Title	Whitecaps and the marine atmosphere, report no. 7
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Publication Date	1984-10
Item record	http://hdl.handle.net/10379/4263

WHITECAPS AND THE MARINE ATMOSPHERE

REPORT NO. 7

by

E.C. MONAHAN, M.C. SPILLANE, P.A. BOWYER, M.R. HIGGINS and P.J. STABENO

Capaill Mhananáinn agus Caitheadh na dTonn

Aigeaneolaíocht Fhisiciúil

MISEX'83
video (W_A)
PRELIMINARY
p.24

MISEX'83
fílm (W_B)
p.22

REPORT PERIOD: 1 JUNE 1983 –
30 SEPTEMBER 1984
UNIVERSITY COLLEGE,
GALWAY, IRELAND.

OCTOBER 1984

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University College,
Galway, Ireland

October 1984

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CHAPTER I

INTRODUCTION

by

Edward C. Monahan

This report describes the general activities and findings of the
Whitecap Project in the 16-month-long period 1 June 1983-30
September 1984. Additional results obtained during this period
from this study of whitecaps and the marine atmosphere are to be
found in Report No. 6 (Marine Aerosol Research in the Gulf of
Alaska and on the Irish West Coast (Inishmore)), written by
D.M. Doyle and issued in June 1984.

The research emphasis during the period covered by the present
report was on the collection of whitecap (and aerosol and electro-
static charge) data, primarily in cold water regimes. Specifically,
during this interval project personnel participated in MIZEX 83
and MIZEX 84. On figure 1.1 are illustrated the relevant cruise
tracks of the POLARSTERN (MIZEX 83), the HAAKON MOSBY (MIZEX 84),
and the KVITBJORN (MIZEX 84).

In this report period a Hamamatsu Area Analyser (Model C1143-00)
was purchased from Hakuto, Ltd., for use in the efficient analysis
of the video whitecap records collected during the MIZEX 83 and
subsequent research cruises. A stainless steel windowed instrument
shelter was obtained from Logstrup Ireland, Ltd., and a heating
system and insulation were installed to make a suitable shipboard
shelter for whitecap video and film cameras (Figure 1.2). A
second SONY SMF Trinicon Colour Video Camera (Model DXC 1800P)
was purchased so that one such camera could remain mounted in the
instrument shelter routinely monitoring oceanic whitecap coverage
while the second camera could be used, shoulder-mounted at the
ship's rail, to record the decay of individual whitecaps and the
formation of bubbles as waves interact with specific ice floes.

A SONY Camera Control Unit (Model CCU-1800P), a small monitor (Model DXF-40CE), and the required power supplies were obtained to make it possible for the camera mounted in the instrument shelter (situated above the starboard wing of the bridge aboard the HAAKON MOSBY during MIZEX 84) to be controlled from an interior laboratory (on the main deck of the HAAKON MOSBY). A second SONY U-matic Portable Colour Video Recorder (Model VO-4800P) was purchased so that the analysis of the MIZEX 83 video tapes could go forward at U.C.G. while MIZEX 84 whitecap video records were being taped at sea, and so that in the future it would be possible to record whitecaps at two field locations simultaneously.

A perception of whitecap project activities in this report period can be drawn from Table 1.1, in which is listed the research cruise participation of whitecap project personnel in the interval 1 May 1983 - 31 August 1984, and the meetings attended by, and relevant lectures given by, them between the same dates. The results obtained in the past 16 months as a consequence of whitecap project research are summarised in the recent project-related papers listed in Table 1.2.

In the following section (Chapter 2) are to be found summaries of the whitecap observations carried out in the past 16 months, and of the results obtained from the analyses of these records.

September 1984

Edward C. Monahan
Galway
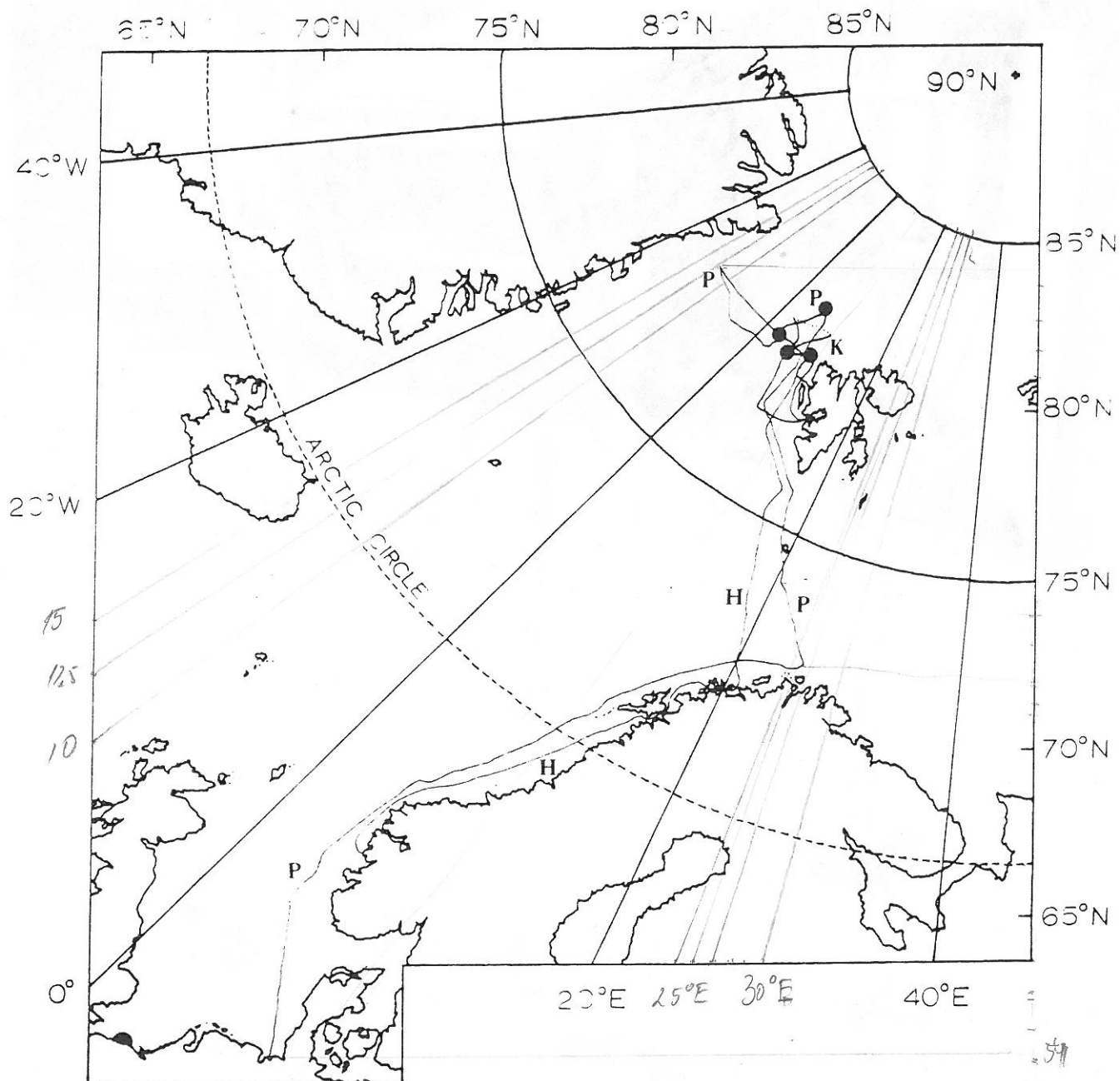
Research cruises and areas of scientific activity of
E.C. Monahan in the North Sea, Norwegian Sea, and the
Arctic. Dotted line represents ship to ship travel via
helicopter. P, POLARSTERN (83); H, HAAKON MOSBY (84);
and K, KVITBJORN (84).

Figure 1.2. Heated video-and film camera shelter, and supporting framework, as used aboard the HAAKON MOSBY during MIZEX 84 cruise.
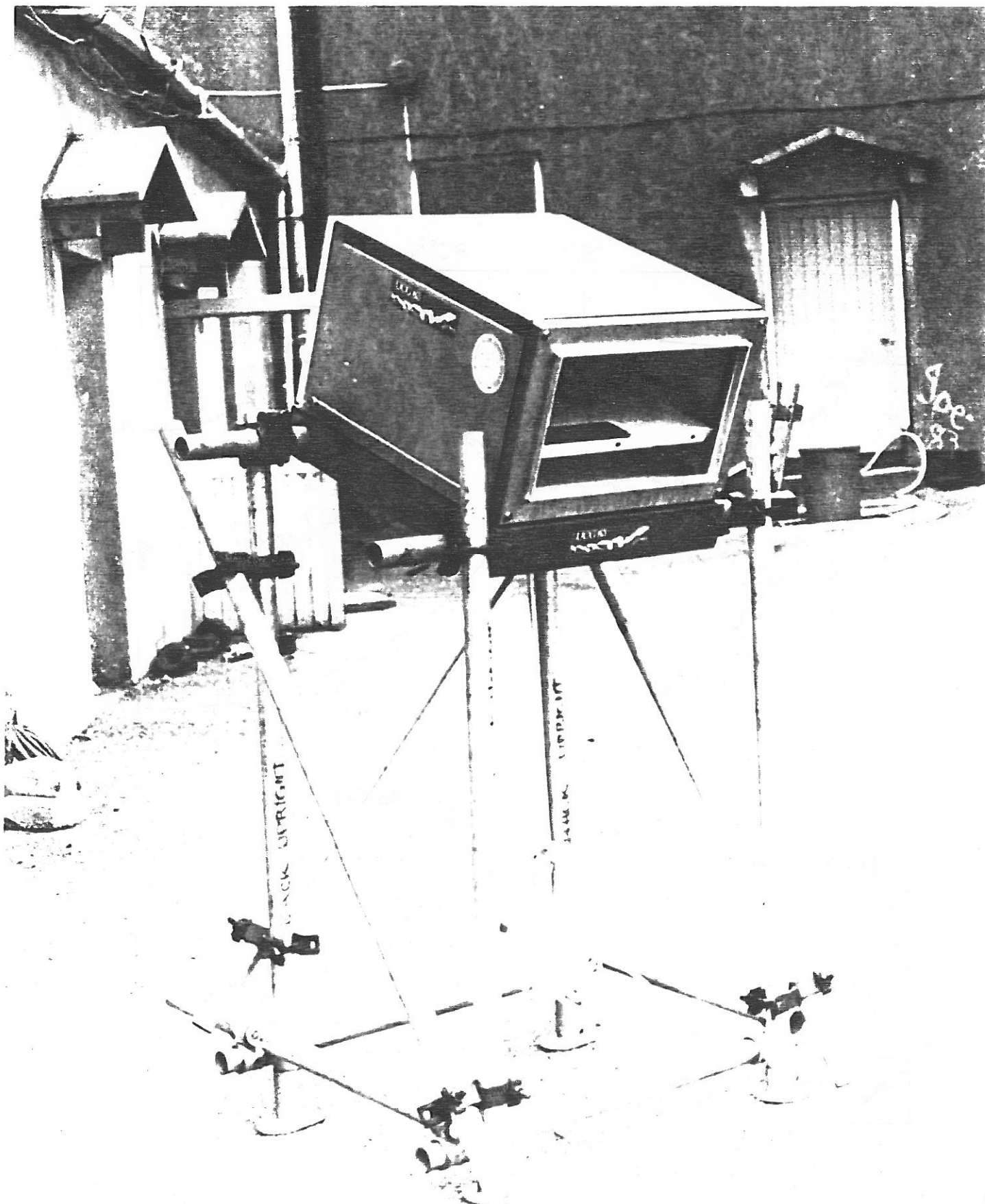
Table 1.1: Whitecap Project Log of Research Cruise
Participation, Lecture Presentations, and Meeting Attendance
of Project Personnel in 1 May 1983 - 31 August 1984 Interval.

5 May 1983	Day cruise in Galway Bay aboard the R/V LOUGH BELTRA, testing of video whitecap data acquisition system (E.C. Monahan, M.C. Spillane, J.J. Taper, and P.A. Bowyer).
5-8 June 1983	Attended Ninth Conference on Aerospace and Aeronautical Meteorology of the American Meteorological Society, Omaha, Nebraska, U.S.A. (E.C.M.).
7 June 1983	Gave paper (co-authored with D.E. Spiel and K.L. Davidson), "Model of Marine Aerosol Generation via Whitecaps and Wave Disruption", at Ninth Conference on Aerospace and Aeronautical Meteorology, in Omaha, Nebraska, U.S.A. (E.C.M.).
12-15 June 1983	Attended International Symposium on Gas Transfer at Water Surfaces, Cornell University, Ithaca, New York, U.S.A. (E.C.M.).
13 June 1983	Gave paper (co-authored with M.C.S.), "The Role of Oceanic Whitecaps in Air-Sea Gas Exchange", at International Symposium on Gas Transfer at Water Surfaces, in Ithaca, New York, U.S.A. (E.C.M.).
17 June 1983	Gave lecture, "Breaking Waves, Whitecaps and the Production of Marine Aerosol", Geochemistry Seminar, Lamont-Doherty Geological Observatory, Columbia University, Palisades, New York, U.S.A. (E.C.M.).
26-28 June 1983	In Bremerhaven preparing for MIZEX 83 cruise (E.C.M.).
29 June-19 July 1983	Carried out whitecap observations aboard F/S POLARSTERN of Alfred-Wegener-Institut fur Polarforschung during MIZEX 83 cruise; Bremerhaven, Fram Strait, $81^\circ31^\circ$N, Longyearbyen (E.C.M.).
26-30 July 1983	Work at Inishmore (Gort na gCapall) Aerosol Field Station (J.J. Taper and D.M. Doyle).

21-27 August 1983	Attended XVIII General Assembly of International Union of Geodesy and Geophysics, Hamburg, F.R.G. (E.C.M., M.C.S., and P.J. Stabeno).
26 August 1983	Gave paper (co-authored with M.C.S.), "The Role of Oceanic Whitecaps in the Exchange of Mass Across the Air-Sea Interface", at I.U.G.G. XVIII, in Hamburg, F.R.G. (E.C.M.).
3-17 September 1983	U.C.G./N.P.S. co-operative Whitecap Simulation Tank Experiment IV, Galway.
4-7 September 1983	Hosted International Whitecap Workshop at University College, Galway, sponsored by O.N.R.
6 September 1983	I.G. O'Muircheartaigh gave paper (co-authored with E.C.M.), "A Statistical Analysis of Factors Influencing Whitecapping", at U.C.G. Whitecap Workshop.
6 September 1983	M.C. Spillane gave paper (co-authored with E.C.M. P.A.B., D.M.D., and P.J.S.), "Whitecaps and Global Fluxes", at U.C.G. Whitecap Workshop.
6 September 1983	Poster presentation, "The Influence of Fetch on Whitecap Coverage as Deduced from the Alte Weser Light-Station Observers'Log", at U.C.G. Whitecap Workshop (E.C.M. and C.F. Monahan).
26-28 September 1983	Attended Second International Meeting on Statistical Climatology, Lisbon, Portugal (E.C.M. and I.G. O'M).
26 September 1983	I.G. O'Muircheartaigh gave paper (co-authored with E.C.M.), "Aspects of Oceanic Whitecap Coverage Dependence on Wind Speed: Hetero-scedasticity in the Data and the Estimation of the Beaufort Velocity" at Second International Meeting on Statistical Climatology, Lisbon, Portugal.
16 November 1983	I.G. O'Muircheartaigh gave paper (co-authored) with E.C.M.), "Use of the Box-Cox Trans-formation in Determining the Functional Form of the Dependence of Oceanic Whitecap Coverage on Several Environmental Factors", at Eighth Conference on Probability and Statistics in Atmospheric Sciences, in Hot Springs, Arkansas, U.S.A.
18 November 1983	Attended Second Alfred-Wegener-Conference on Air-Sea-Ice Interactions, in Bremerhaven, F.R.G. (E.C.M.).

19-21 November 1983	Attended MIZEX 84 Science Group and General Planning Meeting, Alfred Wegener Institut fur Polarforschung, Bremerhaven, F.R.G. (E.C.M.).
10-11 January 1984	Visit to Hakudo, Ltd., in Enfield, England, to inspect Hamamatsu Area Analyser (E.C.M. and M.C.S.).
9-11 February 1984	Work carried out at Gort na gCapall (Inishmore) Field Station (D.M.D., P.A.B., Mary R. Higgins, and T. Furey).
11-15 February 1984	Attended MIZEX 84 Final Operational Planning Meeting, University of Miami Environmental Field Station, Pigeon Key, Florida, U.S.A. (E.C.M.).
1-2 March 1984	Attended meeting at O.N.R., Arlington, Virginia, U.S.A., to discuss "Bubbles in ocean surface layer experiment" (E.C.M.).
13 March 1984	Gave talk, "Oceanic Whitecaps (Whitehorses) and their Effect on the Remote Sensing Signature of the Sea Surface", at mini-seminar on Remote Sensing: Sensors and Applications, Meeting of Irish Society of Surveying and Photogrammetry, Trinity College, Dublin (E.C.M.).
30 April 1984	Dr. M.C. Spillane and Dr. P.J. Stabeno resign to go to America.
6-10 May 1984	Visit to Bergen, Norway, in regard to instrument shelter installation aboard the R/V HAAKON MOSBY (E.C.M.).
9 May 1984	Gave seminar, "The Role of Oceanic Whitecaps in the Generation of Marine Aerosols", at Geofysisk Institutt, Universitetet i Bergen, Norway (E.C.M).
11 May 1984	Day cruise aboard LOUGH BELTRA in Galway Bay, testing electrostatic space charge/potential gradient apparatus (P.A. Bowyer).
9-11 June 1984	In Bergen preparing for MIZEX 84 cruise (E.C.M. and P.A.B.).
12-27 June 1984	Carried out video and film whitecap observations (E.C.M.), and made space charge concentration measurements (P.A.B.), aboard the R/V HAAKON MOSBY of the University of Bergen during MIZEX 84 cruise: Bergen, Tromso, Ny Aalesund, Fram Strait, $81^{\circ}35'$N.

27-30 June 1984	Sailed from 81°37'N in Fram Strait to Long-yearbyen aboard KVITBJORN (E.C.M.).
27 June-17 July 1984	Continued with film whitecap observations and space charge measurements aboard HAAKON MOSBY; Fram Strait to Tromso (P.A.B.).
19 July 1984	Mr. David M. Doyle was awarded the M.Sc. degree by the National University of Ireland, his thesis having dealt with whitecap and aerosol observations during STREX, and further aerosol observations from Gort na gCapall (see report No. 6 in this series).
19 July 1984	Dr. E.C. Monahan was awarded the D.Sc. (on published work) degree by the National University of Ireland, based on his submission of 30 published papers (20 of which dealt with whitecaps and marine aerosols), and on the assessment of these papers by anonymous External Examiners.
29 July-2 August 1984	Attended 10th General Assembly of the European Geophysical Society at the Catholic University of Louvain-la-Neuve, Belgium (E.C.M.).
1 August 1984	Gave paper (co-authored with P.A.B. and M.C.S), "The Temperature Dependence of Whitecap Aerosol Productivity and the Implications for Regional Sea-Air Salt Fluxes" at E.G.S. Assembly X, in Louvain-la-Neuve, Belgium, (E.C.M.).

Table 1.2: Supplementary List of Project Related Publications, as of 31 August 1984.

Note: See Table 1.1 of publication No. 17 for a listing of publications 1 through 16, Table 1.1 of publication No. 30 for a listing of publications 17 through 29, and Table 1.1 of publication No. 39 for a listing of publications 30 through 38.

A.   Amended Earlier Listings

29. Monahan, E.C., C.W. Fairall, K.L. Davidson, and P. Jones Boyle, 1983. Observed inter-relations between 10m winds, ocean whitecaps and marine aerosols, Quarterly Journal of the Royal Meteorological Society, 109, pp. 379-392.

35. Monahan, E.C., D.E. Spiel, and K.L. Davidson, 1983. Model of marine aerosol generation via whitecaps and wave disruption, Ninth Conference on Aerospace and Aeronautical Meteorology, 6-9 June, 1983, Omaha, Nebraska, American Meteorological Society, Preprint Volume, pp. 147-158.

36. Monahan, E.C. and M.C. Spillane, 1983. The role of oceanic whitecaps in the exchange of mass across the air-sea interface, 20/23, IUGG Inter-Disciplinary Symposia, Programme and Abstracts, Vol. 2, International Union of Geodesy and Geophysics, XVIII General Assembly, Hamburg, F.R.G., 15-27 August, 1983, p. 884, (Abstract).

37. O'Muircheartaigh, I.G. and E.C. Monahan, 1983. Aspects of oceanic whitecap coverage dependence on wind speed; heteroscedasticity in the data, and the estimation of the Beaufort velocity, Preprint Volume, Second International Meeting on Statistical Climatology, Sept. 26-30, 1983, Lisbon, Portugal, (2.7.1-4).

38. Monahan, E.C., and M.C. Spillane, 1983. The role of oceanic whitecaps in air-sea gas exchange, p.83 in W.H. Brutsaert and G.H. Jinka, Eds. Symposium Proceedings, Abstracts of Scientific Papers, International Symposium on Gas Transfer at Water Surfaces, School of Civil and Environmental Engineering, Cornell University, Ithaca, N.Y., pp. 1-127, (Abstract).

B.   New Listings

39. Monahan, E.C., M.C. Spillane, P.A. Bowyer, D.M. Doyle, and P.J. Stabeno, 1983. Whitecaps and the Marine Atmosphere, Report No. 5, to the Office of Naval Research, from University College, Galway, pp. 1-93.

40. O'Muircheartaigh, I.G., and E.C. Monahan, 1983. Whitecap-Wind Algorithms, Final Report, to the Office of Naval Research, from University College, Galway, pp. 1-6 plus 38 pp. appendices, (Supported via N00014-82-G-0024).

41. O'Muircheartaigh, I.G., and E.C. Monahan, 1983 A statistical analysis of factors influencing whitecapping, Book of Abstracts, Whitecap Workshop, University College, Galway, 4-7 September, 1983, p. 18, (Abstract).

42. Spillane, M.C., E.C. Monahan, P.A. Bowyer, D.M. Doyle, and P.J. Stabeno, 1983. Whitecaps and global fluxes, Book of Abstracts, Whitecap Workshop, University College, Galway, 4-7 September, 1983, p. 20, (Abstract).

43. Stabeno, P.J., and E.C. Monahan, 1983. The influence of whitecaps on the albedo of the sea surface, Book of Abstracts, Whitecap Workshop, University College, Galway, 4-7 September, 1983, p. 26, (Abstract).

44. Monahan, E.C., and C.F. Monahan, 1983. The influence of Fetch on Whitecap Coverage as Deduced from the Alte Weser Lightstation Observer's Log, Book of Abstracts, Whitecap Workshop, University College, Galway, 4-7 September, 1983, p. 40, (Abstract).

45. O'Muircheartaigh, I.G., and E.C. Monahan, 1983. Use of the Box-Cox transformation in determining the functional form of the dependence of oceanic whitecap coverage on several environmental factors, Preprint Volume: Eighth Conference on Probability and Statistics in Atmospheric Sciences, November 16-18, 1983, Hot Springs, Arkansas, 3.5, pp. 55-58.

46. Monahan, E.C., and M.C. Spillane, 1984. The Role of Oceanic Whitecaps in Air-Sea Gas Exchange, pp. 495-503 in "Gas Transfer at Water Surfaces", W. Brutsaert and G.H. Jirka, Eds., Water Science and Technology Library, D. Reidel Publishing Company, Dordrecht.

47. Monahan, E.C., and P.A. Bowyer, 1984. Arctic Whitecapping: Preliminary Results, pp. 1-6, for MIZEX 84 Planning Meeting, 13-15 February 1984, University of Miami Environmental Field Station, Pigeon Key, Florida.

48. Monahan, E.C., 1983. Positive charge flux from the world ocean resulting from the bursting of whitecap bubbles, pp. 85-87, in L.H. Ruhnke and J. Latham, Eds. Proceedings in Atmospheric Electricity, A. Deepak Publishing, Hampton, Virginia.

49. Monahan, E.C., 1983. Workshop - Whitecap Workshop (2.5.7. in Participation of EARSeL Members at Conferences), EARSeL NEWS, no. 23, December 1983, p. 9.

50. Doyle, D.M., 1984. Marine Aerosol Research in the Gulf of Alaska and on the Irish West Coast (Inishmore), Whitecaps and the Marine Atmosphere, Report No. 6, to the Office of Naval Research from University College, Galway, pp. 1-140 (and M.Sc. thesis to the N.U.I.).

51. Monahan, E.C., P.A. Bowyer, and M.C. Spillane, 1984. The Temperature Dependence of Whitecap Aerosol Productivity and the Implications for Regional Sea-Air Salt Fluxes, S10.10, Terra Cognita, 4, pp. 347-348.

52. Spillane, M.C., E.C. Monahan, P.A. Bowyer, D.M. Doyle, and P.J. Stabeno, 1984. Whitecaps and Global Fluxes, in Oceanic Whitecaps and their Role in Air-Sea Exchange Processes, E.C. Monahan and G. Mac Niocaill, Eds., Galway U. Press (in press).

53. Stabeno, P.J. and E.C. Monahan, 1984. The influence of Whitecaps on the Albedo of the Sea Surface, in Oceanic Whitecaps and their Role in Air-Sea Exchange Processes, E.C. Monahan and G. Mac Niocaill, Eds., Galway U. Press (in press).

54. O'Muircheartaigh, I.G. and E.C. Monahan, 1984. Statistical Aspects of the Relationship between oceanic Whitecap coverage, Wind Speed and other Environmental Factors, in Oceanic Whitecaps and their Role in Air-Sea Exchange Processes, E.C. Monahan and G. Mac Niocaill, Eds., Galway U. Press (in press).

55. Monahan, E.C., D.E. Spiel, and K.L. Davidson, 1984. A Model of Marine Aerosol Generation via Whitecaps and Wave Disruption, in <u>Oceanic Whitecaps and their Role in Air-Sea Exchange Processes</u>, E.C. Monahan and G. Mac Niocaill, Eds., Galway U. Press (in press).

CHAPTER 2

WHITECAP OBSERVATIONS, DATA, AND RESULTS

Included in this concise chapter are descriptions of the
whitecap observations taken during the 1983 and 1984 MIZEX
experiments, copies of the two MIZEX whitecap observation
logs, and tabular and graphic summaries of the results
obtained to date from the analyses of the MIZEX '83 film
and video tape records.   Specifically, this chapter con-
sists of the following sections:

A)   MIZEX '83 Whitecap Study Report (E.C. Monahan), as
     subsequently reproduced in Fahrtbericht der POLARSTERN
     Reise ARKTIS I, 1983, by E. Augstein, et. al., Report
     on Polar Research no. 17, Alfred Wegener Institute for
     Polar Research, Bremerhaven, Federal Republic of Germany

B)   MIZEX '83 Whitecap Observation Log (E.C. Monahan)

C)   Results from Analyses of MIZEX '83 whitecap film records
     (analysts; M.R. Higgins, T. Luibheid, S. MacGearain, and
     C. Maloney: computations, M.R. Higgins and D.M. Doyle)

D)   Preliminary Results from Analyses of MIZEX '83 whitecap
     video records (analyst: N.E. Monahan)

E)   Whitecap Observations and Associated Measurements during
     MIZEX '83 (E.C. Monahan) and

F)   MIZEX '84 Preliminary Whitecap Observation Log (E.C. Monahan
     and P.A. Bowyer).

We find that the results obtained from analysing the 1983 MIZEX
whitecap films (see Figure 2.1) differ from the results obtained
previously in various oceans in the manner suggested in Appendix
B.   From Figure 2.2 we conclude tentatively that the results
obtained from the video records are in general consistent with
the results obtained from the traditional film records.

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1.2.5 Whitecap observations (UCG)

Images of the sea surface are recorded on 114 occasions during this cruise. The 55 photographic observation intervals, encompassing a total of 1042 photographs taken with a Beattie Varitron automatic sequence camera, are divided into 44 whitecap observation intervals and 11 ice coverage observation intervals. The 59 video observations, recorded on some 250 minutes of video tape by means of a colour video camera and a portable videocassette recorder, include 53 whitecap coverage (W) observation intervals and 6 intervals devoted to recording the decay of a sequence of individual whitecaps. At least 3 of the whitecap observation interval tape segments can also be used to assess percentage ice coverage.

The images collected during this cruise will be particularly useful in widening our understanding of whitecapping, and for improving our related model of marine aerosol generation, in that not only do these whitecap observations cover (a) a wind speed (u) range of from less than 2 ms to greater than 14 ms, and (b) a great range in atmospheric stability T (water) $- T$ (air) varying from $-6.5°C$ to $+ 6.1°C$. But no less than 30 whitecap observation intervals have associated with them T (water) values less than or equal to $2°C$. Thus, these observations, when combined with our previous observations (e.g., BOMEX, JASIN, STREX) will provide the data base required to define a W (T(water) to T(air), T(water)) expression to superceed the previous $W(u)$ relation. Some 18 of the video whitecap coverage observation intervals are associated with the condition of ice floe fetch limitation, while 2 video intervals contain segments documenting bubble production via wave-floe interaction.

The 6 video recording segments devoted to the decay of individual whitecaps are obtained under a broad range of surface water temperatures T(water) between $10°$ and $-0.9°C$, and thus should provide insights into the T(water) - dependence of the time constant characterising whitecap decay. The latter expression along with the W ((u), T(water) $- T$(air), T(water)) relationship, are explicit terms in our sea surface aerosol generation model.

* Key: f: film observation for W determination, v: video observation for W determination, T: video observation for "tau" determination, g: film observation for % ice cover determination.

