SYDNEY DEEPWATER OUTFALLS

ENVIRONMENTAL MONITORING PROGRAM

EPA

Environment Protection Authority New South Wales

POST-COMMISSIONING PHASE
INTERIM REPORT

Aspects of ORS Data
Significant to Numerical Modelling
for the EMP

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Authority
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This report was prepared by Australian Water and Coastal Studies Pty Ltd (AWACS) acting on behalf of the Environment Protection Authority as part of the Post-Commissioning Phase of the Sydney Deepwater Outfalls Environmental Monitoring Program.

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SYDNEY DEEPWATER OUTFALLS ENVIRONMENTAL MONITORING PROGRAM POST-COMMISSIONING PHASE

ASPECTS OF ORS DATA SIGNIFICANT TO NUMERICAL MODELLING FOR THE EMP

AWACS INTERIM REPORT 92/01/14 FEBRUARY 1994

Prepared by:

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Foreword

This report documents work undertaken during the Post-Commissioning Phase of the Sydney Deepwater Outfalls Environmental Monitoring Program (EMP). It describes the results of statistical analyses of Ocean Reference Station (ORS) investigating aspects of the data relevant to the numerical modelling component of the EMP.

The AWACS client for this work was the NSW Environment Protection Authority.

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Table of Contents

List of Figures

List of Tables

Summary

In this report, Ocean Reference Station (ORS) data was used to answer a number of questions of relevance to the Numerical Modelling Component of the EMP.

The appropriateness of 2D depth averaged modelling was assessed using one year of ORS current and temperature data. The results showed that 2D depth averaged modelling was rarely appropriate to the modelling of the ocean offshore of Sydney. Based on a vertical temperature stratification of less than 1°C, a difference in current directions of less than 45° and a difference in current speeds of less than 10 cm/s, 2D modelling would be applicable only 6.8% of the time. Conditions where 2D modelling was suitable were generally of short duration, with 90% of these occasions less than 11 hours in length.

Simple models using ORS current and wind data were used to estimate the percentage of the time that flotables and plumes from the outfalls would reach the coast. The results showed that for both flotables and plumes, landfall could be expected about 20% of the time.

1. Introduction

As part of the Environmental Monitoring Program (EMP) for Sydney's three deepwater outfalls, numerical modelling of the outfall plumes is being undertaken. Development of the modelling capability has been a continuous process, progressing along with our increasing understanding of the important oceanographic processes affecting the transport and dispersion of the effluent plumes. A summary of the present status of the numerical modelling component of the EMP is given in Peirson (1992).

In this report current, temperature and wind data from the Ocean Reference Station (ORS) 3 km offshore of Sydney is used to answer a number of important questions influencing the direction of the numerical modelling program. These are:

(i) How often is a 2D modelling approach applicable to offshore Sydney?

(ii) How often would winds cause transport of surface floatables onto the shore?

(iii) How often would a surfacing plume be transported onshore?

(iv) How often would a submerged plume be transported onshore?

2. Ocean Reference Station Data

The ORS is located 3 km offshore of Bondi (Figure 1) and is owned by the Sydney Water Board. Instrumentation on the ORS consists of a wave rider buoy, two anemometers mounted 4.5 m and 5.0 m above the water surface, two S4 current meters moored at 17 m and 52.5 m depth and a thermistor string.

In this report, current and temperature data from the ORS current meters and wind data will be used. The S4 current meters record 5 minute averaged currents and an instantaneous temperature at 5 minute intervals, while the anemometers record instantaneous samples every 30 seconds which are averaged every 5 minutes.

The manufacturers specifications for the relevant instruments are given in Table 1 below. Further details of the ORS instrumentation are described in Lawson and Treloar (1993).

Table 1: Instrument Specifications

Instrument	Parameter	Resolution	Accuracy	Noise	Threshold
S4 current meter	Current speed	0.2 cm/s	2% ± 1 cm/s	0.2 cm/s	0
	Current dirn.	0.5°	2°		
	Temperature	0.05°C	± 0.2°C		
R M Young anemometer	Wind speed	± 0.03 m/s			1 m/s
	Wind dirn.	± 3°			

Hourly data has been used be used in this report rather than the raw 5 minute data, as it was considered to be sufficient to resolve the time scales of variability to be included in the numerical models. To obtain the hourly data, the 5 minute data has been filtered using a Lanczos-Cosine filter with a cutoff period of two hours. Further details of the filtering process are given in Lim and Cox (1991). Both the raw and filtered data are stored on an EMP database located at Australian Water and Coastal Studies Pty Ltd (AWACS).

3. Applicability of 2D Modelling

3.1 General

In comparison to a depth averaged 2D model, a full 3D model is computationally slow and expensive, and it is therefore preferable to use a 2D model wherever possible. A proper assessment of the suitability of 2D modelling for a particular location is important, however, as a 2D model may not give even qualitatively correct results in situations where the current varies with depth, for example in two layer flow or where there are wind generated currents.

The two main considerations which are of importance in assessing the applicability of 2D modelling of the ocean offshore of Sydney are:

1. The vertical density profile.

   The density of the receiving waters is dependent upon both temperature and salinity. Since salinities are not measured at the ORS, assessing the applicability of 2D depth averaged modelling must be restricted to a consideration of the vertical temperature profile. If the temperature difference between the top and bottom is small enough, the receiving waters can be characterised by the one ambient density.

   Data from the ORS typically shows a seasonal variation in the temperature stratification, with up to 8 or 10°C temperature difference between 17 m and 52.5 m depth during late summer and less than 1°C during winter. Previous statistical analyses of ORS temperature data (Cox, 1991, 1992a, 1992b and 1993) have obtained exceedance curves showing that the temperature stratification is less than 1°C for about 30% of the time in any given year.

2. The vertical homogeneity of the horizontal component of the current.

   If the top and bottom currents are of comparable size and in the same direction the flow field can be characterised by a single depth-averaged velocity vector.

For the purposes of this report, 2D depth-averaged modelling will be assumed to be applicable when:

- the temperature stratification between 17 m and 52.5 m is less than 1°C
- there is less than 45° difference in the current directions at 17 m and 52.5 m
- the difference in current speeds at 17 m and 52.5 m depth is less than 10 cm/s

3.2 Data Analysis

In this section, hourly ORS data from the EMP database was partitioned using the temperature stratification, ΔT, current directions, $\Delta\theta_U$, and the current speeds at 17 m and 52.5 m depth. The data used in this analysis was recorded over a 12 month period (so as to include seasonal variability) between June 1991 and May 1992. The data was partitioned in three ways:

1. Using only the temperature stratification and the current directions. Bin sizes of 1°C for the temperature stratification and 45° for the current direction difference were used. Where one or both of the current speeds were less than 3 cm/s, the currents were taken to be co-flowing ($\Delta\theta_U \leq 45°$). The results of this analysis is given in Section 3.3 below.

2. Using the temperature stratification, current directions and depth averaged current speed, $|\overline{U}|$, between 17 m and 52.5 m depth. These results are given in Section 3.4.

3. In terms of all three of the above criteria for 2D modelling (temperature stratification, current directions and difference in current speeds, $\Delta|U|$, between 17 m and 52.5 m depth). Again, where one or both of the current speeds were less than 3 cm/s, the currents were taken to be co-flowing ($\Delta\theta_U \leq 45°$). These results are given in Section 3.5.

Statistics on the duration of events in which 2D depth averaged conditions applied were also compiled. For the purpose of simplifying the analysis, these statistics were calculated on the basis of the difference in current direction between 17 m and 52.5 m depth. Events where the temperature stratification is less than 1°C tend to be mainly on relatively long time scales (seasonal) with fewer shorter events lasting for days or hours (upwelling and downwelling events), while current speed and direction are usually much more variable on shorter time scales. For this reason, the most important factor limiting the duration of depth-averaged conditions is likely to be the vertical difference in current directions rather than the temperature stratification. Depth averaged conditions were defined as occurring when the difference between ORS current directions at 17 m and 52.5 m depth was less than 45°. These results are given in Section 3.6.

3.3 Depth Averaged Assumption Based on Temperature Stratification and Current Directions

The results of the analysis based only on the temperature stratification, ΔT, and current direction difference between 17 m and 52.5 m depth, $\Delta\theta_U$, is given in Table 2.

Table 2: Percentage Occurrences of Temperature Stratification, ΔT, and Current Direction Difference, $\Delta\theta_U$, between 17 m and 52.5 m depth

	ΔT< 1°C	1°C ≤ΔT< 2°C	2°C ≤ΔT< 3°C	3°C ≤ΔT< 4°C	4°C ≤ΔT< 5°C	5°C ≤ΔT< 6°C	ΔT≥ 6°C	Total
$0° < \Delta\theta_U \leq 45°$	10.5	10.1	6.1	3.9	4.7	3.5	1.5	40.2
$45° < \Delta\theta_U \leq 90°$	7.5	5.4	3.0	2.2	2.0	1.7	.6	22.5
$90° < \Delta\theta_U \leq 135°$	5.3	3.0	3.1	2.2	2.1	2.0	.6	18.3
$135° < \Delta\theta_U \leq 180°$	4.0	2.6	2.9	2.3	2.8	3.5	1.0	19.0
Total	27.3	21.1	15.1	10.6	11.7	10.6	3.7	100.0

Number of data points = 7175

The results show that considering temperature and current directions simultaneously, a 2D depth averaged modelling approach (with ΔT less than 1°C and $\Delta\theta_U$ less than 45°) would be applicable only 10.5% of the time. Extending the allowable temperature stratification for 2D modelling to 2°C, the depth averaged approach would still only be applicable 20.6% of the time.

Considering the temperature stratification only, homogeneity (ΔT less than 1°C) would occur about 27% of the time during the 12 month period, which is consistent with the results of previous analyses of ORS data. Considering only the difference in top and bottom current directions, homogeneity ($\Delta\theta_U$ less than 45°) will occur about 40% of the time.

3.4 Depth Averaged Assumption Based on Temperature Stratification, Current Directions and Vertically Averaged Current Speed

This segment of work is an extension of that contained in Section 2.2. The data has been further partitioned according to the depth averaged current speed, in intervals of 10 cm/s. The results of the analysis based on the temperature stratification, ΔT, current directions, $\Delta\theta_U$, and the depth averaged current speed, $|\overline{U}|$, are given in Tables 3-8 below:

Table 3: Percentage Occurrences of Temperature Stratification, ΔT, and Current Direction Difference, $\Delta\theta_U$, between 17 m and 52.5 m depth

0 ≤ Average current speed < 10 cm/s

	ΔT< 1°C	1°C ≤ΔT< 2°C	2°C ≤ΔT< 3°C	3°C ≤ΔT< 4°C	4°C ≤ΔT< 5°C	5°C ≤ΔT< 6°C	ΔT≥ 6°C	Total
$0^o < \Delta\theta_U \leq 45^o$	2.4	.8	.8	.4	.5	.5	.1	5.4
$45^o < \Delta\theta_U \leq 90^o$	1.2	.3	.3	.2	.2	.2	.0	2.4
$90^o < \Delta\theta_U \leq 135^o$	1.6	.5	.5	.4	.3	.3	.0	3.7
$135^o < \Delta\theta_U \leq 180^o$	1.9	.5	.5	.3	.5	.5	.2	4.5
Total	7.1	2.2	2.1	1.4	1.4	1.5	.3	16.0

Number of data points = 1147

Table 4: Percentage Occurrences of Temperature Stratification, ΔT, and Current Direction Difference, $\Delta\theta_U$, between 17 m and 52.5 m depth

10 ≤ Average current speed < 20 cm/s

	ΔT< 1°C	1°C ≤ΔT< 2°C	2°C ≤ΔT< 3°C	3°C ≤ΔT< 4°C	4°C ≤ΔT< 5°C	5°C ≤ΔT< 6°C	ΔT≥ 6°C	Total
$0^o < \Delta\theta_U \leq 45^o$	3.7	2.3	1.9	1.0	1.5	1.5	.3	12.1
$45^o < \Delta\theta_U \leq 90^o$	4.4	2.4	1.2	1.0	1.2	.8	.1	11.1
$90^o < \Delta\theta_U \leq 135^o$	3.0	1.7	1.7	1.0	1.3	1.0	.3	10.0
$135^o < \Delta\theta_U \leq 180^o$	1.8	1.8	2.0	1.3	1.7	1.7	.5	10.7
Total	12.9	8.1	6.8	4.3	5.7	5.0	1.1	43.9

Number of data points = 3147

Table 5: Percentage Occurrences of Temperature Stratification, ΔT, and Current Direction Difference, $\Delta\theta_U$, between 17 m and 52.5 m depth

20 ≤ Average current speed < 30 cm/s

	ΔT< 1°C	1°C ≤ΔT< 2°C	2°C ≤ΔT< 3°C	3°C ≤ΔT< 4°C	4°C ≤ΔT< 5°C	5°C ≤ΔT< 6°C	ΔT≥ 6°C	Total
$0^o < \Delta\theta_U \leq 45^o$	2.7	2.4	1.7	1.0	1.5	1.2	.8	11.2
$45^o < \Delta\theta_U \leq 90^o$	1.6	2.2	1.0	.6	.4	.5	.4	6.6
$90^o < \Delta\theta_U \leq 135^o$	.6	.7	.7	.7	.4	.6	.2	3.9
$135^o < \Delta\theta_U \leq 180^o$	.2	.3	.3	.5	.6	1.2	.2	3.4
Total	5.1	5.5	3.7	2.9	3.0	3.4	1.6	25.2

Number of data points = 1805

Table 6: Percentage Occurrences of Temperature Stratification, ΔT, and Current Direction Difference, $\Delta\theta_U$, between 17 m and 52.5 m depth

30 ≤ Average current speed < 40 cm/s

	ΔT< 1°C	1°C ≤ΔT< 2°C	2°C ≤ΔT< 3°C	3°C ≤ΔT< 4°C	4°C ≤ΔT< 5°C	5°C ≤ΔT< 6°C	ΔT≥ 6°C	Total
$0° < \Delta\theta_U \le 45°$	1.4	2.5	1.2	1.3	.8	.4	.3	7.9
$45° < \Delta\theta_U \le 90°$	.3	.3	.5	.3	.1	.2	.1	1.9
$90° < \Delta\theta_U \le 135°$	.0	.0	.0	.1	.1	.1	.1	.5
$135° < \Delta\theta_U \le 180°$	.0	.0	.0	.1	.0	.0	.0	.2
Total	1.7	2.9	1.8	1.9	1.1	.6	.6	10.5

Number of data points = 750

Table 7: Percentage Occurrences of Temperature Stratification, ΔT, and Current Direction Difference, $\Delta\theta_U$, between 17 m and 52.5 m depth

