PROPOSED METHODS FOR OBSERVING AND RECORDING THE OCCURRENCE OF FLOATING MARINE DEBRIS

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PROPOSED METHODS FOR OBSERVING AND RECORDING
THE OCCURRENCE OF FLOATING MARINE DEBRIS:

1. BACKGROUND

For this report, marine debris is considered as any man-made object of wood, glass, metal, rubber, cloth, paper, plastic, etc. that is derelict in the marine environment. Marine debris may float at the surface, be suspended at mid-depths, or sink to the ocean floor. Contributors to the marine debris problem include merchant ships; commercial fishing vessels; world navies; recreational fishing and boating; and land based sources via beaches, rivers and industrial ports.

Until recently, marine debris was considered to be of little importance compared to other pollutants. Information now available suggests that the increasing problems caused by marine debris may already rival or exceed those resulting from some better known pollutants, such as oil and oil products. Not only are increasing amounts of debris finding their way into the world's oceans but a growing proportion consists of plastics which deteriorate slowly and pose a special threat to marine life and birds.

Of particular concern is the harm that pelagic animals may suffer from floating marine debris. The buoyant and persistent nature of this debris increases the likelihood of encounter by marine animals, encounters which are often harmful. Sea turtles mistake floating plastic bags for jellyfish, a common food: once swallowed, the bags block the intestinal passage. Marine mammals drown or suffocate after entangling in net fragments, plastic bands, and other debris. Seabirds eat plastics that may look like food, or are entrapped in debris or net fragments.

During the past several years, numerous efforts have been undertaken to apply and assess various methods for monitoring marine debris at sea and on beaches. These methods include the sampling of small plastic particles by neuston nets, sighting surveys to collect data on large marine debris adrift at sea, and beach surveys to assess the amount and distribution of beached marine debris. The following sections contain proposed procedures for collecting and recording such data.

2. OVERVIEW OF SHIPBOARD MARINE DEBRIS RESPONSIBILITIES

Three marine debris monitoring procedures are described in this manual: line transect surveys, detailed observations of animal encounters with debris, and neuston tows.

Debris transect surveys (Sec 3.2) provide the basic sampling tool to develop statistically valid estimates of debris densities and oceanic distribution. Surveys should be conducted 3-4 hours
per day while the vessel is in transit.\(^1\) Often, these transects will be carried out in conjunction with marine animal surveys.

Detailed observation of animal encounters with debris, derelict net sightings, and lethal debris observations are taken whenever they are observed (Sec 4.0).

Deployment of the Sameoto neuston net (Sec 5.0) requires assistance from the ship's crew. Sampling stations should be firmly established prior to cruise and a pre-cruise briefing held to review the cruise plan and discuss exactly how and when the tows will be conducted including who will set and retrieve the neuston net.

3. SHIPBOARD SIGHTING SURVEYS

3.1 SIGHTING SURVEY OBJECTIVES

A. Determine the distribution and density of large (\(\geq 2.5 \times 2.5\) cm) floating marine debris by using line transect survey methods. Associate this distribution to the oceanographic characteristics of the survey area.

B. Describe the types, sizes, and colors of floating debris.

C. Estimate the oceanic abundance of debris types which are particularly harmful to wildlife, namely, gill net fragments, trawl net fragments, plastic sheeting and bags, and pieces of uncut plastic strapping.

D. Observe, record, and describe associations between animals and marine debris.

3.2 LINE TRANSECT SURVEY THEORY

In the line transect method, an observer travels a known distance across the population of interest in nonintersecting and nonoverlapping lines, counting the number of objects sighted and recording the distance (for this design, the right-angle distance) from the object sighted to the path of the observer. Population densities can be estimated by modeling the probability of an object being seen, for a given right-angle distance transect path. To satisfy the basic assumptions 1) the sighting

\(^1\)Priorities and constraints on activities are likely to be different for different cruises. The recommendation that 3-4 hours be spent observing debris is a general recommendation which may be adjusted up or down depending on the cruise. Before disembarking scientific observers should know how to prioritize their responsibilities.
of one object is independent of the sighting of another and 2) that the sighting probability is a simple function of the right-angle distance, sighting observations are restricted to a 270-90° forward arc where 000° is the reading of the vessel.

Of particular concern is the impact of glare on the sighting probabilities. Preliminary observations indicate that glare may be the most important single environmental factor affecting the sighting probability, causing density estimates to be very dependent on glare conditions. Appendix B contains a discussion of glare parameters and the need for study of the relation between environmental parameters and sighting probabilities.

Ideally, the area of survey would only extend out 50-100 m and on one side of the vessel. Wave formation, atmospheric conditions, and glare affect sighting probabilities. The effects of environmental factors except glare, seem to be reasonably small within this range; beyond 50-100 m there is a notable reduction in debris observations as variations in environmental conditions significantly affect the probability of sighting debris objects. Extensive analyses of sighting probabilities relating distance, wave height, and light conditions to type, sizes, and colors of marine debris will be needed to incorporate these data into debris estimation procedures.

Combining marine animal and marine debris transects allows better use of observation time while aboard the vessel. Because of the need to combine marine animal and marine debris transects and because marine animal transects extend to the horizon, transects described in this procedure manual also extend to the horizon. If marine animal transects are not being conducted, then 50-100 m wide transects may be done with only minor modifications to these procedures.

