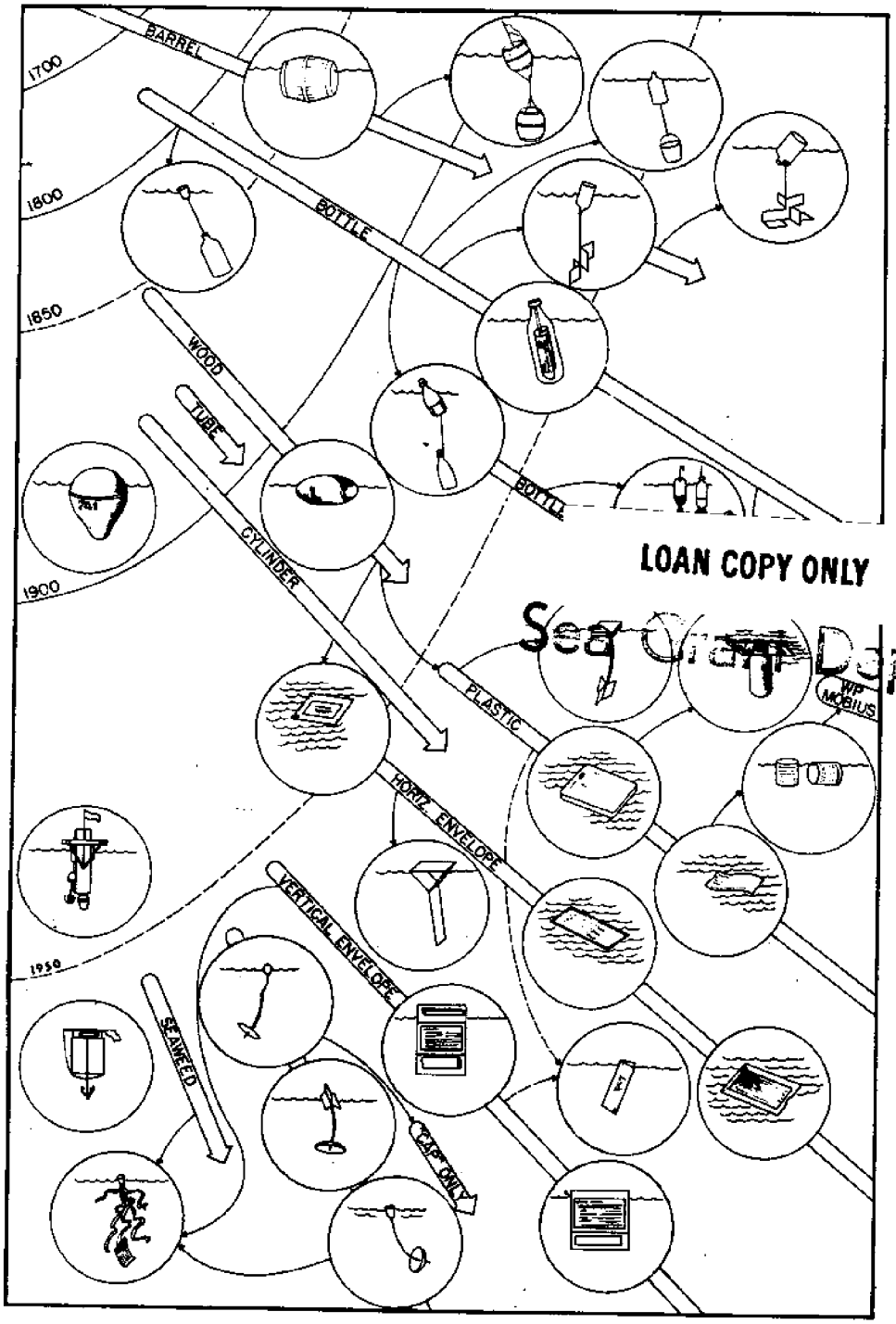
SURFACE CURRENT DRIFTERS EVOLUTION and APPLICATION



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MICHIGAN SEA GRANT PROGRAM

SURFACE CURRENT DRIFTERS: EVOLUTION AND APPLICATION

BY

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SECTION A: INTRODUCTION AND BACKGROUND

E. C. Monahan

While spending several years in residence at the Woods Hole Oceanographic Institution working on my dissertation, I was impressed with the extensive drift-bottle study of the coastal currents then being conducted at that institution by Mr. Dean F. Bumpus (e.g., Bumpus and Lauzier, 1965). It was thus quite natural, when I subsequently found myself sailing up and down Lake Superior on Great Lakes Ore Boats in the conduct of an entirely different kind of research effort, to nonetheless consider, and then implement, a drift-bottle current study (Monahan, 1968; Hughes, et al, 1970), to supplement the meager circulation data then available on that body of water.

From that time forward, I have been convinced that an explicit, computer-based, technique is needed to enhance the worth and acceptability of drifter current study results.

At present, in conjunction with Mr. Philip Pilgrim and Prof. John H. Holland of the Computer and Communications Science Department of this university, we are working on two such techniques. Since these techniques will be presented in detail in Mr. Pilgrim's dissertation, I will only sketch them here.

The first scheme, which I refer to as the "diagnostic points" technique, is a method of testing, via intercomparison, several hypothetical circulation patterns for the body of water under study. The alternative circulation patterns can be derived from numerical dynamical circulation models, from previous (or preliminary) measurement programs, or from intuition. Each hypothetical circulation pattern is used, in turn, to assign current vectors to each cell into which the body of water is subdivided in the computer. A simple diffusion model is also programmed into the computer. A geographical point is then selected in the body of water under study, and in computer simulation a large number of drifters are released from that point, and via the processes of advection and diffusion, many will be seen to intersect, or strand on, the shoreline. The distribution of these stranded drifters is then intercompared, as we go from one hypothetical circulation pattern to another. If the variation in the distribution of stranding between the various hypothetical patterns is slight, then this particular geographical point is deemed unsuited as a "diagnostic point", and we proceed to other

points and other simulations, until we identify several geographical points that should make good "diagnostic points", in that the computer simulations indicate that for each point, the patterns of drifter stranding will vary markedly between the various hypothetical circulation patterns. We then release, in the actual body of water, large clusters of surface drifters at these predetermined "diagnostic points" and thereby hope to economically conduct the critical experiments that will enable us to select the hypothetical circulation pattern that most closely mimics nature.

The second scheme, which we might well call the "tabula rasa" technique, is the more demanding and comprehensive approach, and may in the long run have the greater potential. Here we begin with a "clean slate", i.e. no assumptions about the specific circulation pattern within the body of water under study. We do have a list of physical constraints to be applied to our body of water, and they are arranged in a hierarchy, with only one of them held absolute (that the water can't cross the shoreline), and all of the others given finite and different, weights. The non-absolute constraints include: 1) the requirement that the flow in the body of water be horizontally non-divergent, 2) the minimization of the system's kinetic energy, 3) the minimization of streamline curvature, and 4) the minimization of speed changes along a trajectory, to name only a few. We then begin to introduce our observational data, one drifter return at a time. After each new set of data (release point, recovery point, time elapsed, for each additional drifter return) is introduced, we iterate our circulation pattern to minimize the violation of our weighted constraints. Due to diffusion and other factors it is clear that simple trajectory analyses for the various drifter returns might give us a set of markedly different current vectors for the same cell in the computer simulation of our body of water. Thus we must devise explicit techniques for establishing the "optimum" current vector for each cell and for assigning penalty weights to each cell based on the trajectory scatter through that cell. Without going into further detail, it should be apparent that the "tabula rasa" technique of drifter return analysis is considerably more complex than the "diagnostic points" procedure. It is my belief though that this second scheme will be more fruitful in establishing and sustaining the desired interaction between the applied physical oceanographers (or limnologists) who use it in interpreting their observations, and the geophysical fluid dynamicists, who are developing the various numerical dynamical models. Indeed, by determining the sensitivity of the computer-produced circulation patterns to variations in the weighting of the various physical constraints, we can hope to add to the fundamental knowledge about the general behavior of bodies of water.