40 ≤ Average current speed < 50 cm/s

	ΔT< 1°C	1°C ≤ΔT< 2°C	2°C ≤ΔT< 3°C	3°C ≤ΔT< 4°C	4°C ≤ΔT< 5°C	5°C ≤ΔT< 6°C	ΔT≥ 6°C	Total
$0° < \Delta\theta_U \le 45°$	.3	1.5	.7	.2	.2	.0	.1	2.9
$45° < \Delta\theta_U \le 90°$	.0	.2	.1	.0	.0	.0	.0	.3
$90° < \Delta\theta_U \le 135°$	.0	.0	.0	.0	.0	.0	.0	.0
$135° < \Delta\theta_U \le 180°$	.0	.0	.0	.0	.0	.0	.0	.0
Total	.3	1.7	.7	.2	.2	.0	.1	3.2

Number of data points = 233

Table 8: Percentage Occurrences of Temperature Stratification, ΔT, and Current Direction Difference, $\Delta\theta_U$, between 17 m and 52.5 m depth

Average current speed ≥ 50 cm/s

	ΔT< 1°C	1°C ≤ΔT< 2°C	2°C ≤ΔT< 3°C	3°C ≤ΔT< 4°C	4°C ≤ΔT< 5°C	5°C ≤ΔT< 6°C	ΔT≥ 6°C	Total
$0° < \Delta\theta_U \le 45°$	.2	.8	.0	.0	.3	.0	.0	1.3
$45° < \Delta\theta_U \le 90°$	.0	.0	.0	.0	.0	.0	.0	.0
$90° < \Delta\theta_U \le 135°$	.0	.0	.0	.0	.0	.0	.0	.0
$135° < \Delta\theta_U \le 180°$	.0	.0	.0	.0	.0	.0	.0	.0
Total	.2	.8	.0	.0	.3	.0	.0	1.3

Number of data points = 93

The main conclusion from these results is that there is a strong correlation between the strength of the average ambient current and the difference between the top and bottom current directions. For low depth averaged current speeds (less than 20 cm/s), the currents at 17 m and 52.5 m depth are fairly evenly distributed between co-flowing, counter-flowing and cross-flowing. As the current strength increases, co-flowing currents become more likely (at the expense of the cross- and counter-flowing cases). This is because the strongest currents at the ORS usually occur during times where the East Australian Current encroaches on the shelf, resulting in strong southerly currents throughout the water column. When the longshore current is weaker, currents due to other processes (including baroclinic coastal trapped waves and internal waves and tides) dominate and the current directions are more variable both spatially and with depth. High averaged current speeds were not necessarily associated with high stratification.

3.5 Depth Averaged Assumption Based on Temperature Stratification, Current Directions and Vertical Difference in Current Speeds

The results of the analysis based on the temperature stratification, ΔT, current directions, $\Delta\theta_U$, and the difference in current speeds, $\Delta|U_A|$, between 17 m and 52.5 m depth are given in Tables 9-13 below:

Table 9: Percentage Occurrences of Temperature Stratification, ΔT, and Current Direction Difference, $\Delta\theta_U$, between 17 m and 52.5 m depth

$0 \leq$ Difference in current speeds < 10 cm/s

	$\Delta T <$ 1°C	1°C $\leq \Delta T <$ 2°C	2°C $\leq \Delta T <$ 3°C	3°C $\leq \Delta T <$ 4°C	4°C $\leq \Delta T <$ 5°C	5°C $\leq \Delta T <$ 6°C	$\Delta T \geq$ 6°C	Total
$0° < \Delta\theta_U \leq 45°$	6.8	3.0	1.7	.9	.7	.6	.0	13.8
$45° < \Delta\theta_U \leq 90°$	6.0	2.8	1.2	.7	.7	.4	.1	11.9
$90° < \Delta\theta_U \leq 135°$	3.7	1.6	1.6	.8	1.0	.7	.1	9.5
$135° < \Delta\theta_U \leq 180°$	3.2	1.6	1.6	.9	1.3	1.3	.4	10.5
Total	19.8	9.0	6.1	3.4	3.7	3.0	.6	45.7

Number of data points = 1851

Table 10: Percentage Occurrences of Temperature Stratification, ΔT, and Current Direction Difference, $\Delta\theta_U$, between 17 m and 52.5 m depth

$10 \leq$ Difference in current speeds < 20 cm/s

	$\Delta T <$ 1°C	1°C $\leq \Delta T <$ 2°C	2°C $\leq \Delta T <$ 3°C	3°C $\leq \Delta T <$ 4°C	4°C $\leq \Delta T <$ 5°C	5°C $\leq \Delta T <$ 6°C	$\Delta T \geq$ 6°C	Total
$0° < \Delta\theta_U \leq 45°$	2.9	2.8	1.5	.9	1.4	1.1	.2	10.8
$45° < \Delta\theta_U \leq 90°$	1.3	1.5	.8	.5	.5	.3	.0	5.0
$90° < \Delta\theta_U \leq 135°$	1.2	.9	.9	.7	.5	.4	.1	4.9
$135° < \Delta\theta_U \leq 180°$	.6	.8	.9	.8	.9	1.0	.2	5.1
Total	6.0	6.0	4.2	3.0	3.3	2.9	.5	25.8

Number of data points = 1854

Table 11: Percentage Occurrences of Temperature Stratification, ΔT, and Current Direction Difference, $\Delta\theta_U$, between 17 m and 52.5 m depth

20 ≤ Difference in current speeds < 30 cm/s

	ΔT< 1°C	1°C ≤ΔT< 2°C	2°C ≤ΔT< 3°C	3°C ≤ΔT< 4°C	4°C ≤ΔT< 5°C	5°C ≤ΔT< 6°C	ΔT≥ 6°C	Total
$0° < \Delta\theta_U \leq 45°$	.8	2.3	1.3	.8	.9	.7	.6	7.4
$45° < \Delta\theta_U \leq 90°$	.1	.5	.4	.3	.4	.4	.2	2.4
$90° < \Delta\theta_U \leq 135°$	.2	.2	.3	.4	.3	.4	.2	2.1
$135° < \Delta\theta_U \leq 180°$	.1	.2	.2	.3	.4	.5	.2	1.7
Total	1.2	3.1	2.2	1.7	2.1	2.0	1.2	13.6

Number of data points = 979

Table 12: Percentage Occurrences of Temperature Stratification, ΔT, and Current Direction Difference, $\Delta\theta_U$, between 17 m and 52.5 m depth

30 ≤ Difference in current speeds < 40 cm/s

	ΔT< 1°C	1°C ≤ΔT< 2°C	2°C ≤ΔT< 3°C	3°C ≤ΔT< 4°C	4°C ≤ΔT< 5°C	5°C ≤ΔT< 6°C	ΔT≥ 6°C	Total
$0° < \Delta\theta_U \leq 45°$	.1	1.0	1.1	.9	1.3	.7	.3	5.4
$45° < \Delta\theta_U \leq 90°$	.0	.4	.4	.3	.2	.4	.2	1.9
$90° < \Delta\theta_U \leq 135°$	.0	.1	.1	.1	.2	.3	.1	1.0
$135° < \Delta\theta_U \leq 180°$	.0	.0	.1	.2	.2	.4	.2	1.2
Total	.2	1.5	1.8	1.4	1.9	1.8	.8	9.4

Number of data points = 678

Table 13: Percentage Occurrences of Temperature Stratification, ΔT, and Current Direction Difference, $\Delta\theta_U$, between 17 m and 52.5 m depth

Difference in current speeds ≥ 40 cm/s

	ΔT< 1°C	1°C ≤ΔT< 2°C	2°C ≤ΔT< 3°C	3°C ≤ΔT< 4°C	4°C ≤ΔT< 5°C	5°C ≤ΔT< 6°C	ΔT≥ 6°C	Total
$0° < \Delta\theta_U \leq 45°$	.1	1.1	.5	.5	.4	.4	.4	3.4
$45° < \Delta\theta_U \leq 90°$	.0	.2	.2	.3	.1	.2	.1	1.1
$90° < \Delta\theta_U \leq 135°$	.0	.1	.0	.2	.1	.1	.1	.6
$135° < \Delta\theta_U \leq 180°$	.0	.0	.0	.0	.0	.2	.0	.3
Total	.1	1.4	.8	1.0	.6	.9	.6	5.3

Number of data points = 383

These results show that when the vertical temperature stratification, vertical difference in current directions and current speeds are taken into account, 2D depth averaged conditions are rarely achieved. While the additional condition that the difference in current speeds from top to bottom be less than 10 cm/s is achieved almost half of the time (45.7%), the applicability of 2D modelling based on all three criteria ($\Delta T < 1^{o}C$, $\Delta\theta_U \leq 45^{o}$ and $\Delta|U_A| < 10$ cm/s) is reduced to only 6.8% of the time.

3.6 Duration of Depth Averaged Conditions

The exceedance curve for the duration of depth averaged conditions is shown in Figure 2. These results show that events where depth-averaged conditions apply are typically fairly short. Only 10% of the events where depth averaged conditions apply (based on the difference between current directions at 17 m and 52.5 m depth being less than 45^{o}) were longer than 19 hours in length.

4. Onshore Transport of Floatables

4.1 General

In this section, the duration of onshore wind events and the likelihood of onshore transport of floatable materials from the outfalls will be investigated using one year of hourly filtered ORS wind data, from June 1991 to May 1992.

4.2 Duration of Onshore Wind Events

Duration statistics for onshore wind events were firstly obtained for different threshold velocities, which were used to define the start and end of each onshore wind event. The ORS winds were resolved into a shore normal and a shore parallel component and duration statistics were obtained for the onshore component only. An angle of 13.5°T was used to define the longshore direction, for consistency with previous analyses of ORS data. An onshore wind event with a threshold velocity of 4 m/s, for example, is an event where the onshore component of the wind is always greater than 4 m/s, while an event with a threshold velocity of 0 m/s simply defines an event which always has a positive onshore component.

The durations of onshore wind events for different threshold velocities are plotted on Figure 3. Exceedance curves for events defined by different threshold velocities are given in Figure 4. Figure 4 shows, for example, that 90% of onshore wind events have a duration less than 20 hours. For onshore wind events where the velocity is always above 6 m/s, 90% have a duration less than 11 hours.

A summary of the onshore wind events with different threshold velocities and durations during the year are also given in tabular form in Appendix A. Table A-1 shows the number of onshore wind events for each threshold velocity and duration, while Table A-5 gives the percentage of the time occupied by such events. Overall, the wind at the ORS has an onshore component 48.5% of the time.

4.3 Condition for Floatables Reaching the Shoreline

Clearly, not all onshore wind events will be of sufficient strength or duration to result in grease reaching the shore. For the purposes of this report, a simple model using the 3% of the wind speed to estimate the advection speed of the particles, has been used to determine which onshore wind events will result in grease landfalls.

To facilitate the calculations, the following assumptions have been made:

- grease from the outfalls always surfaces regardless of whether the plume surfaces or is trapped below the surface;
- transport of grease is due to winds only and the grease moves in the direction of the wind;
- the coastline is straight; and;
- winds are uniform over the Sydney coastline.

If a particle moves a distance dX in an onshore direction, due to a wind with an onshore velocity component w', in a time dT we have:

$$dX = 0.03\ w'\ dT$$

Since this relationship is linear, the condition for grease moving from the outfalls to the shore during a particular onshore wind event can be written in terms of the average velocity during the event, as:

$$X_{land} \leq 0.03\ w'_{av}\ T_w$$

where: X_{land} is the outfall-land distance (measured perpendicular to the shoreline)
w'_{av} is the average onshore wind velocity during the event
T_w is the duration of the event

As the outfall-land distance varies depending on the outfall (Bondi is closer to the shore than North Head and Malabar) and the location up and down the coastline, calculations have been carried out for outfall-land distances of 2 km, 3 km and 4 km.

The average velocities and durations for onshore wind events, showing those events which will result in grease from the outfalls reaching the shore from a distance of 3 km, are shown in Figure 5. The period of time for which grease reaches the shore during each onshore wind event is:

$$T_w - X_{land} / 0.03\ w'_{av}$$

Summing over all onshore wind events results in grease reaching the shore a total of 27.4% of the time from 2 km, 23.9% from 3 km and 21.4% from 4 km offshore.

In addition to the other assumptions listed above, this analysis is simplistic in that past events have been ignored. Only the effluent released from the outfalls during a particular wind event has been considered. Obviously if there is still grease from a previous onshore wind event close to the shore at the start of an onshore wind event, grease will reach the shore sooner than predicted from the approach used. A better approach would be to run a time-series deterministic grease transport model for one year of wind data and compile statistics of the percentage of the time that grease reaches the shoreline at various locations. Such a model would predict the location of grease from the outfalls as a function of time, but would necessarily be much more complex than the model used here. Additional processes such as dispersion of the grease plumes and grease breakdown would need to be included to give realistic results.

5. Onshore Transport of Plumes

5.1 Surfacing Plumes

Since the thicknesses of surfacing plumes are typically 20 m to 40 m, the most appropriate currents to use are those from the ORS current meter at 17 m depth. Assuming that the waters of a surfacing plume would be transported towards the coast at the rate of the onshore component of the ambient current at the ORS, a simple analysis analogous to the equation for grease transport by winds can be used. The current can be resolved into an onshore and a longshore component and the analysis performed using the onshore component of the current.

5.1.1 Duration of Onshore Current Events

The duration of onshore current events for different threshold velocities is shown in Figure 6. Exceedance curves for onshore current events with different threshold velocities are given in Figure 7.

As was the case for the onshore wind events, most onshore current events are fairly short lived, with 90% lasting for less than 21 hours. It is interesting to note that onshore currents and onshore winds operate on similar time scales, even though onshore currents do not normally result from onshore winds. Onshore and offshore currents are usually associated with internal waves and tides or upwelling and downwelling events (which result from longshore winds, or a strong longshore current in the case of upwelling). Internal waves and tides probably account for most of the shorter duration onshore current events measured by the ORS current meter at 17 m while the longer duration events will mainly due to downwelling events.

The number of events and percentage of the time occupied by onshore wind events with different threshold velocities and durations during the year are given in tabular form in Tables A-2 and A-6 in Appendix A. Overall, the ORS current at 17 m depth has an onshore component 51.1% of the time.

5.1.2 Condition for Onshore Transport of Plumes

Using a similar approach to that used for grease transport, the percentage of the time that a plume from the outfalls will reach the shore can be estimated. The assumptions are:

- the plumes are advected with the prevailing current without spreading due to diffusion;
- the coastline is straight; and;
- the current is uniform over the Sydney coastline.

The condition for the plume moving from the outfalls to the shore during a particular onshore current event can be written in terms of the average velocity during the event, as:

$$X_{land} \leq u'_{av} T_u$$

where: X_{land} is the outfall-land distance (measured perpendicular to the shoreline)
u'_{av} is the average onshore current velocity during the event
T_u is the duration of the event

Average velocities and durations for onshore current events, and those events resulting in onshore transport of the plumes from the outfalls from a distance of 3 km are shown in Figure 8. Summing over all onshore current events results the plume reaching the shore a total of 27.1% of the time from 2 km, 22.4% from 3 km and 18.9% from 4 km offshore.