3.3 LINE TRANSECT SURVEY METHOD: INSTRUCTIONS TO OBServers

Before starting your survey you will need to identify an observation station. Find a comfortable, elevated vantage point, such as the flying bridge, which is out of the way of the crew's activities. You will need a clear forward view. Your range of observation will describe a 180° forward arc, from 270 - 90° degrees relative to the direction of travel. Changing locations decreases the internal consistency of your observations, so try to select and use a place that will be available throughout the cruise.

Observations must be taken while the vessel is in transit and traveling at a constant speed. Surveys are valid only during daylight hours (sunrise + 1 h to sunset - 1 h) when visibility is greater than 1 nmi and conditions are Beaufort 4 or less. Stop the surveys when visibility becomes less than 1 nmi or sea surface conditions are greater than Beaufort 4.
Begin the survey by recording time of day position and environmental information on an effort form (Appendix A). Once this form is completed, for the next 20 to 60 min record all sightings of floating debris on the marine debris sighting form (Appendix A) and any lethal debris and animal debris encounter in your field notebook. Use a sharp, soft lead (#2) pencil to record data and print legibly. If a marine animal sighting is distracting to the extent that marine debris observations are affected, temporarily interrupt the transect, noting the amount of time your attention was diverted from marine debris work. This time will be entered on a data form. After a maximum of 60 min, the next line in the effort form is filled out, ending the survey. Surveys should not be conducted for less than 20 min.

A survey should be ended when any of the following events occur:

1) Course changes by more than 5°.
2) Speed changes by more than 3 kn.
3) Environmental conditions change.
4) After 60 min of observation time.

On days when environmental conditions are changing frequently you may want to wait 5 min or so after a change to make sure it is stabilized before ending the transect. If conditions are fluctuating frequently enough that it will be difficult to get in 20 min transects, break the transect every 30 min and record the average conditions for that period.

Keep in mind that most variables on this form are discrete, While in the field, categorize the observations as best as you can, because judgments concerning descriptions of debris or environmental descriptions are inferior and considerably more difficult months after they occur. Some guidelines on how to categorize data in situations of varying degrees of certainty are given in Appendix A under the specific variable in question.

3.4 RECORDING LINE TRANSECT SURVEY DATA

Sighting observations, survey effort and concomitant environmental information are entered on data forms and a field notebook throughout the duration of the survey.

FIELD NOTEBOOK

Organize a field notebook into two sections, the first should contain supplemental information for each survey and the second should contain detailed observations discussed in section 3.3. At the beginning of each transect, record the transect number and station data. Station data are the height of your platform, and the port and starboard perpendicular distances where your visibility of the transect area begins. These distances depend
on the configuration of the ship and will, therefore, vary with the location of your station. Also, if you are looking through binoculars more than 10% of the time, note your estimated usage in this first section. An example of a page from the first section of a marine debris notebook:

<table>
<thead>
<tr>
<th>J Observer</th>
<th>RV MARU 851</th>
<th>1987</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARINE DEBRIS NOTE BOOK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRANSECT SURVEYS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRNSCT NO.</td>
<td>VIEW BLOCKED</td>
<td>PLTFM HT.</td>
</tr>
<tr>
<td>001</td>
<td>LEFT 5 m</td>
<td>RIGHT 7 m</td>
</tr>
<tr>
<td>002</td>
<td>LEFT 5 m</td>
<td>RIGHT 7 m</td>
</tr>
<tr>
<td>003</td>
<td>LEFT 5 m</td>
<td>RIGHT 7 m</td>
</tr>
<tr>
<td>004</td>
<td>LEFT 4 m</td>
<td>RIGHT 3 m</td>
</tr>
<tr>
<td>005</td>
<td>LEFT 4 m</td>
<td>RIGHT 3 m</td>
</tr>
<tr>
<td>006</td>
<td>LEFT 5 m</td>
<td>RIGHT 7 m</td>
</tr>
</tbody>
</table>

**FORMS**

The effort and sighting forms are the two forms used in the basic survey. Specific information about the data fields on the effort and sighting forms are described in Appendix A.

**Effort Form**

Survey effort information is recorded at the beginning and end of each observation period on the transect effort forms. Either the marine debris or marine mammal form may be used. In the latter case be sure and follow the amended procedures for use of the marine mammal form in Appendix A. The effort form contains the following variables:
Individual observations of debris are entered on separate lines of the marine debris sighting form immediately upon sighting. The sighting format is composed of the following variables:

- **Vessel Identification**
- **Transect Number**
- **Longitude**
- **Visibility**
- **Time Zone**
- **Time Out**
- **Observer Name**
- **Time of Day**
- **Sea State**
- **Visibility Code**
- **Platform Code**
- **Date**
- **Latitude**
- **Weather**
- **Temperature**
- **Platform Height**

### 4.0 DETAILED OBSERVATIONS

#### 4.1 ANIMAL ENCOUNTERS WITH DEBRIS

When marine animals are observed encountering debris, a detailed account of the event should be recorded in field notebooks and on marine mammal sighting forms (for birds and turtles as well as marine mammals). Observations should be recorded in the second part of your marine debris field notebook and include the following information:

1. Detailed description of debris object (i.e., color, material, shape, and size).
2. Description of animal (species, maturity, etc.).
3. Notable animal behavior.
4. Proximity of animal to debris.