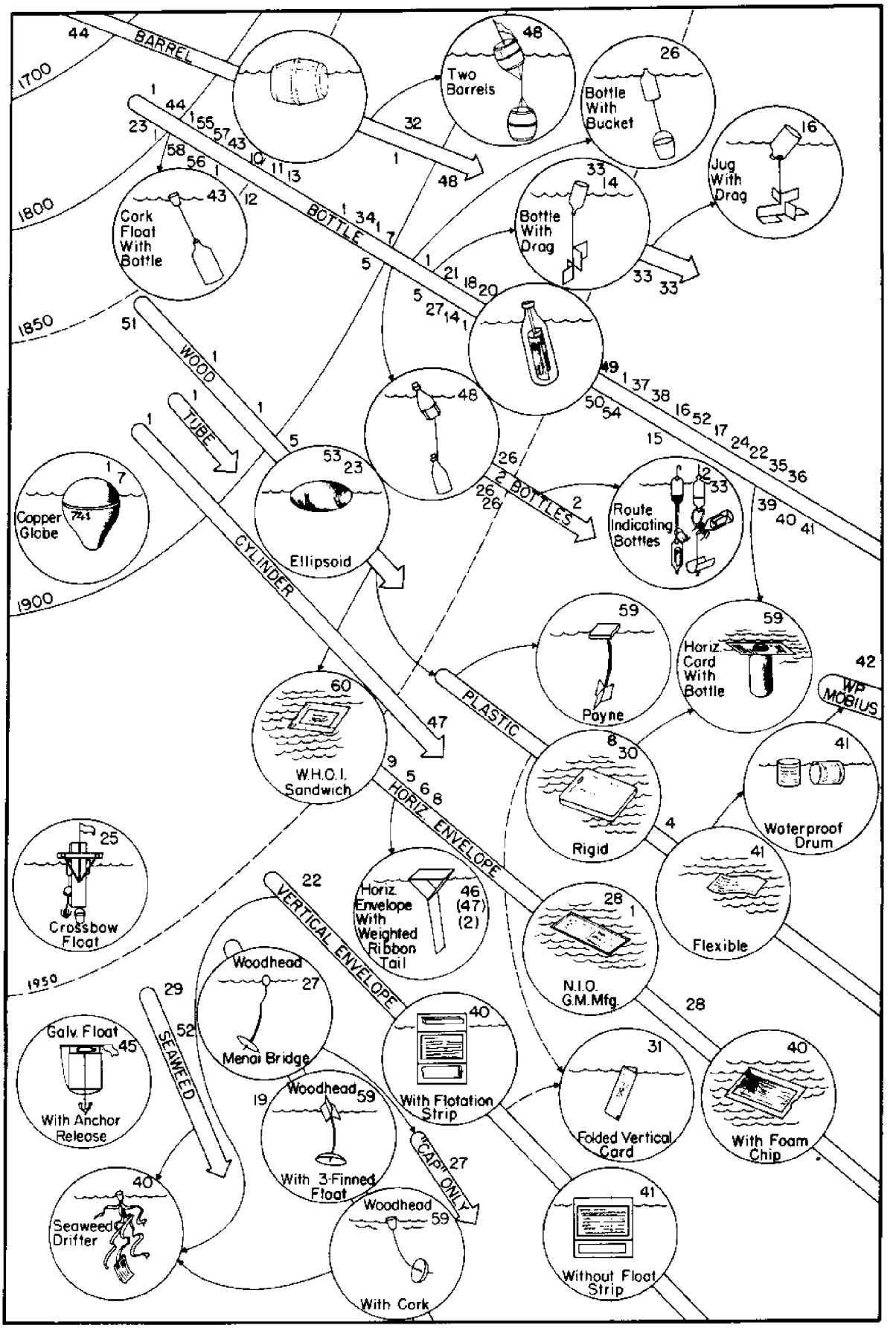
1700
1800
1850
1900
1950
BARREL
BOTTLE
WOOD
TUBE
CYLINDER
PLASTIC
HORIZ. ENVELOPE
VERTICAL ENVELOPE
SEAWEED
"CAP" ONLY
Two Barrels
Bottle With Bucket
Jug With Drag
Cork Float With Bottle
Bottle With Drag
Copper Globe
Ellipsoid
2 BOTTLES
Route Indicating Bottles
Payne
Horiz. Card With Bottle
WP MOBIUS
W.H.O.I. Sandwich
Rigid
Waterproof Drum
Crossbow Float
Horiz. Envelope With Weighted Ribbon Tail
Flexible
N.I.O. G.M.Mfg
Woodhead Menai Bridge
With Flotation Strip
Galv. Float With Anchor Release
Woodhead With 3-Finned Float
Folded Vertical Card
With Foam Chip
Seaweed Drifter
Woodhead With Cork
Without Float Strip

FIGURE 1

KEY

1. Carruthers 1956
2. Barnes 1959
3. Nelson 1922
4. Terrell and Green 1972
5. Brodie 1960
6. Heath 1969
7. Garstang 1898
8. Duncan 1965
9. Olson 1951
10. Bache 1856
11. Bache 1854
12. Bache 1855
13. Bache 1849
14. Trites and Banks 1958
15. Dodimead and Hollister 1958
16. Chevrier and Trites 1960
17. Hamby 1964
18. Schulz 1935
19. Woodhead 1970
20. Tibby 1939
21. Uda 1936
22. Magliocca and Leudemann 1970
23. Gakkel and Samsoniya 1961
24. Norcross and Stanley 1967
25. Carruthers 1939
26. Crestani 1931
27. Harvey and Gould 1966
28. Tomczak 1968
29. Innman and Quinn 1952
30. Stander and Campbell 1969
31. Martin 1967
32. Pillsbury 1890
33. Carruthers 1928
34. Harrington 1895
35. Hughes, Farrell and Monahan 1970
36. Monahan 1968
37. Ruschmeyer, Olson and Bosch 1957
38. Ruschmeyer and Olson 1958
39. Cayan 1971
40. Higgins 1972
41. McCown 1973
42. Monahan and Monahan 1973
43. Daussy 1840
44. Bulletin Trimestriale 1954
45. Cahiers Oceanographiques 1954
46. Bougis and Ruivo 1955
47. Duboul-Razavet 1958
48. Thoulet 1908
49. Bumpus and Lauzier 1965
40. Bumpus 1965
51. Babinet 1856
52. Yoshida 1963
53. Bulletin of the Arctic Institute, USSR 1932
54. Tulloch and Tait 1959
55. Philosophical Magazine 1819
56. Philosophical Magazine 1822a
57. Philosophical Magazine 1822
58. Philosophical Magazine 1809
59. GM Mfg. (undated)
60. Bumpus 1971

For several years after my work on Lake Superior I had no opportunity to carry out additional drifter studies, but beginning in 1971, when I first conducted the University of Michigan's spring Oceanography Field Practicum Program in Woods Hole, I again, in conjunction with my students, had an opportunity to use sea surface drifters in current measurement programs. By the spring of 1972 we were conducting field intercomparisons of various drifter designs which, when coupled with laboratory tank studies, quickly convinced us that all drifters do not behave alike (see, e.g.,Higgins, 1972; Monahan et al, 1974). Some designs proved to be much too susceptible to direct wind influence.

I began to consider designing new types of sea surface drifters, and was led to look to the literature to see what had already been tried. This literature search, which became protracted and was conducted in large part by Mrs. Elizabeth A. Monahan, yielded a quantity and variety of sea surface drifter designs that are truely staggering. A summary of these numerous designs, arranged to show their historical evolution, is given in Figure 1. The key which accompanies this figure provides the association of the small numbers on the face of Figure 1 with the extensive bibliography included in this report.

There have been at least a half-dozen significant mutations of the simple drift-bottle design alone.

Prince Albert the First of Monaco, patron of that principality's Oceanographic Museum, was responsible for a number of drifter designs that were introduced in the latter part of the nineteenth century. His most elaborate drifter was in the form of a pear, made of copper, and contained a glass enclosed note and a suitable amount of ballast (Figure 2). Dr. J. N. Carruthers, of England's National Institute of Oceanography, noted for his many ingenious current measuring techniques, has in the past several decades designed several route indicating drifters, ranging from a double drift bottle device to a "crossbow float".

With the advent of durable plastics after the Second World War, a number of new surface drifter types made partially or entirely of plastic were introduced. Among these were a rigid plastic card that floats horizontally on the sea surface and a card-containing envelope made of plastic film which also floats flat in the water. Another popular drifter consists of a plastic envelope containing a postcard which is ballasted with a metal tab or washer so that it floats vertically.