Whitecap Observation Interval	Date	Time (GMT)	Latitude	Longitude	Wind $U_{35.8}$	Wind U_{10}	Wind Direction Azimuth	T_{Air} °C	T_{Water} °C	Ships Speed Kts	Ships Direction Azimuth
580 f*	29/6/83	14:35-14:45	54°8'.45N	7°31'.60E	13.4	12.2	254/256	13.1	14.4	12.7	333.4
581 f	30/6/83	07:25-07:32	57°50'.20N	4°09'.33E	12.1	11.0	335/340	11.1	11.9	9.6	332.6
582 f	30/6/83	08:33-08:37	58°02'.02N	4°00'.08E	13.6	12.4	331/337	11.1	12.2	14.7	000.7
583 f	30/6/83	09:40-09:46	58°17'.91N	3°59'.92E	12.4	11.3	328/335	11.1	12.5	14.6	000.7
584 f	30/6/83	11:23-11:29	58°32'.00N	3°59'.95E	12.0	10.9	337/341	11.5	13.1	8.5	359.9
585 v	30/6/83	11:37-12:00	58°37'.71N	3°59'.95E	13.5	12.3	337/342	11.5	13.0	11.9	003.4
586 f	30/6/83	12:10-12:14	58°40'.16N	4°00'.05E	12.9	11.8	331/337	11.4	12.9	11.6	020.3
587 f	30/6/83	14:15-14:18	59°04'.83N	4°00'.78E	11.9	10.8	332/338	11.4	12.3	12.1	357.4
588 v	30/6/83	16:02-16:08	59°28'.03N	3°59'.87E	11.6	10.6	332/338	11.5	12.4	12.4	000.4
589 f	1/7/83	08:48-08:55	62°50'.33N	5°01'.97E	1.2	1.1	312/319	10.2	11.4	13.6	027.5
590 v	1/7/83	10:28-10:43	63°09'.76N	5°26'.25E	1.4	1.3	232/215	10.5	12.6	12.1	027.8
591 f	1/7/83	13:05-13:09	63°36'.97N	6°00'.84E	2.1	1.9	217/208	10.9	13.1	12.9	030.1
592 v	1/7/83	14:34-14:37	63°52'.78N	6°22'.18E	4.3	3.9	210/208	11.0	12.1	12.4	029.8
593 f	1/7/83	18:38-18:42	64°37'.05N	7°20'.49E	4.1	3.7	153/144	10.6	11.7	13.0	029.7
594 f	2/7/83	08:33-08:36	67°19'.26N	11°09'.22E	6.7	6.0	093/094	10.7	10.4	13.4	030.9

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Whitecap Observation Interval	Date	Time (GMT)	Latitude	Longitude	Wind $U_{35.8}$	Wind U_{10}	Wind Direction Azimuth	T_{Air} °C	T_{Water} °C	Ships Speed Kts	Ships Direction Azimuth
595 v	2/7/83	09:42-09:47	67°32'.85N	11°30'.70E	5.7	5.1	077/079	10.4	10.4	13.2	032.1
596 f	2/7/83	12:42-12:45	67°56'.55N	12°07'.21E	8.9	8.1	046/053	10.5	10.2	3.9	326.2
		Cruise 3, Station 1.									
597 v	2/7/83	13:07-13:12	67°58'.22N	12°10'.45E	9.1	8.3	047/052	10.5	10.1	2.5	050.2
		Cruise 3, Station 1.									
598 f	2/7/83	13:22-13:26	67°58'.45N	12°10'.59E	10.0	9.1	051/055	10.5	10.1	0.9	335.4
		Cruise 3, Station 1.									
599 T	2/7/83	13:35-13:58	67°59'.52N	12°09'.35E	11.4	10.4	054/057	10.7	10.0	7.0	040.8
		Cruise 3, Station 1.									
600 v	2/7/83	14:23-14:31	68°00.05N	12°10'.86E	11.4	10.4	056/064	10.6	9.8	0.0	000.0
		Cruise 3, Station 1.									
601 f	2/7/83	16:11-16:14	68°00'.53N	12°09'.48E	11.3	10.3	046/051	10.7	9.8	0.5	311.5
		Cruise 3, Station 1.									
602 f	3/7/83	08:12-08:16	70°30'.40N	19°04'.54E	13.3	12.1	115/118	14.7	8.8	13.3	051.9
603 f	3/7/83	09:23-09:27	70°40'.56N	19°43'.32E	12.4	11.3	117/120	15.7	8.8	13.5	052.9
604 v	3/7/83	09:45-09:52	70°44'.33N	19°57'.41E	13.8	12.6	131/133	15.5	9.0	13.2	052.0
605 f	3/7/83	11:17-11:22	70°56'.60N	20°40'.15E	10.7	9.7	100/103	16.0	9.5	12.8	047.7
606 f	3/7/83	14:35-14:39	71°21'.13N	22°25'.60E	15.3	14.0	132/135	13.3	9.0	13.4	076.8
607 f	3/7/83	17:20-17:24	71°28'.97N	24°18'.99E	3.6	3.3	097/103	17.3	9.2	13.7	079.4
608 f	3/7/83	19:02-19:08	71°32'.21N	25°04'.29E	5.1	4.6	106/109	12.4	9.2	0.2	350.0
		Cruise 3, Station 2.									
609 v	3/7/83	19:27-19:31	71°32'.34N	25°05'.01E	4.0	3.6	115/120	12.8	9.5	2.3	86.5
		Cruise 3, Station 2.									
610 f	3/7/83	23:27-23:31	72°02'.05N	24°03'.84E	4.3	3.9	148/152	11.3	8.5	0.1	300.6
		Cruise 3, Station 3.									
611 v	3/7/83	23:42-23:47	72°02'.04N	24°03'.78E	4.8	4.3	148/151	11.5	8.8	0.1	121.2
		Cruise 3, Station 3.									
612 f	4/7/83	03:31-03:35	72°26'.94N	23°12'.25E	1.3	1.2	247/241	11.7	8.4	0.7	330.8
		Cruise 3, Station 4.									(Heading 132.3)

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Whitecap Observation Interval	Date	Time (GMT)	Latitude	Longitude	Wind $U_{35.8}$	Wind U_{10}	Wind Direction Azimuth	T_{Air} °C	T_{Water} °C	Ships Speed Kts	Ships Direction Azimuth
613 f	4/7/83	03:55-04:01	72°29'.18N	23°08'.80E	3.8	3.4	253/251	12.2	8.9	10.0	330.2
614 f	4/7/83	07:47-07:52	73°00'.82N	21°59'.72E	5.5	4.9	259/263	10.0	8.8	0.1	240.3
		Cruise 3, Station 5.								(Heading 240.2)	
615 v	4/7/83	09:14-09:16	73°00'.78N	21°59'.72E	7.2	6.5	257/260	10.0	9.2	0.3	057.3
		Cruise 3, Station 5.								(Heading 240.5)	
616 v	4/7/83	10:54-10:58	73°02'.23N	21°53'.91E	7.5	6.8	253/254	9.2	8.3	10.7	329.1
617 v	4/7/83	14:18-14:23	73°34'.57N	20°45'.23E	6.5	5.8	240/245	7.3	7.8	0.6	270.4
		Cruise 3, Station 6.								(Heading 250.3)	
618 f	4/7/83	17:50-17:54	73°44'.70N	20°28'.28E	5.9	5.3	261/264	7.2	7.1	0.8	085.4
		Cruise 3, Station 7.								(Heading 254.2)	
619 v	4/7/83	18:12-18:14	73°44'.89N	20°29'.54E	5.5	4.9	255/259	7.6	7.9	1.2	66.8
		Cruise 3, Station 7								(Heading 282.4)	
620 v	4/7/83	19:55-19:58	73°51'.94N	20°11'.88E	6.5	5.8	241/245	7.1	7.2	1.9	88.4
		Cruise 3, Station 8								(Heading 234.9)	
621 v	4/7/83	22:40-22:45	74°06'.80N	19°35'.52E	8.1	7.3	221/226	6.5	2.9	0.6	135.4
		Cruise 3, Station 9								(Heading 225.4)	
622 v	5/7/83	08:44-08:47	75°36'.67N	17°33'.55E	4.5	4.1	165/170	5.3	2.9	1.2	161.4
		Cruise 3, Station 12.								(Heading 174.5)	
623 v	5/7/83	10:55-11:02	75°36'.43N	17°33'.14E	5.9	5.3	157/151	4.7	3.1	0.2	211.9
		Cruise 3, Station 12.								(Heading 010.2)	
624 f	5/7/83	15:07-15:13	76°00'.25N	17°10'.72E	7.5	6.8	144/155	4.1	5.2	0.5	348.9
		Cruise 3, Station 13.								(Heading 79.0)	
625 f	5/7/83	20:25-20:30	76°35'.80N	14°57'.66E	10.5	9.6	126/130	4.0	3.9	15.7	310.8
626 v	5/7/83	23:02-23:08	77°00'.89N	12°37'.20E	11.1	10.1	125/125	6.1	6.8	15.4	308.2
627 f	6/7/83	08:09-08:13	78°59'.58N	8°09'.86E	13.8	12.6	134/147	5.1	5.4	14.8	354.9
628 v	6/7/83	08:50-08:57	79°08'.59N	8°09'.09E	13.3	12.1	140/147	5.3	5.5	14.7	357.2
629 v	6/7/83	09:05-09:25	79°17'.53N	8°02'.12E	11.7	10.7	141/153	5.3	5.3	14.6	355.4
630 f	6/7/83	09:37-09:41	79°21'.16N	8°00'.56E	11.8	10.7	139/153	5.4	5.4	16.0	355.2
631 f	6/7/83	11:06-11:10	79°41'.05N	7°54'.52E	10.9	9.9	155/153	5.1	4.2	12.4	356.2

Whitecap Observation Interval	Date	Time (GMT)	Latitude	Longitude	Wind $U_{35.8}$	Wind U_{10}	Wind Direction Azimuth	T_{Air} °C	T_{Water} °C	Ships Speed Kts	Ships Direction Azimuth
632 f	6/7/83	13:07-13:11	80°06',17N	7°49',17E	8.7	7.9	165/165	4.8	4.7	13.0	358.2
633 v	6/7/83	13:44-13:48	80°13'.92N	7°50',62E	7.8	7.0	157/167	5.0	5.0	13.6	355.9
634 v	6/7/83	15:24-15:31	80°35'.88N	7°42'.26E	7.4	6.7	153/167	4.1	2.3	11.4	357.7
635 f	6/7/83	15:51-15:55	80°41'.01N	7°42'.19E	6.9	6.2	165/164	4.0	1.6	9.5	355.5
		Just before Station 15 of Cruise 3.									
636 f	6/7/83	16:46-16:50	80°43',29N	7°39'.12E	5.6	5.0	167/166	3.6	1.7	11.8	345.0
		Just after Station 03/15.									
637 f	6/7/83	18:22-18:26	80°53'.38N	7°25',48E	8.2	7.4	166/158	3.2	1.4	0.1	231.8
		Station 03/16								(Heading 348.4)	
638 v	6/7/83	18:44-18:49	80°54'.28N	7°23'.41E	7.8	7.0	159/157	2.8	1.3	12.0	345.5
		Station 03/16 just ending									
		Entering the Marginal Ice Zone									
639 f	6/7/83	19:53-19:57	80°59'.82N	7°19'.09E	8.0	7.2	149/159	2.3	-0.5	0.5	284.9
										(Heading 83.9)	
640 v	6/7/83	21:00-21:11	81°04'.15N	7°12'.69E	8.6	7.8	160/158	2.3	-0.7	7.3	347.6
641 f	8/7/83	12:36-12:42	80°56'.29N	5°44'.27E	7.0	6.3	218/221	0.4	-1.4	0.2	193.5
		Station 03/24 on Ice Edge								(Heading 190.5)	
642 v	8/7/83	12:55-13:02	80°56'.41N	5°45'.13E	6.9	6.2	214/216	0.2	-1.3	0.1	239.6
		Station 03/24								(Heading 190.2)	
643 T	8/7/83	13:13-13:36	80°56'.38N	5°45'.31E	4.3	3.9	218/223	0.3	-1.1	0.1	215.6
		Station 03/24								(Heading 190.2)	
644 f	8/7/83	14:29-14:33	80°56'.24N	5°45'.33E	1.7	1.5	191/197	0.7	-1.1	0.1	169.4
		Station 03/24								(Heading 189.4)	
645 f	8/7/83	16:17-16:21	80°54'.42N	5°45'.71E	3.7	3.4	098/104	0.5	1.8	0.1	57.3
		Station 03/25								(Heading 35.7)	
646 f	8/7/83	18:56-19:03	80°52'.75N	5°44'.37E	5.4	4.9	165/163	2.1	2.0	0.3	330.5
		Station 03/26								(Heading 50.8)	
647 v	8/7/83	19:12-19:17	80°52'.73N	5°44'.54E	5.1	4.6	161/162	2.3	2.0	1.8	106.2
		Station 03/26 just ending								(Heading just got underway)	
648 v	8/7/83	20:35-20;39	80°51'.54N	5°45'.38E	5.2	4.7	137/142	2.6	1.6	0.4	311.6
		Station 03/27								(Heading 045.7)	

Whitecap Observation Interval	Date	Time (GMT)	Latitude	Longitude	Wind $U_{35.8}$	Wind U_{10}	Wind Direction Azimuth	T_{Air} °C	T_{Water} °C	Ships Speed Kts	Ships Direction Azimuth
649 v	9/7/83	08:23-08:27	80°31'.79N	5°38'.88E	9.4	8.6	178/182	3.5	3.2	2.3	232.1
		Station 03/30 just ended.								(ship has been heading ~180)	
650 v	9/7/83	11.02-11:09	80°13'.07N	3°44'.75E	8.3	7.5	168/170	3.6	0.1	12.4	223.6
651 v	9/7/83	13:35-13:46	79°58'.76N	2°21'.55E	5.8	5.2	153/157	2.4	-0.7	3.4	192.9
652 v	9/7/83	17:02-17:06	79°54'.29N	1°50'.94E	3.2	2.9	096/087	2.8	0.6	1.2	157.5
	NB. For at least part of 652, I was looking over lee rail.										
653 v	9/7/83	18:19-18:23	79°54'.37N	1°48'.93E	3.5	3.2	044/039	2.9	0.1	0.1	029.1
		Station 03/31								(Heading 050.3)	
654 v	9/7/83	21:32-21:35 21:42-21:47	79°53'.04N	2°28'.34E	6.4	5.7	011/016	1.6	-0.6	3.8	108.5
										(Heading 176.8)	
655 v	9/7/83	23:23-23:28	79°56'.06N	3°10'.97E	8.7	7.9	007/014	3.6	5.5	9.7	047.1
656 f	9/7/83	23:54-23:58	79°58'.78N	3°27'.58E	10.1	9.2	007/012	3.3	5.5	7.9	046.7
657 v	10/7/83	10:10-10:13	79°53'.87N	1°58'.80E	10.3	9.4	334/332	-0.8	0.5	0.3	279.1
		Moored to Ice Floe.									
658 v	10/7/83	15:16-15:23	79°50'.90N	1°54'.52E	11.8	10.7	314/319	0.6	0.5	1.0	182.0
		Station 03/33								(Heading 92.1)	
659 v	10/7/83	21:15-21:17	79°47'.32N	1°52'.22E	9.7	8.8	297/302	0.6	0.1	0.4	180.0
		Station 03/33								(Heading 339.3)	
660 g	11/7/83	09:50-09:55	79°44'.91N	2°00'.58E	5.9	5.3	263/278	0.7	0.3	0.3	83.9
		Station 03/34								(Heading 350.8)	
661 v	11/7/83	11:06-11:09	79°41'.57N	1°58'.76E	6.2	5.6	247/251	0.6	0.1	0.4	274.8
		Station 03/34								(Heading 198.4)	
662 g	11/7/83	13:00-14:00	79°42'.53N	2°07'.11E	5.9	5.3	235/240	0.9	0.1	0.9	046.5
		Station 03/34								(Heading 263.9)	
663 v	11/7/83	15:04-15:09	79°41'.07N	2°10'.88E	8.1	7.3	244/252	0.9	0.3	1.5	145.9
		Station 03/34								(Heading 190.7)	
664 g	11/7/83	16:19-16:29	79°41'.08N	2°15'.61E	6.5	5.8	242/249	0.9	0.0	0.8	119.5
		Station 03/34								(Heading 185.5)	
										(Heading 171.5)	

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Whitecap Observation Interval	Date	Time (GMT)	Latitude	Longitude	Wind $U_{35.8}$	Wind U_{10}	Wind Direction Azimuth	T_{Air} °C	T_{Water} °C	Ships Speed Kts	Ships Direction Azimuth
665 g	11/7/83	17:01-17:11	79°40'.63N	2°18'.60E	6.5	5.8	229/233	0.8	0.5	1.2	160.7
		Station 03/34									
666 g	11/7/83	20:33-20:42	79°39'.74N	2°21'.52E	5.9	5.3	205/210	1.0	0.3	(Heading 211.5) 0.8	125.4
		Station 03/35									
667 v	12/7/83	08:06-08:59	79°38'.62N	2°45'.27E	6.5	5.8	198/203	-1.2	0.9	(Heading 334.9) 0.6	041.6
		Station 03/37									
668 v	12/7/83	12:10-12:19	79°38'.40N	3°24'.57E	5.5	4.9	245/252	-0.7	3.4	(Heading 208.9) 9.9	089.2
669 v	12/7/83	12:33-12:44	79°38'.36	3°38'.18E	5.8	5.2	226/234	-0.4	5.1	3.7	090.0
670 v	12/7/83	13:08-13:13	79°38'.52N	3°42'.13E	7.1	6.4	233/227	-1.1	5.0	1.6	065.0
		Station 03/38									
671 f	12/7/83	13:21-13:25	79°38'.85N	3°47'.45E	5.2	4.7	224/224	-1.0	5.0	(Heading 089.3) 3.2	079.5
672 T	12/7/83	13:40-14:00	79°39'.07N	3°50.92E	5.3	4.8	224/219	-0.8	5.0	(Heading 091.8) 0.4	021.0
		Station 03/39									
673 v	12/7/83	15:53-15:58	79°39'.59N	3°45'.91E	6.6	5.9	226/231	-1.3	5.1	(Heading 88.8) 0.9	265.3
		Station 03/41									
674 T	12/7/83	16:12-16:25	79°39'.54N	3°43'.87E	5.9	5.3	217/222	-1.5	4.6	(Heading 268.4) 0.6	070.2
		Station 03/42									
675 v	13/7/83	12:45-12:48	79°19'.28N	3°36'.61E	2.4	2.2	260/264	-1.2	3.0	(Heading 276.4) 0.5	068.7
		Station 03/59									
676 g	13/7/83	14:02-14:31	79°19'.38N	2°35'.09E	2.4	2.2	249/259	-1.3	0.8	(Heading 099.3) 6.5	269.1
					Every Minute for 30 minutes						
677 g	13/7/83	14:50-15:04	79°19'.12N	2°18'.26E	2.4	2.2	260/272	-1.1	-0.2	5.0	272.0
					Every Minute for 15 minutes.						
678 g	13/7/83	18:52-19:01	79°15'.39N	0°41.30E	1.7	1.5	282/279	-0.6	-0.3	0.7	118.2
679 g	14/7/83	10:49-11:09	79°03'.35N	4°59'.66W	5.2	4.7	329/334	-0.2	0.0	5.4	222.9
					Every Minute for 20 minutes.						
680 g	14/7/83	22:27-22:42	79°35'.07N	7°40'.66W	7.1	6.4	208/210	-0.1	-0.1	5.1	280.0
					Every Minute for 15 minutes.						

Whitecap Observation Interval	Date	Time (GMT)	Latitude	Longitude	Wind $U_{35.8}$	Wind U_{10}	Wind Direction Azimuth	T_{Air} °C	T_{Water} °C	Ships Speed Kts	Ships Direction Azimuth
681 g	15/7/83	12:58-13:08	79°48'.52N	11°04'.33W	9.9	9.0	013/016	-0.8	-0.1	10.7	061.3
682 v	16/7/83	14:16-14:18	79°43'.95N	3°29'.28W	12.0	10.9	015/017	-0.3	-0.7	11.6	118.0
683 v	16/7/83	16:02-16:06	79°49'.55N	3°12'.75W	13.6	12.4	007/013	-0.1	-1.2	10.3	106.9
684 v	16/7/83	20:04-20:09	79°49'.55N	3°16'.49W	13.2	12.0	355/360	-0.5	-1.1	5.5	358.9
685 v	17/7/83	08:18-08:23	79°45'.03N	1°09'.11W	15.7	14.3	355/004	-2.0	-1.8	0.5 (Heading 290.1)	307.9
686 v	17/7/83	15:07-15:12	79°45'.21N Station 03/67A	0°03'.55E	9.2	8.4	326/330	-1.3	-1.1	0.8 (Heading 222.7)	218.0
687 T	17/7/83	15:24-15:36	79°44'.38N Station 03/67A	0°02'.83E	9.8	8.9	326/328	-0.9	-1.0	1.4 (Heading 217.3)	195.8
688 v	17/7/83	19:00-19:05	79°45'.13N Station 03/67	0°39'.75E	8.6	7.8	312/314	-1.3	-0.1	0.5 (Heading 290.1)	188.9)
689 f	18/7/83	08:50-08:55	79°46'.45N Station 03/69	3°59'.16E	5.7	5.1	002/010	1.0	4.6	1.3 (Heading 300.4)	069.3
690 v	18/7/83	09:16-09:22	79°45'.64N	4°21'.76E	7.2	6.5	006/004	0.8	4.5	16.4	099.1
691 f	18/7/83	10:37-10:45	79°43'.02N Station 03/70	5°21'.59E	4.4	4.0	005/011	1.3	5.4	2.1 (Heading 280.5)	163.0
692 f	18/7/83	12:16-12:21	79°43'.66N Station 03/70	5°16'.77E	5.2	4.7	008/015	1.1	5.3	0.5 (Heading 280.7)	245.6
693 v	18/7/83	14:27-14:33	79°43'.92N Station 03/70	5°11.08E	4.6	4.2	028/038	1.1	5.4	1.0 (Heading 299.0)	286.5

Every Minute for 10 minutes.

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MISEX'83 film

| Obs #	Date m/d	Time GMT	# of frames analysed	U10 m/s	Ta °C	Tw °C	ΔT °C	TS	W	Std. dev.
580	6/29	1445	10,10,10,10	12.2	13.1	14.4	1.3	U	0.0027	0.00131
581	6/30	0732	9, 9, 9, 9	11.0	11.1	11.9	0.8	U	0.0022	0.00122
582	6/30	0837	11, 9,11, 9	12.4	11.1	12.2	1.1	U	0.0014	0.00193
583	6/30	0946	10,10,10,10	11.3	11.1	12.5	1.4	U	0.0036	0.00204
584	6/30	1129	10,10,10,10	10.9	11.5	13.1	1.6	U	0.0040	0.00445
586	6/30	1214	9, 9, 9, 9	11.8	11.4	12.9	1.5	U	0.0040	0.00216
587	6/30	1418	10,10,10	10.8	11.4	12.3	0.9	U	0.0050	0.00187
589	7/01	0855	10, 5, 5	1.1	10.2	11.4	1.2	U	0.0000	0.0000
591	7/01	1309	5, 5, 5	1.9	10.9	13.1	2.2	U	0.0000	0.0000
593	7/01	1842	5, 5, 5	3.7	10.6	11.7	1.1	U	0.0000	0.0000
594	7/02	0836	9, 5, 5	6.0	10.7	10.4	-0.3	N	0.0000	0.0000
596	7/02	1245	9, 9, 9, 9	8.1	10.5	10.2	-0.3	N	0.0016	0.00109
598	7/02	1326	8, 8, 8	9.1	10.5	10.1	-0.4	S	0.0046	0.00200
601	7/02	1614	9, 9, 9, 9	10.3	10.7	9.8	-0.9	S	0.0021	0.00070
602	7/02	0816	5, 5, 5	12.1	14.7	3.8	-5.9	S	0.0000	0.0000
603	7/03	0927	9, 9, 9	11.3	15.7	8.8	-6.9	S	0.0001	0.00021
605	7/03	1122	5,10,10	9.7	16.0	9.5	-6.5	S	0.0001	0.00011
606	7/03	1439	9, 9, 9	14.0	13.3	9.0	-4.3	S	0.0004	0.00041
607	7/03	1724	5, 5, 5	3.3	17.3	9.2	-8.1	S	0.0000	0.0000
608	7/03	1903	5, 5, 5	4.6	12.4	9.2	-3.2	S	0.0000	0.0000
610	7/03	2331	5, 5, 5	3.9	11.3	8.5	-2.6	S	0.0000	0.0000
612	7/04	0335	5, 5, 5	1.2	11.7	8.4	-3.3	S	0.0000	0.0000
613	7/04	0401	5, 5, 5	3.4	12.2	8.9	-3.3	S	0.0000	0.0000
614	7/04	0752	5, 5, 5	4.9	10.0	8.8	-1.2	S	0.0000	0.0000
618	7/04	1754	5, 5, 5	5.3	7.2	7.1	-0.1	N	0.0000	0.0000
624	7/05	1513	5, 5, 5	6.8	4.1	5.2	1.1	U	0.0000	0.0000
625	7/05	2030	3, 8, 8	9.6	4.0	3.9	-0.1	N	0.0003	0.0003
627	7/06	0813	8, 8, 8	12.6	5.1	5.4	0.3	N	0.0083	0.0050
630	7/06	0941	10,10,10,10	10.7	5.4	5.4	0.0	N	0.0036	0.00206
631	7/06	1110	9, 9, 9	9.9	5.1	4.2	-0.9	S	0.0026	0.00087
632	7/06	1311	10,10,10	7.9	4.8	4.7	-0.1	N	0.0005	0.00058
635	7/06	1555	5, 5, 5	6.2	4.0	1.6	-2.4	S	0.0000	0.0000
636	7/06	1650	5, 5, 5	5.0	3.6	1.7	-1.9	S	0.0000	0.0000
637	7/06	1826	5, 5, 5	7.4	3.2	1.4	-1.8	S	0.0000	0.0000
641	7/08	1242	20, 5, 5	6.3	0.4	-1.4	-1.8	S	0.0000	0.0000
644	7/08	1433	9, 5, 5	1.5	0.7	-1.1	-1.8	S	0.0000	0.0000
645	7/08	1621	5, 5, 5	3.4	0.5	1.8	1.3	U	0.0000	0.0000
646	7/08	1903	5, 5, 5	4.9	2.1	2.0	-0.1	N	0.0000	0.0000
656	7/09	2358	5, 5, 5	9.2	3.3	5.5	2.2	U	0.0000	0.0000
671	7/12	1325	10,10,10	4.7	-1.0	5.0	6.0	U	0.0002	0.00029
689	7/18	0855	9, 9, 9	5.1	1.0	4.6	3.6	U	0.0002	0.00020
691	7/18	1045	5, 5, 5	4.0	1.3	5.4	2.1	U	0.0000	0.0000
692	7/18	1221	7, 7, 7	4.7	1.1	5.3	4.2	U	0.0002	0.00021

Obs # is the observation interval number.
U_{10} is the 10m elevation wind speed.
T_a and T_w are the air and sea surface temperatures
respectively. $\Delta T = T_w - T_a$
TS is the thermal stability, U : unstable, N : neutral,
S : stable. Near neutral defined as $-0.4 < \Delta T < 0.6$ C
W is the fractional whitecap coverage.

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MIZEX '83

——	MIZEX
—·—	ONR, 5
—— —	O'M+M '83

W

$U_{ms^{-1}}$

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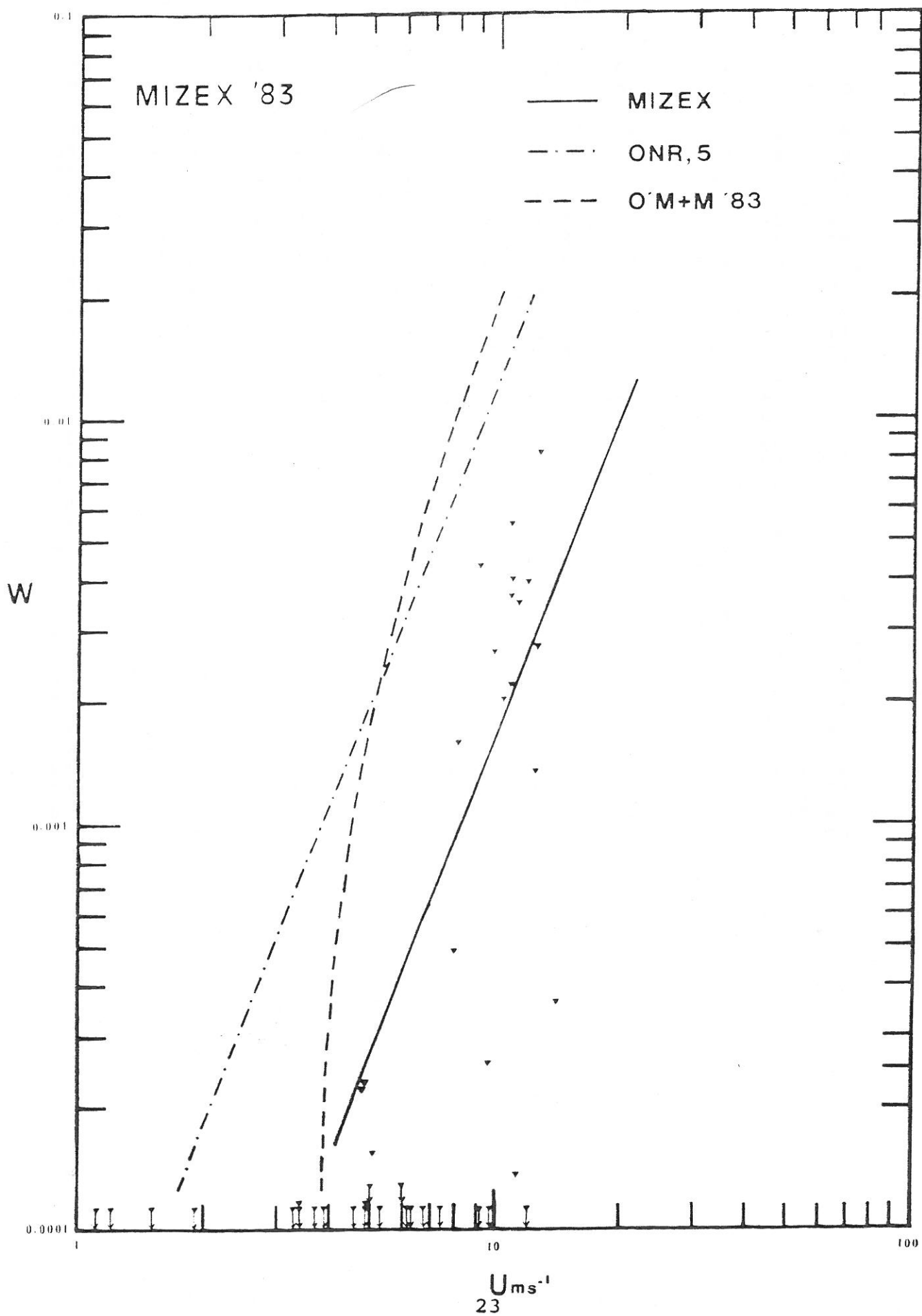
Preliminary MIZEX 83 Whitecap (Video) Results

Obs No.	Date m/d	Time GMT	No. of frames *	U_{10} m/s	T_a °C	T_w °C	ΔT °C	TS	W	Std. Dev.
585	6/30	1137	3	12.3√	11.5	13.0	1.5	U	0.0011	0.0005
588	6/30	1602	30	10.6√	11.5	12.4	0.9	U	0.0004	0.0005
590	7/01	1082	18	1.3√	10.5	12.6	2.1	U	0.0000	0.0000
592	7/01	1434	17	3.9√	11.0	12.1	1.1	U	0.0000	0.0000
595	7/02	0942	27	5.1√	10.4	10.4	0.0	N	0.0000	0.0000
597	7/02	1307	26	8.3√	10.5	10.1	-0.4	S	0.0003	0.0002
600	7/02	1423	44	10.4√	10.6	9.8	-0.8	S	0.0015	0.0011
604	7/03	0945	42	12.6√	15.5	9.0	-6.5	S	0.0000	0.0001
609	7/03	1927	24	3.6√	12.8	9.5	-3.3	S	0.0000	0.0000
611	7/03	2342	29	4.3√	11.5	8.8	-2.7	S	0.0000	0.0000
615	7/04	0914	16	6.5√	10.0	9.2	-0.8	S	0.0000	0.0000
616	7/04	1554	18	6.8√	9.2	8.3	-0.9	S	0.0000	0.0000
617	7/04	1418	21	5.8√	7.3	7.8	0.5	N	0.0001	0.0001
619	7/04	1812	15	4.9√	7.6	7.9	0.3	N	0.0000	0.0000
620	7/04	1955	22	5.8√	7.1	7.2	0.1	N	0.0001	0.0002
621	7/04	2240	21	7.3√	6.5	2.9	-3.6	S	0.0000	0.0000
622	7/05	0844	21	4.1√	5.3	2.9	-2.4	S	0.0000	0.0000
623	7/05	1055	17	5.3√	4.7	3.1	-1.6	S	0.0000	0.0000
626	7/05	2302	32	10.1√	6.1	6.8	0.7	U	0.0008	0.0013
628	7/06	0850	31	12.1√	5.3	5.5	0.2	N	0.0048	0.0084
633	7/06	1344	26	7.0√	5.0	5.0	0.0	N	0.0001	0.0002
634	7/06	1524	41	6.7√	4.1	2.3	-1.8	S	0.0000	0.0000
638	7/06	1844	29	7.0√	2.8	1.3	-1.5	S	0.0000	0.0000
642	7/08	1255	41	6.2√	0.2	-1.3	-1.5	S	0.0002	0.0003
647	7/08	1912	25	4.6√	2.3	2.0	-0.3	N	0.0000	0.0000
648	7/08	2035	12	4.7√	2.6	1.6	-1.0	S	0.0000	0.0000
649	7/09	0823	15	8.6√	3.5	3.2	-0.3	N	0.0000	0.0000
650	7/09	1102	32	7.5√	3.6	0.1	-3.5	S	0.0000	0.0000
655	7/09	2323	29	7.9√	3.6	5.5	1.9	U	0.0004	0.0008
657	7/10	1010	19	9.4√	-0.8	0.5	1.3	U	0.0000	0.0000
658	7/10	1516	18	10.7√	0.6	0.5	-0.1	N	0.0000	0.0000
659	7/10	2115	14	8.8√	0.6	0.1	-0.5	S	0.0000	0.0000
667	7/12	0806	13	5.8√	-1.2	0.9	2.1	U	0.0000	0.0000

* Stop-Frames along video tape (10 second intervals)

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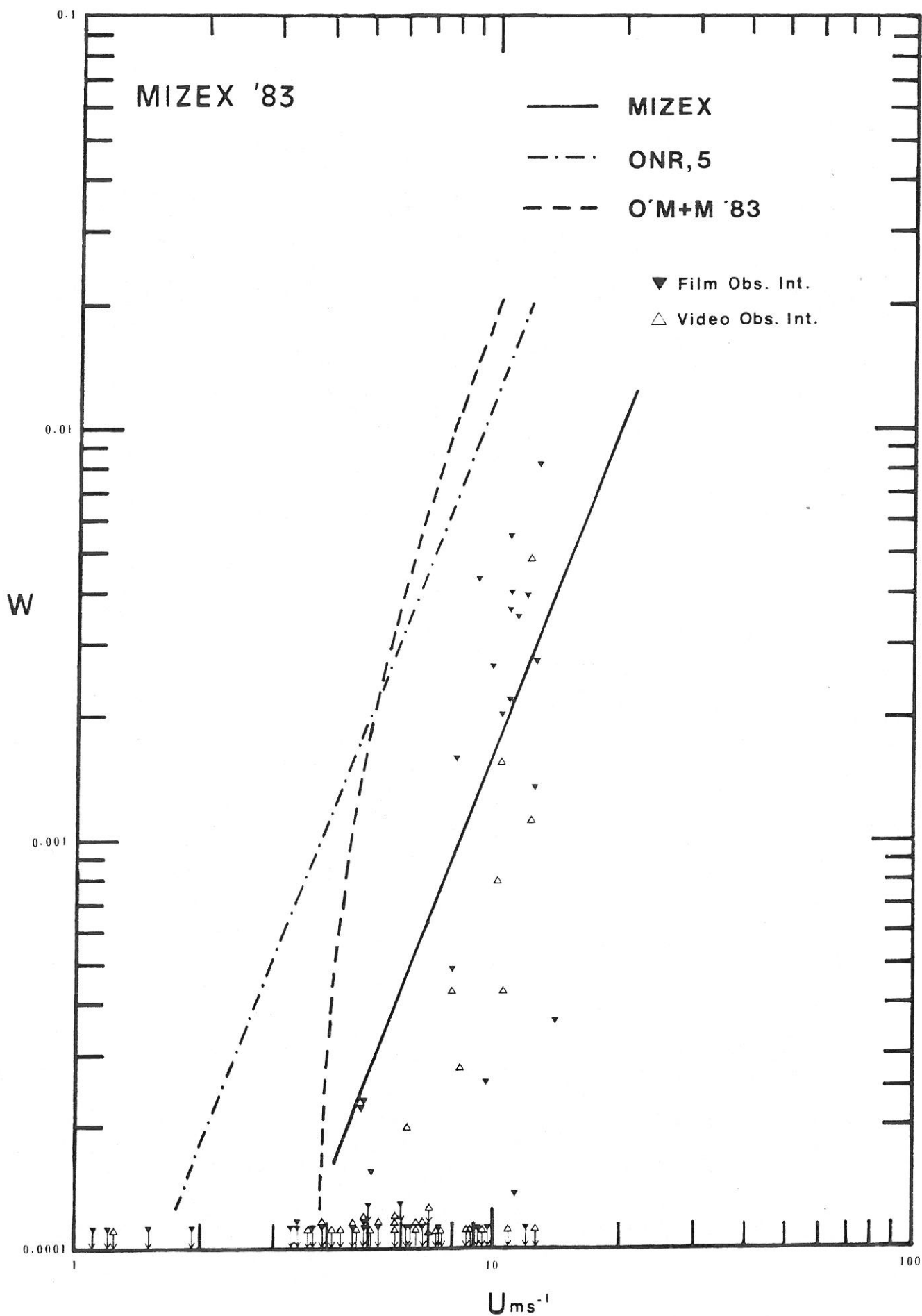
WHITECAP OBSERVATIONS AND ASSOCIATED
MEASUREMENTS DURING MIZEX 84

Edward C. Monahan

During MIZEX 84 we carried out whitecap observations aboard the HAAKON MOSBY, while aboard the same vessel the NPS, Monterey, group took detailed aerosol measurements, recorded a complete suite of meteorological variables, and used an acoustic sounder and radiosondes to characterise the structure of the MABL. On this ship P. Bowyer of U.C.G. measured the aerosol-related electrostatic space charge concentration. In this manner the essential data needed to test recent models of the aerosol budget of the MABL (those incorporating an explicit aerosol production-via-white-caps term and an inversion sink term) were collected.