#### 4.2 LETHAL DEBRIS

**Derelict Net Sightings**

In addition to marine animal/debris encounters, the presence of derelict gill nets, trawl webbing, and other fishing gear is of great interest. If possible, all derelict nets should be hauled aboard the research vessel for close examination. Collection of samples and observations of nets should be detailed and include, if possible:
1) Dimensions (m) of the net and number of sections.
2) Number, type, material and color of floats.
3) Dimensions (m) and color of the net components, i.e., webbing, hanging twine, leadline, and corkline.
4) Stretched mesh size (mm).
5) Presence of a leadline (for gill nets).
6) Degree of barnacle encrustation and marine growth.
7) Observed entrapment of fish or other marine animals.
8) Saving a single cork and a sample of net.
9) Photographs.

Data should be recorded on the derelict net sighting forms provided, a marine mammal sighting form, or in the second part of your marine debris notebook. The forms should be kept with the marine debris data.

Other Lethal Debris

Other noticeably lethal debris objects should be noted in your marine debris notebook. Please note whether packing straps are open or closed.

5. NEUSTON TOWS

5.1 OBJECTIVES

1) Determine the distribution and abundance of small floating particles of plastic and tar in the study area.
2) Describe distribution and abundances with respect to the surface layer circulation and water mass movement of the region.
3) Describe the types and colors of plastic particulates.

5.2 METHODS

5.2.1 LAB DEPARTURE PREPARATIONS

Label vials and preweigh dried vials to ±1 mg. Go through the check list and make sure all the necessary equipment is together and functional.

5.2.2 SAMPLING DEVICE

Samples of floating plastic particles are collected with a Sameoto neuston sampler net (Sameoto and Jaroszynski 1969; Figure 1). The boxlike metal frame is 0.5 m wide by 0.3 m high by 0.6 m long. Attached to the frame is a nylon zooplankton net 1.8 m
long with a sample bucket at the distal end; both the net and the bucket are of 505 micron mesh.

A chain on the frame hooks directly to the end of a tow cable. A rope hooks to the opposite side of the frame and a clamp on the rope hooks onto the cable. The clamp slides up and down the cable to adjust the angle of the plane through which the frame tows.

Figure 1. Sameoto neuston tow apparatus.
5.2.3 INITIAL ONBOARD CHECK LIST

1) Make sure all equipment has arrived.
2) Check with the proper deck officer and find out which winch is to be used in setting and retrieving the net.
3) Examine mechanism for attaching chain to cable.
4) Locate hoses, or establish how net will be washed down after retrieval.
5) Equipment:
   a. Neuston Box with chain portion of harness.
   b. Rope Harness: Single rope with clamp.
   d. Bucket: 505 micron.
   e. Sample containers: Preweighed and labeled vials.
   f. Stop watch or hand counter.
   g. For processing samples from 505 micron nets at sea: shallow pan, eye dropper, tweezers, ruler (metric), 303 micron screening net.

5.2.4 SAMPLING METHODS

When set correctly, the neuston frame will ride partially up out of the water. The high end of the fins will be forward and the low end aft. The chain portion of the harness will be nearest to the boat and the opening of the frame perpendicular to the direction of travel.

The neuston net is towed at the surface for a relatively short period of time. Tows of 10 min at a ship's speed of 2 kn are recommended. Performance of the nets must be visually observed during the tow; the amount of time that the net was not sampling (net either completely out of the water or completely submerged) must be recorded. To measure the time in and out of water, use a stop watch to count seconds. Record the appropriate data at time of tow. The time the net was towed minus the time the net was not sampling equals the actual time of sampling at each station. If wind is greater than 20 kn, and/or seas greater than 10 ft, it may be too rough for towing the net.

5.2.5 SAMPLE PREPARATION

Once the net is back on board start at the top of the net and carefully wash down the sides until all of the sample is in the bucket.
Strain the sample with a 303 net to remove smaller particles. The remaining particles are washed into a shallow sorting tray, where the plastic is removed. All pieces of plastic \( \geq 0.5 \) mm are counted, measured (the two longest dimensions), identified by type, categorized to color, and placed in the prepared viles for later analyses.
If samples are to be sorted back at the lab, stop after step 4 above and:

1) wash sample into plastic storage containers.
2) add formalin until a 5% solution is reached.
3) label samples appropriately.

Once in the laboratory, sorted samples are dried at room temperature for one week. The sample vials are then reweighed to determine the net weights of plastic caught at each station.

5.3 RECORDING NEUSTON TOW DATA

There are two forms you may use: the tow form and the sample form. Note that the sample form is used only if you process samples at sea. Details on how to fill out these forms are given in Appendix C.

The tow form is comprised of the following variables:

<table>
<thead>
<tr>
<th>Vessel Identification</th>
<th>Observer Name</th>
<th>Net Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station Number</td>
<td>Date</td>
<td>Time Zone</td>
</tr>
<tr>
<td>Time Start</td>
<td>Time Stop</td>
<td>Correction (Time)</td>
</tr>
<tr>
<td>Total Corrected Time</td>
<td>Ship's Speed</td>
<td>Area Sampled</td>
</tr>
<tr>
<td>Latitude</td>
<td>Longitude</td>
<td>Sea State</td>
</tr>
<tr>
<td>Sea Surface Temperature</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The sample form is comprised of the following variables:

<table>
<thead>
<tr>
<th>Vessel Identification</th>
<th>Observer Name</th>
<th>Station Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Vial Wt.</td>
<td>Dry Sample Wt.</td>
<td>Type</td>
</tr>
<tr>
<td>Length</td>
<td>Width</td>
<td>Color</td>
</tr>
</tbody>
</table>
REFERENCE

APPENDIX A: TRANSECT FORMS

Each form has the following data fields in common:

1) Vessel Identification (name and radio call sign of the vessel from which the observations are made)
2) Observer (full name(s) of the scientist(s) collecting data)
3) Date (entered as year-month-day (YYMMDD); for example, 860723 is 23 July 1986)

Effort Form

Survey effort information is recorded at the beginning and end of each observation period.

