WORKSHOP SERIES No. 6

WORKSHOP ON RESPONSE TO HAZARDOUS CHEMICAL SPILLS IN THE GREAT BARRIER REEF REGION

Proceedings of a Workshop held in Townsville, Australia, Friday, 3 August 1984

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SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

1. There is a need to establish a scientific response capability for spills of hazardous materials (including oil) in the Great Barrier Reef Region.

2. Any response capability which is developed should be for all hazardous materials, not just oil.

3. In responding to hazardous chemical spills in the Great Barrier Reef Region - three elements of the response need consideration:

- combat of spill
- co-ordination between combat and assessment teams
- environmental assessment.

4. Criteria are essential to determine the timing and nature of the scientific assessment response in relation to the combat response. These criteria would be used first by the On-site Co-ordinator (OSC) (combat) and the Scientific Support Co-ordinator (SSC) (scientific response).

5. GBRMPA should establish a working group to investigate who/what/equipment/training etc should be involved in the scientific response. This working group should also investigate existing analytical capability, extent and cost of upgrading to desirable levels etc.

6. The SSC must be designated by organisation and he must be named.

7. There is need for development of models to enable spill trajectory, diffusion and dispersion to be predicted.

8. There is a need to collect and collate information on the:

- nature of hazardous materials;
- volumes of hazardous cargoes;
- degree of risk and hazard profiles of cargoes being carried through the Great Barrier Reef Region.

9. Funding mechanisms for scientific response need investigation. QFMRAAC should be approached. Department of Transport has funding available for immediate combat response. The cost of obtaining scientific environmental advice can probably be met from within the existing system.

10. The data base on ecotoxicological effects of hazardous chemicals requires further work particularly at the macro-organism level. At the micro-organism level, much data is already available.

11. There may be a need for better control of shipping through the Great Barrier Reef Region and aiming efforts to prevent spillage. A possibility exists for notification of noxious cargoes when entering the Great Barrier Reef Region through the AUSREP system.

12. Transport for the scientific response must be available. A linkage might be established through the National Plan to the Armed Services. The Queensland National Parks and Wildlife Service day-to-day management staff should be involved in this activity.

BACKGROUND

The Department of Transport, as part of their responsibility for the National Plan to Combat Pollution of the Sea by Oil, has been preparing a response plan for the Great Barrier Reef Region. An element of that plan which has not yet been finalised is the scientific response which might be initiated in the event of an oil spill. Such a response has two components; to provide advice on environment protection matters, and to investigate the spill and control measures to provide information which may improve future responses.

Oil spills are an area of potential concern, but there may be other hazardous chemicals transported through the Great Barrier Reef Region. To date, there appears to have been little attention directed towards either a scientific or environmental protection response, in the event of a spill of hazardous chemicals other than oil in the Great Barrier Reef Region. There may be a need to link plans to protect the Reef from an oil spill with similar responses in the event of other hazardous spills.

As part of its Great Barrier Reef Region management responsibilities, the Great Barrier Reef Marine Park Authority conducted a workshop on response to hazardous chemical spills in the Great Barrier Reef Region. The workshop was organised to take advantage of the presence in Australia of Professor John Gray from Oslo University, Senior Queen's Fellow in Marine Science at James Cook University and Professor Michael Champ of The National Oceanic and Atmospheric Administration (NOAA) and the American University, who is also a Senior Queen's Fellow in Marine Science. Both Queens Fellows are experts in oil (and other oceanic) pollution matters and the measurement and monitoring of its impacts.

The workshop brought together researchers in the areas of risk analysis, marine chemistry, oceanography and marine contaminants, officers from State and Commonwealth Government agencies with interests in this area, and representatives from the Queensland and Torres Strait Pilot Service and industry.

The objective of the workshop was to examine the necessity and feasibility of establishing a response capability, particularly a scientific response capability, for hazardous chemical spills in the Great Barrier Reef Region.

The workshop was presented with a series of papers, covering the United States (NOAA) experience with scientific response to hazardous material spills, the Norwegian scientific response to oil spills, the status of the current arrangements regarding the Great Barrier Reef Region through the National Plan to Combat Pollution of the Sea by Oil and risk analysis in the Great Barrier Reef Region. Following general discussion, the workshop participants were divided into three groups to discuss the objectives outlined in the following section. Group Chairmen presented the groups findings to the general workshop and a series of recommendations were developed, based on the group and general discussion.

OBJECTIVES

The objective of the workshop was to examine the necessity and feasibility of establishing a response capability, particularly a scientific response capability for hazardous chemical spills in the Great Barrier Reef Region.

In meeting this objective, a framework was considered covering the following points:

- identification of hazardous chemicals and risks;
- decisions to respond; and
- organising the response.

A more detailed coverage is given below.

1. What are the nature and relative magnitudes of the major potential hazardous chemical spills in the Great Barrier Reef ecosystem in terms of:

   - materials, source, fate and effects;
   - risk estimation, sensitivity mapping;
   - prediction of outcome; and
   - cost of spills.

2. Response to hazardous chemical spill situations:

   Two basic elements of response are relevant

   (i) Immediate environmental protection response (role of National Plan)

   - oil;
   - other chemicals;
   - criteria for response; and
   - type of response.

   (ii) Utilising such situations to enhance knowledge basic to the protection of the Great Barrier Reef:

   - criteria for response; and
   - type of response.

3. Organisation of response

Four principal elements of organisation should be addressed:

- who should organise;
- what should be organised;
- how it should be organised; and
- costs.

4. Establishment of working groups to consider future action for 1 to 3

This may require:

- definition of terms of reference of such (a) group(s); and
- nomination of leader and members of group(s).

PROGRAM

Chairman: Dr. Alistair Gilmour, GBRMPA

9.00-9.05	Opening (Dr. Alistair Gilmour, GBRMPA)
9.05-9.45	United States experience with oil and other hazardous chemical spills. (Professor Michael Champ, National Oceanographic and Atmospheric Administration, the American University and Senior Queen's Fellow in Marine Science).
9.45-10.15	Norwegian experience with oil spills: Scientific response (Professor John Gray, University of Oslo and Senior Queen's Fellow in Marine Science).
10.15-10.45	Morning Tea
10.45-11.05	Resume of state of existing Great Barrier Reef Region response arrangements (National Plan to Combat Pollution of the Sea by Oil) (Dr. David Kay, Department of Transport).
11.05-11.30	Risk assessment with particular reference to the Great Barrier Reef Region (Dr. Maurice James, Department of Civil and Systems Engineering, James Cook University).
11.30-12.30	General discussion.
12.30-2.00	Lunch
2.00-3.15	Discussion groups. Attendees will be divided into three discussion groups. The objectives of the discussion groups are to consider: . the necessity and feasibility of establishing a response capability; . terms of reference for working groups to discuss the objectives; . possible working group Chairmen and members.

Discussion group Chairman and Rapporteurs:

A.	Dr. Wendy Craik	Mr.Richard Kenchington
B.	Dr. David Kay	Mr. Dan Claasen
C.	Captain Roger Neve	Mr. Ian Dutton

3.15-3.45 Afternoon Tea

3.45-4.50 Reports from Chairmen, Rapporteurs of Discussions Groups and General Discussion.

4.50-5.00 Summary (Dr. Alistair Gilmour).

LIST OF PARTICIPANTS: (Discussion groups in parentheses)

Dr. Trevor Beckman (A)	Qld Government Chemical Laboratory
Dr. Lance Bode (B)	Department of Civil & Systems Engineering James Cook University
Professor Cyril Burden-Jones (A)	Department of Biological Sciences James Cook University
Professor Michael Champ (A)	National Oceanic and Atmospheric Administration, The American University Senior Queen's Fellow in Marine Science
Mr. Dan van R. Claasen (B)	Planning Section, Great Barrier Reef Marine Park Authority
Mr. Richard Clark (C)	Research and Monitoring Section Great Barrier Reef Marine Park Authority.
Dr. Michael Coates (C)	Australian Environmental Studies, Griffith University
Dr. Wendy Craik (A)	Research and Monitoring Section, Great Barrier Reef Marine Park Authority
Mr. Geoff Crane (B)	Bureau of Meteorology
Mr. Bob Craswell (C)	Water Quality Council of Queensland

Dr. Colin Dahl (B)	Australian Government Analytical Laboratory
Dr. Gary Denton (A)	Department of Marine Biology, James Cook University
Mr. Ian Dutton (C)	Research and Monitoring Section, Great Barrier Reef Marine Park Authority
Dr. Frank Gillan (A)	Australian Institute of Marine Science
Dr. Alistair Gilmour (B)	Great Barrier Reef Marine Park Authority
Dr. Brush Gordon-Smith (C)	Department of Home Affairs and Environment
Captain Donald Grant (A)	Queensland and Torres Strait Pilots Service
Professor John Gray (B)	Oslo University, Senior Queen's Fellow in Marine Science
Mr. Peter Gregory (C)	Australian Institute of Petroleum
Professor Dilwyn Griffiths(A)	Department of Botany James Cook University
Dr. Maurice James (C)	Department of Civil and Systems Engineering James Cook University
Dr. David Kay (B)	Federal Department of Transport
Mr. Richard Kenchington(A)	Planning Section, Great Barrier Reef Marine Park Authority

Dr. Peter Murphy (B)	Sir George Fisher Centre for Tropical Marine Studies, James Cook University
Captain Roger Neve (C)	Department of Harbours and Marine
Mr. John O'Dwyer (A)	Planning Section, Great Barrier Reef Marine Park Authority
Mr. Peter Ogilvie (B)	Queensland National Parks and Wildlife Service
Dr. John Reichelt (C)	Sir George Fisher Centre for Tropical Marine Studies, James Cook University
Mr. Brian Slattery (A)	Petroleum Institute Environmental Conservation Executive
Mr. John Wheeler (B)	Queensland Premier's Department

<u>INTRODUCTION</u>: by Alistair J. Gilmour, Executive Officer, Great Barrier Reef Marine Park Authority.

The National Plan to Combat Pollution of the Sea by Oil, (the National Plan) has been in operation since 1973. It is a joint Commonwealth/State initiative with assistance from the oil industry to combat coastal oil spills.

Supplements to the National Plan are prepared for each State e.g. The Queensland Supplement to the National Plan. However, there is no plan yet in place to combat oil pollution of the reef, although 'REEFPLAN' is currently being drawn up to meet this need. This, of course, relates only to oil.

It may also be necessary to mount a response in the event of a spill of other hazardous cargoes.

There remains, however, the need to focus on the provision of scientific advice in combatting the spill to minimal environmental impact, and garnering scientific information on the impact of the spill.

The workshop is designed to address these aspects and the need to be able to respond. Three elements need consideration:

- evaluation of the hazard
- criteria for response
- how to organise the response.

I trust that the workshop will produce a useful statement of where and how we ought best proceed and that such a statement ought be relevant to all interests represented here today.

UNITED STATES EXPERIENCE WITH OIL AND OTHER HAZARDOUS CHEMICAL SPILLS: by Michael Champ, National Oceanic and Atmospheric Administration, The American University and Senior Queen's Fellow in Marine Science.

Historical perspective

In 1967 the "Torrey Canyon" incident generated world-wide awareness of the potential problem of large oil spills at sea. Australia has been involved in this area from very early days. A brief outline of relevant events since 1967 follows:

1969 - Australia establishes a National Oil Spill Contingency Plan.

1970 - "Oceanic Grandeur" grounded in Torres Strait.

1971 - September - Meeting between Commonwealth and State Ministers.

1972 - "Strait Chatham" grounded on Gubbins Reef in 1972

1973 - October - Australia establishes the National Plan to Combat Pollution of the Sea by Oil.

1976 - December - "Argo Merchant" spill - Nantucket Island.

1977 - August - "USNS Potomac" Oil Spill Melville Bay, Greenland.

1978 - March - Amoco Cadiz" Spill - Brittany Coast.

1979 - June 3 - IXTOC I Spill (spilled until 27 March 1980).

1984 - Reefplan - Oil Spill Contingency Plan for the Great Barrier Reef (Department of Transport) - Drafted.

The relative volumes of major spills are:

"Argo Merchant" - 7.6 million gallons.

"Amoco Cadiz" - 68 million gallons.

IXTOC I - spilled almost 1 year, estimated up to 50,000 barrels per day.

EPA - NOAA Hazardous materials response teams

In the USA, scientific response teams were assembled as a result of the "Argo Merchant" oil spill in 1976.

At the time of the "Argo Merchant" oil spill near Nantucket Island in December 1976, a research team of scientists from the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Coast Guard (USCG) undertook a limited reserach project designed to describe the movement and fate of the oil released by this tanker. This was a first step in assessing the ecological effects of the spill. Many other Federal agencies, state organisations, and academic groups were drawn into the work. During this effort, it became apparent that forecasts of the oil's movement and scientific chemical and biological studies could be of considerable assistance to the on Site Co-ordinator (OSC), who has the responsibility for preventing and combatting such incidents. Therefore, after the "Argo Merchant", NOAA established the Hazardous Materials Response Project to provide operational scientific advice to the Federal OSC during oil and toxic chemical spills in the marine environment. Head quartered in Seattle, Washington, this group has the capability of bringing together the talents of a wide range of experts from Federal, State and local agencies as well as universities and the private sector. These experts have been called upon during numerous spills around the coast of the United States, and have also been requested to lend their assistance at foreign spills, most notably during the "Amoco Cadiz" disaster in 1978.

Following the "Argo Merchant" oil spill EPA and NOAA developed an Interagency Oil Spill Response Team with the following functions:

(1) To provide authorities responsible for clean-up with highly qualified scientific assistance in mitigating the environmental and socio-economic impact of spills of oil and other hazardous substances.

(2) To provide scientific assistance in assessing the damage resulting from such spills.

(3) To maximise the research advantage offered by the spill situation, especially with respect to improving the effectiveness of future responses.

On June 3, 1979, a Petroleos Mexicanos (PEMEX) exploratory well, Ixtoc I, blew out in the Bay of Campeche, about 80 km northwest of Ciudad Del Carmen, Mexico. The spill, not brought under control until 27 March, 1980, became the largest oil spill in history.

During the Ixtoc I spill, more than 200 scientists from a number of Federal and State agencies, academic institutions and private companies were marshalled to forecast the trajectory of the spilled oil and to give advice on beach processes, danger to living resources and changing composition and toxic qualities of the petroleum over the several months that much of the oil remained at sea (NOAA, 1981).

These agencies are listed below:

Federal agencies

- United States Coast Guard
- Environmental Protection Agency
- U.S. Department of Interior, Bureau of Land Management, Fish and Wildlife Service
- U.S. Geological Survey
- National Park Service
- Food and Drug Administration
- National Oceanic and Atmospheric Administration
- United States Navy

State of Texas Agencies

- Department of Health
- Parks and Wildlife Department
- Department of Roads
- Department of Transportation

Universities

- Corpus Christi State University
- University of New Orleans
- Texas A & M
- University of Texas, Institute of Marine Sciences
- Woods Hole Oceanographic Institute

Private Contractors

- Coastal Ecosystems Company
- Computer Sciences Corporation
- Ecology and Environment, Inc.
- Energy Resources Company
- Research Planning Institute
- Science Applications, Inc.
- SRI International
- USR Company.

Measures taken to mitigate environmental damage by the scientific team included the following general activities:

- Identification and prioritization of sensitive areas using ground surveys and remote sensing;
- Tidal, wind, and bathymetric studies in support of boom placement efforts;
- Fishery resources protection through a voluntary shrimp inspection program to ensure consumer confidence as well as slick location broadcasts to minimize lost fishing time and losses of catch and gear;
- A monitoring program to detect the presence of hydrocarbons in key shellfishing areas;
- Establishment of bird, mammal, and turtle clean-up stations along the Texas coast;
- Testing of dispersants and biological agents to determine the feasibility of their use to break up and degrade the oil as it reached U.S. waters;
- Studies to determine the most environmentally sound clean-up and disposal techniques.

The Galt Model was used to forecast spill trajectory (Figure 1). Use of this model led to the realisation that more oceanographic data was required and a number of oceanographic ships were moved into the Gulf of Mexico to collect more oceanographic data to enable better spill forecasting.

The deposition of oil on the shoreline was an area of potential concern (Figures 2 and 3) particularly on the Mexican coast. The oil coverage of the shoreline (250 miles) was spatially and temporally variable (Figures 4,5,6,7,8) particularly as the oil was not released as a simple pulse but over a period of months (Figure 9). All Figures are appended.

Conclusions

Field studies suggest that Ixtoc 1 oil may have caused:

(1) significant population shifts and avoidance by major wading and shore-bird species at heavily oiled beaches;

(2) subtle reductions of infaunal population densities throughout the intertidal beach habitat, with significant declines occurring only in the lower intertidal zone and the second bar and trough of subtidal habitats; major population declines in two species of crustaceans (mole crabs and amphipods);

(3) minor impacts to marsh vegetation; and

(4) minor impacts to marine turtles and mammals.

However, it was difficult to distinguish the effects of spilled oil from effects from natural factors such as tropical storms, seasonality, and normal population variation.

Laboratory studies further indicated that:

(1) acute exposures of dominant beach infauna such as mole crabs, surf clams, and polychaete worms to the oil-accommodated seawater fraction were not acutely toxic, although significant sublethal physiological effects and avoidance behaviour were observed in mole crabs;

(2) acute exposures of subtidal amphipods and zooplankton to the oil-accommodated seawater fraction were not toxic;

(3) acute exposures of redfish larvae to the oil-accommodated seawater, water soluble fractions, and mousse fractions were toxic, with highest toxicity being observed in the mousse and oil-accommodated seawater fractions (rather than the water soluble fraction);

(4) acute exposures of seatrout to the oil-accommodated seawater fraction resulted in significant toxicity in juvenile fish, but no toxicity in adult fish; and

(5) acute exposures of brown shrimp to the oil-accommodated seawater fraction were not toxic.

Laboratory studies indicated that Ixtoc-1 oil was not acutely toxic to the adult marine organisms tested. These laboratory findings tend to support results from field studies which indicated that Ixtoc I oil caused only limited impacts to beach infauna and other marine organisms. Results of subtidal amphipod and zooplankton toxicity tests were inconclusive, in that both species were resistant to low concentrations of oil tested. However, effects of high concentrations other than those tested are unknown.

One of the major lessons to emerge from the IXTOC-I spill was that legislation is necessary to ensure assessment damage and appropriate compensation as a result of spills of hazardous materials. Most legislation (including REEFPLAN) does not include an assessment of the economic impact of spills on resources. However, in the USA, the Comprehensive Environmental Rehabilitation, Compensation and Liability Act (CERCLA) of 1980 requires the Federal Government to establish a damage assessment program to provide compensation for damages to natural resources held in public trust for large spilled oil and hazardous substances.

Economic costs of oil spills

Such assessment provides the social justification to respond to spills. An assessment of the economic costs of such a spill was made by NOAA for the "Amoco Cadiz" spill, which occurred on the Brittany Coast in March 1978 (Figure 10).

The objectives of the NOAA (1983) study were:

(1) to apply and to assess the applicability of existing analytical methods for estimating damages;

(2) to estimate the total net economic costs of the spill.

The total net economic cost to the French Government was calculated to be $US 190 to 290 million (1978) (NOAA, 1983).

The largest components of that cost were:

- cleanup expenditures $US 103-114 million
- losses to the oyster-culturing industry $US 107 million
- loss of the tanker and cargo
- recreation losses $US 1.5 - 100 million.

The field objectives of the study were:

(1) aerial photographic mapping and ground surveys of impacted beaches;

(2) statistical mapping of the distribution of oil on the water surface using vertical photography;

(3) surveys of the concentrations of oil in subsurface water;

(4) evaluation of the effect of weathering on the composition of surface oil as a function of time/distance from the wreck site;

(5) evaluation of the long-term effects of weathering on the composition of oil in sediments from tidal flats and beaches;

(6) evaluation of the biological consequences of the spill;

(7) observation and assessment of clean-up techniques; and

(8) assessment of economic impact to resources.

From the "Amoco Cadiz" the following balance for spilled oil has been calculated:

- oil spilled approximately 220,000 tons
- into water approximately 145,000 tons
- onto beach approximately 65,000 tons
- into atmosphere approximately 80,000 tons

Social costs of the spill varied over time as shown in Figure 11. Clean up costs were in excess of $US 100 million (1978) (Table 1), and costs to marine resources were over $US 33 million (Table 2) (NOAA, 1983).

The need for a written record of events during the cleanup of a spill enables an accurate estimation of costs, as it is impossible to accurately recall numbers of people and volumes of equipment transported well after the event. Fortunately such data were kept during the "Amoco Cadiz" spill as shown below:

(a) Daily reports on number in spill zone and total days of operation or work listed:

Portable pumps	Backhoe tractors
Dump trucks	Road levellers
Sanitation trucks	Cranes
tank trucks	Mechanical shovels
Fire engines	Bulldozers
Heavy equipment transporters	DDE workers
Honey wagons	Military personnel
Farm tractors	Firemen
Front-end loaders	Volunteers

(b) Daily reports on quantities listed:

Mousse pumped, m^3
Mixed oiled sand, seaweed, and detritus picked up, m^3
Mixed oiled sand, seaweed, and detritus picked up in sacks m^3
Beach areas cleaned, m^2 of surface area
Rocky areas cleaned, m^2 of surface area
Marsh areas and mudflats cleaned m^2 of surface area.

This enables relatively accurate cost accountability of the exercise, something which is absolutely essential to enable governments to be able to decide if they want to respond.

Table 1 - Estimated Cleanup Costs to France, Amoco Cadiz Oil Spill

Cost Item	Amount (1978 FR x 10^6)
At-Sea operations (Plan Polmar-Mer)	
Rented private vessels	15
Rented pumping equipment	6
Planes and helicopters, private and military	5
French Navy vessels	14
French Navy labor costs	9
Miscellaneous purchased equipment and supplies	1
Repairs and maintenance of Navy vessels	4
Chemicals	11
Transportation of Navy equipment and personnel	0.5
Total At-Sea Cleanup Costs	65
(NOAA, 1983)	
On-Shore operations (Plan Pomar-Terre)	
Army	97
Volunteer labour	8
Police	4
Miscellaneous expenditures by communes	2
Department of Equipment employees	9
Fire departments	4
Purchased equipment and supplies	87-130[a]
Rented equipment	86
Waste transportation and final disposal	42
Fuel	0.5
Equipment repairs	10
Restoration and bird cleaning	14
Department of lighthouses and buoys	0.5
Prefecture workers	0.5
Interest charges	3
Total On-Shore Cleanup Costs	364-409
TOTAL COSTS	430-475 (103-114)[b]

(NOAA, 1983)

a The range reflects the two alternative assumed residual values of purchased equipment i.e. 50 percent and 25 percent, respectively.

b U.S. dollars (x 10^6) at exchange rate of 4.18 francs per dollar.

Table 2- Summary of Estimated Costs to Marine Resources

Category	Present Value of Cost (1978 FR x 10^6)
Oyster-culturing industry	107
Seaweed harvesting and processing industry	0.1
Holding tank operations for shellfish	11
Salmon, sea trout, abalone experimental aquaculture operations	0.1
Open-sea fisheries	20
Uncompensated damage to fishing boats and equipment	1
Marine sand and gravel operations	0.1
Damage to real and personal property	1
Changes in value of real property	Negligible
Non-commercial marine biomass	a
Marine-related birds	a
TOTAL COSTS	140 (33)[b]

a No estimate of monetary cost possible

b U.S. dollars (x10^6) at an exchange rate of 4.18 francs per dollar.

Summary:

In the event of a spill of hazardous materials, the key areas of concern are:

(1) Chemical, and physical characterstics of the spilled material
(2) Toxicity (acute and chronic)
(3) Transport offshore or inshore of contaminated water mass (as a plume or surface slick)
(4) Resources at risk
(5) Research protection measures
(6) Impact-predictive studies (Post Spill)
(7) Economic damage resource studies, and
(8) Social and economic studies.

