Environmental assessment for the proposed exploration drilling operations offshore the Falkland Islands

ERT 97/061

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This document has been prepared in accordance with ERT Ltd's quality procedures and has been approved and authorised for issue by the following signatory

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Date of issue October, 1997

Contents

Summary

This report presents the findings of an Environmental Impact Assessment (EIA) conducted by Environment and Resource Technology Ltd (ERT) on behalf of Shell Exploration and Production South West Atlantic BY, Amerada Hess (Falkland Islands) Limited, LASMO International Ltd and IPC Falklands Ltd. The EIA applies to an exploratory drilling programme proposed for the northern licence Tranches A, B, C, D and F, offshore the Falkland Islands.

The four operators have addressed the importance of appropriate environmental management from the initiation of exploration activities. This report therefore addresses the potential environmental impacts from the proposed drilling programme and details the procedures that will be in place to minimise and/or avoid the identified impacts.

The operators have contracted the Borgny Dolphin semi-submersible drilling rig which will be mobilised from the North Sea to complete the proposed programme. Drilling is due to commence in May 1998 and continue through the rest of the year and into 1999. The duration of drilling operations at each well site is dependent on the total well depth, but estimated to be between 45 and 90 days. Following the drilling of each well there may be a well testing phase, after which each well will be suspended or abandoned.

The proposed well sites are located over 150 km north of the Falkland Islands, at the edge of the continental shelf. Water depths at the drilling locations range from less than 200 m in the south to 500 m in the north. This area of the continental shelf represents the convergence zone of the east and west Falkland current and is an area of upwelling and high biological productivity, supporting ecologically important populations of krill. Krill are an important food source for the marine life of the area including seabirds and commercial fish and squid resources.

Seabed communities will be influenced by sediment type and water depth. Extrapolation of existing research on the seabed sediments and fauna of the Patagonian shelf suggests that the infauna will be diverse and dominated by polychaete worms. The epifauna is likely to include echinoderms, corals, sponges and crabs. Specific characteristics of the benthic fauna around the drilling locations will be confirmed prior to drilling operations.

The coastal areas of the islands support internationally important breeding populations of many seabird species. In addition, the waters offshore the islands support large numbers of migrant seabirds. However the marine distribution and abundance of both breeding and migrant species is not well studied.

Offshore are dominated by commercial fishing and fishing industry revenue is the mainstay of the Island's economy. Commercially important cephalopod species are the Patagonian (Loligo), short fin and Argentine (Illex) squid. Illex represent the largest resource and is fished for to the north and west of the Islands, including the area of the northern Tranches. March to June represents the main fishing season. Southern blue whiting and hoki are the most important commercial finfish species.

As part of the assessment, the expected discharges and inputs from exploration drilling operations have been described and where possible quantified. Consideration has been given to all aspects of the proposed programme from rig tow to well abandonment. Having identified the potential impacts, consideration is given to the procedures in place to minimise or avoid these impacts.

From routine operations the effects of drill cuttings discharges have the greatest potential for environmental impact. However on the basis of past experience in the use of water based muds for single exploration wells, these effects are not considered to be significant. Other effects from routine operations will have a minor or negligible environmental impact. These include:

- seabed disturbance from rig anchoring operations;
- potential interference to other sea users, including fishing, due to the physical presence of the rig;
  .chemical discharges from cementing and well completion activities;

- atmospheric emissions and potential hydrocarbon fallout to sea from well testing;
- atmospheric emissions from power generation exhausts;
- aqueous discharges from the rig's drainage and sewage systems and rig washing.

Risk analysis has shown that the greatest potential for a spill would be a diesel spill or leak of less than 1 tonne. Following such a spill it is unlikely that there would be any measurable impacts upon the environment.

The greatest, but highly unlikely environmental threat would result from a large oil spill, for example from a well blowout. Analysis of historical blowout data anti oil spill modelling results has shown that there is a low probability (6.75 x 10:f per well year) of oil reaching the north coast of the Falkland Islands from the northern Tranches. As the risk of an oil spill beaching is very low it is therefore the offshore marine resources that can be considered to be at greatest risk from an oil spill. Offshore flightless birds e.g. penguins will be vulnerable to surface pollution. There may also be limited mortality to krill populations in the immediate vicinity of a spill location.

In light of the low level of impacts predicted from routine operations, and the management and control measures that will be in place, it is considered that the drilling programme proposed by the operators will not have any significant environmental impacts. However in the unlikely event of a large accidental oil spill the potential exists for significant impact to offshore resources.

Section 1

Introduction

1 Introduction

1.1 Background

Following the Falkland Islands first offshore licensing round, four of the operators who were successful in gaining licensed Tranches (see Figure 1.1) have conducted seismic survey and now propose to undertake exploration drilling activities during 1998 and 1999.

- Shell Exploration and Production South West Atlantic BV (SEPSWA) (operator) with Agip South Atlantic BV (partner) (hereafter referred to as Shell).

- Amerada Hess (Falkland Islands) Limited (operator) with Fina Exploration Atlantic BV, Argos Evergreen Ltd, Murphy South Atlantic Oil Company and Teikoku Oil (Falkland Islands) Co Ltd (partners) (hereafter referred to as Amerada Hess).

- LASMO International Ltd (Operator) with Desire Petroleum Ltd and Clyde Euro plc (partners) (hereafter referred to as LASMO).

- IPC Falklands Ltd (operator) with Sands Oil and Gas Ltd (partner) (hereafter referred to as IPC).

From the initiation of exploration activities offshore the Falkland Islands the operators have addressed the importance of appropriate environmental protection. It is recognised internationally that if appropriate procedures are in place the risk of any major environmental impact from exploration drilling operations is low. The purpose of this report is therefore to provide an assessment of the potential environmental effects that may arise from exploration drilling operations. Having identified the potential impacts offshore the Falklands, procedures in place to minimise these impacts are considered. Where appropriate, additional mitigation measures have been recommended.

1.2 Environmental policy and management

Each operator is committed to ensure that all operations are carried out with due regard for environmental protection and to meet legal requirements and consents (ref Appendix A). All four operators have established corporate environmental policies.

This is achieved through the implementation of company environmental management systems (EMSs). These systems enable environmental issues to be efficiently and systematically managed for continuous improvement. A key element within any EMS is the evaluation of the effects of operations on the environment. Emissions and discharges from the proposed operation are compared to internal requirements and with industry and government standards. Potential environmental impacts on the environment are then evaluated and prioritised action plans developed to reduce environmental effects. Key elements in a typical EMS are illustrated in Figure 1.2.

In addition to the evaluation of environmental effects the EMS's ensure that all contractors comply to company environmental standards. These includes the auditing of facilities and training of contractor personnel on the environmental sensitivities in areas of operation.

Figure 1.1 Location of tranches acquired by Shell, Amerada Hess, LASMO and IPC in the offshore waters of the Falkland Islands (adapted from NERC, 1994)

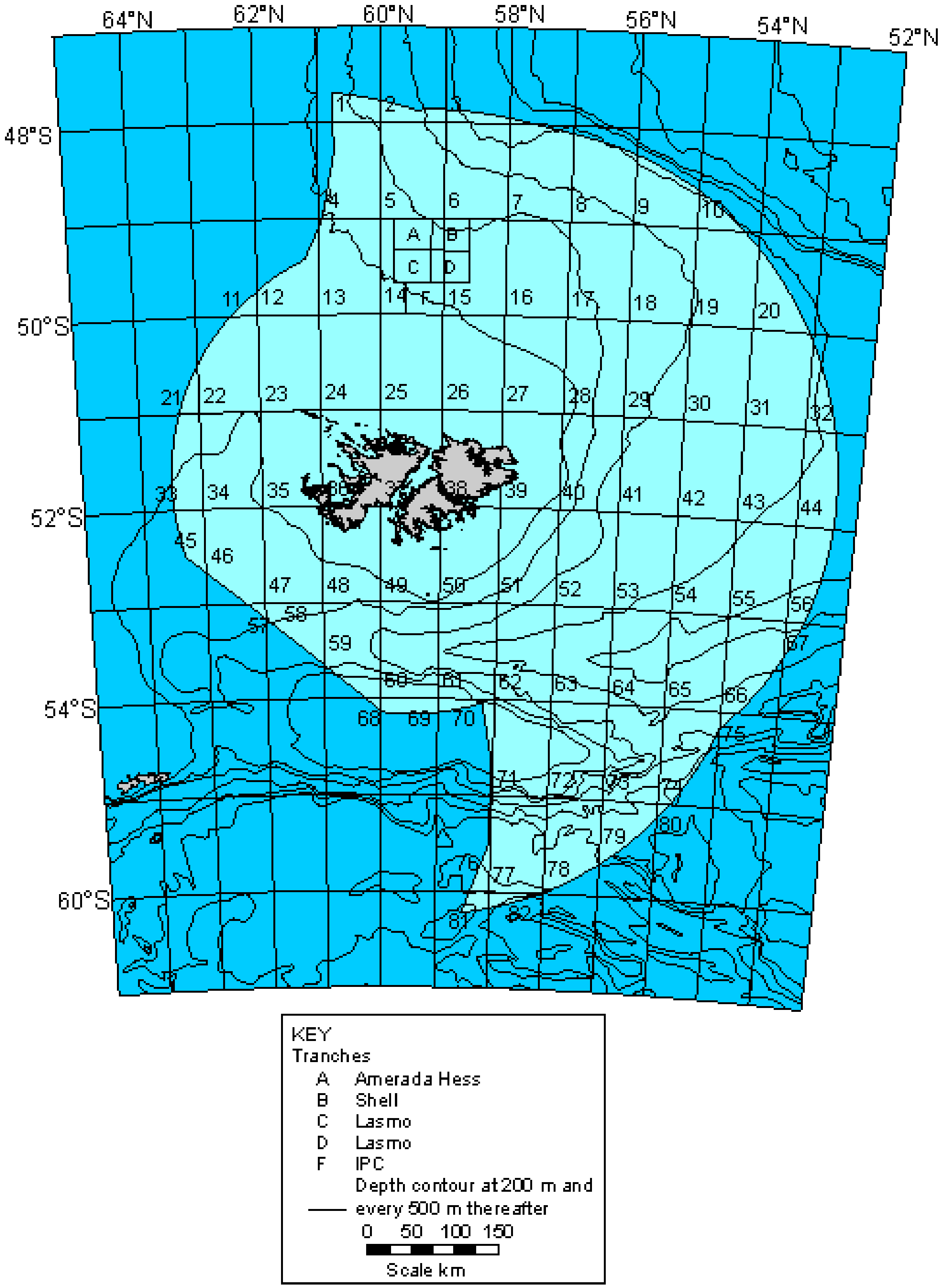
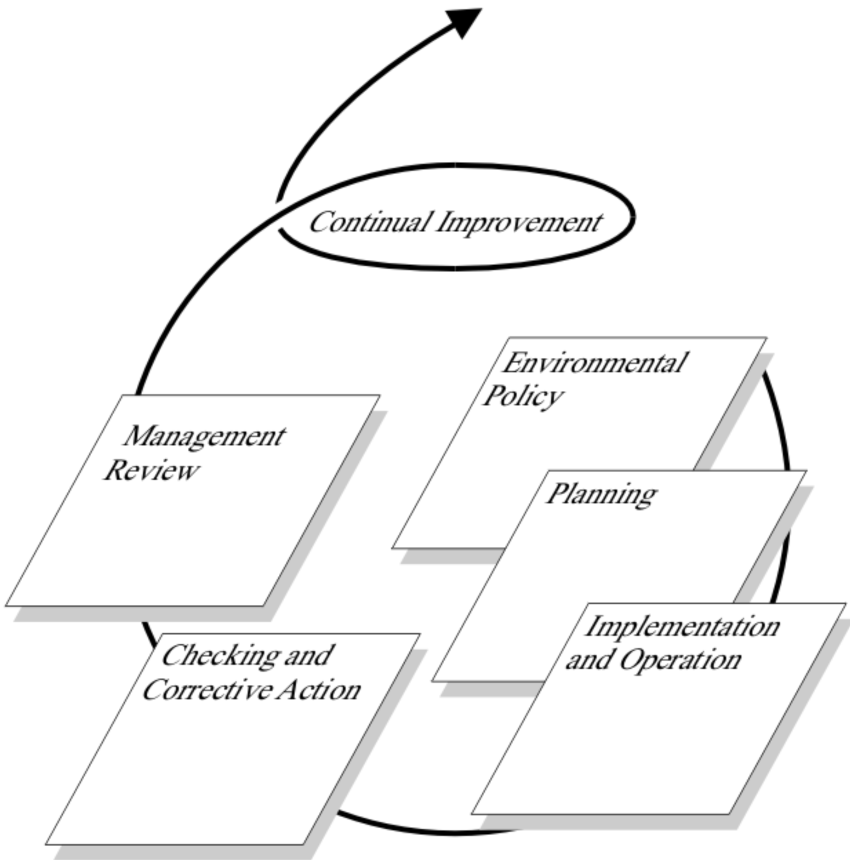