A small stainless-steel instrument shelter, equipped with window and heater, was mounted above the starboard wing of the bridge, thus providing a suitably elevated site for the U.C.G. video- and film cameras dedicated to recording large areas of the sea surface. These films and tapes will be used, as in the past, to determine the fraction of the sea surface covered by foam patches, W. W, which has long been known to depend on wind speed (U) and on the stability of the lower atmosphere (associated with the air-water temperature difference), appears, from the initial analyses of the MIZEX 83 films and tapes, to be also markedly affected by variations in sea surface temperature. It is

hypothesised that this is a consequence of the fact that the whitecap bubble spectrum alters with changes in water temperature, and the decay time of individual whitecaps alters with changes in bubble spectrum.

A second, portable (shoulder-mounted), video camera was used from deck level to record the decay of individual foam patches, bubble production via ice floe-wave interaction (a candidate mechanism for significant bubble, and hence aerosol, generation in the MIZ), and windrows.

By 27 June, the date the P.I. transferred to the KVITBJORN, 44 film observations, and 88 video observations, for the purpose of determining W had been recorded. A further 7 tape segments had been devoted to recording the decay of individual whitecaps, bubble production around ice floes, and windrows. The distribution of these observations with wind speed is shown in the histogram of Figure 1.

P. Bowyer, using an Obolenski filter and a foot pump above the bridge, measured the concentration of space charge on more than 130 occasions, and subsequent to 27 June obtained several dozen additional film records of the sea surface for W-determination. Setting aside the complications caused by fog, fetch limitation, etc., a correlation is apparent between

wind speed (U), the number of
jet-drop aerosols, and the
concentration of space charge.
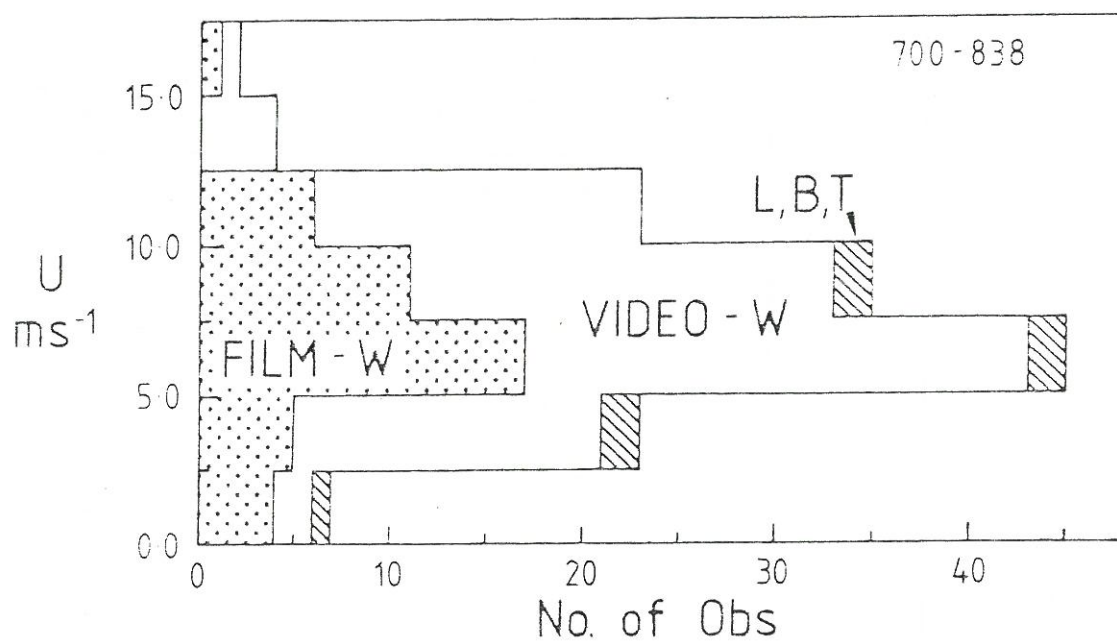
Key: v:video ob.for W determination
f:film ob. for W determination
T:video ob. for "Tau" determination
L:video ob. of windrows,
B:video ob.of bubbles from wave-floe interactions

Whitecap Observation Interval	Date	Time (GMT)	Latitude	Longitude	Wind ms⁻¹ U_{14}	Wind ms⁻¹ U_{AA}	Wind Direction Azimuth	T_{air} °C	T_{water} °C	Ship's Speed ms⁻¹	Ship's Direction Azimuth
v 700 v	13/6/84	12:37-12:41	64°17.4N (64.19)	7°48.7E (7.81)	--	6.0	057M	9.5	--	6.1	031M
v 701 f	13/6/84	12:55-12:57	64°20.0N (64.33)	7°53.0E (7.88)	--	6.8	059M	7.6	--	6.1	031M
v 702 v	13/6/84	14:44-14:48	64°37.7N (64.63)	8°21.0E (8.35)	--	6.9	057M	9.6	--	6.0	023M
703 f	13/6/84	15:00-15:02	64°39.9N	8°24.3E	--	6.7	054M	9.5	--	5.9	030M
v 704 v	13/6/84	17:20-17:24	65°02.7N (65.05)	9°01.4E (9.02)	--	7.6	062M	9.9	--	6.0	031M
v 705 v	13/6/84	20:14-20:18	65°31.3N (65.52)	9°50.9E (9.85)	--	6.3	049M	9.6	--	5.9	031M
706 v	14/6/84	13:50-13:53	68°14.1N	15°39.3E	--	4.9	237M	13.1	--	6.2	055T
707 v	15/6/84	10:00-10:03	70°42.1N (70.7)	19°44.5E (19.77)	--	7.6	211M	8.1	--	6.1	348T
708 v	15/6/84	12:00-12:03	71°05.3N (71.09)	19°27.9E (19.42)	8.5	7.8	291T	6.53	7.45	6.14	355T
709 f	15/6/84	13:02-13:04	71°17.3N	19°20.1E	8.32	--	287T	6.27	7.15	6.12	355T
710 v	15/6/84	14:27-14:30	71°33.9N (71.57)	19°11.1E (19.19)	7.19	--	275T	6.08	6.19	5.84	355T
711 v	15/6/84	16:02-16:05	71°51.3N (71.86)	18°56.6E (18.94)	6.58	--	283T	6.43	6.85	5.74	355T
712 f	15/6/84	18:01-18:03	72°12.5N	18°36.6E	5.42	--	277T	6.07	6.55	6.09	355T
713 f	16/6/84	09:39-09:41	75°04.9N	16°00.1E	6.45	--	287T	5.16	5.61	6.07	355T
714 v	16/6/84	12:33-12:36	75°36.0N	15°12.2E	6.74	--	266T	4.08	4.16	6.08	355T
715 f	16/6/84	14:31-14:33	75°58.3N	14°49.9E	5.88	--	293T	3.74	4.68	6.05	355T
716 v	16/6/84	16:31-16:34	76°23.1N	14°29.6E	8.19	--	303T	3.40	5.53	5.96	353T
717 v	16/6/84	18:31-18:34	76°42.8N	13°45.1E	8.50	--	297T	3.20	3.91	5.88	353T
718 v	17/6/84	14:58-15:03	79°24.8N (79.41)	8°56.8E (8.95)	5.67	--	241T	-0.50	1.76	5.76	326T

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Whitecap Observation Interval	Date	Time (GMT)	Latitude	Longitude	Wind ms⁻¹ U_{14}	Wind ms⁻¹ U_{AA}	Wind Direction Azimuth	T_{air} °C	T_{water} °C	Ship's Speed ms⁻¹	Ship's Direction Azimuth
719 f	17/6/84	18:42–18:44	79°47.3N	5°52.9E	6.63	--	232T	-2.09	2.46	5.75	313T
✓ 720 v	17/6/84	21:02–21:05	79°45.2N	6°14.8E	5.72	--	256T	-1.62	3.09	2.05	051T
721 v	18/6/84	05:54–05:58	79°51.0N	5°06.4E	4.61	--	254T	-4.16	0.69	0.04	178T
722 f	18/6/84	08:28–08:32	79°53.6N	4°09.1E	2.55	--	277T	-3.40	0.73	0.27	191T
723 v	18/6/84	08:47–08:50	79°53.3N	4°08.9E	2.65	--	240T	-2.67	0.71	0.12	166T
724 v	18/6/84	10:33–10:36	79°52.9N	4°09.3E	3.03	--	254T	-2.51	0.72	0.09	176T
725 f	18/6/84	11:54–11:56	79°52.9N	4°09.6E	2.97	--	186T	-2.54	0.78	0.05	126T
726 v	18/6/84	13:56–13:59	79°50.8N	4°26.9E	5.00	3.8	229T	-2.29	0.68	1.29	158T
727 f	18/6/84	16:30–16:33	79°44.0N	5°26.6E	2.38	--	263T	-1.89	2.24	0.75	195T
728 v	18/6/84	18:14–18:17	79°38.2N	4°51.8E	5.18	3.1	274T	-1.96	3.87	3.31	208T
729 v	18/6/84	20:58–21:03	79°34.0N	4°58.7E	2.32	1.4	279T	-1.73	3.78	1.30	208T
✓ 730 f	19/6/84	06:17–06:19	79°54.5N	5°25.8E	8.88	9.3	049T	-1.23	0.84	2.00	015T
✓ 731 v	19/6/84	07:21–07:26	79°56.4N	6°10.1E	9.93	9.0	015T	-1.59	2.54	4.96	084T
✓ 732 v	19/6/84	08:01–08:05	79°55.6N	6°13.7E	7.78	6.5	029T	-1.71	2.45	2.23	076T
733 L	19/6/94	08:17–08:20	79°55.0N	6°19.7E	7.78	--	029T	-1.71	2.45	8.20	149T
✓ 734 f	19/6/84	08:35–08:40	79°53.8N	6°19.0E	8.72	--	031T	-1.75	2.27	0.88	053T
✓ 735 v	19/6/84	09:56–10:00	79°48.1N	6°34.7E	8.78	7.4	060T	-0.55	1.92	0.50	051T
✓ 736 v	19/6/84	11:32–11:36	79°40.4N	7°00.7E	10.0	12.1	057T	-0.13	2.44	1.39	065T
✓ 737 f	19/6/84	11:44–11:46	79°40.2N	6°59.8E	10.0	12.1	057T	-0.13	2.44	1.39	065T
✓ 738 v	19/6/84	12:51–12:55	79°36.0N	7°10.4E	12.9	10.3	094T	0.40	2.42	5.05	160T
✓ 739 v	19/6/84	14:12–14:18	79°28.0N	7°39.5E	15.1	14.5	104T	0.31	2.88	5.44	164T
✓ 740 f	19/6/84	14:23–14:27	79°28.2N	7.39.6E	15.1	14.0	104T	0.31	2.88	5.44	164T
✓ 741 v	19/6/84	14:50–14:53	79°28.5N	7°37.5E	13.8	14.1	052T	0.32	2.93	0.44	044T
742 f	20/6/84	08:26–08:30	79°37.3N	10°29.9E	8.36	10.1	047T	-0.28	1.61	3.49	104T

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Whitecap Observation Interval	Date	Time (GMT)	Latitude	Longitude	Wind ms^{-1} U_{14}	Wind ms^{-1} U_{AA}	Wind Direction Azimuth	T_{air} °C	T_{water} °C	Ship's Speed ms^{-1}	Ship's Direction Azimuth
743 v	20/6/84	09:06-09:10	79°39.5N	10°24.7E	9.52	8.3	072T	-0.39	1.50	0.46	040T
744 v	20/6/84	09:35-09:38	79°43.9N	10°08.3E	11.4	14.2	063T	-0.83	1.61	5.54	335T
745 v	20/6/84	10:16-10:19	79°47.6N	9°55.6E	12.5	9.9	074T	-1.04	3.23	5.28	345T
746 v	20/6/84	11:24-11:29	79°56.2N	9°33.4E	8.13	8.5	078T	-0.77	2.61	4.81	359T
747 v	20/6/84	12:48-12:51	80°03.2N	9°11.0E	8.65	10.5	048T	-1.23	1.33	4.91	347T
748 v	20/6/84	13:50-13:53	80°08.0N	8°55.1E	7.30	8.4	035T	-1.58	0.01	1.69	024T
749 B	20/6/84	13:58-14:46	80°08.9N	8°48.7E	7.30	8.9	035T	-1.58	0.01	1.69	204T
750 v	20/6/84	15:17-15:32	80°11.4N	9°39.0E	3.91	5.8	356T	-1.55	2.07	4.72	348T
751 v	20/6/84	16:13-16:16	80°11.1N	9°49.3E	--	4.8	056M	-1.08	2.47	0.31	051T
752 f	20/6/84	16:24-16:27	80°10.8N	9°49.1E	5.38	--	064T	-1.08	2.47	0.31	051T
753 v	20/6/84	17:33-17:36	80°07.0N	10°07.0E	5.79	6.3	048T	-1.15	2.53	0.40	046T
754 v	20/6/84	18:22-18:27	80°01.1N	10°20.2E	3.90	6.7	031T	-1.16	2.65	3.71	098T
755 v	20/6/84	19:40-19:44	79°57.4N	10°07.8E	--	9.3	342M	-0.92	2.76	--	283T
756 v	20/6/84	21:02-21:06	79°57.1N	8°41.6E	--	8.8	340M	-1.53	2.69	--	276T
√ 757 f	21/6/84	06:08-06:11	79°36.0N	7°10.4E	7.95	8.5	037T	-1.00	2.62	0.37	042T
⌵ 758 v	21/6/84	07:11-07:15	79°39.9N	7°46.0E	5.86	8.8	043T	-0.03	2.42	4.63	065T
√ 759 f	21/6/84	08:12-08:15	79°44.2N	7°59.3E	7.75	10.1	056T	-0.34	3.07	4.90	345T
⌵ 760 v	21/6/84	08:23-08:27	79°45.1N	7°57.0E	7.75	10.5	056T	-0.34	3.07	4.90	345T
⌵ 761 v	21/6/84	08:58-09:05	79°47.7N	7°50.9E	5.57	8.1	064T	-0.52	3.28	4.42	351T
⌵ 762 v	21/6/84	09:43-09:48	79°50.7N	7°42.5E	5.29	7.4	046T	-0.64	3.18	1.64	018T
763 B	21/6/84	12:10-12:18	80°02.6N	7°37.3E	3.18	--	357T	-1.34	2.16	5.76	086T
√ 764 v	21/6/84	13:36-13:41	80°05.4N	7°59.4E	3.12	6.7	332T	-1.33	2.28	0.71	266T
⌵ 765 f	21/6/84	14:07-14:10	80°03.1N	8°03.9E	5.30	6.8	240T	-1.20	2.38	2.55	255T
√ 766 v	21/6/84	14:29-14:33	80°02.3N	8°04.6E	4.01	4.5	019T	-1.04	2.72	5.03	171T

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Whitecap Observation Interval	Date	Time (GMT)	Latitude	Longitude	Wind ms⁻¹ U_{14}	Wind ms⁻¹ U_{AA}	Wind Direction Azimuth	T_{air} °C	T_{water} °C	Ship's Speed ms⁻¹	Ship's Direction Azimuth
√ 767 v	21/6/84	16:26-16:30	79°51.0N _(79.85)_	8°39.3E _(8.66)_	2.94	3.5	311T	-0.46	2.67	0.45	260T
√ 768 v	21/6/84	16:59-17:04	79°47.1N _(79.79)_	8°49.5E _(8.83)_	3.12	5.9	355T	-0.28	2.95	0.10	285T
√ 769 v	21/6/84	19:17-19:21	79°32.4N _(79.54)_	9°38.6E _(9.57)_	5.26	5.1	045T	-0.22	2.23	4.23	328T
√ 770 f	21/6/84	19:48-19:51	79°36.0N _(79.6)_	9°27.9E _(9.47)_	3.72	5.5	067T	-0.10	2.38	3.21	348T
√ 771 v	21/6/84	21:26-21:30	79°54.0N _(79.9)_	9°30.2E _(9.5)_	1.54	2.5	091T	-0.73	2.78	6.03	014T
√ 772 v	21/6/84	22:52-22:56	80°11.0N _(80.18)_	9°39.4E _(9.66)_	3.29	5.9	093T	-0.60	1.94	5.97	018T
773 v	22/6/84	05:54-05:59	79°57.1N	9°33.5E	--	5.1	074M	0.04	2.79	0.89	0357
774 f	22/6/84	06:29-06:31	80°00.3N	9°22.1E	--	6.0	022M	-0.09	2.27	4.68	351T
775 v	22/6/84	07:10-07:16	80°03.5N	9°10.6E	--	6.2	036M	-0.26	1.65	4.59	354T
776 v	22/6/84	07:44-07:49	80°06.2N	9°00.4E	--	5.0	037M	-0.29	1.26	2.49	341T
777 B	22/6/84	08:27-08:47	80°10.8N	8°41.3E	--	4.7	034M	-0.63	2.13	2.66	329T
778 V	22/6/84	10:32-10:37	80°01.1N	9°19.8E	5.33	6.5	040M	-0.02	1.94	2.65	297T
779 f	22/6/84	11:16-11:18	79°59.6N	8°42.8E	--	2.5	354M	-0.07	2.63	5.52	215T
780 v	22/6/84	12:12-12:18	79°56.2N	8°25.0E	--	3.2	356M	0.29	2.70	0.94	276T
781 v	22/6/84	13:14-13:18	79°52.5N	7°57.0E	--	2.8	322M	0.41	2.87	5.85	239T
782 f	22/6/84	14:39-14:41	79°47.0N	7°10.0E	--	2.6	310M	0.60	3.22	2.58	227T
783 v	22/6/84	15:53-15:57	79°43.9N	6°39.4E	--	3.4	208M	0.34	2.68	3.36	240T
784 f	22/6/84	17:14-17:16	79°41.8N	5°53.9E	--	1.3	310M	0.84	3.24	3.75	288T
785 f	22/6/84	19:02-19:05	79°34.1N	5°00.3E	0.10	1.1	340M	0.62	3.69	4.90	114T
786 f	22/6/84	20:54-20:57	79°33.0N	4°49.0E	--	1.4	075M	0.56	2.46	1.67	232T
787 T	23/6/84	08:05-08:13	79°59.9N	7°19.4E	--	8.8	045M	-0.80	1.00	--	039T
√ 788 v	23/6/84	11:48-11:53	79°35.1N _(79.59)_	8°00.7E _(8.01)_	--	7.8	340M	1.92	2.63	3.86	020T
√ 789 f	23/6/84	13:48-13:56	79°41.7N _(79.1)_	7°18.6E _(7.31)_	--	9.6	049M	0.90	2.40	--	321T
√ 790 f	23/6/84	16:49-16:52	79°51.8N _(79.86)_	6°17.6E _(6.29)_	6.07	7.1	050T	1.60	2.32	2.83	001T

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Whitecap Observation Interval	Date	Time (GMT)	Latitude	Longitude	Wind ms^{-1} U_{14}	Wind ms^{-1} U_{AA}	Wind Direction Azimuth	T_{air} °C	T_{water} °C	Ship's Speed ms^{-1}	Ship's Direction Azimuth
791 B	23/6/84	17:20-17:28	79°52.0N	6°13.3E	2.19	6.8	009M	0.76	1.53	3.44	139M
√ 792 v	23/6/84	17:48-17:53	79°50.9N ^{79.85}	6°12.5E ^{6.21}	--	6.8	331M	0.76	1.53	3.44	187T
√ 793 f	23/6/84	18:40-18:44	79°48.3N ^{79.81}	5°11.2E ^{5.19}	6.93	6.1	013T	1.05	3.07	6.34	277T
794 v	24/6/84	05:59-06:03	79°50.0N	4°36.6E	7.31	7.3	141T	4.49	2.71	2.71	111T
795 f	24/6/84	06:40-06:45	79°50.0N	5°03.2E	9.73	13.3	152T	5.35	3.14	2.66	118T
796 v	24/6/84	07:14-07:18	79°49.9N	5°14.2E	8.38	9.8	147T	4.79	3.84	2.23	123T
797 v	24/6/84	08:08-08:13	79°56.8N	4°57.7E	11.20	10.5	054T	4.39	2.57	5.94	007T
798 f	24/6/84	09:14-09:18	80°10.4N	5°02.3E	8.81	7.2	115T	3.26	1.19	5.92	028T
799 B	24/6/84	10:52-10:58	80°14.0N	5°12.2E	7.09	7.3	053T	3.51	2.95	0.24	351T
800 v	24/6/84	13:39-13:44	79°49.8N	5°30.2E	--	7.3	135M	2.50	2.90	0.90	126M
801 f	24/6/84	14:08-14:11	79°49.9N	5°44.4E	--	6.2	119M	2.50	2.90	0.60	128M
802 v	24/6/84	14:39-14:43	79°50.1N	6°00.8E	--	8.2	155M	2.80	2.62	5.40	094M
803 f	24/6/84	15:12-15:15	79°50.0N	6°15.1E	7.06	6.4	175T	2.60	2.58	2.28	144T
√ 804 f	25/6/84	07:12-07:16	79°54.0N ^{79.9}	6°49.9E ^{6.83}	10.20	9.8	146T	2.53	2.80	0.51	016M
√ 805 v	25/6/84	07:46-07:52	79°54.8N ^{79.91}	6°49.8E ^{6.83}	7.95	10.0	211T	2.07	2.68	1.87	144T
√ 806 v	25/6/84	08:21-08:26	79°57.4N ^{79.96}	6°49.7E ^{6.83}	6.53	9.2	208T	1.87	1.89	1.98	123M
√ 807 v	25/6/84	08:57-09:02	80°00.0N ^{80.00}	6°50.4E ^{6.84}	--	3.6	228M	2.27	1.87	3.76	112M
√ 808 v	25/6/84	09:54-09:59	79°56.9N ^{79.95}	7°10.2E ^{7.17}	--	11.1	152M	1.90	1.37	2.11	132M
√ 809 v	25/6/84	10:32-10:36	79°54.9N ^{79.92}	6°59.9E ^{7.00}	--	10.6	153M	1.76	1.84	2.64	138M
√ 810 v	25/6/84	11:51-11:55	79°52.0N ^{79.87}	6°37.6E ^{6.63}	--	10.5	151M	1.55	2.71	4.46	139M
√ 811 v	25/6/84	13:02-13:06	79°48.0N ^{79.8}	6°23.3E ^{6.39}	--	12.4	187M	1.28	3.42	2.49	157M
√ 812 v	25/6/84	14:10-14:15	79°48.0N ^{79.8}	7°11.6E ^{7.19}	--	13.7	168M	1.67	2.96	0.34	151M
√ 813 v	25/6/84	14:46-14:52	79°49.8N ^{79.83}	7°01.9E ^{7.03}	--	8.5	179M	1.49	2.80	5.00	164M
√ 814 f	25/6/84	15:23-15:27	79°50.9N ^{79.85}	6°55.1E ^{6.92}	--	11.6	170M	1.04	2.78	2.41	160M

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Whitecap Observation Interval	Date	Time (GMT)	Latitude	Longitude	Wind ms⁻¹ U$_{14}$	Wind ms⁻¹ U$_{AA}$	Wind Direction Azimuth	T$_{air}$ °C	T$_{water}$ °C	Ship's Speed ms⁻¹	Ship's Direction Azimuth
∨ 815 v	25/6/84	16:33-16:38	79°53.8N *79.90*	6°40.1E *6.67*	--	9.4	176M	0.98	2.81	4.54	169M
∨ 816 v	25/6/84	17:50-17:56	79°56.1N *79.97*	6°25.1E *6.42*	11.4	10.2	136M	0.64	1.83	1.95	161M
✓ 817 v	25/6/84	18:32-18:38	79°57.3N *79.96*	6°17.9E *6.3*	10.6	9.5	179M	-0.55	2.03	2.43	174M
✓ 818 v	25/6/84	19:04-19:12	79°58.3N *79.97*	6°09.4E *6.16*	10.2	8.0	194M	0.43	2.24	0.91	188M
∨ 819 v	25/6/84	20:09-20:13	79°53.1N *79.89*	5°59.8E *6.00*	9.28	8.2	210T	0.45	2.66	0.26	198T
✓ 820 v	25/6/84	22:11-22:16	79°52.8N *79.88*	6°44.6E *6.74*	10.5	9.2	196T	0.56	2.03	0.58	165T
821 v	26/6/84	06:26-06:31	79°54.4N	6°51.6E	10.8	9.2	210T	1.30	2.33	0.20	207T
822 f	26/6/84	07:15-07:18	79°51.7N	6°38.2E	12.1	10.4	201T	0.98	2.66	0.42	189T
823 f	26/6/84	07:49-07:53	79°50.1N	6°30.5E	11.5	10.5	205T	1.08	3.46	0.20	195T
824 v	26/6/84	08:52-08:56	79°46.9N	6°40.5E	11.8	9.3	211T	1.11	2.94	0.31	193T
825 v	26/6/84	09:25-09:31	79°49.0N	6°39.8E	11.6	10.2	199T	0.99	3.43	0.36	191T
826 v	26/6/84	09:56-10:00	79°51.1N	6°39.7E	10.6	9.6	204T	1.17	2.69	0.25	195T
827 v	26/6/84	10:35-10:39	79°52.8N	6°39.7E	10.6	--	203T	0.98	2.04	0.24	201T
828 f	26/6/84	11:08-11:11	79°54.7N	6°39.1E	10.8	10.0	214T	1.00	2.22	0.49	195T
829 v	26/6/84	11:51-11:55	79°57.0N	6°39.2E	10.4	9.2	212T	0.95	2.42	0.26	201T
830 f	26/6/84	12:29-12:33	79°58.7N	6°40.7E	8.21	9.7	187T	1.10	2.67	2.44	118T
831 v	26/6/84	13:33-13:37	80°03.8N	6°40.6E	8.83	7.7	222T	0.73	2.33	0.48	202T
832 f	26/6/84	14:28-14:32	80°08.8N	6°40.7E	7.72	7.0	225T	0.45	1.42	0.47	196T
833 f	26/6/84	15:19-15:23	80°13.7N	6°40.9E	6.76	6.1	208T	0.29	1.37	0.53	205T
834 f	26/6/84	16:31-16:40	80°18.9N	6°41.3E	6.78	5.7	213T	0.62	1.28	0.44	192T
835 v	26/6/84	17:46-17:52	80°24.0N	6°40.3E	5.44	4.3	227T	-0.50	-0.64	0.27	207T
836 f	26/6/84	18:48-18:51	80°29.4N	6°40.4E	5.92	4.1	207T	-0.73	-1.08	4.77	009T
∨ 837 f	27/6/84	07:10-07:15	80°18.2N *80.3*	3°06.2E *3.1*	6.98	5.7	291T	-2.56	0.04	4.04	200T
838 v	27/6/84	07:53-07:58	80°17.4N	2°57.8E	5.34	5.5	017T	-2.52	0.29	0.27	360T

