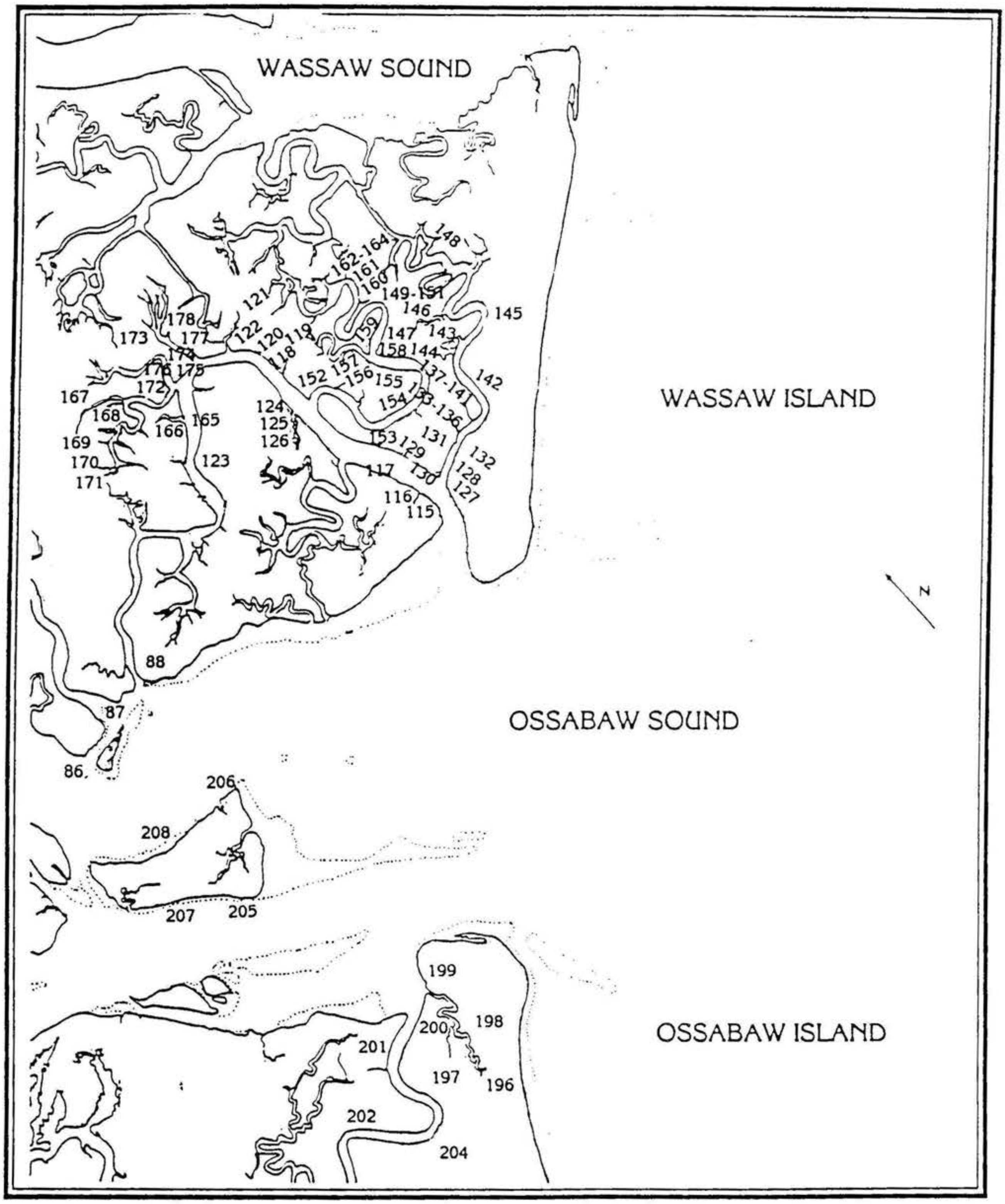

Figure A2. Oyster drill, Urosalpinx cinerea, collection stations for Ossabaw Sound, Georgia.