Figure 1.2 Key elements in a typical environmental management system



This approach has been demonstrated in activities offshore the Falkland Islands to date. Prior to licence application operators undertook preliminary studies to ascertain the environmental sensitivities of the licence Tranches and surrounding area. These studies were used to indicate the nature of environmental management planning that would be appropriate. Upon award of licences an Environmental Working Group consisting of the operators who successfully acquired Tranches was established to manage the environmental issues associated with the exploration activities in the northern Tranches. The resultant programme of work has included environmental assessment of seismic operations, this present study to assess the key environmental issues related to exploration drilling operations and oil spill contingency planning. The operators have also committed to undertake studies to increase the environmental understanding of certain aspects of the Falklands environment.

Such studies not only add to the scientific understanding of the offshore area of interest but also enable the planning of future oil and gas industry activities to take into account identified environmental sensitivities. Prior to exploration drilling operations the operators have committed to undertake:

- Metocean survey within the northern Tranches to determine the water current and wave characteristics of the area.
- An offshore baseline sampling survey and sample analysis to characterise the seabed sediments and benthic fauna of the northern Tranche area.

In addition, the Environmental Working Group will audit the drilling rig prior to drilling operations and make the rig crew aware of the environmental sensitivities of the area offshore the Falkland Islands.

In addition to the operator working group, industry together with a number of Falkland Government departments and other organisations has established the Falkland Islands Exploration and Production Environmental Forum. This Forum enables dialogue between the Falkland Islanders and the operating companies including discussion over industry involvement in potential future environmental projects. At present the Forum is considering a survey to establish a better understanding of offshore abundance and distribution of seabirds and cetaceans.

1.3 Proposed drilling programme

The proposed exploration drilling programme will commence in March 1998 when the drilling rig the *Borgny Dolphin* will be mobilised from the North Sea to the Falkland Islands. Drilling will begin in May 1998 and continue throughout the rest of the year and into 1999 until all exploration wells have been completed. At present it is planned to drill five definite wells with the option to drill a further three commitment wells if required.

The *Borgny Dolphin* is a semi-submersible type drilling rig, a floating vessel which is moored by a system of anchors. The wells will be drilled with water based drilling muds. During the drilling of the top hole sections rock cuttings from the well and associated muds will be discharged directly to the seabed. Further well sections will be drilled with a marine riser in place which carries the drill cuttings and mud back to the rig into the solids control system. In this system the cuttings will be separated from the mud. Separated mud is recycled and the 'cleaned' cuttings disposed of overboard. The duration of drilling operations at each well site is dependent on the total well depth but estimated to be between 45 and 90 days.

Once each well has been drilled well testing may then be carried out to assess reservoir characteristics. This is achieved by the controlled flow of reservoir fluids to the rig where they are then burnt in a test flare. If well testing is carried out it is estimated the rig will be on location at each site for an additional 15 days.

In addition to the drill cutting discharges there are a number of other discharges associated with drilling operations including used cement, sewage, wastes, drainage waters and atmospheric emissions from power generators.

A full description of the proposed drilling operations is presented in Section 2 of this report.

1.4 Key environmental characteristics

In order that the environmental impacts from offshore exploration activities can be adequately addressed it is important to have an understanding of the environment within which these operations will take place. An extensive data base of existing environmental information for offshore the Falkland Islands has been developed from pre-licence application through to the present time. This is presented in Appendix B of this document. In addition to summarising the data presently available, it identifies the key gaps in the existing information that may need to be addressed as operations progress.

The key environmental characteristics are described below.

The harsh physical environment offshore the Falkland Islands experiences predominantly westerly winds, the distribution of which are relatively constant throughout the year. Rapid frontal movements in this area of the south Atlantic can bring about rapid changes in weather conditions.

The northern licence Tranches are located on the edge of the Falkland Islands continental shelf in water depths which range from 150 m in the south to over 500 m in the northeast. Although no specific seabed sampling has been undertaken within the licence Tranches, extrapolation of existing research suggests seabed sediments may be characterised by fine and medium sands (ref Appendix B; Section B3). The exact nature of the seabed sediments will be confirmed prior to exploration drilling operations by a baseline seabed sampling survey in January-February 1998.

This area of the continental shelf represents the convergence zone of the east and west Falklands currents. The general water flow is south to north. Tidal currents are generally negligible in water depths exceeding 200 m (ref Appendix B; Section 84). The ongoing metocean survey will provide a more detailed understanding of the oceanographic conditions of the area once results are available. Although sea ice is not usually encountered off the north coast of the Falkland Islands there is a small potential for icebergs from the Antarctic to be carried into the area.

The northern Tranches lie in the vicinity of an area of upwelling and high biological productivity, and support ecologically important populations of krill. Krill constitute a key food source for cetaceans, seals and penguins in addition to seabirds and commercial fish species and squid. For this reason the waters around the Falkland Islands are the most important ocean feeding ground for marine life between the south American mainland and the islands (ref Appendix B; Section B5).

No quantitative data on benthic populations in the northern licence Tranches are available, however an indication of the likely species present can be given from the extrapolation of existing research (see Appendix D). The infauna is believed to be diverse and dominated numerically by polychaete worms, but is also likely to include significant populations of molluscs and crustaceans. The epifauna is likely to include echinoderms, bryozoans, corals, sponges and crabs. Community composition and structure at individual locations will be influenced by sediment type and water depth (ref Appendix B; Section B5). The specific characteristics of the benthic fauna of the northern Tranches will be confirmed prior to exploration drilling operations by analysis of the samples collected during the baseline seabed sampling survey.

The Falkland Islands support internationally important breeding populations of many seabird species. A high percentage of these are associated with the marine environment. Land based surveys of breeding populations have allowed an understanding of the important breeding habitats and species. The islands represent the most important site in the world for Rockhopper penguins, support over 80% of the world's population of Black-browed albatross and approximately 25% and 35% of the world population of gentoo and Magellanic penguins respectively. The Falklands are also regarded as the main global site for the 3 thin-billed prion and host 16 bird taxa which are endemic to the islands. In addition to breeding populations, the waters offshore the islands support large numbers of migrant seabirds which move north at the start of the winter (ref Appendix B; Sections B5 and B6). However, the marine distribution and abundance of both breeding and migrant species is not well understood.

Twenty three species of cetacean may be found in the waters offshore the Falkland Islands. It may be assumed that most of these species may be present in the study area at some time. Similarly, groups of sea lions and seals may also be encountered in the area during the year (ref Appendix B; Section B5).

Commercially important demersal fish stocks are present in the northern licence Tranches. These include common hake, patagonian hake, hoki, southern blue whiting, Antarctic cod, red cod, kingclip, toothfish, skate and rays. Southern blue whiting and hoki represent the two species of highest catch (23,500 tonnes and 13,750 tonnes respectively during 1996). In addition to finfish species three commercially important cephalopod species, Patagonian *(Loligo)*, short fin and Argentine short finned squid *(lllex)* are also present in this area of high biological activity (ref Appendix B; Section B7).

Fishing industry licence revenue forms the mainstay of the islands' economy *Illex* squid represents the largest fishery resource, which is fished for to the north and northwest of the Islands. Almost 80,000 tonnes were caught during 1996. March to June is the main fishing season for *Illex* which is fished for by Polish, Japanese, Taiwan and Korean jigging vessels. The northern licence Tranches lie at the edge of the continental shelf within the main *lllex* fishing area. *Loligo* is fished for by trawlers from Poland, Spain, the UK and other EC countries to the east and south of the Islands. 61,000 tonnes of this species was caught during 1996, although northern licence Tranches are therefore not an important area for this fishery (ref Appendix B; Section B7).