Whitecap Observation Interval	Date	Time (GMT)	Latitude	Longitude	Wind ms^{-1} U_{14}	Wind ms^{-1} U_{AA}	Wind Direction Azimuth	T_{air} °C	T_{water} °C	Ship's Speed ms^{-1}	Ship's Direction Azimuth
839 f	28/6/84	07:06-07:10	79°30.1N	8°10.4E	6.33	6.6	342T	1.9	4.11	0.3	321T
840 f	28/6/84	10:42-10:46	79°51 N	8°48 E	--	5.5	328M	1.4	3.13	0.2	329M
841 f	28/6/84	14:24-14:28	80°12 N	8°48 E	4.5	4.9	343T	-0.5	2.95	0.2	332M
842 f	29/6/84	13:22-13:25	79°56 N	6°44 E	9.3	8.3	300M	-0.9	2.49	--	180T
843 f	29/6/84	16:53-16:58	79°48 N	6°09 E	8.41	8.9	052T	-0.2	4.50	0.2	050T
844 f	02/7/84	10:36-10:42	79°33 N	3°00 E	7.91	13.6	037T	2.03	1.27	0.2	031T
845 f	02/7/84	13:20-13:25	79°37.8N	3°00.8E	6.81	7.2	038T	2.51	3.21	0.3	045T
846 f	02/7/84	15:58-16:02	79°45.1N	2°59.2E	9.4	9.7	288T	2.16	3.36	0.3	035M
847 f	02/7/84	18:15-18:18	79°50 N	2°59 E	9.75	10.9	034T	1.55	3.13	0.3	028T
848 f	02/7/84	22:31-22:35	79°25 N	4°59 E	9.61	10.2	029T	1.72	1.98	0.3	030T
849 f	03/7/84	00:03-00:06	79°25 N	4°28 E	13.4	10.7	033T	1.09	3.7	0.2	033T
∨ 850 f	03/7/84	12:06-12:11	79°40 N _79.67_	1°31 E _1.52_	7.66	9.6	037T	-0.32	-0.37	0.2	042T
∨ 851 f	03/7/84	14:30-14:35	79°40 N _79.67_	2°31 E _2.52_	9.03	9.5	032T	0.05	2.81	0.2	037T
∨ 852 f	03/7/84	16:54-16:59	79°40 N _79.67_	4°01 E _4.02_	8.7	8.6	031T	-0.14	1.3	0.2	044T
853 f	04/7/84	07:55-08:00	79°49 N	6°09 E	2.7	5.3	016T	-1.51	3.54	2.7	071T
854 f	06/7/84	14:35-14:40	79°03 N	3°18 E	9.72	--	321T	0.6	1.75	6.1	222T
∨ 855 f	07/7/84	07:39-07:44	78°24 N _78.4_	2°29 W _2.78_	11.8	12.0	392T	-1.3	4.12	0.2	350T
∨ 856 f	07/7/84	08:45-08:50	78°25 N _78.421_	2°42 W _2.7_	9.28	11.6	333T	-1.56	2.97	0.5	342T
∨ 857 f	07/7/84	09:35-09:40	78°29 N _78.18_	2°24 W _2.4_	11.1	11.9	340T	-1.15	3.53	0.5	039M
858 f	08/7/84	09:55-10:00	78°57 N	2°37 W	10.1	--	260T	0.2	1.1	5.4	232T
∨ 859 f	09/7/84	09:45-09:50	78°47 N _78.78_	1°29 W _1.48_	10.8	--	315T	0.35	1.81	5.9	230T
860 f	10/7/84	08:00-08:05	78°28 N	1°02 W	7.15	7.3	237T	0.27	4.0	0.4	214T
861 f	10/7/84	14:05-14:08	78°30 N	1°00 W	--	11.1	--	1.8	4.2	0.4	--
∨ 862 f	10/7/84	20:00-20:05	78°34 N _78.57_	1°17 W _1.18_	--	9.3	103M	1.3	2.6	1.0	159T

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Whitecap Observation Interval	Date	Time (GMT)	Latitude	Longitude	Wind ms^{-1} U_{14}	Wind ms^{-1} U_{AA}	Wind Direction Azimuth	T_{air} °C	T_{water} °C	Ship's Speed ms^{-1}	Ship's Direction Azimuth
862 f	11/7/84	07:00-07:05	78°34 N _(78.57)_	1°25 W _(1.72)_	9.15	9.5	225T	0.5	3.09	0.3	215T
863 f	11/7/84	10:55-11:00	78°28 N _(78.47)_	0°28 W _(0.47)_	11.3	11.9	230T	1.18	4.35	0.3	229T
864 f	13/7/84	09:08-09:12	78°33 N _(78.55)_	0°58 W _(0.97)_	7.23	6.6	231T	-0.18	1.66	0.5	163T
865 f	13/7/84	11:15-11:18	78°31.4N _(78.52)_	0°51 W _(0.85)_	6.53	5.9	220T	1.75	2.55	0.4	164T
866 f	14/7/84	07:45-08:50	78°43 N	0°28 W	6.97	7.4	233T	-0.26	2.22	0.5	203T

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CHAPTER 3

PRELIMINARY MIZEX '83 ICE-COVER RESULTS

A limited number of photographs were taken during MIZEX '83 for the purpose of ascertaining the local ice cover fraction, I. A facsimile of one such photograph (taken during observation interval 660) has been reproduced as Figure 3.1. Note the division of the region between the horizon and the bottom of the picture into three zones designated the far-field, the mid-field, and the near field. The table which follows lists the results to date obtained from the analysis of the ice-coverage photos by M.R. Higgins, T. Luibheid and S. MacGearain. The computations were carried out by D.M. Doyle and M.R. Higgins. In Figures 3.2 and 3.3 we see the ice coverage fraction, in the far-, mid-, and near-fields for each frame in the observation interval 660 (Figure 3.2) and 666 (Figure 3.3). Note that in both of these figures the mid-field ice coverage is consistently less than the far-field coverage. This is because the extreme obliqueness with which we view the far-field, combined with the fact that the ice floes protrude above the sea surface, results in a positive bias in our estimate of ice coverage in this far-field zone. In the typical circumstance encountered in observation interval 660 (Figures 3.1 and 3.2), where the POLARSTERN was moving through a lead in the Marginal Ice Zone, the ice coverage in the near-field zone is lower than in the mid-field region. Given that the actual area of the sea surface represented by the near-field zone is small, it is quite possible, as during observation interval 666 (Figure 3.3), to find exceptionally high ice coverage in this region due to the presence there of one, or a few, relatively large floes.

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In Figure 3.4 is depicted the ice coverage, frame-by-frame for observation interval 666, as deduced by three different analysts, for the mid-field zone, the most appropriate portion of the photographs for use in estimating Marginal Ice Zone ice coverage. We note a good agreement between the results obtained for each frame by the several analysts. It remains to compare the mid-field ice coverage values listed in the following table with the ice coverage values determined for the same locations and at the same times by the MIZEX remote sensing aircraft.

Obs #	Date	Time GMT	Latitude North	Longitude	Frames Analysed	Int s	T_a °C	T_w °C	Ice Cover Fraction (Std. Dev.)		
									Far	Mid.	Near
639	7/06	1957	80°59.82′	7°19.98′E	9, 9, 9	10	2.1	-0.4	0.1082	0.0748	0.0234
									(0.0083	0.0749	0.0159)
660	7/11	0955	79°44.91′	2°00.58′E	9, 9, 9	10	0.7	0.3	0.7556	0.4532	0.1022
									(0.0406	0.0780	0.0415)
662	7/11	1400	79°42.53′	2°07.11′E	9,12	300	0.9	0.1	0.5132	0.4241	0.4123
									(0.2590	0.3309	0.3825)
664	7/11	1629	79°41.08′	2°15.61′E	8, 8	60	0.9	0.0	0.6761	0.1909	0.0704
									(0.0686	0.2455	0.1506)
665	7/11	1711	79°40.63′	2°18.60′E		60	0.8	0.5			
666	7/11	2012	79°39.74′	2°21.52′E	10,10,10	60	1.0	0.3	0.6963	0.4756	0.9556
									(0.0318	0.1004	0.0490)
676	7/13	1431	79°19.38′	2°35.09′E	8, 8	60	-1.3	0.8	0.1123	0.1880	0.1422
									(0.0787	0.3479	0.2902)
677	7/13	1504	79°19.12′	2°18.26′E		60	-1.2	-0.2			
678	7/13	1901	79°15.39′	0°41.30′E		60	-0.4	-0.1			
679	7/14	1109	79°03.35′	4°59.66′W		60	-0.5	0.1			
680	7/14	2242	79°35.07′	7°40.66′W		60	-0.4	-0.1			
681	7/15	1308	79°48.52′	11°04.33′W		60	-1.0	-0.8			

Figure 3.1: Facsimile of one MIZEX '83 ice-cover photograph (Frame No. 5147) taken from the F/S POLARSTERN during observation interval 660. Note that the region from the horizon to the bottom of the photograph has been divided into three equal zones which we designate as the far-field, mid-field, and near-field, respectively.

Figure 3.2: Ice coverage versus frame number for far (▲), middle (■) and near (●) fields for interval number 660. Note that photographs were taken at ten second intervals.

Figure 3.3: Ice coverage versus frame number for Far (▲), middle (■) and near (●) fields for interval number 666. Note that photographs were taken at one minute intervals.

Figure 3.4: Ice coverage in mid-field versus frame number for three analysts for interval 666.

HORIZON

ICE

CLOCK
&
COUNTER

No.660

40

TIME (GMT)

FRAME NUMBER

666

42
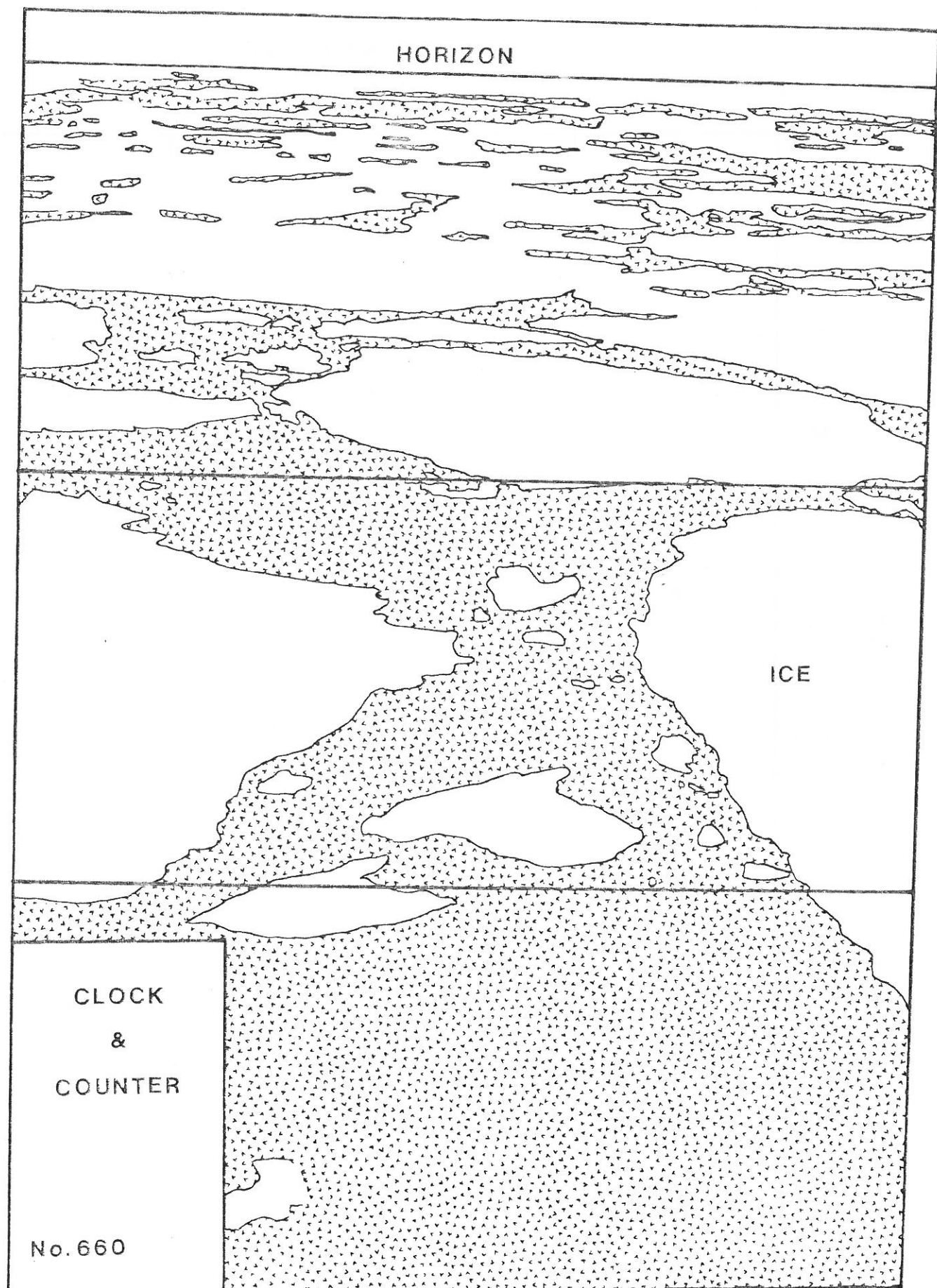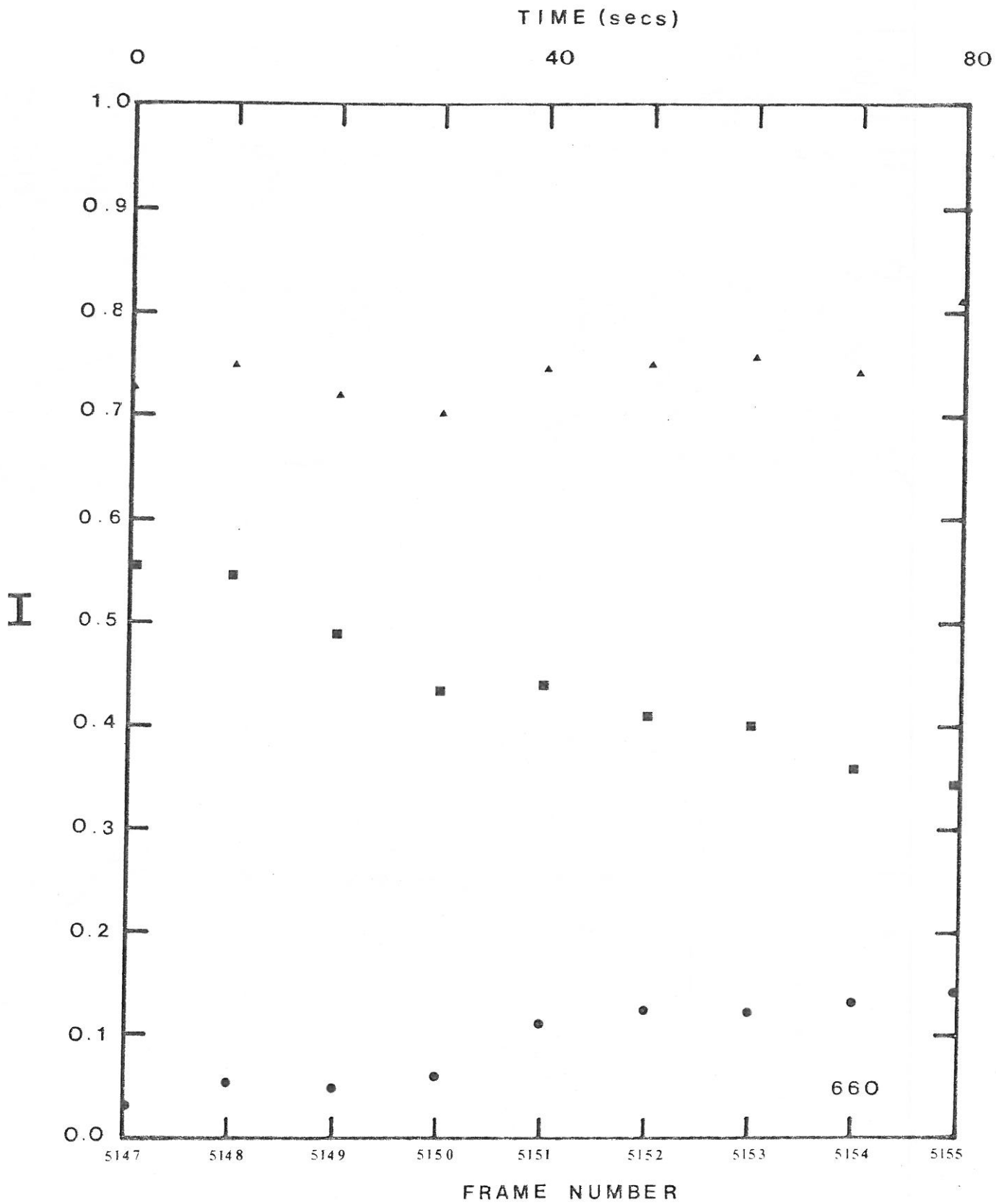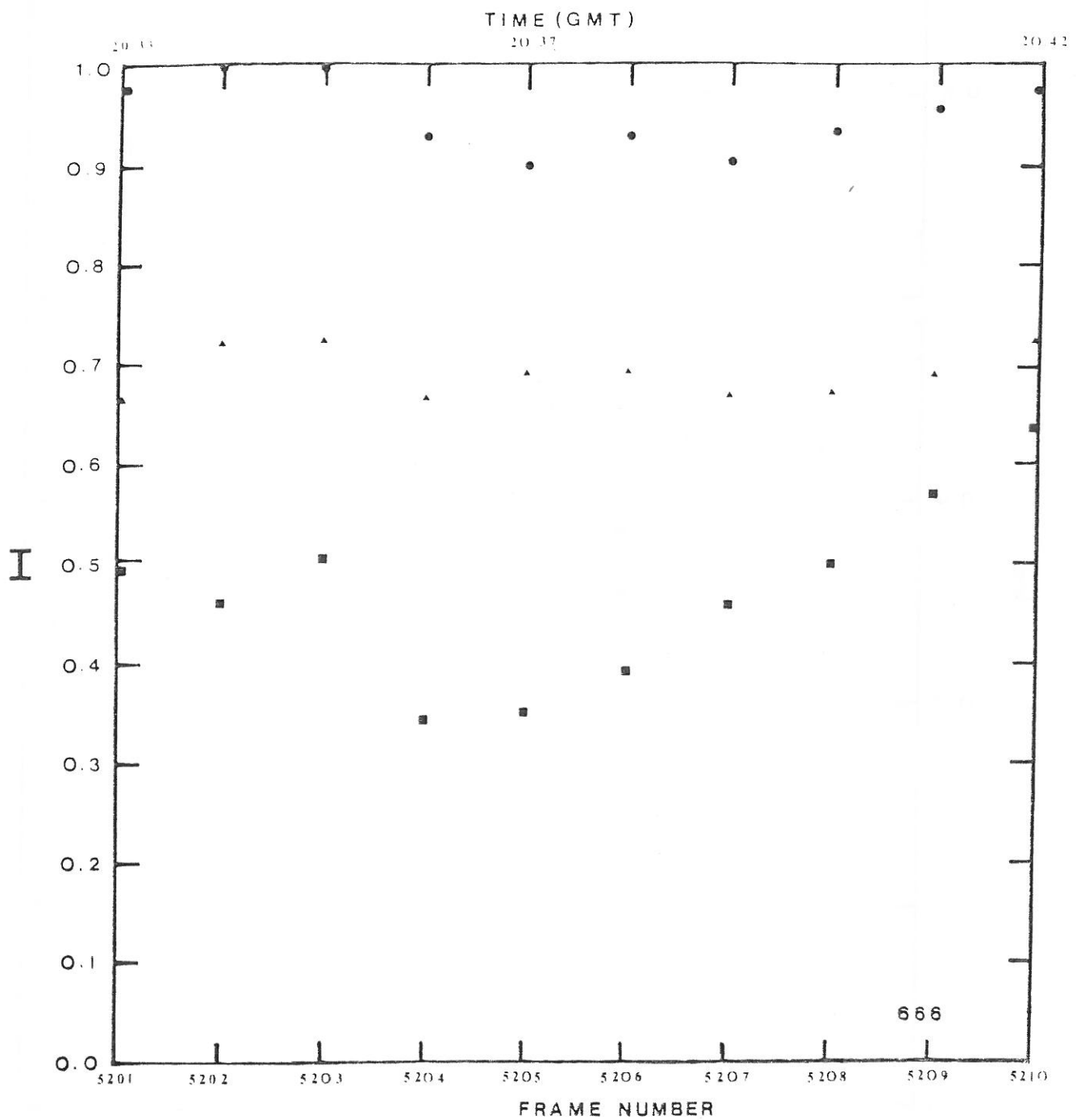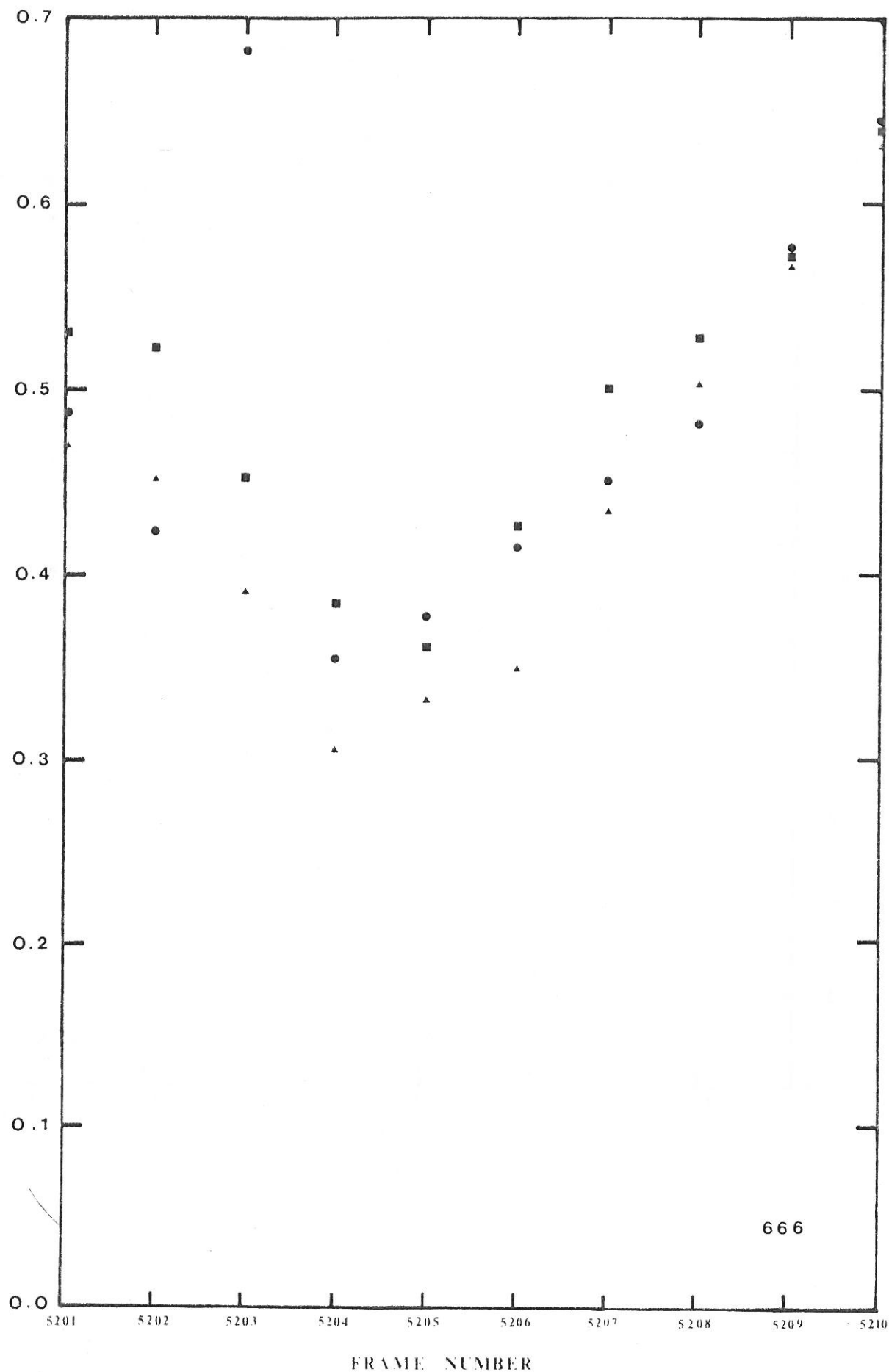
CHAPTER 4

FORMATION OF FOAM ABOUT ICE FLOES

P.J. Stabeno

It has been noticed that about certain ice floes there
appears a ring of bubbles or foam. The observations from
on board ship are reinforced by the examination of films
of the polar ice floes taken by Dr. E.C. Monahan when he
was on board the POLARSTERN. While in the open ocean,
whitecaps are caused directly by the wind, the bubbles about
an ice floe are not directly caused by the wind, but rather
by the interaction of the ice with the surface waves.

Waves whose wavelength is much smaller than the horizontal
dimensions of the piece of ice can assist in the formation
of bubbles because of the shape of the ice floe. A piece
of ice often has sloping edges that form 'beaches' on which
these waves can break. Waves whose wavelength is the same
order as the horizontal dimension of the ice can excite the
floe to oscillate at its natural frequency. This oscillation
can cause the entrainment of air in two slightly different
ways. First, the tilting causes water to flow off the
beaches of the berg and flow into the ocean introducing air
into the water. Second, if the oscillation becomes large,
then the edges of the floe can breach the surface and air
is then forced into the ocean by the slapping of the water
surface by the floe edge as it descends.

If both the size and shape of the ice floes and the surface
wave spectrum are known as a function of position in the
ice field then the amount of energy available for the
breaking waves can be estimated. To determine the amount

of energy available to cause the blocks to oscillate it is
necessary to know to which wavelengths the block is most
sensitive. Since each piece of ice is non uniform in shape,
a computer would be necessary to model the oscillation
exactly. Here we simplify the problem by considering a
rectangular block of length 2ℓ and height $2h$ as is sketched
in Figure 4.1. The block has density ρ_b and the water ρ_w.
Each of the distances and parameters shown in figure 4.1
are defined below:

$$f(y) = F + A\sin(ky-wt) \qquad , \quad F = (\frac{2\rho_b}{\rho_w} - 1)h$$

$$b = \ell\cos\theta \; ; \quad r = -\ell\sin\theta \; ; \quad s = 2h\cos\theta$$

$$d = -2h\sin\theta \; ; \quad c = -h\sin\theta \; ; \quad h' = h\cos\theta$$

$$h* = h/\cos\theta \; ; \quad a = b+c = \ell\cos \; - h\sin\theta$$

Thus we are considering a block that is being forced by
a travelling wave.

The equations, as a function of y, for the four sides of
the block are:

$$Z_T(y) = -y\tan\theta + h/\cos\theta$$

$$Z_B(y) = -y\tan\theta - h/\cos\theta$$

$$Z_L(y) = y\cot\theta + \ell/\sin\theta$$

$$Z_R(y) = y\cot\theta - \ell/\sin\theta$$

Finally the intersects of walls of the block with the
travelling wave are at $y = \alpha$ and $y = \beta$, and are determined
by:

$$F + A\sin(k\alpha - wt) = \alpha \cot\theta + \ell/\sin\theta \qquad (1)$$
$$F + A\sin(k\beta - wt) = \beta \cot\theta - \ell/\sin\theta \qquad (2)$$

Thus the torque, τ, on the block is defined as:

$$\tau = \rho_w g \left\{ \int_\alpha^\beta f(y) \, y \, dy - \int_{-a+d}^a Z_B(y) \, y \, dy \right.$$

$$\left. + \int_\beta^a Z_R(y) \, y \, dy - \int_\alpha^{-a+d} Z_L(y) \, y \, dy \right\}$$

Thus we write

$$I\ddot{\theta} = \tau \qquad (3)$$

The derivation so far is relatively general. To continue
however some simplifications and approximations are necessary.
We can begin by considering that the angle θ is small. Thus
the trigometric equations can all be approximated as:

$$\sin\theta = \theta - \frac{\theta^3}{6} \quad ; \quad \cos\theta = 1 - \frac{\theta^2}{2} \quad \text{etc.}$$

Also for a small parameter ε , $\varepsilon \ll \gamma$ we can write:

$$\sin(\gamma+\varepsilon) = \sin\gamma + \varepsilon\cos\gamma + O(\varepsilon^2)$$

$$\cos(\gamma+\varepsilon) = \cos\gamma - \varepsilon\sin\gamma + O(\varepsilon^2)$$

It is now possible to solve approximately transcendental
equations (1) and (2).

$$\alpha = \alpha_0 + \alpha_1\theta + \alpha_2\theta^2 + \cdots$$

where

$$\alpha_0 = -\ell$$

$$\alpha_1 = F + A\sin(k\alpha_0 - wt)$$

and

$$\beta = \beta_0 + \beta_1\theta + \beta_2\theta^2 + \ldots$$

where

$$\beta_0 = \ell$$

$$\beta_1 = F + A\sin(k\beta_0 - wt)$$

through careful integration equation (3) can now be explicitly written as:

$$I\ddot{\theta} = -\rho_w g \{ 2Ak^{-2}\left[\sin(k\ell) - k\ell\cos(k\ell)\right]\cos(wt)$$

$$+ \theta\ell\left[2F^2 - 4FA\sin(wt)\cos(k\ell)\right.$$

$$+ A^2(1-\cos(2k\ell)\cos(2wt))$$

$$\left. + \frac{2}{3}\ell^2 - h^2 - \tfrac{1}{2}(\beta_1^2 + \alpha_1^2)\right] + O(\theta^2)\}$$

To further simplify the problem, it is required the amplitude of the wave, A, is small compared to F (or to the height of the block 2h). This is not excessively restrictive since it is small amplitude waves that hold the greatest interest. Considering this approximation and that the block is taken to be rectangular we have:

$$I\ddot{\theta} + \ell\rho_w g\{F^2 + \frac{2}{3}\ell^2 - h^2\}\theta = -2\rho_w gAk^{-2}\left[\sin(k\ell) - k\ell\cos(k\ell)\right]\cos(wt)$$

$$I = \frac{4}{3}\ell h(\ell^2 + h^2)\rho_b$$

or simply:

$$\ddot{\theta} + w_0^2 \theta = A_0 \cos(wt) \tag{4}$$

Here w_0 is the natural frequency of the block. The period T is then:

$$T = \frac{2\pi}{w_0} = 2\pi\sqrt{\frac{2\ell}{g}} \left\{ \frac{(1+r^2)}{1-6r^2} \frac{r(1-\rho^1)}{(1-\rho^1)\rho^1} \right\}^{\frac{1}{2}} \tag{5}$$

where r is the aspect ratio,

$$r = h/\ell$$

and,

$$\rho' = \frac{\rho_w - \rho_b}{\rho_b}$$

A_0 is the amplitude of the forcing function,

$$A_0 = \frac{-3\rho_w g(Ak)\{\sin(k\ell) - k\ell \cos(k\ell)\}}{2\rho_b (\ell k)^3 r(1-r^2)\ell}$$

If we had considered a cylinder instead of a rectangular box the change would have been relatively small. For instance the period,

$$T = 4\pi\sqrt{\frac{2\ell}{g}} \left\{ \frac{(r^2+3/4)\ r(1-\rho')}{3(1-8r^2\rho'(1-\rho')} \right\}^{\frac{1}{2}} \tag{6}$$

for cylinder where ℓ is the radius.

Consider now how these periods would compare to those of deep water wave. The dispersion relationship for D.W.W. is:

$$w^2 = kg \tan(kh) = kg$$

$$\text{or} \quad T = (2\pi L/g)^{\frac{1}{2}}$$

where L is wavelength, $K = 2\pi/L$. Note that the natural period of the roll depends linearly upon $\ell^{\frac{1}{2}}$ and the period of D.W.W. linearly upon $L^{\frac{1}{2}}$. If we consider waves whose wavelength is twice the length of block ($\ell = \frac{1}{4}L$) then for an aspect ratio r=.300...the curves would coincide. Figure 4.2 shows the D.W.W. along with curves for forced roll at several aspect ratios. The density of ice is taken to be 0.90.

The dispersion relationship for shallow water waves is:

$$w^2 - f^2 = Hgk^2$$

where H is the depth of the water. Thus:

$$T = 2\pi \left[f^2 + Hg(2\pi/L)^2 \right]^{-\frac{1}{2}}$$

Figure 4.3 shows the relationship between wavelength and period of S.W.W. and between half-length of the block and the period for natural roll of a rectangular block. This relationship could prove useful in designing laboratory experiments to confirm the theoretical results presented here.