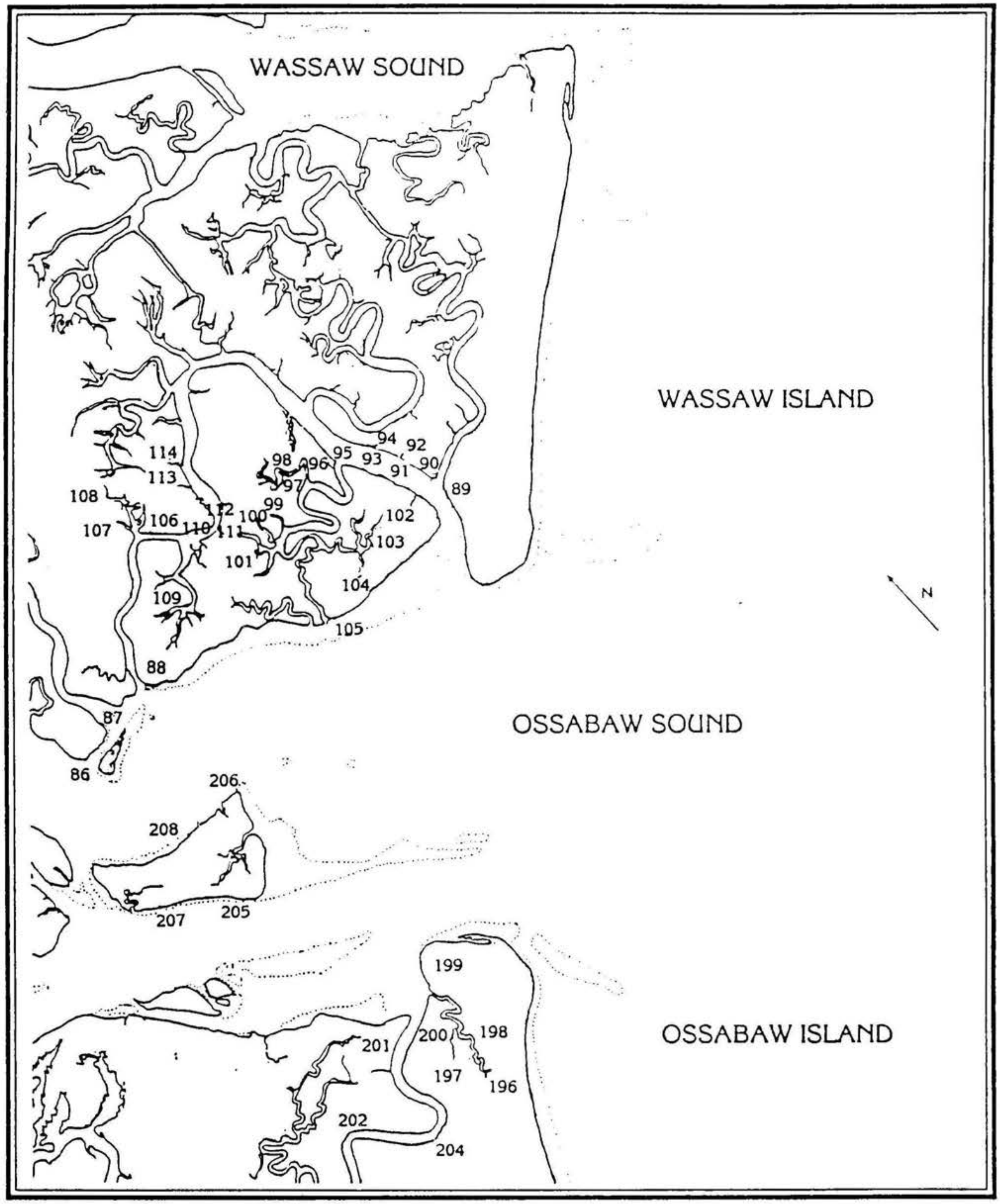

Figure A3. Oyster drill, Urosalpinx cinerea, collection stations for Ossabaw Sound, Georgia continued.