Table I: Record of Use of Sea Surface Drifters Made of "Ascot"

Date	Drifter Type*	Location	Vessel	Cooperating Scientists	Released	Recovered	%	Comments
May 8, 1973	C	Buzzards Bay, Mass.	R/V ASTERIAS	D. McCown	105	52	49.5	(1)
"	0	" "	(W.H.O.I.)	"	105	56	53.3	"
10	C	" "	"	"	50	16	32.0	"
10	0	" "	"	"	50	26	52.0	"
17	C	Vineyard Sound, Mass.	"	"	20	1	5.0	"
17	0	" "	"	"	20	4	20.0	"
22	C	Buzzards Bay, Mass.	"	"	39	15	38.5	"
22	0	" "	"	"	39	8	20.5	"
August 29-31, 1973	M	Saginaw Bay, L. Huron	R/V SHENEHON (N.O.A.A.)	D. McCown & L. Danek	110	22	20.0	(2)
August 31, 1973	M	Lake Huron	"	N.O.A.A. Officers	26	0	0.0	"
September 20-21, 1973	M	Mona Passage, Atl. Ocean-Carib. Sea	R/V CRAWFORD (U.P.R.)	M. Stalcup & D. Atwood	100	0	0.0	"
February 6 - March 5, 1974	M	Windward Pas., throughout Carib. Sea	R/V KNORR (W.H.O.I.)		826	1	0.1	(2), (3)
May 10, 1974	0	Vineyard Sound Mass.	R/V ASTERIAS (W.H.O.I.)	D. Eriksson	60	6	10.0	(4)
10	M	" "	"	"	39	6	15.4	"
10	C	" "	"	"	60	15	25.0	"
10	S	" "	"	"	60	9	15.0	" , (5)
10	0	Buzzards Bay, Mass.	"	"	60	24	40.0	"
10	M	" "	"	"	60	13	21.7	"
10	C	" "	"	"	60	8	13.0	"
10	S	" "	"	"	58	6	10.3	" , (5)
July 18-20, 1974	M	South. Lake Michigan	R/V LAURENTIAN (U-M)		645	247	38.3	*
July 18-20, 1974	0	" "	"		920	215	23.4	*
August 6-9, 1974	0	" "	"	R. Monier	774	157	20.3	*

✓changed on table I

Addendum

to

Surface Current Drifters: Evolution and Application (MichU-T-74-004)

I. Revisions and Additions to Table I, based on drifter releases and returns subsequent to 21 August 1974 but prior to 12 December 1974.

Table 1 Update

Date	Drifter Type*	Released	Recovered	%	Comments
✓July 18-20, 1974	M	645	247	38.3	*
✓July 18-20, 1974	0	920	215	23.4	*
✓Aug. 6-9, 1974	0	774	157	20.3	*
Aug. ? , 1974	M	200	1	0.5	(7)
Sept. 14-15, 1974	M	200	0	0.0	(8)
Oct. 3, 1974	0	20	0	0.0	(9)
Oct. 3, 1974	M	20	0	0.0	(9)
Oct. 3, 1974	S	10	2	20.0	(5)*(9)(11)
Oct. 18-24, 1974	0	763	15	2.0	(10)
? ? 1974	M	?	1	?	(12)

Additions

*See Table I in report for details

(7) Irish drifters, released from Gulf Oil tanker out of Bantry Bay, release log not yet available. First return from Head of Kinsale, Co. Cork.

(8) Irish drifters, released in North Atlantic Ocean from O.W.S. WEATHER SURVEYOR (from I.M.E.R. Edinburgh) on way to Ocean Station "Juliett", by Captain P.E. Robertson.

(9) UMSG drifters, released in Saginaw Bay, Lake Huron, from R/V SHENEHON (N.O.A.A./G.L.E.R.L.), by L. Danek.

(10) UMSG drifters, released in southern Lake Michigan from R/V LAURENTIAN, by P. Pilgrim.

(11) Two returns from Ontario, Canada.

(12) Irish drifters, released by University College Galway off West Coast of Ireland, release log not yet available. First return from Donegal.

Added to page 7

14 ✓ II. Correction to Figure 6

Meridians are incorrectly labeled. Meridian marked as 88°W is actually 87°30'W. Likewise, meridian labeled 87°W should bear notation 86°30'W.

39 ✓ III. Addition to Bibliography

The following citation should be added to the bibliography:
Metcalf, W.G. and M.C. Stalcup, 1974: Drift bottle returns from the Eastern Caribbean. Bull. Mar. Sci. 24; 392-395.

Table 1 (continued)

*Encoded in accord with Table IV, N.O.D.C. Manual M-6, with modifications proposed by us.

(1) Returns as of 27 June 1973
(2) Returns as of 24 June 1974
(3) Single return from Haiti as of this date
(4) Returns as of 7 June 1974
(5) "Ascot" orange cards inside flint glass bottles
(6) Returns as of 21 August 1974
(7) Irish drifters, released from Gulf Oil tanker out of Bantry Bay, release log not yet available. First return from Head of Kinsale, Co. Cork.
(8) Irish drifters, released in North Atlantic Ocean from O.W.S. WEATHER SURVEYOR (from I.M.E.R. Edinburgh) on way to Ocean Station "Juliett", by Captain P.E. Robertson.
(9) UMSG drifters, released in Saginaw Bay, Lake Huron, from R/V SHENEHON (N.O.A.A./G.L.E.R.L.), by L. Danek.
(10) UMSG drifters, released in southern Lake Michigan from R/V LAURENTIAN, by P. Pilgrim.
(11) Two returns from Ontario, Canada.
(12) Irish drifters, released by University College Galway off West Coast of Ireland, release log not yet available. First return from Donegal.

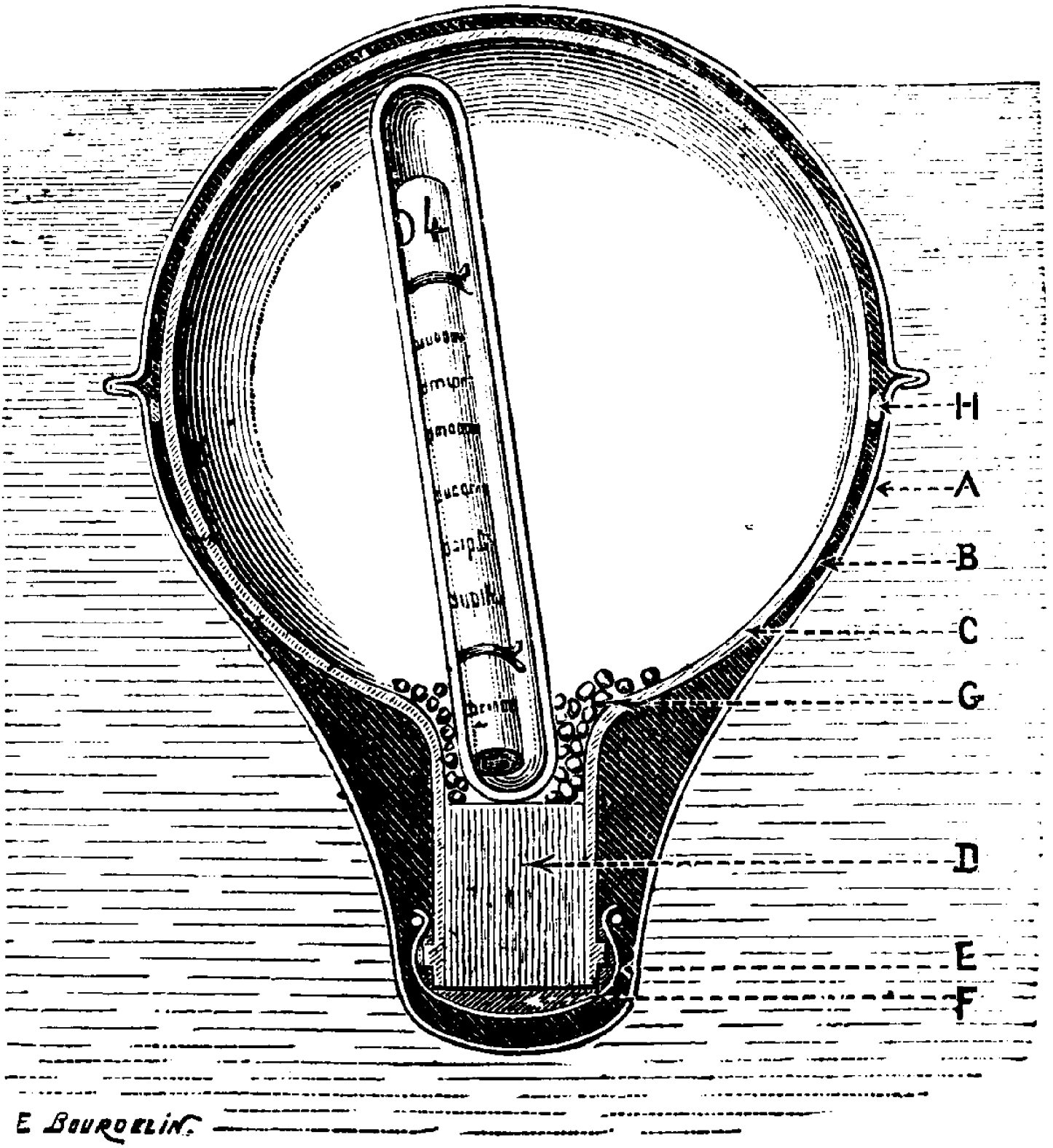

FIGURE 2 — **Flotteur du Prince de Monaco : coupe montrant la disposition intérieure.**

One of my students had read of a "waterproof paper" used in divers' tablets, and knowing of my search for a suitable material for sea surface drifters he called this material to my attention. It turned out to be a product of Appleton Papers, Inc., Appleton, Wisconsin, going by the trade name of "Underwater Ascot". It is produced by applying a special coating to both sides of sheets of Dupont's "Tyvek", a spun-bonded olefin. I was pleased to find that I could obtain from Appleton Papers sheets of orange fluorescent "underwater Ascot". It is from this material that all of our recent drifters have been made. (We have been informed by Dupont's Public Affairs Department that ours is the first use of this material in the manufacture of printed sea surface drifters.)