From an examination of (4) it is evident that the solution is:

$$\theta = \begin{cases} c_1 \cos(w_0 t) + c_2 \sin(w_0 t) + \dfrac{A_0}{w_0^2 - w^2} \cos(wt) & , \ w \neq w_0 \quad (7) \\[3mm] c_1 \cos(w_0 t) + c_2 \sin(w_0 t) + \dfrac{A_0}{2w_0} t \sin(w_0 t) & , \ w = w_0 \quad (8) \end{cases}$$

Equation (8) is the case of resonance. The boundary conditions are taken to be:

$$\theta = Ak \quad , \quad \theta' = 0 \qquad at \ t=0$$

thus Eq. (7) can now be written as:

$$\theta = Ak \left\{ \cos(w_0 t) + Q \sin\left(\frac{w_0 - w}{2} t\right) \sin\left(\frac{w_0 + w}{2} t\right) \right\}$$

where, $\quad Q = \dfrac{2A_0}{(w_0{}^2 - w^2) Ak}$

It is clear that when w goes to w_0 , Q becomes large. In fact Q is a measure of how close w must be to w_0 to obtain a large response (i.e. oscillations) in the block.

It is useful at this point to non-dimensionalize in the following manner:

$$k' = k\ell \ ; \quad w' = w/w_0 \ ; \quad A' = Ak$$

then

$$Q(k',w') = \frac{-6\left[\sin k' - k'\cos k'\right]}{k'^3 (1-w'^2) \left[1 - 6r^2 \left(1 - \frac{\rho_b}{\rho_w}\right) \frac{\rho_b}{\rho_w} \right]} \tag{9}$$

Shown in Figure 4.4 are contours of $|Q|$ as a function of non-dimensional wave number and frequency. For this figure an aspect ratio, r, of .1 is used. In general it shows behaviour of equation (9). As k' increases $|Q|$ decreases rapidly. This is to be expected since waves whose length is much shorter than the length of an ice block should provide little or no energy to cause oscillation. Their influence is filtered out

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by the block size. There is an expected pole at $w'=1$,
which is resonance. The influence of the aspect ratio, r,
on $|Q|$ is very weak (as long as $r < .3$).

Consider once again the D.W.W. If we use the same non-
dimensionalization we have:

$$w'^2 = \frac{2.r(1-r^2)\;\rho_b/\rho_w}{1-6r^2\,\frac{\rho_b}{\rho_w}\,(1-\frac{\rho_b}{\rho_w})}\;k' \qquad (10)$$

We are interested in the value of $|Q|$ along curves determined
by this dispersion relationship. That is if there are
deep water waves in the region, energy in the wave field can
be found along this curve. This energy can be used to excite
the ice floe to oscillate. Substituting (10) into (9)
yields:

$$|Q| = \frac{6\left[\sin k' - k'\cos k'\right]}{k'^3\left[1-br^2\,\frac{\rho_b}{\rho_w}(1-\frac{\rho_b}{\rho_w})-2k'\,r\,(1+r^2)\frac{\rho_b}{\rho_w}\right]} \qquad (11)$$

Figures 4.5 and 4.6 are plots of (11) as a function of k'
for two different aspect ratios. Figure 4.5 has an aspect
ratio of .1. Here the response is small except for close to
resonance. On the other hand, for $r=.25$ the peak is spread
out significantly. Thus for this particular wave, D.W.W.,
the larger the aspect ratio the more oscillation is expected
in the block.

A different wave with a different dispersion relationship will
provide different results.

From this extremely simple model, it is clear that there should be energy in some part of the wave spectrum that can be used to excite oscillations in ice floes. To elaborate on this it will be necessary to implement a mathematical model on a computer that would include the complex shapes and the effect of water running off the ice floe. A knowledge of the types of waves and the shape of the ice floes at different positions in the ice field is also necessary.

Figure 4.1: A schematic representation of a block of ice
            that is being forced to roll by a travelling wave.

Figure 4.2: The dispersion curve for D.W.W. is shown together
            with period as function of half length of block
            (for several aspect ratios labelled here Z_r
            instead of r) for natural roll of the cylinder.

Figure 4.3: The dispersion curve for S.W.W. for two depths
            as function of wavelength is shown together
            with the period of natural roll of a
            rectangular block as a function of the half
            length of block. Curves for several aspect
            ratios.

Figure 4.4: Contours of the forcing function $|Q|$. The
            aspect ratio r = .1 and ρ_b = .9

Figure 4.5: $|Q|$ along the dispersion curve for D.W.W.
            The aspect ratio r = .1

Figure 4.6: $|Q|$ along the dispersion curve for D.W.W.
            The aspect ratio r = .25

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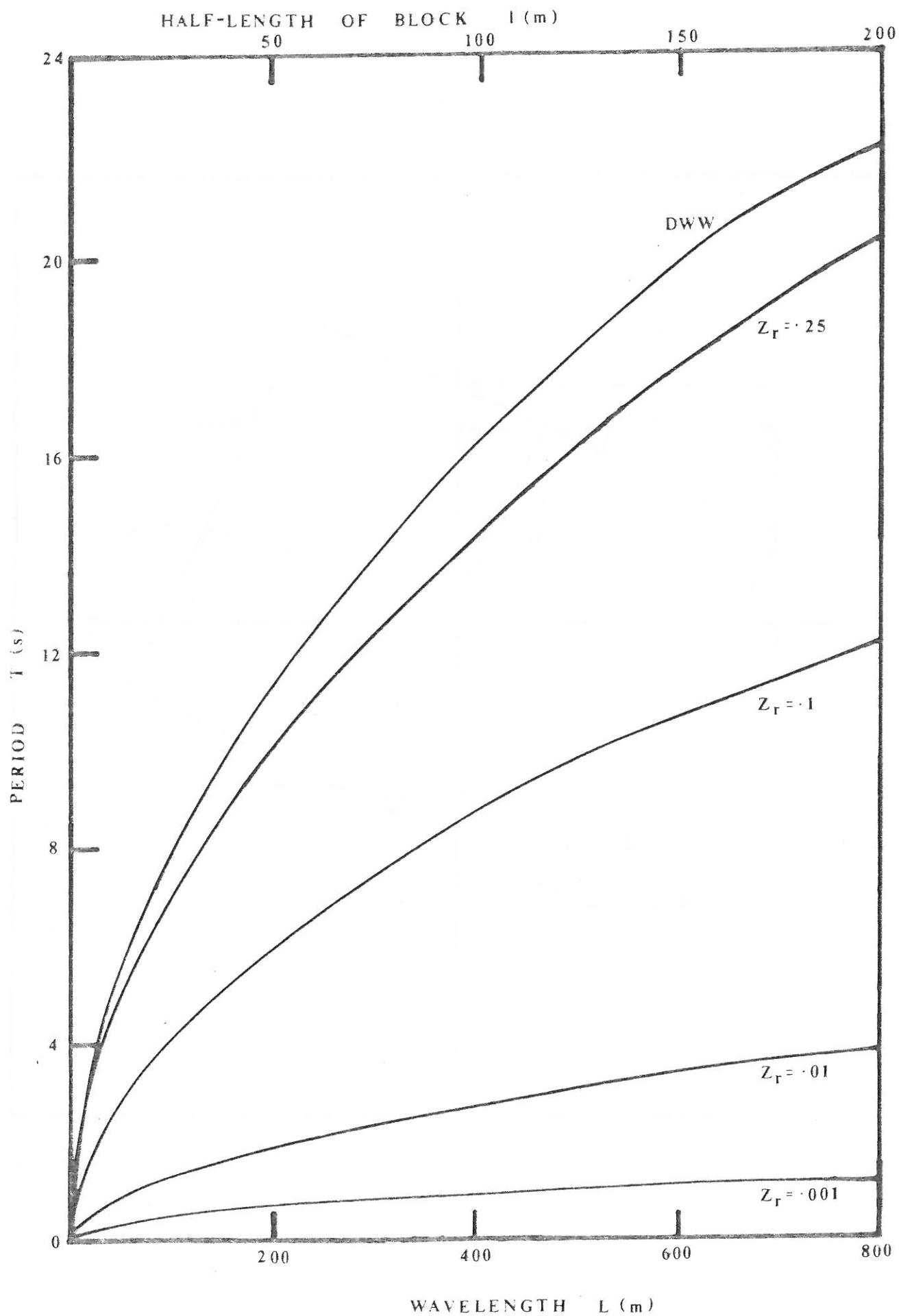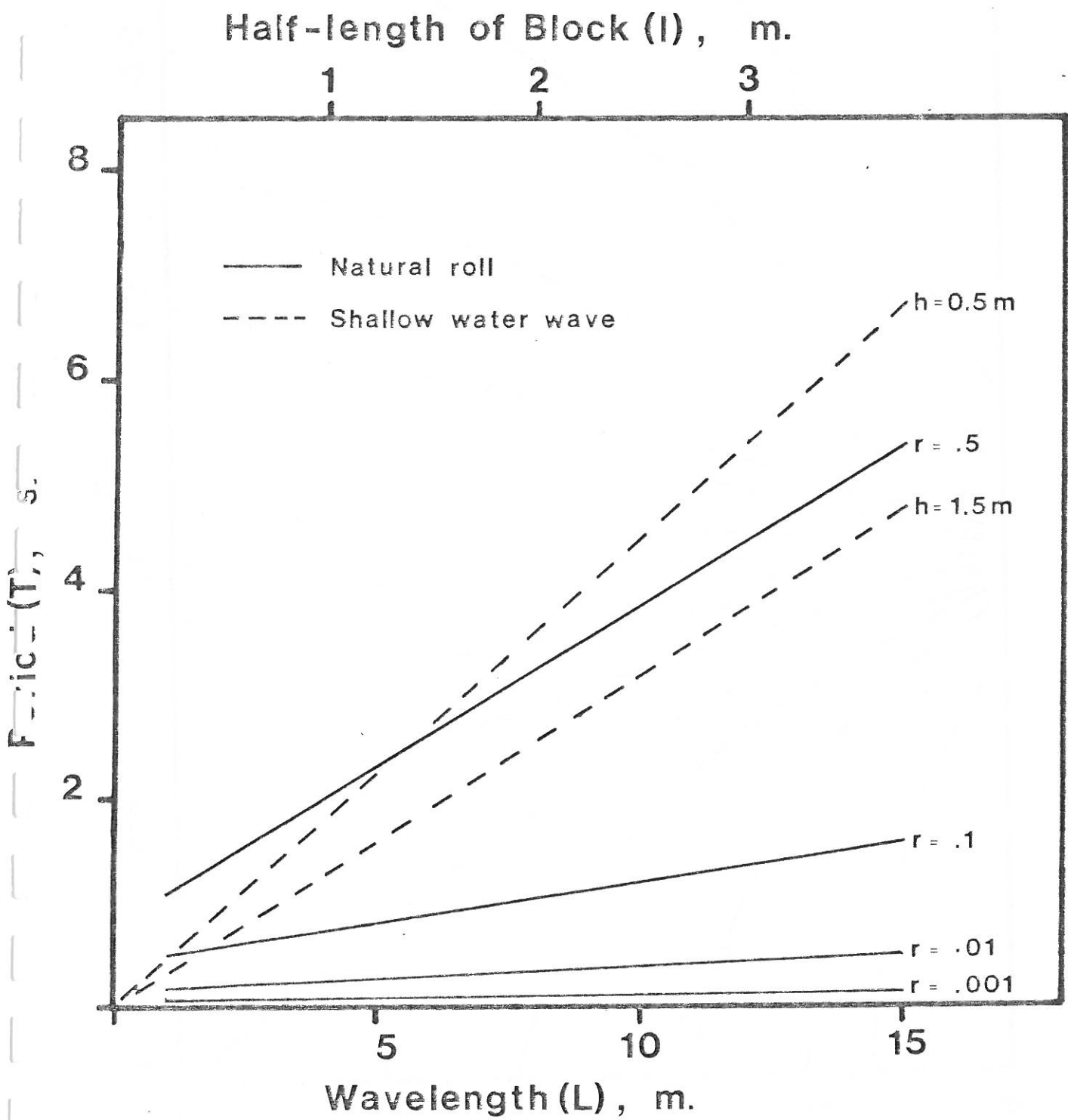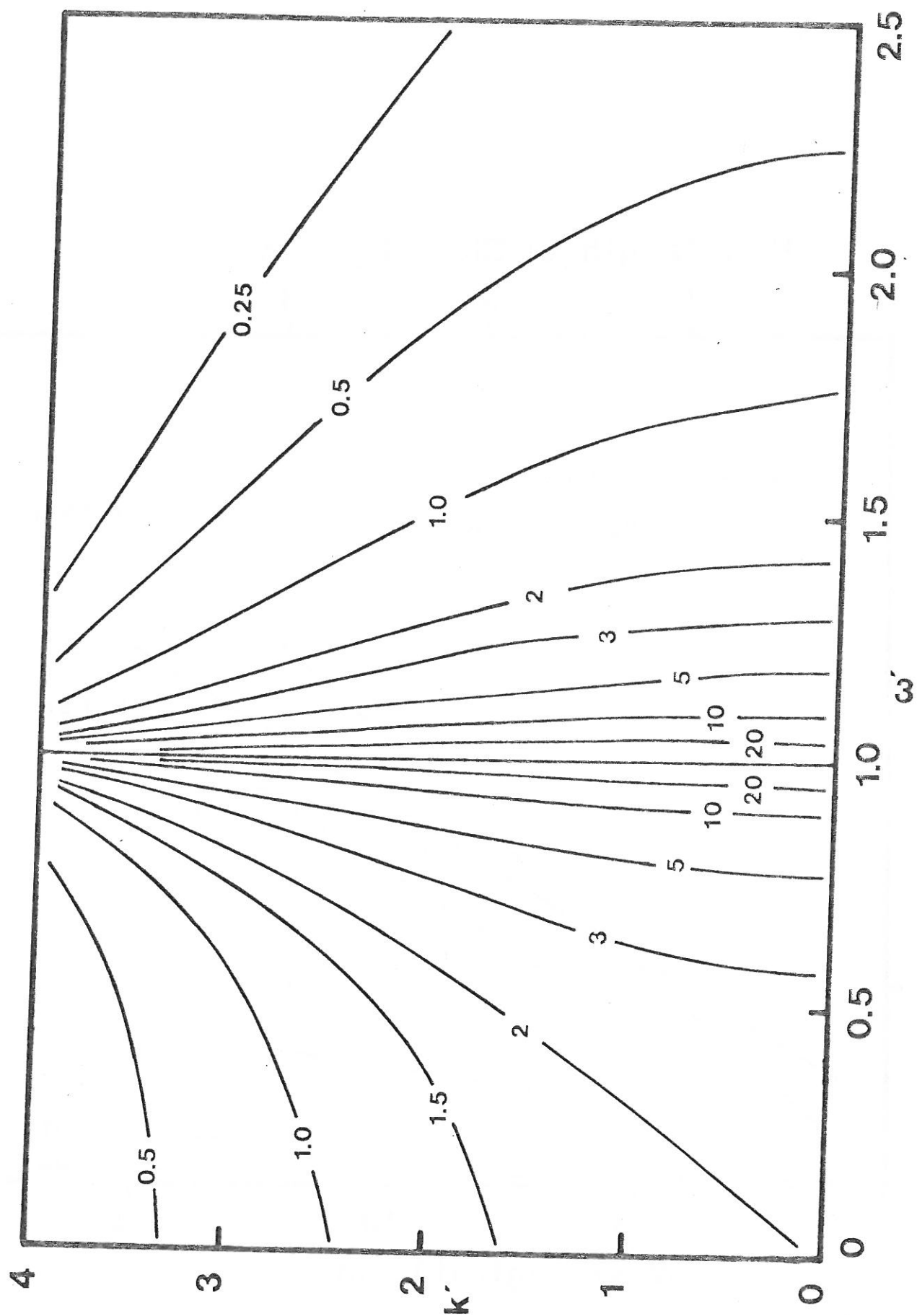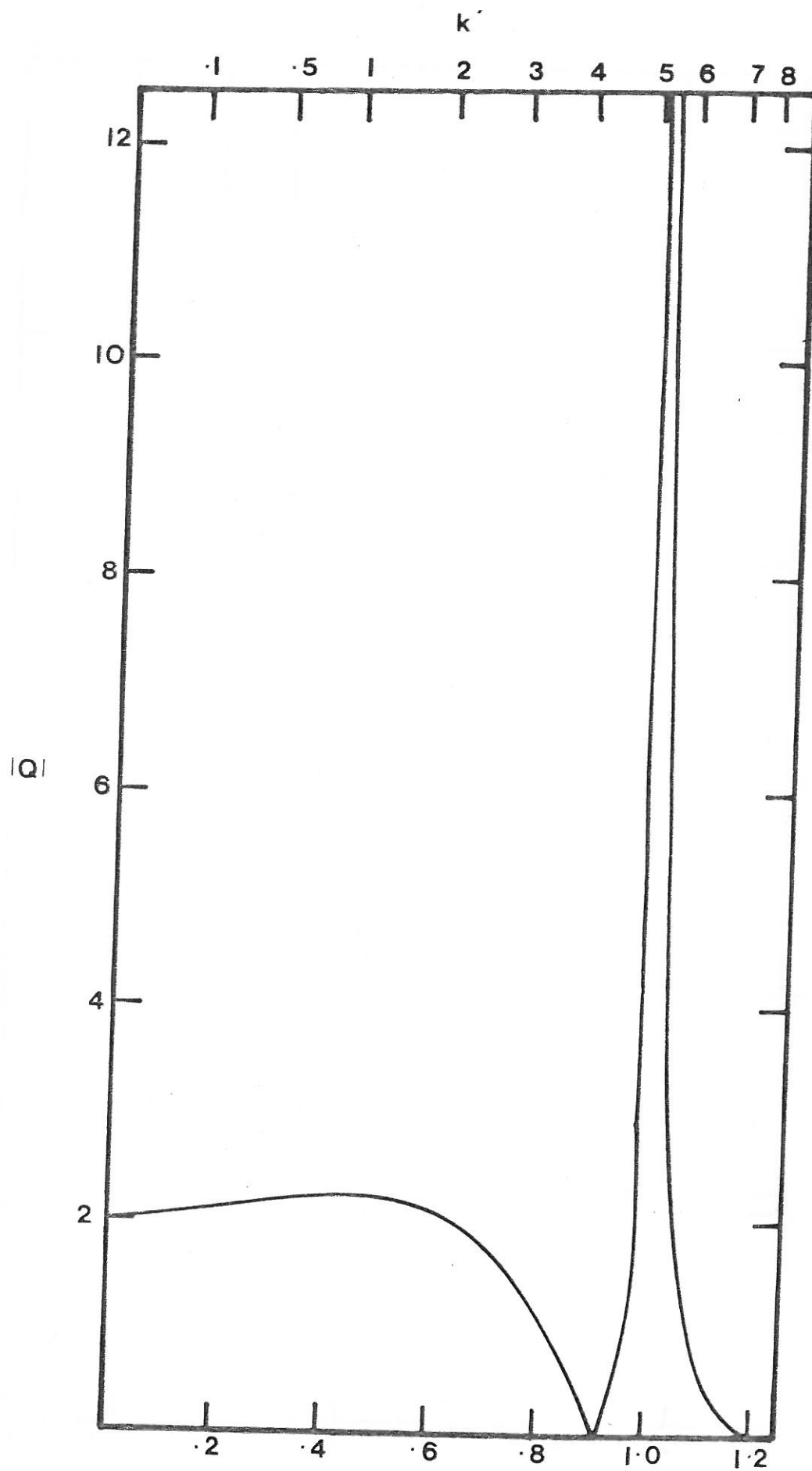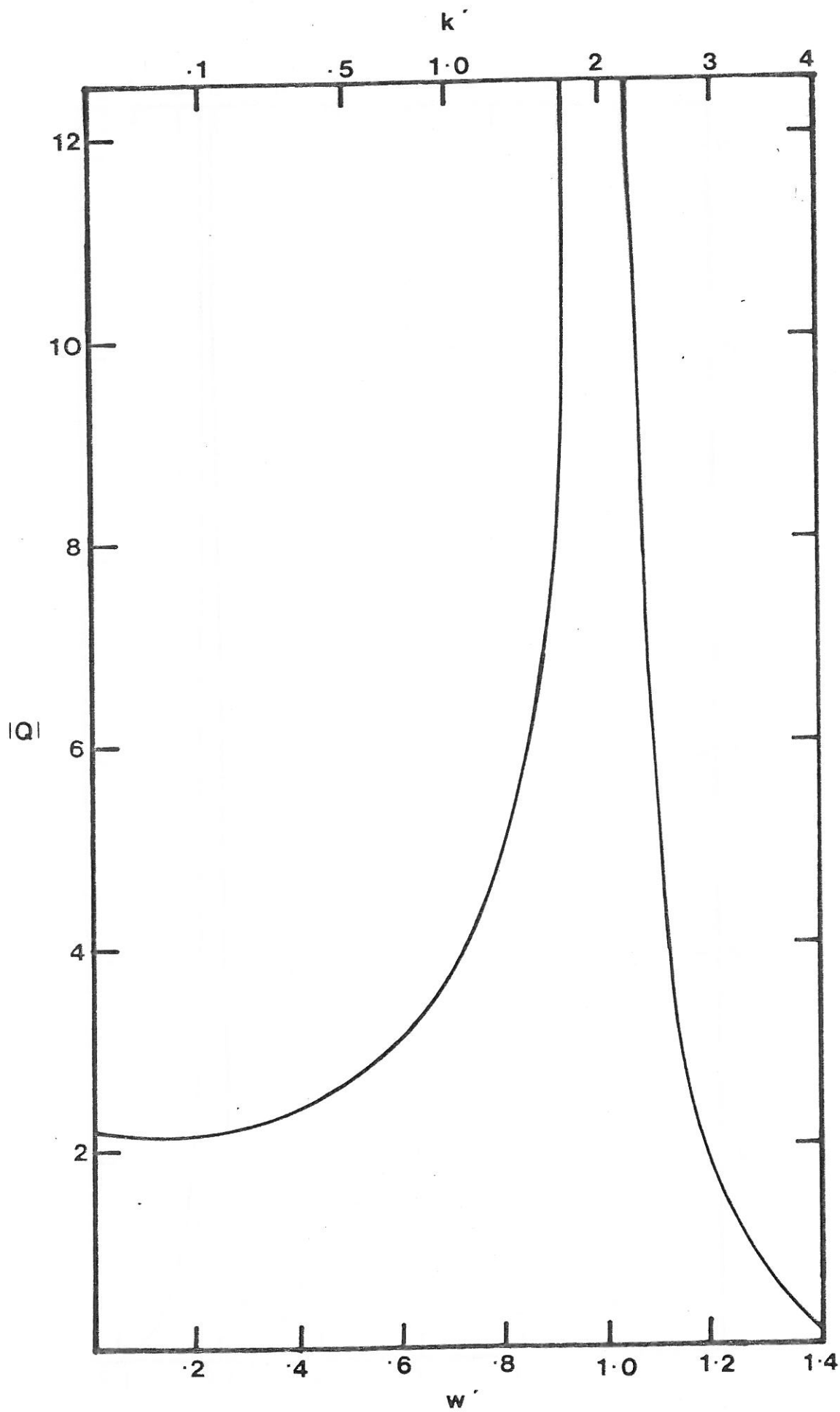
APPENDIX A:

THE INFLUENCE OF FETCH ON WHITECAP COVERAGE AS
DEDUCED FROM THE ALTE WESER LIGHT-STATION
OBSERVER'S LOG

Herein is reproduced the abstract that appears in publication 44 of Table 1.2, plus all of the captional figures which were used to illustrate the poster paper by E.C. Monahan and C.F. Monahan at the 1983 Whitecap Workshop.

Also included in this appendix are the further results obtained by Mr. Peter J. Mohr and Mr. David M. Doyle from the application of formal, statistical, curve-fitting procedures to these same data, with particular attention to the effects of atmospheric stability on whitecapping.

The Influence of Fetch on Whitecap Coverage
as Deduced from the Alte Weser Light-
station Observer's Log

by

E.C. Monahan and C.F. Monahan
University College, Galway.

Some 1500 visual observations of whitecapping as logged at
the Alte Weser Light-station offshore from Bremerhaven in the
period from September 1970 to May 1972 were made available by
Dr. H. Gienapp of the Deutsches Hydrographisches Institut.
Each observation included estimates of the fraction of the waves
with whitecaps (F), the average width of these whitecaps (B),
and the wavelength of the swell (L). The mean whitecap
coverage (W) for each observation was estimated using Eq. 1,
and each observation was

$$W = FBL^{-1} \qquad (1)$$

assigned a fetch category: infinite (azimuth 308°-340°),
131 observations; open North Sea (256°-308°, 340°-358°),
235 observations; limited (358°-053°, 247°-256°), 250
observations; or extreme limited (053°-247°), 831 observations.

Preliminary analysis of the 'infinite fetch' data yields a
whitecap-wind power-law relationship (Eq. 2) with

$$W_I(U) = \alpha_I U^{3.25} \qquad (2)$$

a wind-dependence similar to those obtained from the analysis
of whitecap photographs (Monahan and O'Muircheartaigh, 1980),
while the analysis of the 'extreme limited fetch' data shows
significantly lower whitecap coverage at the lower wind
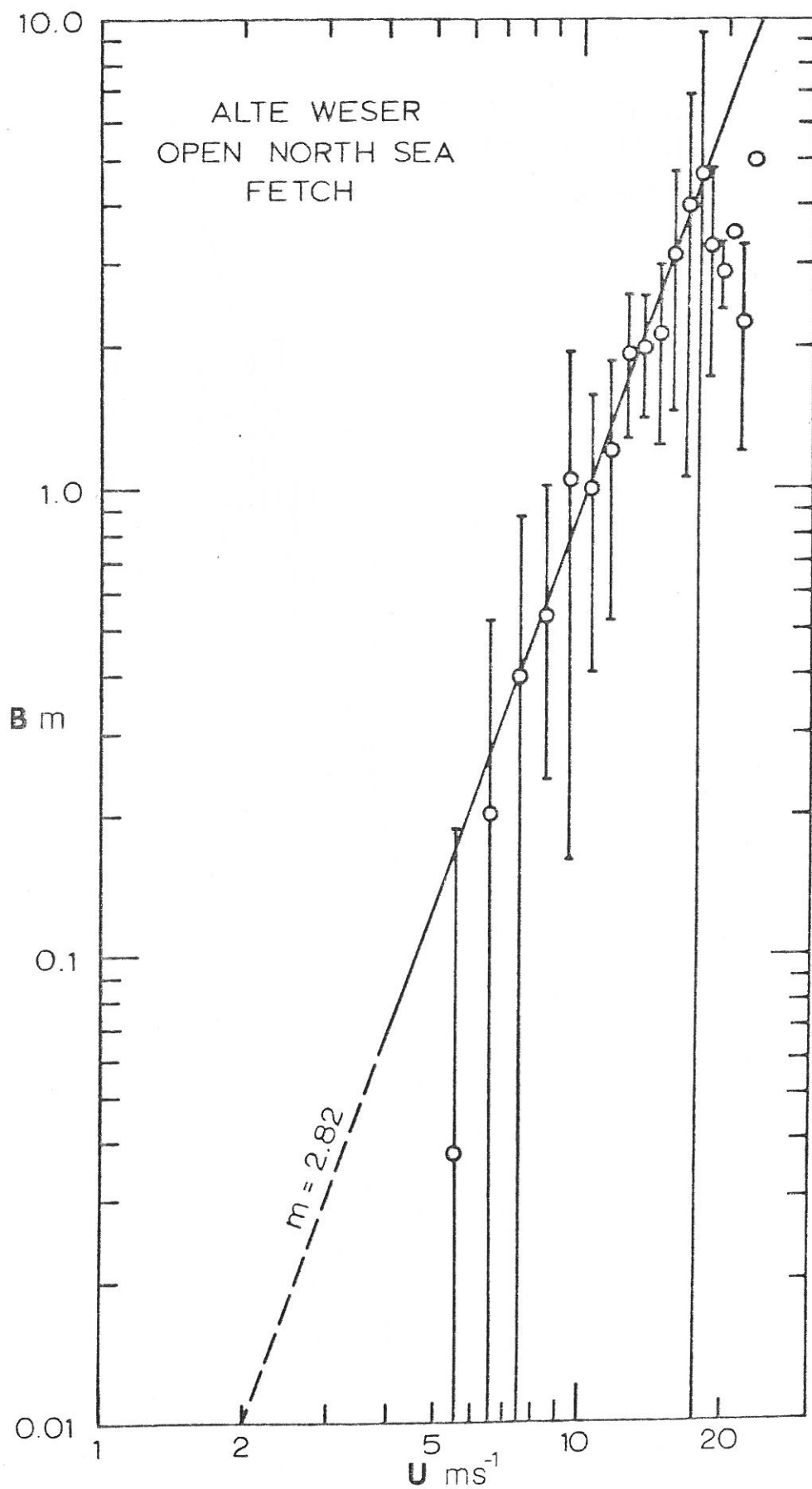speeds but comparable coverage at relatively high ($15 \mathrm{ms}^{-1}$)
winds (Eq. 3).

$$W_E = \alpha_E U^{4.16} \qquad (3)$$
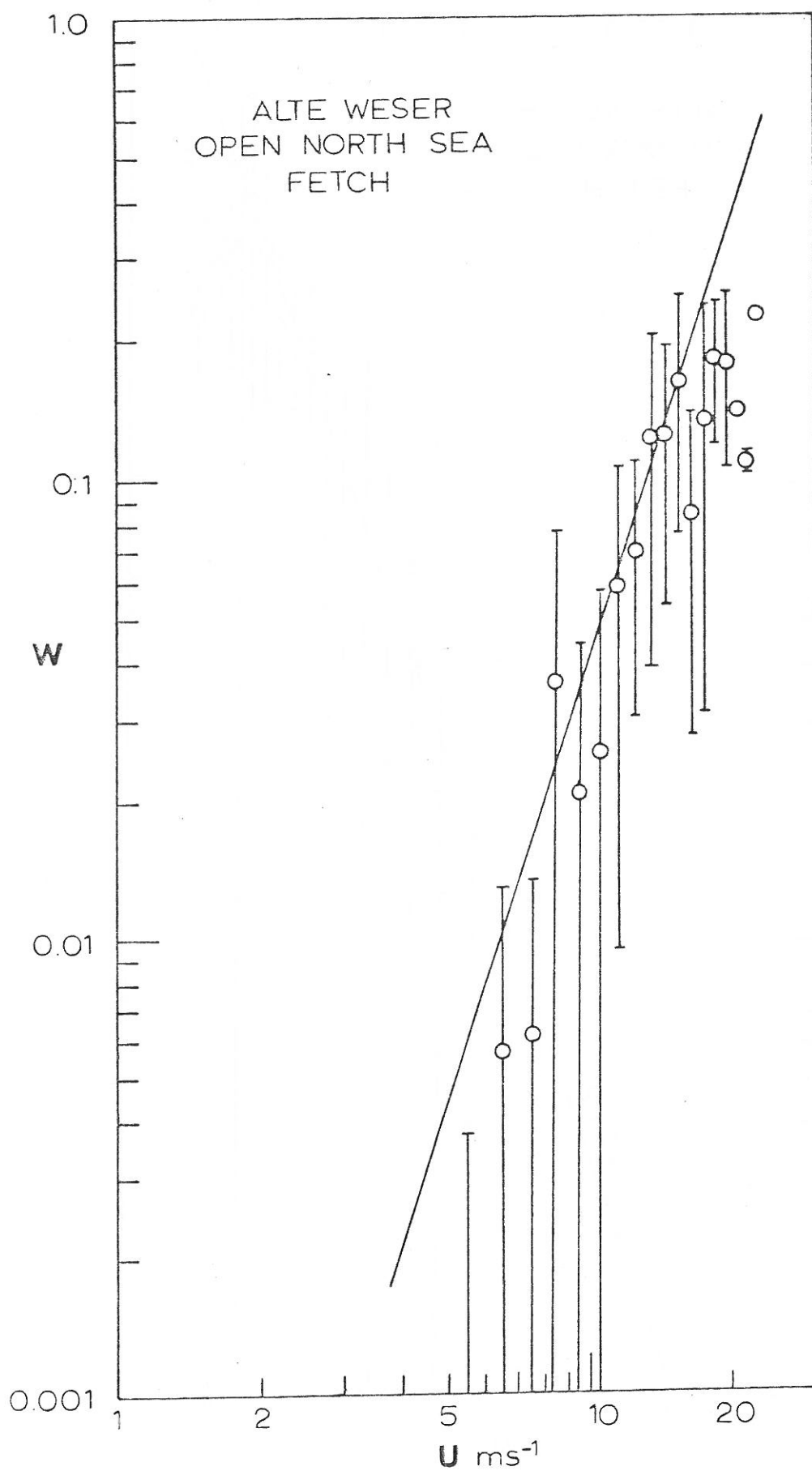
Figure 1: The fraction of waves bearing whitecaps versus wind speed, for conditions of extreme limited fetch.

