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ON THE USE OF DRIFT BOTTLE AND SEABED DRIFTER DATA IN COASTAL MANAGEMENT

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Summary

1. The use of drift bottle and seabed drifter information for use in coastal management is discussed. The drift bottle/ seabed drifter portion of VIMS project MACONS (Mid Atlantic Continental Shelf) is described as an example of how a comprehensive survey using drift bottles and seabed drifters provides data useful for coastal management.

2. The data from MACONS are analyzed to answer specific questions of interest to several different coastal managers: a manager siting a deep oil port, one siting a sewage outfall, a manager responsible for setting up emergency beach protection procedures before an accident occurs, and a manager responsible for the environmental quality of a particular small section of coastline.

3. A description and analysis of a drift bottle/seabed drifter experiment is presented in order to show strengths and weaknesses of the technique as a tool in coastal management. In particular, the value of a comprehensive study such as MACONS is shown to be that it avoids several serious bias problems associated with short term circulation and hydrographic programs and that a single study can be used by a variety of managers.

Recommendations

1. VIMS recommends that a comprehensive drift bottle/seabed drifter program be initiated in the Virginian Sea. As part of the program, the development of an automatic fixed surface and bottom drift card dispenser be undertaken. Such a dispenser should be used in connection with future evaluations of specific sites for all offshore activities which may produce undesirable impacts on the shore. This program should be continued as an interim measure until better methods are available for estimating impacts due to circulation from specific sites.

2. The proposed Hampton Roads Sanitation District sewage treatment plant at Dam Neck, Virginia is located at a site where particularly high return to shore can be expected from a nearby outfall. We recommend that an alternative site be chosen, that the outfall be located at a site with low probability of return, or that the treatment be thorough enough that the presence of effluent on the beach will cause no undesirable impact.

On the Use of Drift Bottle and Seabed Drifter Data in Coastal Management

In the next few years coastal managers will be required to choose sites for offshore installations of various kinds. Examples of such installations are power plant sites, supertanker deep water offloading facilities, and dumping sites for dangerous chemicals, sewage plant effluents, and dredged spoil. In order to minimize harmful impact downstream of heat, effluent, turbidity, or accidental spillage it is imperative in siting such an installation to know as much as possible about the climatological circulation over the continental shelf. Currently, the sparse data that do exist are not for the most part presented in a form useful to coastal managers.

The reason for this is associated with the approach used to study the circulation. The approach has been first to understand the principles of shelf circulation and then to design specific models applying these principles to a given problem. In the case of the coastal circulation problem, oceanographers do not now understand the principles clearly enough to construct a useful model. Even descriptive patterns of circulation have been documented for only the grossest scales. We can reasonably expect that the relevant physical principles will not be understood with sufficient clarity to produce models useful for siting decisions in time for the earliest of these decisions to be made. This is true despite the welcome and necessary focus that oceanographers are starting to apply to the continental shelf.

In the interim, there is a type of data which can be analyzed to answer some coastal management questions despite the lack of understanding of the relevant principles. We present here an approach to the analysis of these data using some examples. In doing so, we acknowledge that it is dangerous to draw conclusions from data when the underlying principles are poorly understood. In the present instance our reservations have been overcome by our awareness of the imminent nature of the siting decisions for which this approach will be beneficial.

The particular data are drift bottle and seabed drifter release and recovery data from the Virginia Institute of Marine Science (VIMS) Mid Atlantic CONtinental Shelf (MACONS) project. The drifter part of the study is described in Norcross and Stanley, 1967. Drift bottles and seabed drifters are objects containing numbered notes which are released at specified positions at sea. The drift bottles float with the surface waters while the seabed drifters are carried by the bottom flows. Some of these objects strand on the beach. If found, the finders send the bottle number, time and location of discovery back to the investigator in exchange for a reward. These data lead to a correspondence between points of entry and stranding. From this correspondence and knowledge of the number of bottles released at each location, several questions of interest to coastal managers may be investigated.