In time for the spring 1973 Oceanography Field Practicum program in Woods Hole, we had had printed by the M.B.L. Press, Ann Arbor, Michigan, a supply of two kinds of drifters: simple, flexible, horizontally-floating cards (3-1/4" x 5-1/2"); and "drums" (simple loops or rings made of strips 3-1/4" wide and 11" long). Mr. Donald L. McCown, a student participant in the Practicum released many of both types in the nearby bays that spring. We had a return of 39.3% on the simple cards and 43.9% on the drums (or rings). See Table 1 for details.

Encouraged by the high fraction returned, we set out to use drifters made of "Underwater Ascot" in our summer 1973 study of the circulation in Saginaw Bay of Lake Huron. While the "rings" were clearly less directly wind influenced than the simple cards, we decided to use even longer (approximately 3 foot) strips of "Ascot" in our Lake Huron work to improve still further the drifter performance. (A return postcard is printed on a portion of each strip, as is a text explaining the nature of our work). To keep these larger loops from "squashing" into elongated ovals, with their major axes lying horizontally near the water surface, we gave each strip of "Ascot" a half-twist before stapling the ends together (preferably with stainless steel or copper staples), thus forming a Möbius loop. The results of this study of Saginaw Bay are depicted on Figure 3. As indicated in Table 1, we had a satisfactory 20% return of postcards from those Möbius drifters, several returns coming in "in good shape" as late as May 1974.

In order to establish the durability of drifters made of this material, over long periods of time on the high seas, we prepared bilingual (Spanish-English) Möbius drifters, and in conjunction with Mr. Marvel C. Stalcup of W.H.O.I., and Dr. Donald K. Atwood of the University of Puerto Rico; and released over 900

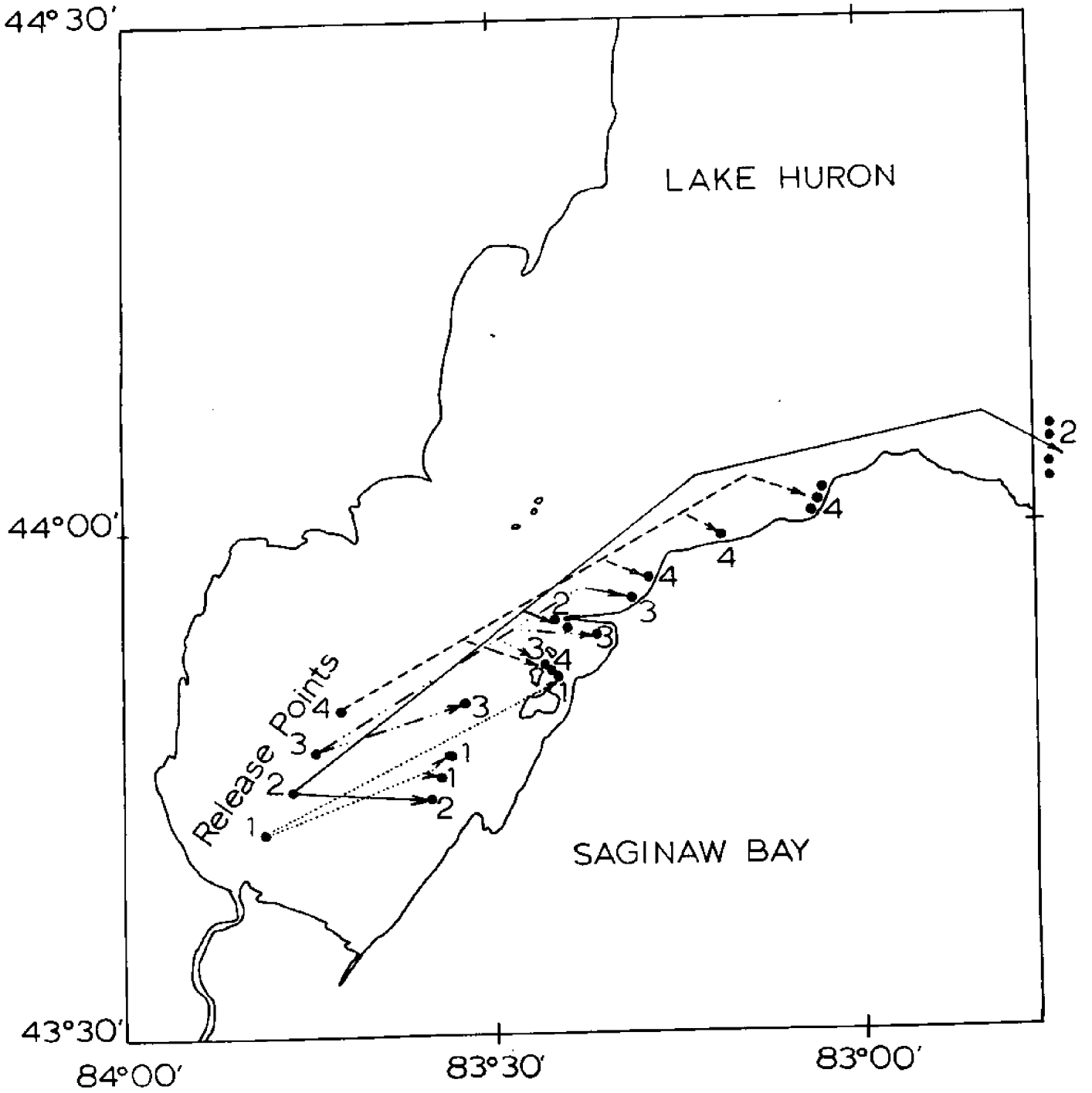
44° 30'
44°00'
43°30'
84°00'
83°30'
83°00'
LAKE HURON
SAGINAW BAY
Release Points