If marine animal transects are being done in conjunction with the marine debris transects, fill out the marine mammal effort forms as you normally would, with the exception of the visibility field, and then note a transect number in the left hand margin for each transect and the time out in the right hand margin. See the example on page 17. If marine animal transects are not being carried out use the marine debris survey effort forms.

In the event that a marine debris survey is suspended because of extensive attention given to marine animal sightings, note the time of the suspension and prefix the transect number with an "S". If you later resume marine debris effort without stopping and starting a new transect, note the time of resumption. At the end of the transect total the "time out" and enter it on the marine debris effort form or in the right-hand margin of the marine mammal effort form. See pages 16 and 17 for examples of how the marine debris and alternatively the marine mammal effort forms should be filled out when marine debris transects are conducted.

Block by block Effort Form instructions are as follows:

1) Transect number--Three digit number starting with 001, assigned by the observer in a consecutive series. If marine debris sightings are suspended while a transect continues attach an "S" as a prefix to the number. See the general discussion of the effort form for additional instructions.
2) Time of day--Ship's time, enter in 24 hour notation and recorded at the beginning and end of each transect. For example, 0700 is 7:00 AM; 1500 is 3:00 P.M.; 0000 is midnight.
3) Latitude--Enter as degrees/minutes/tenths. For example, 241103 is 24 degrees 11 minutes and 3 tenths of a minute. Enter "N" or "S" for degrees north or south latitude.
4) Longitude--Enter as degrees/minutes/tenths. For example, 1593304 is 159 degrees 33 minutes and 4 tenths of a minute. Enter "W" or "E" for degree west or east longitude.

5) Sea State--For purposes of this study note at least the Beaufort Scale measure: see Appendix D. For the marine animal study you may want to include other notations.

6) Weather--Corresponds to cloud cover and precipitation. Cloud cover is described in ascending order of cover with the associated codes as: Clear = 0, Partly Cloudy = 1, Cloudy = 2, Overcast = 3, Drizzle = 4, Rain = 5, Fog = 6, Intermittent Fog = 7, Snow = 8.

7) Visibility--Note glare conditions and any limit on the distance of visibility. In noting glare conditions, note the combined percentage of the port side of the transect path covered by medium and strong glare levels and the percentage of the starboard side covered. Enter these two percentages in the appropriate columns. If using a marine mammal effort form, enter the two numbers on the far right-hand side of the visibility column. Enter the port-side percentage first followed by the starboard-side percentage (right to left). If the port side is 50% covered with medium and high glare and the starboard side is 25% covered, the visibility field might appear as follows: "<3K,haze,50/25".

Glare levels are defined as follows:
Strong--Sunlight reflected directly by the water; may be sparkly.
Medium--Glare is indirect but still fairly intense; generally reflected by clouds nearby the sun. Medium glare may occur from other parts of the sky too, will generally reflect the color of the clouds.
Weak--Glare is indirect at a low level, reflected by clouds away from the sun; the glare will generally be a weak gray, reflecting the clouds.
None--No glare.

8) Visibility Code--This code was developed for observations of marine mammals. The codes and descriptions are given in Appendix D. If estimated wave heights and wave heights associated with the Beaufort levels given under a specific code contradict, follow the Beaufort code.

9) SST (Sea Surface Temperature)--Recorded in °C as measured from bridge instrumentation (engine inlet temperature if necessary). If below freezing, place a "-" in the first column of the field.

10) Time Zone--Current time zone during the observation period. You should keep a log of your starting time zone and any changes in time zones made during your cruise. If you use GMT you will have no changes, however, ships time may be most convenient to use. Negative time zones correspond to longitudes west of 180° longitude, i.e.: the longitude 156°17.1'E occurs in -10 time zone. Positive time zones correspond to longitudes east of 180°.
longitude, i.e.; the longitude 162°59.6'W corresponds to the +11 time zone. Remember, ships time will probably not follow these conventions exactly.

11) Transit Flag--Enter a "1" if the transect is beginning or a "2" if the transect is ending.

12) Platform Code--Enter only for marine mammal sighting effort in accordance with instructions provided in that manual (columns 77-78). This variable will not be found on the marine debris sighting effort form.

13) Platform Height--Eye height above the sea surface. This should be measured to the nearest meter when the ship is stationary, preferably before leaving port. Do this by dropping a rope over the side and measuring it. Or, focus your camera on the sea surface and read distance scale. (Enter in columns 79-80 on the marine mammal sighting effort form.)

14) Time Out--Total time that marine debris sightings were suspended during the transect. If you entering effort on a marine mammal form, as would generally be the case if interruptions are occurring, enter these data in the right hand margin of the form.

SIGHTING FORM

Individual observations of debris are entered on separate lines immediately upon sighting. An example form is on page 18.

1) Transect number--the transect number is the same as on the effort form.

2) Distance--Perpendicular distance in meters from the vessel to the object as the vessel passes by the debris. If tracking the debris item from the initial sighting until the debris passes by proves difficult, note the angle and distance. Later calculate the perpendicular distance. (You may find judging distances at sea difficult. One way to help develop this ability is to note how known lengths of net look as they are deployed from the ship. If you are provided with reticulated binoculars they will help you with objects at a distance, but objects less than about 200 m may still give you problems.)