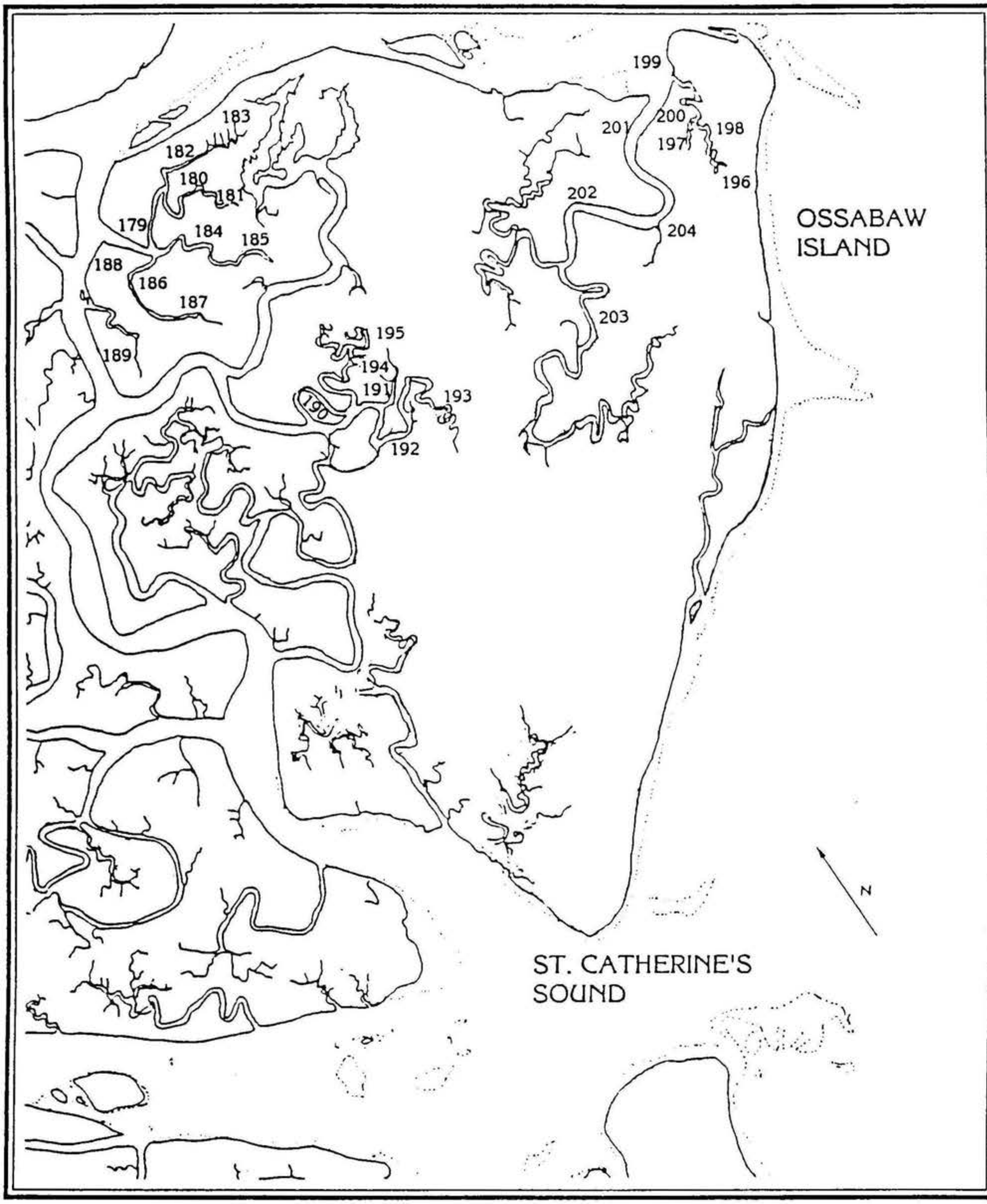

Figure A4. Oyster drill, Urosalpinx cinerea, collection stations for St. Catherines Sound, Georgia.