FIGURE 3

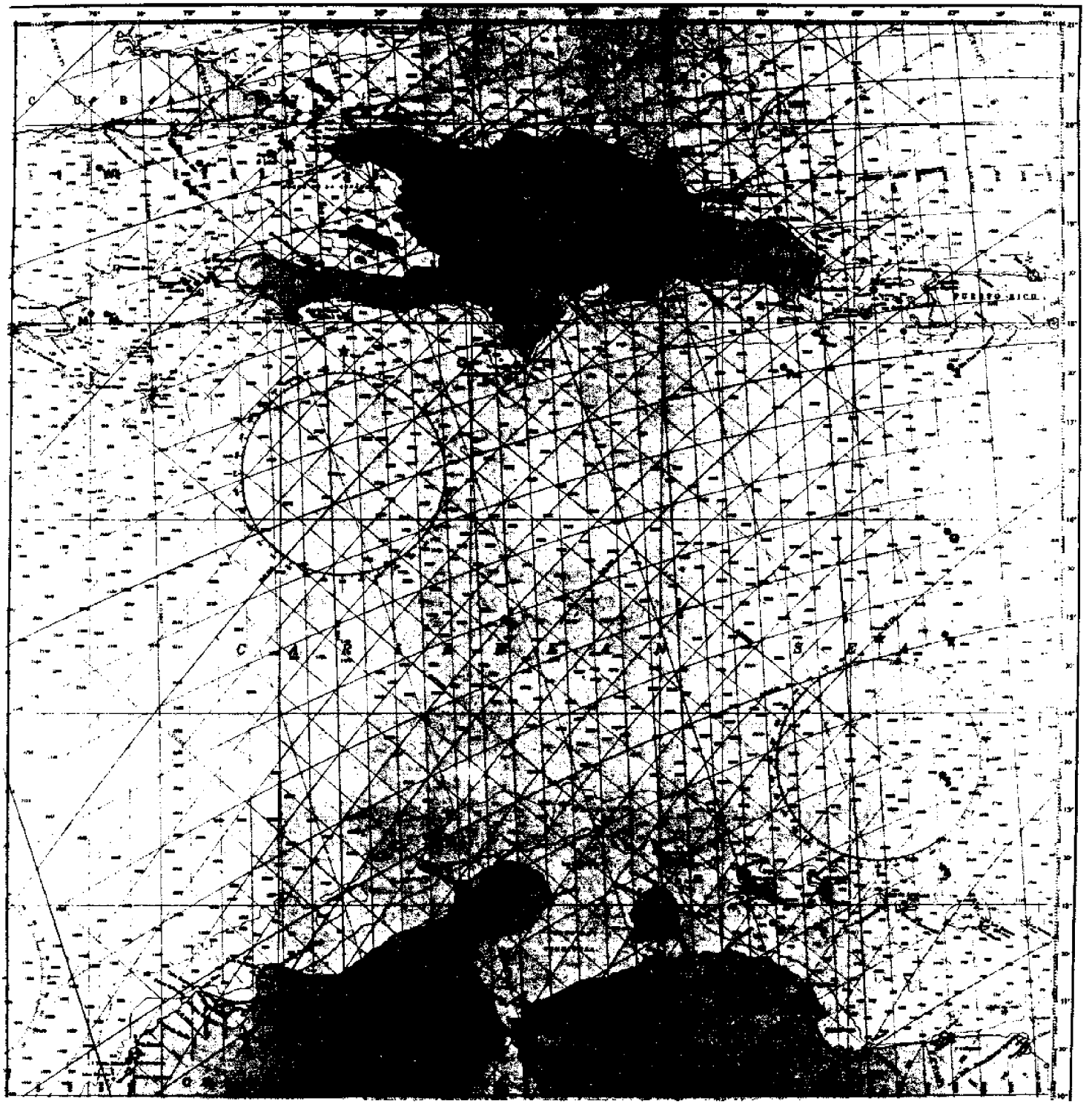

FIGURE 4

of them in the Caribbean Sea between September 1973 and March 1974. We received negligible returns (see Table 1 and Figure 4). Since many of these were released between Cuba and Haiti, political and linguistic difficulties may in part explain the extremely low return rate. It might also be mentioned that the Caribbean is a region notorious for low drift-bottle return rates, e.g. Stalcup and Metcalf (1972) experienced a 3.3% return of drift bottles released during a study of currents in the passages of the Lesser Antilles. In spite of these considerations, and the paradoxical fact that it is invariably the drifter that is adrift a short period of time and travels a modest distance that provides more solid insight into the currents of a region than the drifter that is afloat for years and travels thousands of miles (e.g., see Figure 5), we are nonetheless disappointed in the insignificant return rate from our Caribbean study. We have already begun participating in another open ocean current study and we intend to participate in several additional such studies, to determine, once and for all, the suitability of drifters made of "Ascot" in circumstances where they must endure continuous wave action during long periods afloat.

Tests conducted during the spring 1974 Oceanographic Field Practicum program by Mr. David Eriksson, a student participant, showed that the simple drum drifters and Möbius loop drifters suffered less direct wind influence than did the horizontal "postcard" drifters (See Table 1 for return percentages). An advantage of all the drifter types made from "Underwater Ascot" is that while a herring gull may find one of these drifters as enticing as any other bright floating object, its exploratory pecks will not have the catastrophic effect on this drifter that they often have on a plastic envelope drifter. (A plastic envelope when pierced often floods and sinks, or the enclosed paper card becomes an illegible pulp.)

Starting in July 1974, as one part of a study of the currents in southern Lake Michigan, supported by the University of Michigan Sea Grant Program and the City of Chicago, I, assisted by Mr. Roy Monier and others, have been releasing large clusters of drifters at numerous points in the lake, with as many as 150 to 200 being released at each of several predetermined "diagnostic points" (Figure 6). By 9 August 1974, 2389 drifters (all but 50 of which were either simple drums or Möbius loops made of "Ascot", see Table 1) had been set adrift in Lake Michigan. The initial rate of return (see Table 1) indicates that ultimately a higher fraction of drifter postcards will be returned from Lake Michigan than from the previous year's Saginaw Bay study. (The insert in this report has printed on it samples of the Lake Michigan