In addition to fishing activity there are limited other sea users present offshore the north coast of the Falkland Islands. Merchant shipping levels in the northern Tranches are expected to be low. A number of wrecks lie in the vicinity of the Tranches and in view of the past military activity in the Falkland Islands it is possible that unrecorded, unexploded ordinances may be present in offshore waters (ref Appendix B; Section B7).

1.5 Consultation

Experience has shown that communications are one of, if not the most important factor in relations between the oil and gas industry and the authorities and local communities.

In order to ensure that this report appropriately addressed any local concerns with regard to the potential effects from exploration drilling, discussions have been held with the following organisations during the course of this study:

- Fisheries Department, Falkland Islands Government;
- Falklands Conservation;
- Falklands Environmental Task Group (FENTAG);
- Department of Oil, Falkland Islands Government;

Falkland Islands Exploration and Production Environmental Forum.

Section 2

Proposed drilling operations

2 Proposed drilling operations

2.1 Introduction

Seismic surveys of Tranches A, B, C, D, and F were undertaken by Shell, LASMO, Amerada Hess and IPC between December 1996 and May 1997. As a result of these surveys, it is now proposed to drill exploration wells to assess the commercial viability of any hydrocarbon reserves present. An exploration well, in addition to confirming the presence of oil or gas in a structure, will also provide additional information on which to base any further exploration and future field development plans.

The four operators plan to drill five definite wells with the option to drill a further three commitment wells if required. This Section of the report describes operations proposed for the undertaking of the exploration drilling programme.

2.2 Proposed operations

All four operators will utilise the same rig for their proposed drilling operations offshore the Falkland Islands. At present the rig is on contract in the North Sea from where it will be mobilised in March 1998. From the North Sea it will be towed to Falkland Islands to commence drilling operations. The rig will be contracted to drill five wells between May 1998 and July 1999, as indicated in the preliminary schedule detailed in Table 2.1.

Table 2.1 Preliminary schedule for drilling operations offshore Falklands

OPERATION	START DATE	DURATION
Rig on contract (estimate)	February 1998	
Mobilise rig North Sea to Falkland Islands •	-	60 days
Amerada Hess drill 3,000 m well*	-	45 days †
LASMO drill 3,000 m well*	-	45 days †
Shell drill 4,500 m well*	-	90 days †
IPC drill 3,000 m well*	-	45 days †
Amerada Hess drill 3,000 m well*	-	45 days †
Demobilise rig	July 1999	60 days

• assuming a ' wet' tow

* Includes anchor handling

† timing for dryhole only. If well completion and testing is undertaken, an additional 15 days would be expected.

If LASMO, Shell and IPC drill additional commitment wells during the same drilling campaign then the overall programme could be extended by a further 3 x 45 days, with demobilisation being delayed.

2.2.1 Rig selection

The *Borgny Dolphin* has been selected by the operators as the drilling rig for the proposed drilling programme. The rig is a modified Aker H-3 rig design and is a semi-submersible type drilling rig. Semi-submersibles are used in deep water drilling as they are a floating unit which are kept in place by a system of anchors rather than having to be placed on the seabed. The *Borgny Dolphin* has a rectangular working deck with a series of vertical circular-sectioned columns fitted beneath the deck at each side, terminating in underwater pontoon hulls containing large tanks for ballast, fuel and freshwater. The columns and pontoons provide buoyancy to the drill rig, and in addition some of the tanks in them are ballasted in order to submerge the drilling vessel to a sufficient depth to maximise stability and minimise movement from wave action, thereby providing a stable work platform for undertaking drilling operations. In addition to stability, the columns also provide deck strength and support (see Figure 2.1 and Plate 1). The adaptability and stability control of semi-submersible drilling rigs make them ideal for drilling in deep water conditions such as offshore Falklands.

Figure 2.1 *Borgny Dolphin* – Starboard Elevation of drill rig

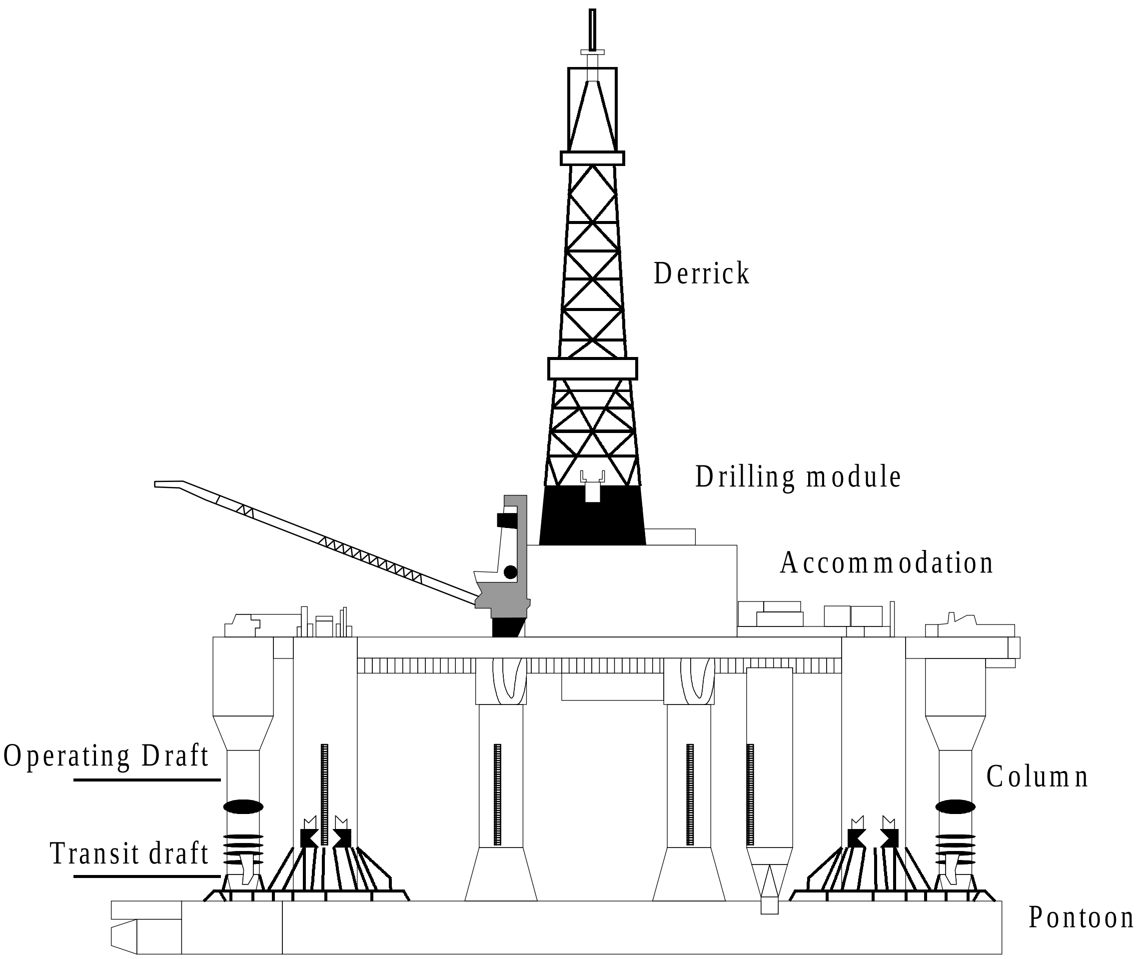


Plate 1 *Borgny Dolphin* **– semisubmersible drilling rig**

Drilling rig specifications are given below:

Name: *Borgny Dolphin*	
Owner:	K/S Borgny Dolphin a/s
Operator	Dolphin Drilling Ltd
Dimensions:	
Overall length:	108.20 m
Overall width:	67.36 m
Height of main deck above keel:	36.58 m
Towing draft:	6.71 m
Operating draft:	21.34 m
Operating parameters:	
Maximum operating water depth:	457 metres
Minimum operating water depth:	61 metres
Fuel consumption:	
Transit:	14 tonnes/day
Operating:	10 tonnes/day
Power supply:	4 diesel generators, 1500 kw -6000 kw each
Storage capacities:	
Fuel oil:	2,300 m^3
Drilling water:	2,295 m^3
Fresh (potable) water:	495 m^3
Liquid mud:	3,000 m^3
Piperack storage:	900 t
Sack material:	600 x 100 lb.
Bulk mud and cement:	1,837 cu ft
Ballast (seawater):	240 m^3
Mooring system:	12 x 30,000 lb. anchors 4,5000 ft continuous length chain maximum chain storage capacity 5,400 ft
Windlass units:	4 x double windlass units with stalling pull of 250 tons each 4 x single windlass units with stalling pull of 250 tons each
Accommodation:	Total number of beds onboard: 104
Propulsion:	2 x steerable kort nozzles rudders Electric DC motors. Total power 3,400 BHP

2.2.2 Tow out and anchoring

As described above, drilling will be undertaken using a semi-submersible drilling rig. The *Borgny Dolphin* will be towed from the North Sea to the Falkland Islands before commencement of the drilling programme.

At the time of writing this report no final decision has been made to whether the rig will be towed ' wet' or ' dry' from the North Sea to the Falklands. In the event the rig is ' wet' towed it will be ballasted to a certain depth and towed by a single vessel through the water. A dry tow would involve the rig being transported on a barge. A dry tow would reduce the travel time between the North Sea and Falkland Islands. Provision will also be made at various stages along the route for areas where the rig can moor/anchor in the event of unsuitable weather conditions. It is not planned the rig will visit the Falkland Islands, unless seeking sheltered waters should it become damaged and seek repairs.

The final approach to the location will be made under tow with assistance from the rigs own propulsion systems. The aftermost anchor on the weather side will be the first to be deployed and is dropped by the rig as it passes from windward over the anchor' s seabed position. Following this the towing vessel and the dropped weatherside anchor will keep the rig more or less on location while fine positioning adjustments and anchoring preparations are made. Anchor chain arrangements used will depend on the strength of prevailing tides and currents and presence of any pipelines or other moorings. All twelve of the rigs anchors will be required to keep it in position. Additional piggy-back anchors will be employed if required. This will be dependent on the seabed anchor holding capacity. Two vessels will be required to position the rig and its anchors. A third vessel will also be present to assist if required. The laying of anchors and rig positioning at each location is likely to take approximately two days.

When all anchors have been deployed in their correct position, the rig will be ballasted down and the anchors bedded in firmly by tensioning up each chain, the chains are then slackened off to a working pre- tension suitable for the water depth.