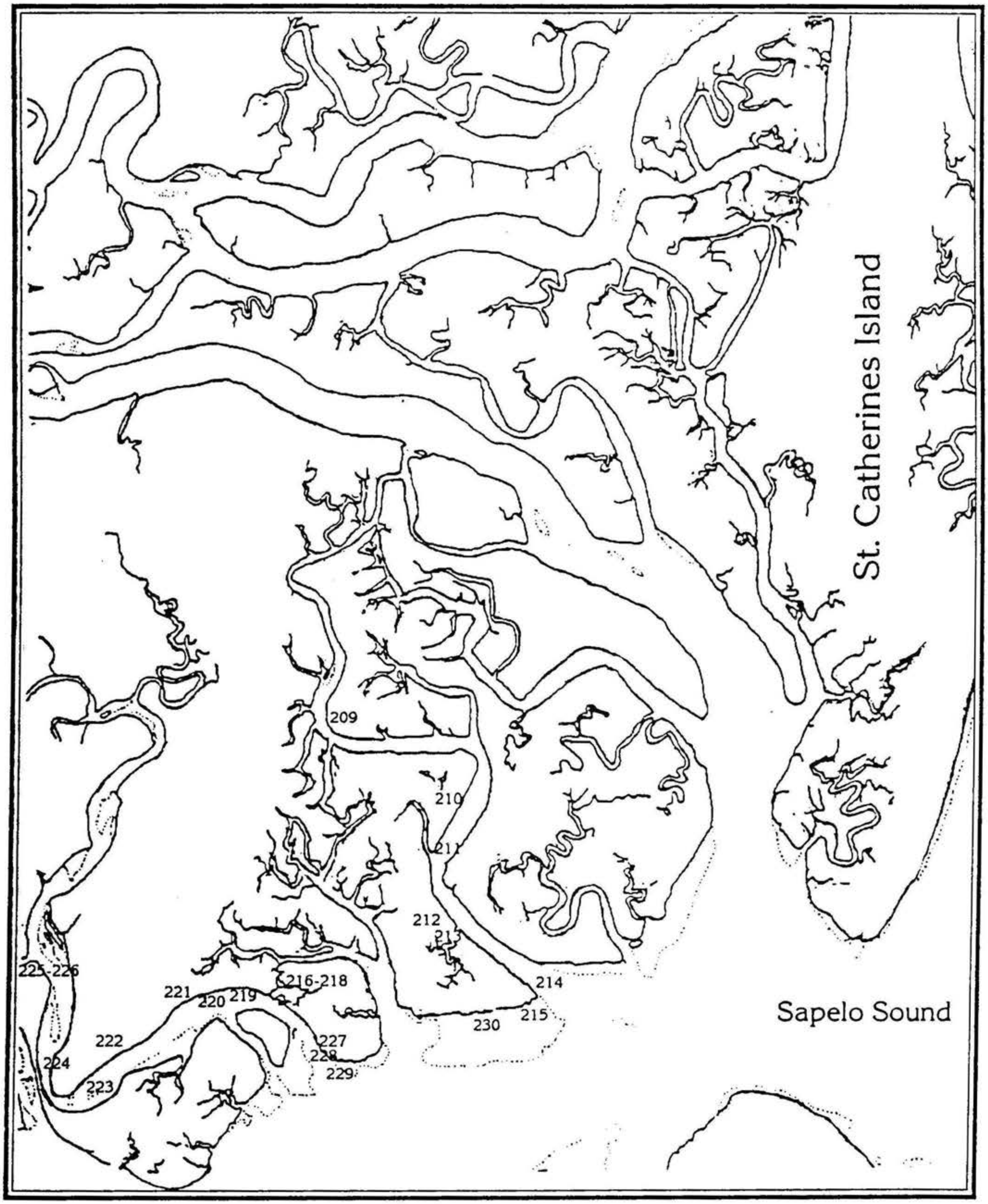

Figure A5. Oyster drill, <u>Urosalpinx</u> <u>cinerea</u>, collection stations for Sapelo Sound, Georgia.

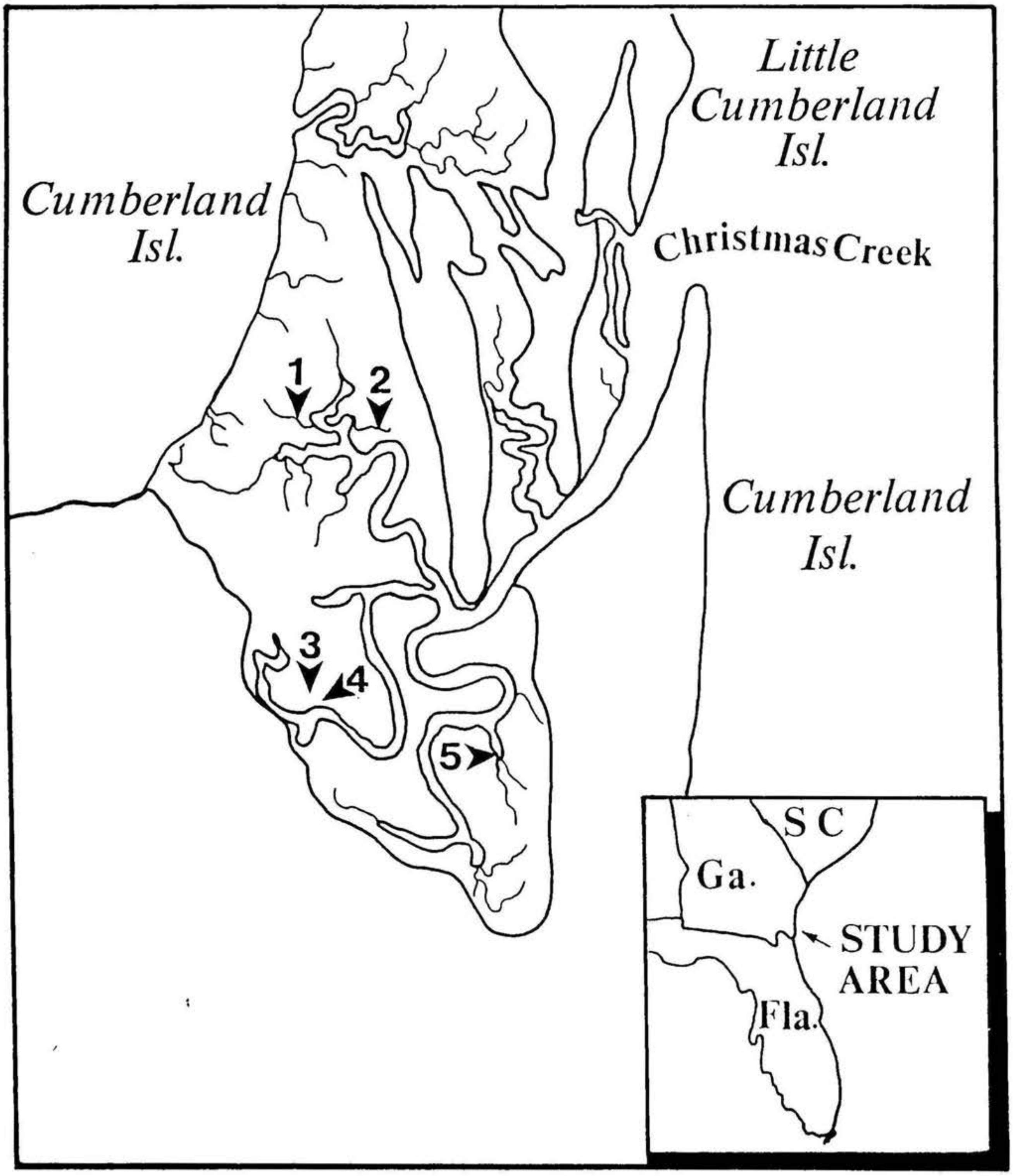

Figure A6. Oyster drill, Urosalpinx cinerea, collection stations for Christmas Creek, Little Cumberland and Cumberland Islands, Georgia.