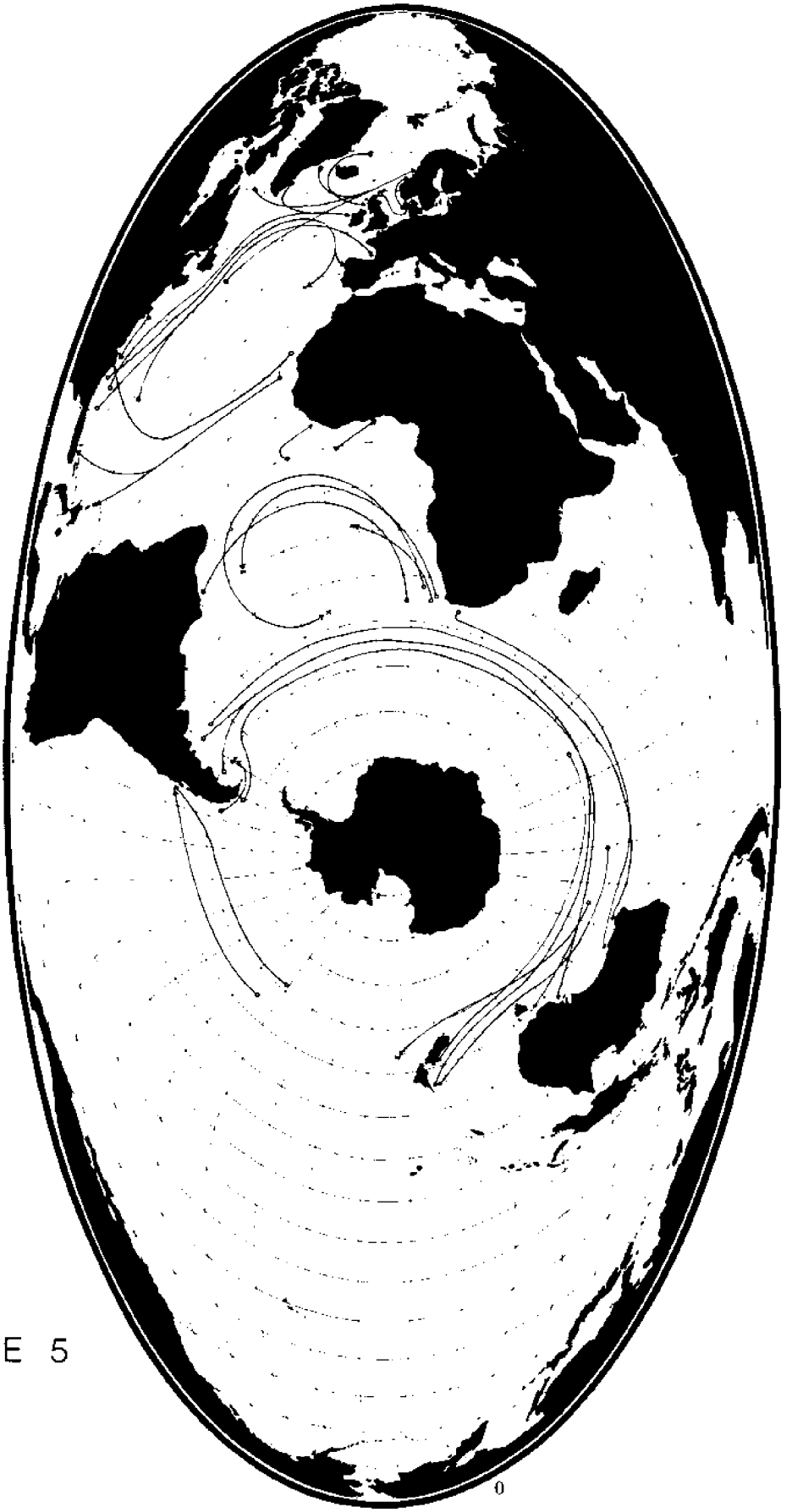

FIGURE 5

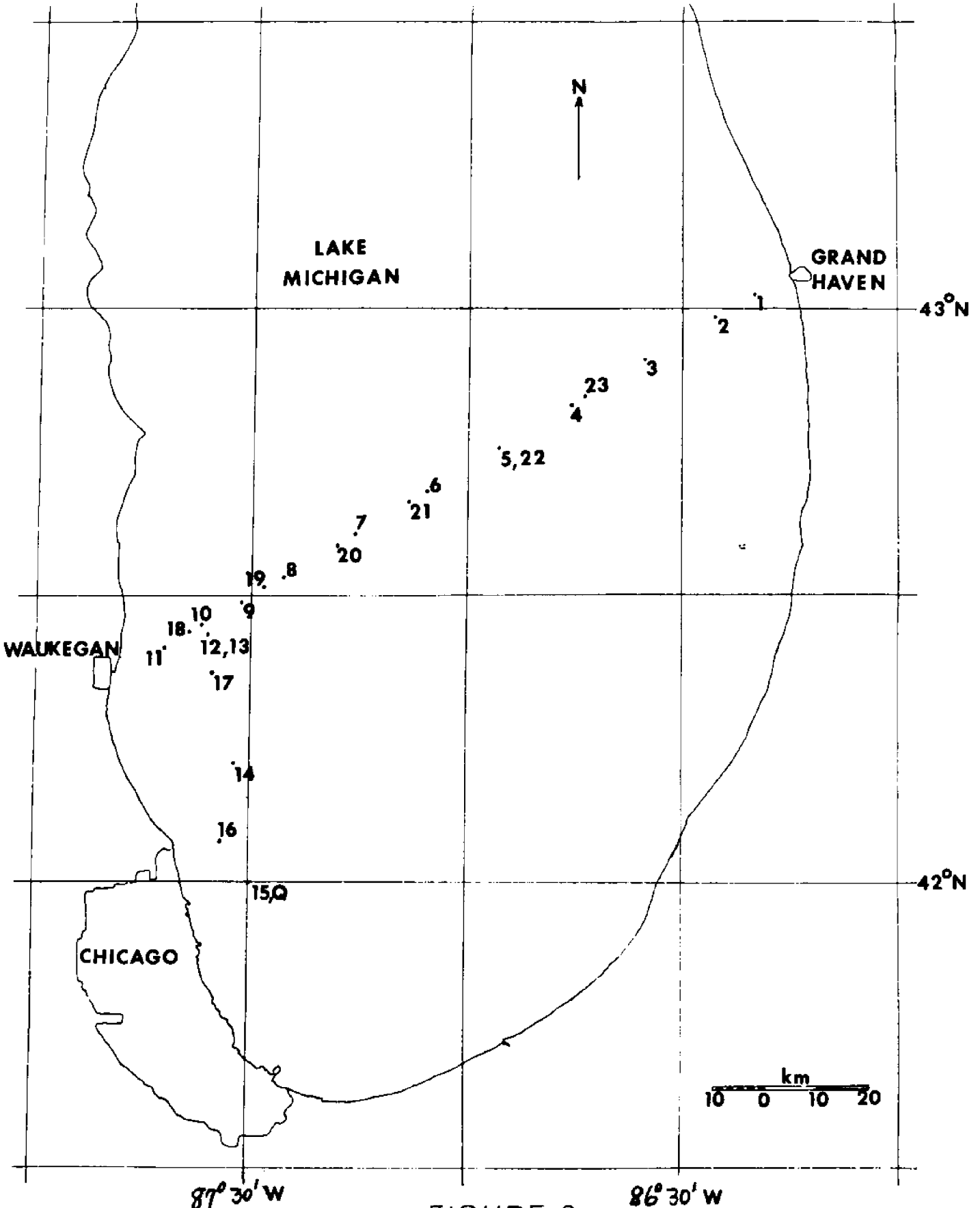
N
LAKE
MICHIGAN
GRAND
HAVEN
43°N
42°N
WAUKEGAN
CHICAGO
1
2
3
23
4
5,22
6
21
7
20
8
19
9
10
18
11
12,13
17
14
16
15,Q
km
10 0 10 20
87° 30' W
86° 30' W

FIGURE 6

version of our drifter. When cut from the sheet it can be bent into the drum or ring shape and stapled, or by adding a 22" additional strip to the end of the basic 11" strip, one can then form, as previously described, a larger Möbius drifter).

In order to carry out a second open ocean test of our "Ascot" drifters, we have joined Prof. Brian McK. Bary, of University College Galway, in the conduct of a study of the currents off the west coast of Ireland. The west coast of Ireland, being for much of its length rugged, should provide a critical test of our drifters, again in a situation where drift-bottles have fared badly (Tulloch and Tait, 1959). By the summer of 1974, 1200 of the 2000 trilingual (English, French, and Irish) drifters printed for this study had been sent to Ireland, and the Gulf Oil Corporation Marine Department had agreed to assist us by providing for the release of drifters from their tankers sailing in and out of Bantry Bay.

In conjunction with Dr. R. Molina of the Laboratorio Oceanografico de Canarias, and Sr. N. Gonzalez of the Laboratorio Oceanografico de La Coruña, I am at present preparing the text (to appear ultimately in Spanish, Portuguese, French and English) for "Ascot" drifters that will be released in a study of the currents off the northwest coast of Spain, and in the Ria (estuary) de Arosa. Participating in this study will be scientists from the Instituto Español de Oceanografica, the Woods Hole Oceanographic Institution, and the University of Michigan.

I have likewise begun, with Dr. David A. Ross of W.H.O.I., to prepare an Arabic-English drifter to be used in the Eastern Mediterranian off the coast of Egypt.

The next section of this report, prepared by Mr. P. Hawkins, describes in detail the steps involved in preparing drifters and processing drifter postcard returns.

A bibliography, listing 260 papers and publications dealing with surface current drifters, and prepared by Mrs. E. A. Monahan, represents the final section of this report.

In conclusion, I would suggest that others, even those not primarily interested in physical oceanography (or physical limnology) but with a need of information about the currents in their regions of study, consider mounting modest circulation studies using drifters of the type I have described. They are relatively inexpensive to manufacture, simple to assemble, occupy negligible volume on even the smallest of research vessels, and can be deployed with ease from aircraft as well as from ships. In addition, the use of drifters of these types does not present

the environmental specter of broken glass. Granted it is ideal to use sea surface drifters to complement current determinations obtained via extensive drogue tracking and the analysis of eulerian records from moored current meters, but when it is not possible to carry out a full-scale current study (for fiscal or other reasons), rather than curse one's fortune, I recommend that a surface drifter study be undertaken.

SECTION B: PROCEDURE FOR PROCESSING DRIFT CURRENT MARKER DATA

Peter C. Hawkins

I. Introduction

The purpose of this procedure is to outline in detail those steps concerned with the collection and processing of data in a scientific program designed to measure water currents with drift current markers. The procedure covers the preparation, release and recovery of drift current markers as well as the transmitting of appropriate data to the NODC. It is intended that the steps outlined will be applicable for drift current markers in large bodies of fresh water (eg. Great Lakes) as well as ocean waters. The procedure has been developed in connection with an investigation by the University of Michigan - Sea Grant Program which is sponsored by NOAA (U.S. Dept. of Commerce).

II. Preparation of Current Markers

The proper preparation of current markers will serve to minimize or avoid many possible pitfalls in the subsequent processing of data following the release and recovery of the drift current markers. A checklist of critical areas appears below.

General

1. Postal Permits. To facilitate and encourage returns, it is suggested postal permits be used on the reply cards whenever possible.

   When current markers are released in waters where the geography or prevailing currents may lead to multi-national recoveries, there is no "international postal permit" which can be employed. In this case, you will have to request that the finder mail in the reply card at his own expense with a promised refund of postage charges.

2. Ink Fading. Drift current markers are subjected to continuous exposure to sunlight. Such exposure will normally result in a relatively quick (eg. 2-3 weeks) and substantial fading of the fluorescent dyes used in some drift marker reply cards.

3. Water-proofness. Despite all precautions, some reply cards are subjected to a water soaking either prior to recovery or during the process of recovery. Waterproof reply cards will permit, in many cases, the finder to use the reply card for its intended purpose where in the past a water soaked reply card would likely be discarded.

4. Writing Surface. The concern for a waterproof reply card has led to the use of various plastics as a material for the drift current marker reply card. Care should be taken to select a material which can be written on with both pen and pencil clearly and with ease.

Inducements

When a drift current marker is recovered along the shore, whether the reply card is sent on to the investigator or discarded may well depend on how much you can arouse the curiosity and interest of the finder. The copy on the reply card, therefore, becomes an extremely important factor in maximizing the number of returns relative to recoveries. Some suggestions are noted below as inducements to the finder to return the reply card properly filled out.

1. Letter. Tell the finder that he will receive a letter from the investigatory group acknowledging his efforts. The letter will indicate the time and point of release (Lat., Long.) of the drifter which was discovered.

2. Brochure. Tell the finder he will receive, in addition to a letter, a brochure briefly describing the historical and present application of drift markers as a device used by oceanographers to study currents.

3. Miscellaneous. Other inducements may include an offer to pass on to the finder a) a financial reward, and b) a brief synopsis of the final technical report on the study.

Numbering

All drift current marker reply cards should be numbered to maintain control over the release and recovery position analysis. It is important to maintain a Master Record of these number (and alphabetic) sequences which have been used to identify reply cards to prevent duplication. Especially in those cases where a drift marker current study is going to take place over a period of perhaps 2-3 years, it is wise to lay out prior to the initial release a number (and alphabetic) plan for the reply cards that will encompass the entire project, again, to avoid duplication or confusion in assigning recovered cards to the proper release.