References Cited and Suggested Reading

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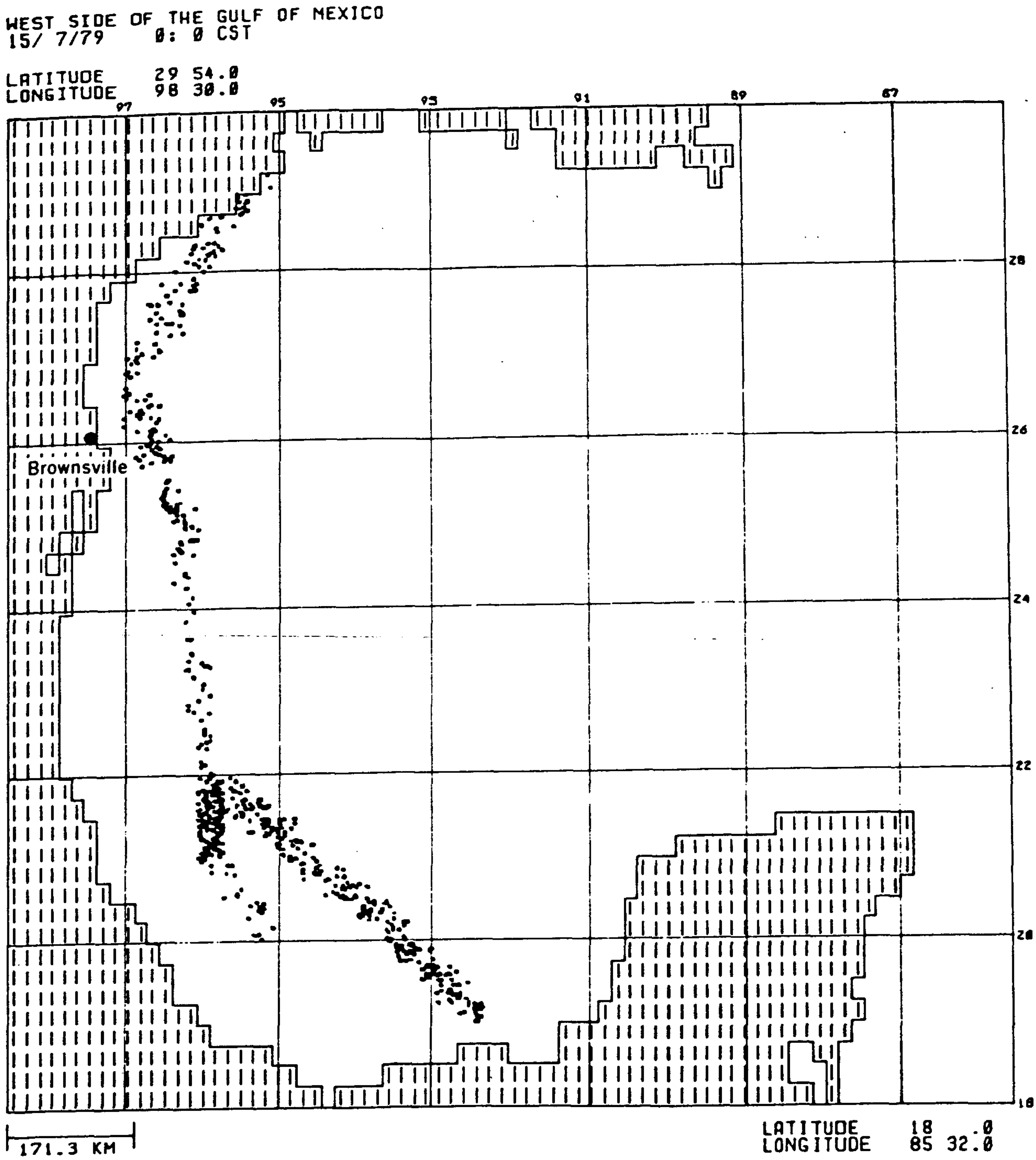


Figure 1. Initial trajectory estimate produced 10 hours after major notification.

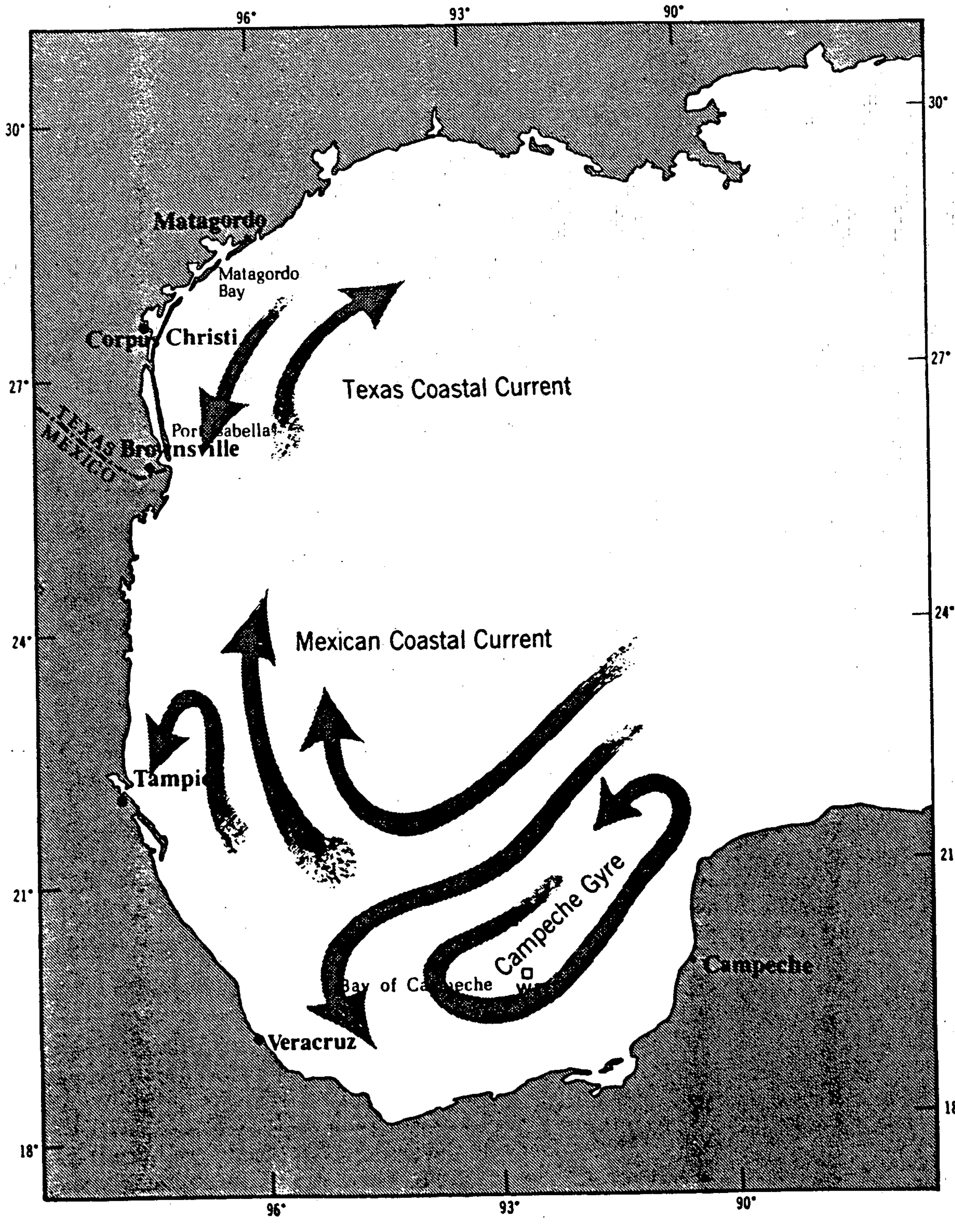


Figure 2. Representation of flow patterns significant to the movement of oil into U.S. waters.

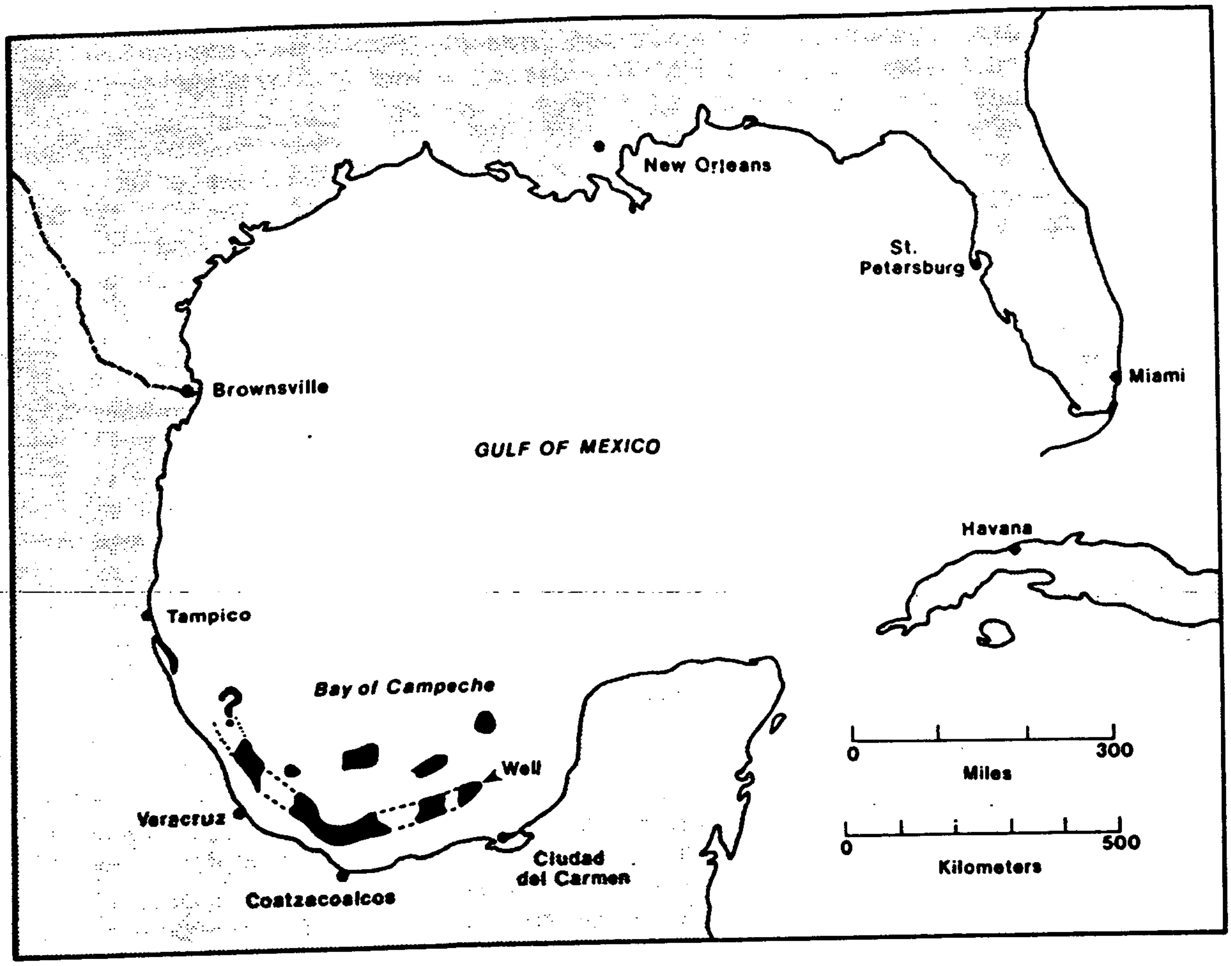


Figure 3. Galt/Kennedy overflight 3 July 1979 showing distribution of oil as seen from the NOAA P-3 aircraft.

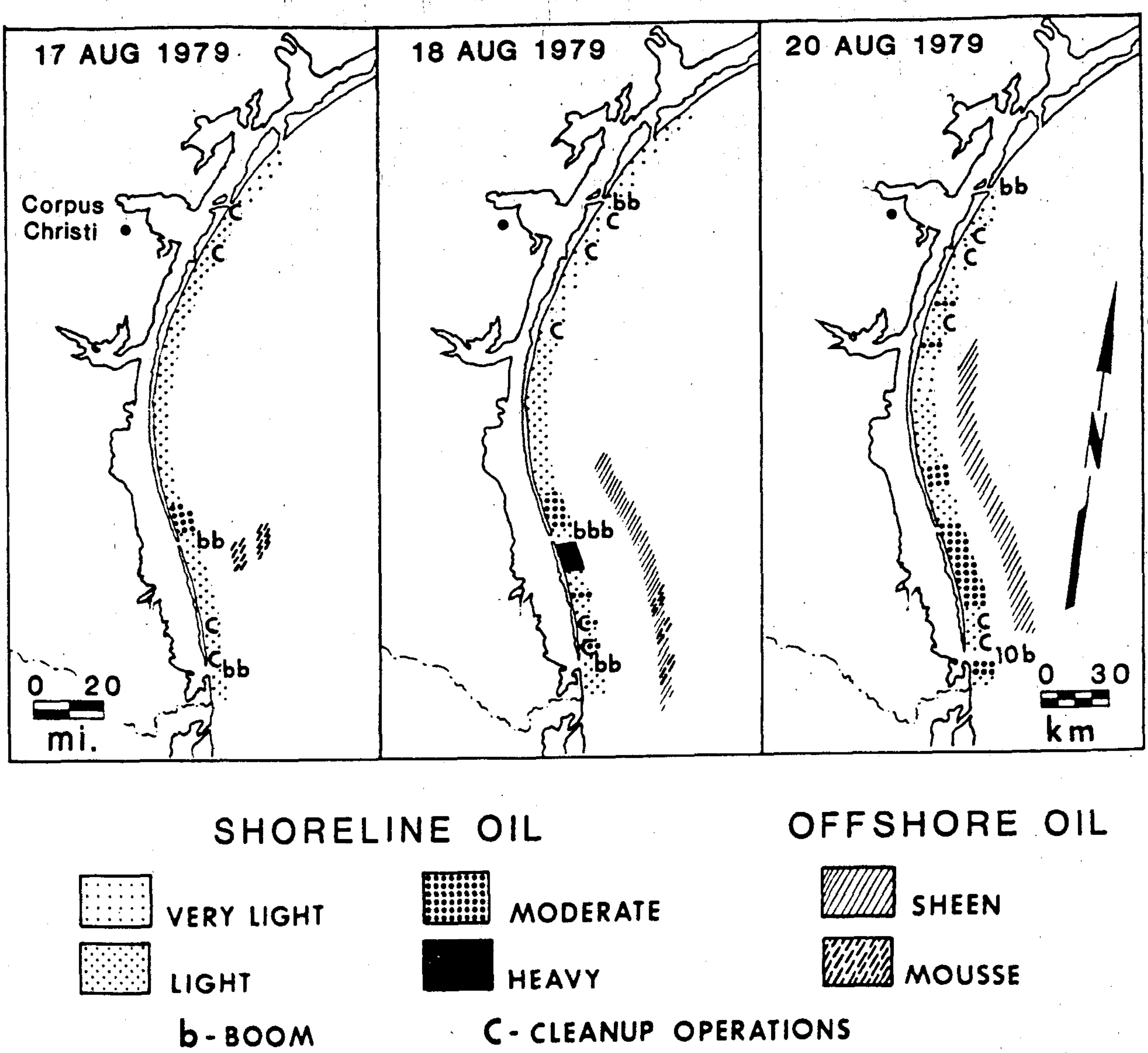


Figure 4. Shoreline and offshore oil along the south Texas coast on 17, 18, and 20 August 1979.

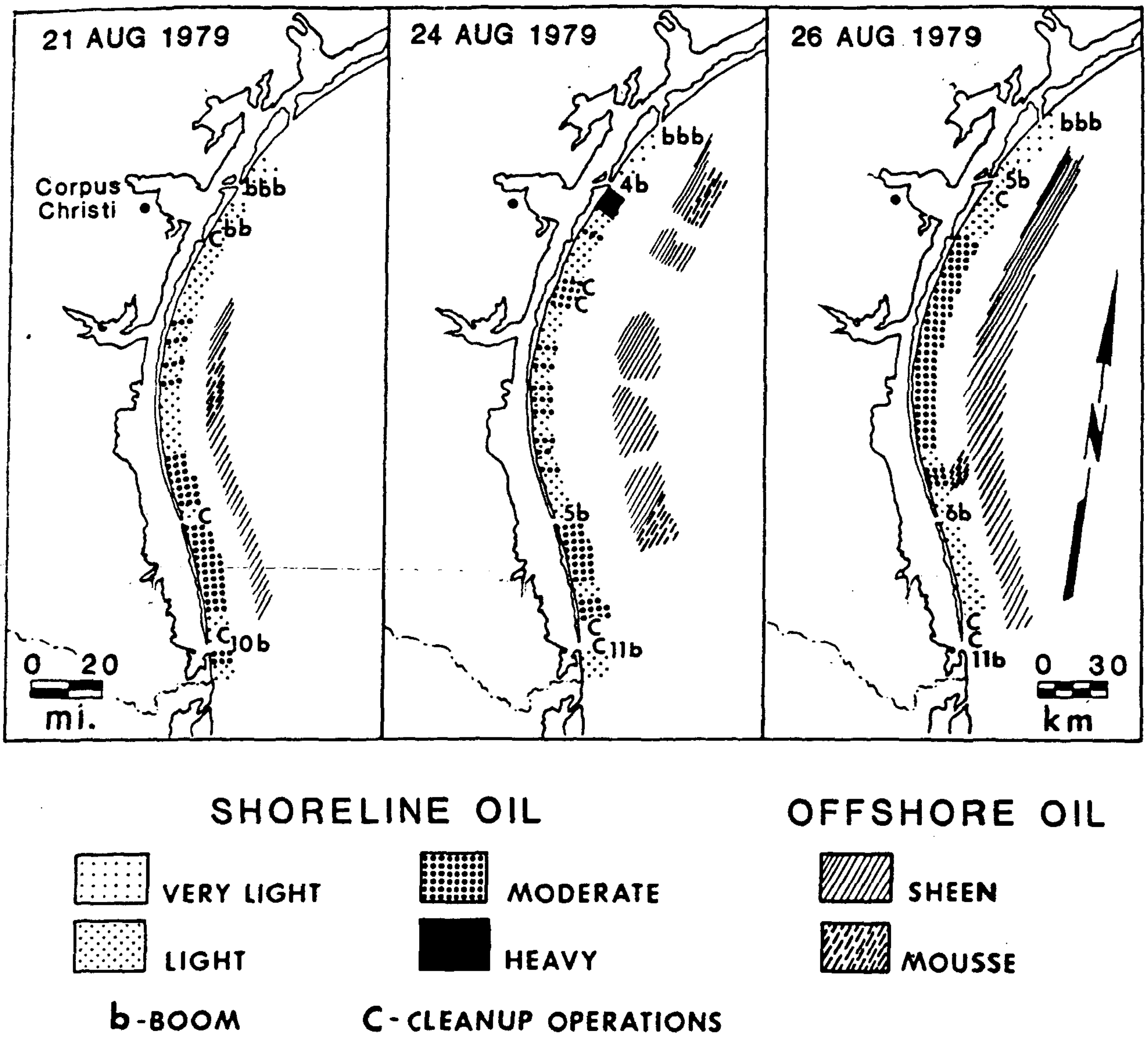


Figure 5. Shoreline and offshore oil along the south Texas coast on 21, 14, and 26 August 1979.

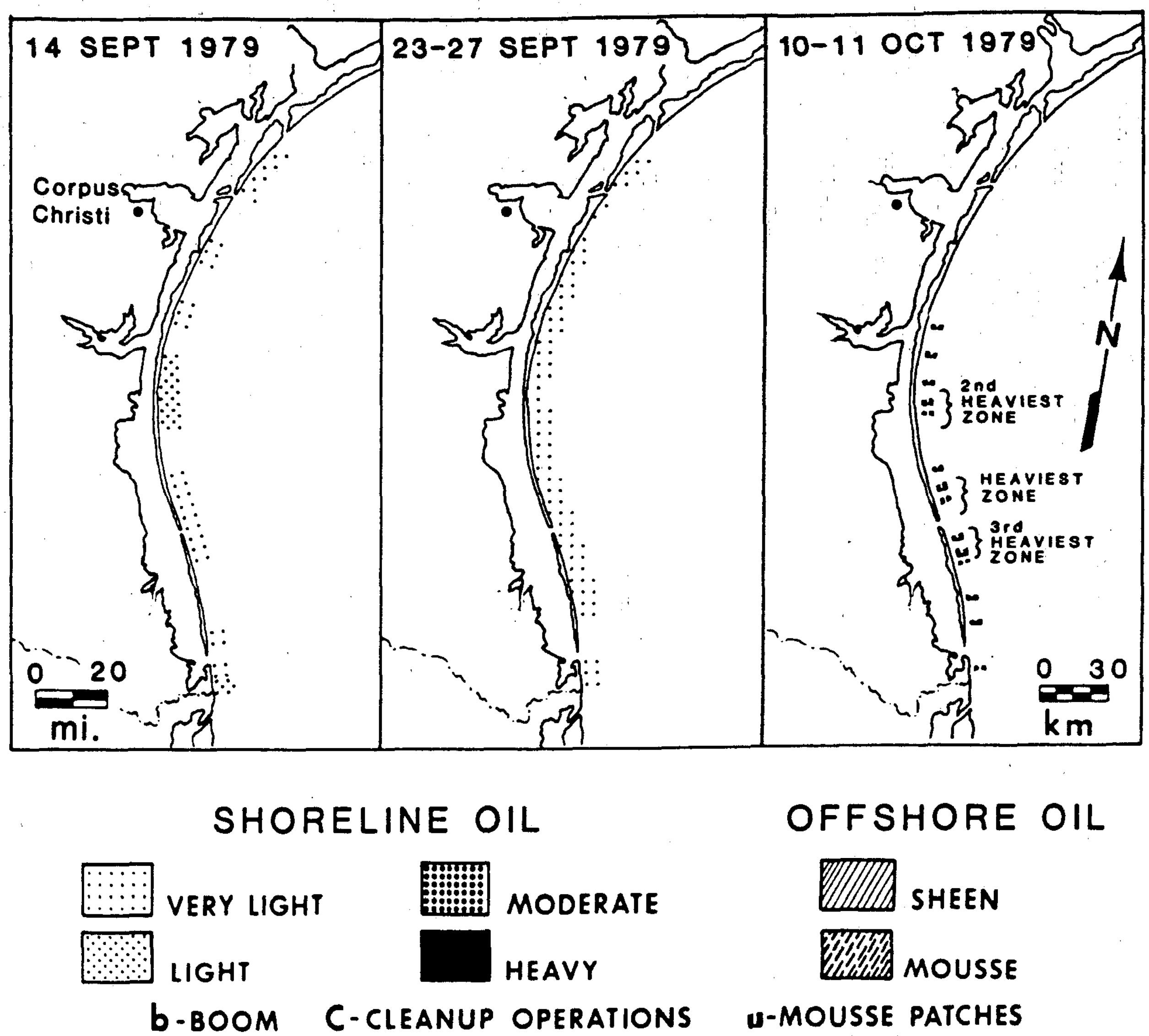


Figure 6. Shoreline and offshore oil along the south Texas coast on 14 and 23-27 September and 10-11 October 1979. The survey of 10-11 October indicated areas where outcropping mousse and sediment were observed. Outcrops ranged from 5 to 65 m long and 2 to 15 m wide.