5.2 Submerged Plumes

This case is very similar to the case of the surfacing plume, except that for a submerged plume, either the ORS current at 52.5 m depth or the depth-averaged current may be more appropriate, depending on the height of rise and thickness of the plume. Both of these cases have been considered.

As before, the currents were resolved into an onshore and a longshore component and a persistence analysis was performed on the onshore component of the current at 52.5 m or the depth averaged onshore component.

5.2.1 Duration of Onshore Current Events

The duration of onshore current events at 52.5 m depth for different threshold velocities is shown in Figure 9. Exceedance curves for onshore current durations at 52.5 m depth with different threshold velocities are given in Figure 10. The durations of onshore currents at 52.5m depth are similar to those at 17m depth, although the current dynamics are such that the cross-shelf component of the currents will normally be in opposite directions. Upwelling, downwelling and internal waves all may result in two layered flow with opposing cross-shelf currents in the top and bottom layers. Extended onshore current events at 52.5m are due to upwelling events.

The duration of onshore current events based on depth-averaged currents at the ORS is given in Figures 12 and 13.

The number of events and percentage of the time occupied by onshore depth-averaged current events and onshore current events at 52.5 m depth with different threshold velocities and durations during the year are given in tabular form in Tables A-3, A-4, A-7 and A-8 in Appendix A. Overall, the ORS current at 52.5 m had an onshore component 55.2% of the time, while the depth averaged ORS current had an onshore component 63.9% of the time.

The percentage of onshore depth averaged currents is higher than either the percentage of onshore currents at 17 m or at 52.5 m depth. As noted above, upwelling, downwelling and internal waves all may result in two layered cross-shelf flow with opposing currents in the top and bottom layers. This situation appears fairly commonly in the ORS data, particularly during summer when conditions are stratified. It appears that the relative current speeds at 17 m and 52.5 m under these conditions are such that the depth-averaged cross-shelf component of the current is onshore more often than it is offshore.

5.2.2 Condition for Onshore Transport of Plumes

Average velocities and durations for onshore current events, and those events resulting in onshore transport of plumes in the lower and middle part of the water column are shown in Figures 11 and 14 respectively.

Considering all events, the percentage of the time that a plume in the middle of the water column would reach the shore is 24.4% from 2 km, 18.1% from 3 km and 14.7% from 4 km offshore. The percentage of the time that a plume near the bottom would reach the shore is 24.3% from 2 km, 21.2% from 3 km and 19.4% from 4 km offshore.

In the case of plumes trapped below the surface by a thermocline, the nearshore dynamics of the thermocline will play an important role in such transport. Because the plume is contained within waters of greater density than those above, upward motion will be resisted. Events in which upwelling plays an important role are obvious candidates for such occurrences. However, simple analyses based on model results would indicate that such processes would also raise plume dilution by between 1 and 2 orders of magnitude. Internal waves have also been identified as a possible means of transporting trapped effluent higher in the water column (Wallace, 1984).

6. Results and Conclusions

6.1 Applicability of 2D Modelling

The results show that a 3D model is generally required for modelling the coastal waters offshore of Sydney, as 2D modelling is rarely applicable. Based on a temperature stratification, ΔT, of less than 1^oC, a difference in current directions, $\Delta\theta_U$, of less than 45^o and a difference in current speeds, $\Delta|U_A|$, of less than 10 cm/s, 2D modelling would be applicable only 6.8% of the time.

Considering only the temperature stratification and current direction criteria, 2D depth averaged modelling would still be applicable only 10.5% of the time.

The results also showed that, based on the current directions only, conditions suitable for 2D modelling are generally short lived. 90% of the occasions where 2D modelling could be used were less than 11 hours in length.

A possible alternative to full 3D modelling is unstratified 3D modelling, where stratification is included in the near-field component of the model (which describes the initial momentum and buoyancy dominated spreading of the plume) but not in the far-field component (which describes the advection and diffusion of the plume beyond the initial dilution zone). The far field model still has a 3D velocity field. This approach assumes that once the plume has risen to either a trap depth or the surface, its far-field behaviour is relatively unaffected by stratification. The applicability of this approach could be assessed by comparing the results of unstratified 3D modelling and full 3D modelling for a range of different conditions.

6.2 Onshore Transport of Floatables and Plumes

The results of the study of onshore transport of floatables and plumes are summarised in Table 14 below.

Table 14: Onshore Transport of Floatables and Plumes - Summary of Results

	Floatables	Plumes		
		Surface	Middle	Bottom
% time material transported in an onshore direction	48.7	51.1	63.9	55.2
% time shore reached from an offshore distance of:				
2 km	27.4	27.1	24.4	24.3
3 km	23.9	22.4	18.1	21.2
4 km	21.4	18.9	14.7	19.4

For both floatables and plumes, landfall could be expected around 20% of the time somewhere on the coastline, depending on the outfall-land distance and the location of the plume in the water column. The incidences of onshore transport of non-surfacing plumes would probably be much lower in practice because the sloping sea bed would prevent further onshore movement of the plume unless accompanied by upwelling at the coast. The incidence of onshore transport of flotables may be higher than indicated as there may be grease from a previous event close to the shoreline at the start of an onshore wind event.

The above results were obtained using simplistic models, and are intended only as a first approximation of the likelihood of how often the plumes and grease from the outfalls are likely to reach the shore. As pointed out above and in Chapters 4 and 5, the approach used has many limitations. More realistic estimates will be available when the more sophisticated numerical models in the EMP numerical modelling suite have been run for sufficient data to enable similar statistics to be compiled.

7. References

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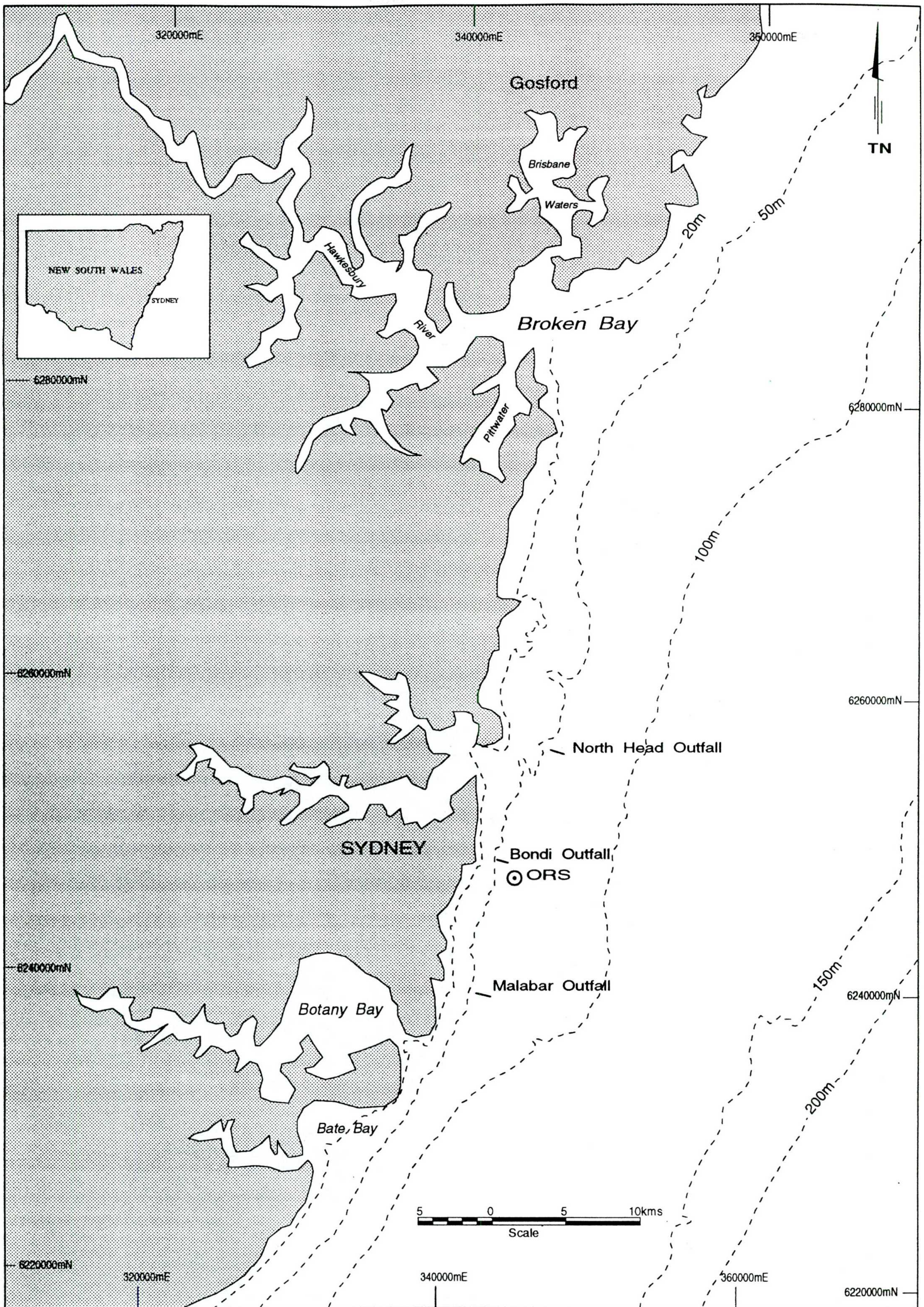

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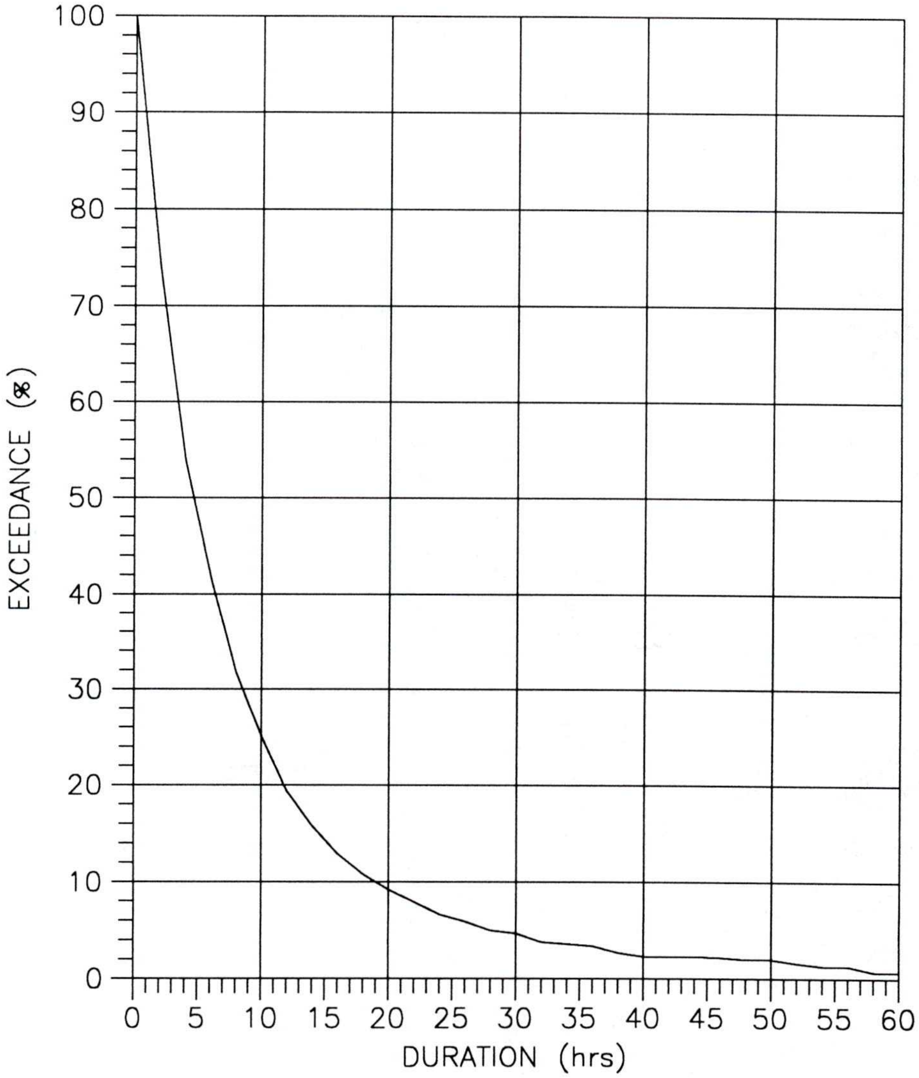
LOCATION MAP

Figure 1



(Based on the condition that the difference between current directions at 17m and 52.5m depth is < 45°)

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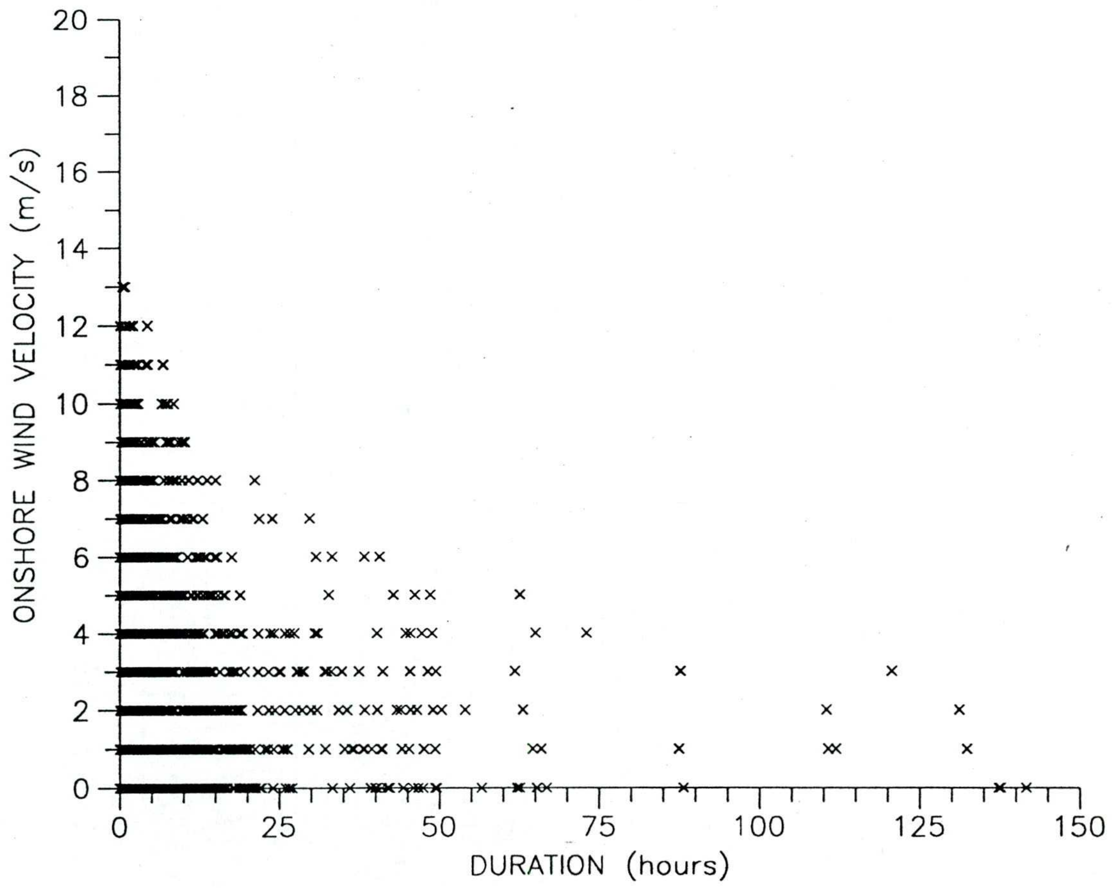
Report No. 92/01/14