Figure 2: The fraction of waves bearing whitecaps versus wind speed, for essentially infinite fetch conditions. While at high wind speeds (e.g., 20 ms^{-1}) F(infinite fetch) is comparable to F(extreme limited fetch), at lower wind speed (e.g., 5 ms^{-1}) F(infinite fetch) is markedly higher than F(extreme limited fetch).

Figure 3: The typical breadth of the whitecaps observed versus wind speed, for conditions of extreme limited fetch.

Figure 4: The typical breadth of the whitecaps observed versus wind speed, from observations taken when the wind was from the open North Sea. At all wind speeds, B(extreme limited fetch) is about 50%-60% of B(open North Sea).

Figure 5: Whitecap coverage, determined from W = FB/L, versus wind speed, for open North Sea fetch conditions.

Figure 6: Whitecap coverage versus wind speed, for extreme limited fetch conditions. Note strong dependence of whitecap coverage on wind speed: $W = \alpha U^{4.16}$

Figure 7: Whitecap coverage versus wind speed, for various fetch conditions (I, infinite; O, open North Sea; L, limited; and E, extreme limited). Note that at relatively low wind speeds W_E is much less than other W's, but at high wind speeds, e.g. 15ms^{-1}, all W's are comparable. Note also that W_I and W_O show a similar wind dependence to that of the W_{RBF} expression of Monahan and O'Muircheartaigh (1980), but that at any wind speed the value of W_I (or W_O) is 3 to 4 times as great as the value of W_{RBF} at that wind speed. This discrepancy probably reflects the observers' tendency to exaggerate when making visual estimates of such quantities. (The W_{RBF} expression was obtained by applying the technique of robust biweight fitting the W-values obtained from the analysis of photographic data.)
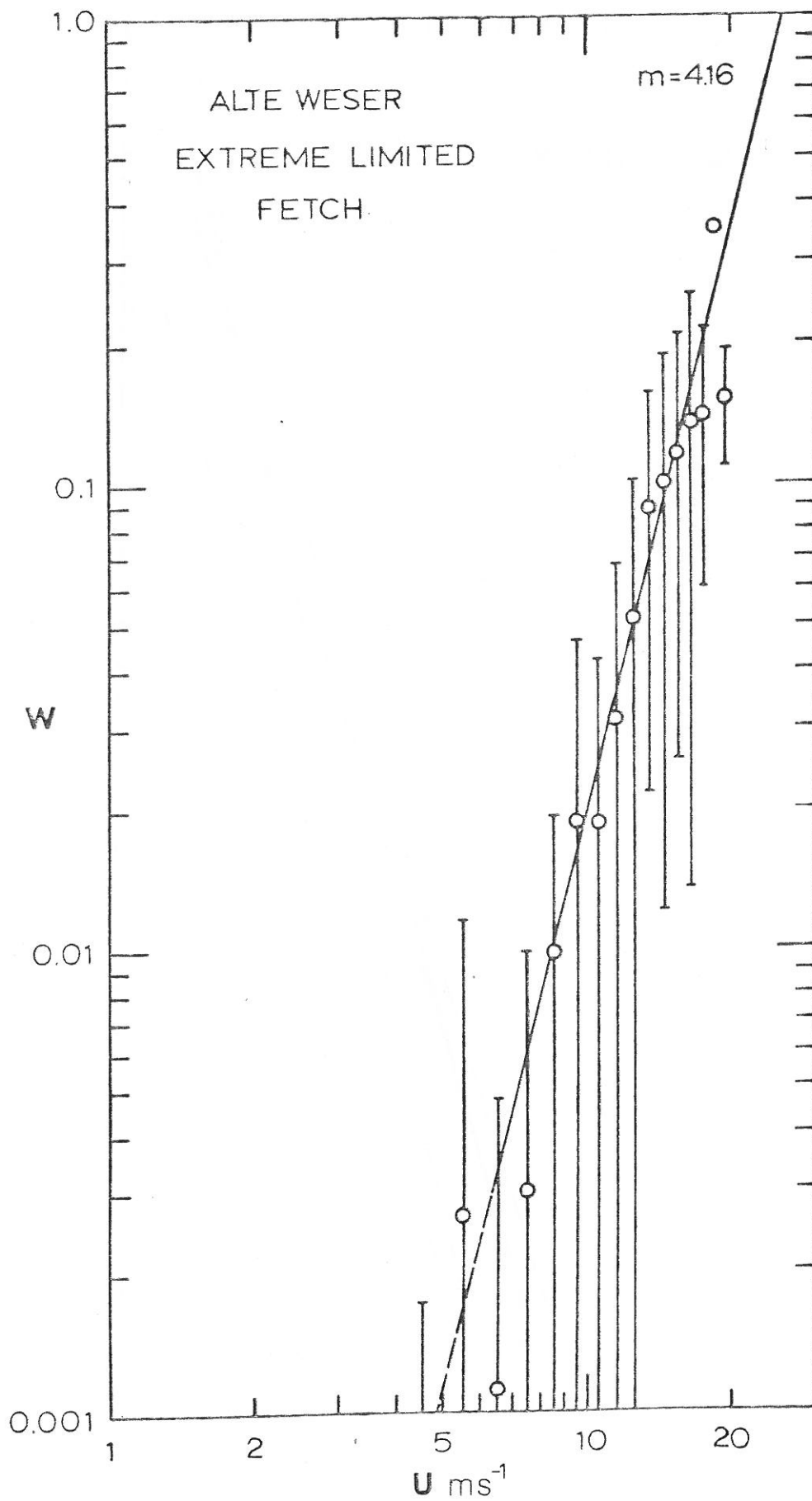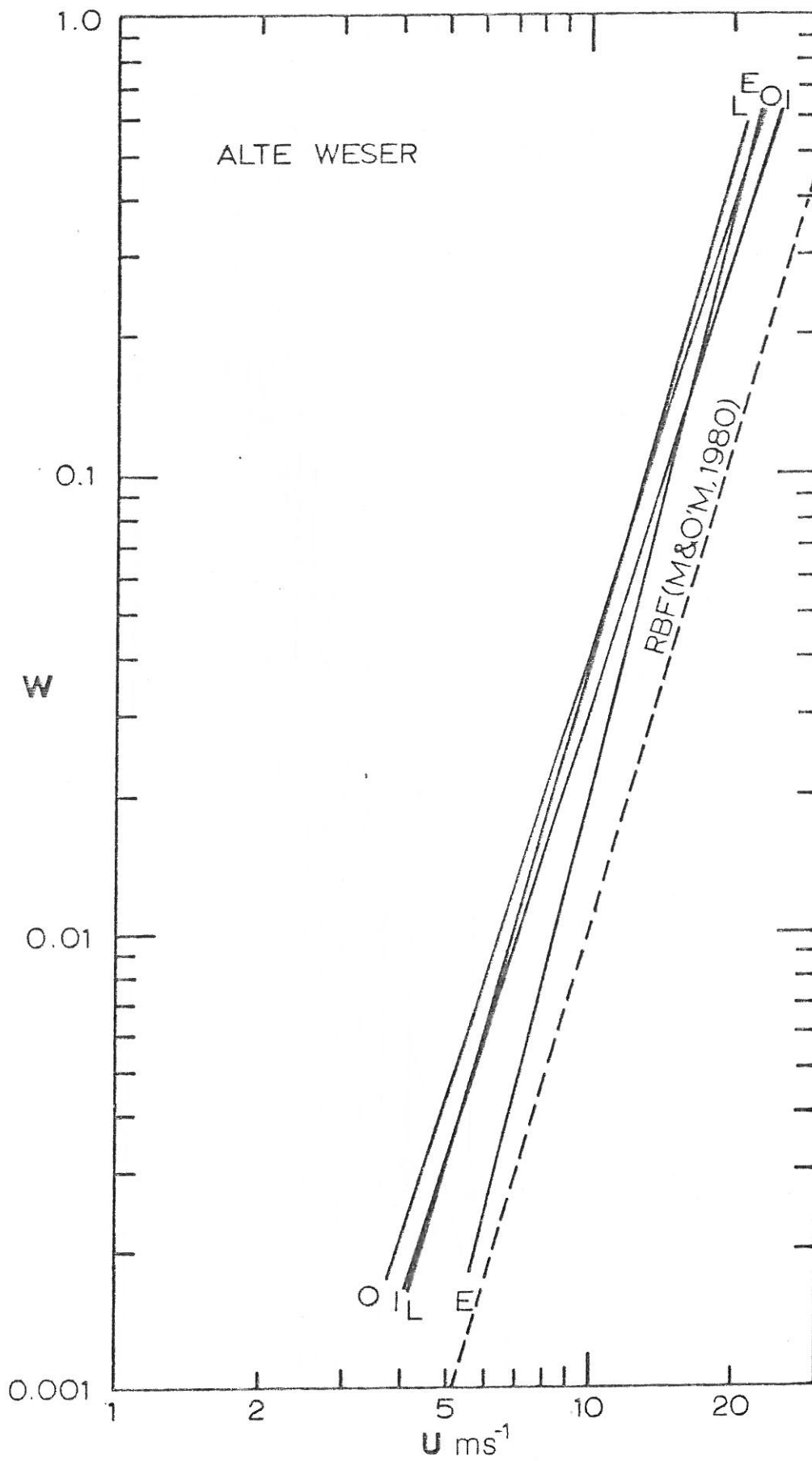
ALTE WESER

EXTREME LIMITED

FETCH

$m = 3.63$

ALTE WESER
INFINITE FETCH

m = 3.03

ALTE WESER
EXTREME LIMITED
FETCH

$m = 2.96$

ALTE WESER
OPEN NORTH SEA
FETCH

$m = 2.82$

B m

U ms^{-1}

ALTE WESER
OPEN NORTH SEA
FETCH

W

U ms⁻¹

ALTE WESER
EXTREME LIMITED
FETCH

$m = 4.16$

ALTE WESER

RBF(M&O M.1980)

W

U ms⁻¹
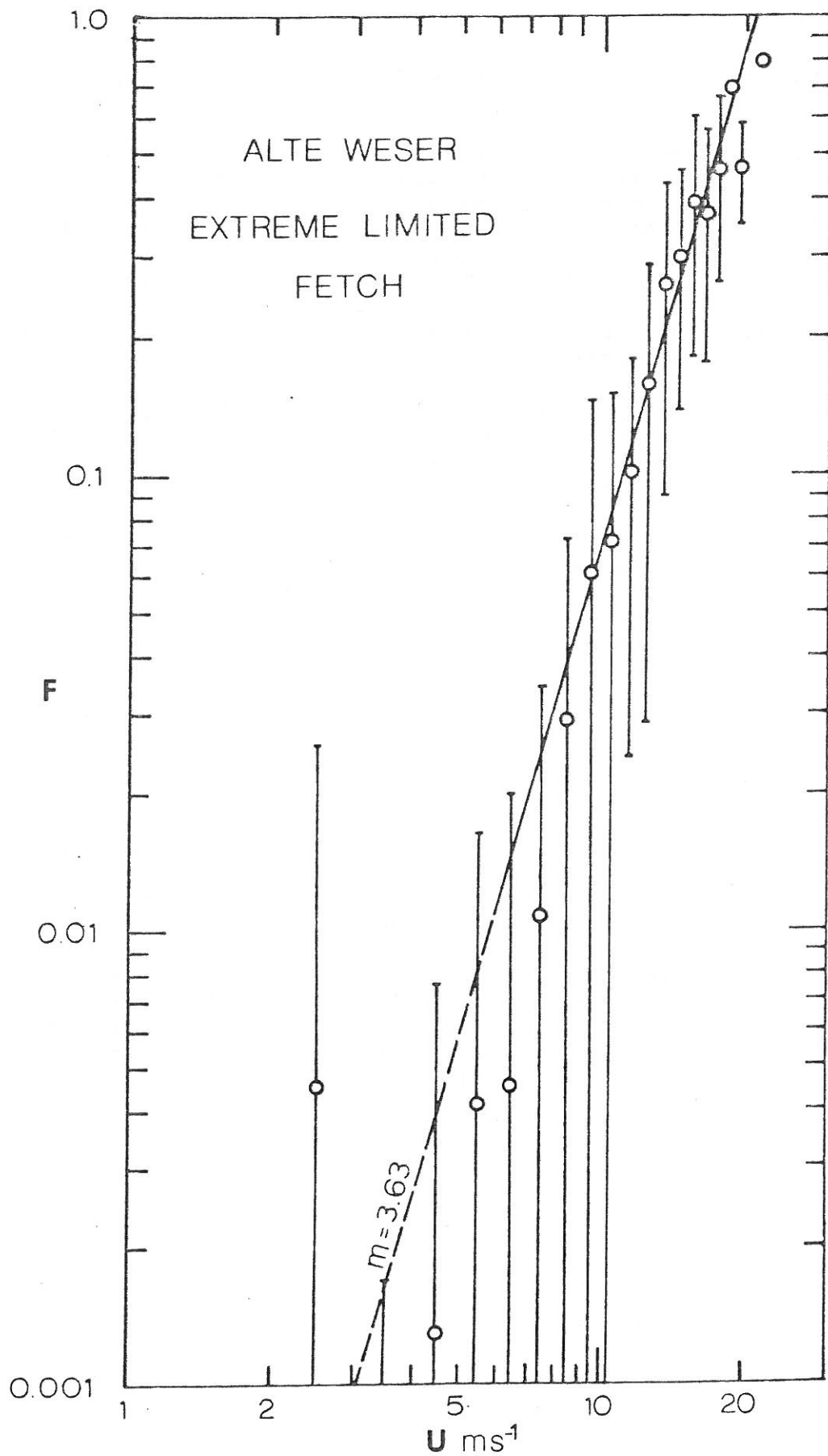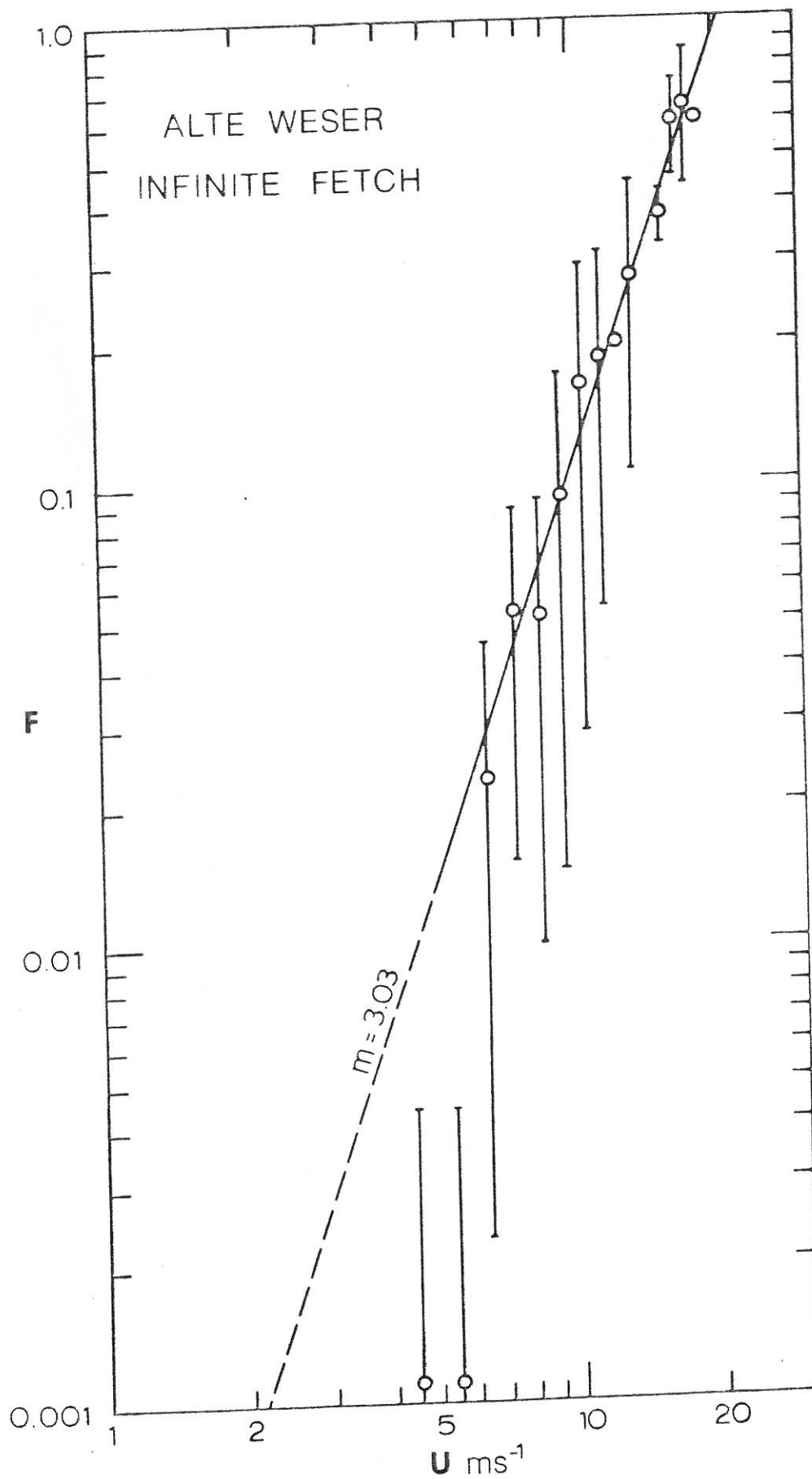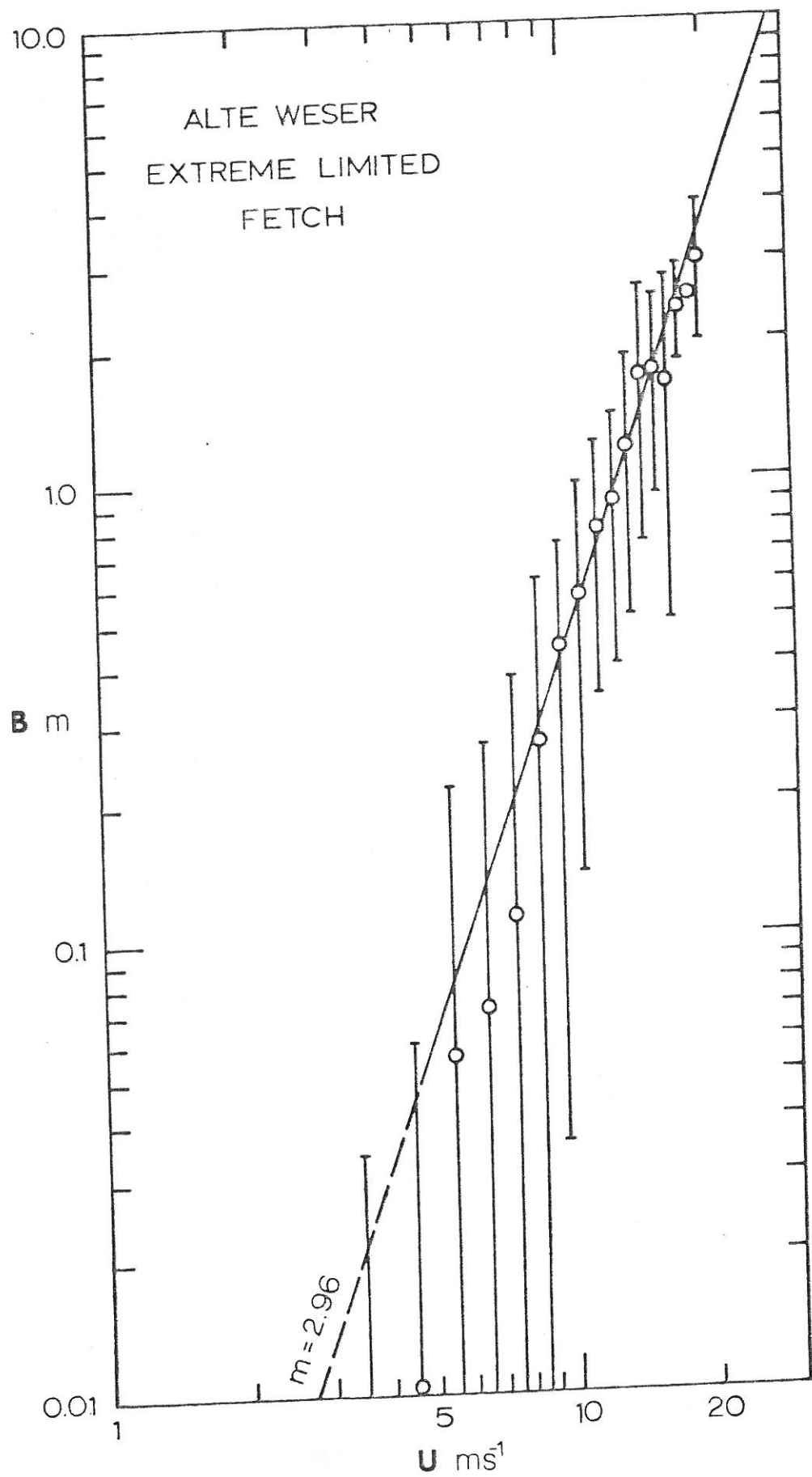
FETCH CATAGORIES

PLOT	EXTREME		LIMITED		OPEN		INFINITE		COMBINED	
	SLOPE	INTER	SLOPE	INTER	SLOPE	INTER	SLOPE	INTER	SLOPE	INTER
(STABLE)										
F(U)	2.268	-1.404	1.507	-0.548	3.188	-2.255	2.329	-1.335	2.328	-1.389
B(U)	1.286	-1.532	1.577	-1.714	1.852	-1.949	2.282	-2.335	1.674	-1.822
W(U)	2.394	-2.102	1.963	-1.703	3.704	-3.445	2.388	-2.098	2.764	-2.481
(NEUTRAL)										
F(U)	2.960	-2.077	1.387	-0.580	4.026	-3.313	1.995	-0.841	2.568	-1.636
B(U)	2.339	-2.675	1.399	-1.621	1.236	-1.231	1.267	-1.238	1.651	-1.815
W(U)	3.017	-2.866	2.841	-2.785	3.968	-3.775	2.585	-2.061	2.981	-2.735
(UNSTABLE)										
F(U)	1.450	-0.478	3.502	-2.298	2.031	-0.822	1.941	-0.622	2.192	-1.022
B(U)	0.983	-1.241	2.342	-2.424	2.398	-2.442	2.373	-2.245	1.956	-2.047
W(U)	1.200	-0.856	4.773	-4.230	2.930	-2.475	4.031	-3.493	2.714	-2.203
(COMBINED)										
F(U)	1.884	-0.954	2.386	-1.237	2.570	-1.543	2.368	-1.260	2.274	-1.247
B(U)	1.310	-1.564	1.870	-1.976	2.025	-2.106	2.023	-2.005	1.770	-1.901
W(U)	1.730	-1.420	3.221	-2.792	3.287	-2.955	2.948	-2.515	2.730	-2.365

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Open North Sea Fetch

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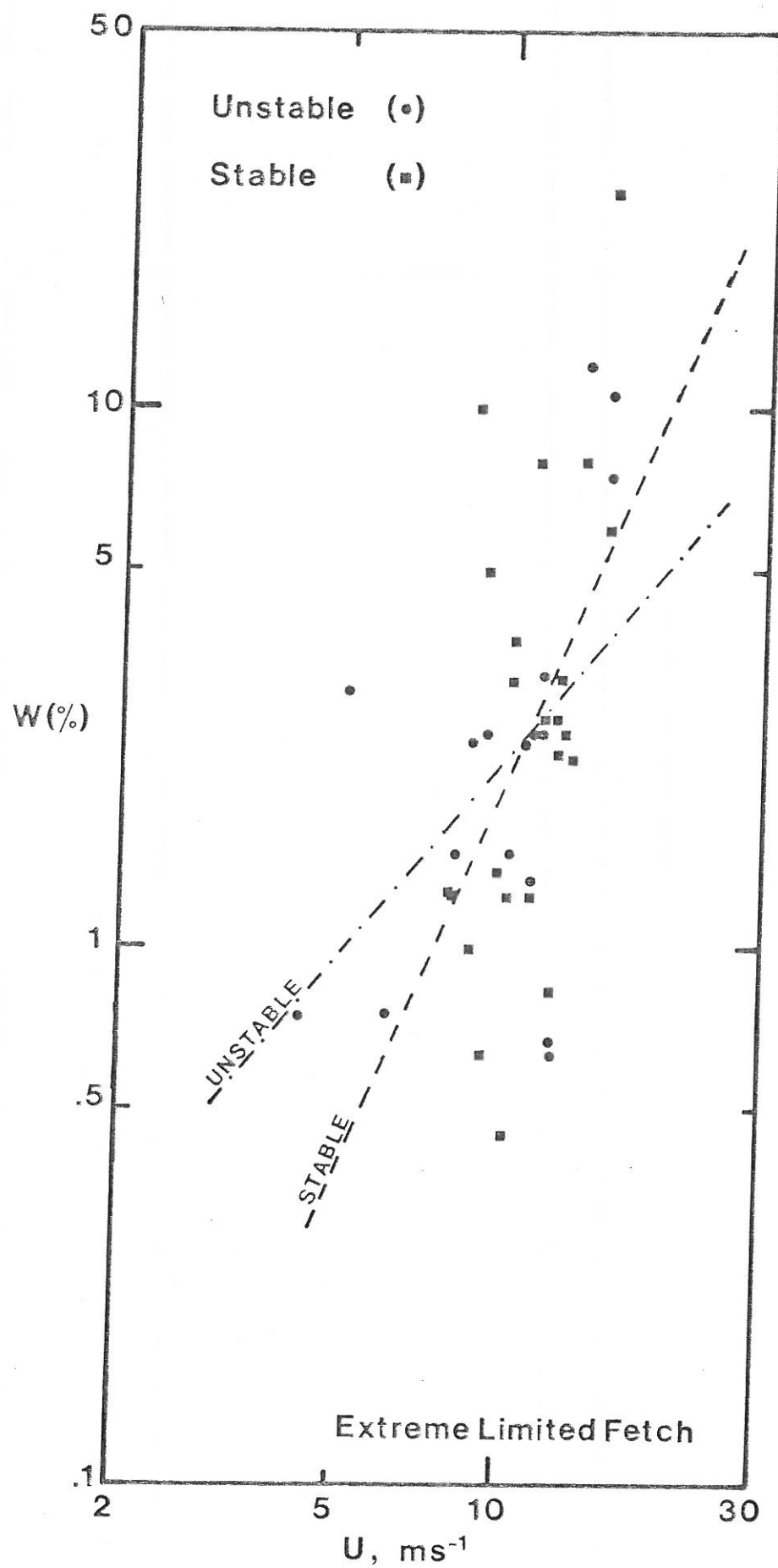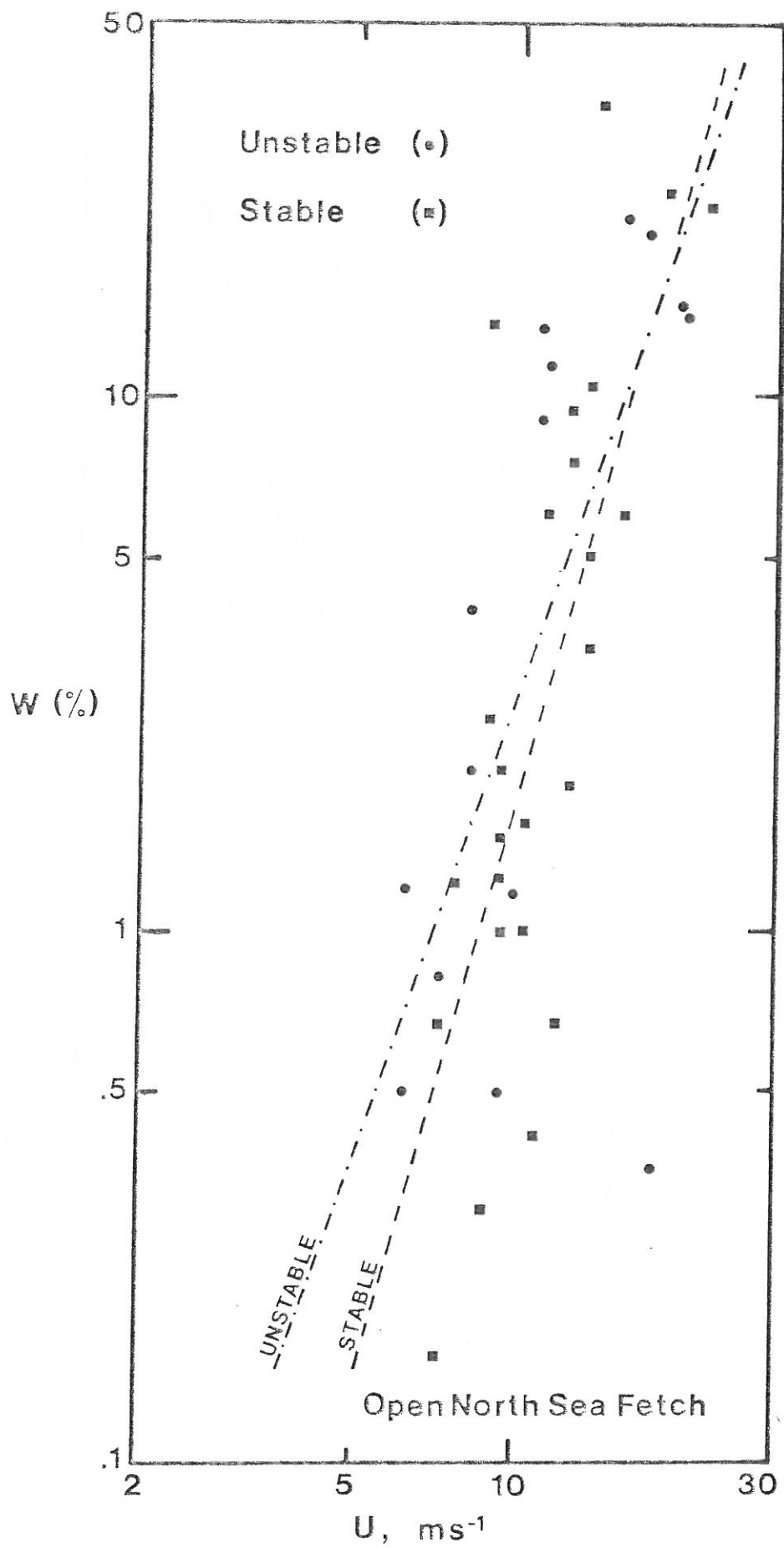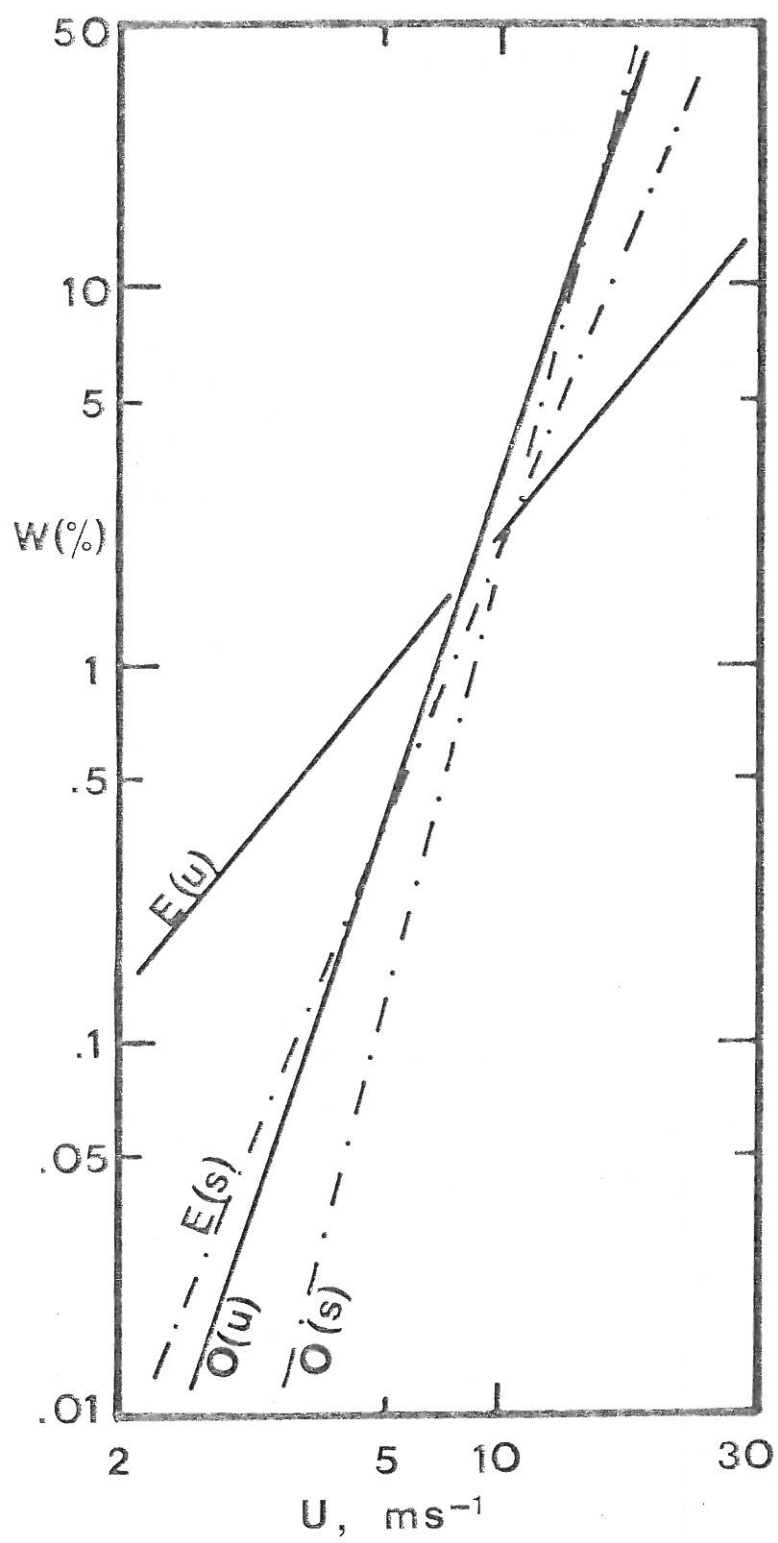
APPENDIX B:

ARCTIC WHITECAPPING: PRELIMINARY RESULTS

E.C. Monahan and P.A. Bowyer

Reproduced in this appendix is the separate (publication
47 of Table 1.2) prepared for the MIZEX Planning Meeting
held at the University of Miami Environmental Field
Station, Pigeon Key, Florida, in February 1984.