Once the rig is anchored and ballasted, final preparations prior to drilling will be carried out. This will include the loading of supplies from the supply vessel.

2.2.3 Drilling operations

LASMO, IPC and Amerada Hess propose to drill wells to 3,000 m (9,800 ft) in each of their Tranches, with Shell drilling a well to 4,500 m (14,700 ft). Each of the five planned wells will be drilled using a similar process. Drilling bits of different sizes are used to drill a series of concentric holes from the seabed to the planned well total depth. A drilling fluid (drilling mud) is circulated through the inside of the drill string to the bit to impart hydraulic force which assists in the cutting action of the bit, cooling of the bit and lifting of the cut rock from the well. The drilling fluid is prepared by mixing mud additives and chemicals on site to the desired concentrations in fresh or sea water, such that the required physical properties of the mud result.

Figure 2.2 illustrates the proposed drilling programme for a typical 3,000 m (9,800 ft) well. Table 2.2 details a representative schedule for drilling operations for a typical 3,000 m (9,800 ft) well.

Figure 2.2 Schematic diagram for running order of typical drilling operations (not to scale)

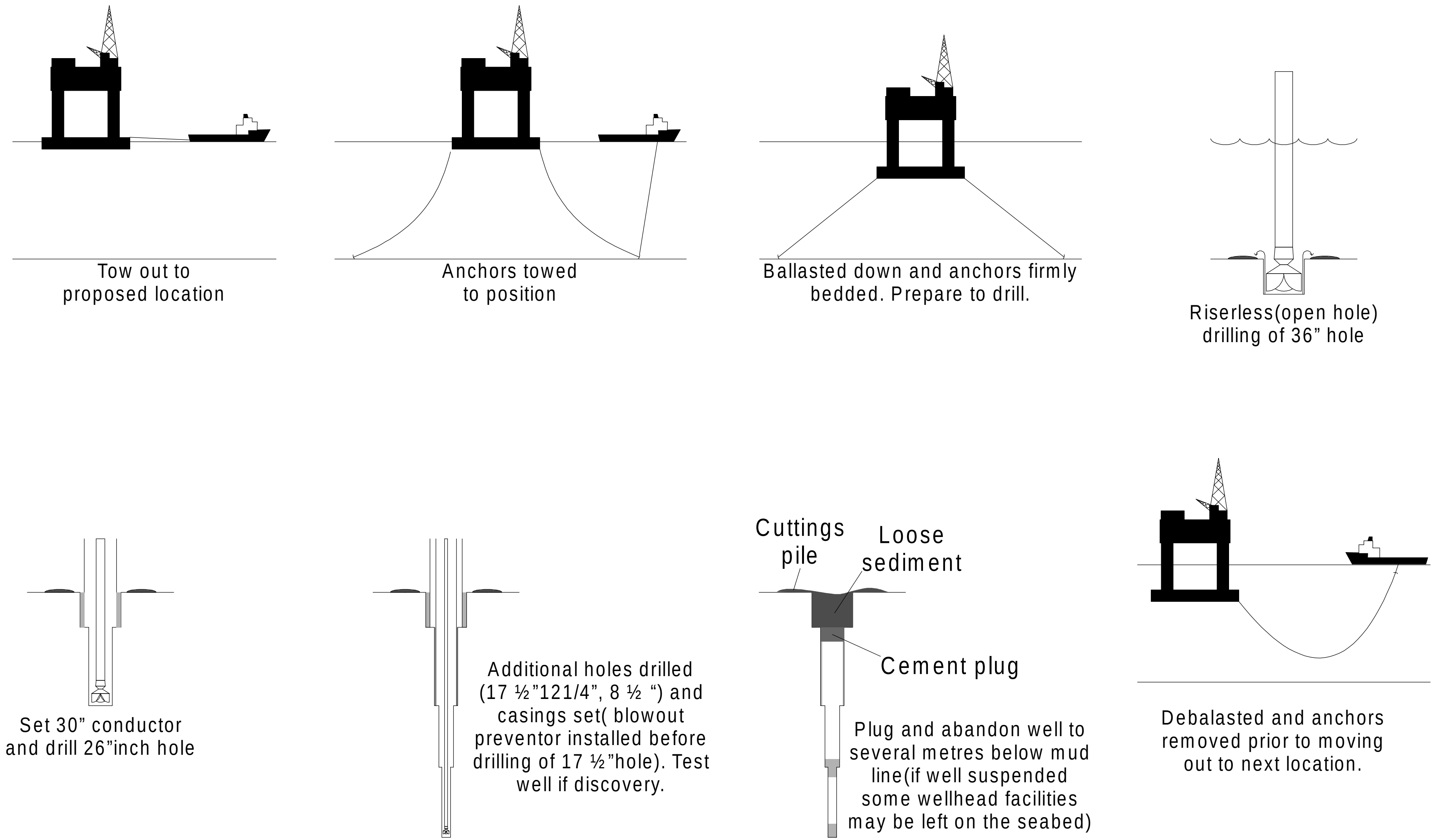


Table 2.2 Representative schedule for drilling operations for a typical 3,000 m well

	Time (days)	Cumulative time (days)
Mob/tow on location. Prepare for drilling. Run anchors.	3.0	3.0
Drill 36" hole from 1,410 ft to 1,575 ft.	1.0	4.0
Run and cement 30" conductor.	2.0	6.0
Drill 26" hole 1,575 ft to 3,010 ft.	2.0	8.0
Run and cement 20" casing. Run and test BOPs.	4.0	12.0
Drill 17½" hole from 3,010 ft to 4,740 ft.	1.5	13.5
Log. Run and cement 133/8" casing.	2.5	16.0
Drill 12¼" hole from 4,740 ft to 6,825 ft.	3.0	19.0
Log. Run and cement $9^5/_8$" casing.	4.0	23.0
Drill 8½" hole from 6,825 ft to 6,990 ft.	1.0	24.0
Core 8½" hole from 6,990 ft to 7,170 ft (2 x 90 ft)	3.0	27.0
Drill 8½" hole from 7,170 ft to 9,940 ft (TO)*	7.0	34.0
Log.	3.0	37.0
P&A.	3.0	40.0
Pull anchors. Prepare for rig move. Tow off location/ demob	2.0	42.0
Total Hole		42.0 days

* For Shell' s deeper well, assume a total of 90 days for drilling programme (dry hole).

Drilling at each location will begin as soon as possible after anchoring operations are complete. The well will be spudded (started) using a 36" diameter bit. This will be lowered to the seabed using a guide frame that has been run down on a previously positioned guidebase. A relatively short section of hole will be drilled with the hole opener. This section will be drilled using seawater as the circulation fluid rather than mud which is used on deeper well sections. The water will contain occasional chemical sweeps to clean the hole, the frequency of which will depend on well characteristics. Seawater will be pumped down the drill string to the bit from where it will enter the well. It will gradually be forced up the well section and into the water column. Drill cuttings generated by this section of the well will be passed directly to the seabed at the wellhead where they will accumulate.

Further well sections will be drilled with a riser in place using a low toxicity, water based drilling mud. The operators will operate in accordance with the UK Offshore Chemical Notification Scheme (OCNS). The OCNS groups substances and preparations according to their environmental effects and provides operators and sub-contractors with guidance to the chemicals and components preferred on environmental grounds, thereby enabling them to take this into account when selecting mud and chemical products for use offshore. The scheme aims to control and monitor the use of chemicals by the offshore industry. This will inform the Falkland Islands Government of the substances likely to be used and the potential scale of use, in compliance with FIG licence conditions, and provide for prior consultation between operators and government in the case of proposed large scale use of chemicals, or any chemicals with a high potential for damage to the marine environment.

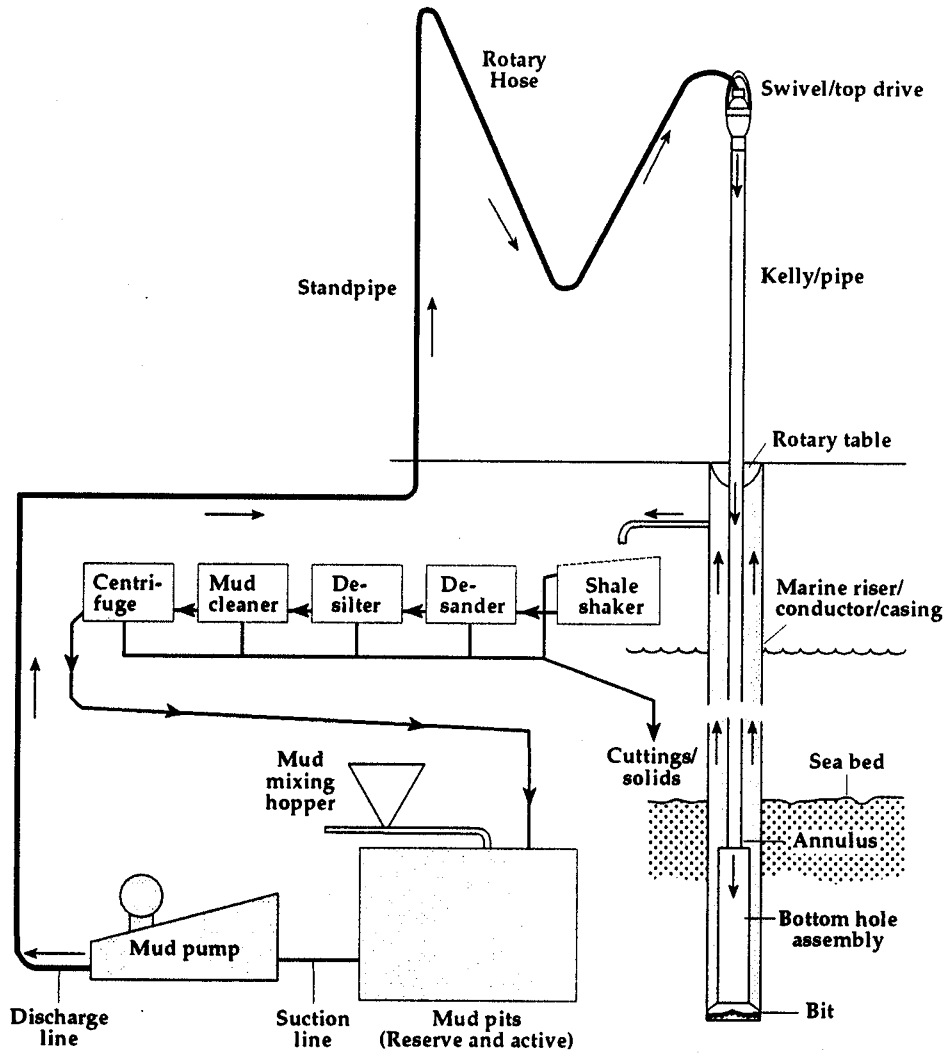
Under the OCNS, substances and preparations for use by the offshore industry are classified into Groups A to E (A being the most harmful), depending upon biodegradation and bioavailability. The categories enable tonnage triggers to be established for the cumulative quantity of all chemicals used within each group at installations. The triggers are notification limits which restrict the discharge of large amounts of chemicals without consultation between the regulators and operators.