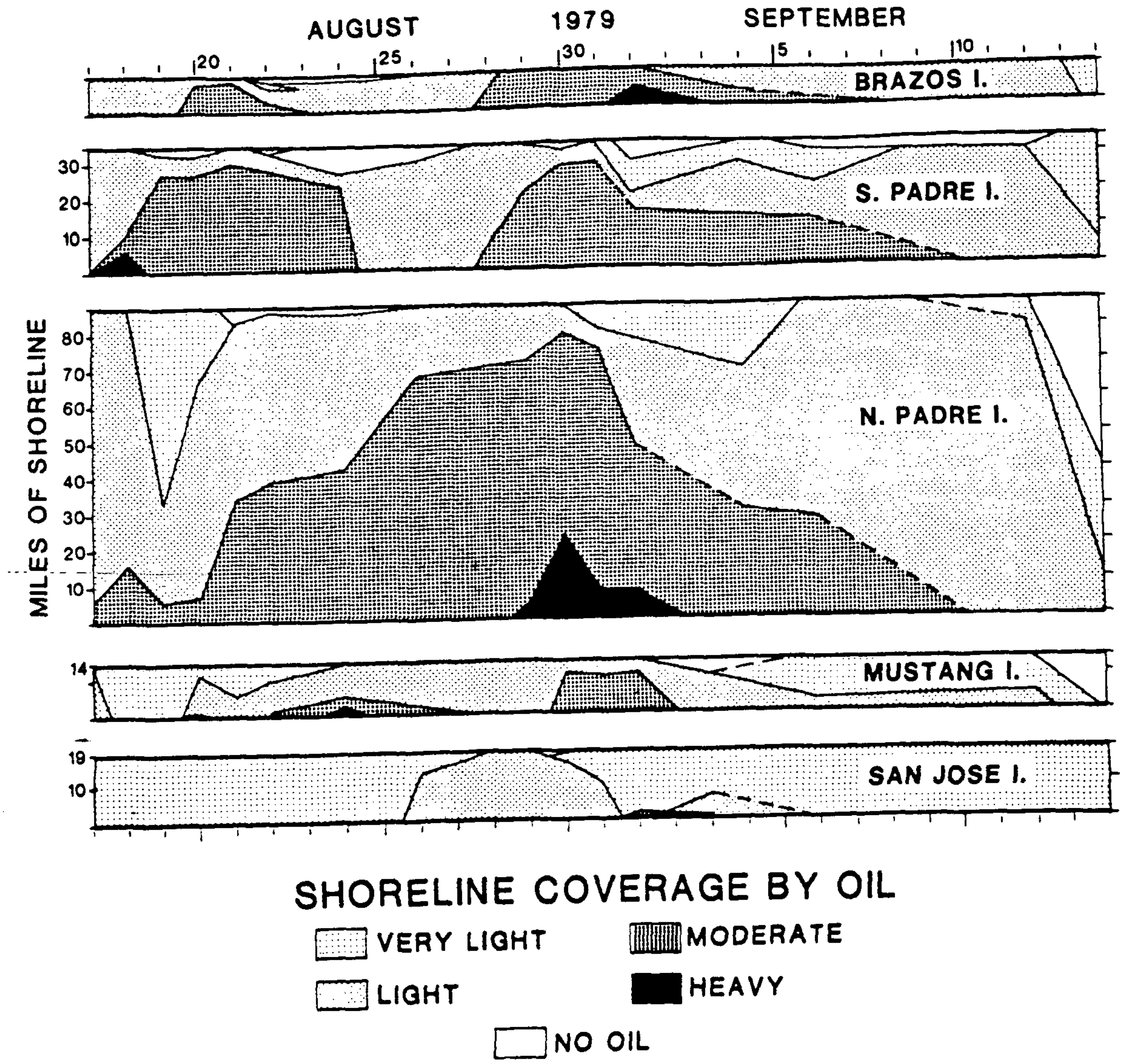


Figure 7. Extent of oil coverage along the individual islands of the south Texas shoreline.

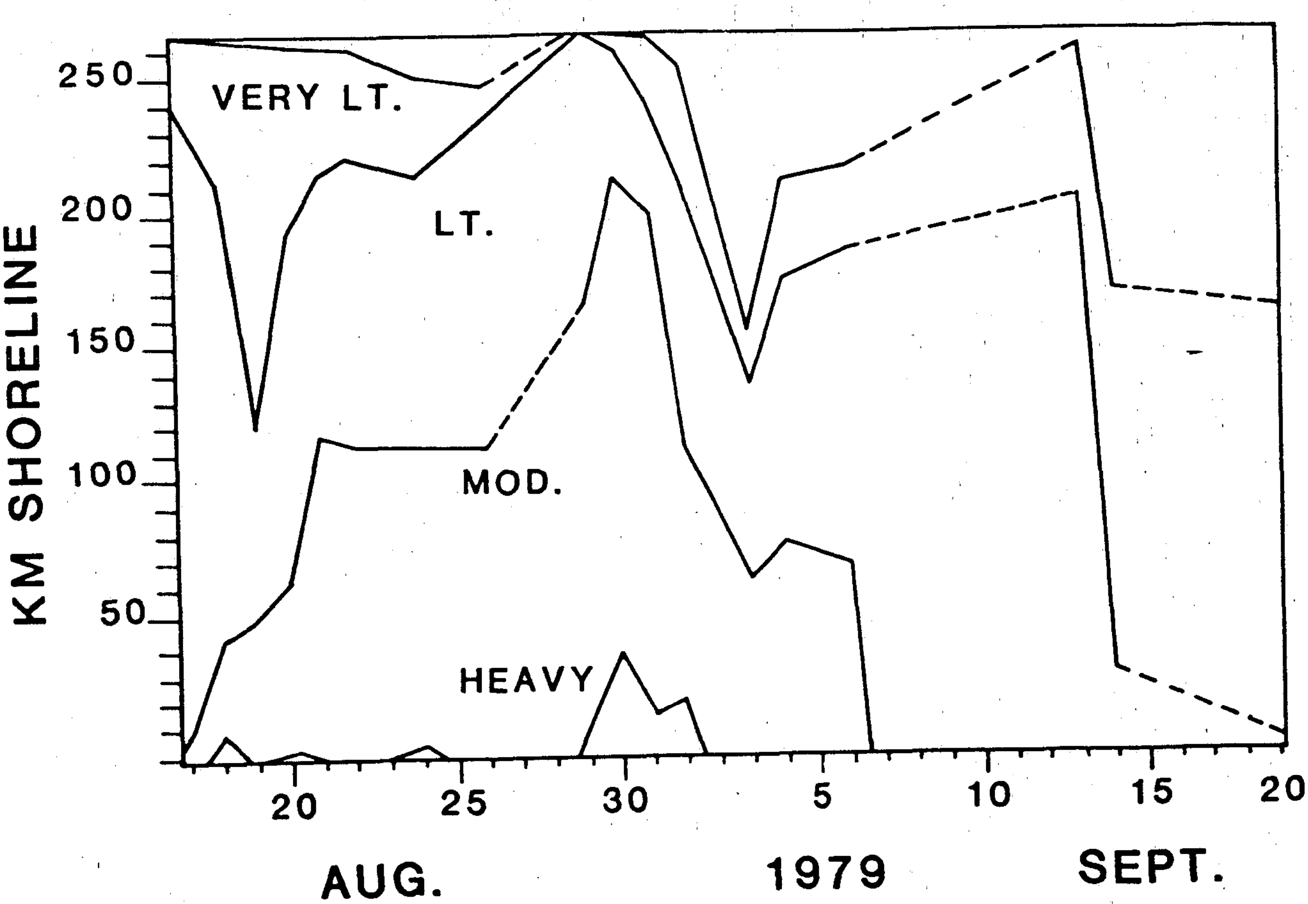


Figure 8. Summary of oil coverage along the south Texas shoreline. The extent of oil coverage reached a maximum during late August. Storm activity on 13 September caused a rapid decrease in oil coverage.

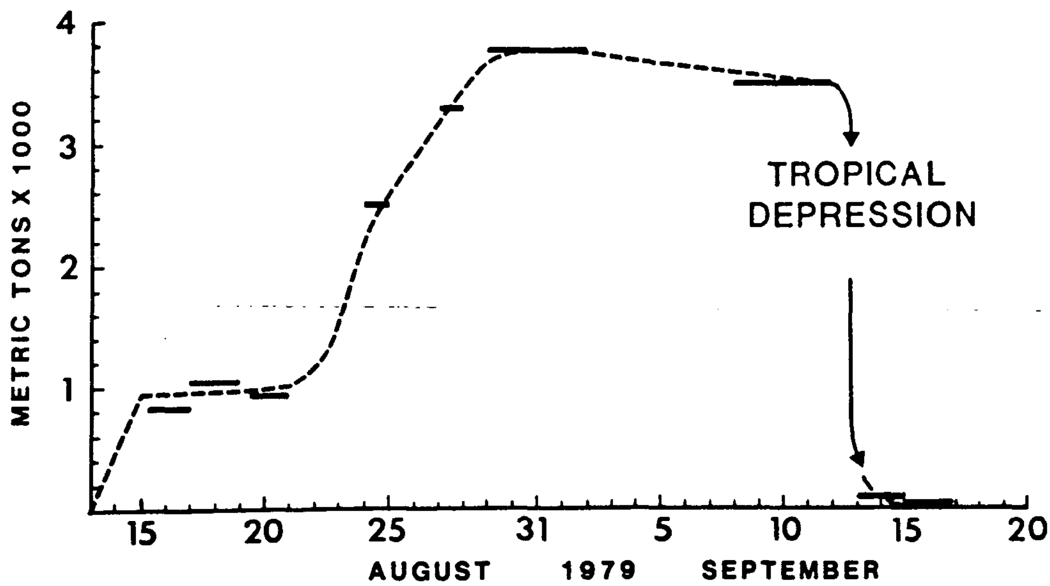


Figure 9. Estimated metric tons of oil deposited onshore during the spill.

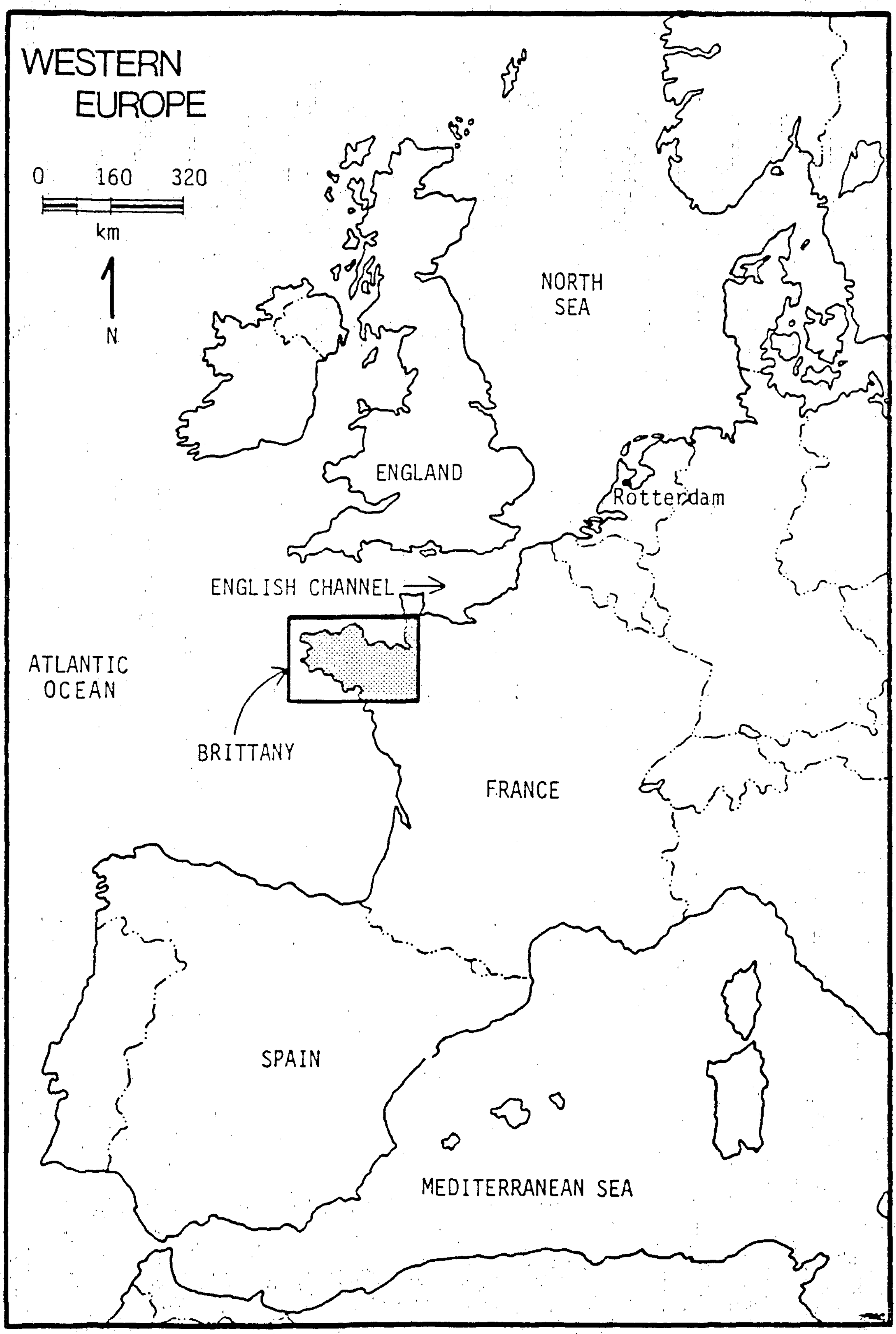


Figure 10 —Location of Brittany.

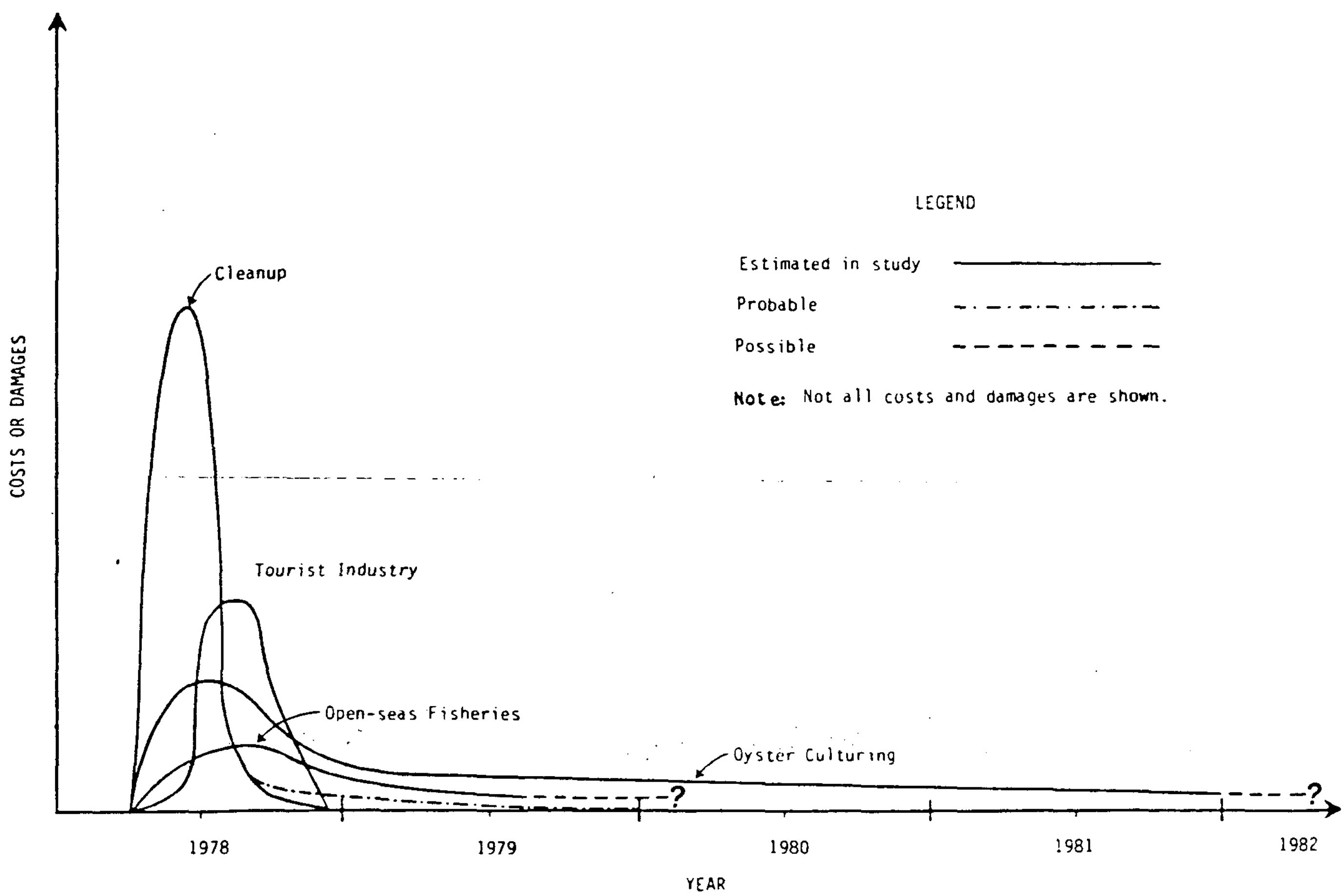


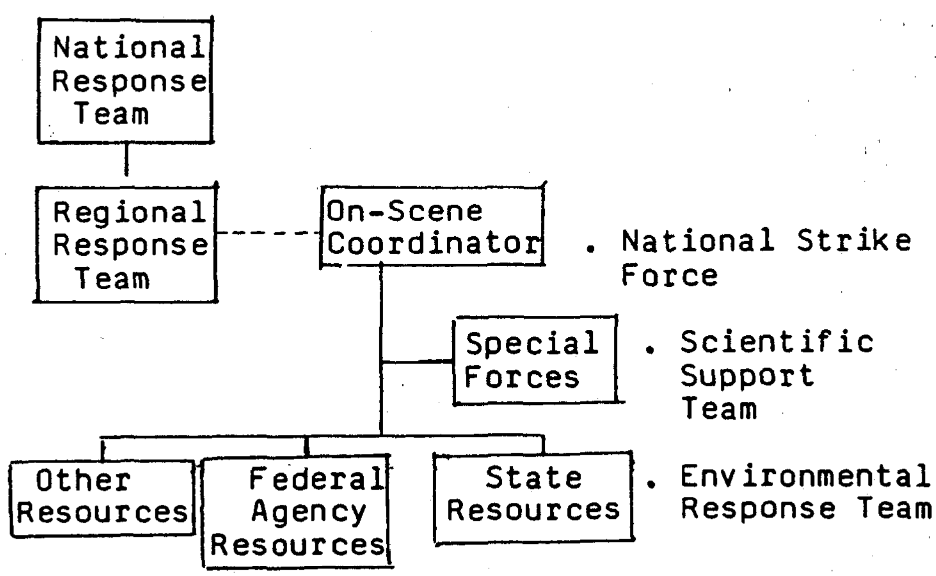
Figure 11 —Time Patterns of Costs and Damages, Amoco Cadiz Oil Spill.

NOAA'S SCIENTIFIC SUPPORT COORDINATORS (SSC) AND HAZARDOUS MATERIALS RESPONSE PROJECT: Paper provided to workshop by Professor M. Champ

What is a SSC?

A Scientific Support Coordinator (SSC) is a member of one of the groups special forces available upon request to federal On-Scene Coordinators (OSC) for response to actual or potential releases of pollutants, such as oil and hazardous materials, as well as for contingency planning. The role of a SSC in relation to the other special forces is described in the National Contingency Plan (Fig. 1). During spills, SSC's serve on the OSC's staff and provide technical assistance in support of the OSC's operational decisions by integrating the scientific information pertinent to a particular incident and by generally coordinating scientific activity on-scene. During non-response periods, SSC's can be utilized by the OSC and their Marine Safety Office's (MSO's) and the Regional Response Teams (RRT) to assist in the development of local and regional contingency plans.

Figure 1. National Response Organisation



The SSC's for coastal areas, where the OSC is a predesignated Coast Guard official, are provided by NOAA's (National Oceanic and Atmospheric Administration) Hazardous Materials Response Project (HAZMAT). This project consists of a team of scientific support coordinators, assigned to various regions of the country, and five functional support groups. To supplement this core response group the SSC's and the HAZMAT response team seek out and synthesize information from regional scientific experts and industry representatives e.g. chemical manufacturers, as part of their response activities. The HAZMAT organisation is displayed in Figure 2.

Response Objectives

The overall goal of the SSC's is to provide timely and effective coordination of scientific resources for emergency response to potential or actual oil and hazardous material spills for the purpose of protecting public welfare and minimizing adverse environmental and/or socioeconomic impacts. The major objectives of SSC's are:

(1) To provide the National Response Team, Regional Response Team and On-Scene Coordinators with highly qualified scientific assistance in:

(a) evaluating the imminent hazards to human health and the need for protection strategies, and

(b) mitigating or preventing the environmental and socioeconomic impacts of release of oil and other hazardous substances;

(2) To provide scientific assistance in assessing public health hazards, and the environmental and socioeconomic damage resulting from such incidents; and

(3) To maximize the research advantage offered by the spill situation, especially for improving future response capabilities.

In an emergency situation, these objectives will be approached in the order of precedence indicated.

Response Assistance from SSC's

During actual or potential pollution incidents, SSC's are organized to provide assistance in the three areas discussed below requiring different types of scientific activity. The level and depth of scientific activity and the sources of information utilized depends on the particular incident and the request(s) of the OSC. The SSC's are most useful to the OSC when dealing with major oil spills, and chemical incidents of any size. Assistance from SSC's can be obtained on a 24-hour basis by a telephone request from the OSC. Notification of SSC's is discussed in a later section.

Rapid Assessment of Adverse Effects and Mitigation Strategies

This type of scientific coordination and assistance is frequently required during the initial phases of an incident when response operations and cleanup strategies are being developed. Depending upon the specific incident, the SSC's notify and work with groups such as state agencies, universities, CHEMTREK, shipper and manufacturer of the material and others, in compiling the technical information pertinent to immediate response actions. Specific types of scientific activity pertinent to protecting and mitigating adverse effects on human health and environmental and socioeconomic resources include:

(1) Liaison with natural resource, chemical and medical experts;

(2) Support in trajectory modelling i.e. prediction of the movement of a contaminant in a given period, time and location of landfall, etc.;

(3) Rapid assessment of and advice on the nature, behaviour and fate of the pollutant, e.g., toxic properties, alteration in physical and chemical characteristics which can be expected under a variety of environmental conditions, and the prospects of water column mixing, sinking etc.;

(4) Advice on safety precautions for response personnel and general public health considerations, and the location of emergency medical experts and facilities (if requested);

(5) Identification of critical habitats requiring extraordinary protective efforts;

(6) Advice in dealing with oil and hazardous materials under unusual environmental conditions, e.g. sea ice and severe storms; and

(7) Assistance in public relations efforts on scientific issues.

Assessment of Damage

Damage to natural resources includes :

(1) immediate or long-term injury, alteration, or destruction of naturally occurring organisms, populations, communities, habitats or functional properties of ecological systems, and

(2) associated impacts on aesthetic, recreational commercial or other benefits derived from these resources. The purpose of this area of assistance is to provide sound scientific information, analysis and opinions that can be used in litigation or administrative proceedings. The emphasis on litigation is important and has major bearing on both the conduct and the scope of work performed under this objective.

Operationally, environmental damage assessment activities involve four major components:

(1) On-scene surveys (sampling and analysis) of acute and other directly measurable impacts on natural resources;

(2) Other scientific studies, including laboratory investigations, that establish the more subtle, sub-lethal environmental effects of the incident;

(3) Surveys of potential socioeconomic losses; and

(4) Interpretation and analysis of findings from the studies above to provide information to be used in legal or administrative proceedings.

Hazardous Substance Assistance and Research

Impact mitigation and assessment activities require extraordinary organization and the "state-of-the-art" knowledge can be improved with a greater degree of planning and coordination of experts. To this end, the SSC's and the HAZMAT team are concentrating on hazardous substances as a focal point of their contingency planning activity.