EXCEEDANCE CURVE FOR DURATION OF DEPTH AVERAGED CONDITIONS

Figure 2



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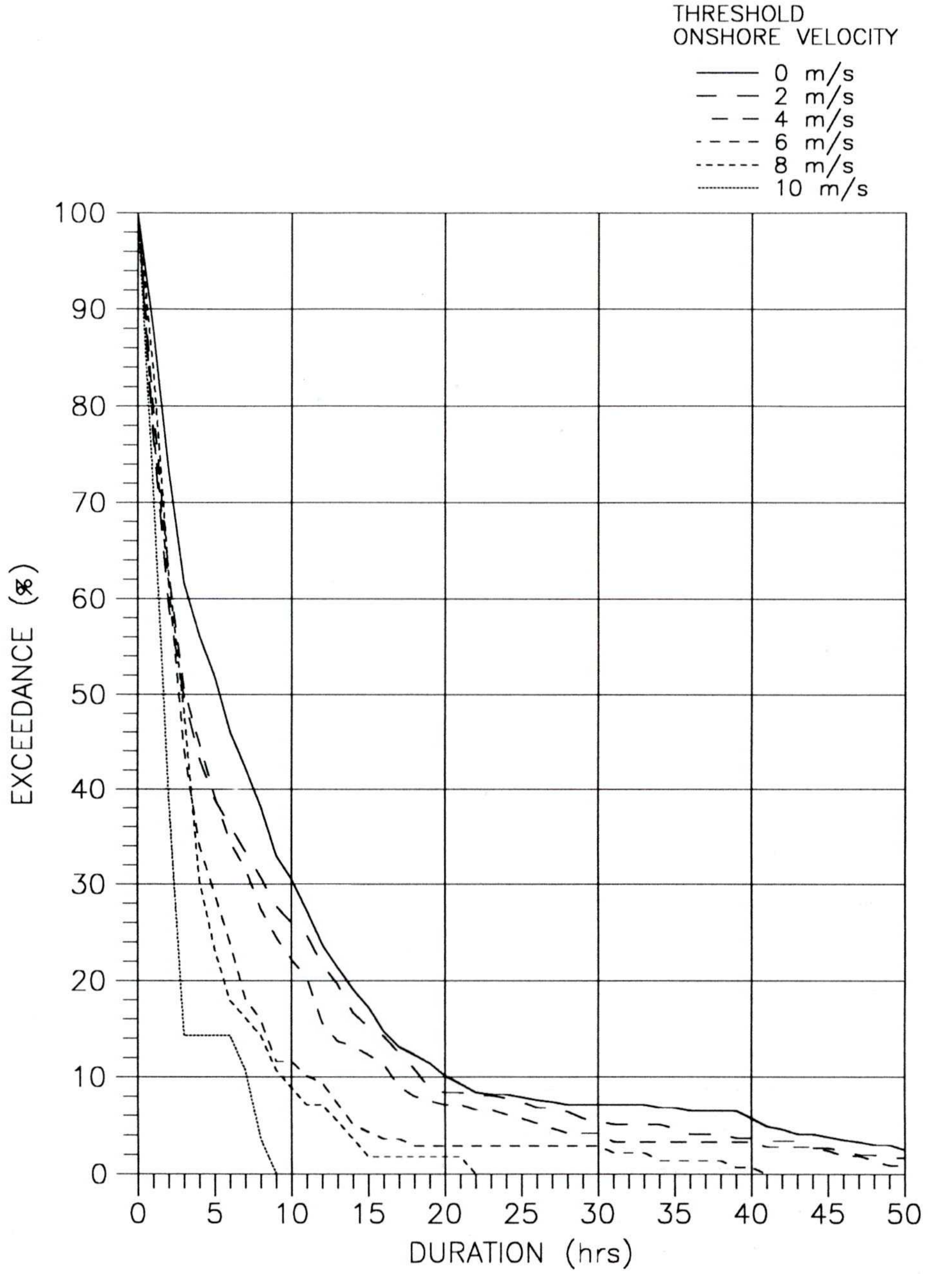
DURATION OF ONSHORE WIND EVENTS WITH DIFFERENT THRESHOLD VELOCITIES

Figure 3



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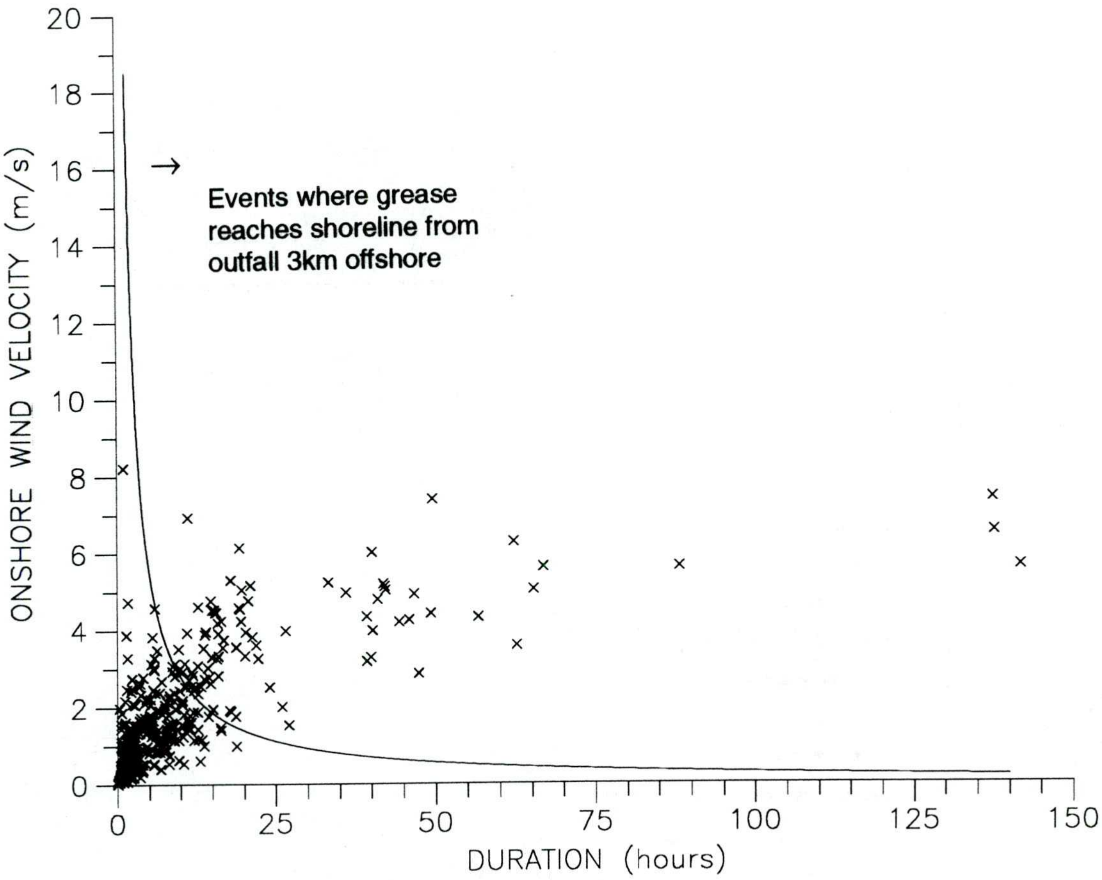
EXCEEDANCE CURVES FOR ONSHORE WIND EVENTS

Figure
4



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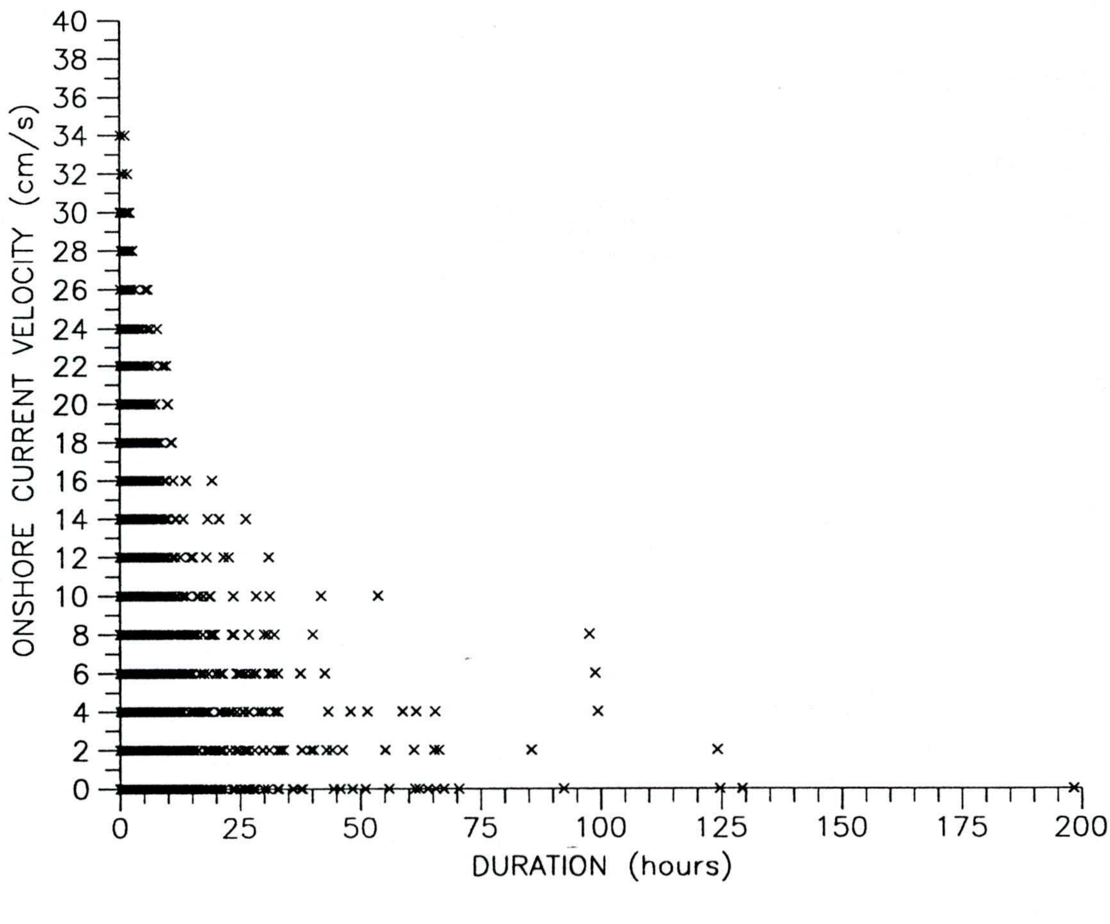
AVERAGE VELOCITIES AND DURATIONS FOR ONSHORE WIND EVENTS

Figure 5



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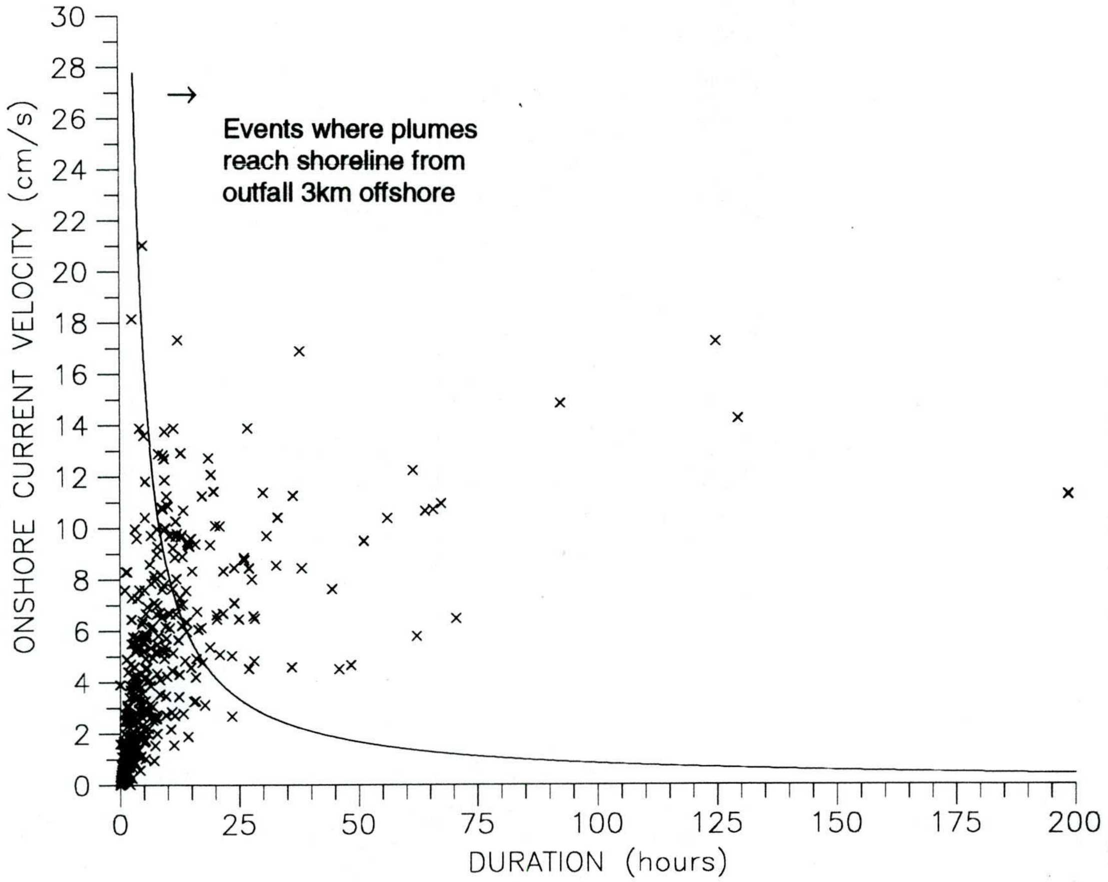
DURATION OF ONSHORE CURRENT EVENTS AT 17m DEPTH WITH DIFFERENT THRESHOLD VELOCITIES