Table 2.3 Annual usage requiring pre-notification for drilling chemicals (including cementing, completion and work- over chemicals) cumulative tonnes (OTI, 1996)

Category/group	Annual usage requiring pre-notification (cumulative tonnes)
4/ A	All proposed usage to be notified
3/B	3
2/C	15
1/D	350
0/E	4,750

The drilling mud is stored in dedicated tanks within the drilling unit before being pumped downhole to aid the drilling process. The drilling mud system is a closed system in that the muds which are pumped down the well are returned to the surface and then reused. A typical drilling fluid circulation system is detailed in Figure 2.3.

Figure 2.3 typical drilling fluid circulation system



Drilling muds perform a variety of functions which are critical to the success of a drilling operation. These functions include:

- maintaining formation pressure so as to prevent formation fluids entering the drill hole;
- creating a downward pressure to prevent the walls of the hole from caving in;
- carriage of drill cuttings to the surface;
- lubricating and cooling the drill bit;
- keeping cuttings in suspension if circulation stops;
- electrical conductivity and resistivity properties assist in obtaining "electric logs".

Drill cuttings and mud will be carried back to the drilling rig and cleaned using shale shakers. Separated mud is recycled and cleaned drill cuttings disposed of overboard. The cuttings cleaning system onboard the *Borgny Dolphin* consists of three Thule VSM shale shakers and one Thule VSM 200 mud cleaner, consisting of hydrocyclones.

When each section of the well has been drilled, steel casing will be run into the hole and cemented into place using a high pressure cementing pump prior to drilling the next section of the well. Setting and cementing casing has the objectives of ensuring pressure control of formations by isolating sections of the well with different pore pressure regimes and preventing the contamination of potential aquifers by hydrocarbons which may occur in other formations. In addition, the uppermost section of casing provides a firm base and anchorage for the blowout preventer (BOP) stacks and for additional smaller strings of smaller diameter casing which will be run into later sections of the hole.

During cementing of the 30" conductor (top well section) there may be some displacement of cement to the seabed adjacent to the well.

2.2.4 Well testing

If the results of logging indicate a potential for hydrocarbon bearing formations the well may be tested. This is achieved by the controlled flow of well fluids to the surface in order to establish information on the reservoir properties.

A production liner or casing will be set to isolate the formation. The specialist well testing equipment required consists of a testing string of production tubing, packers to seal off the production zones, downhole valves that can be remotely operated from the surface and downhole pressure gauges. On the surface, a test separator measures and separates produced solids, oil, gas and water. When the fluids are flowing to the surface, pressure, temperature and flowrate measurements will be taken to confirm the reservoir' s performance characteristics.

The produced fluids from the well test will be ignited at the end of the flare bloom. This flaring may be initiated using diesel or similar fuel to start the flare and to ensure combustion is as efficient as possible throughout the test.

Should well testing take place it is estimated that the total testing period would be 15 days per well. During this period it is likely that the burning of hydrocarbons would occur for a maximum of a few days per well.

2.2.5 Well abandonment

On completion of drilling activities the wells will be suspended or abandoned. The procedures will follow industry wide practices and procedures to prevent the contamination of potential aquifers by hydrocarbons and to prevent the flow of hydrocarbons to the surface, by plugging the well bore and physically isolating zones known to contain moveable hydrocarbons.

If the well is suspended retrievable bridge plugs will be set to seal the well as an additional barrier against the well blowing out. A corrosion cap may be set over the wellhead.

If the well is to be abandoned, cement plugs will be set to seal off the well as required. The casing will be cut several metres below the wellhead and guidebases can be recovered, leaving the seabed clear of any obstructions.

2.2.6 Rig move off site

Once the well is secured the rig is ready to move off location to the next well site. This will essentially be a reverse of the installation process. Firstly the rig is deballasted, then each of the anchors will be retrieved and the rig towed to the next location.

2.3 Rig utilities

2.3.1 Power generation

Power onboard *Borgny Dolphin* is provided by a total of four 2,500 BHP diesel generators each capable of developing 1,500 -6,000 kw. Each of these generators consume 217 gm of fuel per kw hour. There is also a 1,000 BHP emergency generator onboard the rig. This generator consumes 216 gm of fuel per kw hour.

2.3.2 Rig drainage

Drainage discharges from onboard the rig may occur from a variety of sources, including:

- clean area floor drains;
- deluge drains;
- drill floor drainage;
- bilge water; machine area floors drainage;
- bunded areas between fuel or chemical storage areas;
- overflow drains in diesel fuel tank systems.

These discharges are handled by a number of systems, as described below.

Clean water drainage

Drainage from this system is designed to handle water run-off from those areas which will not be contaminated by oils or chemicals i.e. clean areas. This will include rain, seawater and deck washings. Drains from these areas will discharge either directly overboard or via a common collection point.

Bilge and oily water drainage

Both bilge water and drainage from machine area floors are likely to be contaminated with hydrocarbons and/or chemicals. Waters from these areas are therefore separated from clean water drainage and are routed to the oily water treatment system.

Overboard discharge from the oily water treatment system is monitored by an oil-in-water monitor. The overboard pump will automatically shut down if the concentration of oil in discharged water exceeds 15 parts per million (15 ppm) oil in water. Oily residues will be retained onboard for disposal at appropriate waste reception facilities

Contaminated drainage

This system deals with discharges that have arisen as a direct result of drilling and will include the drill floor and solids control areas. These drains onboard the *Borgny Dolphin* are collected into a collection tank and routed through the shale shakers.

2.4 Rig servicing

The drilling rig operations will be serviced from a temporary supply base which will be established for the duration of the drilling programme. At the time of completing this report the final location for the supply base is not yet decided. Whatever the chosen location the operators will keep any socio-economic impacts to a minimum. The supply base will be the location through which bulk materials and other equipment/supplies required onboard the rig will be transported. It is anticipated two or three vessels in total will provide support to the rig during drilling operations, depending on the supply base location.

The Falkland Islands will act as a transit point for the drill rig crew. Crew changes to and from the rig will take place using a dedicated helicopter, connecting directly with flights from the islands. Helicopter flights to the rig should be no greater than 4-5 per week.

Section 3

Potential environmental impact from exploration drilling operations

3 Potential environmental impacts from exploration drilling activities

3.1 Introduction

Offshore exploration drilling activities are known to lead to a number of environmental interactions (see Figure 3.1). As with most industrial activities, drilling operations can involve discharges, general disturbance and the risk of accidental releases (see Figure 3.1). This Section of the report discusses the potential environmental impacts of the proposed drilling programme anti is based on international experience of offshore exploration drilling operations.

In undertaking this environmental assessment for the proposed exploration drilling operations offshore the Falkland Islands all potential sources of risk to the environment were first identified (Figure 3.2). Each source of risk identified was described and its potential environmental impact considered in brief (Table 3.1). At the same time consideration was given to how such sources of risk might be managed to minimise or mitigate potential impacts. Having identified management and mitigation measures to minimise/avoid impacts a judgement of the remaining risk of potential impact is given (i.e. residual impact). This has been classified as negligible, minor, moderate or major as defined below:

Negligible: effects which are unlikely to be noticed or measurable against background activities.

Minor: change which is within scope of existing variability but can be measured and/or noticed.

Moderate: change in ecosystem or activity in a localised area for a short time, with good recovery potential. Similar scale of effect to existing variability but may have cumulative implications.

Major: change in ecosystem or activity over a wide area leading to medium term damage (+2 years) but with a likelihood of recovery within 10 years.

Figure 3.1 Potential environmental effects form exploration drilling operations (not to scale)