The need for promoting and coordinating research activities during response to enhance the general understanding of pollution discharges in marine estuarine environments is addressed by this type of SSC assistance. Research included under this objective to be initiated and coordinated by the SSC's includes both field and laboratory studies, baseline studies, and socioeconomic analyses. The specific intents of this objective are to:

(1) Provide a mechanism for timely notification of appropriate scientists of research opportunities;

(2) Coordinate research activities in the spill area to prevent unnecessary duplication and minimize interference with operational activities; and

(3) Assist in the direction of national research efforts toward improving damage mitigation and assessment capabilities.

Notification and Activation

Of major importance in any spill response is the timing of notification and activation of response forces. Acute environmental impacts will be most severe during the early stages of the incident. Thus mitigation efforts must be most concentrated at the outset. This fact argues strongly for the prompt activation of the special forces whose assistance will be needed during the initial stages of an incident.

The SSC is activated by a call from the OSC or his representative. This phone call requesting assistance is all that is required to initiate the SSC's involvement. The level of the SSC's involvement depends upon the nature of the OSC's requests, i.e. what the OSC asks for in the way of scientific assistance, the specifics of a particular pollution incident and the status of the federal fund. The SSC is available for consultation on any or all spills - the key to the SSC's involvement is activation by the OSC. When the OSC determines that scientific support is required, he contacts the SSC and, in conjunction with the SSC, identifies the operational questions to be addressed.

More often than not, initial details on a pollution incident are sketchy, and the first order of business is usually one of assembling information which is critical in determining the ultimate nature and scope of the response - what is the potential magnitude of the spill, the nature of the pollutant, and the prognosis for containment.

In a spill situation, the SSC will respond by phone or report to the scene of the incident if requested to provide whatever immediate assistance may be required and to gather information necessary to determine the scope of the eventual response likely to be required. If the spill has potentially serious consequences, the SSC would notify the appropriate HAZMAT response team functional leaders, and regional and local experts to provide the OSC with the scientific information pertinent to his response decisions.

Contingency Planning Assistance from SSC's

In addition to assisting the OSC during spills, SSC's also work with the Regional Response Team, USCG Marine Safety Offices and the scientific community on response-related scientific matters in between pollution incidents. During these non-response periods, the SSC concentrates on sharpening the scientific aspects of the contingency plans to improve the quality of future response activities.

Prior to a spill, considerable information can be provided to the OSC to help in the development of contingency plans. This information includes:

(1) the probability that spills originating from selected sites will impact specific areas of critical environments,

(2) the locations of environmentally sensitive regions,

(3) background data on the behaviour of the various pollutants known to be present in a given area under a range of environmental conditions, and

(4) the likely environmental impact of various alternative cleanup strategies.

Information is also needed prior to a spill for the purpose of damage assessment. Data needs include only environmental information but also socioeconomic "baselines". Assessing damage following a spill and relating it directly to the pollutant as the cause is extremely difficult; it is even more difficult, however, if there is no information on conditions prior to the incident against which a change can be determined. Consequently, efforts are being made to collect, organize, and evaluate existing information on the environmental and socioeconomic characteristics of a region. Critical information gaps are being identified and, where (NOAA or other) funds allow, studies will be initiated to address these areas.

At a minimum, SSC's are working toward having the following elements in place prior to a major spill event:

(1) A trained core scientific response team whose members are current in the "state-of-the-art" in mitigation, damage assessment, and operational functions;

(2) Development of sufficient equipment and supplies with which to undertake an effective response;

(3) Ensuring that regional scientific response plans are developed and updated, as necessary, including the formulation of activation and notification procedures; identification of personnel, equipment and communications resources; and establishment of reporting requirements;

(4) Developing detailed scientific plans, including chemical action plans, for varying spill scenarios (e.g. differing pollutants, location, environmental conditions, size of spill, and impacted areas) in conjunction with the MSO's;

(5) Establishing an information network among representatives of Federal, state, academic, and public groups concerned with pollution in coastal and offshore waters;

(6) Establishing prior contractual agreements with potential scientific response personnel, chemical laboratories, and sources of logistics support to ensure an adequate, immediate response;

(7) Identifying, integrating and ensuring access to regional data bases;

(8) Conducting or contracting for scientific studies that are supportive or prespill or spill activities (e.g., mapping of the sensitivity of coastal environments to spilled oil, identification of critical natural resources and habitats, and projections of pollutant trajectories);

(9) Identifying priority research projects (and appropriate researchers) that may benefit from field verification;

(10) Providing scientific assistance to the RRT and OSC in planning regional responses; and

(11) Establishing data management and chain of custody systems according to specific guidelines for samples taken during spills.

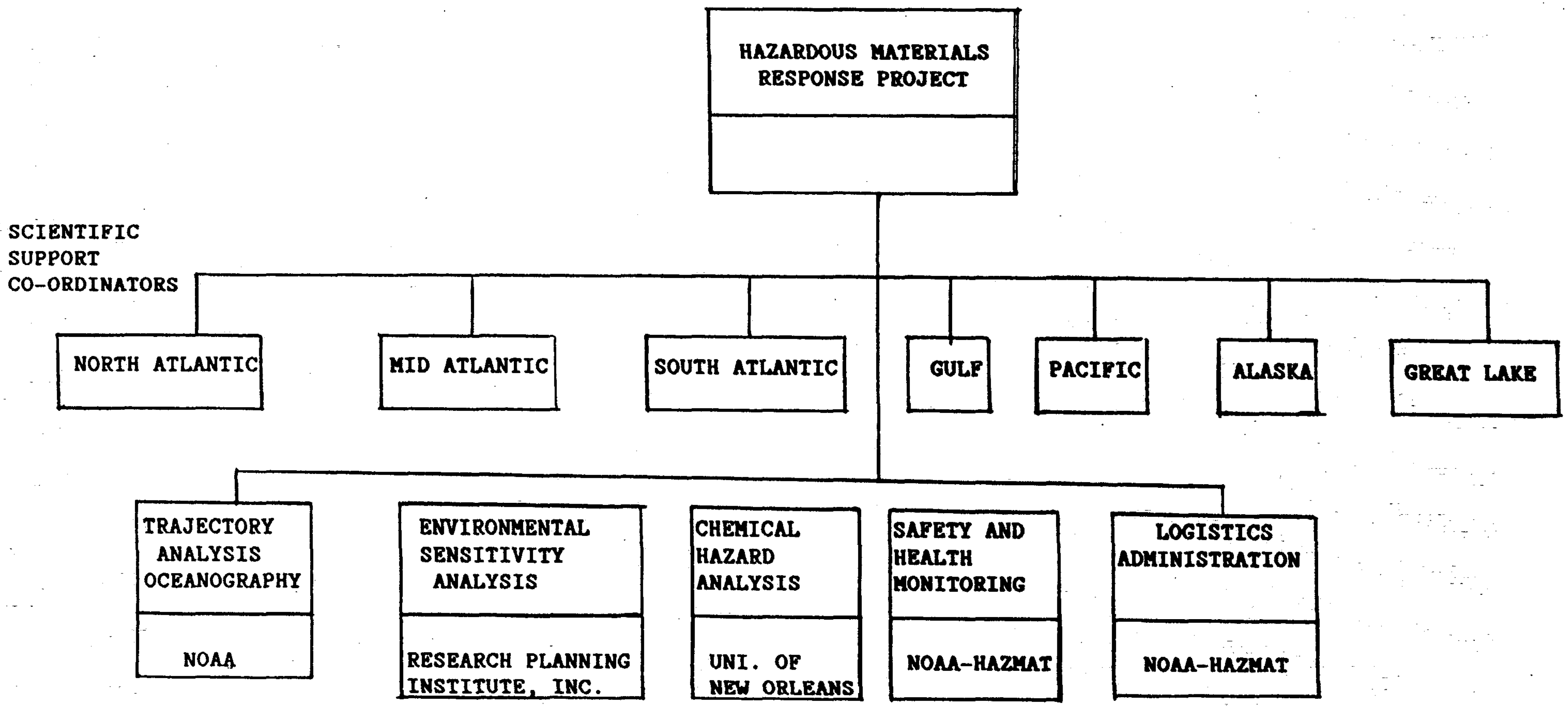
For further information

The SSC's can be reached through the Hazardous Materials Response (HAZMAT) Project located in Boulder, Colorado. The HAZMAT Project has in progress several contingency planning programs which are likely to be of interest to the Coast Guard, state agencies, scientists, and industry representatives. Please feel free to contact the SSC's directly or Mr. John Robinson, Manager of the HAZMAT Project, for additional information. Mr. Robinson can be reached at the following numbers:

Commercial: 303-497-6551
FTS: 320-6551
Pager: 303-443-1414, acct. A-5 (24-hr. number).

FIGURE 2

HAZARDOUS MATERIALS RESPONSE ORGANIZATION



NORWEGIAN EXPERIENCE WITH OIL SPILLS: SCIENTIFIC RESPONSE: by John Gray, Professor of Zoology, Oslo University and Senior Queen's Fellow in Marine Science

Norway has a rugged coastline of approximately 2000 km, similar in length to the Great Barrier Reef, with a population of some 4 million people. It does not have resources of the magnitude of the USA at its disposal in dealing with oil spills, although oil exploration and production are extremely important to the Norwegian economy.

Another important industry in the Arctic circle for Norway is the fishing industry. Because insufficient information was available about the effects of oil on the Arctic region, only the lower third of the country has been explored for oil. In 1984 exploration began within the Arctic circle and already promising finds of gas and oil have been made.

To obtain licences for oil exploration in Norway it is necessary for companies to show "willing", that is provide some finance for Norwegian research. Oil companies and researchers approach the Norwegian Research Council with a project to be funded by the company. Individual $1 million grants are not uncommon. This policy of the Norwegian Government has obviously been of great benefit to researchers and yet the Research Council can control the quality of the proposed research.

The Government also requires companies to collect meteorological and oceanographic data which is transmitted to central locations to improve oceanographic knowledge and provide input for modelling e.g. in the event of an oil spill. As a result current systems are now relatively well understood around Norway and these can be fed into the "Slick Forecast Model".

Four laboratories in Norway are fully equipped for oil analysis on a routine basis and can be mobilised for an oil spill.

Research on oil as a result of the increased funding has been in a number of areas. An early major concern regarding oil spills was biological. Would bacteria break down oil more slowly in the Artic? This led to a major research effort which found that oil bacteria can always be found on the Norwegian coast, but that they compete with phytoplankton for nutrients. The risk of a large spill in spring, therefore, is that the primary plankton bloom may not occur due to microbial utilisation of the available nutrients. This could have severe consequences for fish larvae.

Photoxidation was found to be very important as a releaser of toxic chemicals. This may have some relevance to Great Barrier Reef waters where illumination is high.

Effects of oil on many commercial species have also been examined, and a monitoring program for benthic populations and communities along the coast has been established using stereophotographic methods.

To enable a rapid scientific response, an Action Plan has been developed. Obviously with limited resources the entire coast cannot be covered simultaneously, but five 150' vessels are on full time standby (or on hydrographic survey work when not on oil spill work) to be mobilised in the event of a spill. "Lenses" are available to physically contain the oil and the plan is linked to the coastguard and airforce etc.

To enable a scientific response which is co-ordinated with the combat response, a Norwegian Ecological Action Plan has been developed. This plan co-ordinates the expertise in Norwegian Universities. Ecological response teams are "on call" to respond to spills at two hours notice. The teams consist of a zoologist, botanist, chemist and bacteriologist plus five or six students. Future teams will probably include ornithologists. Equipment is permanently packed in aluminium boxes and not used for any other purpose.

The team can be flown to sites using slick forecast model to take "before" samples over a 50 km stretch of coast in advance of the oil reaching the shore. Agreed predetermined samples and techniques are used. Once the oil has hit the shore, samples are taken daily for the first 14 days, twice per month for the next six months, then once every six months. Many more samples are taken than are analysed, due to the high cost of oil analyses. Choice of samples for analysis is made at a later date.

There is an annual training exercise for teams and formal contracts (including the important consideration of insurance) are drawn up between the government and team members.

Each team is able to give the Government advice on whether a large combat plan should be put into effect.

In two years they have responded to 7 spills - on six of those occasions the Government has been advised there was no need for any combat response.

This type of operation works well for a small nation over a large area.

The annual cost to maintain each team is approximately $A10,000 and includes equipment, equipment maintenance and training. Establishment cost varied between institutions, depending on the equipment they already had.

Reference: The Norwegian Marine Pollution Research and Monitoring Program FOH. Research Projects 1977-83.

THE NATIONAL PLAN TO COMBAT POLLUTION OF THE SEA BY OIL: by David Kay, Department of Transport and Department of Transport Information Paper 1984

Under the National Plan to Combat Pollution of the Sea by Oil (outlined in the Information Paper attached):

- responsibilities are defined;
- a system of providing money is established
- approximately $A1.3 million per year is assigned:
  - 30% to administration and training
  - 60% to equipment including updating
  - 10% to pollution incidents where money cannot be recovered.
- there is a reasonable equipment stockpile.
- there is a reasonable response capacity.

Within Australia, 11 "regions" have been defined and equipped on the basis of the Bureau of Transport Economics study of oil spill risk. The study concentrated on ports as there have only been two spills outside ports in the last ten years, providing a poor statistical base. Based on the BTE prediction of risk, the Plan aims to cope with 98% of spills in a five year period.

The area in which the National Plan is deficient is that of scientific support. In both the National Plan and State Supplements, Scientific Support Co-ordinators (SSC) have been "designated" but there is insufficient support for them to carry out their appropriate activities.

The SSC could and should act as a "filter" between the scientific community and the On Scene Co-ordinator (SSC). At present, post-impact assessment is not built into the National Plan, although post-spill reporting seeks some of this information through the SSC. There is no requirement for evaluation of the social costs of spills.

Regarding spills of other hazardous materials carried through the Great Barrier Reef Region, the Department of Transport assessment is that the risk is at least an order of magnitude less than that for oil spills. To date, there have been no serious reported spills of hazardous materials in the Great Barrier Reef Region. Although no response plan has been established for other hazardous material spills, the Commonwealth has the power to act under the Protection of the Sea (Powers of Intervention Act) which enables the Minister for Transport to take whatever action he sees fit if a pollution accident threatens the Australian coast.

The Department of Transport has the Chemical Hazard Response Information System (CHRIS) which provides summarised information on hazardous materials, i.e. fire, explosion, exposure, water pollution, hazard classification, physical and chemical properties (Figure 1).

Australian shipping follows international regulations and vessels loading chemical cargoes in Australian ports must lodge their manifest and load plan with the Department of Transport. Most international vessels into Australia follow the international code. No record, however, is available of chemical cargoes of vessels transiting through Australian waters.

Data from oil and hazardous chemical cargo information lodged with the Department of Transport for Queensland, N.S.W. and Victoria are provided below.

CARGO MOVEMENTS: '000 tons loaded and discharged

	Oil	Chemicals
Qld	8060	571
NSW	10917	462
Victoria	13866	536

A breakup of data for Queensland ports is given below. Most of this can be expected to pass through the Great Barrier Reef Region.

Figure 1*

AMN — AMMONIUM NITRATE

Common Synonyms: Nitram

Solid pellets or flakes — White to light gray or brown — Odorless

Sinks and mixes with water.

Call Fire department: Keep people away.
Evacuate area in case of large discharge.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

May cause fire and explode on contact with combustibles.
CONTAINERS MAY EXPLODE IN FIRE.
POISONOUS GASES MAY BE PRODUCED WHEN HEATED.
Wear self-contained breathing apparatus.
Evacuate surrounding area.
Combat fires from protected location with unmanned hose holder or monitor nozzle.
Flood discharge area with water.
Cool exposed containers with water.
Continue cooling after fire has been extinguished.

Exposure

CALL FOR MEDICAL AID.

DUST
Irritating to eyes, nose, and throat.
If inhaled, may cause coughing or difficult breathing.
Move to fresh air.
If in eyes, hold eyelids open and flush with plenty of water.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

Water Pollution

Effect of low concentrations on aquatic life is unknown.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook, CG 446-4)

Disperse and flush

2. LABEL

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:** Nitram
3.2 **Coast Guard Compatibility Classification:** Ammonia
3.3 **Chemical Formula:** NH_4NO_3
3.4 **IMCO United Nations Numerical Designation:** 5.1/1942

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Solid
4.2 **Color:** Colorless (pure) to gray or brown (fertilizer grades)
4.3 **Odor:** None

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Wear self-contained breathing apparatus
5.2 **Symptoms Following Exposure:** Irritation of eyes and mucous membranes. Absorption via ingestion or inhalation causes urination and acid urine. Large amount causes systemic acidosis and methemoglobinemia (abnormal hemoglobin).
5.3 **Treatment for Exposure:** Remove from exposure — symptoms reversible.
5.4 **Toxicity by Inhalation (Threshold Limit Value):** Not pertinent
5.5 **Short-Term Inhalation Limits:** Not pertinent
5.6 **Toxicity by Ingestion:** Data not available
5.7 **Late Toxicity:** Data not available
5.8 **Vapor (Gas) Irritant Characteristics:** Not pertinent
5.9 **Liquid or Solid Irritant Characteristics:** None
5.10 **Odor Threshold:** Not pertinent

6. FIRE HAZARDS

6.1 **Flash Point:** Not flammable
6.2 **Flammable Limits in Air:** Not flammable
6.3 **Fire Extinguishing Agents:** Use flooding amounts of water in early stages of fire. When large quantities are involved in massive fires, control efforts should be confined to protecting from explosion.
6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent
6.5 **Special Hazards of Combustion Products:** Decomposes, giving off extremely toxic oxides of nitrogen
6.6 **Behavior in Fire:** May explode in fires. Supports combustion of common organic fuels
6.7 **Ignition Temperature:** Not flammable
6.8 **Electrical Hazard:** Not pertinent
6.9 **Burning Rate:** Not flammable

7. CHEMICAL REACTIVITY

7.1 **Reactivity with Water:** No reaction
7.2 **Reactivity with Common Materials:** No reaction
7.3 **Stability During Transport:** If heated strongly, decomposes, giving off toxic gases and gases which support combustion. Undergoes detonation if heated under confinement
7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent
7.5 **Polymerization:** Not pertinent
7.6 **Inhibitor of Polymerization:** Not pertinent

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** Data not available
8.2 **Waterfowl Toxicity:** Data not available
8.3 **Biological Oxygen Demand (BOD):** Data not available
8.4 **Food Chain Concentration Potential:** None

9. SELECTED MANUFACTURERS

1. Allied Chemical Corp.
   Agricultural Div.
   Morristown, N.J. 07960
2. Hercules Inc.
   Explosives & Chemical Propulsion Dept.
   Bessemer, Ala. 35020
3. Monsanto Co.
   Monsanto Commercial Products Co.
   Agricultural Div.
   800 North Lindbergh Blvd.
   St. Louis, Mo. 63166

10. SHIPPING INFORMATION

10.1 **Grades or Purity:** Pure grade; fertilizer grade (33.5% nitrogen)
10.2 **Storage Temperature:** Data not available
10.3 **Inert Atmosphere:** Data not available
10.4 **Venting:** Data not available

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CG 446-3)

SS

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:** Oxidizing material
12.2 **NAS Hazard Rating for Bulk Water Transportation:** Not listed
12.3 **NFPA Hazard Classifications:**

Category	Classification*	
Health Hazard (Blue)	0	2
Flammability (Red)	1	1
Reactivity (Yellow)	3	3
	oxy	oxy

*First column refers to non-fire situation

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Solid
13.2 **Molecular Weight:** 80.05
13.3 **Boiling Point at 1 atm:** Not pertinent
13.4 **Freezing Point:** 337.8°F = 169.9°C = 443.1°K
13.5 **Critical Temperature:** Not pertinent
13.6 **Critical Pressure:** Not pertinent
13.7 **Specific Gravity:** 1.72 at 20°C (solid)
13.8 **Liquid Surface Tension:** Not pertinent
13.9 **Liquid-Water Interfacial Tension:** Not pertinent
13.10 **Vapor (Gas) Specific Gravity:** Not pertinent
13.11 **Ratio of Specific Heats of Vapor (Gas):** Not pertinent
13.12 **Latent Heat of Vaporization:** Not pertinent
13.13 **Heat of Combustion:** Not pertinent
13.14 **Heat of Decomposition:** Not pertinent
13.15 **Heat of Solution:** Not pertinent
13.16 **Heat of Polymerization:** Not pertinent

(Continued on pages 5 and 6)

NOTES

* GBRMPA thanks the US Coast Guard for permission to reproduce these charts from the CHRIS Manual.

Figure 1 (cont.)

AMH — AMMONIUM HYDROXIDE

(< 28% AQUEOUS AMMONIA)

Common Synonyms
Ammonia water
Aqueous ammonia

Watery liquid — Colorless — Ammonia odor

Floats and mixes with water. Irritating vapor is produced.

Avoid contact with liquid and vapor. Keep people away.
Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves).
Stop discharge if possible.
Stay upwind and use water spray to "knock down" vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

Not flammable.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to skin, eyes, nose and throat.
If inhaled, will cause nausea, vomiting, difficult breathing, *or loss of consciousness.*
Move to fresh air.
IF IN EYES, hold eyelids open and flush with plenty of water.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Will burn skin and eyes.
Harmful if swallowed.
Remove contaminated clothing and shoes
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.

Water Pollution

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook, CG 446-4)

Issue warning—air contaminant
Restrict access
Disperse and flush

2. LABEL

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:** Ammonia water
Aqueous ammonia
Household ammonia

3.2 **Coast Guard Compatibility Classification:** Ammonia

3.3 **Chemical Formula:** NH_4OH-H_2O

3.4 **IMCO United Nations Numerical Designation:** 2/1005

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid
4.2 **Color:** Colorless
4.3 **Odor:** Pungent

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** *Rubber boots, gloves, apron, and coat, broad-brimmed* rubber or felt hat; safety goggles. Use of protective oil will reduce skin irritation from ammonia.

5.2 **Symptoms Following Exposure:** *Contact of liquid or vapor with skin, mucous membranes, lungs,* or gastroenteric tract causes marked local irritation. Ingestion causes burning pain in mouth, *throat, stomach, and thorax, constriction of throat, and coughing. This is soon followed by* vomiting of blood or by passage of loose stools containing blood. Breathing difficulty, convulsions, *and shock may result. Brief exposure to 5000 ppm or ingestion of 3-4 ml may be fatal.*

5.3 **Treatment for Exposure:** INHALATION: give artificial respiration and oxygen if needed, enforce rest. INGESTION: *do NOT induce vomiting; lavage stomach with water or lemon juice, milk,* or demulcents; delay may cause perforation of esophagus or stomach, swelling of glottis may necessitate tracheostomy. EYES OR SKIN: wash with plenty of water.

5.4 **Toxicity by Inhalation (Threshold Limit Value):** 1 ppm

5.5 **Short-Term Inhalation Limits:** (ammonia gas) 100 ppm for 30 min.; 500 ppm for 10 min.

5.6 **Toxicity by Ingestion:** Grade 3; oral rat, LD_{50} = 350 mg/kg

5.7 **Late Toxicity:** Data not available

5.8 **Vapor (Gas) Irritant Characteristics:** Vapors *cause moderate irritation such that personnel will* find high concentrations intolerable. The effect is temporary

5.9 **Liquid or Solid Irritant Characteristics:** Causes *smarting of the skin and first-degree burns on* short exposure; may cause second-degree burns on long exposure.