Figure 6



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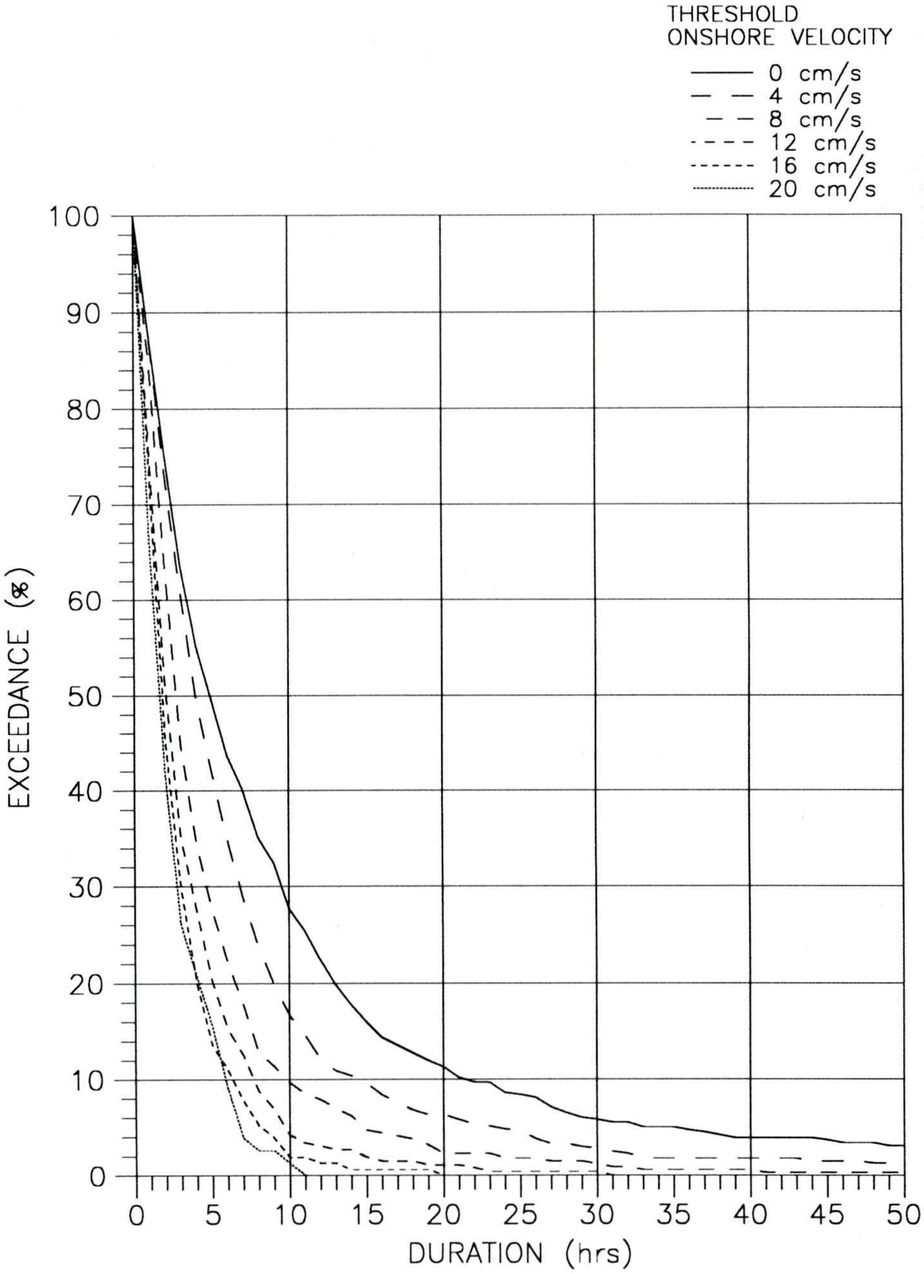
AVERAGE VELOCITIES AND DURATIONS FOR ONSHORE CURRENT EVENTS AT 17m DEPTH

Figure 7



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EXCEEDANCE CURVES FOR ONSHORE CURRENT EVENTS AT 17m DEPTH

Figure 8

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DURATION OF ONSHORE CURRENT EVENTS AT 52.5m DEPTH WITH DIFFERENT THRESHOLD VELOCITIES

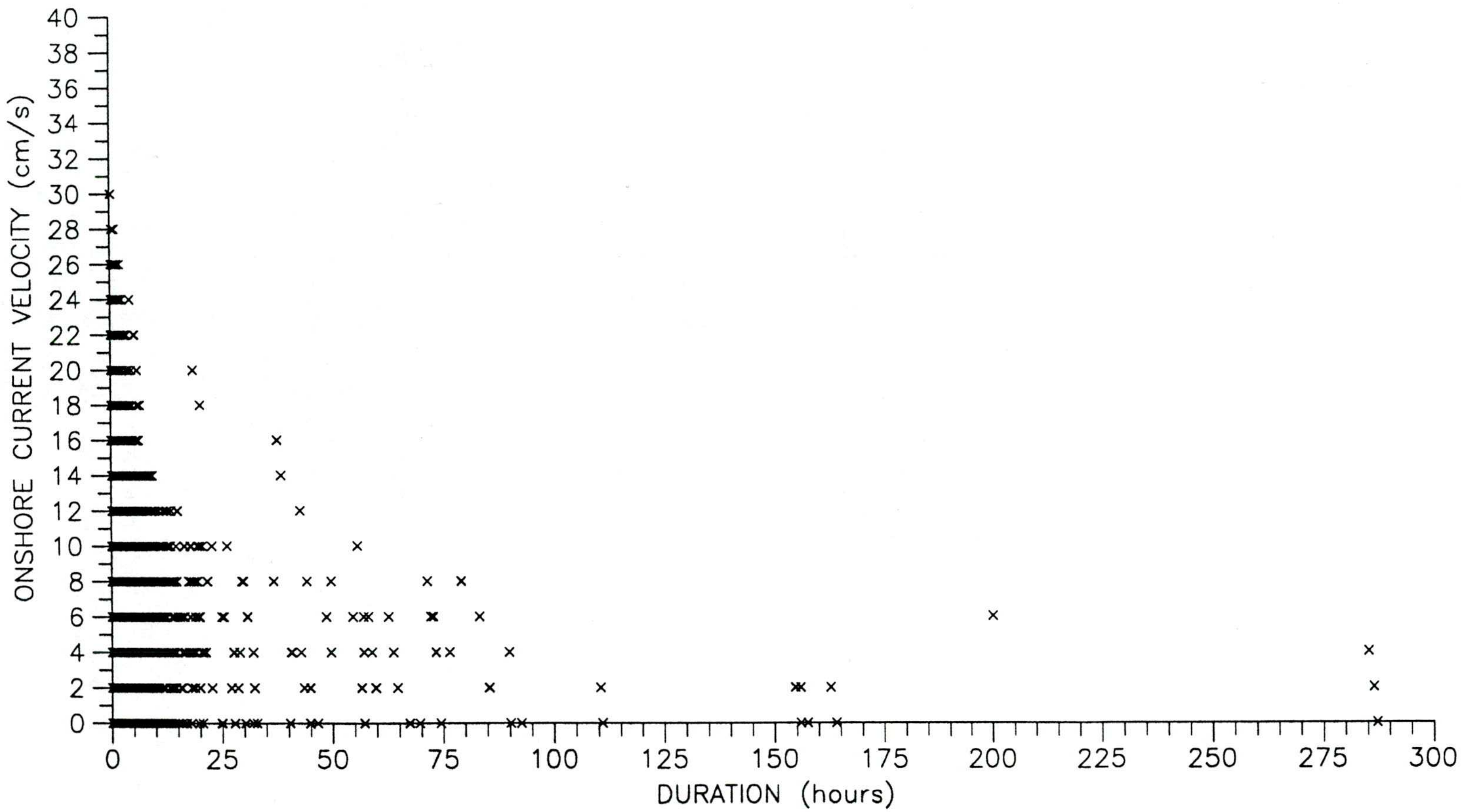
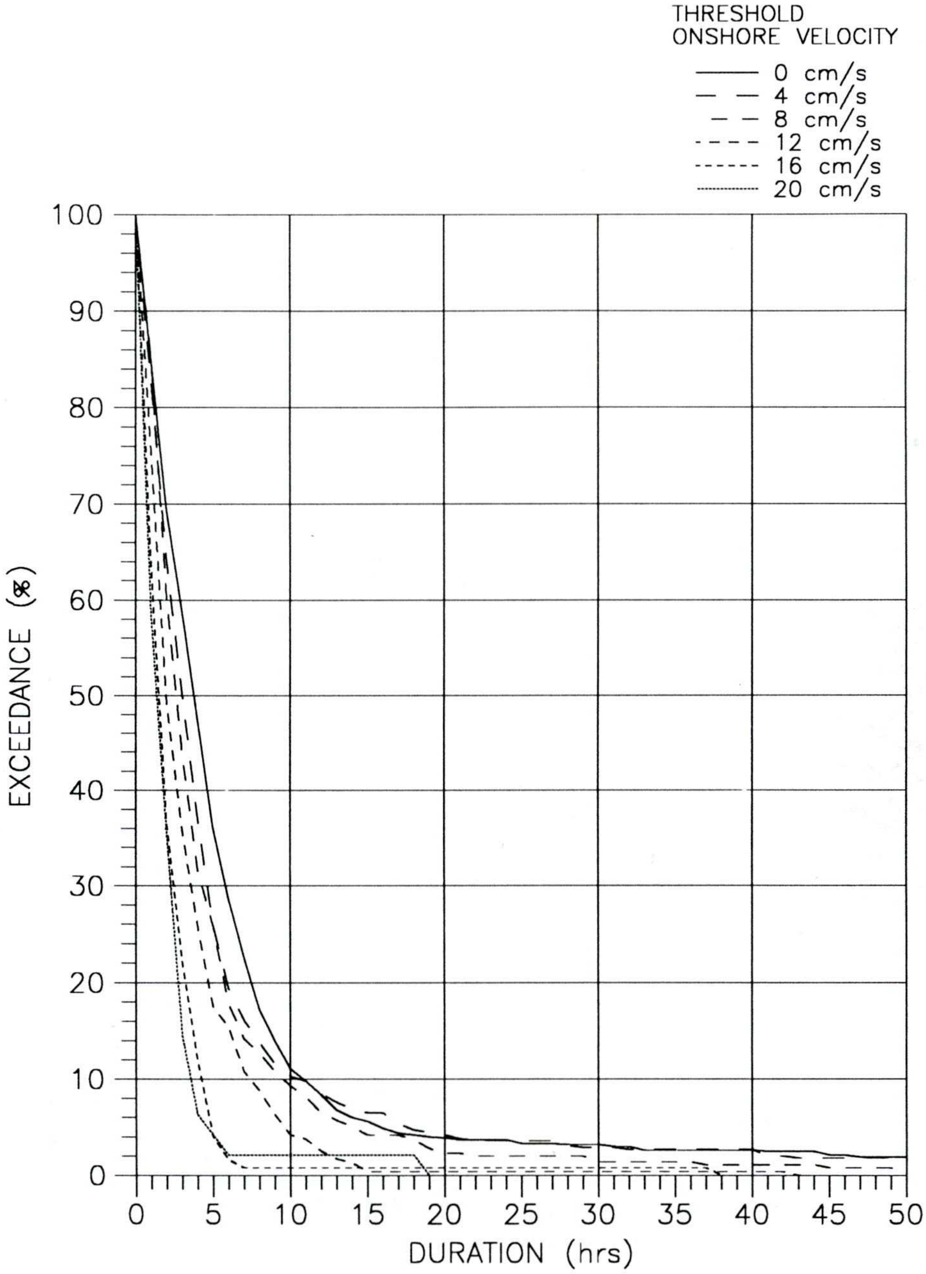


Figure 9



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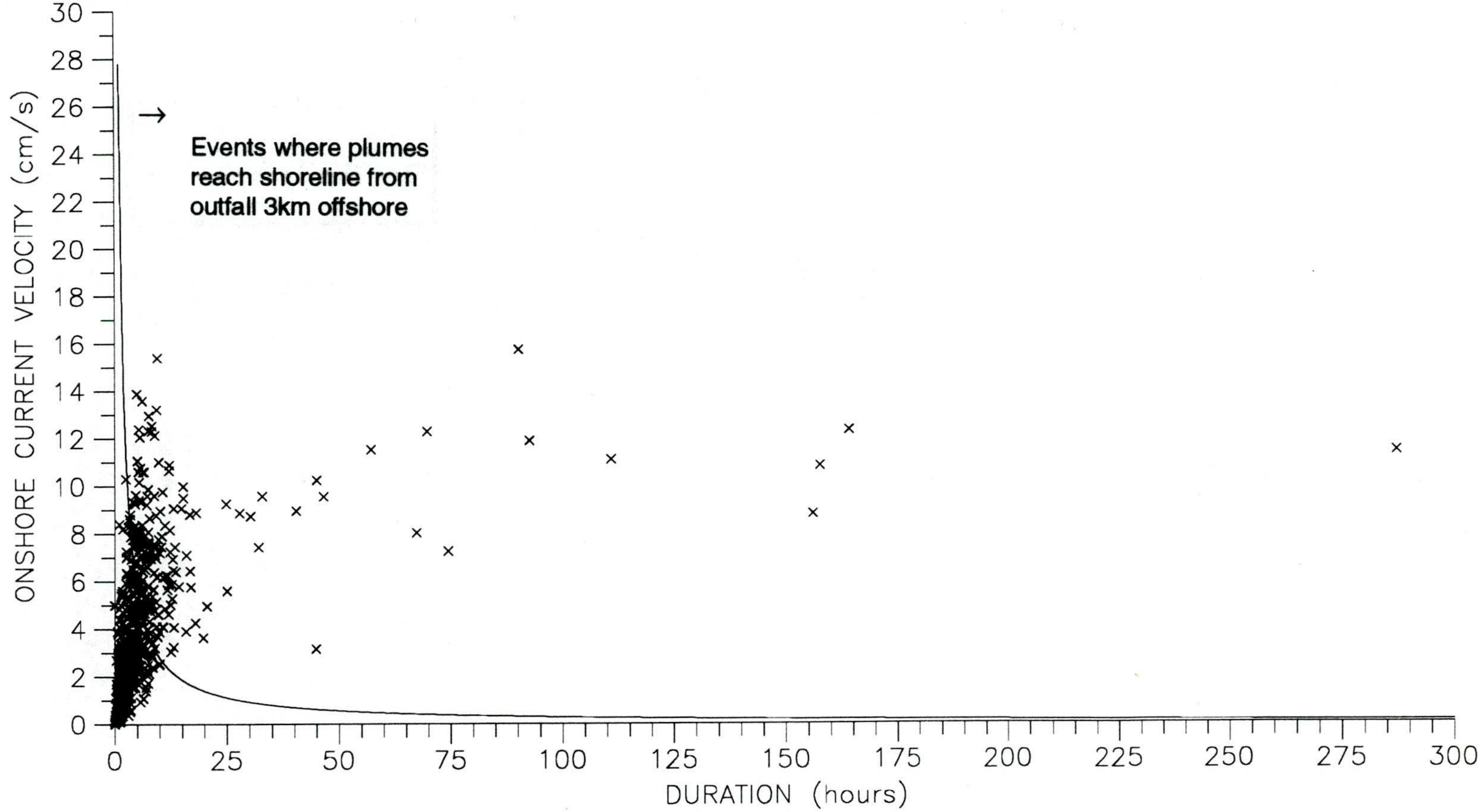
EXCEEDANCE CURVES FOR ONSHORE CURRENT EVENTS AT 52.5m DEPTH