Appendix II

Appendix II. The map numbers, location, total number of drills collected, range in drill size, mean shell height and mean density of oyster drills, *Urosalpinx cinerea*, for the northern coastal waters of Georgia.

Map No.	Location	Total No.	Range in mm	$\bar{x}$ shell height mm ± S.D.	$\bar{x}$ Density 0.1 m^2 ± S.D.
Wassaw Sound					
1	Tybee Cut	21	8.8 to 37.9	24.4 ± 10.4	3.5 ± 5.3
2	Tybee Cut	0	0	0	0
3	Tybee Cut	49	18.8 to 40.9	33.3 ± 5.1	14.8 ± 20.8
4	Tybee Cut	7	9.1 to 38.0	23.6 ± 8.1	1.6 ± 1.0
5	Tybee Cut	0	0	0	0
6	Cabbage Island	121	4.2 to 32.9	21.6 ± 8.0	20.3 ± 28.7
7	Cabbage Island	22	14.2 to 38.0	26.0 ± 7.2	3.7 ± 2.7
8	Cabbage Island	0	0	0	0
9	Cabbage Island	20	15.5 to 41.1	27.4 ± 7.6	3.3 ± 2.4
10	Cabbage Island	124	3.7 to 34.5	23.4 ± 8.0	20.7 ± 26.9
11	Cabbage Island	58	10.2 to 48.2	24.2 ± 8.3	19.3 ± 14.6
12	Cabbage Island	17	11.7 to 35.4	24.9 ± 8.7	2.8 ± 5.5
13	Cabbage Island	30	10.6 to 29.5	24.6 ± 4.2	5.0 ± 4.5
14	Cabbage Island	4	17.6 to 31.4	24.1 ± 5.8	0.7 ± 0.8
15	Cabbage Island	5	19.1 to 30.1	24.4 ± 4.8	0.8 ± 1.3
16	Cabbage Island	0	0	0	0
17	Cabbage Creek	1	45.0	45.0	0.2 ± 0.4
18	Sister Island	0	0	0	0
19	Sister Island	9	11.4 to 25.0	19.6 ± 4.1	1.5 ± 1.8
20	Sister Island	0	0	0	0
21	Mud Island	41	11.9 to 40.5	27.3 ± 7.7	6.8 ± 3.1
22	Halfmoon River	0	0	0	0
23	Halfmoon River	70	8.6 to 45.0	33.9 ± 7.4	11.7 ± 7.3
24	Halfmoon River	17	8.1 to 39.1	24.8 ± 10.2	33.6 ± 32.4
25	Beard Creek	0	0	0	0
26	Dutch Island	0	0	0	0
27	Dutch Island	0	0	0	0
28	Skidaway Island	0	0	0	0
29	Skidaway Dock	0	0	0	0
30	Skidaway Modena	0	0	0	0
31	Skidaway Island	25	10.0 to 39.1	26.3 ± 8.7	4.2 ± 5.2
32	Skidaway Island	23	22.2 to 37.2	30.3 ± 4.9	3.8 ± 5.0
33	Skidaway Island	2	30.8 to 32.7	31.8 ± 1.3	0.3 ± 8.2
34	Joes Cut	0	0	0	0
35	Romerly Marsh	0	0	0	0
36	Romerly Marsh	72	11.4 to 40.3	27.5 ± 8.0	12.0 ± 15.4
37	Romerly Marsh	20	17.4 to 46.7	31.4 ± 7.5	33.3 ± 3.9
38	Romerly Marsh	5	12.3 to 36.3	22.9 ± 9.0	0.8 ± 2.0

Appendix II (Cont'd)