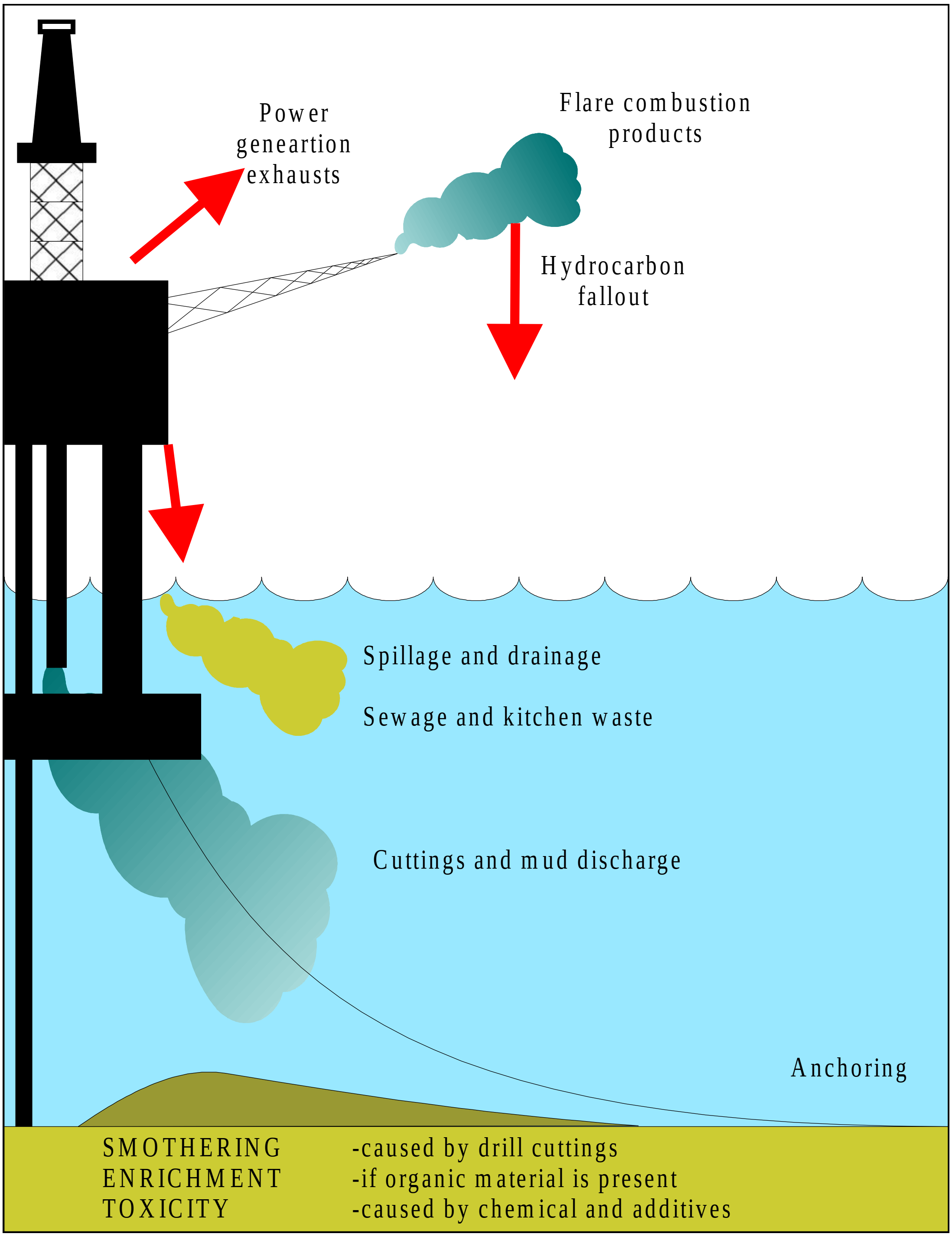


Figure 3.2 Identification of key environmental issues

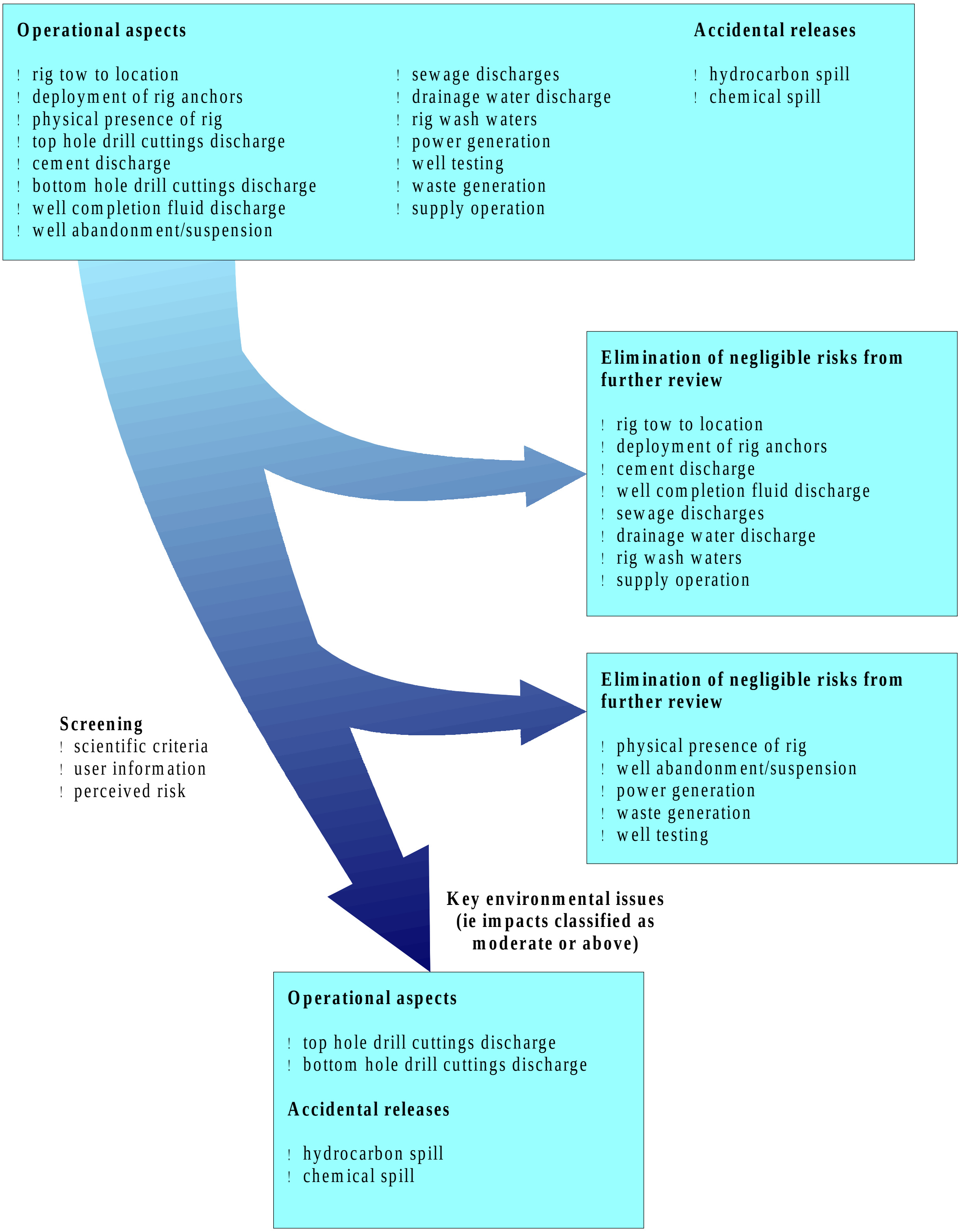


Table 3.1 Assessment of potential environmental impacts and management (control/mitigation) measures for exploration drilling offshore the Falkland Islands

OPERATIONAL ENVIRONMENTAL HAZARDS .				
Source of environmental risk	**Potential environmental impact**	**Environmental consequences offshore the Falkland Islands**	**Management of environmental impacts**	**Residual impact**
Rig tow to well location	Potential interference with other sea users.	Negligible impact in terms of total shipping movements world-wide.	Early consultation will be entered into with all relevant authorities, with respect to the transport and positioning of the rig. Notification to relevant authorities will be undertaken prior to rig mobilisation, detailing routing and scheduling plans.	Negligible
Deployment of rig	Seabed disturbance, both direct disturbance along anchor drag corridor and indirect disturbance from suspended particles in the water column.	Direct disturbance restricted to narrow corridor occupied by the chains and area of seabed over which anchors are dragged. In total 18,000 m^3 of seabed likely to be disturbed during anchor deployment at well site, over a few days duration. This area of seabed disturbance is minor in terms of overall seabed area offshore the Falkland Islands and in comparison to disturbance from fish trawling activities. Indirect disturbance may also be experienced in the form of resettlement of suspended seabed sediments. This will occur along the main water current axis. Experience shows that loadings would be comparable to natural sediment suspension levels.	No further management required.	Negligible

OPERATIONAL ENVIRONMENTAL HAZARDS .				
Source of environmental risk	**Potential environmental impact**	**Environmental consequences offshore the Falkland Islands**	**Management of environmental impacts**	**Residual Impact**
Physical presence of the rig	Potential interference with other sea users.	Rig and 500 m exclusion zone occupy an area of seabed of 0.8 km^2 from which fishing and other vessel activity would be prohibited. This occupied area is only small in comparison with the overall area offshore the Falkland Islands and the rig will only be on location for a limited period of time. Tranches A, C and F lie within the main fishing area for *Illex* squid. The fishing season extends from March to June (ref Appendix B; Section B7). Merchant vessel movements through the northern Tranches are believed to be *low* (ref Appendix B; Section B7). Such vessels will avoid the rig and its exclusion zone in an offshore area.	Consultation with the Falkland Islands Government Fisheries Department has been conducted as part of this study. Regular contact will be maintained with fishing vessels present in the area via the Falkland Island Government Fisheries Department.	Minor
Top hole drill cuttings discharge*(detailed description of impact in section 2.2)*	Localised smothering of the seabed in the immediate vicinity of the well.	Rock cuttings will be discharged directly to the seabed during top hole drilling when no riser is in place. Water current measurements in the area of the licence Tranches suggest that the currents at the seabed will be less than 0.15 m/s (ref Appendix B; Section B4), therefore it is unlikely that the estimated 180 m^3 of discharged cuttings (based on a 3,000 m well) (ref Section 3.2.1) will be dispersed outwith the immediate vicinity of the well location. Smothering of seabed fauna will therefore be localised around the well. The exact nature of the seabed at the proposed well locations is not known at the present	Water based drilling fluid will be used to drill the top hole sections. Operators will have chemical management procedures in place to ensure that the drilling fluids will be of low toxicity and good biodegradability. Only chemicals approved under the UK Offshore Chemical Notification Scheme (OCNS) (this is implemented in the Falkland Island offshore waters) will be used and/ or discharged offshore.	Moderate

OPERATIONAL ENVIRONMENTAL HAZARDS .				
Source of environmental risk	**Potential environmental impact**	**Environmental consequences offshore the Falkland Islands**	**Management of environmental impacts**	**Residual Impact**
Top hole drill cuttings discharge continued		time, but a baseline environmental survey will be completed prior to the commencement of drilling operations.		
Used cement discharge	Minimal amounts of used cementing chemicals will escape to the seabed in the immediate vicinity of the wellhead.	The minimal amounts of cementing chemicals discharged at the wellhead will accumulate within the cuttings pile.	Operators' will have chemical management procedures in place to ensure the use of low toxicity products. Only chemical approved under the UK OCNS will be used and/or discharged offshore.	Negligible
Bottom hole drill cuttings discharge *(detailed description of impact in section 2.2)*	Discharged cuttings and mud have the potential to: • cause turbidity within the water column; • physically smother the seabed/infauna; • cause organic enrichment; • cause chemical effects	In offshore waters throughout the world drill cuttings and spent water based muds are discharged directly to the sea. The control issued through the UK OCNS on the composition of water based muds ensures that chemical additives do not have a high intrinsic toxicity. It is estimated that approximately 160 m^3 of rock will be discharged through the caisson from a 3,000 m well (ref Section 3.2.1).	Operators will have chemical management procedures in place to ensure that the drilling mud will be of low toxicity and good biodegradability. Diesel will not be used in any muds. Only chemicals approved under the UK OCNS will be used and/or discharged offshore. Oils will only be used in extreme conditions, for example stuck pipe, situations for safety and technical reasons. The solids control system onboard the *Borgny Dolphin* will separate mud for reuse from the drill cuttings returned to the rig from the well. Drill cuttings will be discharged several metres below mean sea level to ensure the efficient dispersion of cuttings and avoid discharge into the zone of greatest biological productivity (i.e. surface waters). This will also ensure effective	Moderate