Figure 10



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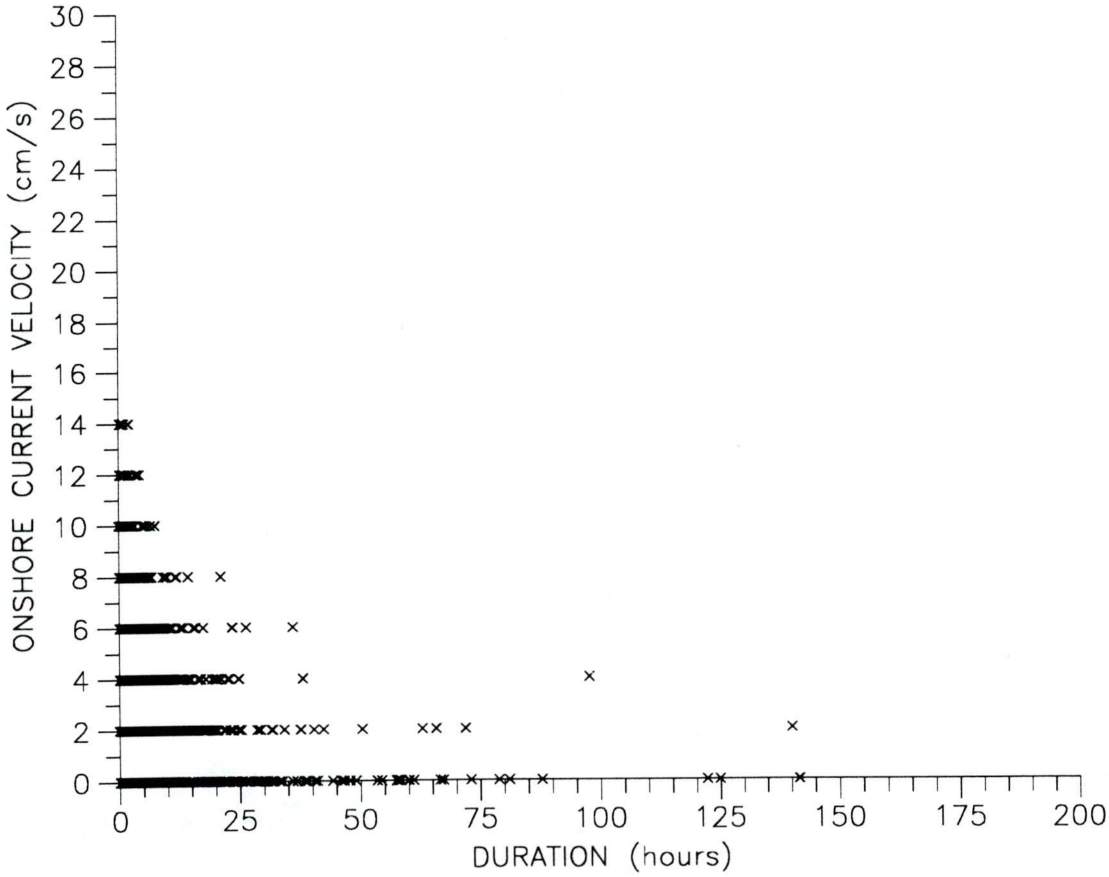
AVERAGE VELOCITIES AND DURATIONS FOR ONSHORE CURRENT EVENTS AT 52.5m DEPTH

Figure 11



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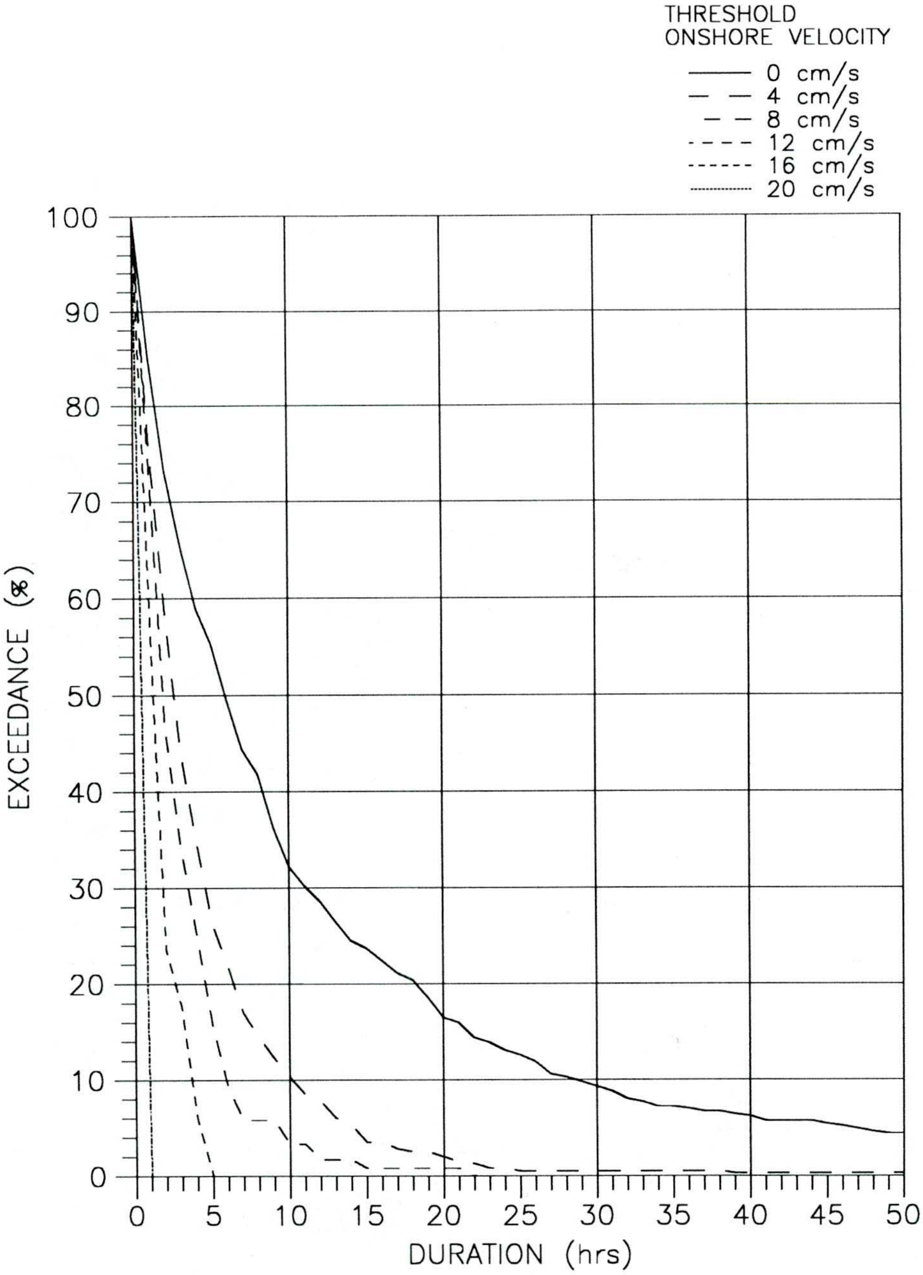
DURATION OF ONSHORE CURRENT EVENTS BASED ON AVERAGE OF CURRENTS AT 17m AND 52.5m DEPTH WITH DIFFERENT THRESHOLD VELOCITIES

Figure 12



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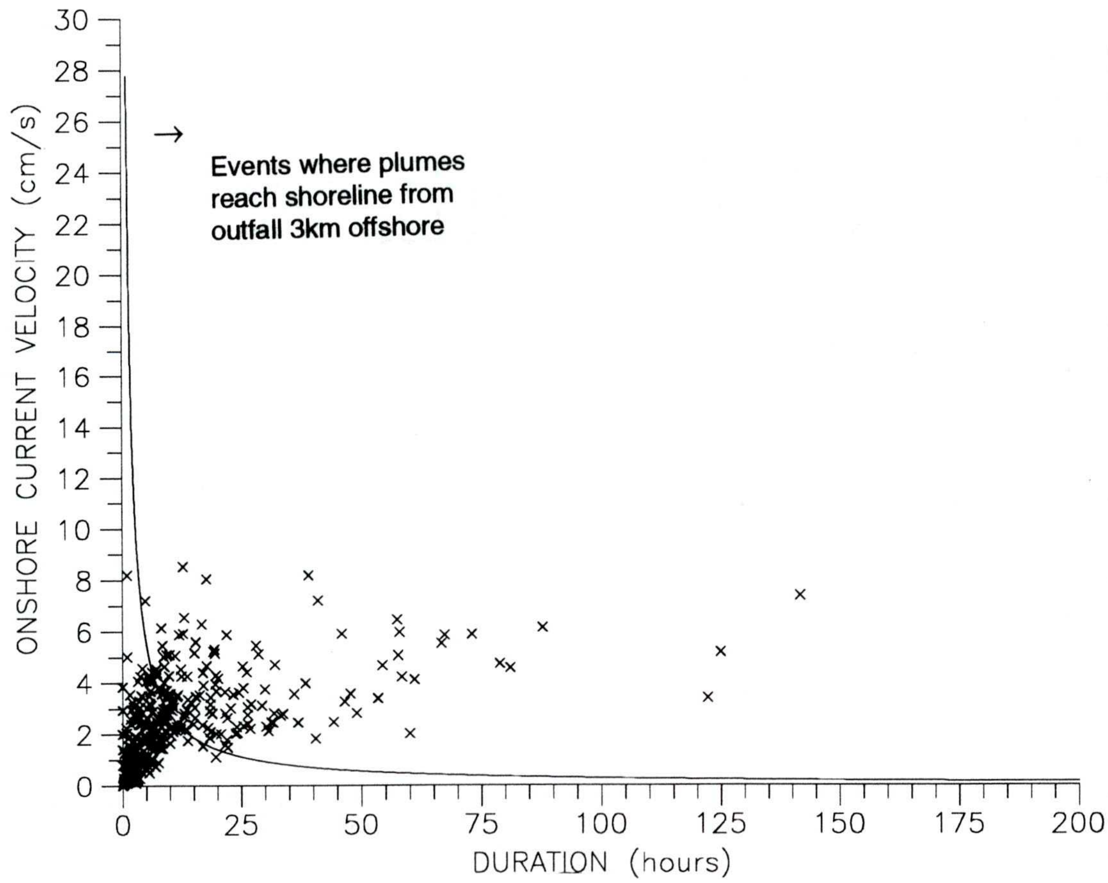
EXCEEDANCE CURVES FOR ONSHORE CURRENT EVENTS
BASED ON AVERAGE OF CURRENTS AT 17m AND 52.5m DEPTH

Figure 13



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AVERAGE VELOCITIES AND DURATIONS FOR ONSHORE CURRENT EVENTS BASED ON AVERAGE OF CURRENTS AT 17m AND 52.5m DEPTH

Figure 14

APPENDIX A:

**ONSHORE WIND AND CURRENT EVENTS
BASED ON HOURLY ORS DATA
JUNE 1991-MAY 1992**

Table A-1: Number of Onshore Wind Events for Different Threshold Velocities and Durations June 1991-May 1992

Duration, T (hrs)	Threshold Onshore Wind Velocity (m/s) 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
0 <T< 1	44	60	69	36	43	35	31	23	9	13	8	5	5	3	0
1 ≤T< 2	54	69	52	45	36	42	22	27	12	12	9	6	3	0	0
2 ≤T< 3	43	32	28	26	26	17	24	11	8	5	7	2	1	0	0
3 ≤T< 4	20	35	19	26	12	17	14	6	10	2	0	0	0	0	0
4 ≤T< 5	16	29	13	11	12	8	7	2	4	4	0	2	1	0	0
5 ≤T< 6	21	15	8	9	10	10	7	8	3	2	0	0	0	0	0
6 ≤T< 7	14	16	8	8	6	6	8	2	1	0	1	1	0	0	0
7 ≤T< 8	15	7	8	7	9	10	3	1	1	3	2	0	0	0	0
8 ≤T< 9	19	10	9	5	6	5	6	3	2	0	1	0	0	0	0
9 ≤T< 10	9	6	5	2	5	5	0	3	1	2	0	0	0	0	0
10 ≤T< 11	12	9	4	3	4	3	2	1	1	1	0	0	0	0	0
11 ≤T< 12	13	3	9	7	10	3	1	3	0	0	0	0	0	0	0
12 ≤T< 13	9	9	6	7	4	3	3	2	1	0	0	0	0	0	0
13 ≤T< 14	8	6	9	8	1	5	3	0	1	0	0	0	0	0	0
14 ≤T< 15	7	11	4	3	2	5	1	0	1	0	0	0	0	0	0
15 ≤T< 16	9	2	3	3	2	1	1	0	0	0	0	0	0	0	0
16 ≤T< 17	6	6	5	0	5	4	0	0	0	0	0	0	0	0	0
17 ≤T<18	3	3	5	3	2	0	1	0	0	0	0	0	0	0	0
18 ≤T< 19	3	4	6	2	1	1	0	0	0	0	0	0	0	0	0
19 ≤T< 20	5	4	1	2	1	0	0	0	0	0	0	0	0	0	0
20 ≤T< 21	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0
21 ≤T< 22	3	1	1	1	1	0	0	1	1	0	0	0	0	0	0
22 ≤T< 23	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
23 ≤T< 24	0	1	1	1	1	0	0	1	0	0	0	0	0	0	0
24 ≤T< 25	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
25 ≤T< 26	1	2	2	3	1	0	0	0	0	0	0	0	0	0	0
26 ≤T< 27	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0
27 ≤T< 28	1	0	1	2	1	0	0	0	0	0	0	0	0	0	0
28 ≤T< 29	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0
29 ≤T< 30	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0
30 ≤T< 35	1	1	2	4	2	1	2	0	0	0	0	0	0	0	0
35 ≤T< 40	4	6	3	1	0	0	1	0	0	0	0	0	0	0	0
40 ≤T< 45	7	3	3	1	2	1	1	0	0	0	0	0	0	0	0
45 ≤T< 50	5	4	3	3	3	2	0	0	0	0	0	0	0	0	0
50 ≤T< 55	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
55 ≤T< 60	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60 ≤T< 65	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0
65 ≤T< 70	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
70 ≤T< 75	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
75 ≤T< 80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80 ≤T< 85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85 ≤T< 90	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
90 ≤T< 95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95 ≤T< 100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100 ≤T< 105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
105 ≤T< 110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110 ≤T< 115	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0
115 ≤T< 120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120 ≤T< 125	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
125 ≤T< 130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130 ≤T< 135	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
135 ≤T< 140	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140 ≤T< 145	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
145 ≤T< 150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150 ≤T< 155	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
155 ≤T< 160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
160 ≤T< 165	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
165 ≤T< 170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170 ≤T< 175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175 ≤T< 180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
180 ≤T< 185	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
185 ≤T< 190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190 ≤T< 195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
195 ≤T< 200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	367	366	296	236	212	185	138	95	56	44	28	16	10	3	0