Batching (Identifying Numbers)

During the preparation of drift current markers for a release cruise, it is suggested the drift markers be batched in "sequential number" groups. In addition, it is recommended a summary record be maintained of the drift markers which have been prepared for the cruise. (See Appendix I)

III. Drift Current Marker Release Log

This form is designed to summarize the pertinent data concerning the release of drift current markers during a cruise.

In addition, as recoveries are made and returned to the investigating body, this record will be the easiest to use in connecting recovery reply cards with the appropriate release information. The form has been designed for easy shipboard use on a clipboard. See Appendix II for a copy of this form.

Following is a brief description of the various headings on the Drift Current Marker Release Log:

Cruise: Name of vessel and cruise number, eg. R/V KNORR No. 347

Investigator: Name of individual completing the Release Log.

Station No.: An arbitrary numerical classification of a given location (Lat., Long.) where the drift markers are released, Example: 129, 029 for No. 29, 007 for No. 7.

Type: Refers to alphabetic identification of various drift marker types. See Appendix III.

Day: Day of month. Example: 21 or 09 for the 9th.

Month: Month of year. Example 12 for December, 07 for July.

Year: Last two digits of year. Example "74" for 1974.

Hour: Notation for time of release in hours and minutes. Use time in time zone of release station. Also, use 0-2400 hours reference. Example 0810 for 8:10 am and 1635 for 4:35 pm. Indicate time zone in heading block.

Lat.: Reference to latitude of release station in "degrees, minutes, tenths of minutes". Example 41°24'.6. In addition, reference to the hemisphere should be noted in the heading of the column in the blank; N for Northern Hemisphere and S for Southern Hemisphere.

Distance from shore: Shortest distance from shore to release station in (nearest) whole nautical miles. Example: "002" for 2 nautical miles, "084" for 84 nautical miles and "121" for 121 nautical miles.

Drift Marker Nos.: Record the numbers of the drift markers released at this station. Be sure to include alphabetical prefixes or suffixes. Examples: "A 0084 - A 0147" (for the 64 drift markers from 84 to 147), "A 9984 - A 9999 and B 0000 - B 0032" (for 49 drift markers), "UMMO 532-581, AOSUM 0093 - 0321".

Subsequently, the information on the Drift Marker Release Log is to be transferred to the NODC Drift Bottle Coding Form (Provisional) Form No. NODC-EXP-3167/37(4-56). See Section B, IV below.

IV. NODC Drift Bottle Coding Form For Release Data

The purpose of this form is to collect drift marker release (and recovery) data in the proper sequence to facilitate key punching (punch) cards for transmission to the NODC. The steps are as follows:

Source of Data

1. Reference is made to the Drift Marker Release Log (Section B, III) as a source of information for completing the Drift Bottle Coding Form release data.

2. Cross Referencing - The Drift Bottle Coding Form should be cross-referenced to the Drift Marker Release Logs. It is suggested the "Ship's Name" and "Cruise No." from the Drift Marker Release Log be inserted in the heading at the top of the Drift Bottle Coding Form entitled "Name of Platform". Additional numerical or alphabetical symbols may be used to assure rapid and specific cross-referencing capability from one form to the other.

3. Instructions for Completion of the Drift Bottle Coding Form. NODC has published a manual with complete and detailed instructions on the completion of this form. These instructions appear in the NODC Manual for Processing Current Data, Part 1, Publication M-6 (Provisional).

Note: Release data is recorded on the NODC Drift Bottle Coding Form immediately. It is then processed onto punch cards and forwarded to the NODC. Recovery data will be processed in a similar manner as it becomes available; there is no delay in recording and processing release data in anticipation of the arrival of recovery data. Release data is processed first and separately.

V. Key-Punching Drift Bottle Coding Release Data

After completion of the NODC Drift Bottle Coding Form, the release data is key-punched on punch cards for transmission to the NODC and computer analysis by the investigating group. Instructions are as follows:

1) Instructions for Key-Punching. Reference is made to NODC Manual for Processing Current Data, Part 1. Complete instructions for key-punching are incorporated in the manual. Only release data is key-punched at this time. Two identical cards are key-punched.

2) Transmission of Punch Cards. The two (2) identical punch cards containing release data are disposed of as follows:

   a) First card should be sent to the NODC at the following address:

      NODC D761
      U.S. Department of Commerce
      National Oceanic and Atmospheric Administration
      Washington, D.C. 20235

   b) The other card is retained by the investigating group for its own information and analysis.

VI. Chart Records of Release Data

A graphic picture of release (and recovery) data is achieved by noting release (and recovery) positions on a chart of the appropriate area. Two types of charts may be employed. A large bathymetric chart may be used as a "situation chart" noting the results from several related cruises in some detail. For publication purposes, smaller simpler renditions of the same geographic area are required similar to the examples shown in Figures 3 and 6.

In those charts used for publication purposes, more than one chart of a given area may be required depending on the number of release stations and/or the number of drift current markers released at each station. For example, if there are only a few release stations and a limited number of drift current markers released at each station, a chart similar to Figure 3 maybe used. On the otherhand, if the release points number 23, for example (see Figure 6), it is obvious you cannot record all recoveries on this one chart. In this instance, additional charts are required for each 3 or 4 release stations.

1) Record data. At each release point on a chart, data related to the following factors may be noted: 1) station number, 2) number of drift markers released, 3) drift marker numbers, eg. A-0009 to A-0143. Colored-coded pins may be used to mark release point positions on the "situation chart". (The same color codes can be retained in the subsequent recording of recovery data for each release point on the chart.)

2) Bathymetric Chart Sources:

Great Lakes

NOAA-National Ocean Survey
Distribution Division - (C-44)
Riverdale, Md. 20840

Tel. (301) 344-2613

U.S. Coastal Waters

Officer in Charge
U.S. Naval Oceanographic Distribution Center
5801 Tabor Avenue
Philadelphia, Pennsylvania 19120

World Coastal Waters

(Same as U.S. Coastal Waters)

VII. Procedure for Processing Recovery Data

When a Drift Current Marker Reply Card is returned by the finder, it will initiate a number of steps. The items noted below will outline those steps which should be followed:

1) Release Log Check. Upon receipt of a drift current marker reply card, check the file of Drift Marker Release Logs to ascertain precisely the cruise, date and point of release of the particular drift marker. Write on the reply card
   a) Date of release
   b) Latitude, and Longitude of point of release,
   c) Any other information required in the acknowledgment letter.

2) Drift Bottle Coding Form Recovery Data. After #1) has been completed, all appropriate information on the reply card should be recorded on the NODC Drift Bottle Coding Form in the Release and Recovery sections. The record of recovery data will appear as a separate and new line item below the release data. Recovery data is added to the NODC Drift Bottle Coding Form in chronological order. All release and recovery information specifically related to each recovery reply card should be recorded on the Drift Bottle Coding Form as a separate (and new) line item. Reference is made to the NODC Manual for Processing Current Data, Part 1 for specific instructions as to how to complete each column in the Drift Bottle Coding Form.

Upon completion of the transfer of information from the reply card to the Drift Bottle Coding Form, the reply card should be stamped (rubber stamp suggested) "F", noting that this step is complete. (Note: The order in which drift current marker data is recorded on the NODC Drift Bottle Coding Forms is not of great importance. Once punch cards have been

developed from the NODC Drift Bottle Coding Form, a collator can easily sequence release and recovery information in any desired manner. It is suggested, however, that release and recovery data for a cruise or series of related cruises be listed in chronological order on the same set of NODC Drift Bottle Coding Form(s). A separate Coding Form would normally be used for another cruise related to a different project or an investigation in different body of water (e.g., Lake Michigan vs. Lake Huron.)

3) Acknowledgment. After completing #2, the reply card acknowledgment letter should be sent to the finder. A sample Acknowledgment letter appears in Appendix IV. The Acknowledgment will normally contain information which relates specifically to the individual reply card (e.g., date of release, Lat. and Long. of release station). Nevertheless, it is recommended a form letter be used where the typist fills in the address, date of release, Lat., Long., etc. A brochure or another insert may also accompany the acknowledgment offering background information on the investigation or drift markers in general.

When the acknowledgment letter has been completed and mailed, stamp the reply card with an "L" (rubber stamp suggested) signifying that the acknowledgment has been sent out.

4) Key Punching-Recovery Data. Again, the NODC Drift Bottle Coding Form serves as an information source for key punching 2 cards with (release and) recovery data. Detailed instructions for key-punching are outlined on the NODC Manual for Processing Current Data, Part 1. One card should be forwarded to:

NODC D761
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Washington, D.C. 20235

The other card is retained by the investigating group as a basis for further analysis.