Arctic Whitecapping: Preliminary Results

by

E.C. Monahan and P.A. Bowyer

University College, Galway

Our motive for recording whitecap coverage of the sea at high latitudes, and particularly in the vicinity of the ice pack during MIZEX 83, was to extend the sea water temperature (Tw) range represented in our whitecap (W), windspeed (U) data file so that we could, by application of a suitable statistical methodology (e.g., O'Muircheartaigh and Monahan, 1983a), obtain an improved W,(U,Tw) expression. Our hypothesis when we undertook this study to determine the influence on W of Tw, as distinct from the influence of atmospheric thermal stability or the stability-related measure Ta-Tw (where Ta is the air temperature), was that W would decrease with increasing Tw. This hypothesis was based on the following assumptions:

1) For a given wind speed (and stability), that a uniform number of waves would break per unit area of sea surface per unit time, regardless of Tw.

2) That, for any Tw, the average breaking wave would entrain the same amount of air to the same depth.

and,

3) That the bubble spectrum resulting from wave breaking would be independent of Tw.

When assumptions 2 and 3 are combined with Blanchard's early observations (personal communication) which showed that for any given bubble size the rise velocity of the bubble increases significantly when there is a modest increase in Tw, the conclusion is reached that cold water whitecaps persist longer than warm water ones, since the whitecaps in cold water are replenished by bubbles from below for a longer period than are whitecaps in warm water. This conclusion, when taken together with assumptions 1 and 2, leads directly to the aforementioned hypothesis.

We now have to hand the first, preliminary, results from the analysis of some of the MIZEX 83 whitecap photographs. While the preliminary results shown in Figure 1 are based on the work of only one analyst (M. Higgins), and ignore the influence of stability and fetch, they have already, when considered in conjunction with some of our recent whitecap simulation tank findings, caused us to drastically revise our working hypothesis: When the points on Figure 1 are compared with the solid W(U) curve (Monahan and O'Muircheartaigh, 1980, Equation 5) based on the warm ocean observations reported in Toba and Chaen (1973) and Monahan (1971), or with the dashed curve

(O'Muircheartaigh and Monahan, 1983b, Equation 9) based on the relatively cool water (12.5^{O} - 14°C) JASIN whitecap observations (Monahan, et al, 1981), the suggestion arises that for a given U, W is less for cold seas than for warmer waters. Indeed, these preliminary MIZEX 83 low W results are reminiscent of the fresh water whitecap observations reported by Monahan (1969), even to the relatively high wind speed for the on-set of whitecapping, the Beaufort velocity discussed in O'Muircheartaigh and Monahan (1983b).

While these surprising initial MIZEX results were coming to light, some equally intriguing results were being obtained with the U.C.G. whitecap simulation tank. The amount of space charge produced during the decay of the whitecap formed by a 'standard' breaking wave in the tank was found to increase several fold as the temperature of the sea water in the tank was increased from 5° to 25°C (see Figure 5, Bowyer, 1983). This finding lent itself to either of two explanations: either the space charge per aerosol droplet increases markedly with increases in Tw, or the number of droplets (particularly jet droplets in this context) produced per whitecap increases significantly with elevation of Tw. Subsequent experiments, in which a Royco Model 225/241 aerosol particle counter was used to measure the number of droplets injected into the hood of the tank as a result of 'standard' breaking waves produced at various Tw's, showed that the actual number of jet droplets produced per breaking wave increases markedly with increasing Tw. While it has not yet been confirmed experimentally, it is probable that this increase in jet droplet production with increasing Tw is due to the fact that as Tw increases the number of bubbles increases and the bubble size spectrum peak shifts to smaller bubble radius, probably as a result of reduced viscosity. (Smaller bubbles are much more efficient generators of jet droplets as was shown by Blanchard, 1963).

If this interpretation of the tank results is correct, then assumption 3 (and perhaps also assumption 2) listed at the outset of this note is wrong. We thus are left with a new working hypothesis: that cold water whitecaps persist for briefer periods of time than warm water whitecaps because, in spite of the greater viscosity of the cold water, the larger bubbles that replenish the cold water whitecaps reach the surface sooner than the small bubbles that sustain the warm water whitecaps. A concomitant of this hypothesis is that for the same U, W is less in cold seas than in warm. Indeed, this argument is essentially the same as regards the effect of bubble spectra on W(U) as that put forth to explain the relatively low W-values observed on the North American Great Lakes as compared to the W-values obtained from oceanic observations (Monahan and Zietlow, 1969; Monahan, 1971).

We hope shortly to use a video area analyser in conjunction with our MIZEX 83 whitecap tapes to test this new hypothesis as regards the short lifetimes of cold sea whitecaps. We look forward to

collecting during MIZEX 84 additional video and photographic records that will enable us to refine the W(U,Tw) expression that we will initially base on the MIZEX 83, STREX (Doyle, 1984), JASIN, and BOMEX whitecap observations. The resulting W(U,Tw) expression can then be introduced into our sea surface aerosol generation model (Monahan, et al; 1982, 1983a), and the improved model can be used to obtain revised estimates of global sea-to-air salt fluxes.

Acknowledgments

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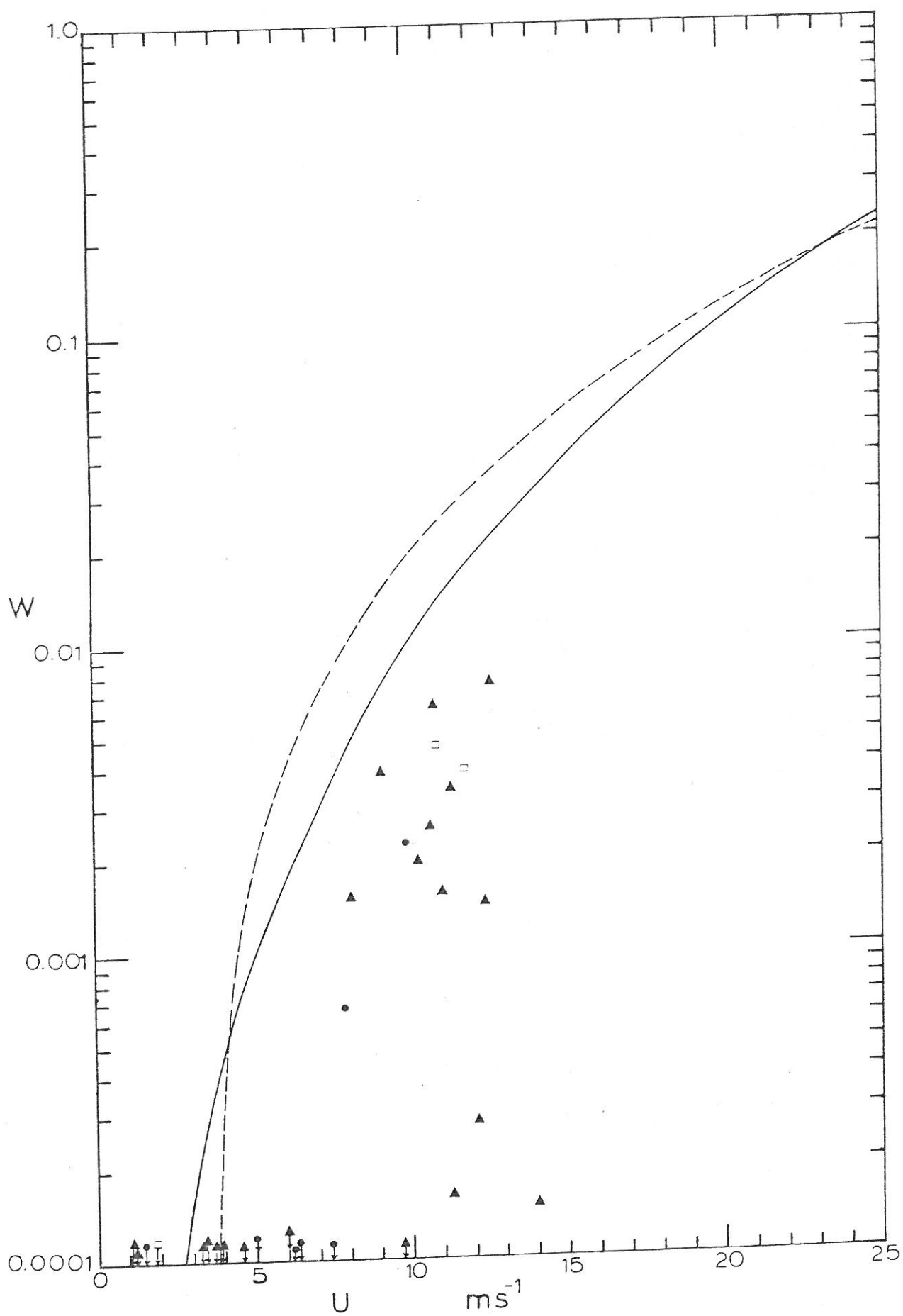
Figure 1. The fraction of the sea surface covered by whitecaps, W, versus the wind speed at 10m—elevation, U; preliminary results. Open squares, MIZEX 83 observations where $12.5^{O}C < T_w < 14.0^{O}C$. Filled triangles, where $5.0^{O}C < T_w \leq 12.5^{O}C$. Filled circles, where $T_w < 5.0^{O}C$. Each point based on the analysis of 8 to 22 photographs by M. Higgins. This preliminary figure based on the analysis of 346 photographs, out of some 1040, taken from F.S. POLARSTERN. The solid and dashed curves are described in the text. N.B. All those points near bottom of panel with downward pointing arrows have W-values less than 0.0001 (many correspond to intervals with no whitecaps).

APPENDIX C:

THE TEMPERATURE DEPENDENCE OF WHITECAP AEROSOL PRODUCTIVITY
AND THE IMPLICATIONS FOR REGIONAL SEA-AIR SALT FLUXES

E.C. Monahan, P.A. Bowyer, and M.C. Spillane

Included in this appendix are the abstract (publication 51 of
Table 1.2) of the paper presented at the European Geophysical
Society assembly in Louvain-La-Neuve, Belgium, on 1 August
1984, the table in which the results are summarised, and the
four figures which were used to illustrate this paper.

THE TEMPERATURE DEPENDENCE OF WHITECAP AEROSOL PRODUCTIVITY AND THE IMPLICATIONS FOR REGIONAL SEA-AIR SALT FLUXES

E.C. Monahan
P.A. Bowyer
M.C. Spillane (all at:University College, Galway, Ireland)

Earlier models used to estimate regional, and global, aerosol production via bursting whitecap bubbles were based on field observations of the wind dependence of whitecap coverage, and laboratory tank measurements of the aerosol particles produced by a decaying whitecap. Imbedded in these models was the implicit assumption that aerosol production is independent of water temperature. Recent results obtained with the UCG whitecap simulation tank show that the number of sea-water droplets injected into the lower atmosphere as a result of a standard breaking wave increases markedly with water temperature. This appears to be a consequence of a shift toward smaller radii of the whitecap bubble spectrum with increasing water temperature. This shift in the bubble spectrum with temperature is consistant with the laboratory findings of Pounder of UMIST, Manchester, and fits in well with the recent Arctic whitecap observations of the UCG group made during MIZEX 83. (The pronounced increase, with increasing temperature, in the electrostatic charge separation that results from a standard breaking wave, which was recently determined by P.A.B. using the UCG tank, is a consequence of the marked increase in jet drop production with increasing water temperature, an increase which results from there being many more small bubbles in the warmer whitecaps.) A new, temperature dependent model is here used to estimate the aerosol production for the various regions of the North Atlantic.

	Whitecap Area ($m2 \times 10^{-11}$)	Salt Mass Flux ($kg/s \times 10^{-4}$)		Water Mass Flux ($kg/s \times 10^{-5}$)		Droplet Area Flux ($m2/s \times 10^{-8}$)	
		A	B	A	B	A	B
January	3.53	1.30	0.98	3.70	2.79	1.72	1.30
February	3.36	1.24	0.90	3.52	2.57	1.64	1.19
March	2.89	1.06	0.78	3.03	2.23	1.41	1.04
April	1.78	0.65	0.51	1.86	1.45	0.87	0.67
May	1.43	0.52	0.45	1.49	1.28	0.69	0.59
June	1.14	0.42	0.39	1.19	1.11	0.56	0.52
July	0.99	0.36	0.37	1.04	1.06	0.48	0.49
August	1.03	0.38	0.39	1.08	1.12	0.50	0.52
September	1.34	0.49	0.48	1.40	1.38	0.65	0.64
October	2.16	0.79	0.71	2.26	2.04	1.05	0.95
November	2.78	1.02	0.86	2.91	2.46	1.35	1.14
December	3.21	1.18	0.94	3.37	2.67	1.56	1.24
ANNUAL TOTALS :		2.47	2.04	7.04	5.81	3.27	2.70
		$\times 10^{11}$ kg		$\times 10^{12}$ kg		$\times 10^{15}$ m2	

TABLE   : Seasonal cycle of climatological estimates of whitecap
coverage and fluxes of mass and particle surface area from
a region of the North Atlantic. The uncorrected values (in
columns headed A) are obtained as described in Spillane et al.
(1983). Temperature corrections (giving columns headed B) are
applied as a multiplicative factor to the integrated flux
expressions for bubble-injected aerosol particles whose 80%
relative humidity radii are in the range 0.8 to 10 microns.

FIGURES

1) Chart of North Atlantic showing the region over which the whitecap coverage and fluxes are integrated to produce the uncorrected and temperature correct results of the table, Also shown are the discrete locations at which the seasonal cycle is produced in Fig. 4.

2) Seasonal cycle of whitecap coverage for the selected region of the North Atlantic.

3) Seasonal cycle of sea surface temperature for the selected region.

4) Seasonal cycle in uncorrected and temperature corrected seawater flux for selected posions on the meriadian 35°W as follows :   1 : 55°N , 2 : 45°N , 3 : 35°N , 4 : 25°N and 5 : 15°N.
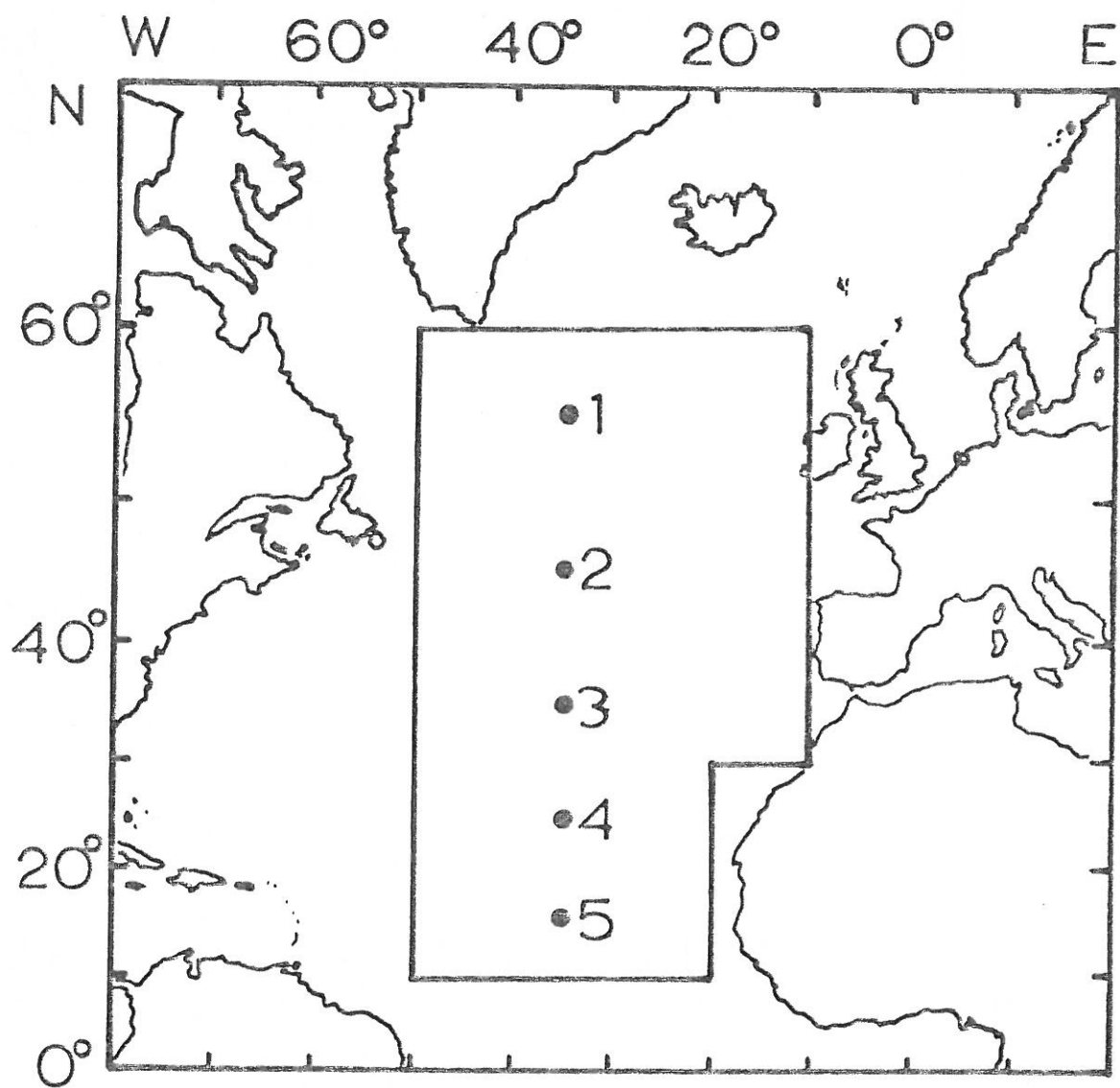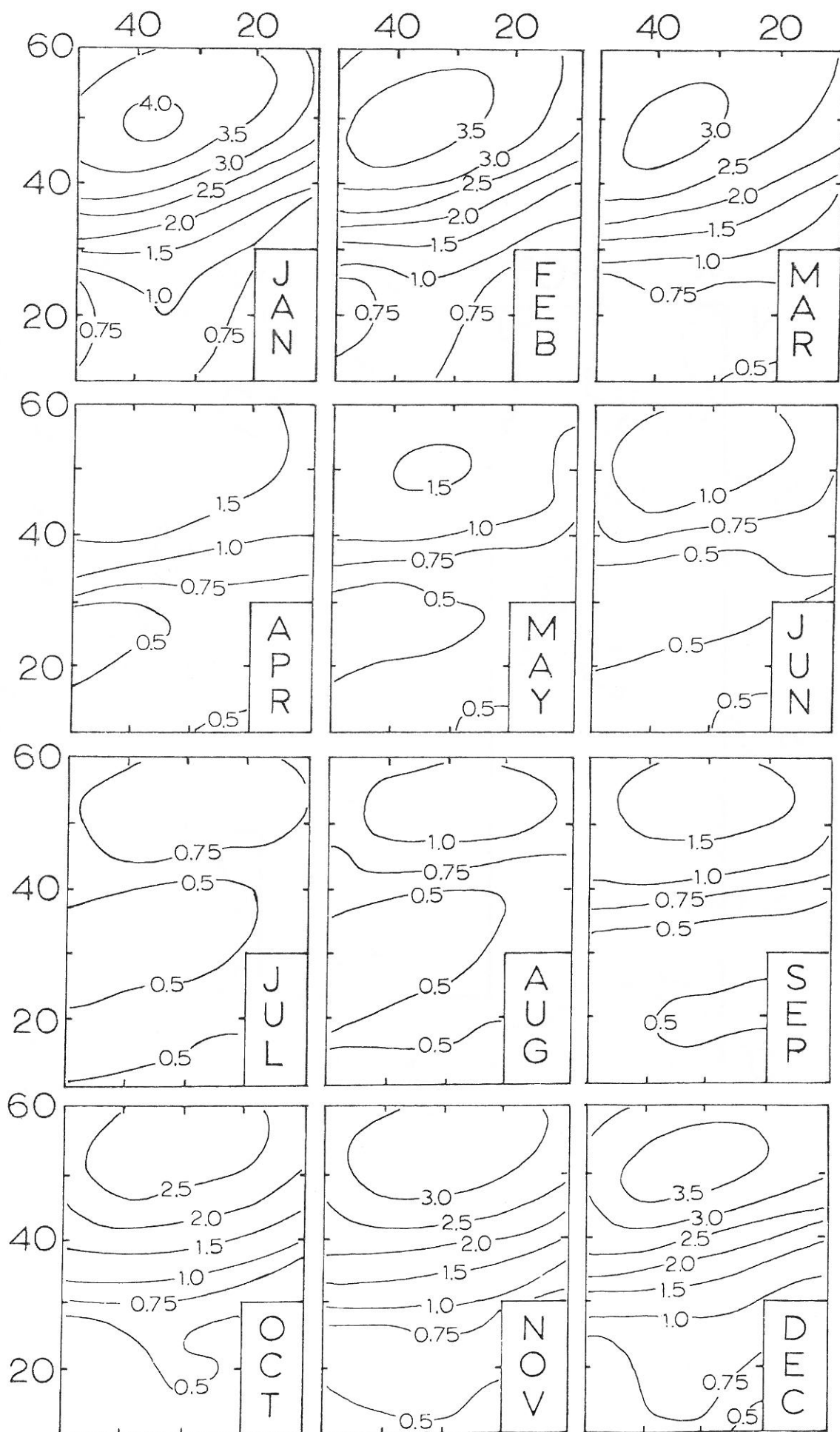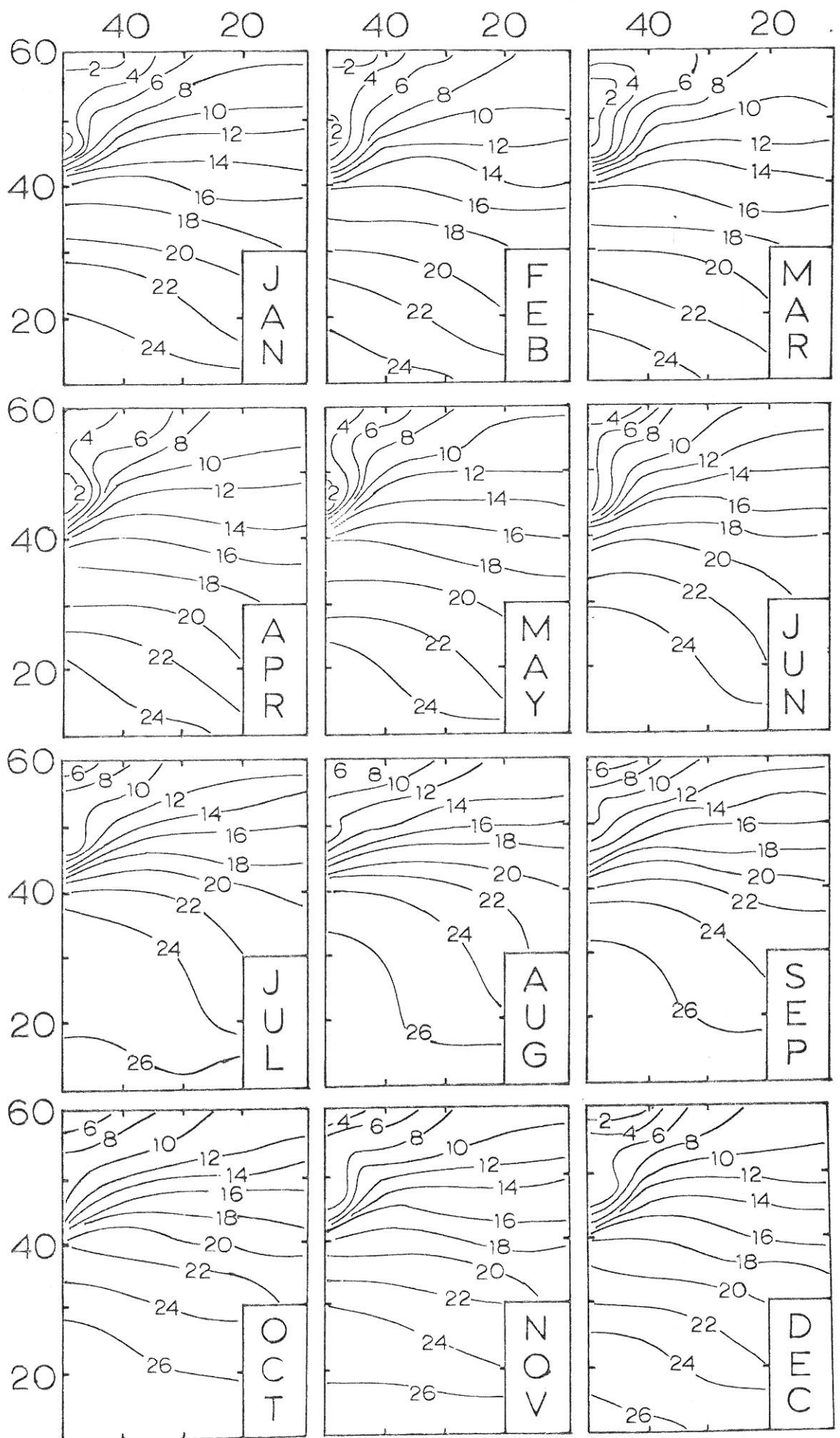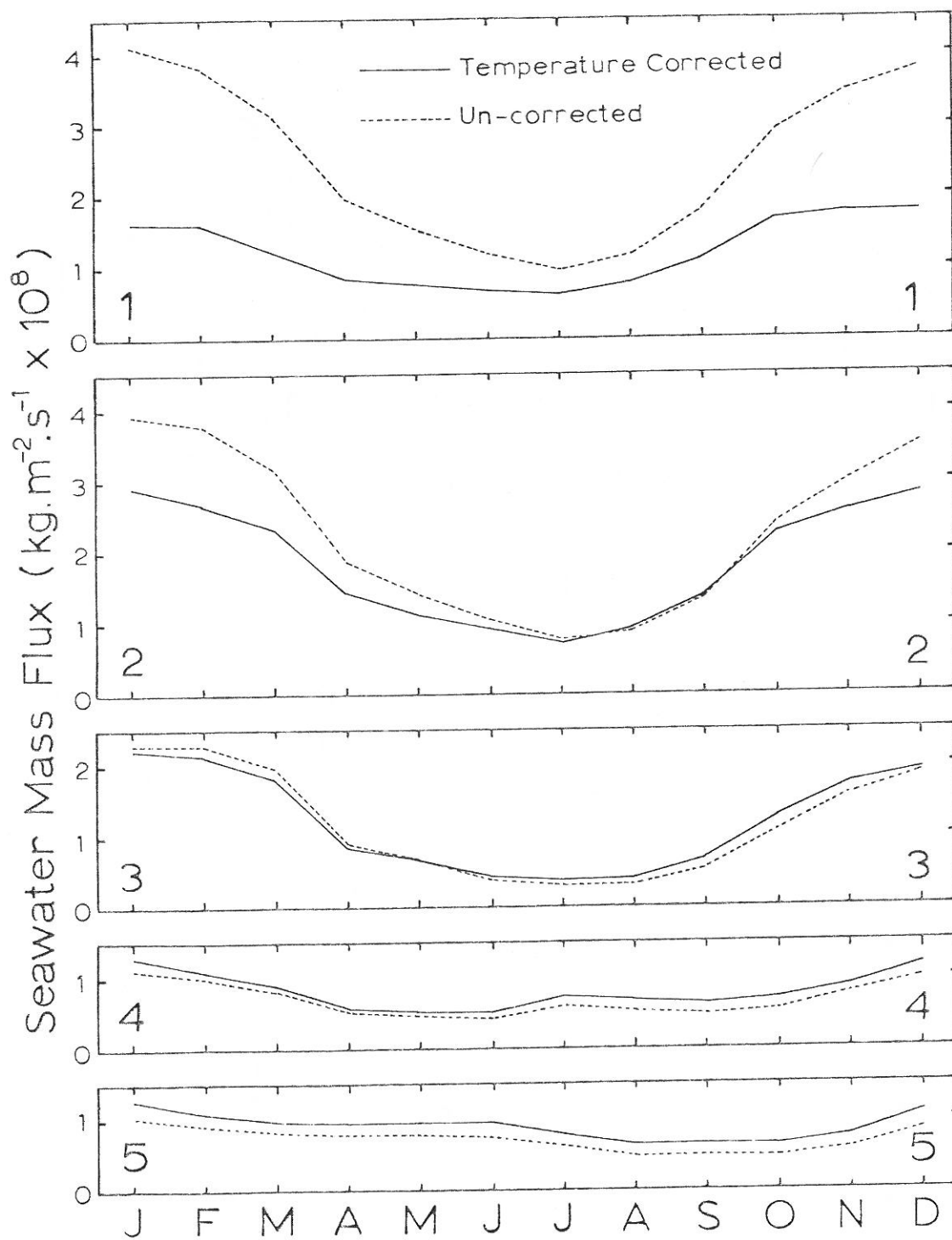
APPENDIX D:

TABLE OF RESULTS FROM MANUAL PHOTO-ANALYSES

OF WHITECAP PHOTOGRAPHS

by

M.C. Spillane

The following is a copy of the computer file WTCAP.DAT maintained in the directory OCE.SPILLANE. The data come from four sources, and are labelled as such in column 1 to facilitate sorting.