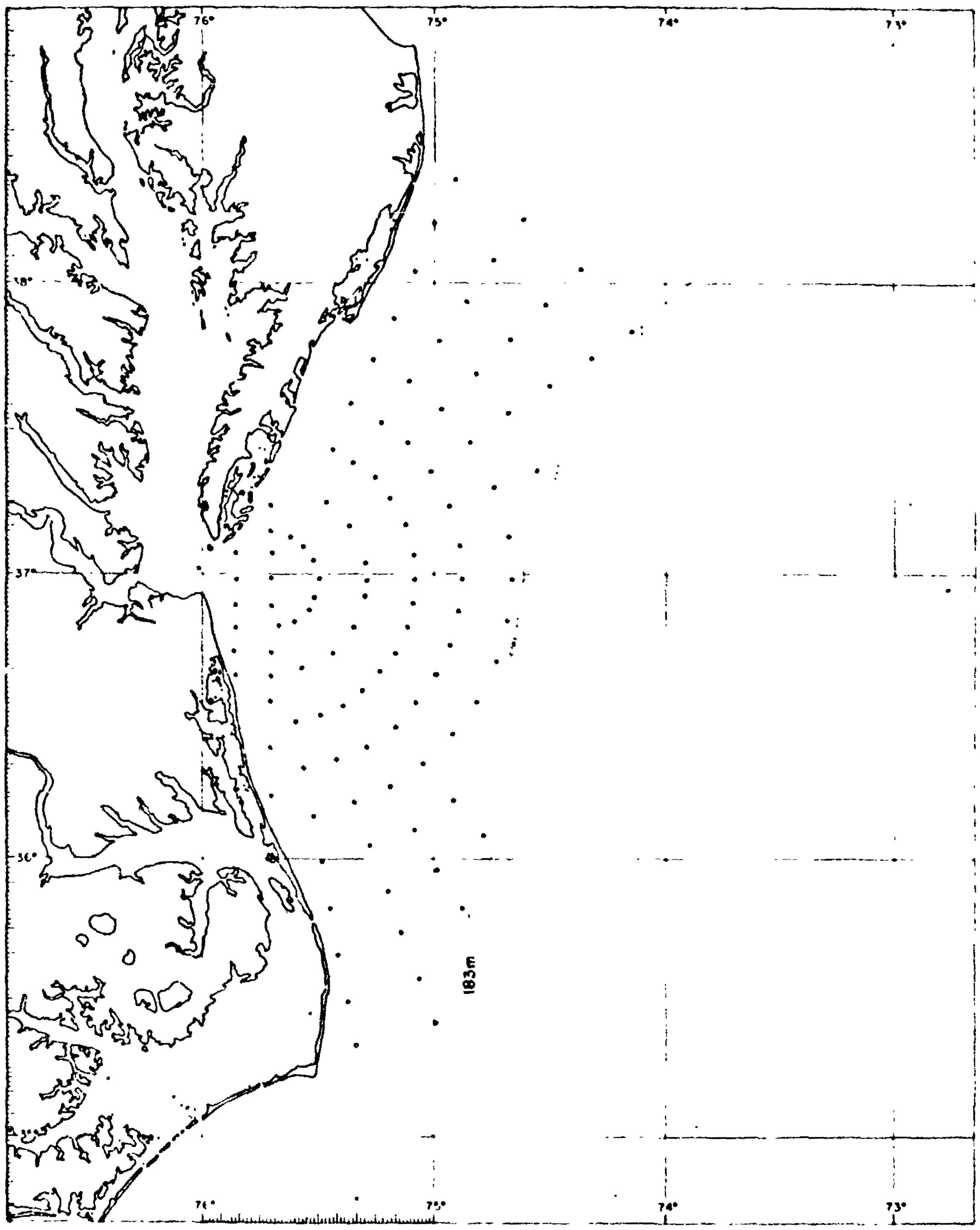

Figure 1. Drift bottle and seabed drifter release stations for project MACONS.

Project MACONS included the release during 16 consecutive months of drift bottles and seabed drifters at 110 stations over the continental shelf between Ocean City, Maryland and Cape Hatteras, North Carolina. For each month at each station, six drift bottles and five seabed drifters were released. The release points were located on a polar grid with the mouth of Chesapeake Bay as the pole. The locations were arranged so that the highest density of release points was near the Bay mouth (Figure 1). It is from the returns from this project that we will obtain answers to several questions of interest to coastal managers.

Q: What is the probability that an object placed in the sea somewhere in the study area will be discovered later on shore?