Table A-2: Number of Onshore Current Events at 17m Depth for Different Threshold Velocities and Durations June 1991-May 1992

Duration, T	Threshold Onshore Current Velocity (cm/s)																		
(hrs)	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
0 <T< 1	49	59	51	56	54	66	65	42	41	38	26	30	11	4	9	3	3	1	0
1 ≤T< 2	46	43	56	57	71	60	63	49	43	27	19	12	7	10	7	4	1	1	0
2 ≤T< 3	44	40	48	64	63	52	41	29	24	24	12	6	5	2	3	1	0	0	0
3 ≤T< 4	32	37	44	52	35	32	20	18	15	6	4	3	4	2	0	0	0	0	0
4 ≤T< 5	22	31	30	32	24	23	19	17	10	4	4	4	2	0	0	0	0	0	0
5 ≤T< 6	22	25	28	19	18	12	13	11	4	5	5	1	1	3	0	0	0	0	0
6 ≤T< 7	14	18	24	16	15	17	7	5	5	5	4	2	1	0	0	0	0	0	0
7 ≤T< 8	19	22	20	15	17	5	10	3	4	4	1	0	1	0	0	0	0	0	0
8 ≤T< 9	10	17	15	10	5	7	5	5	2	1	0	1	0	0	0	0	0	0	0
9 ≤T< 10	18	16	13	4	6	6	7	2	3	0	1	1	0	0	0	0	0	0	0
10 ≤T< 11	9	12	8	9	4	5	2	0	0	2	1	0	0	0	0	0	0	0	0
11 ≤T< 12	11	6	10	5	2	3	1	2	1	0	0	0	0	0	0	0	0	0	0
12 ≤T< 13	10	12	5	3	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0
13 ≤T< 14	8	5	2	5	3	3	0	2	1	0	0	0	0	0	0	0	0	0	0
14 ≤T< 15	7	5	3	4	5	0	2	0	0	0	0	0	0	0	0	0	0	0	0
15 ≤T< 16	6	2	5	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
16 ≤T< 17	3	2	3	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
17 ≤T<18	3	4	3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
18 ≤T< 19	3	3	2	1	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0
19 ≤T< 20	3	4	0	3	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0
20 ≤T< 21	4	2	2	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
21 ≤T< 22	2	3	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
22 ≤T< 23	0	2	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
23 ≤T< 24	4	0	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
24 ≤T< 25	1	2	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 ≤T< 26	1	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26 ≤T< 27	4	3	2	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
27 ≤T< 28	2	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28 ≤T< 29	2	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
29 ≤T< 30	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 ≤T< 35	3	4	4	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
35 ≤T< 40	4	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 ≤T< 45	1	3	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
45 ≤T< 50	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 ≤T< 55	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
55 ≤T< 60	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60 ≤T< 65	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65 ≤T< 70	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70 ≤T< 75	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75 ≤T< 80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80 ≤T< 85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85 ≤T< 90	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90 ≤T< 95	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95 ≤T< 100	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100 ≤T< 105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
105 ≤T< 110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110 ≤T< 115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115 ≤T< 120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120 ≤T< 125	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
125 ≤T< 130	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130 ≤T< 135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
135 ≤T< 140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140 ≤T< 145	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
145 ≤T< 150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150 ≤T< 155	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
155 ≤T< 160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
160 ≤T< 165	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
165 ≤T< 170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170 ≤T< 175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175 ≤T< 180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
180 ≤T< 185	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
185 ≤T< 190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190 ≤T< 195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
195 ≤T< 200	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	382	396	395	379	341	301	261	188	154	116	77	60	32	21	19	8	4	2	0

Table A-3: Number of Onshore Current Events at 52.5m Depth for Different Threshold Velocities and Durations June 1991-May 1992

Duration, T	Threshold Onshore Current Velocity (cm/s)																		
(hrs)	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
0 <T< 1	87	105	78	80	53	64	59	42	46	29	20	14	4	7	3	2	1	0	0
1 ≤T< 2	88	75	83	81	87	74	63	46	34	28	11	8	5	4	0	0	0	0	0
2 ≤T< 3	60	74	62	64	58	56	32	35	18	11	10	6	6	1	0	0	0	0	0
3 ≤T< 4	65	74	59	51	43	25	24	17	13	4	4	3	0	0	0	0	0	0	0
4 ≤T< 5	65	52	50	30	21	28	20	9	10	5	1	0	1	0	0	0	0	0	0
5 ≤T< 6	42	40	29	16	28	13	5	6	3	1	1	2	0	0	0	0	0	0	0
6 ≤T< 7	34	29	15	13	13	5	11	6	1	1	0	0	0	0	0	0	0	0	0
7 ≤T< 8	31	14	10	11	5	12	5	4	0	0	0	0	0	0	0	0	0	0	0
8 ≤T< 9	18	9	10	10	7	7	6	5	0	0	0	0	0	0	0	0	0	0	0
9 ≤T< 10	17	10	6	5	5	4	5	1	0	0	0	0	0	0	0	0	0	0	0
10 ≤T< 11	7	8	2	7	4	5	1	0	0	0	0	0	0	0	0	0	0	0	0
11 ≤T< 12	8	8	6	5	6	2	3	0	0	0	0	0	0	0	0	0	0	0	0
12 ≤T< 13	9	1	4	3	3	4	2	0	0	0	0	0	0	0	0	0	0	0	0
13 ≤T< 14	5	2	3	2	2	3	1	0	0	0	0	0	0	0	0	0	0	0	0
14 ≤T< 15	2	5	2	2	3	1	2	0	0	0	0	0	0	0	0	0	0	0	0
15 ≤T< 16	4	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ≤T< 17	3	1	5	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
17 ≤T<18	1	1	3	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
18 ≤T< 19	1	2	1	1	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0
19 ≤T< 20	1	1	1	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
20 ≤T< 21	1	1	2	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
21 ≤T< 22	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 ≤T< 23	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
23 ≤T< 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24 ≤T< 25	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 ≤T< 26	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26 ≤T< 27	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
27 ≤T< 28	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28 ≤T< 29	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29 ≤T< 30	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 ≤T< 35	3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35 ≤T< 40	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0
40 ≤T< 45	3	2	4	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
45 ≤T< 50	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 ≤T< 55	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55 ≤T< 60	1	3	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
60 ≤T< 65	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65 ≤T< 70	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70 ≤T< 75	1	0	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75 ≤T< 80	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80 ≤T< 85	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85 ≤T< 90	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90 ≤T< 95	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95 ≤T< 100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100 ≤T< 105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
105 ≤T< 110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110 ≤T< 115	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115 ≤T< 120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120 ≤T< 125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
125 ≤T< 130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130 ≤T< 135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
135 ≤T< 140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140 ≤T< 145	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
145 ≤T< 150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150 ≤T< 155	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
155 ≤T< 160	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
160 ≤T< 165	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
165 ≤T< 170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170 ≤T< 175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175 ≤T< 180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
180 ≤T< 185	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
185 ≤T< 190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190 ≤T< 195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
195 ≤T< 200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A-3 (cont): Number of Onshore Current Events at 52.5m Depth for Different Threshold Velocities and Durations June 1991-May 1992

Duration, T (hrs)	Threshold Onshore Current Velocity (cm/s)																		
	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
200 ≤T< 205	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
205 ≤T< 210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210 ≤T< 215	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
215 ≤T< 220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220 ≤T< 225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
225 ≤T< 230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
230 ≤T< 235	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
235 ≤T< 240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
240 ≤T< 245	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
245 ≤T< 250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250 ≤T< 255	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
255 ≤T< 260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
260 ≤T< 265	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
265 ≤T< 270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
270 ≤T< 275	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
275 ≤T< 280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
280 ≤T< 285	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
285 ≤T< 290	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
290 ≤T< 295	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
295 ≤T< 300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	570	529	448	399	353	312	240	172	126	80	48	33	16	12	3	2	1	0	0

Table A-4: Number of Onshore Current Events Based on Average of Currents at 17m and 52.5m Depth for Different Threshold Velocities and Durations June 1991-May 1992

Duration, T	Threshold Onshore Current Velocity (cm/s)																		
(hrs)	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
0 <T< 1	58	70	97	61	32	21	7	4	0	0	0	0	0	0	0	0	0	0	0
1 ≤T< 2	46	75	69	56	32	18	6	0	0	0	0	0	0	0	0	0	0	0	0
2 ≤T< 3	30	60	57	35	15	9	1	1	0	0	0	0	0	0	0	0	0	0	0
3 ≤T< 4	25	36	37	21	11	1	2	0	0	0	0	0	0	0	0	0	0	0	0
4 ≤T< 5	15	36	34	16	11	2	1	0	0	0	0	0	0	0	0	0	0	0	0
5 ≤T< 6	22	29	18	20	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0
6 ≤T< 7	20	32	19	7	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0
7 ≤T< 8	10	20	10	6	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
8 ≤T< 9	21	15	9	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9 ≤T< 10	16	16	8	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 ≤T< 11	8	13	7	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11 ≤T< 12	6	8	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 ≤T< 13	8	11	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13 ≤T< 14	8	7	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 ≤T< 15	3	6	7	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ≤T< 16	5	4	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 ≤T< 17	5	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 ≤T<18	3	5	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 ≤T< 19	7	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 ≤T< 20	8	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 ≤T< 21	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 ≤T< 22	6	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 ≤T< 23	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 ≤T< 24	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24 ≤T< 25	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 ≤T< 26	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26 ≤T< 27	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27 ≤T< 28	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28 ≤T< 29	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29 ≤T< 30	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 ≤T< 35	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35 ≤T< 40	4	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40 ≤T< 45	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45 ≤T< 50	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 ≤T< 55	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55 ≤T< 60	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60 ≤T< 65	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65 ≤T< 70	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70 ≤T< 75	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75 ≤T< 80	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80 ≤T< 85	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85 ≤T< 90	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90 ≤T< 95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95 ≤T< 100	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100 ≤T< 105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
105 ≤T< 110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110 ≤T< 115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115 ≤T< 120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120 ≤T< 125	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
125 ≤T< 130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130 ≤T< 135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
135 ≤T< 140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140 ≤T< 145	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
145 ≤T< 150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150 ≤T< 155	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
155 ≤T< 160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
160 ≤T< 165	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
165 ≤T< 170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170 ≤T< 175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175 ≤T< 180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
180 ≤T< 185	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
185 ≤T< 190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190 ≤T< 195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
195 ≤T< 200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	388	476	399	242	120	57	17	5	0	0	0	0	0	0	0	0	0	0	0

Table A-5: Percentage of Time with Onshore Winds for Different Threshold Velocities and Durations June 1991-May 1992

Duration, T	Threshold Onshore Wind Velocity (m/s)														
(hrs)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
0 <T< 1	.3	.4	.5	.3	.3	.2	.2	.1	.1	.1	.1	.0	.0	.0	.0
1 ≤T< 2	1.0	1.3	1.0	.8	.7	.8	.4	.5	.2	.2	.2	.1	.1	.0	.0
2 ≤T< 3	1.4	1.1	.9	.8	.8	.5	.8	.4	.2	.2	.2	.1	.0	.0	.0
3 ≤T< 4	.9	1.5	.9	1.2	.5	.8	.6	.3	.4	.1	.0	.0	.0	.0	.0
4 ≤T< 5	.9	1.7	.8	.6	.7	.5	.4	.1	.2	.2	.0	.1	.1	.0	.0
5 ≤T< 6	1.5	1.1	.6	.7	.7	.7	.5	.6	.2	.1	.0	.0	.0	.0	.0
6 ≤T< 7	1.2	1.3	.7	.7	.5	.5	.7	.2	.1	.0	.1	.1	.0	.0	.0
7 ≤T< 8	1.5	.7	.8	.7	.9	1.0	.3	.1	.1	.3	.2	.0	.0	.0	.0
8 ≤T< 9	2.1	1.1	1.0	.5	.7	.5	.7	.3	.2	.0	.1	.0	.0	.0	.0
9 ≤T< 10	1.1	.7	.6	.3	.6	.6	.0	.4	.1	.2	.0	.0	.0	.0	.0
10 ≤T< 11	1.6	1.2	.5	.4	.5	.4	.3	.1	.1	.1	.0	.0	.0	.0	.0
11 ≤T< 12	1.9	.4	1.3	1.0	1.5	.4	.2	.4	.0	.0	.0	.0	.0	.0	.0
12 ≤T< 13	1.5	1.5	1.0	1.1	.6	.5	.5	.3	.2	.0	.0	.0	.0	.0	.0
13 ≤T< 14	1.4	1.0	1.6	1.4	.2	.9	.5	.0	.2	.0	.0	.0	.0	.0	.0
14 ≤T< 15	1.3	2.1	.7	.6	.4	.9	.2	.0	.2	.0	.0	.0	.0	.0	.0
15 ≤T< 16	1.8	.4	.6	.6	.4	.2	.2	.0	.0	.0	.0	.0	.0	.0	.0
16 ≤T< 17	1.3	1.3	1.1	.0	1.1	.9	.0	.0	.0	.0	.0	.0	.0	.0	.0
17 ≤T<18	.7	.7	1.1	.7	.5	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0
18 ≤T< 19	.7	1.0	1.5	.5	.2	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0
19 ≤T< 20	1.3	1.0	.2	.5	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
20 ≤T< 21	.8	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
21 ≤T< 22	.8	.3	.3	.3	.3	.0	.0	.3	.3	.0	.0	.0	.0	.0	.0
22 ≤T< 23	.3	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
23 ≤T< 24	.0	.3	.3	.3	.3	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0
24 ≤T< 25	.3	.3	.3	.3	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
25 ≤T< 26	.3	.7	.7	1.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
26 ≤T< 27	.3	.3	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
27 ≤T< 28	.4	.0	.4	.7	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
28 ≤T< 29	.0	.0	.7	1.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
29 ≤T< 30	.0	.4	.4	.0	.0	.0	.0	.4	.0	.0	.0	.0	.0	.0	.0
30 ≤T< 35	.4	.4	.8	1.7	.8	.4	.8	.0	.0	.0	.0	.0	.0	.0	.0
35 ≤T< 40	2.0	2.9	1.4	.5	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	.0
40 ≤T< 45	3.8	1.6	1.7	.5	1.1	.6	.5	.0	.0	.0	.0	.0	.0	.0	.0
45 ≤T< 50	3.1	2.5	1.8	1.9	1.8	1.2	.0	.0	.0	.0	.0	.0	.0	.0	.0
50 ≤T< 55	.0	.0	1.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
55 ≤T< 60	.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
60 ≤T< 65	1.6	.8	.8	.8	.8	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0
65 ≤T< 70	1.7	.9	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
70 ≤T< 75	.0	.0	.0	.0	.9	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
75 ≤T< 80	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
80 ≤T< 85	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
85 ≤T< 90	1.1	1.1	.0	1.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
90 ≤T< 95	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
95 ≤T< 100	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
100 ≤T< 105	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
105 ≤T< 110	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
110 ≤T< 115	.0	2.9	1.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
115 ≤T< 120	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
120 ≤T< 125	.0	.0	.0	1.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
125 ≤T< 130	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
130 ≤T< 135	.0	1.7	1.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
135 ≤T< 140	3.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
140 ≤T< 145	1.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
145 ≤T< 150	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
150 ≤T< 155	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
155 ≤T< 160	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
160 ≤T< 165	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
165 ≤T< 170	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
170 ≤T< 175	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
175 ≤T< 180	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
180 ≤T< 185	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
185 ≤T< 190	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
190 ≤T< 195	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
195 ≤T< 200	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Total	48.5	39.4	31.4	25.1	19.4	13.5	8.4	4.8	2.9	1.6	.8	.4	.2	.0	.0