3) P/S (Port or starboard)--Side of the vessel on which the debris passes.

4) Material--Debris substance. Record material types as unidentified unless you are fairly certain of your identification. The material codes are: C = cloth; F = fiber (cardboard, hemp, etc.); G = glass; M = metal; P = plastic; R = rubber; S = styrofoam; W = wood; U = unidentified.

5) Shape--Shape of debris is coded into 5 categories as follows: C = cylindrical, R = rectangular, S = square, X = round, U = unidentified.
6) Color--The color of each object is coded as follows: BG = black/gray, BL = blue, BR = brown, GR = green, OR = orange, RP = red/pink, SG = silver/gold/metallic, TN = tan, TT = transparent, WH = white, YW = yellow.

7) Description--A brief description of the identity or perceived function of the observed piece of debris. There are 15 character spaces available for recording any descriptive information beyond what is recorded in other coded fields. Be consistent in your descriptions. For example, using box, crate, etc. for the same object is bad practice.

8) Description Code--Observations should be categorized according to the descriptive code categories that follow:
   a. Fragment = FR
   b. Gillnet Float = GF
   c. Gillnet Fragment = GN
   d. Household Items (light bulbs, pans, mops etc.) = HI
   e. Polypropylene Line = PL
   f. Sheet/Bag = SB
   g. Storage and Shipping Containers = SC
   h. Polystyrene Plastic Piece = ST
   i. Trawl Net Fragment = TN
   j. Uncut Strapping = US
   k. Unidentified and Miscellaneous = UM

9) Underwater--Record a "U" in this field if an object is completely under water or at but not above the surface, i.e. a horizontal view would not reveal an above water profile. Otherwise, leave it blank.

10) Length and Width--Size, in centimeters, of the two longest dimensions of an observed debris item. If you are not used to judging sizes at sea or using the metric system, there are several things you can do to help develop your abilities. First, carry a ruler or measuring tape with you to your observation station. After you guess the size, look at your rule and imagine how large the object would be if you had it in hand. Second, measure objects on the ship that you can see from your station, but are also at a distance. (You may also want to measure larger objects, such as life boats, to help you in estimating the size of marine mammals.) If sampling gear is deployed overboard, measure parts of the gear, taking note of how it looks in the water.
# Marine Debris Sighting Effort Form

**Transect No**
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>7</td>
<td>0</td>
<td>8</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

**Name** J. Observer

**Vessel** R.V. MARU 851 / 8UK1

<table>
<thead>
<tr>
<th>Time</th>
<th>Latitude N/S</th>
<th>Longitude E/W</th>
<th>Sea State</th>
<th>Weather</th>
<th>Visibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>38 2 N</td>
<td>10 10 E</td>
<td>Beaufort 3</td>
<td>Puffy Cld</td>
<td>&gt;5K</td>
</tr>
<tr>
<td>10</td>
<td>38 4 N</td>
<td>10 10 E</td>
<td>Beaufort 3</td>
<td>Puffy Cld</td>
<td>&gt;5K</td>
</tr>
<tr>
<td>20</td>
<td>38 5 N</td>
<td>10 10 E</td>
<td>Beaufort 3</td>
<td>Puffy Cld</td>
<td>&gt;5K</td>
</tr>
<tr>
<td>30</td>
<td>38 6 N</td>
<td>10 10 E</td>
<td>Beaufort 3</td>
<td>Puffy Cld</td>
<td>&gt;5K</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Latitude N/S</th>
<th>Longitude E/W</th>
<th>Sea State</th>
<th>Weather</th>
<th>Visibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>38 7 N</td>
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**Year** 1994

**Month** 8

**Day** 14

---

**Additional Notes:**

- **Weather Conditions:** Puffy Cld
- **Visibility:** >5K
- **Sea Surface Temp. (C):** 22.2
- **Brake Code:** 3
- **Time Zone:** +1
- **Transit Flag:** 0
- **Platform:** 0
- **Time Out:** 0
### Marine Mammal Sighting Effort Form

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<td>2</td>
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<td>N</td>
<td>17°00'21&quot;E</td>
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<td>50/30</td>
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| Time Out | 12 |

*Record ID.*

**Name**: J. Observer  
**Vessel**: R.U. Maru 851 / 3 UKJ
## Marine Debris Sighting Form

**Date:** 87 08 14  
**Observer Name:** J. Observer  
**Vessel Name:** R.U. MARU 851 / 3 UKI

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APPENDIX B: GLARE PARAMETERS--THE NEED FOR STUDY

Introduction

Various environmental factors influence sighting probabilities. In order to estimate density of marine debris it will be necessary to model relationships between selected environmental factors and sighting probability.¹

The first step in modeling these relationships is to isolate the relevant environmental phenomena and determine which characteristics of the phenomena are going to impact sighting probabilities. Three relevant phenomena have been identified: glare, wave formation, and atmospheric conditions.

Preliminary results indicate that glare may be the most important single environmental factor affecting sighting probability. The dominance of this environmental factor appears to be particularly strong in the high sighting probability area—the area fewer than 100 m distant. This appendix will be devoted to a discussion of glare, the parameters which describe it, and suggestions for studies to develop a model of the relationship between the glare parameters and sighting probabilities.²

Methods for Measurement and Description of Glare

Glare characteristics which have been identified and can be related to sighting probability are: 1) intensity, 2) area, and 3) pattern. In order to model a relationship between glare and sighting probabilities, these characteristics need to be quantified and a method developed for measuring them in the field.