A: The answer is obtained by counting the number of bottles/drifters returned from each station, dividing by the total number released at that station, and constructing a probability field by assigning the resulting numbers to the geographical locations of release. The resulting isopleths are shown in figure 2 for drift bottles and in figure 3 for seabed drifters. Because breakage and non-return result in decreased returns, these isopleths can be thought of as lower bounds to the actual probabilities of return to the beach. However, if breakage and non-return are not correlated with release points, the ratios of actual probabilities are

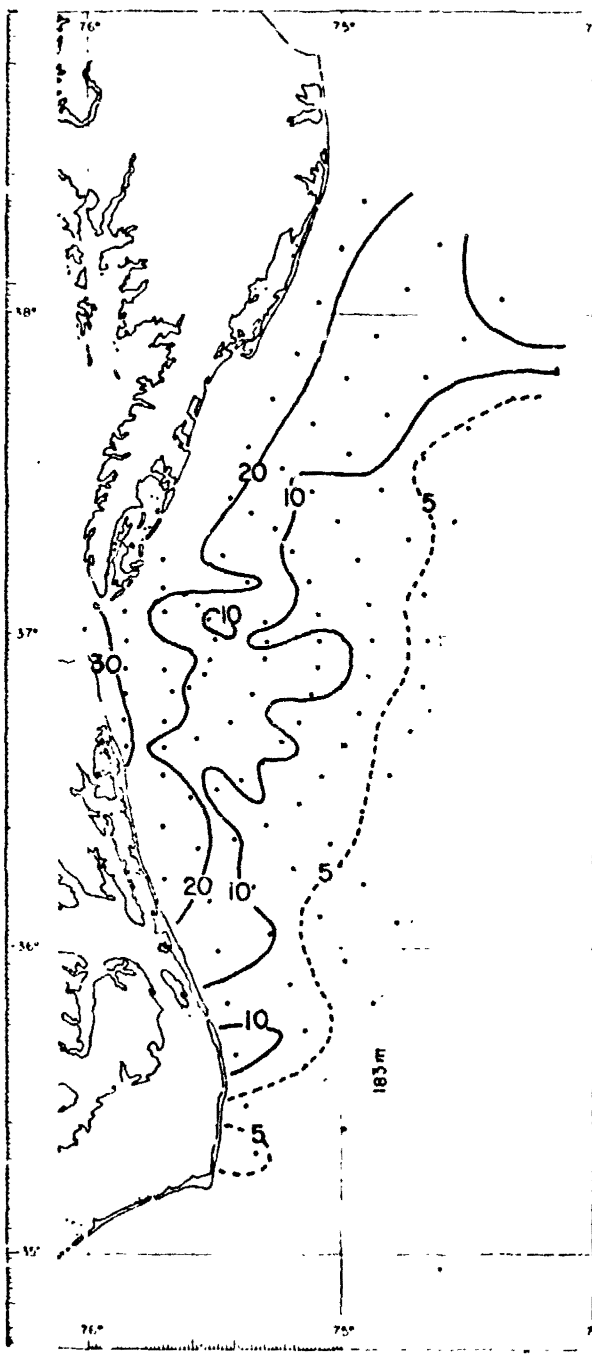

Figure 2. Percent probability of return for all drift bottles from project MACONS.