5.10 **Odor Threshold:** 50 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** Not flammable
6.2 **Flammable Limits in Air:** Not flammable
6.3 **Fire Extinguishing Agents:** Not pertinent
6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent
6.5 **Special Hazards of Combustion Products:** Not pertinent
6.6 **Behavior in Fire:** Not pertinent
6.7 **Ignition Temperature:** Not flammable
6.8 **Electrical Hazard:** Data not available
6.9 **Burning Rate:** Not flammable

7. CHEMICAL REACTIVITY

7.1 **Reactivity with Water:** Mild liberation of heat
7.2 **Reactivity with Common Materials:** Corrosive to copper, copper alloys, aluminum alloys, galvanized surfaces
7.3 **Stability During Transport:** Stable
7.4 **Neutralizing Agents for Acids and Caustics:** Dilute with water
7.5 **Polymerization:** Not pertinent
7.6 **Inhibitor of Polymerization:** Not pertinent

8. WATER POLLUTION

8.1 **Aquatic Toxicity:**
6.25 ppm/24 hr/trout/lethal/fresh water
15 ppm/48 hr/sunfish/TL_m/Phila tap water
8.2 **Waterfowl Toxicity:** Data not available
8.3 **Biological Oxygen Demand (BOD):** Data not available
8.4 **Food Chain Concentration Potential:** None

9. SELECTED MANUFACTURERS

1. American Oil Co.
910 S. Michigan Ave.
Chicago, Ill 60605
2. CF Industries, Inc.
100 S. Wacker Drive
Chicago, Ill 60606
3. Williams Companies
Agrico Chemicals Division
5050 Poplar Ave
Memphis, Tenn. 38101

10. SHIPPING INFORMATION

10.1 **Grades or Purity:** Grade A: 29.4% NH_3, B: 25%; C: 15%; USP: 27 to 29%; CP: 28%
10.2 **Storage Temperature:** Ambient
10.3 **Inert Atmosphere:** No requirement
10.4 **Venting:** Pressure-vacuum

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CG 446-3)

A-P-R-S

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:** Corrosive Material
12.2 **NAS Hazard Rating for Bulk Water Transportation:** Not listed
12.3 **NFPA Hazard Classifications:** Not listed

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Liquid
13.2 **Molecular Weight:** Not pertinent
13.3 **Boiling Point at 1 atm:** Not pertinent
13.4 **Freezing Point:** Not pertinent
13.5 **Critical Temperature:** Not pertinent
13.6 **Critical Pressure:** Not pertinent
13.7 **Specific Gravity:** 0.89 at 20°C (liquid)
13.8 **Liquid Surface Tension:** Not pertinent
13.9 **Liquid-Water Interfacial Tension:** Not pertinent
13.10 **Vapor (Gas) Specific Gravity:** Not pertinent
13.11 **Ratio of Specific Heats of Vapor (Gas):** Not pertinent
13.12 **Latent Heat of Vaporization:** Not pertinent
13.13 **Heat of Combustion:** Not pertinent
13.14 **Heat of Decomposition:** Not pertinent
13.15 **Heat of Solution:** Not pertinent
13.16 **Heat of Polymerization:** Not pertinent

(Continued on pages 5 and 6)

NOTES

CARGO MOVEMENTS '000 TONS (QUEENSLAND PORTS)

	Oil	Chemicals	
Brisbane	5313	47	
Bundaberg	70	4	aqua ammonia
Cairns	333		
Gladstone	65	422	caustic soda sulphuric acid
Lucinda	-	7	aqua ammonia
Mackay	230	44	industrial alcohol and aqua ammonia
Maryborough	61	-	
Rockhampton	81	21	ammonium nitrate
Townsville	711	24	aqua ammonia

CARGOES" '000 TONS (QUEENSLAND PORTS)

Caustic soda	418
Aqua ammonia	41
Industrial alcohol	38
Ammonia nitrate	21
Sulphuric acid	4
Not specified	48

Hazard profiles for the substances listed above are given below. It is evident that the majority of substances carried are not among the most hazardous in terms of potential impact to the environment.

Hazard profiles

Column 1 – Bioaccumulation +2.0
2 – Damage to living Resources 4–0
3 – Hazard to human health (oral) 4–0
4 – Hazard to human health (skin contact and inhalation) II I O
5 – Reduction of amenities XXX XX X O

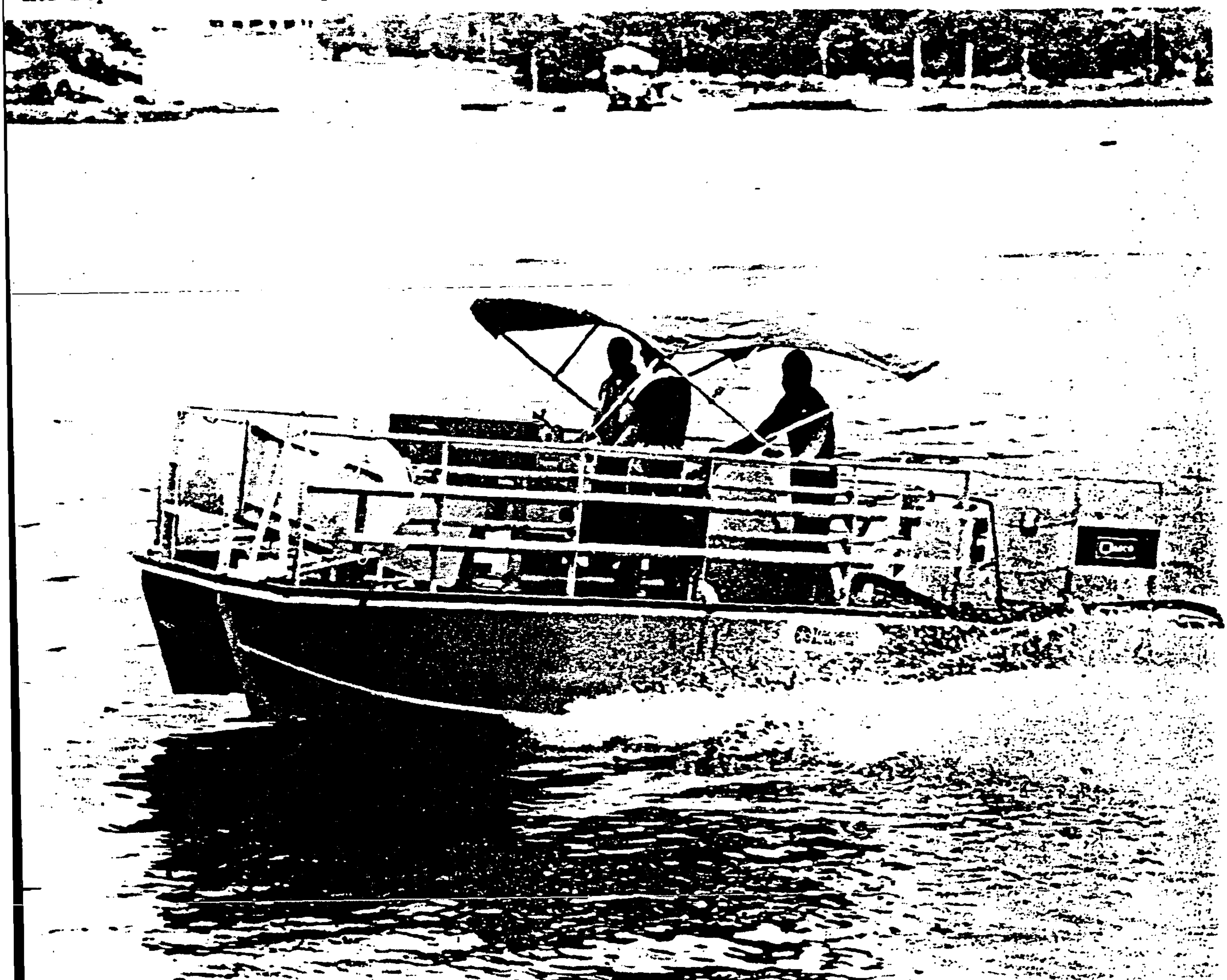
	Bioaccumulation	Damage to living resources	Human health hazard (oral)	Human health hazard (skin & inhalation	Amenity reduction	MARMPOL Rating*
Aqueous ammonia	0	2	1	I	X	C
Ammonium nitrate	0	1	1	0	0	D
Ethyl alcohol	0	0	0	0	0	–
Sodium hydroxide	0	2	1	I	0	C
Sulphuric Acid	0	2	1	I	0	C

Although the above provides some data on hazardous chemicals, it is evident that more work is needed on the nature of chemicals travelling around Australia. There is also a need to establish which agency/agencies should/will take the lead role regarding response to hazardous chemical spills. The Department of Transport view is that adequate controls on shipping will reduce the need for a major effort in organising for response to spills.

DEPARTMENT OF TRANSPORT

National Plan To Combat Pollution Of The Sea By Oil

The following document has been provided by the Department of Transport.



1984

NATIONAL PLAN TO COMBAT POLLUTION OF THE SEA BY OIL

INFORMATION PAPER

INTRODUCTION

The National Plan to Combat Pollution of the Sea by Oil, "National Plan", has been in operation since October 1973. It represents a combined effort by Commonwealth and State governments, with the assistance of the oil industry, to help provide a solution to the threat posed to the coastal environment by oil spills from ships.

BACKGROUND

The grounding of the OCEANIC GRANDEUR in Torres Strait in 1970 accelerated the implementation of a nationwide plan to ensure that Australia would be prepared to respond to ship sourced pollution incidents, not only from oil tankers, but also from large bulk carriers and container vessels which may be carrying significant quantities of bunker fuel.

At a meeting between Commonwealth and State ministers in September 1971, agreement was reached on the basic divisions of responsibility for combating pollution of the sea by oil from ships.

COMMONWEALTH/STATE ADMINISTRATIVE ARRANGEMENTS

An initial requirement for the successful handling of oil spill incidents in Australia was a clear definition of the responsibilities of the two major participants, the Commonwealth and the States. This was provided in a set of Commonwealth/State administrative arrangements which includes such matters as access to Commonwealth stockpiles, financial arrangements and joint use of resources. Based on these arrangements the prescribed role of the Commonwealth, through the Department of Transport, is one of coordination, training, and the provision of technical and logistic support, materials, equipment and finance.

DIVISIONS OF RESPONSIBILITY

Based on the capacity to take action to prevent or clean up pollution by oil from ships, the Commonwealth/State administrative arrangements provide that the responsible authority may request another authority to accept prime responsibility for action. This concept has been implemented already in certain territorial seas. Prime responsibility for action lies with:

(1) within a port or narbour:

the administrative authority of that port or harbour

(2) on beaches and foreshores:

the relevant State government or Territorial authority

(3) in territorial seas:

(a) in Western Australia, Victoria and Tasmania, the relevant State government authority

(b) in all other States and the Northern Territory, the Commonwealth Government authority (represented by Commonwealth regional authorities), at the request of the relevant State government or Territorial authorities

(4) on the high seas:

the Commonwealth Government authority, represented by Commonwealth regional authorities.

Responsible authority is defined as that authority having the appropriate legislative jurisdiction over a pollution incident.

Prime responsibility for action is defined as the responsibility for controlling and coordinating operations to combat a pollution incident.

OPERATION

The basic concept of the plan was to provide spraying equipment and dispersant material at strategic locations around the coast. This has since been supplemented by the purchase of control and recovery devices and a central stockpile of ship-to-ship cargo transfer equipment.

Stockpiles of dispersant and associated spraying equipment are established at Cairns, Brisbane, Sydney, Melbourne, Hobart, Devonport, Adelaide, Perth, Port Hedland and Darwin. The dispersant used is BP-AB and the spraying equipment, based on the British Warren Spring Laboratory equipment, is designed for use aboard fishing vessels, harbour tugs and other similar-sized craft.

Use of dispersants will, however, be limited to incidents where the damage to the coastal and marine environments by the oil would be greater than that caused by any dispersant/oil mixture.

In the event of a major oil spill, a depleted stockpile can be replaced from any or all of the other stockpiles with further supplies available from commercial sources.

The ship-to-ship transfer equipment, located in Sydney, is for use in lightening vessels in the event of a collision, stranding or similar incident. It consists of submersible pumps, hoses, fenders, lighting and power generating equipment.

Oil control booms of varying capacities are held at strategic stockpile locations together with a number of self propelled oil recovery vessels and static oil recovery devices. All are used in exercises at regular intervals. This equipment is complemented by equipment held by port authorities and oil companies.

In the event of a major oil spill this country could call upon assistance from overseas as has been done in similar incidents abroad. Provision has been made for speedy entry into the country of equipment and manpower from overseas if required.

Although technology may develop better methods of dealing with oil spills, each incident is unique and requires the development of its own plan of action.

An Operations and Procedures Manual sets down the various procedures required to implement the National Plan and is complemented in each State by an appropriate supplement.

FUNDING

The National Plan is based on the "polluter pays" principle and to achieve this a levy similar to that applied to maintain navigational aids is imposed on commercial shipping using Australian ports.

In addition to providing funds for maintenance and administration of the Plan the levy provides contingency funds to cover those costs which:

(1) could not be attributed to the polluter; or

(2) upon conviction, the polluter proved unable to meet.

Where a ship sourced incident involves the use of more than 500 litres of dispersant, or where costs of clean up are in excess of $500, the cost of combating the incident is borne by the National Plan pending recovery from the polluter.

LEGISLATION

In November 1972, the 'Pollution of the Sea by Oil (Shipping Levy) Act 1972' and the 'Pollution of the Sea by Oil (Shipping Levy Collection) Act 1972' were passed by the Australian Parliament. These Acts were replaced by the 'Protection of the Sea (Shipping Levy) Act 1981' and the 'Protection of the Sea (Shipping Levy Collection) Act 1981' which were proclaimed in 1982.

In Acts apply to vessels which are in excess of 100 net registered tons, having at least 10 tonnes of oil onboard.

Regulations made under the legislation have set the current rate of levy at 2 cents per net registered ton per quarter and have also set the minimum levy at $10 per quarter.

The levy was first imposed on 1 October 1973, the date on which the National Plan became operational. The rate of levy is reviewed annually.

Related pollution legislation has recently been proclaimed. The Protection of the Sea (Civil Liability) Act 1981 and its Regulations impose strict liability on ships carrying oil in bulk as cargo for oil pollution damage caused by the ship. Shipowners are able to limit their liability and in certain cases must take out insurance for this purpose.

The Protection of the Sea (Powers of Intervention) Act 1981 and Regulations authorizes the Minister or his delegate to take necessary measures to prevent or limit pollution damage caused by a ship in Australian territorial waters or on the high seas.

SUPPORT ORGAISATION

To ensure maximum involvement of those concerned with the effective combat of oil spills in all areas of responsibility and to maintain an awareness of developments in the state of the art and equipment technology, the National Plan receives input from two committees. A Working Group on the National Plan (WGNP) established under the auspices of the Marine and Ports Council of Australia makes decisions on funding, equipment and training. The WGNP includes representatives from relevant operational areas of Commonwealth and State governments and meets at regular intervals.

The Maritime Services Advisory Committee - Marine Pollution, with representatives from Commonwealth Government departments and the oil and shipping industries, provides advice of a more scientific nature and may be required to nominate areas of research for the ongoing development of the Plan.

TRAINING

Three levels of oil spill response training are conducted.

(1) Oil spill clean up operations: personnel from port and marine authorities and the oil industry are trained in the operation of equipment available in their area and are shown the basic techniques for combat of a spill.

(2) On scene coordination: officers who may be required to assume the duties of an on scene coordinator attend a forum at which all aspects of clean up management are addressed.

(3) Contingency planning: this training explores the various requirements for protectin of a section of coastline, grades the area according to sensitivity and assesses the resources necessary to mount a combat operation. Local involvement of Shire councils, press, police and emergency services organisations is encouraged.

SELECTED POLLUTION EQUIPMENT AVAILABILITY REGISTER

The Selected Pollution Equipment Availability Register (SPEAR) is a computer based register of selected oil spill combat equipment availabale in Australia. It contains details of equipment held at National Plan stockpiles as well as equipment owned by State and port authorities, the oil industry and others, including distribution agencies. SPEAR is incorporated in CSIRONET, the CSIRO's national computer network, and may be searched by an on scene coordinator to determine the location and availability of equipment to assist with combat operations.

OIL POLLUTION RISK ANALYSIS

A detailed oil pollution risk analysis has been carried out by the Bureau of Transport Economics (BTE). The purpose of the analysis was to provide an assessment of the desirable distribution of anti-pollution material and equipment around Australia during the 1980's and an indication of stockpile holdings. Utilising all available data the analysis aimed at identifying the most appropriate statistical distributions governing Australian oil spills.

ON SCENE SPILL MODEL

The On Scene Spill Model (OSSM) is a computer model, also accessible via CSIRONET, which simulates the movement of oil spills. Developed in the United States the model enables authorities to take countermeasures to minimise damage to the marine environment. Utilising forecasts of wind, tide and current movements, and taking into account the nature of the oil, OSSM indicates where the oil will spread for several days ahead and what form it will be in. The assessment is continually updated as weather and other conditions change.

The model has been used successfully in the United States and was first used, on a test basis at an actual spill, in Australia following the grounding of the container ship ANRO ASIA in October 1981.

A segment on OSSM is incorporated in the National Plan training courses.

MARINE POLLUTION OPERATIONS

Department of Transport
PO Box 594
CIVIC SQUARE ACT 2608

RISK ASSESSMENT OF SHIPPING ACCIDENTS IN GREAT BARRIER REEF WATERS: by Maurice K. James, Department of Civil and Systems Engineering, James Cook University of North Queensland

ABSTRACT

The concepts, motivation and limitations of the objective assessment of risk are discussed, with reference to the problem of planning a response to marine spills of dangerous chemicals in the Great Barrier Reef region. The role to be played by an assessment of the probabilities and geographical distribution of shipping accidents is outlined. A method is discussed, based on the Monte Carlo simulation of fault-trees, for the estimation of these probabilities.

1. INTRODUCTION

The emerging discipline of risk analysis is motivated by the belief that an objective quantitative assessment of risk is a necessary input to the processes of project design, project evaluation, and planning for response to system failures (e.g. accidents) with undesirable consequences (such as spills of hazardous materials in coastal waters).

In project design and evaluation, risk analysis is concerned with the problem of risk reduction, and the achievement of a level of 'acceptable' risk. In planning response to system failure, one objective is to minimize the undesirable consequences of that failure. The nature and level of preparedness for that response should be consistent with the nature, level and distribution of risk associated with the particular system or activity involved.

1.1 Definition of Risk

The problem of risk is centred on people and their fears of loss or injury (Clark, 1979). 'Risk' is a loosely defined term which has at least two characteristics - the probability of an event, and its associated magnitude or severity (Pearce, 1981; Less, 1981; Dunster and Vinck, 1979). Everyday perceptions of hazards usually involve a qualitative combination of these two characteristics, so that risk is perceived as a composite entity with a general dimension ranging from negligible to severe.

The 'objective' assessment of risk is the process of estimating the probabilities and (physical) consequences of events, often by extrapolation from the frequencies of past occurrences of the event itself. Less tangible is the process of risk 'appraisal' in which the 'severity' of the consequences is evaluated. In most cases this evaluation cannot be carried out within the involvement of human values and emotions (Lee, 1981; Pearce, 1981).

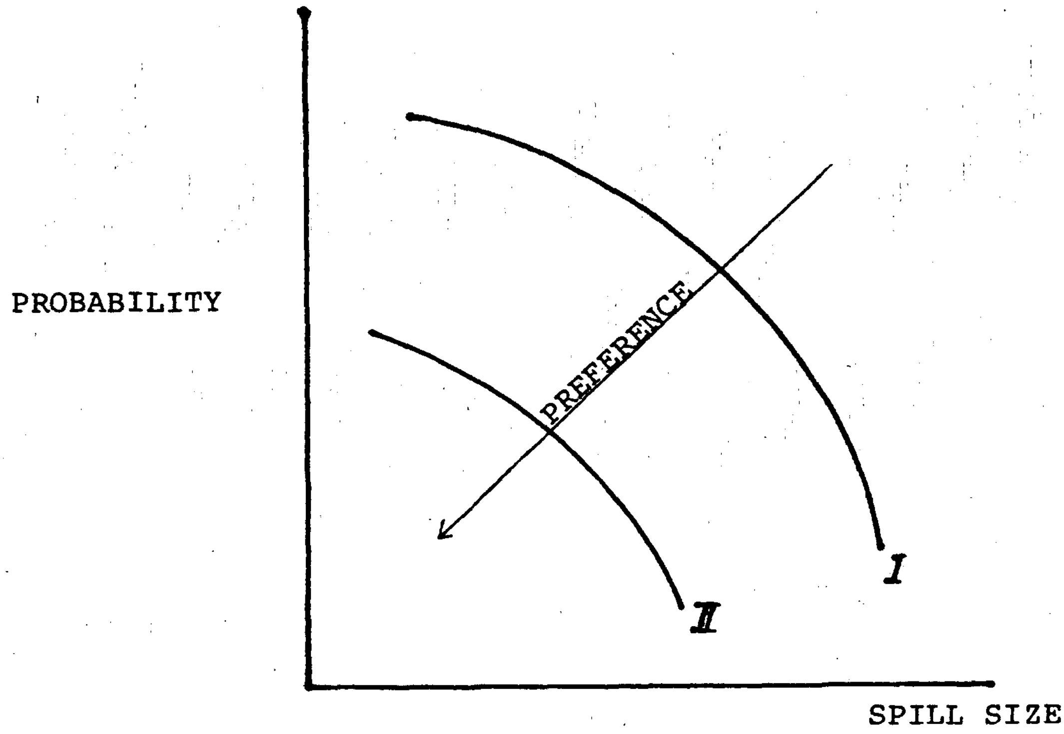


Figure 1
RISK PREFERENCE CURVES

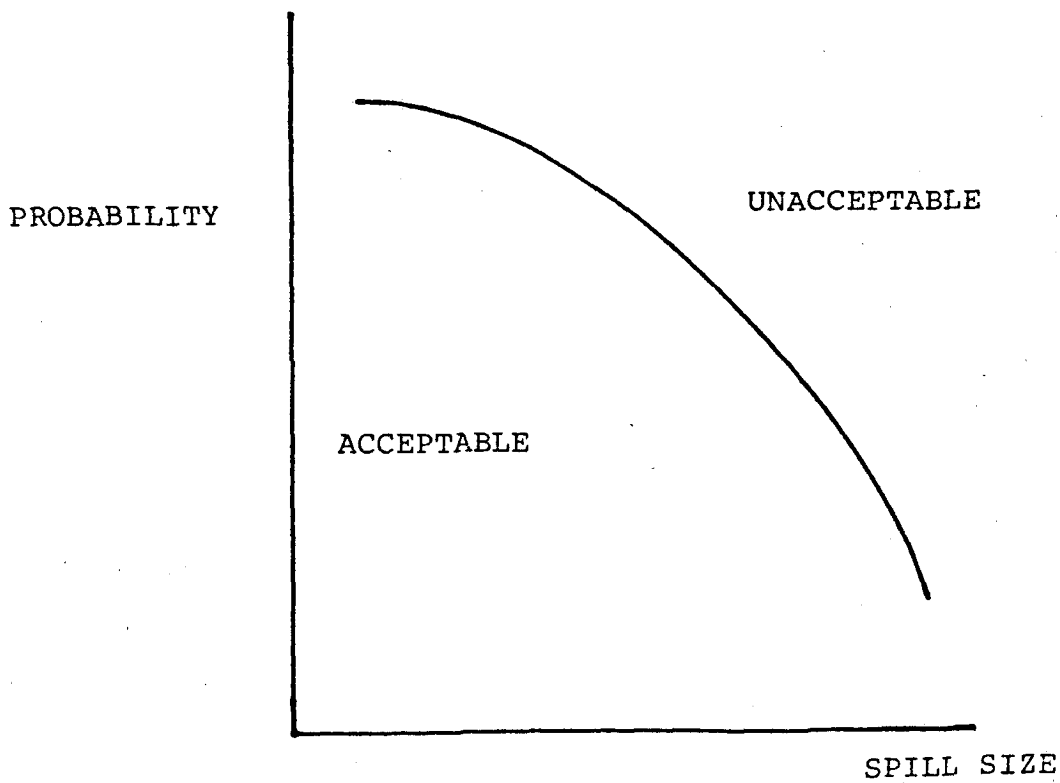


Figure 2
FARMER CURVE - LIMIT OF ACCEPTABLE RISK

The value of objective risk assessment as a direct input to decision-making at the highest level can therefore be seriously diminished in situations where these less tangible issues are important (especially, for example, when danger to life is involved).