Quantification means abstraction, generalization, loss of information. The need to quantify forces the elimination of some information which relates to sighting probability. By our method of quantification we choose what will be lost. It is important at this stage that descriptive aspects which relate glare characteristic to sighting probabilities be preserved.

¹Non-environmental parameters to consider are 1) the relationship between height of the observation platform and sighting of debris, 2) the distance from the ship at which the view of the transect area begins. (How much of the transect is blocked from view by the sides of the ship?) 3) the percent of time spent looking through binoculars 4) the amount that the occurrence of animal sightings distract from the observation of marine debris.)

²While focusing attention and study on glare it will be important not to neglect the interaction between glare and other environmental phenomena.
The price of the lost information will be inaccuracy and possible bias in the inferences of the final modeling of sighting probabilities, but the modeling is, of course, impossible without quantification. Tradeoffs such as this will become more obvious later as we choose the measures to be studied and eventually select a few of the measures for inclusion in the model.

**Glare parameters to consider**

1) **Intensity:** The strength of glare has a direct bearing on the probability of seeing an object that is in an area being scanned. Though it is uncertain, strong glare may cut out over 95% of what would normally be sighted. Moreover, strong glare on one side has implication of increasing sighting on the other (see the pattern parameter). Medium glare may cut out between 50% and 90% of the no glare observations and a weak glare 10% to 40%. However, intensity of glare reacts with sea conditions in dramatic ways. For example in smooth seas, Beaufort 0 or 1 surface conditions, moderate glare may enhance debris sightings. Debris will show up as a dark object and disturbance on an otherwise light smooth surface.

While measuring glare on a continuous scale may be possible and objectivity maintained by the use of light meters, the costs of pursuing such methods would appear to be unreasonable in light of the value of information to be gained and opportunity costs. Therefore four discrete categories have been developed which may be easily used by the observer in the field—much as the Beaufort scale.

**Strong**—Sunlight reflected directly by the water; may be sparkly.

**Medium**—Glare is indirect but still fairly intense, generally reflected by clouds nearby the sun. Medium glare may occur from other parts of the sky too; will generally reflect the color of the clouds.

**Weak**—Glare is indirect at a low level, reflected by clouds away from the sun; the glare will generally be a weak gray, reflecting the clouds.

**None**—No glare.

A study of the consistency of observer classification decisions will have to be made in order to determine whether these categories can be functionally applied.

2) **Area of Glare:** It is recommended that the percent of transect covered by the different glare intensities be used as the measure of area of glare. This quantification will be carried out by estimates made by the observer. Because of the likelihood of errors these
estimates will be recorded to the nearest 5 percent. In modeling sighting probabilities, the measure "percent of transect covered" will interact with limits on visibility due to atmospheric conditions.

3. Pattern: Pattern can be measured in distance and direction. Most debris objects will be observed close to the vessel. Sightings seem to drop off rapidly between 50 and 100 m. At 12 kn an object passing within 10 m of the vessel will be within the 50 m visibility range for approximately 8 s. The time the object is within the 50 m radius extending from the observers position rapidly decreases as distance from the vessel increases. Strong glare from 315° to 360° reduces the time an object is in the high probability sighting area. An object 20 m away will be out of strong glare for only 3 s. On the other hand strong glare from 270° to 315° degrees will completely cut out 20% of the high probability sighting area on the port side, besides reducing the time the object is in the area.

Another implication of pattern is that high glare on one side of the vessel implies high reflectance of light from objects on the opposite side (i.e. a higher probability of sighting on the opposite side than in no glare conditions).

Direction is part of pattern. We have discussed the value of directional measures in terms of degrees. If the degree measure is not selected for use in the model or not recorded in a way that reveals the side of the ship on which the glare is located an indicator should be included. By recording the side, observations under the port-side glare regime can be compared with those under the starboard regime. This comparison can help to refine the relationship between glare parameters and sighting probability.

Distance of glare may also be an important part of pattern. On occasion, the preponderance of sightings will lie close on one side of the ship. This occurrence is particularly dramatic when the entire track is in medium to strong glare except for a 20 m wide section in the shadow of the ship. A distance breakdown would detect this occurrence and allow for compensation in the density estimate for the transect.

Suggestions for glare parameter studies

The next step in developing a model relating environmental conditions is to determine what the functional relationships are between the measured characteristics and sighting probabilities:
1) Study for the impact of glare on sighting probability and possibility.

The basic idea of the glare study is to develop correlations between different glare conditions and actual sightings. The method for this would be to have one person doing intense surveys for all objects within 50 m on one side of the ship. If two people are used, then they would take opposite sides of the ship. One person would conduct a survey from the ship to the horizon.

If it is assumed that the same number of objects were passing on both sides of the ship, and that glare conditions are the only significant factor causing differences in the number of sightings from one side to the other, then a correlation between glare and possible sightings could be developed. These coefficients are being termed sighting possibility coefficients under the assumption that in the intense survey all objects are being observed which it is humanly possible to see.

The next step would be to correlate what was picked up by the intense survey with what was picked up by the to the horizon survey. This correlation would help to develop sighting probability coefficients under different glare conditions.

From these correlations, we can hypothesize that sighting probability coefficients are not linearly correlated with the sighting possibility coefficients developed in the intense surveys. This hypothesis is based on the time it takes for the observer's eyes to adjust to different glare levels, and the observer's ability to develop sensitivity to more subtle environmental queues when intensely examining a small area.

2) Study on the combined effects of glare, distance, and debris characteristics.