OPERATIONAL ENVIRONMENTAL HAZARDS .				
Source of environmental risk	**Potential environmental impact**	**Environmental consequences offshore the Falkland Islands**	**Management of environmental impacts**	**Residual Impact**
Bottom hole drill cuttings discharge continued			dispersion and biodegradability of the cuttings after release.	
Well completion fluid discharge	Potential limited discharge of corrosion inhibitor, biocide and oxygen scavenger during the treating of downhole brine.	In the offshore waters of the Falkland Islands these minimal chemical discharges will quickly disperse and dilute upon release.	Operators will have chemical management procedures in place to ensure the use of low toxicity products. Only chemicals approved under the UK OCNS will be used and/or discharged offshore	Negligible
Well abandonment/ suspension	Any equipment temporarily remaining above the seabed will be a potential hazard to trawl fishing activities.	Low levels of trawling effort in the area of the northern Tranches throughout the year (ref Appendix B; Section B7) should mean that any charted seabed obstruction can be easily avoided by fishermen.	All wells will be appropriately suspended/ abandoned. The location of suspended/ abandoned well heads will be reported to the relevant authorities for charting, notification etc. Operators will make every effort to locate and remove any debris (resulting from licensed activities) following consultation with appropriate authorities. Should it be necessary to temporarily suspend equipment above the seabed, consultation will be held with appropriate authorities with regard to any drill cuttings discharge continued appropriate protection measures.	Minor

OPERATIONAL ENVIRONMENTAL HAZARDS .				
Source of environmental risk	**Potential environmental impact**	**Environmental consequences offshore the Falkland Islands**	**Management of environmental impacts**	**Residual Impact**
Sewage discharge	Organic enrichment in immediate vicinity of discharge location.	A personnel compliment offshore of 100 people (max) can be expected offshore during the drilling programme. On average one person produces 320 litres of sewage per day (sanitary wastes and grey water) and typically sewage discharges have a BOD (Biological Oxygen Demand) of 240 mg/l (ICIT, 1993). It can therefore be calculated that 32 m^3 of sewage will be generated per day with an estimated BOD of 7.68 kg per day. The surface currents in the vicinity of the discharge location will ensure that no organic enrichment results from the low discharge levels.	No further management required.	Negligible
Drainage water discharge	The only risk of environmental impact is if an operational spill is discharged through drains (see accidental hazards below).	Non oily (clear water) and oily waters are discharged from the rig drainage systems.	The rig drainage system is operated in such a way as to comply with international legislation standards. The rigs water overboard discharge is constantly monitored for 15 ppm oil in water concentration. Discharge is automatically stopped if this level is exceeded.	Negligible
Rig wash water discharge	Minimal chemical contamination to water in immediate vicinity of discharge location.	In offshore waters chemical discharges will quickly dilute and disperse upon release.	Operators will have chemical management procedures in place to ensure the use of low toxicity products. Only chemicals approved under the UK OCNS will be used and/ or discharged offshore.	Negligible

OPERATIONAL ENVIRONMENTAL HAZARDS .				
Source of environmental risk	**Potential environmental impact**	**Environmental consequences offshore the Falkland Islands**	**Management of environmental impacts**	**Residual Impact**
Power generation	Gaseous emissions will contribute to ozone depletion and greenhouse gases.	Negligible environmental impact from single well exploration drilling programmes in comparison to other industrial sources, but atmospheric emissions are of increasing general global concern.	Turbines will be maintained and operated to manufacturers standards.	Minor
Well testing	Gaseous emissions will contribute to ozone depletion and greenhouse gases. Unburned hydrocarbons may fall out from test burner and result in an oily sheen on the sea surface.	Gaseous emissions to atmosphere include CO_2 and NOx, with the potential for $H_2$5 and SO_2 depending on the characteristics of the reservoir. Potential emission levels are low in comparison to other industrial sources, but atmospheric emissions are of increasing general global concern. Hydrocarbon fallout from well testing operations will result in input to the water column and can cause minor sheens in the area of the rig.	The duration of periods when hydrocarbons will be burnt will be limited to the operationally required minimum in order to conserve resources and minimise atmospheric emissions. Operators will consider the use of an alternative ' green burner' test flare to improve the quality o flare emissions and prevent hydrocarbon fallout. Test burners will be started up on supplemental fuel to improve flare emission quality. During the test the amounts of these fuels will be modified according to operating guidelines and the visible performance of the flare. In addition, well testing will only commence during daylight hours.	Minor/ moderate

OPERATIONAL ENVIRONMENTAL HAZARDS .				
Source of environmental risk	**Potential environmental impact**	**Environmental consequences offshore the Falkland Islands**	**Management of environmental impacts**	**Residual Impact**
Waste generation	Organic enrichment from small amounts of food waste discharged offshore. Other wastes, including hazardous materials will not be disposed of offshore.	Maceration of small amounts of food wastes will reduce particle size of waste to a level which will either degrade naturally, or be readily consumed by fish or seabirds. Other wastes including hazardous wastes will not be disposed of offshore, and will be disposed of at appropriate waste disposal sites.	All waste transportation and subsequent disposal will be conducted in line with recommendations presented to the Falklands Government in the ongoing waste disposal and management study. Operators will have waste management procedures in place to ensure that wastes are stored and disposed of appropriately (in line with any of the above recommendations and relevant legislation). All wastes will be secured appropriately offshore to prevent loss overboard. All hazardous wastes will be stored separately from other wastes. The potential for reduction and recycling of waste materials will be considered at all times.	Minor

ACCIDENTAL ENVIRONMENTAL HAZARDS .				
Source of environmental risk	**Potential environmental impact**	**Environmental consequences offshore the Falkland Islands**	**Management of environmental impacts**	**Residual Impact**
Accidental hazards				
Hydrocarbon spill *(detailed description of impact in section 2.2)*	Oiling of offshore bird and animal populations. In the very unlikely event of a blowout there is a very low potential for the oil to beach the north coast of the Falkland Islands.	The largest potential environmental impact from exploration drilling operations is from a large oil spill, however the probability (calculated from historical data) (ref Section 3.2.2) of such an event is very low. The majority of hydrocarbon spills are very small (<1 tonne) and have a minimum impact on the environment. In the unlikely event of a large hydrocarbon spill a number of offshore marine resources may be at risk to oiling. Offshore flightless birds e.g. penguins will be vulnerable to surface pollution. There may also be limited mortality local krill in the immediate vicinity of the oil spill location.	Procedures will be in place to minimise operational leaks and spills: • use of drip pans where necessary beneath machinery and plant; • ensure that all pipework and manifolds are oil tight; • supply of absorbent materials to be kept under areas where there is a potential for leak or spillage. Procedures will be in place to minimise the risk of having a spill during bunkering: • transfer operations will only be carried out during suitable weather conditions i.e. good visibility and low/moderate wind speed and sea state; • bunkering will only be carried out during daylight hours; • good direct communications will be maintained between the rig and ship during transfer; • continuous watches will be maintained during bunkering on the supply vessel and rig; • on site dispersant spraying capability will be maintained on the standby vessel.	Negligible - major

ACCIDENTAL ENVIRONMENTAL HAZARDS .				
Source of environmental risk	**Potential environmental impact**	**Environmental consequences offshore the Falkland Islands**	**Management of environmental impacts**	**Residual Impact**
Hydrocarbon spill continued Accidental hazards			The operators will develop an approved oil spill response strategy and detailed plan (see Appendix E). This will include: • site specific spill prevention measures; • definition of responsibilities; • description of response strategy; • oil spill modelling results. • The standby vessel will be equipped with pollution control/response equipment. Relevant personnel will be trained in the use and operation of: • the oil spill response plan; • blowout prevention equipment and procedures. In the event of a major spill event all four operators are members of Oil Spill Response Limited (OSRL). OSRL could mobilise personnel and equipment to support offshore and nearshore response within an estimated timeframe of 30-36 hours.	
Chemical spill	Chemical contamination of resources in the vicinity of the spill location.	In the event of a chemical spill the environmental impact is related to the quantity and properties of the material released. Impact is likely to be restricted to the immediate vicinity of the spill and the spilled chemical expected to quickly dilute and disperse in open area such as offshore the Falkland Islands.	Operators will have chemical management procedures in place to ensure the use of low toxicity products. In the event of a chemical spill all materials will be retained for appropriate disposal, not washed overboard. Damaged or unsuitable chemicals will be retained for appropriate disposal, not discharged to drains.	Minor to moderate

3.2 Key environmental issues

3.2.1 Drill cuttings discharge

As described in Section 2, it is proposed to drill five wells, with an option to drill a further three commitment wells if required. Planned well depths are 3,000 m (9,800 ft) and 4,500 m (14,700 ft). For all wells it is proposed to drill the top section of the hole using seawater as the circulation fluid, with a water based mud for the deeper well sections, when a riser is in place. Table 3.2 indicates the volumes of cuttings that can be expected from a typical 3,000 m (9,8(x) ft) well.

Table 3.2 Volume of drilling cuttings from a typical 3,000 m well

Section (inches)	Hole capacity (bbls/ft)	Depth (ft)	Depth (m)	Rock mass (tonnes)	Rock volume (m^3)
36.0	1.251	1,580	481	74	34
26.00.	653	3,010	917	326	148
17.50	0.296	4,740	1,444	179	81
12.25	0.145	6,825	2,080	106	48
8.5	0.070	9,940	3,029	76	35
TOTALS				761	346

Assumes gauge hole Water depth = 1,410 ft (429 m)

Tophole drilling cuttings

Drill cuttings from the tophole riserless well section will be discharged to the seabed adjacent to the well. In addition there could also be some losses of cement to the seabed from filling the annulus. Again any such cement discharge would remain close to the wellhead.

Cuttings piles from such tophole drilling would contain little contamination, perhaps traces of chemicals used for occasional hole sweeps.

From present data, water currents in the licence Tranches are expected to be low, less than 0.15 mls (ref Appendix B; Section B4), therefore it is unlikely that the discharged cuttings will be rapidly dispersed outwith the immediate vicinity of the well location.