1.2 Risk Assessment and the Concept of 'Acceptable' Risk

The risks accepted by people show a wide range of types and probabilities which can be discussed in terms of risk preference curves (Pearce, 1981). For example, points on curve 1 in Figure 1 represent combinations of probability and spill size which an individual perceives as equally acceptable. Points on curve II are also equally acceptable, but are perceived to be more acceptable than points on curve 1. The Farmer Curve (Henley and Kumamoto, 1981, p.13) is then defined as the preference curve which divides all possible combinations into disjoint sets of acceptable and unacceptable combinations (Figure 2). A limiting curve of this kind, representing the minimum level of acceptable risk, is used by the UKAEA as a guide for design of new plants and for assessing the safety of existing plants.

Direct applications of the simple approach based on a limiting Farmer curve has been strongly criticized for a number of reasons. For example, individual preference curves need somehow to be aggregated to form societal preference functions, a procedure which may not, in fact, be logically possible (Pearce, 1981). Secondly, the position of a particular combination on the (probability, consequence) plane of Figures 1 and 2 implies little concerning the desirability of the project since it involves no comparison between benefits and costs.

Pearce (1981) argues that the "concept of an 'acceptable' risk is without proper meaning unless benefits are known", and suggests that the costs implied by the necessity to accept risk should be treated as an additional component in a thorough cost-benefit analysis. Dunster and Vinck (1979) suggest that risk be divided into three classes:

(1)	unacceptable:	risk is too high whatever the benefit to society;
(2)	potentially acceptable:	benefits might justify therisk could be further reduced at 'reasonable' cost;
(3)	acceptable:	benefits justify the risk,and the level of risk has been reduced to the point where further reduction would cause a decrease in <u>net</u> benefit.

2. RESPONSE TO HAZARD

In planning the response to an event such as the spill of a hazardous chemical in the GBR region, the system under consideration (Figure 3) can be subdivided into two parts:

- the marine transportation system;
- the response mechanism

2.1 Benefits and Costs

Operation of the transportation system generates benefits which can mainly be measured fairly readily in monetary terms. It also implies costs, one of which is associated with the risk of damage to the reef system by accidental or deliberate spills of dangerous chemicals.

The response to this hazard operates in a number of ways:

- by taking steps to reduce the probability of spill events (e.g. by regulating traffic; by providing navigational aids, etc.);
- by action, in the event of a spill, to minimize the severity of the consequences (e.g. by containment; by removal; by dispersal etc.);
- by establishing scientific monitoring activities so that understanding of environmental impacts can be improved.

Thus while the response mechanism involves establishment, maintenance and operating costs, it should also generate benefits in terms of reduction of risk (in both dimensions) and improved assessment of future risks.

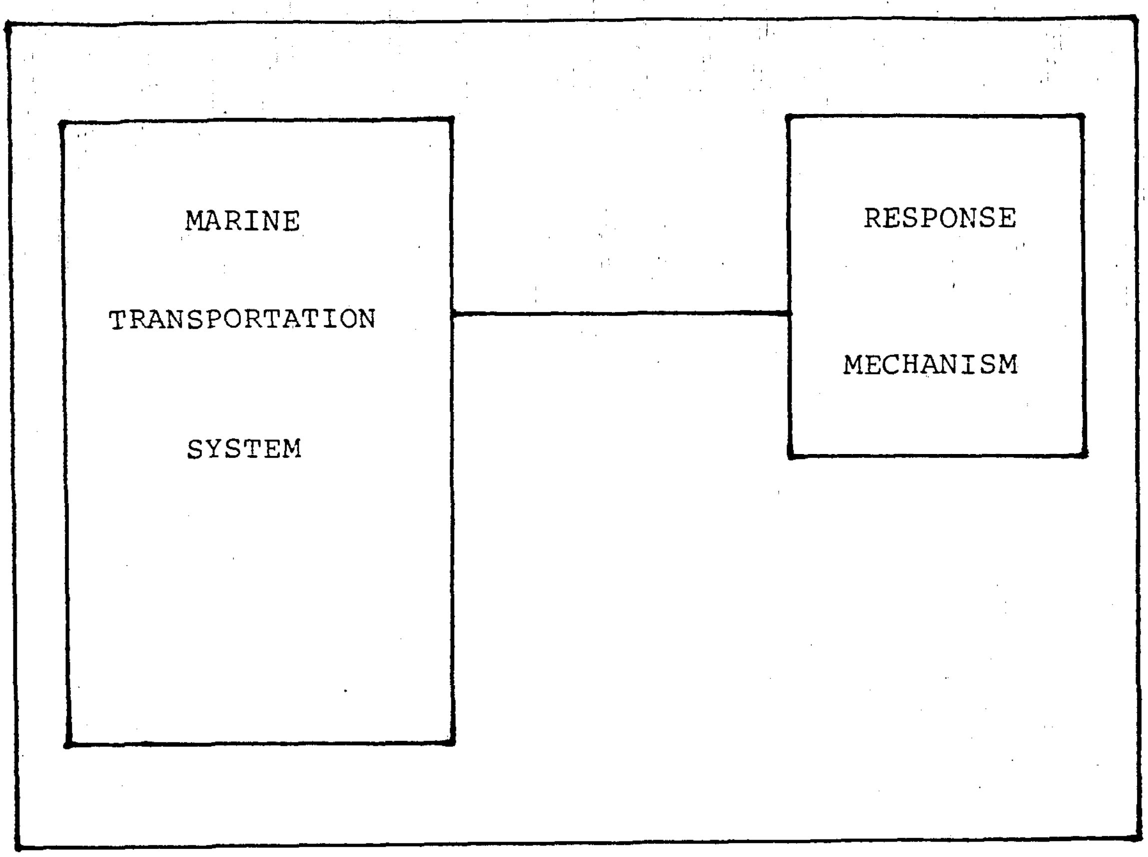


Figure 3

Total system considered in Planning for Response

2.2 The Role of Objective Risk Assessment

Figure 4 illustrates the role which might be played by objective risk assessment in the development of a planned response. It also illustrates the scope of current research by the author. The scheme is iterative.

In the first iteration, the likely occurrences of accidents under existing traffic management systems, and the likely consequences under the existing response mechanism (e.g. the National Plan) are estimated. These consequences are appraised and possible improvements in the response mechanism are determined. The iterations would then be repeated until no further improvement in net benefits could be made.

Current research is concerned with estimating the probability of shipping accidents (collisions and groundings) in Great Barrier Reef waters, and the distribution of that risk over the region; that is, the relative likelihoods of accidents at different locations. This will result in risk distribution maps as illustrated in Figure 5 (preliminary results only).

Later, these accident statistics will be used to determine the probabilistic geographical distribution of spills to provide input to:

(1) Spill trajectory models for the determination of impact zones
(2) Logistic analyses to plan the location and mobilization of materials, equipment and personnel for both protective and scientific responses (e.g. Charnes et al, 1979).
(3) Reliability analyses of the response mechanism, so that different response plans can be evaluated.

3. ASSESSMENT METHOD

Objective risk assessment involves estimating the probabilities of future events on the basis of statistical data from past events. This may be purely statistical, based on the frequency of past occurrences of the event itself. Alternatively, it may employ an aggregation of the probabilities of the chain of events which lead to the accident (Lee, 1981). The latter may be the only rational approach when there are virtually no past records (as applies for shipping accidents in GBR waters).

3.1 Shipping Accident Statistics

Very few serious shipping accidents have been recorded in GBR waters. Consequently there is no statistical base which could be used to estimate probabilities of accidents.

Several major compilations and analyses of shipping accident data have been made for other parts of the world (e.g. Drager, 1980; Grimes, 1972). Grimes has analysed data for 10 years' shipping operations in N.W. European waters and has fitted probability distributions to the accident occurrences. Drager reports on a very comprehensive analysis of casual factors reported for approximately 3000 shipping accidents in Norwegian waters.

The extent to which analyses such as that of Grimes can be used to assess risks in Australian waters is very dubious. It involves an extrapolation in both time and space which would be extremely difficult to justify. In addition it could hardly be used to help achieve the objective of a probabilistic geographical distribution of risk in the region.

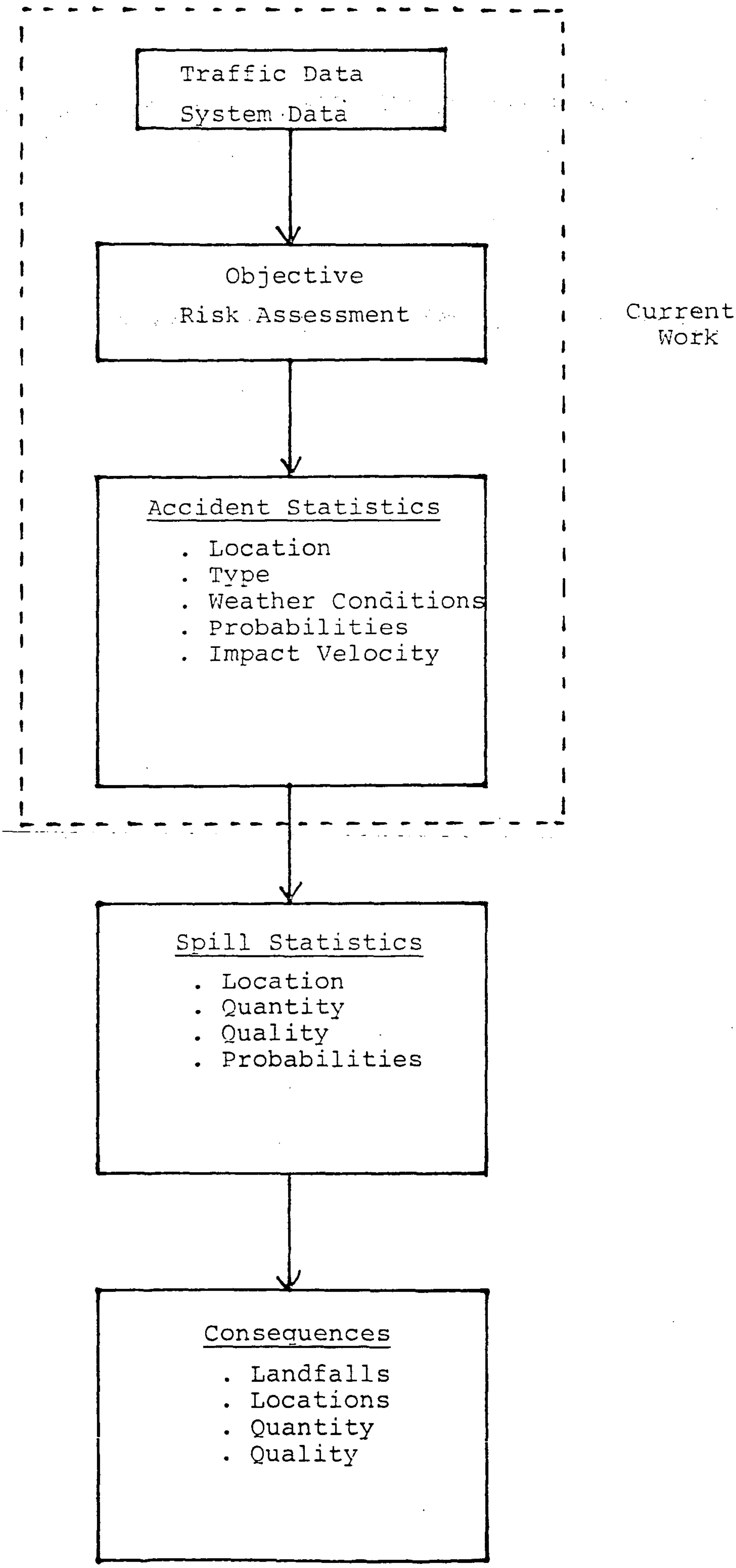


Figure 4(a)

Objective Risk Assessment

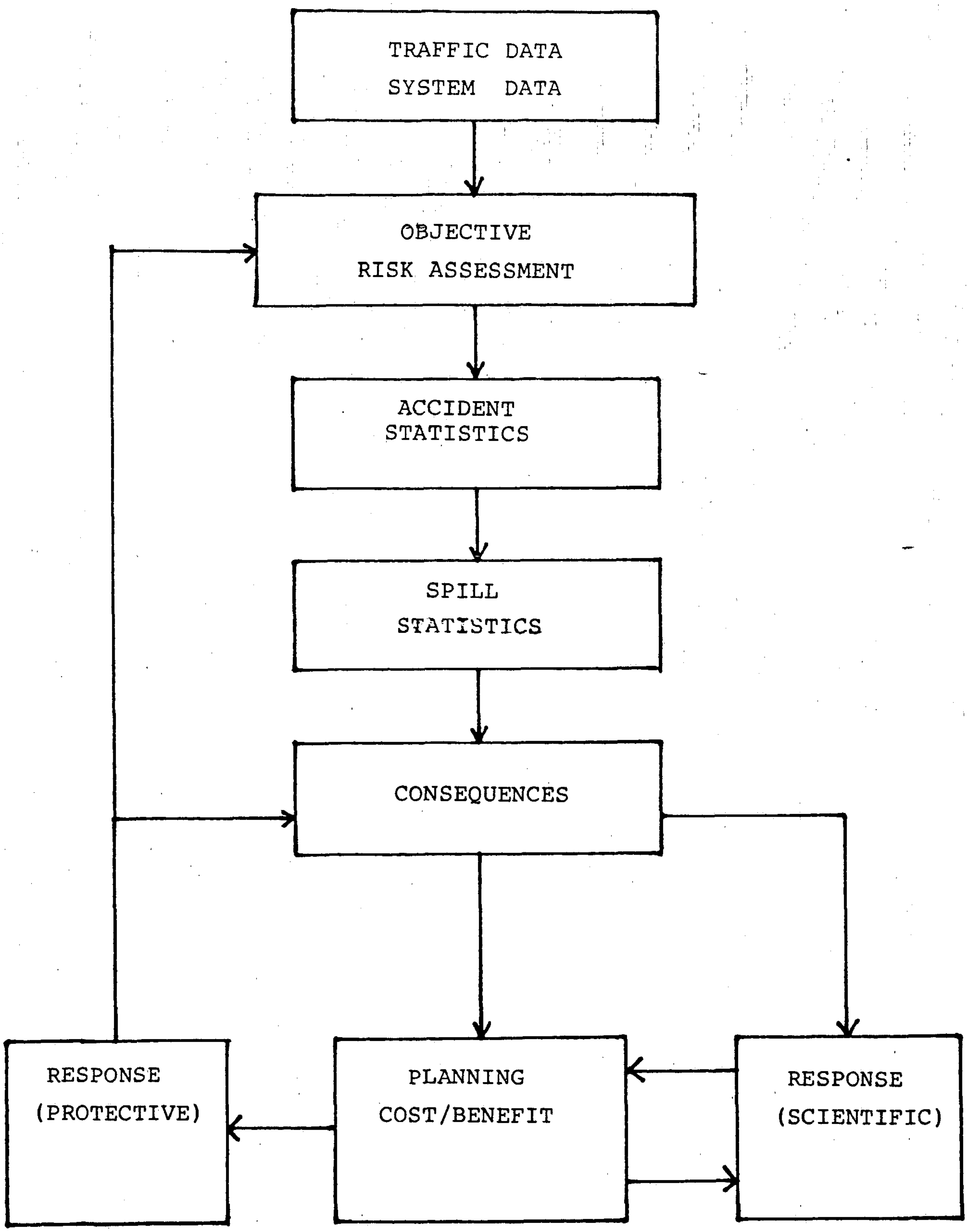


Figure 4(b)

Planning for Response

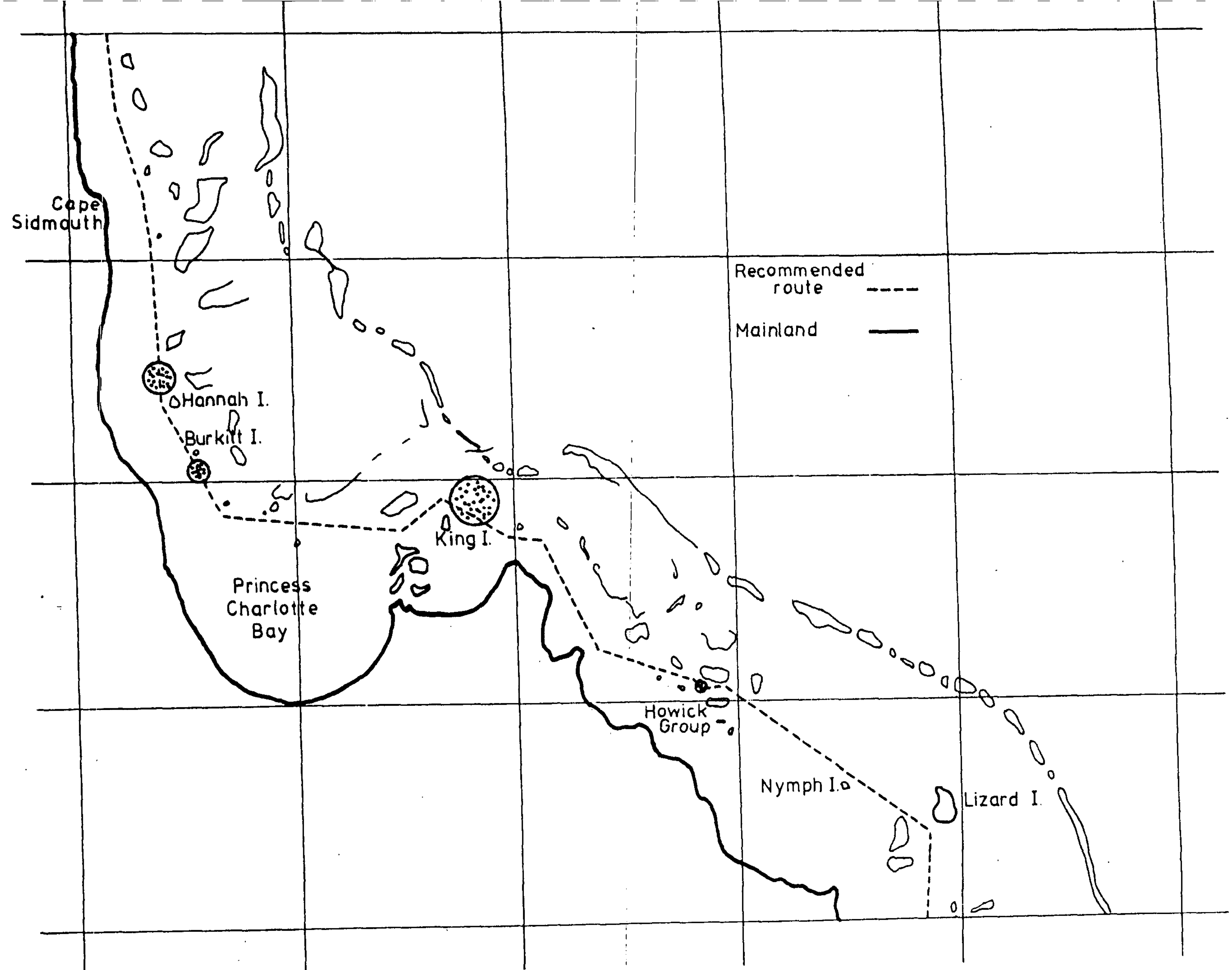


Figure 5.

Relative likelihoods of grounding incidents.

On the other hand the results of Drager's analyses could well find application in guiding a less empirical approach to risk assessment which is described below. This approach should be able to take account of both local conditions and changing navigation technology.

3.2 Modelling for Risk Assessment

The approach currently under development involves the mathematical modelling and computer-based simulation of the navigation of ships and of the collusion process which takes place between ships and fixed obstacles such as reefs, offshore structures, etc. The approach is illustrated in Figure 6.

The model allows important casual factors to be taken explicitly into account, such as: environmental conditions (e.g. poor visibility); mechanical conditions (e.g. steering failure); human error (e.g. positioning errors, mismanoeuvres, navigation errors). The stochastic nature of casual events is also explicity recognised and simulated by the Monte Carlo technique based on the generation of random variables within the computer program.

The advantage of this approach is that very many years' shipping experience can be simulated and a large number of potential accident situations analysed so that valid statistical estimates of probabilities can be made.

3.2.1 Navigation Model

The study region for the current project is shown in Figure 7. Details of the region, including water depths, the location of reefs and navigational aids, are stored in digitized form in the computer. The position of a ship at any time is also stored.

Ships are navigated through sequences of target points at which course changes are made (Figure 8). Depending on external conditions (e.g. wind, current, visibility) and the reliability of steering gear and compass, the actual course made good can differ significantly from that desired, and this stochastic effect is modelled.

In the simulation, navigation is represented by a sequence of events and state changes such as: course changes, course corrections, weather changes, gear failures, encounters with other vessels. At each event, the position of the ship is updated, and the time at which the next event will occur is randomly determined.

3.2.2 The Encounter Model

If, during operation of the navigation model, two ships come within some specified distance of each other, or a ship comes within some specified distance of a reef, the outcome of this encounter is determined by the encounter model.

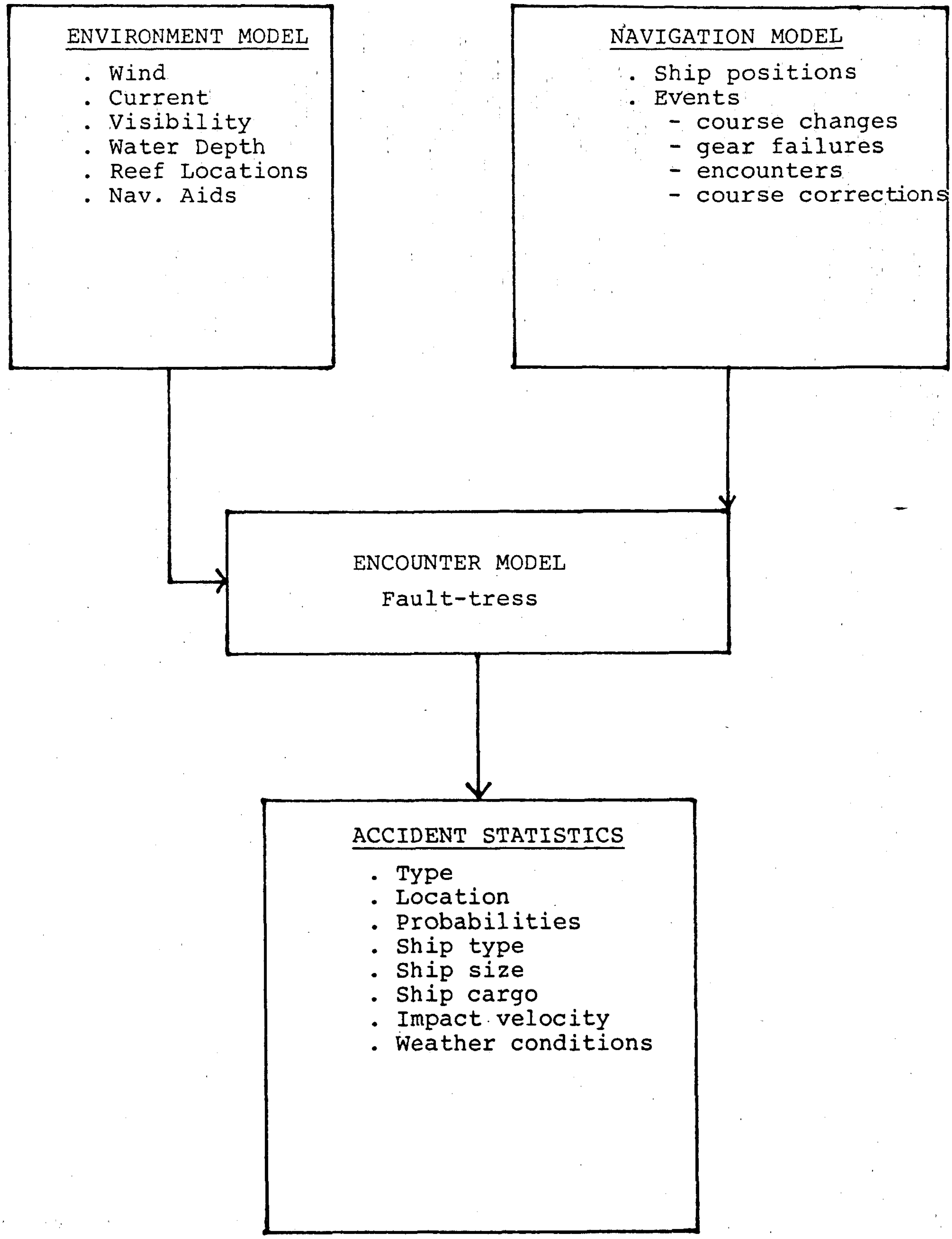


Figure 6

Model Structure

The outcome depends in a complex way on the interaction of a (possibly large) set of casual factors. Conceptually, the model is based on the method of fault-tree analysis first developed in the early 1960's for the U.S. Air Force (Henley and Kumamoto, 1981). A simple example is illustrated in Figure 9. The accident appears as the top event and is linked to more basic fault events by various logic gates. The idea is that an accident occurs when one or more basic failures occur, enabling a casual path which leads to the accident. If the top event can be traced back to basic failures whose probabilities are known, then the probability of the top event can be readily computed.