A second research design would have one observer noting the distances, color, and size of objects as far directly ahead of the ship as he or she could pick them out. Two observers would watch all objects on both sides of the ship. In this study the observers would communicate with each other to note in more detail the characteristics of the objects as they came close to the ship, what the original sighting distance was and which objects were completely missed at distances of over 50 or 100 m. This study of glare conditions should be conducted concurrently with studies of the effects of wave formations and atmospheric conditions.
3) Study on consistency in the evaluation of glare.

A third research protocol should be conducted to determine the consistency of glare categorization between observers. Observers should be instructed on the glare categories and shown slides during training. They may also be provided with some photos to take with them. While at sea, they would be instructed to take about 10 photos of each glare category at predetermined exposure levels. These would then be compared back at the lab.

Conclusion

A study of the effects of glare on the sighting of marine debris will be of value not only to the NMFS study in the North Pacific Ocean, but also a significant contribution to other sighting studies. Likewise, studies conducted by others on the relation between environmental parameters and sighting probabilities will be of great interest to the NMFS program. Once the studies are concluded and relationships determined, decisions will have to be made regarding which measures will be used in the sighting studies. Cooperation in the choice of the final measures of environmental parameters to be used in sighting studies should be sought. Cooperation in this choice will simplify the exchange of data between research programs; allow the development of temporally and spatially broader databases; and hence, facilitate the more rapid development of a better understanding of the processes of concentration and dispersion of marine debris.
APPENDIX C: NEUSTON TOW FORMS

Both forms have two data fields in common. They are:

1) Vessel Identification (name and radio call sign of the vessel from which the observations are made)
2) Observer Name (full name(s) of the scientist(s) collecting data)

TOW FORM

At the top of the form record net specifications:

Width, height, and length of the frame in centimeters; length and mesh size of the net in centimeters and microns respectively; and mesh size of the bucket in microns. Make and model of the net should be noted.

In the columns on the body of the form record:

1) Station Number--Record station numbers as assigned in the original cruise plan. Assign numbers for unplanned stations.
2) Date--Enter as year-month-day (YMMDD). (860723 is 23 July 1986; 871003 is 3 October 1987).
3) Time Zone--Number of hours GMT is E or W of 180°.
4) Time Start--Enter in hours/minutes/seconds, (0700:30 is 7:00:30 AM).
5) Time Stop--Enter in hours/minutes/seconds.
6) Correction--Estimate number of minutes and seconds the net was not fishing. This includes the time that the net was completely submerged or completely out of the water due to rough sea conditions.
7) Total Corrected Time--Number of minutes and seconds that the net was fishing. This is the total number of minutes between the starting and ending tow time, with the correction, in minutes, subtracted out, (if time start was 0800, time stop was 0810 and the correction was 2 minutes, then the total corrected time would be 8 minutes). This column may be left blank. It will be calculated later by the computer.
8) Ship's Speed--Enter in whole knots.
9) Area Sampled--The product of the total corrected time, the speed of the vessel (converted to meters per second), and the
width of the net. This calculation can be left for the computer to calculate.

10) Latitude--Enter as degrees/minutes/tenths. For example, 241103 is 24 degrees, 11 minutes, and 3 tenths of a minute. Enter "N" or "S" for degrees north or south latitude.

11) Longitude--Enter as degrees/minutes/tenths. For example, 1593304 is 159 degrees, 33 minutes, and 4 tenths of a minute. Enter "W" or "E" for degree west or east longitude.

12) Sea State--Enter the Beaufort scale number as described in Appendix D.

13) SST (SEA SURFACE TEMPERATURE)--Record this in whole °C as measured from bridge instrumentation (engine inlet temperature if necessary). If below freezing, place a "-" in the first column of the field.

SAMPLE FORM

If you are processing the samples at sea, you will fill out the sample form. At the top of the sample form record the vessel identification, date (YYYYMMDD), scientist's name, station number, and dry vial weight. Dry sample weight will be added during lab analysis.

1) Date--As recorded on the Tow Form.

2) Station Number--As recorded on the Tow Form.

3) Dry Vial Weight--Record in grams to three decimal places.

4) Dry Sample Weight--Weigh (in grams), after sample has dried at room temperature for at least one week, as the difference between the empty vial weight and the filled vial weight. It is recorded in grams to three decimal places.

5) Type: Six basic types of particles are defined below. In addition, any types not included but obviously identifiable should be recorded.

   a. Fragments = FRG: chips, sheet fragments, and any other fragments broken from larger objects.

   b. Monofilament line fragments = MLF: single-strand, unwoven line that is either from gill nets or from monofilament fishing line; probably composed of nylon.

   c. Pellets = PTS: pill-shaped pieces that represent the 'raw' form of the plastic as it comes from the synthesizing plants.
d. Polypropylene line fragments = PLF: small pieces of woven polypropylene line.

e. Polystyrene fragments = PSF: small pieces of polystyrene broken from larger pieces.

f. Miscellaneous/unidentified = MUD: miscellaneous pieces of plastic.

6) Length: Size, (in mm) of the longest axis of the plastic particulate.

7) Width: Size, (in mm) of the second longest axis of the plastic particulate.