1) Data previously referred to as MON71
2) Data reported by Toba & Chaen (TC73)
3) Data collected in the JASIN experiment
4) Data collected during the STREX experiment

The data are correct as of the end of March 1984, with the environmental values having the values used in the contribution by Spillane & Doyle in the 1983 Annual Report. Note that the data from group 2 have been truncated in some cases to the standard 4 significant figures maintained in the Monahan datasets. No standard deviations of whitecap coverage are available for TC73 data. This fact is indicated by the missing data code "-99." in the last column. Some blank lines have been added to the following listing. These do not appear in the computer file.

Other columns are as follows:
  2 - Observation number
  3 - date of observation
  4 - no. of frames analysed by each of the several analysts
  5 - wind speed in metres/second
  6 - water temperature in $^{\circ}$C
  7 - temperature difference (water minus air)
  8 - thermal stability category
  9 - fractional whitecap coverage, mean of all analyses
  10 - standard deviation of whitecap coverage estimates

1	256	7-10-68	10,10,10,10	5.4	23.85	0.55	N	0.0000	0.0000
1	257	7-12-68	12,12,12,12	1.2	20.90	2.00	U	0.0000	0.0000
1	9272	8-13-68	10,10,10,10	5.4	21.60	0.50	N	0.0000	0.0000
1	9273	8-16-68	10,10,10,10	3.9	19.10	2.10	U	0.0005	0.0003
1	9274	8-16-68	20,20,20,20	2.8	20.60	1.00	U	0.0000	0.0000
1	9275	8-16-68	20,20,20,20	1.2	21.20	1.80	U	0.0000	0.0000
1	9276	8-16-68	20,20,20,20	0.6	21.90	2.60	U	0.0000	0.0000
1	279	5- 2-69	5, 5, 5, 5	6.8	28.40	-0.20	N	0.0041	0.0012
1	280	5- 2-69	5, 5, 5, 5	6.4	28.30	0.00	N	0.0052	0.0014
1	281	5- 3-69	5, 5, 5, 5	6.6	28.00	0.20	N	0.0034	0.0009
1	282	5- 3-69	5, 5, 5, 5	5.5	28.40	-0.80	S	0.0019	0.0011
1	283	5- 4-69	5, 5, 5, 5	6.6	28.60	-0.60	S	0.0079	0.0013
1	284	5- 4-69	5, 5, 5, 5	6.1	28.60	0.00	N	0.0034	0.0015
1	285	5- 5-69	5, 5, 5, 5	7.3	28.30	-0.05	N	0.0050	0.0022
1	286	5- 5-69	5, 5, 5, 5	6.8	28.60	-0.85	S	0.0040	0.0011
1	287	5- 6-69	5, 5, 5, 5	6.7	28.30	-0.85	S	0.0047	0.0007
1	288	5- 7-69	5, 5, 5, 5	6.4	28.30	-0.05	N	0.0012	0.0003
1	289	5- 9-69	5, 5, 5, 5	8.5	28.65	0.60	U	0.0093	0.0047
1	291	5- 9-69	5, 5, 5, 5	7.5	28.50	0.15	N	0.0044	0.0012
1	292	5- 9-69	5, 5, 5, 5	6.4	28.50	1.35	U	0.0036	0.0021
1	293	5-10-69	5, 5, 5, 5	6.1	28.45	0.40	N	0.0011	0.0003
1	294	5-10-69	5, 5, 5, 5	6.6	28.60	0.00	N	0.0042	0.0015
1	295	5-11-69	5, 5, 5, 5	6.3	28.80	-1.20	S	0.0020	0.0009
1	296	5-11-69	5, 5, 5, 5	5.8	28.40	0.05	N	0.0007	0.0003
1	297	5-12-69	5, 5, 5, 5	4.9	28.40	-0.95	S	0.0031	0.0005
1	298	5-12-69	5, 5, 5, 5	4.9	28.60	0.00	N	0.0015	0.0010
1	299	5-13-69	5, 5, 5, 5	6.9	28.10	-0.80	S	0.0075	0.0047
1	304	5-16-69	5, 5, 5, 5	7.3	28.50	-0.10	N	0.0036	0.0011
1	305	5-16-69	5, 5, 5, 5	4.1	28.50	0.45	N	0.0012	0.0001
1	306	5-17-69	5, 5, 5, 5	7.9	28.50	-2.35	S	0.0100	0.0008
1	307	5-17-69	5, 5, 5, 5	8.5	28.50	0.15	N	0.0029	0.0002
1	308	5-18-69	5, 5, 5, 5	9.0	28.50	-1.10	S	0.0225	0.0017
1	309	5-18-69	5, 5, 5, 5	8.5	28.50	-0.65	S	0.0165	0.0032
1	311	5-18-69	5, 5, 5, 5	8.0	28.50	0.45	N	0.0092	0.0031
1	312	5-19-69	5, 5, 5, 5	7.8	28.00	-0.50	S	0.0147	0.0033
1	315	5-19-69	5, 5, 5, 5	8.4	28.00	-0.35	N	0.0059	0.0027
1	316	5-23-69	5, 5, 5, 5	10.0	28.00	1.00	U	0.0059	0.0008
1	317	5-23-69	5, 5, 5, 5	7.4	28.00	1.00	U	0.0041	0.0008
1	319	5-24-69	5, 5, 5, 5	5.4	28.20	0.30	N	0.0000	0.0000
1	321	5-25-69	5, 5, 5, 5	4.9	28.00	1.70	U	0.0005	0.0003
1	322	5-25-69	5, 5, 5, 5	4.7	28.00	0.95	U	0.0000	0.0000
1	323	5-26-69	5, 5, 5, 5	5.6	28.10	-0.80	S	0.0045	0.0041
1	324	5-26-69	5, 5, 5, 5	5.4	28.30	-0.45	S	0.0006	0.0005
1	325	5-26-69	5, 5, 5, 5	8.6	28.30	-0.45	S	0.0013	0.0008
1	326	5-26-69	5, 5, 5, 5	7.6	28.20	0.75	U	0.0018	0.0014
1	327	5-27-69	5, 5, 5, 5	10.0	28.00	-1.65	S	0.0251	0.0191
1	335	5-28-69	5, 5, 5, 5	7.8	28.10	-0.65	S	0.0140	0.0047
1	345	7-16-69	5, 5, 5, 5	12.8	18.80	-2.40	S	0.0015	0.0004
1	9349	7-23-69	5, 5, 5, 5	13.0	24.20	1.80	U	0.0211	0.0019
1	363	7-24-69	5, 5, 5, 5	12.8	17.50	-0.30	N	0.0127	0.0046
1	364	7-24-69	5, 5, 5, 5	13.5	17.50	-0.30	N	0.0221	0.0108
1	365	7-25-69	5, 5, 5, 5	11.0	17.40	-0.30	N	0.0091	0.0063
1	9352	7-26-69	5, 5, 5, 5	2.3	28.90	-1.10	S	0.0001	0.0001
1	368	7-27-69	5, 5, 5, 5	8.4	17.40	-0.10	N	0.0013	0.0001
1	369	7-27-69	5, 5, 5, 5	7.7	17.40	-0.10	N	0.0012	0.0005
1	370	7-27-69	5, 5, 5, 5	7.8	17.40	-0.10	N	0.0000	0.0000
1	9359	7-29-69	5, 5, 5, 5	6.8	28.90	-1.65	S	0.0037	0.0021
1	9360	7-31-69	10,10,10,10	5.8	28.90	1.70	U	0.0000	0.0000
1	9361	8- 1-69	10,10,10,10	3.8	30.00	1.60	U	0.0000	0.0000
1	9362	8- 1-69	5, 5, 5, 5	1.4	30.00	0.65	U	0.0000	0.0000
1	9363	8- 1-69	5, 5, 5, 5	1.8	30.55	1.45	U	0.0002	0.0002

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1 9364  8- 1-69  10,10,10,10      6.7 30.55   3.15 U 0.0000 0.0000
1 9365  8- 2-69   5, 5, 5, 5      3.6 30.55   1.50 U 0.0000 0.0000
1 9366  8- 3-69   5, 5, 5, 5      6.3 29.45   2.70 U 0.0003 0.0001
1  371  8-10-69   5, 5, 5, 5     17.4 25.60  -0.80 S 0.0761 0.0110
1  372  8-11-69   5, 5, 5, 5      7.4 25.40   0.70 U 0.0000 0.0000
1  373  8-14-69   5, 5, 5, 5      8.3 28.40   0.05 N 0.0000 0.0000
1  374  8-17-69   5, 5, 5, 5     10.8 27.40   1.60 U 0.0030 0.0021
1  375  8-17-69   5, 5, 5, 5      9.2 28.00  -0.35 N 0.0038 0.0006
1  376  8-17-69   5, 5, 5, 5      9.5 27.80   1.10 U 0.0050 0.0010


2    2  7- 5-70   4                7.3 22.10  -6.40 S 0.0021  -99.
2    3  7- 5-70   4                7.9 21.30  -6.20 S 0.0064  -99.
2    4  7- 5-70   4                9.3 22.00  -5.20 S 0.0032  -99.
2    5  7- 5-70   4               10.7 21.80  -5.20 S 0.0217  -99.
2    6  7- 5-70   4               13.9 21.50  -4.30 S 0.0122  -99.
2    8  7- 5-70   4               11.2 21.30  -4.70 S 0.0197  -99.
2   10  7- 5-70   4               13.0 21.10  -4.00 S 0.0231  -99.
2   11  7- 5-70   4               14.4 21.00  -4.50 S 0.0735  -99.
2   12  7- 5-70   4               16.6 20.90  -2.50 S 0.0496  -99.
2   13  7- 6-70   4                3.8 23.90  -0.10 N 0.0082  -99.
2   14  7- 6-70   4                3.8 23.30  -0.90 S 0.0011  -99.
2   15  7- 6-70   4                3.2 25.40  -1.50 S 0.0000  -99.
2   16  7- 6-70   4                3.3 25.60   0.10 N 0.0000  -99.
2   17  7- 8-70   4                5.1 22.70   1.60 U 0.0012  -99.
2   18  7- 8-70   4                4.9 23.00   1.20 U 0.0000  -99.
2   19  7- 8-70   4                4.4 23.00   0.70 U 0.0001  -99.
2   20  7- 8-70   4                4.2 23.30   0.80 U 0.0000  -99.
2   21  7- 8-70   4                3.7 23.00   1.30 U 0.0000  -99.
2   22  7- 9-70   4                3.3 23.20   1.10 U 0.0000  -99.
2   24  7- 9-70   4                3.5 23.50   0.00 N 0.0001  -99.
2   25  7- 9-70   4                2.8 23.30   0.00 N 0.0000  -99.
2   26  7-10-70   4                6.3 23.60   0.20 N 0.0000  -99.
2   27  7-10-70   4                7.6 23.50   0.20 N 0.0000  -99.
2   28  7-10-70   4                6.5 23.80   0.40 N 0.0001  -99.
2   29  7-11-70   4                6.4 23.60   0.60 U 0.0007  -99.
2   31  7-11-70   4                7.9 23.60   1.50 U 0.0013  -99.
2   32  7-11-70   4                6.1 23.60   0.40 N 0.0009  -99.
2   33  7-11-70   4                2.4 24.20   1.10 U 0.0000  -99.
2   37  7-12-70   4                8.0 23.90  -0.70 S 0.0005  -99.
2   38  7-16-70   4                4.7 28.30   0.80 U 0.0005  -99.
2   40  7-17-70   4                5.5 28.40   0.00 N 0.0004  -99.
2   42  7-17-70   4                6.2 28.60  -0.80 S 0.0031  -99.
2   43  7-17-70   4                6.1 28.40  -1.00 S 0.0011  -99.
2   45  7-17-70   4                4.0 28.80   0.00 N 0.0007  -99.
2   46  7-18-70   4                6.2 28.90   0.50 N 0.0018  -99.
2   47  7-18-70   4                6.7 29.00  -0.60 S 0.0051  -99.
2   48  7-18-70   4                6.9 28.60  -1.20 S 0.0079  -99.
2   49  7-19-70   4                9.7 27.70   0.30 N 0.0065  -99.
2   52  7-19-70   4                9.8 26.70  -0.70 S 0.0060  -99.
2   53  7-19-70   4                8.8 26.90  -0.50 S 0.0092  -99.
2   58  7-20-70   4                6.5 27.20  -0.20 N 0.0003  -99.


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3  406  8- 2-78   9, 9, 9         5.0 13.60   1.60 U 0.0002 0.0002
3  407  8- 2-78   8, 9, 8         4.3 13.40   3.20 U 0.0024 0.0033
3  408  8- 2-78  13,12,13         5.8 13.40   3.00 U 0.0027 0.0017
3  409  8- 2-78  12,12,12         6.2 13.40   2.90 U 0.0011 0.0008
3  410  8- 2-78   8, 9, 8         5.5 13.30   1.40 U 0.0007 0.0005
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3   411   8- 3-78  10,10,10          4.5 13.80   0.80 U 0.0015 0.0020
3   412   8÷ 3÷78   7, 8, 7          4.0 13.90   1.30 U 0.0043 0.0045
3   413   8- 3-78   4, 4, 4          3.0 14.00   1.40 U 0.0001 0.0001
3   414   8- 3-78   5, 5, 5          4.0 14.00   1.70 U 0.0009 0.0013
3   415   8- 3-78   6, 3, 3, 3       4.8 14.00   1.80 U 0.0009 0.0009
3   416   8- 4-78   8, 8, 8          4.4 13.60   0.50 N 0.0005 0.0004
3   417   8÷ 4-78   7, 7, 7          2.5 13.60   0.70 U 0.0001 0.0002
3   418   8- 5-78  16,15,15          4.1 13.50   1.20 U 0.0016 0.0016
3   419   8÷ 5-78   7,13,12          4.5 13.70   1.20 U 0.0042 0.0073
3   420   8- 5-78  10,11,12          4.3 13.70   1.40 U 0.0011 0.0011
3   421   8÷ 5-78  10,10, 8          3.0 13.70   1.30 U 0.0006 0.0010
3   422   8÷ 5-78  12, 7, 3,10       4.5 13.70   1.10 U 0.0028 0.0035
3   423   8- 5-78  12,12,12          3.7 13.30   2.50 U 0.0009 0.0008
3   424   8÷ 6-78  16,16,15,15       6.7 12.90   0.40 N 0.0034 0.0030
3   425   8- 6-78  12,12,12          5.6 13.10   0.70 U 0.0018 0.0018
3   426   8÷ 6-78  16,16,16          5.5 13.00   0.80 U 0.0059 0.0071
3   427   8÷ 6-78  16,16,16          5.1 12.90   1.10 U 0.0049 0.0037
3   428   8- 6÷78  11,12, 4,12       4.5 13.00   1.20 U 0.0033 0.0041
3   429   8÷ 6-78   8,14,14, 9       4.5 13.00   1.30 U 0.0004 0.0005
3   430   8- 7-78  14,14, 2          4.9 13.10   1.30 U 0.0016 0.0019
3   431   8- 7-78  11,11,11,11       4.9 13.20   1.00 U 0.0018 0.0013
3   433   8- 7÷78  17,17,16          4.7 13.20   1.10 U 0.0010 0.0023
3   434   8- 7-78   7,19, 4          5.8 13.20   1.90 U 0.0028 0.0038
3   436   8÷ 8-78  10,13,15          4.0 12.90   1.60 U 0.0009 0.0010
3   437   8÷ 8-78  12,11,12          3.0 13.00   1.40 U 0.0004 0.0005
3   438   8- 8-78  12,14, 2,14       3.2 13.00   1.00 U 0.0025 0.0023
3   439   8- 8-78   8, 7, 7          3.0 13.10   1.10 U 0.0003 0.0007
3   440   8- 8-78   7, 7, 7          3.5 13.20   1.20 U 0.0001 0.0001
3   441   8- 8÷78   9, 9, 3          3.5 13.10   1.30 U 0.0000 0.0001
3   442   8- 9-78   2, 5, 5          3.0 13.30   1.80 U 0.0001 0.0002
3   444   8-10-78  10,10, 9          4.4 13.30  -0.10 N 0.0028 0.0027
3   445   8-10-78  10,11,11          5.0 13.40  -0.50 S 0.0036 0.0020
3   446   8-10-78   9, 9, 8          4.7 13.20  -0.50 S 0.0010 0.0025
3   447   8÷10-78  11,11,11          5.5 13.70  -0.30 N 0.0009 0.0008
3   449   8÷11-78   2, 6, 4          5.5 13.30  -0.80 S 0.0053 0.0066
3   451   9- 4-78  10,13,10          8.0 12.90  -0.20 N 0.0074 0.0059
3   452   9÷ 4-78  10,14,10          7.3 12.90  -0.60 S 0.0102 0.0229
3   453   9- 4-78  15,15,14          9.5 12.90   0.30 N 0.0095 0.0110
3   454   9- 4-78   9, 9,10         10.0 12.90   0.70 U 0.0149 0.0331
3   455   9÷ 5-78  10,15,10         13.9 12.50   1.00 U 0.0331 0.0240
3   456   9- 5-78  10,10, 6          9.1 12.50   0.50 N 0.0568 0.0602
3   457   9- 6-78   8,10, 9          7.9 12.70   0.20 N 0.0035 0.0046
3   458   9÷ 6-78  15,14,11         10.3 12.80   0.60 U 0.0082 0.0137
3   459   9÷ 6÷78  15, 9,15          6.2 12.80   0.20 N 0.0009 0.0015
3   460   9- 6-78  10,13,15          8.3 12.70   0.10 N 0.0026 0.0103
3   461   9÷ 7÷78  10,10,10          6.8 12.70   0.10 N 0.0000 0.0000
3   462   9- 7÷78  10, 9, 9         10.0 12.60  -1.80 S 0.0238 0.0235
3   463   9÷ 7÷78  10,10, 9          6.5 12.80  -0.40 S 0.0032 0.0028
3   464   9- 7-78  10,10,10          7.5 12.70  -0.40 S 0.0009 0.0028
3   465   9÷ 8-78   9,10,10          4.7 12.70   0.00 N 0.0016 0.0023
3   466   9- 8÷78  10, 9,10          6.2 12.80   0.40 N 0.0004 0.0009
3   467   9÷ 9-78   8, 9, 9          8.1 13.30   0.40 N 0.0009 0.0010
3   468   9÷ 9÷78  10,10,10          5.4 13.30  -0.20 N 0.0006 0.0008
3   469   9÷ 9-78   5, 4, 5          4.3 13.00  -0.30 N 0.0004 0.0007
3   470   9-11-78   5, 5, 4, 5      14.4 13.40   1.00 U 0.0814 0.0807
3   471   9÷13-78  10,10,15, 9       9.2 14.00   0.60 U 0.0237 0.0176
3   473   9-14÷78   9,10, 9         15.3 13.90   1.30 U 0.0160 0.0154
3   475   9÷14÷78  10,10,10         10.9 13.50   0.70 U 0.0113 0.0127
3   476   9-14÷78   9,10,10         10.4 13.20   0.50 N 0.0102 0.0251
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4	480	11- 6-80	10, 9,10	9.1	9.86	0.50	N	0.0028	0.0012
4	481	11- 7-80	8, 8, 8	16.2	10.11	1.45	U	0.0139	0.0055
4	482	11- 7-80	7, 8, 9	15.4	10.12	1.42	U	0.0236	0.0069
4	483	11- 7-80	9,10, 9	14.3	11.11	3.65	U	0.0190	0.0039
4	484	11- 7-80	10,10,10	11.9	10.50	3.00	U	0.0152	0.0041
4	485	11- 8-80	10,10,10	9.8	10.17	3.37	U	0.0099	0.0022
4	486	11- 8-80	7, 8, 8	9.2	9.90	2.10	U	0.0129	0.0078
4	487	11- 8-80	8,10,10	9.8	10.17	4.35	U	0.0140	0.0056
4	488	11- 8-80	10,10,10	9.7	10.17	3.27	U	0.0056	0.0018
4	489	11- 9-80	9,10,10	10.4	10.24	3.00	U	0.0104	0.0024
4	490	11-10-80	10,10,10	6.3	9.83	2.87	U	0.0047	0.0024
4	491	11-10-80	9, 9,10	5.9	9.81	2.82	U	0.0007	0.0009
4	492	11-10-80	11,10, 6	2.7	9.78	2.79	U	0.0007	0.0006
4	493	11-11-80	10,10,10	5.5	9.78	1.00	U	0.0021	0.0025
4	494	11-12-80	9,10,10	4.2	9.83	1.94	U	0.0029	0.0017
4	495	11-12-80	8,10,10	6.3	9.81	0.92	U	0.0128	0.0023
4	496	11-12-80	9,10,10	6.0	9.82	1.27	U	0.0087	0.0022
4	497	11-12-80	6, 6, 5	10.8	9.77	1.03	U	0.0074	0.0036
4	498	11-13-80	10,10,10	5.9	9.60	2.52	U	0.0059	0.0031
4	499	11-13-80	10,10,10	7.5	9.66	1.40	U	0.0062	0.0021
4	501	11-14-80	9, 8, 8	12.0	9.56	-0.36	N	0.0139	0.0036
4	502	11-14-80	5, 5, 5	12.2	9.41	-0.79	S	0.0092	0.0080
4	503	11-14-80	8,10,10	11.5	9.36	-0.86	S	0.0153	0.0062
4	504	11-14-80	8, 8, 8	12.5	9.38	-0.76	S	0.0108	0.0020
4	505	11-15-80	10,10,10	11.1	9.17	2.94	U	0.0102	0.0024
4	506	11-16-80	10,10,10	5.8	9.19	2.54	U	0.0015	0.0009
4	507	11-16-80	10,10, 8	6.0	9.20	1.44	U	0.0012	0.0006
4	508	11-17-80	8, 8, 8	17.2	9.30	0.00	N	0.0517	0.0104
4	509	11-17-80	10, 9, 7	14.5	9.13	0.99	U	0.0479	0.0116
4	510	11-17-80	10,10,10	13.9	9.20	0.80	U	0.0476	0.0081
4	511	11-18-80	10,10,10	11.9	9.09	0.91	U	0.0512	0.0085
4	512	11-18-80	8, 7, 6	7.3	9.05	1.45	U	0.0183	0.0043
4	513	11-18-80	9, 9, 9	7.9	8.93	0.86	U	0.0213	0.0050
4	515	11-18-80	10,10,10	4.9	9.20	0.50	N	0.0009	0.0005
4	516	11-19-80	10,10,10	10.3	8.92	0.84	U	0.0169	0.0056
4	517	11-19-80	10,10,10	7.7	8.92	0.41	N	0.0171	0.0060
4	518	11-19-80	10,10,10	6.6	9.10	0.40	N	0.0045	0.0014
4	519	11-19-80	10,10,10	6.6	8.95	0.82	U	0.0018	0.0014
4	520	11-20-80	7, 7, 7	10.7	8.92	1.75	U	0.0155	0.0025
4	521	11-20-80	10,10,10	7.2	8.91	1.71	U	0.0275	0.0054
4	522	11-20-80	10,10,10	9.0	8.89	1.56	U	0.0098	0.0027
4	523	11-20-80	9, 9, 9	5.5	8.96	2.14	U	0.0128	0.0036
4	524	11-20-80	9, 9, 9	7.5	8.93	1.83	U	0.0077	0.0022
4	525	11-20-80	10, 9,10	7.9	8.89	1.80	U	0.0021	0.0009
4	526	11-21-80	10,10,10	3.4	8.92	2.00	U	0.0002	0.0004
4	527	11-21-80	10,10,10	7.3	8.96	1.54	U	0.0031	0.0009
4	528	11-21-80	10,10,10	7.1	8.85	1.39	U	0.0050	0.0013
4	529	11-29-80	10,10,10	15.7	7.35	1.56	U	0.0586	0.0124
4	530	11-29-80	9, 9, 9	13.5	7.41	1.53	U	0.0156	0.0036
4	531	11-29-80	10,10,10	13.4	7.37	1.59	U	0.0303	0.0065
4	532	11-29-80	9, 9, 9	13.6	7.39	1.93	U	0.0217	0.0038
4	533	11-29-80	9, 9, 9	13.8	7.38	1.91	U	0.0150	0.0050
4	534	11-30-80	10,10,10	8.0	7.01	1.75	U	0.0122	0.0041
4	535	11-30-80	10,10,10	8.4	7.06	2.27	U	0.0166	0.0033
4	536	12- 1-80	10,10,10	10.8	7.39	3.62	U	0.0093	0.0018
4	537	12- 2-80	8,10, 8	12.8	7.21	3.67	U	0.0123	0.0024
4	538	12- 2-80	8, 8, 8	14.3	7.18	3.46	U	0.0211	0.0036
4	539	12- 2-80	10,10, 9	14.5	7.10	2.40	U	0.0221	0.0058
4	540	12- 2-80	9, 9, 9	15.1	7.25	2.09	U	0.0210	0.0065
4	541	12- 3-80	10,10,10	13.3	5.37	-0.10	N	0.0103	0.0020
4	542	12- 3-80	8, 9, 8, 8	12.2	5.50	-0.15	N	0.0101	0.0033
4	543	12- 3-80	8,10, 8	12.1	5.63	0.13	N	0.0100	0.0060
4	544	12- 3-80	9, 9, 9	12.0	5.60	0.15	N	0.0184	0.0036

4	545	12- 4-80	9, 9, 9	10.1	5.74	0.65	U	0.0062	0.0018
4	546	12- 4-80	10,10,10	10.2	5.72	0.42	N	0.0134	0.0042
4	547	12- 5-80	10,10,10	6.3	6.08	1.57	U	0.0008	0.0006
4	548	12- 5-80	10,10,10	3.3	5.84	1.12	U	0.0000	0.0000
4	549	12- 6-80	10,10,10	12.9	7.20	0.70	U	0.0098	0.0022
4	550	12- 6-80	10,10,10	12.1	5.74	-0.62	S	0.0126	0.0025
4	551	12- 6-80	9, 9, 9	12.5	5.71	-0.86	S	0.0069	0.0021
4	552	12- 6-80	10,10,10	12.2	7.19	0.29	N	0.0058	0.0015
4	553	12- 7-80	8, 8, 8	11.7	5.97	-1.41	S	0.0176	0.0035
4	554	12- 7-80	9, 9, 9	9.8	5.79	-1.65	S	0.0194	0.0032
4	555	12- 8-80	7, 8, 9	14.2	5.96	-2.52	S	0.0151	0.0020
4	556	12- 8-80	9, 8, 9	12.6	5.94	-2.95	S	0.0316	0.0183
4	557	12- 8-80	8, 8, 8	14.0	5.90	-3.04	S	0.0125	0.0028
4	558	12- 8-80	7, 8, 8	14.5	5.92	-2.93	S	0.0187	0.0039
4	559	12- 8-80	9, 9,10	12.9	6.00	-2.60	S	0.0108	0.0022
4	560	12-11-80	8, 8, 9	13.0	5.14	-1.93	S	0.0442	0.0069
4	561	12-11-80	5, 6, 5	14.8	5.19	-2.01	S	0.0509	0.0103
4	562	12-11-80	4, 4, 4	14.2	5.11	-2.25	S	0.0407	0.0082
4	563	12-11-80	7, 7, 7	11.6	5.30	-2.12	S	0.0116	0.0026
4	564	12-11-80	5, 5, 6	9.9	5.38	-1.97	S	0.0027	0.0022
4	565	12-12-80	6, 6, 5	15.0	7.39	-1.82	S	0.0230	0.0082
4	566	12-12-80	5, 5, 6	16.5	7.39	-1.82	S	0.0290	0.0047

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APPENDIX E:

1. AEROSOL PRODUCTION IN THE WHITECAP SIMULATION TANK AS
    A FUNCTION OF WATER TEMPERATURE

AND

2. SPACE CHARGE MEASUREMENTS DURING MIZEX 84

both by

Peter A. Bowyer

1. AEROSOL PRODUCTION IN THE WHITECAP SIMULATION TANK AS A FUNCTION OF WATER TEMPERATURE

There is a relationship between water temperature and electric charge produced by a breaking wave in the whitecap simulation tank (WST) (1). In seeking an explanation for this temperature dependence of charge production it was decided to investigate the relationship between particle production by a breaking wave and water temperature.

The Royco model 225 particle counter was used with a shortened inlet hose which could be lowered to a height of 3cm above the water after a splash in order to improve the sampling of larger particles (>10μ diameter) which have a short fall-out time. Before each splash the air in the tank was cleaned with a Vokes model 66MA absolute filter. In the worst case (particles >.5μ diameter) this left <1% of the particle concentration produced by a breaking wave. The humidity was kept between 70% and 90% throughout the experiment, and the air temperature was kept within 3°C of the water temperature. Particle spectra were obtained at water temperatures between 5°C and 28°C.

Results are plotted in figures 1 and 2 for particles >5μ diameter, and >0.65μ diameter, together with best-fit straight lines. About 10 splashes were carried out at each temperature and the large variation in production between splashes can be seen. There is a positive temperature dependence for the particles of diameter >5μ but little, or slightly negative, dependence for the smaller size range particles. This positive dependence begins to appear in the >3μ diameter size range. The dependence of charge on temperature (1) could be explained if it was assumed that the particles of diameter >3μ carried the

charge; and recalling Blanchard's observation that the jet droplets carry charge, while the film droplets do not contribute significantly to the charge production by a bursting bubble, this could indicate that the jet droplets predominate over 3μ diameter, while the film droplets are in the majority below this size (see also Monahan, et al (3), Monahan (4) and Blanchard (2)).

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2. Blanchard, D.C., 1963. The Electrification of the Atmosphere by Particles from Bubbles In the Sea, Progress in Oceanography, 1, 71-202.

3. Monahan, E.C., B.D. O'Regan, and D.M. Doyle, 1980. The influence of whitecaps on the marine atmosphere, U.C.G. Report to ONR, pp. 1-123, Chapter 8.

4. Monahan, E.C., 1983. Positive Charge Flux from the World Ocean Resulting from the Bursting of Whitecap Bubbles, pp. 85-87, in L.H. Ruhnke and J. Latham, Eds., Proceedings in Atmospheric Electricity, A. Deepak Publishing, Hampton, Virginia.

2. SPACE CHARGE MEASUREMENTS DURING MIZEX 84

In June and July 1984 Dr. Monahan and myself had berths on
MS HAAKON MOSBY, participating in MIZEX 84 in the Fram Strait.
Dr. Monahan was measuring whitecap coverage, and a group from
N.P.S. in Monterey were measuring aerosol concentration (in the
size range 0.5μ to 20μ radius) and other relevant meteorological
parameters.

In order to measure space charge, a portable Obolensky filter
was constructed. The heart of the apparatus was a steel wool
filter, electrically isolated from earth, but connected to
the inverting input of an AD 515L electrometer operational
amplifier. The feedback circuit was placed in a sealed container
along with some silica gel dessicant, and consisted of a 100 GΩ
resistance in parallel with a 220 pF capacitor, which converts
the current off the filter into a voltage which is then amplified
by a factor of 25 by a potential divider. The output of the
apparatus was 2.5V/PA, and was read using a conventional
multimeter. Air was drawn through the filter at an average
rate of 550cm^3/sec., so the space charge density could be
calculated.

Readings were taken from a point above the bridge, 9.2m above
sea level. The ship made many CTD stations during which she
was hove to with her bow to the wind, which was when most of
the charge readings were taken (this eliminated spurious effects
produced by the bow wave, and smoke from the ship (the smoke
stock was located well aft of the measuring position)).

A graph of windspeed against space charge density is shown in
fig. 3. In preparing this figure measurements taken in the
presence of fog or precipitation have been left out, as
have measurements taken when ice was visible, or when the ship
was in the lee of any land. Above about 3m/s some correlation
can be seen between windspeed and space charge, while below 3m/s
the values of space charge are curiously high.

Figure 1

Concentrations of aerosols of diameter >0.5μ immediately
after a splash in the Whitecap Simulation Tank. The height
of water behind the gates prior to each splash was 27cms.
Readings taken at a height of 3cms using the Royco model
225 particle counter.

Figure 2

As figure 1, but for aerosols of diameter >5μ

Figure 3

Space Charge Density plotted against windspeed. Measurements
taken during the MIZEX 84 cruise on M.S. HAAKON MOSBY. Space
Charge was measured using a portable Obolensky filter.

>5 μ diameter

x10⁵ m⁻³

°C

> .65 µ diameter