Map No.	Location	Total No.	Range in mm	$\bar{x}$ shell height mm ± S.D.	$\bar{x}$ Density 0.1 m^2 ± S.D.
39	Romerly Marsh	14	20.5 to 39.1	32.0 ± 4.4	2.3 ± 4.1
40	Romerly Marsh	2	23.8 to 34.4	29.1 ± 7.5	0.3 ± 0.5
41	Romerly Marsh	8	13.1 to 28.8	23.2 ± 6.2	1.3 ± 2.3
42	Romerly Marsh	3	27.6 to 36.9	31.6 ± 4.8	0.5 ± 0.6
43	Romerly Marsh	2	38.4 to 40.4	39.4 ± 1.4	0.3 ± 0.8
44	Romerly Marsh	25	24.4 to 41.9	34.0 ± 4.2	4.2 ± 2.1
45	Romerly Marsh	10	21.5 to 38.2	33.3 ± 5.3	1.7 ± 2.3
46	Romerly Marsh	28	15.1 to 42.3	29.6 ± 8.8	4.7 ± 2.8
47	Old Romerly Marsh	0	0	0	0
48	Old Romerly Marsh	0	0	0	0
49	Old Romerly Marsh	3	17.4 to 31.6	26.4 ± 7.8	0.5 ± 0.5
50	New Cut	0	0	0	0
51	Wassaw Island	81	4.5 to 36.9	25.6 ± 7.6	13.5 ± 6.9
52	Wassaw Island	126	9.2 to 37.9	22.2 ± 7.8	21.0 ± 15.3
53	Wassaw Island	79	6.3 to 37.2	24.7 ± 8.0	13.5 ± 11.8
54	Wassaw Island	0	0	0	0
55	Wassaw Island	0	0	0	0
56	Wassaw Island	2	13.4 to 15.0	14.2 ± 1.1	0.3 ± 0.8
57	Wassaw Island	0	0	0	0
58	House Creek	3	19.8 to 30.1	24.9 ± 5.2	0.5 ± 0.5
59	House Creek	23	10.6 to 33.9	22.0 ± 6.9	3.8 ± 5.7
60	House Creek	3	26.1 to 39.4	33.8 ± 6.9	0.5 ± 0.8
61	House Creek	15	3.2 to 38.3	23.0 ± 13.3	2.6 ± 3.9
62	House Creek	4	30.5 to 37.8	35.1 ± 3.2	0.7 ± 1.6
63	House Creek	7	10.6 to 24.0	14.6 ± 9.6	1.2 ± 1.2
64	House Creek	0	0	0	0
65	House Creek	0	0	0	0
66	House Creek	40	5.3 to 43.1	17.0 ± 9.8	6.7 ± 7.7
67	House Creek	0	0	0	0
68	Little Tybee Creek	0	0	0	0
69	Unnamed Creek	5	9.8 to 31.1	21.3 ± 8.8	0.8 ± 1.0
70	Unnamed Creek	14	31.5 to 43.2	37.3 ± 4.5	2.3 ± 3.3
71	Unnamed Creek	3	37.4 to 44.1	41.4 ± 3.5	0.5 ± 0.8
72	Bull River	3	14.4 to 24.2	19.9 ± 5.0	0.5 ± 0.8
73	Bull River	3	21.9 to 31.1	26.9 ± 4.6	0.5 ± 0.6
74	Bull River	9	26.6 to 41.1	32.8 ± 4.8	1.5 ± 1.8
75	Bull River	11	17.4 to 38.4	28.0 ± 6.5	1.8 ± 1.9
76	Bull River	12	4.6 to 39.3	27.6 ± 11.1	2.2 ± 2.5
77	Bull River	0	0	0	0
78	Bull River	0	0	0	0
79	Wilmington Island	7	23.8 to 33.1	27.8 ± 4.0	1.2 ± 1.2
80	Wilmington Island	0	0	0	0
81	Wilmington Island	30	11.1 to 35.2	22.2 ± 7.3	5.0 ± 5.1
82	Wilmington Island	73	8.2 to 35.8	22.8 ± 7.9	12.2 ± 9.7

Appendix II (Cont'd)

Map No.	Location	Total No.	Range in mm	$\bar{x}$ shell height mm ± S.D.	$\bar{x}$ Density 0.1 m^2 ± S.D.
83	Wilmington Island	0	0	0	0
84	Wilmington Island	1	17.9	17.9	0.2 ± 0.4
85	Wilmington Island	50	18.5 to 39.9	29.8 ± 4.7	8.3 ± 4.4
	Ossabaw Sound/Wassaw Island				
86	Steamboat Cut	0	0	0	0
87	Green Island	0	0	0	0
88	Delegal Creek	19	8.1 to 38.2	26.6 ± 8.4	3.8 ± 1.9
89	Odingsell River	9	16.6 to 37.8	30.3 ± 8.0	1.5 ± 2.8
90	Odingsell River	10	8.8 to 38.9	27.8 ± 9.0	1.3 ± 0.6
91	Odingsell River	8	13.3 to 41.2	20.9 ± 11.6	1.3 ± 1.8
92	Odingsell River	0	0	0	0
93	Odingsell River	17	12.3 to 42.0	29.6 ± 9.5	2.8 ± 3.2
94	Odingsell River	0	0	0	0
95	Curtis Creek	48	14.7 to 47.9	29.8 ± 7.5	8.0 ± 3.4
96	Curtis Creek	0	0	0	0
97	Curtis Creek	6	18.8 to 39.1	28.6 ± 8.1	1.0 ± 1.1
98	Curtis Creek	0	0	0	0
99	Curtis Creek	23	21.4 to 37.2	30.2 ± 6.0	3.8 ± 3.1
100	Curtis Creek	0	0	0	0
101	Curtis Creek	0	0	0	0
102	Pine Island	11	25.5 to 34.6	29.8 ± 3.0	1.8 ± 1.0
103	Pine Island	0	0	0	0
104	Pine Island	0	0	0	0
105	Pine Island	0	0	0	0
106	Adams Creek	0	0	0	0
107	Adams Creek	0	0	0	0
108	Adams Creek	10	17.8 to 37.7	30.1 ± 5.8	1.7 ± 1.5
109	Adams Creek	0	0	0	0
110	Adams Creek	13	16.6 to 40.1	28.1 ± 8.2	2.2 ± 2.5
111	Adams Creek	0	0	0	0
112	Adams Creek	14	23.6 to 38.9	31.4 ± 4.5	2.3 ± 1.6
113	Adams Creek	0	0	0	0
114	Adams Creek	0	0	0	0
115	Odingsell River	0	0	0	0
116	Odingsell River	0	0	0	0
117	Odingsell River	3	17.8 to 29.1	24.9 ± 6.2	2.0 ± 3.3
118	Odingsell River	7	15.6 to 39.7	29.5 ± 8.4	1.2 ± 1.6
119	Odingsell River	0	0	0	0
120	Odingsell River	0	0	0	0
121	Habersham Creek	0	0	0	0
122	Habersham Creek	3	18.7 to 29.2	25.5 ± 0.6	0.5 ± 0.5
123	Odingsell River	7	11.9 to 41.2	28.5 ± 10.4	1.2 ± 1.3