Table A-6: Percentage of Time with Onshore Currents at 17m Depth for Different Threshold Velocities and Durations June 1991-May 1992

Duration, T	Threshold Onshore Current Velocity (cm/s)																		
(hrs)	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
0 <T< 1	.2	.4	.3	.3	.4	.5	.4	.3	.2	.3	.1	.2	.0	.0	.1	.0	.0	.0	.0
1 ≤T< 2	.9	.9	1.1	1.1	1.4	1.3	1.3	.9	.9	.5	.3	.2	.1	.2	.1	.1	.0	.0	.0
2 ≤T< 3	1.4	1.3	1.6	2.1	2.1	1.7	1.3	.9	.8	.8	.4	.2	.2	.1	.1	.0	.0	.0	.0
3 ≤T< 4	1.5	1.7	2.1	2.4	1.6	1.5	.9	.9	.7	.3	.2	.1	.2	.1	.0	.0	.0	.0	.0
4 ≤T< 5	1.3	1.9	1.8	1.9	1.4	1.4	1.1	1.0	.6	.2	.2	.2	.1	.0	.0	.0	.0	.0	.0
5 ≤T< 6	1.6	1.8	2.0	1.4	1.3	.9	.9	.8	.3	.4	.4	.1	.1	.2	.0	.0	.0	.0	.0
6 ≤T< 7	1.2	1.5	2.1	1.4	1.3	1.5	.6	.4	.4	.4	.3	.2	.1	.0	.0	.0	.0	.0	.0
7 ≤T< 8	1.9	2.2	2.0	1.5	1.7	.5	1.0	.3	.4	.4	.1	.0	.1	.0	.0	.0	.0	.0	.0
8 ≤T< 9	1.1	2.0	1.7	1.1	.6	.8	.6	.6	.2	.1	.0	.1	.0	.0	.0	.0	.0	.0	.0
9 ≤T< 10	2.3	2.0	1.7	.5	.8	.8	.9	.3	.4	.0	.1	.1	.0	.0	.0	.0	.0	.0	.0
10 ≤T< 11	1.3	1.7	1.1	1.2	.6	.7	.3	.0	.0	.3	.1	.0	.0	.0	.0	.0	.0	.0	.0
11 ≤T< 12	1.7	.9	1.5	.8	.3	.5	.2	.3	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
12 ≤T< 13	1.7	2.0	.8	.5	.5	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
13 ≤T< 14	1.4	.9	.3	.9	.5	.5	.0	.4	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
14 ≤T< 15	1.3	1.0	.6	.8	1.0	.0	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
15 ≤T< 16	1.3	.4	1.0	.2	.2	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
16 ≤T< 17	.7	.4	.7	.4	.2	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
17 ≤T<18	.7	.9	.7	.2	.2	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
18 ≤T< 19	.8	.7	.5	.2	.5	.5	.2	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
19 ≤T< 20	.8	1.1	.0	.8	.8	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
20 ≤T< 21	1.1	.6	.5	.8	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
21 ≤T< 22	.6	.9	.6	.3	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
22 ≤T< 23	.0	.6	.3	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
23 ≤T< 24	1.3	.0	.3	.0	.6	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
24 ≤T< 25	.3	.7	.3	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
25 ≤T< 26	.3	.3	1.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
26 ≤T< 27	1.4	1.1	.7	.3	.4	.0	.0	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
27 ≤T< 28	.7	.4	.0	.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
28 ≤T< 29	.8	.0	.4	.4	.0	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
29 ≤T< 30	.4	.4	.4	.0	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
30 ≤T< 35	1.3	1.8	1.7	1.7	.8	.4	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
35 ≤T< 40	2.0	1.6	.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
40 ≤T< 45	.6	1.7	.6	.6	.5	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
45 ≤T< 50	1.3	.6	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
50 ≤T< 55	.7	.0	.7	.0	.0	.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
55 ≤T< 60	.7	.7	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
60 ≤T< 65	2.5	.8	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
65 ≤T< 70	1.8	1.8	.9	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
70 ≤T< 75	.9	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
75 ≤T< 80	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
80 ≤T< 85	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
85 ≤T< 90	.0	2.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
90 ≤T< 95	1.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
95 ≤T< 100	.0	.0	1.3	1.3	1.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
100 ≤T< 105	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
105 ≤T< 110	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
110 ≤T< 115	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
115 ≤T< 120	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
120 ≤T< 125	1.7	1.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
125 ≤T< 130	1.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
130 ≤T< 135	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
135 ≤T< 140	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
140 ≤T< 145	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
145 ≤T< 150	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
150 ≤T< 155	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
155 ≤T< 160	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
160 ≤T< 165	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
165 ≤T< 170	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
170 ≤T< 175	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
175 ≤T< 180	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
180 ≤T< 185	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
185 ≤T< 190	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
190 ≤T< 195	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
195 ≤T< 200	2.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Total	51.1	43.6	35.7	28.5	21.5	16.0	11.5	8.0	5.5	3.6	2.4	1.5	.9	.6	.3	.1	.0	.0	.0

Table A-7: Percentage of Time with Onshore Currents at 52.5m Depth for Different Threshold Velocities and Durations June 1991-May 1992

Duration, T	Threshold Onshore Current Velocity (cm/s)																		
(hrs)	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
0 <T< 1	.5	.7	.4	.5	.3	.4	.4	.2	.3	.2	.1	.1	.0	.1	.0	.0	.0	.0	.0
1 ≤T< 2	1.7	1.4	1.6	1.5	1.6	1.5	1.2	.8	.7	.6	.2	.1	.1	.1	.0	.0	.0	.0	.0
2 ≤T< 3	1.9	2.3	2.0	2.0	1.8	1.8	1.0	1.1	.6	.4	.3	.2	.2	.0	.0	.0	.0	.0	.0
3 ≤T< 4	2.9	3.4	2.6	2.3	1.9	1.1	1.1	.8	.6	.2	.2	.1	.0	.0	.0	.0	.0	.0	.0
4 ≤T< 5	3.8	3.0	2.9	1.7	1.2	1.6	1.2	.5	.6	.3	.1	.0	.1	.0	.0	.0	.0	.0	.0
5 ≤T< 6	2.9	2.8	2.1	1.1	2.0	.9	.3	.4	.2	.1	.1	.1	.0	.0	.0	.0	.0	.0	.0
6 ≤T< 7	2.8	2.4	1.2	1.1	1.1	.4	.9	.5	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0
7 ≤T< 8	3.0	1.3	1.0	1.1	.5	1.1	.5	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
8 ≤T< 9	2.0	1.0	1.1	1.1	.8	.8	.7	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
9 ≤T< 10	2.1	1.2	.7	.6	.6	.5	.6	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
10 ≤T< 11	.9	1.1	.3	1.0	.5	.7	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
11 ≤T< 12	1.2	1.2	.9	.7	.9	.3	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
12 ≤T< 13	1.4	.2	.7	.5	.5	.6	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
13 ≤T< 14	.8	.3	.5	.4	.4	.5	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
14 ≤T< 15	.4	.9	.4	.4	.6	.2	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
15 ≤T< 16	.8	.2	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
16 ≤T< 17	.6	.2	1.1	.4	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
17 ≤T<18	.2	.2	.7	.2	.5	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
18 ≤T< 19	.2	.5	.2	.2	.7	.0	.0	.0	.0	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0
19 ≤T< 20	.3	.3	.2	.3	.5	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
20 ≤T< 21	.3	.3	.5	.3	.0	.3	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0
21 ≤T< 22	.0	.0	.3	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
22 ≤T< 23	.0	.3	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
23 ≤T< 24	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
24 ≤T< 25	.6	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
25 ≤T< 26	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
26 ≤T< 27	.0	.0	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
27 ≤T< 28	.4	.3	.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
28 ≤T< 29	.0	.4	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
29 ≤T< 30	.0	.0	.0	.0	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
30 ≤T< 35	1.3	.4	.4	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
35 ≤T< 40	.0	.0	.0	.0	.5	.0	.0	.5	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
40 ≤T< 45	1.8	1.2	2.2	.0	.6	.0	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
45 ≤T< 50	.6	.0	.7	.7	.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
50 ≤T< 55	.0	.0	.0	.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
55 ≤T< 60	.8	2.4	1.6	1.6	.0	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
60 ≤T< 65	.0	.9	.9	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
65 ≤T< 70	1.9	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
70 ≤T< 75	1.0	.0	1.0	2.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
75 ≤T< 80	.0	.0	1.0	.0	1.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
80 ≤T< 85	.0	.0	.0	1.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
85 ≤T< 90	.0	1.2	1.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
90 ≤T< 95	2.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
95 ≤T< 100	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
100 ≤T< 105	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
105 ≤T< 110	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
110 ≤T< 115	1.5	1.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
115 ≤T< 120	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
120 ≤T< 125	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
125 ≤T< 130	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
130 ≤T< 135	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
135 ≤T< 140	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
140 ≤T< 145	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
145 ≤T< 150	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
150 ≤T< 155	.0	2.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
155 ≤T< 160	4.2	2.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
160 ≤T< 165	2.2	2.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
165 ≤T< 170	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
170 ≤T< 175	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
175 ≤T< 180	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
180 ≤T< 185	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
185 ≤T< 190	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
190 ≤T< 195	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
195 ≤T< 200	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

Table A-7 (cont): Percentage of Time with Onshore Currents at 52.5m Depth for Different Threshold Velocities and Durations June 1991-May 1992

Duration, T (hrs)	Threshold Onshore Current Velocity (cm/s) 0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
200 ≤T< 205	0	0	0	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
205 ≤T< 210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210 ≤T< 215	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
215 ≤T< 220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220 ≤T< 225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
225 ≤T< 230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
230 ≤T< 235	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
235 ≤T< 240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
240 ≤T< 245	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
245 ≤T< 250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250 ≤T< 255	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
255 ≤T< 260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
260 ≤T< 265	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
265 ≤T< 270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
270 ≤T< 275	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
275 ≤T< 280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
280 ≤T< 285	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
285 ≤T< 290	3.9	3.9	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
290 ≤T< 295	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
295 ≤T< 300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	55.2	45.2	36.6	29.2	22.0	16.0	10.4	6.3	3.6	2.1	1.2	.7	.4	.2	.0	.0	.0	.0	.0

Table A-8: Percentage of Time with Onshore Currents Based on Average of Currents at 17m and 52.5m Depth for Different Threshold Velocities and Durations June 1991-May 1992

Duration, T	Threshold Onshore Current Velocity (cm/s)																	
(hrs)	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
0 <T< 1	.3	.5	.6	.4	.2	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1 ≤T< 2	1.0	1.5	1.4	1.2	.6	.4	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2 ≤T< 3	1.1	2.1	2.0	1.2	.5	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
3 ≤T< 4	1.2	1.8	1.8	1.0	.5	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
4 ≤T< 5	.9	2.2	2.1	1.0	.7	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
5 ≤T< 6	1.7	2.2	1.4	1.5	.6	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
6 ≤T< 7	1.8	2.9	1.7	.7	.4	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
7 ≤T< 8	1.0	2.1	1.0	.6	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
8 ≤T< 9	2.5	1.8	1.1	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
9 ≤T< 10	2.1	2.1	1.1	.5	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
10 ≤T< 11	1.2	1.9	1.0	.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
11 ≤T< 12	1.0	1.3	.5	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
12 ≤T< 13	1.4	1.9	1.2	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
13 ≤T< 14	1.5	1.3	.6	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
14 ≤T< 15	.6	1.2	1.4	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
15 ≤T< 16	1.1	.9	.0	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
16 ≤T< 17	1.2	.2	.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
17 ≤T<18	.7	1.2	.3	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
18 ≤T< 19	1.8	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
19 ≤T< 20	2.2	.5	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
20 ≤T< 21	.6	.6	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
21 ≤T< 22	1.8	.9	.3	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
22 ≤T< 23	.6	.6	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
23 ≤T< 24	1.0	.3	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
24 ≤T< 25	.7	.7	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
25 ≤T< 26	1.1	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
26 ≤T< 27	1.8	.0	.0	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
27 ≤T< 28	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
28 ≤T< 29	.8	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
29 ≤T< 30	.8	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
30 ≤T< 35	3.5	1.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
35 ≤T< 40	2.1	.5	.5	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
40 ≤T< 45	1.8	1.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
45 ≤T< 50	2.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
50 ≤T< 55	1.5	.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
55 ≤T< 60	3.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
60 ≤T< 65	1.7	.9	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
65 ≤T< 70	1.9	.9	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
70 ≤T< 75	1.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
75 ≤T< 80	1.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
80 ≤T< 85	1.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
85 ≤T< 90	1.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
90 ≤T< 95	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
95 ≤T< 100	.0	.0	1.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
100 ≤T< 105	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
105 ≤T< 110	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
110 ≤T< 115	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
115 ≤T< 120	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
120 ≤T< 125	3.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
125 ≤T< 130	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
130 ≤T< 135	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
135 ≤T< 140	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
140 ≤T< 145	2.0	2.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
145 ≤T< 150	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
150 ≤T< 155	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
155 ≤T< 160	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
160 ≤T< 165	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
165 ≤T< 170	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
170 ≤T< 175	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
175 ≤T< 180	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
180 ≤T< 185	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
185 ≤T< 190	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
190 ≤T< 195	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
195 ≤T< 200	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Total	63.9	44.2	24.0	11.3	4.8	1.5	.3	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0