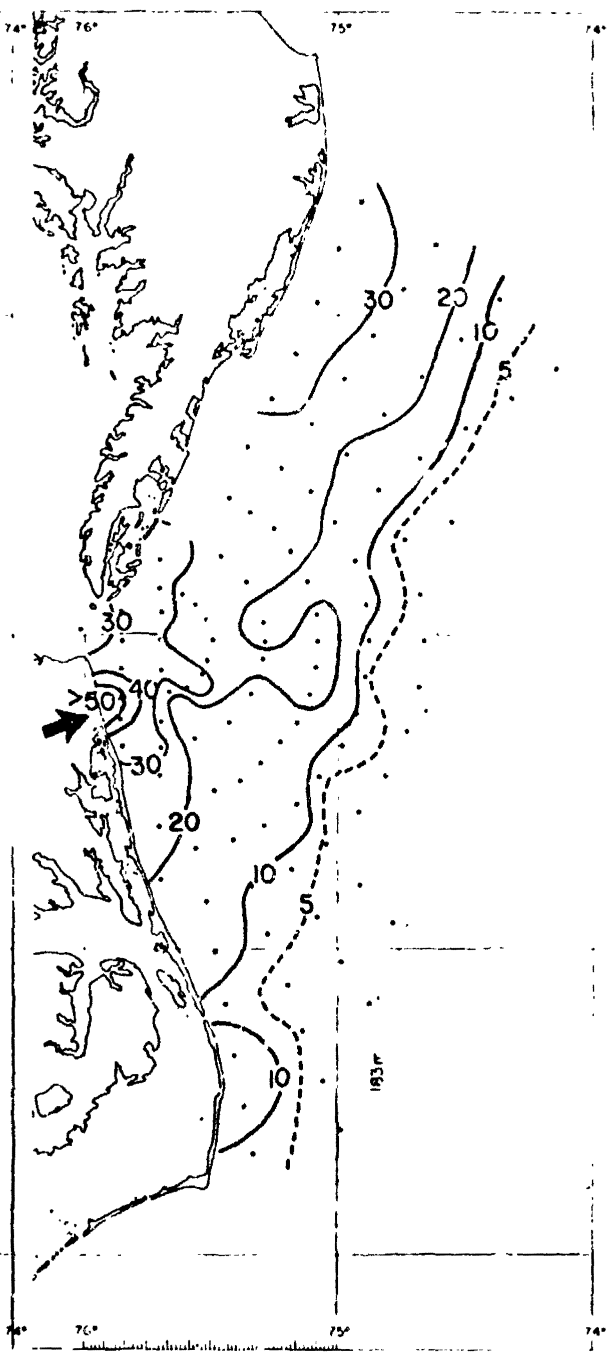

Figure 3. Percent probability of returns for all seabed drifters from project MACONS.

the same as those of the given isopleths.

The application of this analysis to coastal management decisions is straightforward. For instance, assume that you, as a coastal manager, are choosing a site for a deep oil port on the Virginia continental shelf near the Chesapeake Bay mouth. Part of your concern is to minimize the probability that oil from an unforseen accident will foul the beach anywhere before it can be cleaned up. From figure 2 for drift bottles, it is clear that the area just offshore between Cape Henry and False Cape is the worst site. On the other hand, the area thirty-five nautical miles due east of the Bay mouth has less than one-third the hazard value. As another example, assume that you are in charge of choosing a site for a sewage outfall just south of Virginia Beach at Dam Neck, Va. (36°47'N). With a pipe length of ten nautical miles and optimum placement of this outfall, a minimum of 30% of the effluent heavier than sea water and 20% of the effluent lighter than sea water can be expected to return to a beach. Doubling the length of the pipe can, in this instance, reduce the amount of effluent returning to the beach to half of the above figures. On the other hand limiting the pipe length to four nautical miles ensures that at least 50% of the heavy effluent and 30% of the light effluent will return to shore.

Q: If an object is placed in the water in a given area, comes ashore, and is discovered, where is it likely to be found?