The basic events may be of three types:

(1) events related to human beings (e.g. incorrect interpretation of a navigational aid);

(2) events related to hardware (e.g. failure of a gyro compass);

(3) events related to the environment (e.g. failure of visibility).

In the simulation, the determination of a failure event is achieved stochastically by Monte Carlo sampling. For example, suppose at a particular point in an encounter, a course change is required, and the steering gear is known to be 98% reliable. A uniform random number is generated in the interval (0,1). If its value falls between .98 and 1.0, then the steering gear is determined to have failed at that point.

The structure and detail of the fault tree must, of course, be consistent with the data available. This investigation is currently in train, with heavy reliance on the analytical results of the project reported on by Drager (1980).

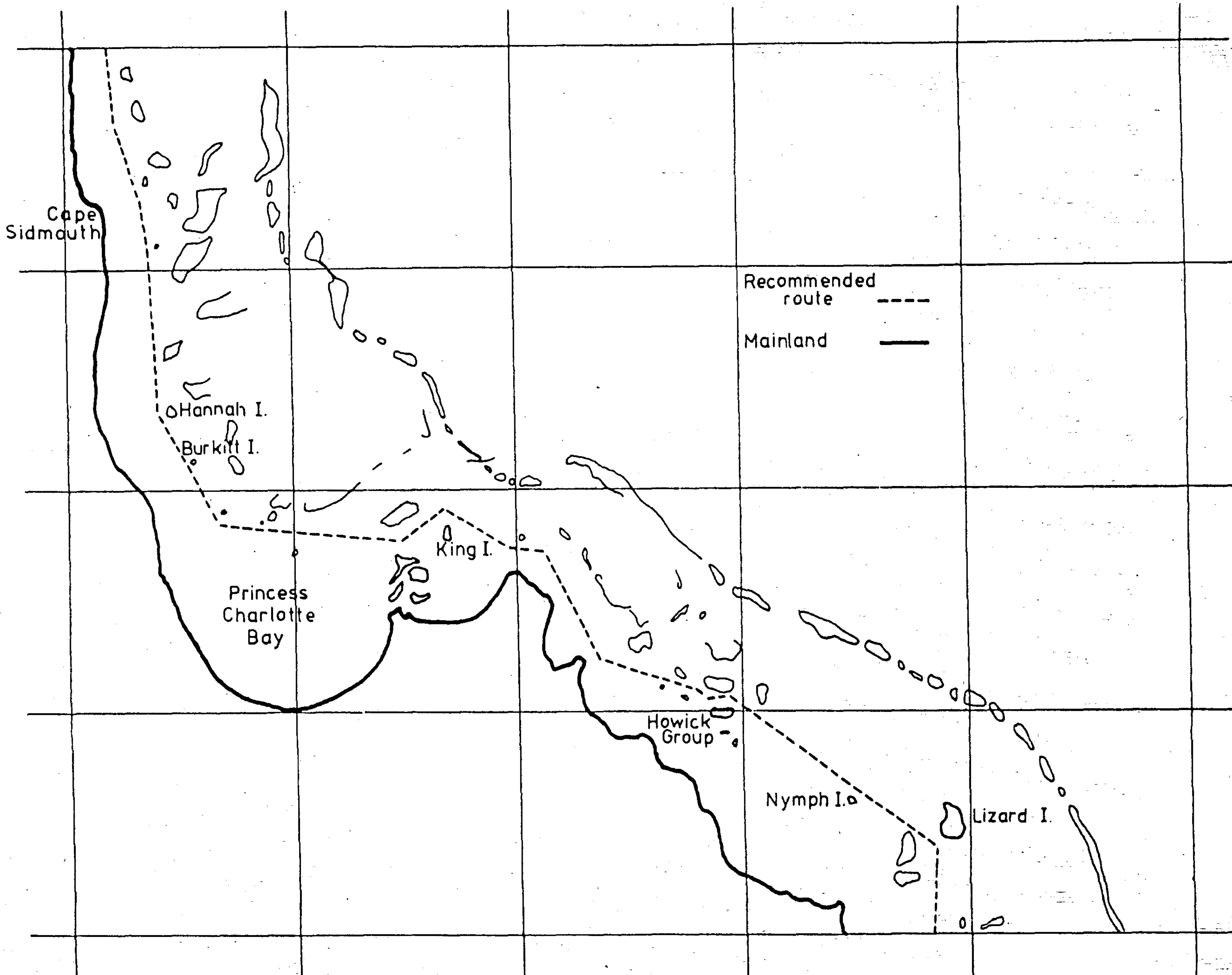


Figure 7.

Study Area.

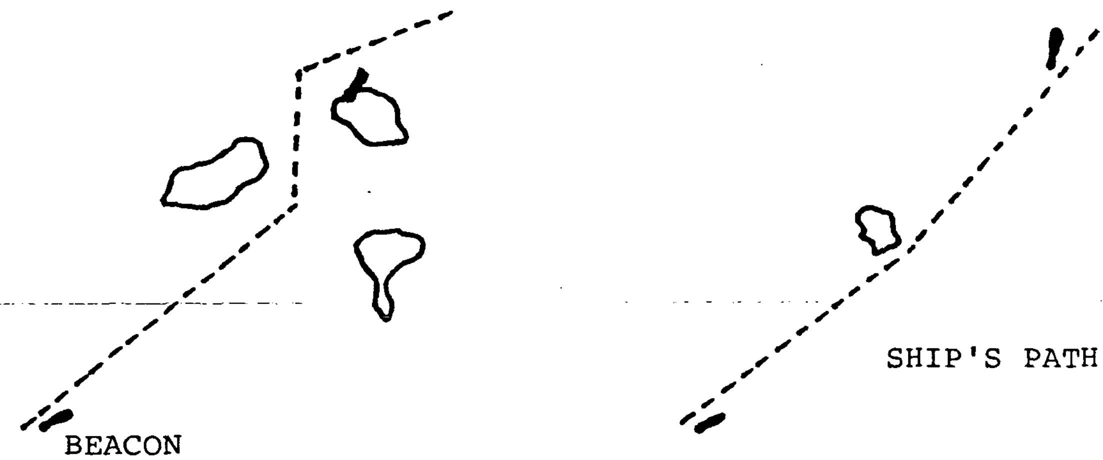


Figure 8

NAVIGATION PROCESS

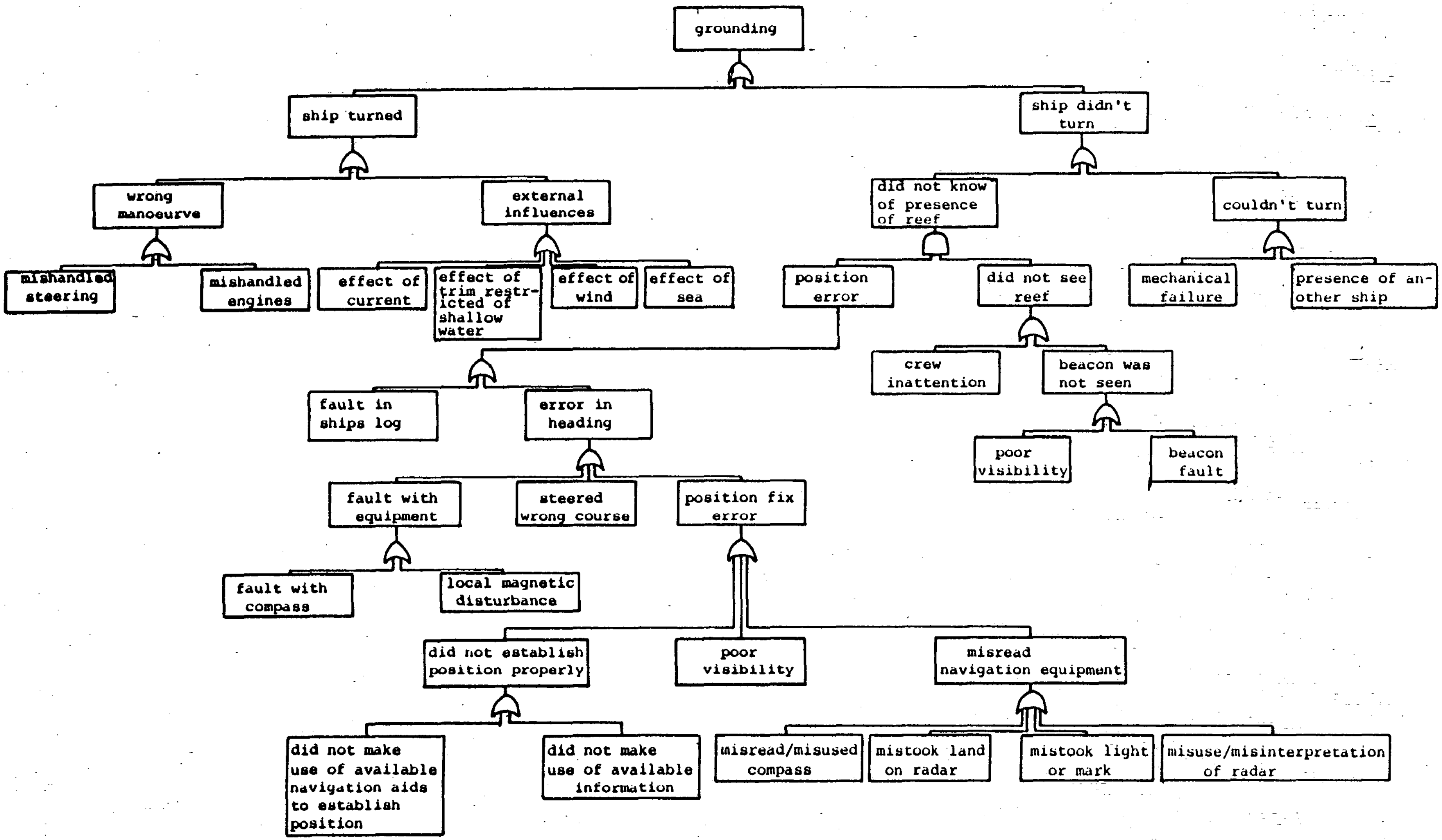


Figure 9

Fault-Tree Example

3.3 Validation

The risk assessment model will be generalized, in the sense that it will be readily adapted to any particular region. The methodology can only be validated by implementing and testing the model for some region for which significant historical data exist. It may be possible, at a future stage of the research program, to perform this validation task by applying the model to shipping in Norwegian waters, in collaboration with Det Norske Veritas.

4. CONCLUSION

Development has commenced of a method for the objective assessment of shipping risk in Great Barrier Reef waters. The method will yield an estimate of the probabilistic geographical distribution of the risk of collisions and groundings. This will complete the first phase of an overall approach to the development of a planned response to accidental spills of hazardous chemicals.

5. ACKNOWLEDGEMENTS

Support from a Universities Commission Special Research Grant and receipt of a research grant from Det Norske Veritas are gratefully acknowledged.

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GENERAL DISCUSSION

General discussion focussed on a number of aspects of the problems as outlined on the following pages:

(a) Transport of hazardous materials

There appeared to be general agreement that there is a requirement for more work on the volume and nature of these cargos, particularly the "unspecified" cargo. Additionally, concern was expressed that probably some 10% of GBRR shipping is in transit and their chemical cargos unrecorded. Much of this shipping is destined for South Pacific countries whose economics suggest chemicals are not a major import item. However some investigation is required.

It was pointed out that in the United States, the US Coastguard Strike Teams responded in 40% of occasions to oil spills and on 60% to hazardous chemical spills; cargo figures for Australia appear to suggest relatively much smaller volumes of chemicals are carried here.

Additional work may also be required on marine toxicity and impact of the hazardous materials carried. The Department of Home Affairs and Environment has a computer based rapid access system on hazardous chemicals called "Chemdata". This is available on "instant call" to functional and other designated agencies in all States although it does not appear to have been taken up yet in Queensland.

TDB which provides toxicology data is also accessible on CSIRONET or the Department of Health Network.

(b) Risk Assessment

Det Norske Veritas have conducted a study risk assessment in which members of the public are questioned on the levels of risk they are prepared to accept. This is useful in terms of making decisions as to whether to respond to spills.

(c) Scientific capability

In developing a scientific response capability it is necessary to know the capability, competence and degree of commitment of the scientific institutions which may be involved, so that the most appropriate institutions can be involved.

(d) SSC role in Norwegian Plan

In Norway the SSC sits on the National Plan. He provides an important liaison and conduit between the scientists and the OSC. He also serves the vital function of keeping the press out of the way until the action is over and then informing the press about the scientific response.

GROUP DISCUSSIONS

Group A

1. **Scientific Response Capability**

There was general agreement on the need for a scientific response capability to hazardous materials spills. A single response plan to both oil and other hazardous materials was seen as most sensible (as NOAA has done) from organisational, funding and scientific response points of view.

2. **Nature of hazards**

It was suggested that there is need for future work on toxicity concentrations and effects for appropriate marine organisms. Most toxicity work has been based on brine shrimp assays; coral reef organisms may be several orders of magnitude more sensitive.

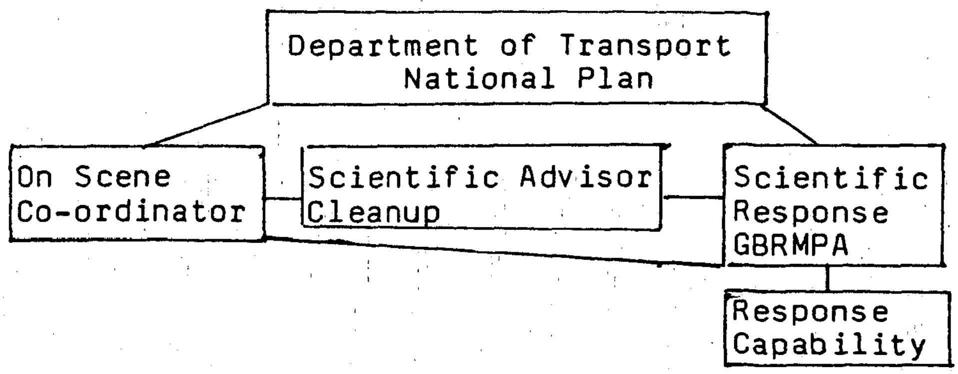
Work is also needed to provide more detailed information on the major chemical substances passing through the Great Barrier Reef Region, both entering and leaving Australian ports and in transit through the Region. It was suggested that cargo information might be obtained using the AUSREP radio contact system.

The Queensland and Torres Strait Pilot are about to reevaluate navigation channels in the Great Barrier Reef Region and will in the near future be able to provide an updated list of the areas where the risk of collision is greatest. Reduction of this risk by reducing the possibility of spills at source was also suggested as a worthwhile avenue of endeavour.

3. Decision to respond

The size, nature and location of the spill are obvious criteria for assisting in determining the subsequent response. Senior expertise is necessary and in established scientific response plans, one person (at least) is usually sent out to establish whether there is a need for further response.

The relationship of the scientific response to the combat response was discussed and the following model proposed.



4. **Organisation of response**

(a) There is a need to organise teams of trained people who can be mobilised to carry out pre determined tasks.

It will be necessary to determine:

what tasks
what training
who to involve
institutions/individuals

- capability
- commitment
- competence
- compensation
- contractual arrangements

The need to include an economist in such teams to enable the cost of the spill to be evaluated was stressed.

It was suggested that a working group be set up by GBRMPA to investigate these questions in greater detail.

(b) There is also a need to address the question of funding the scientific response. Three types of funding require resolution:

- maintenance of team (GBRMPA)
- capital establishment (?)
- episodic crises

(c) **Accountability**

It is essential that response teams be trained in leaving appropriate paper trails for future decision making on responses and to evaluate responses made.

Group B:

1. Scientific Response Capability

The group agreed to focus on the subject of the Scientific Response Capability. Specifically, what an appropriate response would be and how it should be organised.

It was noted that the National Plan had provision for a scientific component in the response team. The Scientific Support Co-ordinator's (SSC) primary responsibility is to advise and assist in evaluating and dealing with the hazard - that is, how the response group could best deal with the problem. It was agreed that an initial scientific response effort would be needed to feed information into the SSC for input to the combat team but would, at the same time, need to consider longer term efforts to evaluate damage to the resource together with possible research advantages associated with a spill. Such research could result in recommendations to improve the response effort.

The group felt that organisation of any scientific effort could best be co-ordinated by GBRMPA. Some discussion focussed on the role of the media liaison officer. It was agreed that this media contact role would be the responsibility of the On Scene Co-ordinator or his Team which would prepare regular media releases.

There was some concern that confusion would arise between the responsibilities of the State/Federal agencies during a hazardous materials spill as it moved through different geographic areas. It was felt that this problem would probably be resolved at the onset of an event by discussion between the Queensland State Committee and the Federal Authority (DOT).

The Group next dealt with the desirability of a Scientific Response Group. Was such a response really necessary? The group unanimously agreed such a group response was required so that it could provide reliable information as a means to resolve conflicting reports, make reasonable assessments of the damage if any, and improve future responses. Given that it was necessary the group agreed that scientific representation must include oceanographic and chemical, as well as standard biophysical, expertise.

The availability and quality of existing information raised some discussion. Whereas additional information would always be useful it was felt that sufficient data was probably available to permit some form of organised response. It was therefore agreed that

- there should be continued development of oceanic water movement models in the region along the lines of the GBRMPA/JCU/AIMS effort.

- the best currently available data should be obtained and maintained in an accessible database.

- the oceanographic and remaining meteorological data gaps should be identified and resolved.

- basic research should be continued especially in oceanography.

- the DOT, OSSM-8 oil spill model and the Bureau of Meteorology 'Oil Spill' Extract model should be used to respond to any events occurring in the meantime. It was noted that these computer models could be accessed through CSIRONET. Some steps should be taken to familiarise some Townsville people, perhaps at GBRMPA in the first instance.

The discussion returned to Protective Strategies to be used by the Response Team. The feeling was that reefs could be protected by current equipment held by DOT but that this was function of size of the spill and weather and sea conditions at the time. The On-Scene-Co-ordinator (OSC) would require specific advice at the time of the spill as to whether dispersal was warranted. He would need to know where to deploy the equipment.

It was agreed that a generalised map of the Reef Region should be developed which identified "areas at risk" or sensitive areas. It was felt that such information already resided in the records of GBRMPA for areas already zoned or being zoned at a synoptic scale. More detailed information could be provided by an on-scene team with QNPWS and Fisheries representation.

A chemical analysis of the spill substance would probably be required, especially if the information was needed for prosecution. The general feeling was that there was no need to duplicate chemical analysis facilities in the Region if they existed elsewhere but that logistics for movement of samples should be spelt out.

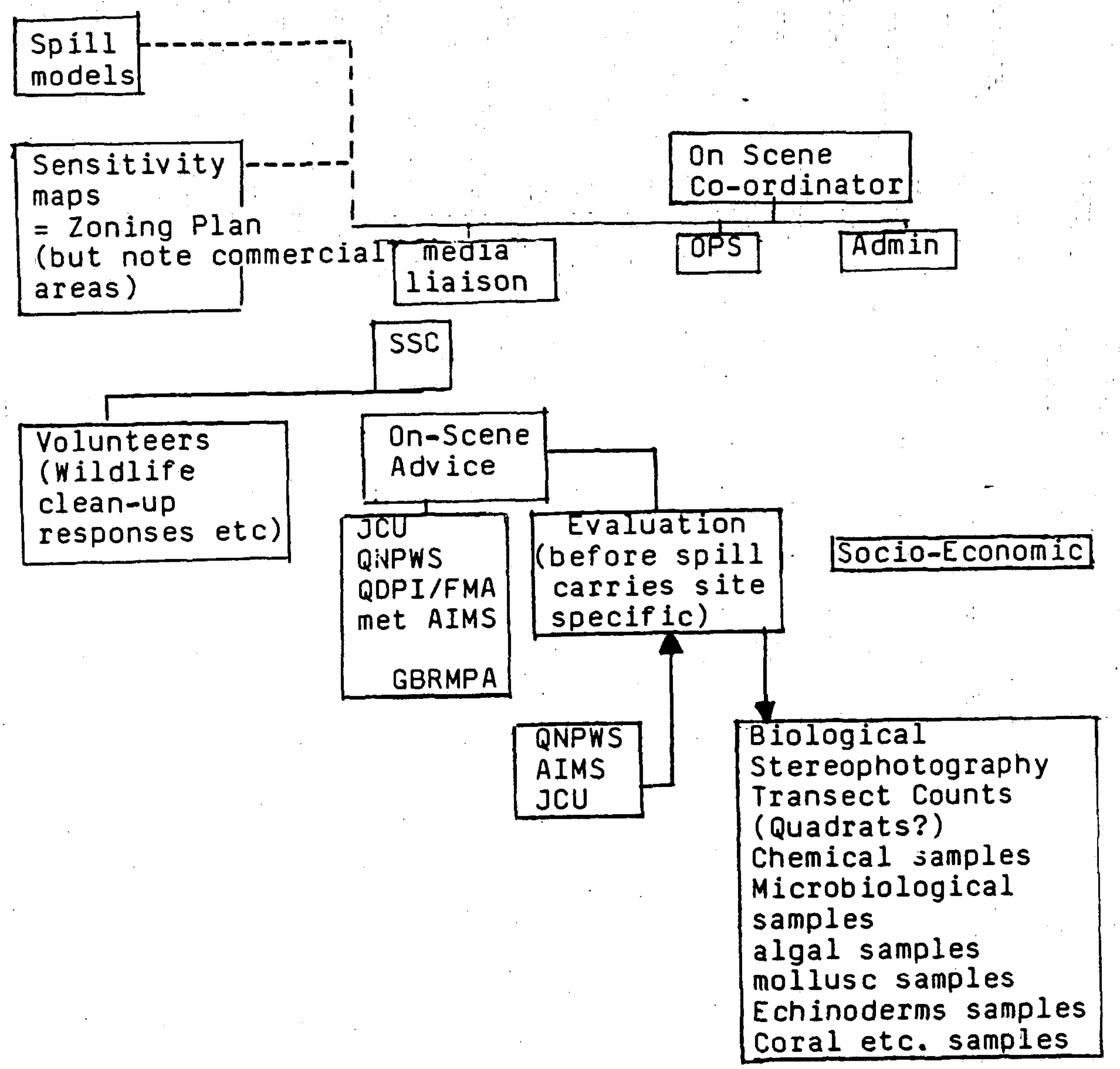
It was agreed that detailed advice on "areas at risk" during a spill could be provided by QNPWS. What they had to measure should be laid out before hand. The techniques and measurements used by the Norwegians should be reviewed, adopted and applied as relevant.