Appendix II (Cont'd)

Map No.	Location	Total No.	Range in mm	x̄ shell height mm ± S.D.	x̄ Density 0.1 m^2 ± S.D.
124	Flora Hammock	3	25.4 to 30.1	28.0 ± 2.4	0.5 ± 0.5
125	Flora Hammock	0	0	0	0
126	Flora Hammock	0	0	0	0
127	Wassaw Creek	0	0	0	0
128	Wassaw Creek	11	15.9 to 32.5	24.7 ± 6.7	1.8 ± 1.9
129	Wassaw Creek	3	19.5 to 29.4	24.4 ± 5.2	0.5 ± 0.6
130	Wassaw Creek	0	0	0	0
131	Wassaw Creek	21	6.6 to 38.7	24.8 ± 8.6	3.5 ± 4.6
132	Wassaw Creek	3	15.6 to 27.4	20.6 ± 6.1	0.5 ± 8.4
133	Wassaw Creek	31	5.9 to 31.3	16.6 ± 6.8	5.2 ± 7.1
134	Wassaw Creek	0	0	0	0
135	Wassaw Creek	0	0	0	0
136	Wassaw Creek	0	0	0	0
137	Wassaw Creek	0	0	0	0
138	Wassaw Creek	0	0	0	0
139	Wassaw Creek	11	21.1 to 44.4	32.0 ± 6.9	1.8 ± 2.9
140	Wassaw Creek	0	0	0	0
141	Wassaw Creek	2	34.1 to 41.1	37.6 ± 4.9	0.3 ± 0.5
142	Wassaw Creek	3	11.1 to 32.2	24.9 ± 12.0	0.5 ± 0.8
143	Wassaw Creek	0	0	0	0
144	Wassaw Creek	2	32.1 to 40.1	36.1 ± 5.7	0.3 ± 0.5
145	Wassaw Creek	1	12.6	12.6	0.2 ± 0.4
146	Wassaw Creek	11	16.2 to 31.4	25.3 ± 5.5	1.8 ± 1.3
147	Wassaw Creek	3	28.8 to 32.4	30.6 ± 1.8	0.5 ± 0.8
148	Wassaw Creek	0	0	0	0
149	Wassaw Creek	0	0	0	0
150	Wassaw Creek	0	0	0	0
151	Wassaw Creek	16	12.3 to 39.5	26.4 ± 8.4	2.3 ± 3.1
152	Rhodes Creek	3	21.9 to 33.7	27.9 ± 5.9	0.5 ± 0.6
153	Rhodes Creek	4	29.8 to 37.7	33.3 ± 4.1	0.7 ± 0.8
154	Rhodes Creek	4	33.4 to 37.8	36.1 ± 2.0	0.7 ± 0.8
155	Rhodes Creek	2	32.1 to 37.6	34.9 ± 3.9	0.3 ± 5.2
156	Rhodes Creek	1	26.7	26.7	0.2 ± 0.4
157	Rhodes Creek	0	0	0	0
158	Rhodes Creek	1	39.2	39.2	0.2 ± 0.4
159	Rhodes Creek	0	0	0	0
160	Rhodes Creek	0	0	0	0
161	Rhodes Creek	8	35.5 to 44.4	35.1 ± 10.8	1.3 ± 1.6
162	Rhodes Creek	1	22.0	22.0	0.2 ± 0.4
163	Rhodes Creek	0	0	0	0
164	Rhodes Creek	8	33.7 to 42.3	38.1 ± 2.8	1.3 ± 1.8
165	Adams Creek	0	0	0	0
166	Adams Creek	0	0	0	0
167	Adams Creek	1	25.6	25.6	0.2 ± 0.4