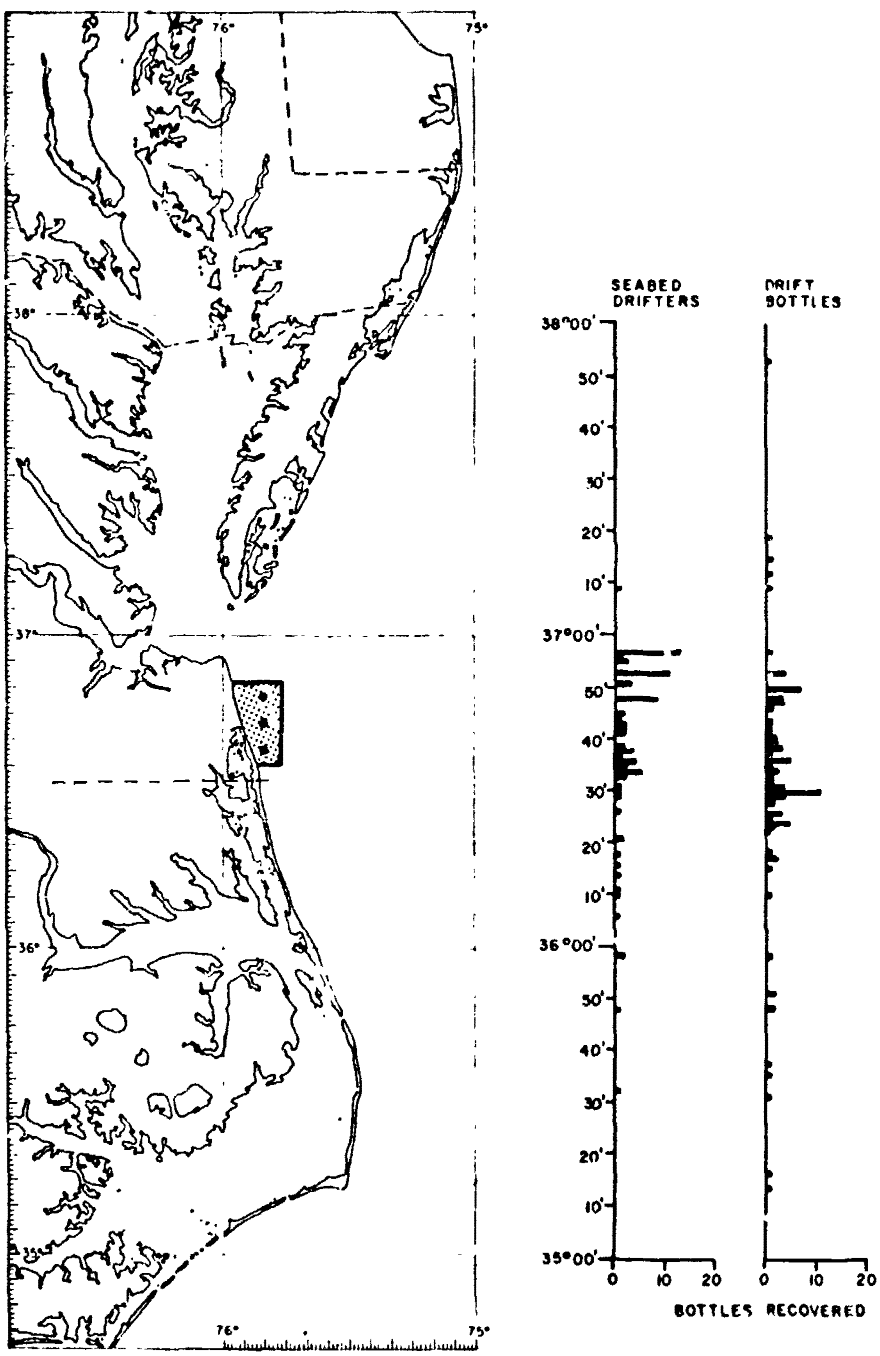

Figure 4. Number of bottles and drifters released from shaded area returning to beach at designated locations.

A: Consider the particular source area seen in figure 4, the three stations near Virginia Beach with particularly high returns in figure 3. The returns from MACONS were logged by 1 minute intervals of latitude. On the Virginia coastline, these correspond closely with one nautical mile intervals of beach. The returns from the three stations in question are shown in figure 4 as number of bottles recovered on a given minute of latitude of coastline. The seabed drifters seem to cluster at particular sections of beach, while the drift bottle returns are more diffuse. These clusters or accumulation points appear to be a feature of drifter returns. For coastal managers, the implication of accumulation points is that the stranding of objects over a given section of shoreline is likely to be highly localized and concentrated.

Interpretation of the figure is again straightforward. If objects, effluent, or cargo spills enter the ocean near Virginia Beach, those that come ashore will tend to be distributed to the south of the source. In addition bottom following objects will tend to concentrate at Cape Henry, Virginia Beach, Sandbridge, and Corolla, North Carolina. About half of such material will come ashore in North Carolina between the Virginia State Line and Cape Hatteras. If, as a coastal manager, you were responsible for designing emergency procedures to respond to an accidental spillage in the area in question, this analysis would allow you to deploy your resources near the sites of