8) Color: The color of each plastic particle is coded as follows: BG = black/gray, BL = blue, BR = brown, GR = green, OR = orange, RP = red/pink, TN = tan, TT = transparent, WH = white, YW = yellow.
TOW FORM

VESSEL **Ry Maru 851/3UKJ** OBSERVER **J. Observer**

NET SPECIFICATIONS

- **Frame:** Width 5m, Height 3m, Length 6m
- **Net:** Length 1.8m, Mesh Size 505
- **Bucket:** Mesh Size 505

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SAMPLE FORM

VESSLE RV MARU 851 / 30KJ

IDENT J. Observer

STATION NUMBER 001

DATE 84 08 14

DRY VIAL WEIGHT 2.135 g

DRY SAMPLE WEIGHT 880 g

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## APPENDIX D: VISIBILITY CODES AND BEAUFORT SCALE

### Visibility Code

Explanation of surface visibility codes used in the Platforms of Opportunity Program and Marine Debris Program computer format.

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<th>Explanation</th>
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<td>Excellent - Surface of water calm, a high overcast solid enough to prevent sun glare. Marine mammals will appear black against a uniform gray background. Beaufort 0. Visibility &gt;5 km.</td>
</tr>
<tr>
<td>2</td>
<td>Very Good - May be alight ripple on the surface or slightly uneven lighting, but still relatively easy to distinguish animals at a distance. Beaufort 1 or 2. Visibility &gt;5 km.</td>
</tr>
<tr>
<td>3</td>
<td>Good - May be light chop, some sun glare or dark shadows in part of the survey track. Animals up close (&lt;400 m) can still be detected and fairly readily identified. Beaufort 2 or 3. Visibility ≤ 5 km.</td>
</tr>
<tr>
<td>4</td>
<td>Fair - Choppy waves with some slight whitecapping, sun glare or dark shadows in ≤ 50% of the survey track. Animals much further away than 400 m are likely to be missed. Beaufort 3. Visibility ≤ 1 km.</td>
</tr>
<tr>
<td>5</td>
<td>Poor - Wind in excess of 15 knots, waves over 2 ft with whitecaps, sun glare may occur in &gt; 50% of the survey track. Animals may be missed unless within 100 m of the survey trackline; identification difficult except with the larger species. Beaufort 4 or 5. Visibility ≤ 500 m.</td>
</tr>
<tr>
<td>6</td>
<td>Unacceptable - Wind in excess of 25 kn, waves over 3 ft with pronounced whitecapping. Sun glare may or may not be present. Detection of any marine mammal unlikely unless the observer is looking directly at the place where it surfaces. Identification very difficult due to improbability of seeing animals more than once. Beaufort &gt; 6. Visibility ≤ 300 m.</td>
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### Beaufort Scale

Description of sea conditions which correlate to Beaufort wind conditions (number).

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<th>Number</th>
<th>Wave height (m)</th>
<th>Knots</th>
<th>Sea conditions</th>
<th>Description</th>
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<td>0</td>
<td>-</td>
<td>0-1</td>
<td>Calm</td>
<td>Sea smooth and mirror-like.</td>
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<td>1</td>
<td>0.6</td>
<td>1-3</td>
<td>Light air</td>
<td>Scale-like ripples without foam crests.</td>
</tr>
<tr>
<td>2</td>
<td>0.6</td>
<td>4-6</td>
<td>Light breeze</td>
<td>Small, short wavelets; crests have a glassy appearance and do not break.</td>
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<tr>
<td>3</td>
<td>0.6</td>
<td>7-10</td>
<td>Gentle breeze</td>
<td>Large wavelets; some crests begin to break foam of glassy appearance. Occasional white foam crests.</td>
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<tr>
<td>4</td>
<td>1.2</td>
<td>11-16</td>
<td>Moderate breeze</td>
<td>Small waves, becoming longer; fairly frequent white foam crests.</td>
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<tr>
<td>5</td>
<td>1.8</td>
<td>17-21</td>
<td>Fresh breeze</td>
<td>Moderate waves, taking a more pronounced long form; many white foam crests; there may be some spray.</td>
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<tr>
<td>6</td>
<td>3.1</td>
<td>22-27</td>
<td>Strong breeze</td>
<td>Large waves begin to form; white foam crests are more extensive everywhere; there may be some spray.</td>
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<tr>
<td>7</td>
<td>4.3</td>
<td>28-33</td>
<td>Near gale</td>
<td>Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind; spindrift begins.</td>
</tr>
<tr>
<td>8</td>
<td>5.5</td>
<td>34-40</td>
<td>Gale</td>
<td>Moderately high wave of greater length; edges of crests break into spindrift; foam is blown in well-</td>
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### Beaufort Scale—cont.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Description</th>
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<td>7.0</td>
<td>41-47</td>
<td>Strong gale</td>
<td>High waves; dense streaks of foam storm along the direction of the wind; crests of wave begin to topple, tumble, and roll over; pray may reduce visibility.</td>
</tr>
<tr>
<td>10</td>
<td>8.9</td>
<td>48-55</td>
<td>Storm</td>
<td>Very high waves with long over-hanging crests. The resulting foam in great patches is blown in dense white streaks along the direction of the wind. On the whole, the surface of the sea is white in appearance. The tumbling of the sea becomes heavy and shock like. Visibility is reduced.</td>
</tr>
<tr>
<td>11</td>
<td>11.3</td>
<td>56-63</td>
<td>Violent storm</td>
<td>Exceptionally high waves that may obscure small and medium sized ships. The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere the edges of the wave crests are blown into froth. Visibility reduced.</td>
</tr>
<tr>
<td>12</td>
<td>13.7</td>
<td>64-71</td>
<td>Hurricane</td>
<td>The air is filled with foam and spray. Sea completely white with driving spray; visibility very much reduced.</td>
</tr>
</tbody>
</table>