Further discussion focussed on the use and organisation of volunteers and communication of scientific advice to the OSC. It was felt that QNPWS staff would be useful in the immediate on-site advisory role and would provide a strong support role in evaluating the effects of the spill. It was felt that a Fisheries representative should also be on the scientific advice team.

The following diagram sums up some of the major considerations proposed for discussion by the group.

Criteria for Response

- size of the spill
- proximity to reef(s)
- sensitivity ranking
- weather conditions



Group C:

The Group focussed discussion on the three subobjectives of the workshop.

1. Identification of risk

The group felt that the risk for hazardous chemicals was generally lower than that for oil. Two categories of substances were identified:

i high volume, low toxicity
ii small volume, high toxicity

and it was suggested that there is a need to look further at the types of chemicals shipped, the industries involved, and their potential for growth.

The chemical characteristics of the substances carried are obviously important, i.e. whether the substances are "floaters", e.g. oil or "sinkers", e.g. tetraethyl lead..
Different kinds of accidental threat were identified:

i collision
ii sinking
iii grounding

Each may result in the spillage of cargo, but the circumstances of spillage could vary significantly - thus influencing the response requirement. The group observed that there are many unknowns about the fate of chemicals in the Great Barrier Reef system. This will affect costs and benefits and therefore influence the response decision.

Concern was also expressed about the variability of risks in the Great Barrier Reef Region and how this may influence both the response decision and the response capacity. If for example a spill were to occur in the Far Northern Section of the Great Barrier Reef Marine Park, the organisation of the response would be considerably more difficult than if it occurred adjacent to the Townsville Harbour.

2. Decision to respond

It was agreed that a response capacity is necessary - even if only for "PR" value. The nature of response will be influenced by whether the effect is localised or dispersed. If, as suspected, most hazardous chemical spills are limited to localised effects then response will be limited to scientific investigation, damage assessment and monitoring - to do nothing may also be a feasible alternative particularly where access is difficult or where potential damage is considered low. Another active response may be to enhance dispersion - more research is needed, however, before this is practicable. (Also there was some discussion on potential for salvage of spilled material.)

3. Response

In view of the marginal incremental effect involved in extending scientific response capacity to include hazardous chemicals, the group agreed that such an extension is advisable.

REEFPLAN should form the basis of response in terms of use of logistics, structure, communications, etc. The Commonwealth should continue to assume a major role in response. The Great Barrier Reef Marine Park Authority should be a major participant, particularly in the role of SSC.

Recommendations

The group proposed that the following action be undertaken:

- establishment of a working group which should address the role and responsibilities of a SSC in terms of both oil and hazardous chemicals spills as well as related matters such as the designation of laboratories etc
- further research into modelling of dispersion
- more information be sought on hazardous chemicals (shipping patterns and destinations and their potential ecotoxicological effects).
- support be provided to enable extension of risk analysis work of M. James.

REVISED DRAFT JULY, 1983

OIL SPILL WORKSHOP REPORT

Venue & Date: GBRMPA Conference Room, March 3, 1983, 8.05 a.m.

Participants: Dr Gilmour, Chairman, Drs Kermond (GBRMPA), Tomczak (CSIRO), Sobey (JCU), Spillane (CSIRO), J.C. Andrews (AIMS), Ray Steedman (AIMS Council); and, Professor Stark (JCU)

The format for the workshop was established and agreed upon. Essentially this consisted of an introduction by Dr Gilmour, a review of part of the Galt Oil Spill Model by Dr J.C. Andrews, and discussion leading to the formulation of recommendations to the GBRMPA regarding its role in oil spill decision-making.

Introduction (A Summary)

In the introduction, Dr Gilmour stressed three main points: as the Galt model is established on CSIRONET it is accessible and being used by the States; there is a need to consider oil spill contingencies in the Region especially in regard to the co-ordination of advice to other agencies or authorities more directly involved in the oil spill containment, clean-up etc; and, the Authority requires advice in its role as a technical-policy body in the preparation for and response to oil spills in the Great Barrier Reef Region.

Galt Model Review

Dr J.C. Andrews addressed his review of part of the NOAA developed "Galt" model. In general, he found the diagnostic sub-routine of the model that deals with geostrophic ocean currents inadequate in reef applications, and cited the following:

(i) Model requires constant initialization, and unlike the research and operational situation in the U.S., this may not always be possible in the reef region;

(ii) Model has 3 open boundaries which creates problems;

(iii) Time variability is not good;

(iv) Because of the simplistic data input needs, (e.g. around 200 bathymetric points and sea surface elevations) the model can only simulate linear sections, which, at approximately $100 per min on CSIRONET make the model fairly expensive in terms of computer costs;

(v) Model is useful in defining risk areas, but is not as useful in calamity management as it could be;

(vi) No shoals or reefs included in original assumptions underlying the Galt model.

Discussion Summary

Oceanographic data needs were discussed for models in general, including the JCU Hydrodynamic model. Data sets for modelling were held by AIMS for the reef region near Townsville, while JCU held data for the Capricornia/Mackay region. It was agreed that the minimum basic needs for modelling and predicting the movement of an oil spill were the following advection components: geostrophic current, wind driven layer, tides, surface driven slick speed.

Steedman and Associates have developed hydrodynamic models for use in the NW shelf waters. These have both wind field and waves input. It was pointed out, though, that such models have problems with non-linear processes such as shoreline rips and in accommodating mangroves and mudflats.

There was some discussion on the characteristics of an oil slick on the ocean. Data needs included information on the nature of the oil (chemical-physical changes and surface tension, decay, dispersants, viscosity, microbial attack etc), the turbulent dispersion (shearflow, transport down the gradient).

Final Remarks

1. There can be some danger in applying northern hemisphere oceanographic computer models in the southern hemisphere if due regard is not given to the constants, etc..

2. There is a need for more accurate, reliable and timely input of data from the Bureau of Meteorology.

3. One way to address the problem of providing advice regarding an oil spill in the Region would be to have a person devoted full-time to such a task -- for instance an Experimental Officer position could be created. The discussion suggested that such a position would be appropriate to generate background data for GBRMPA which might be used on a long-term basis in future search and rescue operations. This data would be provided in the form of solutions of the hydrodynamics of all areas within the Great Barrier Reef Region selected in order of priority for study so that a compendium of results would be available for use in emergency type situations which might require quick decisions to be made concerning possible movement of oil spills. The Officer could also be used to develop a co-ordinated program which might be used by the Search and Rescue Unit. The Search and Rescue Unit on the other hand is an operational unit with emergency capabilities which would not utilise, for the first few years at least, large computer real time solutions during operations. This information will have already been provided in the data compendium. (There was no discussion on the responsibility of various organizations, cost estimates, timing, management and funding.)

4. The following stages were recommended for Authority consideration:

(i) the risk of oil spills in the Great Barrier Reef region should be made to establish the acceptable risk level in selected areas. At present many ships use the area and there appears to be few spills. The study should highlight areas of high risk. Other toxic chemicals or substances may also be considered. The study should qualify to some degree the magnitude of the problem if there is one;

(ii) review the existing literature and information on winds, waves, currents and water levels. The review should include studies of circulation, theoretical modelling (circulation and oil transport), and list in detail the available data. The data list would aid future oil spill studies, model evaluation and operational problems;

(iii) evaluate the existing numerical models of Galt and JCU using both Capricornia and Townsville data sets. Circulation models in other high risk areas may be established and tested. The number of models required to cover the Great Barrier Reef region should be assessed. Recommendations on the best type of model, i.e. the equations of motion, boundary conditions, grid size and numerical scheme, assuming the wind and tide forcing, and bathymetry are available.

Once the circulation models have been evaluated the oil transport model(s) may be considered;

(iv) to improve the understanding of the physical and chemical transport processes associated with oil spill in the region, certain processes may need investigation with the aim of improving the model parameterization, e.g. the decay rate, or evaporation, of the viscosity of a specific oil may be important to the mass transport;

(v) establish organizational and operation procedures in the event of an oil spill, bearing in mind the State and Commonwealth Government Departments responsible.

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SHIPPING WITHIN THE GREAT BARRIER REEF REGION
SUMMARY OF RELEVANT AVAILABLE INFORMATION

The shipping route through the Far Northern Section contains more potential hazards than the more southerly areas of the Great Barrier Reef Region (Mort 1980). This is due to the combined influences of shallow waters and fringing reefs along the coast, the reef proper coming close to the coast in places and vast areas of uncharted reefs and shoals. The shipping channels through the Far Northern Section are narrow in places (only 3/4 mile) and necessitate many sharp turns (Whiteman 1978). A list of potentially hazardous waters in the Great Barrier Reef has been compiled by Mort (1980).

The "Inner Route" through the Great Barrier Reef and Torres Strait now used only became popular from the 1860's even though the waters inside the Great Barrier Reef are generally calmer.

The early days of shipping saw numerous shipwrecks along the outer reef, but the Outer Route was favoured because of perceived dangers of navigating through the reefs of the Inner Route. The emergence of pilots for the inner route in a service which eventually became the Queensland Coast and Torres Strait Pilot Service allowed an increase in shipping through the Inner Route (Foley, 1982). Today the Inner Route has the greatest use by coastal shipping.

The number of ships piloted through the Inner Route over the last five years is shown below. The total number using the inner route is estimated at 10% above the piloted number. The main cargoes carried are bauxite, sugar, coal, frozen foods (meat), oil and silica sand. In addition, small local coastal vessels servicing Thursday Island and Gulf of Carpentaria ports make 200-300 trips per annum through the Far Northern Section (Whiteman 1978).

TABLE 2: NUMBER OF SHIPS PILOTED THROUGH THE INNER ROUTE GREAT BARRIER REEF

1978/79	1319
1979/80	1442
1980/81	1360
1981/82	1300
1982/83	1250(estimate)

(Source: Queensland Coast and Torres Strait Pilot Service)

Mort (1980) notes that a large increase in fishing in Great Barrier Reef waters plus an increase in the size of the ships navigating the area has led to a number of close encounters in recent years. Large ships using the inner route have deep drafts and must keep to deep water channels. Manouverability is limited and ships do not always keep to recommended routes.

Recommended shipping routes are determined by the Commonwealth Department of Transport and Construction. An advisory two way shipping route has been implemented from 1 September 1983. This two way route is for moderate draft ships. Ships with deep drafts (the maximum clearance is 11.89m) (Mort 1980) will need to keep to the deepest channels.

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Collision dangers on the Great Barrier Reef

by S.W. Mort*

RECENTLY there has been a large increase in fishing in Great Barrier Reef waters and also in the size of the ships navigating the area.

This has led to a number of close encounters, and to the sinking of the trawler *Suzie PK*.

To help avoid further accidents, I want to draw the attention of fishermen to some of the problems of piloting a large vessel through the inner route of the Great Barrier Reef, particularly insofar as those problems concern fishing vessels.

Confined waters

Large vessels have deep drafts — 11.89 m (39 ft) being the present maximum draft capable of navigating the inner route — and they must keep to deepwater channels, thereby limiting the area in which to manoeuvre. By day they display a black cylinder, and by night three red lights vertically, in addition to their navigation lights.

Passage of such ships is quite safe, provided they do not have to deviate from the deep channels, which are well known to the pilots and usually approximate the recommended tracks printed on the charts. However recommended tracks are not always followed.

Ships invariably pass to the east of Burkitt Island and close to Magpie and Iris Reefs and usually to the east of Eden Reef. They also pass on either side of Heath Reef. These waters are particularly 'confined' to say the least.

On observing a fishing boat, the pilot has to start planning his avoiding action at a range of about five miles in order not to have to take drastic action at close range, which could result in getting too far off course.

This is fine if the fishing vessel is on a constant course and maintains a constant speed and provided it has been seen. But if the fishing boat moves erratically it compounds the problem, especially if its navigations lights cannot be distinguished because of the intense glare from its working lights, which in themselves are frequently blinding to the people on the ship's bridge.

Low visibility

Small vessels, under about 30 m (100 ft) long, can be extremely difficult to see from a large ship's bridge, particularly if there is any sea running, because they are hidden against a background of white water. Also, many boats have a lot of white paint or other low-visibility paint that makes them merge into the background, so they are not always seen at a range of five miles. In rough weather the radar echo of a fishing vessel is frequently undetectable due to the 'clutter' or sea return on the screen, so it is quite possible for the ship not to be aware of the fishing vessel's existence.

Problems with lights

A number of close encounters have occurred at night in clear weather because of a fishing vessel's working deck lights.

POTENTIALLY HAZARDOUS WATERS

Chart	Locality
AUS 832	The area around the Howick Group
AUS 833	The area between C. Melville and Pipon Is. The area between Eden Reef and Taiwan Shoal The area east of Burkitt and Hannah Islands to Iris and Magpie Reefs and on either side of Iris Reef Buoy.
AUS 834	The area between Hay and Fife Islands The area between either side of Heath, Bow and Waterwich Reefs The area between Eel Reef and Kemp Rock
AUS 835	The area between Piper Is. and Inset Reef The area around Home Islands (Clerke Island)
AUS 839	The area between Wyborn Reef and Edborac Is. (The Adolphus Channel) The area from west of Sue Reef to east of Bet Reef (Vigilant Channel)
AUG 293	The area from Herald Patches to Harrison Rock (Prince of Wales Channel)
AUS 296	The area between The Buoys of Gannet Passage

* Captain Mort is a Queensland and Torres Strait pilot.

These lights are brilliant, making it impossible for the pilot to distinguish the port and starboard side lights, so that he has no idea in which direction the fishing vessel is heading.

This is a particular problem when the vessel has her gear in and is free running. Many fishing vessels under these circumstances do not switch off their fishing and working lights, and turn on their navigation lights. This is very confusing and is an extremely dangerous practice.

Even if the proper lights are exhibited and the working lights are extinguished, the navigation lights of the trawler are difficult to see because of the height difference between the ship's bridge and the trawler.

Navigation lights are dioptic — that is, the light emanating from them is beamed in a horizontal plane so that little light is projected either up or down — so the pilot of the ship is well above the focal plane of the trawler's lights and the trawler's skipper is well below the focal plane of the ship's lights. This makes seeing each other's lights quite difficult, particularly at close quarters (see Figure 1).

If the trawler has its working lights on then the chances of the pilot seeing its side lights are very much diminished. Also, with these working lights on, the trawler skipper's vision must be limited to the circle of light surrounding him.

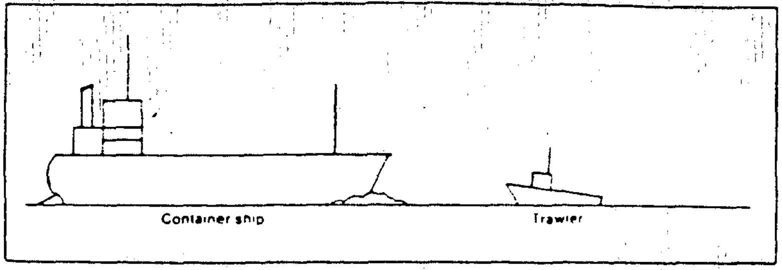

Figure 1: Dioptic light beams are horizontal and each vessel's navigation lights are on a different focal plane. It is very difficult for the vessels to see each other's lights, particularly if they are close.

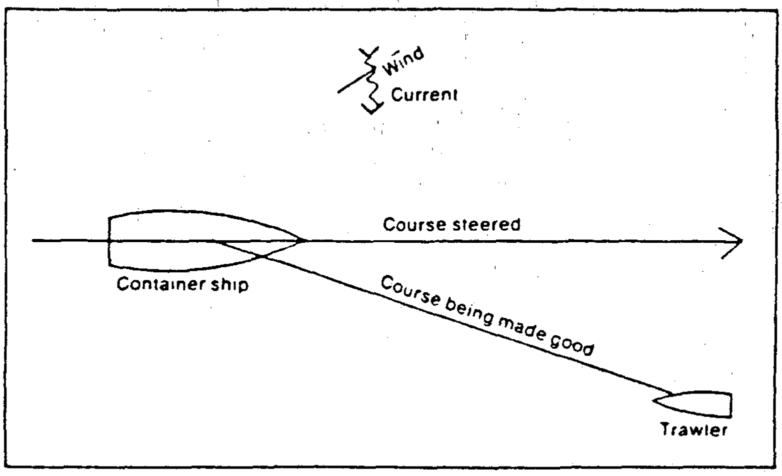

Figure 2: Trawler sees open masts by day and open mast lights and a green side light by night. Normally the trawler would be safe but because of the container ship's leeway it is in the ship's path and could be run down, irrespective of right of way.

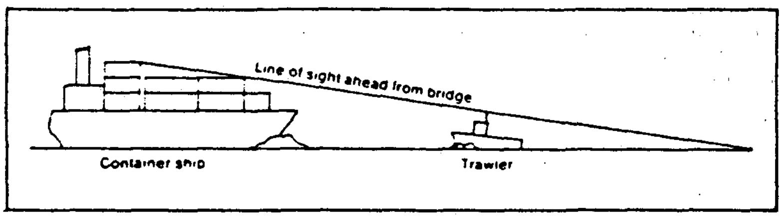

Figure 3: Line of sight ahead from container ship's bridge is restricted by deck cargo. Trawler could be run down, irrespective of right of way, because it might not even be seen.

Lookout

At sea a lookout is required to be kept by all means at the ship's disposal, namely visually, by hearing and by radar. A radar watch alone is not considered a proper lookout, and in any case, unless plotting of an approaching vessel is resorted to, it is extremely dangerous to try to assess a collision potential from watching a radar screen. In fact, radar-assisted collisions can be caused by this practice.

Also, by looking into a radar screen, the operator's night vision is very much impaired, so that even if he does go outside into darkness he would not be able to see properly for some considerable time.

Leeway problems

An average speed for ships passing through the inner route is about 15 knots. However some passenger ships and container ships are considerably faster, reaching more than 20 knots.

Both these types of ships have the problem of leeway due to a moderate draft and large wind-catching surfaces. This is particularly so in strong winds. Due to leeway being made, the course being steered can vary from the course being made good by as much as 10 degrees, so that it would be possible for a trawler to be in the direct line of approach of the ship but think otherwise, because the ship's masts would appear open by day, and by night the mast lights would be open and only one side light would be visible (see Figure 2).

Steering difficulties

Large deep ships frequently do not steer well in shallow water — under 18.3 m (10 fathoms) — but tend to yaw from side to side, in some cases up to 10 degrees from the course being steered.

Also, they take a *long time* to stop, and frequently engineers need considerable notice to manoeuvre engines without damaging them a great deal. They also tend to get out of control in shallow water when the engines are put astern, swinging either to port or starboard in an unpredictable way. Due to their immense weight and consequent inertia it is not possible to stop them by dropping an anchor. In fact anchors and cables on modern large vessels are very delicate pieces of equipment, and are very easily broken or damaged if too much stress is put on them. They are also very expensive.

Restricted vision

On some container ships, deck cargo restricts vision from the bridge. Frequently there is a blind spot extending from the bow of the ship forward for about two miles (see Figure 3). Also, a person standing on one side of the bridge might not be able to see the water on the opposite side of the ship.

When the language difficulties encountered on a foreign-flag ship are added to these limitations, fishermen can appreciate the difficulties pilots *face to avoid* fishing vessels in the confined shallow waters of the inner route of the Great Barrier Reefs.

Recommendations

Fishing vessels would greatly assist pilots by observing the following recommendations.

1. Do not fish in areas designated as 'Deep Draft Routes', particularly in the potentially hazardous waters *listed on page 5*.

2. At night turn off working lights when they are not required, or on the approach of or to a ship, and keep a **very good lookout** at all times.

3. Keep a constant listening watch on VHF channel 16, but do not converse on it; change to another *channel* for conversations.

4. Keep it constantly in mind that the pilot *on an approaching* ship may not have seen you or, if he has, he may not be able to tell what you are doing because he has been blinded by your working lights and is unable to see your side lights.

5. Keep to the letter of the International Regulations for the Prevention of Collisions at Sea, especially the steering and sailing rules and the rules concerning lights. (Rules 7, 8 and 9 are particularly important, as is rule 20b, which states that lights additional to the prescribed lights must **not** be shown if they impair the visibility or distinctive character of the specified lights or interfere with the keeping of a proper lookout. Many trawler lights contravene this rule.)

6. If on passage **do not** display *fishing lights* or have the working lights on. Both practices contravene the regulations and are very dangerous.

7. Remember the limitations of large vessels and the fact that fishing vessels do not have the right to impede the passage of other vessels navigating in narrow channels — (Rule 9c).

8. If you see an approaching ship's mast lights slightly open and see only one side light, do not assume all is well, because the ship may be making a lot of leeway, or yawing a lot in shallow water.

9. Keep a sharp lookout at all times, and especially when fishing near the shipping lanes on the chart. Remember, you can get off them but the ship cannot.

10. Assume the shipping lanes to be one mile wide on either side of the charted track unless otherwise obstructed. One mile is not much from a ship's bridge.

11. The people on the bridge may be 214 m (700 ft) from the bow of the ship and *more* than 30 m (100 ft) above the water. If there is a collision they possibly might not know about it, because in a loaded ship the impact would be absorbed, and any noise would not be heard due to the shielding effect of the bow and the ambient noise on the bridge from engines, radar, fans, etcetera.

12. Ships' lights when close are considerably above the normal line of sight from a trawler, so keep your eyes lifted. And do not forget, it is quite likely that your lights have not *been seen* from the ship's bridge.

13. The bow wave from a large ship when close can affect the steering of a small ship dramatically. The small ship may steer into the side of the large ship even against full helm in the opposite direction. There can also be a suction effect if the vessels are very close.

From the foregoing it might appear that large ships want everything their own way. Such is not the case — we all have a living to make — but they do want a fair go in the narrow channels to which they are restricted. They will give way where possible, as required by the regulations, but so should trawlers, which in any case should not restrict other traffic in these areas.

Ships are extraordinarily expensive. Even a moderate-size tanker costs about $60 million and has to earn about $40 000 a day during its life. This works out at about $1 667 an hour or almost $28 a minute.

Should this earning rate not be achieved, freight rates must rise, causing most other costs to rise, so even from this point of view it is in everybody's interest that these ships are not hampered.

GBRMPA thanks S.W. Mort for permission to reproduce this article.

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ACRONYMS

AIMS	-	Australian Institute of Marine Science
AUSREP	-	Australian Shipping Reports
BTE	-	Bureau of Transport Economics
CERCLA	-	Comprehensive Environmental Rehabilitation Compensation and Liability Act
CHEMTREK	-	Chemical Abstract Condensates
CHRIS	-	Chemical Hazard Response Information System
CNEXO	-	National Centre for Oceanographic Research
CSIRONET	-	Commonwealth Scientific and Industrial Research Organisation Computing Network
DOT	-	Department of Transport
EPA	-	Environment Planning Authority (U.S.)
FMA	-	Fish Management Authority
GBRMPA	-	Great Barrier Reef Marine Park Authority
GBRR	-	Great Barrier Reef Region
HAZMAT	-	Hazardous Material Response Project
JCU	-	James Cook University
MSO	-	Marine Safety Officers
NOAA - CNEXO	-	National Oceanic and Atmospheric Administration
OSC	-	On Site Coordinator
PEMEX	-	Petroleus Mexicanos
QDPI	-	Queensland Department of Primary Industries
QFMRAAC	-	Queens Fellowship and Marine Resources Allocation Advisory Committee
QNPWS	-	Queensland National Parks and Wildlife Service
RRT	-	Regional Response Team
SRI	-	Scientific Research Institute
SSC	-	Scientific Support Co-ordinator
TDB	-	Toxicology Data Base
UKAEA	-	United Kingdom Atomic Energy Authority
US	-	United States
USCG	-	United States Coast Guard
USNS	-	United States Navy Ship
USR	-	United States Reserves