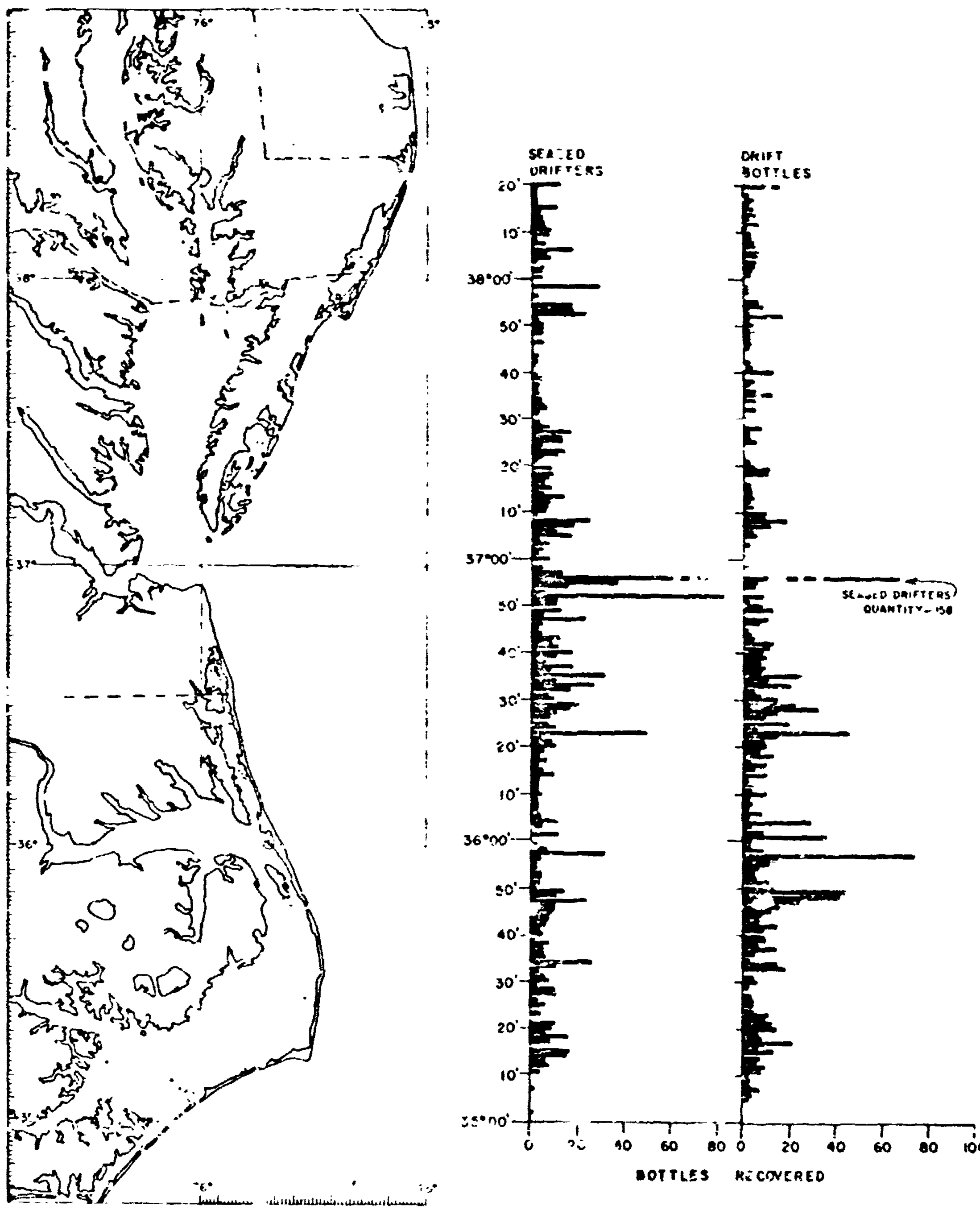

Figure 5. Number of bottles and drifters released during entire MACONS project discovered at designated latitudes.

their most probable need far in advance of an accident.

Q: From the entire set of release points, where do drifting objects at the surface or at the bottom tend to come ashore and be discovered?

A: The entire MARMAP/ONS recovery data are grouped by latitude of recovery in figure 5. The grouping interval of one minute of latitude is the smallest permitted by the spatial resolution of the discovery information. At this level of resolution, returns for both drift bottles and bottom drifters seem to follow a pattern of a general low level except for several strong accumulation areas. To the north of the mouth of Chesapeake Bay, both the general level of returns and the number of returns at each accumulation point is lower than between the Bay mouth and Cape Hatteras. Perhaps more relevent to the coastal manager than the average level is the existence of accumulation points. These imply that certain small areas of the coastline are particularly likely to be beaching places from the shelf waters. Of particular note are the strong accumulation points for bottom drifters at Cape Henry and Virginia Beach. These small areas are about ten times as likely as neighboring coastal areas to have strandings of bottom drifters.

Q: For a given accumulation area, where are the source areas for the drift bottles and seabed drifters which strand there?