5) Chart Record of Recovery Data. (Reference should be made to Section VI, p. 5). All recoveries should be spotted on charts on which the release station is noted. Since recovery points by their nature are going to be more numerous than release stations, some thought should be given to the method for noting recoveries to avoid the creation of a cluttered and confusing graphic portrayal of release and recovery data.

VIII. COMPUTER SUMMARY OF RELEASE AND RECOVERY DATA

Both the release and recovery punch cards can be used to tabulate release-recovery data on a computer printout. This printout is nothing more than a numerical summary of release data (as detailed on the NODC Drift Bottle Coding Form) and recovery data (as detailed on the same form). No analysis is performed. A sample portion of such a printout appears in Appendix V.

IX. ANALYSIS

The raw data for release and recovery of drift current markers are gathered for the purpose of analysis to determine the characteristics of water movement in a given area under a variety of aquatic and atmospheric conditions. Such analyses may vary depending on the location of the body of water, season, weather conditions, and the ingenuity of the investigator. The nature and magnitude of the raw data, in most cases, lends itself to computer analysis.

SECTION C: APPENDICES

APPENDIX I: PREPARATION OF DRIFT CURRENT MARKERS

Requisition

For (e.g., City of Chicago) Date (requisition filled out)

To be completed by (date need current markers)

TYPE	QUANITITY	NO./BAG, CARTON, ETC.*
(see Appendix III)		

Authorization (signature).

Production Record

DATE	QUANTITY	ACCUM. TOTAL	MARKER NOS.
6/5/74	300	300	A-0000 to A-0299
6/6/74	400	700	A-0300 to A-0699

*Each bag, carton, etc. containing a number of drift markers should be labelled with the identifying Reply Card Nos. contained therein.

Appendix II

Drift Current Marker Release Log
(Revised)

DRIFT MARKER RELEASE LOG

VESSEL/CRUISE_____ INVESTIGATOR_____ INSTITUTION_____

Station No.	Type *	No. of Markers	Day	Mo.	Yr.	Hour: Min. T. Zone	Lat. ___	Long. ___	Distance from Shore ***	Drift Marker Numbers
							°	°		

* S = BALLASTED BOTTLES
B = SEA BED DRIFTERS
E=Vertical Envelopes
O=Cylindrical Drums

N= NO BALLAST
C= DRIFT CARD
M=Mobius Loop

*** DO NOT WRITE IN THIS COLUMN

Appendix III

Drift Marker Types

Type	Alphabetical Code
Seaweed (real or artificial) with drift card attached	A
Sea bed drifter	B
Drift card (or envelope) - horizontal	C
Drogue bottle	D
Vertical envelopes	E
Drogue lost	L
Waterproof Mobius loop	M
Unballasted bottle[1]	N
Waterproof drum (cylinder)	0
Ballasted bottle[1]	S
Cap of woodhead drifter	U
Folded vertical card	V
Woodhead Sea Bed drifters modified to float at surface	W
Payne surface drifter	X
Horizontal Envelope with weighted ribbon	Y
Double drift bottles	Z

[1]Bottles floating at an angle equal to or greater than 45 degrees from the horizontal position are designated as "ballasted"; bottles floating at an angle less than 45 degrees from the horizontal position are designated as "unballasted".

Appendix IV

Acknowledgment

Date

Dear _____:

We appreciate very much your cooperation in returning to us the drift current marker which you found on the shore recently. It may interest you to know that this drift marker was released on (date) at (Lat., Long.) in (body of water). Your reply added to the many others we receive allows us to analyze in detail the prevailing water movements.

Most people are unaware of the fact the drift markers have been employed for many centuries by oceanographers as a scientific tool for studying water currents. We are enclosing a brochure entitled Drift Bottles and Other Surface Current Markers which briefly describes the history of drift current markers and their modern day application.

Thank you very much for your help in our investigation of water currents. If you ever see another drift bottle or marker, we hope it will, again, arouse your curiosity.

Sincerely yours,

Institution
Program (eg. Sea Grant Program - NOAA)

enc: brochure

APPENDIX V

Sample of Summary of Release and Recovery Data

R.NO.	DATA	1974 UNIV. OF MICHIGAN DRIFT CARD EXPERIMENT		
00053	31021	7405101241250704 6	02608010997405264132070 3 9E03500100160062	10
00054	31021	7405101241250704 6	0261SC183574052641 2E07033E0570011016 0072	10
00055	31021	7405101241250704 6	0260C00336740527413507052E300001301700 82	10
00056	31021	7405101241250704 6	0239M00665740527413507052E300001301700 82	
00057	31021	7405101241250704 6	0239E00582740512412707055E300000800204 02	
00058	31021	7405101241250704 6	0239EC0590740513412907102E2650016003 0532	
00059	31021	7405101241250704 6	0260C00320740522413507050E32000110120092	
00060	31021	7405101241250704 6	0239E00589740524412607053E300000701400 52	
00061	31021	7405101241250704 6	0239E00611740524412607052E300000601400 42	
00062	31021	7405101241250704 6	0239MC0702740525412507054A27800050150032	
00063	31021	7405101241250704 6	0260SC0569740602412707035E0600012023 0052	
00064	31021	7405101541330704 7	03608 1	10
00065	31021	7405101541330704 7	0360M 1	10
00066	31021	7405101541330704 7	0360C 1	10
00067	31021	7405101541330704 7	0324E 1	10
00068	31021	7405101541330704 7	0336E 1	10
00069	31021	7405101541330704 7	0324E 1	10
00070	31021	7405101541330704 7	0358S 1	10
00071	31021	7405101541330704 7	0360S 1	10
00072	31021	7405101541330704 7	0360CC02487405134132070 57A26000080030272	10
00073	31021	7405101541330704 7	0360MC0750740513413207056A2640007003 0232	10
00074	31021	7405101541330704 7	0360801001740513413207056A2640007003 0232	10
00075	31021	7405101541330704 7	0360801 0C5740513413207056A2640007003 0232	10
00076	31021	7405101541330704 7	0360801 0147405134132070 56A2640007003 0232	10
00077	31021	7405101541330704 7	0324EC11777405134132070 56A2640007003 0232	10
00078	31021	7405101541330704 7	0324EC11867405134132070 56A2640007003 0232	10
00079	31021	7405101541330704 7	0336EC0558740514412907047F1820003004 0082	10
00080	31021	7405101541330704 7	0360MC0756740514412707048E1940007004 0182	10
00081	31021	7405101541330704 7	0324EC11797405144132070 58E2540009004 0222	10
00082	31021	7405101541330704 7	0360801040740515413407039A0780006005 0122	10
00083	31021	7405101541330704 7	0360CC0022174051641350705 6A2830008006 0132	10
00084	31021	7405101541330704 7	0360CC0023574051641450703 8A0310012006 0202	10
00085	31021	7405101541330704 7	0360MC0718740516413707039A0590007006 0122	10
00086	31021	7405101541330704 7	0324EC11857405164140070 43A0190008006 0132	10
00087	31021	7405101541330704 7	0324EC11877405164140070 43A0190008006 0132	10
00088	31021	7405101541330704 7	0358S0062674051641380703 9A0490008006 0132	10
00089	31021	7405101541330704 7	0360MC0075174051641410704 3A0200008006 0132	10
00090	31021	7405101541330704 7	0360801015740517413607039A0620007007 0102	10
00091	31021	7405101541330704 7	0324EC11987405174136070 39A0620007007 0102	10
00092	31021	7405101541330704 7	0360S0236474051741380703 9A0490008007 0112	10
00093	31021	7405101541330704 7	0360CC0025574051841410703 8A0380010008 0132	10
00094	31021	7405101541330704 7	0358SC0059374051841360703 9A0600007008 0092	10
00095	31021	7405101541330704 7	0358S0062474051841360703 9A0600007008 0092	10
00096	31021	7405101541330704 7	0360M0073974051841360703 9A0600007008 0092	10
00097	31021	7405101541330704 7	0360501003740518413607039A0600007008 0092	10
00098	31021	7405101541330704 7	0360801009740518413607039A0600007008 0092	10
00099	31021	7405101541330704 7	0360801010740518413607039A0600007008 0092	10
00100	31021	7405101541330704 7	0360801012740518413607039A0600007008 0092	10
00101	31021	7405101541330704 7	0360801019740518413607039A0600007008 0092	10
00102	31021	7405101541330704 7	0360801043740518413607039A0600007008 0092	10
00103	31021	7405101541330704 7	0360801044740518413607039A0600007008 0092	10
00104	31021	7405101541330704 7	0360801055740518413607039A0600007008 0092	10

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