Appendix II (Cont'd)

Map No.	Location	Total No.	Range in mm	$\bar{x}$ shell height mm ± S.D.	$\bar{x}$ Density 0.1 m^2 ± S.D.
168	Adams Creek	0	0	0	0
169	Adams Creek	0	0	0	0
170	Adams Creek	0	0	0	0
171	Adams Creek	1	11.5	11.5	0.2 ± 0.4
172	Adams Creek	6	15.3 to 39.8	27.7 ± 8.8	1.0 ± 1.1
173	Adams Creek	1	34.9	34.9	0.2 ± 0.4
174	Adams Creek	0	0	0	0
175	Adams Creek	0	0	0	0
176	Adams Creek	1	26.4	26.4	0.2 ± 0.4
177	Adams Creek	0	0	0	0
178	Adams Creek	0	0	0	0
Ossabaw Island					
179	Bear Island	0	0	0	0
180	Queen Bess Creek	0	0	0	0
181	Queen Bess Creek	0	0	0	0
182	Queen Bess Creek	0	0	0	0
183	Queen Bess Creek	0	0	0	0
184	Queen Bess Creek	0	0	0	0
185	Queen Bess Creek	0	0	0	0
186	Queen Bess Creek	0	0	0	0
187	Queen Bess Creek	0	0	0	0
188	Florida Passage	0	0	0	0
189	Florida Passage	0	0	0	0
190	Buckhead Creek	0	0	0	0
191	Buckhead Creek	0	0	0	0
192	Buckhead Creek	0	0	0	0
193	Buckhead Creek	0	0	0	0
194	Buckhead Creek	0	0	0	0
195	Buckhead Creek	0	0	0	0
196	Bradley River	0	0	0	0
197	Bradley River	0	0	0	0
198	Bradley River	0	0	0	0
199	Bradley River	0	0	0	0
200	Bradley River	0	0	0	0
201	Bradley River	0	0	0	0
202	Bradley River	0	0	0	0
203	Bradley River	0	0	0	0
204	Bradley River	0	0	0	0
205	Raccoon Key	20	16.1 to 29.6	21.4 ± 4.0	5.0 ± 6.3
206	Raccoon Key	0	0	0	0
207	Raccoon Key	11	15.0 to 28.4	21.5 ± 5.7	10.7 ± 11.6
208	Raccoon Key	0	0	0	0

Appendix II (Cont'd)

Map No.	Location	Total No.	Range in mm	$\bar{x}$ shell height mm ± S.D.	$\bar{x}$ Density 0.1 m^2 ± S.D.
Sapelo Sound					
209	Swain River	7	33.0 to 38.1	36.5 ± 1.8	6.0 ± 3.0
210	Barbour Is. River	25	20.0 to 39.2	31.7 ± 5.8	21.0 ± 16.5
211	Barbour Is. River	20	23.9 to 43.6	34.7 ± 5.6	16.5 ± 11.5
212	Barbour Is. River	3	30.5 to 37.7	33.5 ± 3.7	1.0 ± 2.0
213	Barbour Is. River	10	17.6 to 39.1	28.6 ± 8.6	8.5 ± 7.0
214	Sapelo Sound	3	19.6 to 42.2	29.5 ± 11.6	2.5 ± 4.0
215	Sapelo Sound	2	28.0 to 36.7	32.4 ± 6.2	1.5 ± 4.0
216	Julienton River	0	0	0	0
217	Julienton River	0	0	0	0
218	Julienton River	0	0	0	0
219	Julienton River	0	0	0	0
220	Julienton River	0	0	0	0
221	Julienton River	4	5.7 to 7.8	6.7 ± 0.9	3.5 ± 8.0
222	Julienton River	0	0	0	0
223	Julienton River	1	16.0	16.0	1.0 ± 2.0
224	Julienton River	0	0	0	0
225	Julienton River	0	0	0	0
226	Broro River	0	0	0	0
227	Julienton River	0	0	0	0
228	Julienton River	0	0	0	0
229	Sapelo Sound	1	26.1	26.1	1.0 ± 2.0
230	Sapelo Sound	3	29.8 to 36.8	34.4 ± 4.0	2.5 ± 3.0

Appendix III

Appendix III. The map numbers, location, total number of drills collected, range in drill size, mean shell height, and mean density of oyster drills, *Urosalpinx cinerea*, for the Christmas Creek area of Georgia.

Map No.	Location	Total No.	Range in mm	$\bar{x}$ shell height mm ± S.D.	$\bar{x}$ Density 0.1 m^2 ± S.D.
	Christmas Creek				
1	Upper Branch	0	0	0	0
2	Upper Branch	0	0	0	0
3	Middle Branch	3	24.2 to 39.6	31.6 ± 7.7	0.5 ± 0.6
4	Middle Branch	8	26.1 to 33.4	29.9 ± 2.6	1.3 ± 1.6
5	Lower Branch	4	29.4 to 35.1	32.2 ± 2.5	0.7 ± 0.8