A: The analysis for this question is done by plotting the source regions for all bottles or drifters

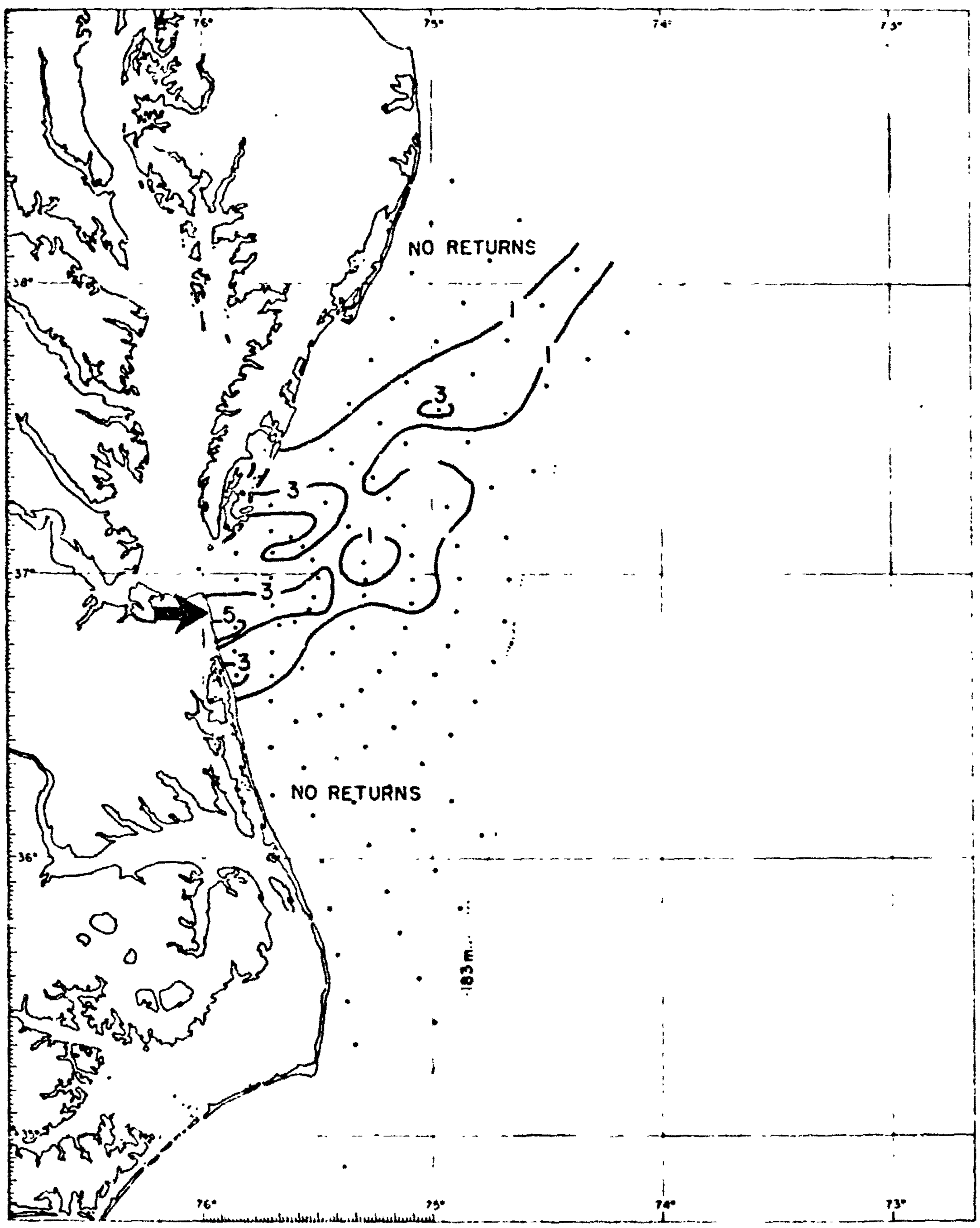

Figure 6. Source areas of seabed drifters from MACONS project stranding at Virginia Beach between 30th Street and 47th Street. Contours are number of drifters returned from each release point.

which are returned from that section of beach. Consider, for example, the source of seabed drifters which accumulate near 36°52'N at Virginia Beach. This includes the part of Virginia Beach between 30th Street and 47th Street. The source chart for this area is shown in figure 6.

A manager interested in the particular section of coastline would be most interested in this presentation of the data. If, for instance, he were asked to give an opinion of an offshore dumping site near the mouth of Chesapeake Bay, he could determine that the effect on his section of beach of a dumping site eight miles to his north would be less than that of a site three times as far straight out to sea or one four times as far to the northeast. A site 24 miles to his southeast or anywhere south of False Cape (36°33'N) would be best from his standpoint.

These examples have shown several ways in which a single body of drift bottle/seabed drifter data can be analyzed. The various analyses appear quite different and each is pertinent to a specific class of coastal management questions. From the general body of data, analyses can be tailored to many specific uses to answer specific questions.

The examples above illustrate some particular uses to which coastal managers can put drift bottle/seabed drifter data. In order that managers may recognize the utility and ease of such experiments as well as their limitations, we present some background material about drift bottle/seabed drifter experiments.

Drift bottle and, more recently, seabed drifter experiments have been used extensively on all coasts of the U.S. as well as other places as a method of trying to determine circulation patterns. The technique has also been used as a teaching aid in laboratory experiments. One result of this widespread application has been that extensive drift bottle data have been collected. Another result has been an appreciation of the variability of coastal circulation along with general frustration with this method of attempting to specify it. We attempt to show that these data may well be better suited to direct application to management questions than to circulation studies.

Much of this information is available from the National Ocean Data Center. For many applications, an analysis of existing data may serve the purpose. For others, new experiments will have to be undertaken. For still others, particularly where coasts are rocky or inaccessible, drift bottle studies may be inappropriate.

A chain of events must occur in order for the return of a drift bottle or seabed drifter to be recorded. First, the object must have a successful launch, frequently from a fast-moving aircraft. Next, it must be carried close to shore by the general shelf circulation. Third, it must get passed through the nearshore circulation and wave region and fourth be washed ashore. Fifth it must be discovered by some person before becoming buried in the shifting sand. Finally, the discoverer must decide to report his find to the data collection center for the experiment. The general shelf circulation, the second link in the chain, is somewhat masked by the other events which must occur before the recovery is reported. In addition, a bottle may be carried out to sea and never even get to the third link. On the other hand, coastal managers are particularly interested in events 2-5, and so interpretation of drift bottle/seabed drifter data is clearer for coastal management questions than for circulation studies.

Drift bottle/seabed drifter experiments are suited more to the climatological studies desired by coastal managers than are many more intensive experiments. This is so for two reasons. First, drift bottle/seabed drifter studies can be feasibly run over large areas for an entire seasonal cycle if not longer. It is important to cover a large area for a long time if a set of typical conditions is to be specified. Otherwise, the risk of establishing a non-representative set of observations as typical is great because of the variability of the shelf circulation over time scales between tidal and seasonal. The other reason is that many intensive studies are of limited seaworthiness. Their results are necessarily biased towards good weather conditions. Thus, they miss many important events which are associated primarily with storms and stormy conditions. Drift bottle/seabed drifter experiments do not contain this bias. In these two important respects, the climatological data from drift bottle/seabed drifter experiments are likely to give a truer picture of conditions in the shelf waters than those from more intensive studies conducted over smaller areas for shorter times using more fragile equipment.

A bias which can arise in drifter data is caused by the population density of a given section of beach. If a beach is inaccessible or otherwise seldom frequented, drifters washing ashore will be buried or washed back out to sea without being reported. There are three ways of investigating whether this effect is important for a given study. First, bottles and drifters can be placed along the beach in question and their returns analyzed for population bias. Such a presurvey was conducted for the MACONS program. Also, a background number can be established by assuming that all the drifters strand with an even or a smooth distribution over the shoreline in question. Any peaks which exceed this level are likely to reflect a feature of the stranding part of the chain and not the discovery part. In the MACONS study, for instance, the background number, about 50 per mile, is greatly exceeded by the bottom drifter returns both at Cape Henry and at Virginia Beach. Finally, at any station, the likelihood of a stranded drift bottle being reported is the same as that of a seabed drifter. Thus, if a peak is found in one and not the other, this peak can be attributed to factors other than discovery. This feature is apparent in the MACONS data particularly in the seabed drifter return peaks at Cape Henry and Virginia, for which there are no corresponding peaks in drift bottle returns.

We have attempted to show that judicious use of drift bottle and seabed drifter data can be valuable in making coastal management decisions. This value arises because much of the data are available, other data are relatively easily obtained, and experiments can be run without the effects of short term unrepresentitiveness or of good weather bias. These data can be obtained in time to be of use in making near term siting decisions. They are not a substitute for and should be replaced as soon as possible by circulation models based on hydrodynamic theory. In short, as an interim measure, drifter data can tell us where some effects are likely to occur but not why they occur or how to change the effects.

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