Until the proposed baseline surveys have been undertaken the exact nature of the benthic (seabed) fauna is unknown, but it can be assumed that the immediate cuttings pile would result in physical smothering of infauna. As there are no expected toxic effects, recolonisation of benthic fauna can be expected (Kingston, 1987 and 1992).

Bottom hole cuttings

The lower hole sections (below 26") will be drilled using a water based (silicate) mud with very low intrinsic toxicity. Drilling fluids and cuttings will be carried to the surface where cuttings will be removed in a solids control system. It is intended to discharge both used water based drilling muds (WBM) and cuttings overboard via a caisson a few meters below the sea surface.

It is estimated that approximately 160 m^3 of rock will be discharged from a 3,000 m well (see Table 3.2).

Drill cuttings modelling has been completed for both shallow and deep wells in the northern Tranches. The results showed that in the Tranche area off the edge of the continental shelf (i.e. Tranches A, B) there is a net current of less than 0.15 m/s. The modelling only considers those drill cuttings discharges from the well sections drilled once the marine riser is in place. These discharges will accumulate on top of those deposited directly to the seabed from the top hole sections. The majority of the discharges will be restricted to within 200 m of release and the maximum height of the pile is predicted to be less than 80 mm. This has the effect of causing a low density plume of fine cuttings particles downstream of the release point. Within a distance of 0.5 km from the release point only a very fine cover is predicted (<2 mm thickness) (RGU, 1997) (see Figure 3.3).

In shallower waters on the continental shelf there is no significant residual current and water movement is dominated by tides. In both 150 m and 250 m water depths coarse particle distribution is restricted to within 100 m of the release point. The maximum height of the cuttings pile in both scenarios is predicted to be less than 130 mm. Fine debris (< 2 mm thickness) will be deposited up to 500 m in 150 m of water, and a maximum of 700 m from the release point in 250 m water depth (see Figure 3.4).

Discharged cuttings and mud could have four potential effects on the marine environment:

- they may cause an increase in turbidity in the water column, mainly caused by fine particulates, which can temporarily reduce planktonic photosynthesis or impair feeding or vision of other organisms;
- they may physically smother the seabed and cause:
  i) potentially suffocate aerobic marine organisms, notably benthic infauna,
  ii) potential physical alteration to surface sediment structure, with effects on colonisation;
- any organic components may provide a nutrient source e.g. for bacterial activity with potential beneficial or detrimental (e.g. organic enrichment: oxygen depletion) effects;
- specific chemicals within muds could have toxic effects.

Studies worldwide have suggested that in cases where water based muds have been used the main impact is physical smothering, often with associated suffocation in the immediate vicinity of the discharge point.

Barites used in the drilling programme will be selected from low contaminant sources to reduce toxic effects. Risk from specific chemical components in water based muds has been minimised by the rigorous implementation of UK OCNS procedures (reference Section 2). This scheme aims to control and monitor the use of chemicals by the offshore industry and is incorporated into Falkland Islands Government licence conditions.

It must be emphasised that studies into the impact of drill cuttings on the seabed relate primarily to the use of oil based muds (OBMs) (studies of the effects of WBMs have been less intensive). There is considerable environmental concern about the impact of OBMs on the seabed, resulting mainly from the early policy of extensive use of OBMs in UKCS operations, initially diesel based, then through a series of alternative muds - low toxicity muds and pseudo-oil based muds (POBMs). Initially there was excessive emphasis placed on removing acute toxicity properties, more recently it was realised that many of the alternative muds have very low biodegradation rates. Key concerns relate to:

- Presence of undegraded hydrocarbons in cuttings piles which are potentially available to the environment in the long term and elevated levels of hydrocarbons in sediments with concentrations varying with distance from the cuttings pile.

- Smothering of benthic organisms within the area of the cuttings pile with recovery likely to be a long process.

- High organic loading and sediment oxygen depletion which increases the smothering effect.

Toxic effects on marine benthic organisms.

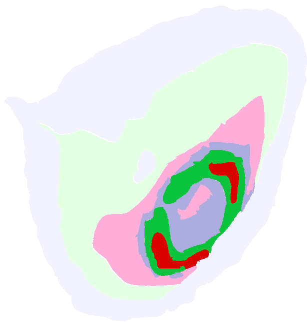
(Kingston 1987 and 1992; Addy *et al*, 1984).

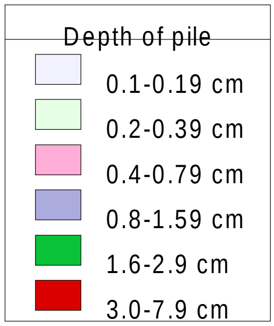
The latest step has been the introduction of synthetic mud systems (SMS' s) many of which seem to be presenting similar environmental problems. It is not proposed to use any oil or alternative mud based systems in exploration drilling offshore the Falkland Islands. A direct comparison of the effects resulting from the use of OBMs and WBMs is provided by the history of the Beatrice field (Addy *et al*, 1984). Localised benthic effects were found after the WBM drilling however after the use of OBM the nature of the effects differed substantially (including marked organic enrichment, elevation of hydrocarbon levels, de-oxygenation of sediments, reduced species richness and increasing abundances of indicator species.

The exact nature of the seabed around the proposed locations is not known at present, but a baseline environmental survey will be completed prior to the commencement of drilling operations. This will allow for the long term monitoring of any contamination. However the use of water based mud will minimise any potential impact.

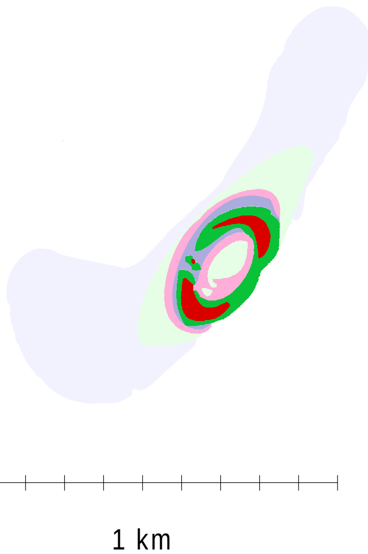
Figure 3.3 Modelling results of overboard discharge of cuttings at the northern location

a) Cutting dispersion from a 4,500 m (14,700 ft) well





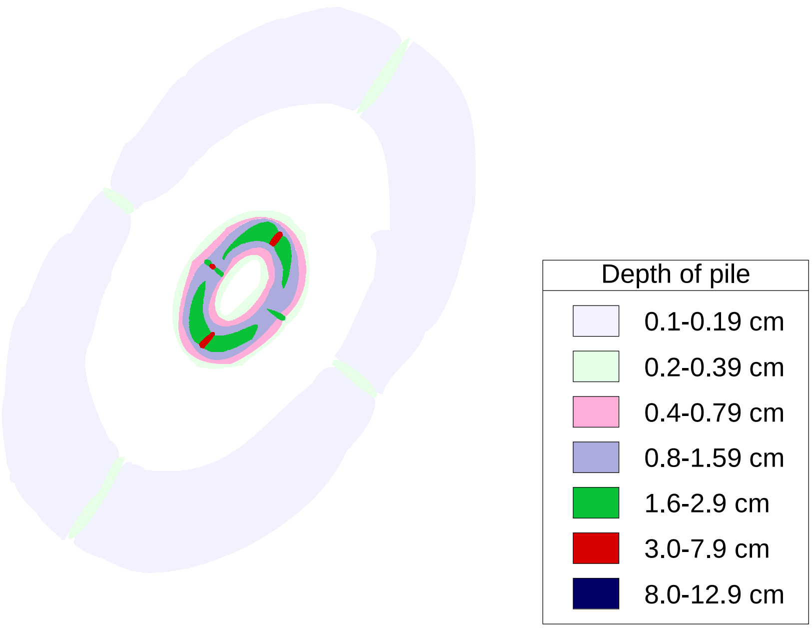
b) Cutting dispersion from a 3,000 m (9,800 ft) well



The above modelling scenarios assume a water depth of 450 m and that the cuttings are released from a 30 cm diameter caisson at 10 m below the sea surface.

Figure 3.4 Modelling results of overboard discharge of cuttings at the southern location

a) Cutting dispersion from a 3,000 m (9,800 ft) well in 250 m water depth



b) Cutting dispersion from a 3,000 m (9,800 ft) well in 160 m water depth

The above modelling scenarios assume the cuttings are released from a 30 cm diameter caisson at 10 m below the sea surface.

3.2.2 Accidental releases

Throughout the proposed drilling programmes, and as in all aspects of hydrocarbon exploitation, there is the potential risk of non-routine/accidental events occurring. These in turn may lead to unwanted emissions or impacts. A limited number of incidents have been identified as having a potential to occur, with consequences that may impact the environment. The two main mechanisms for accidental pollution can be identified as:

- a hydrocarbon spill, or
- a mud / chemical spill.

This section of the report examines the above two pollution mechanisms in further detail.

Oil spill risk

The most important environmental risk associated with exploration drilling is an accidental release of hydrocarbons to the sea. Since these spills could occur from a range of incidents, their size could vary greatly. For example, a leak during the transfer of diesel to the rig may cause a small spill several barrels in size, whereas a well blowout from a crude reservoir may result in thousands of tonnes of oil being lost to sea. Obviously when drilling an exploration well there is only a risk of a large oil spill if oil is present in the reservoir. Oil Spill Response Limited (OSRL) have been commissioned by the operators to look at the risk of hydrocarbon spills from the proposed exploration drilling operations. The following section provides a summary of their findings.

Operational spills

Analysis of historical data of reported spills from drilling rigs on the United States and United Kingdom Continental Shelves both indicate that the typical platform spill is less than 1 barrel. In the period 1971 - 1992, the number of United States Offshore Chemical Shelf (US OCS) spills of < 1 barrels represented 92% of the total but only 4.3% of the volume spilled. Whereas the number of spills of > 1,000 barrels stood at 0.1 % of total but the majority (77%) of the volume spilled. The United Kingdom Continental Shelf (UKCS) spill data over the period 1977 -1993 correlates with the US experience. It provides a useful indication of the most likely size of spill and the type of spill that could occur. Examination of this source data shows that the most probable types of spills from a drilling rig are small operational spills of fuel oils such as diesel. Table 3.3 provides summary statistics of diesel spills reported to the UK Department of Trade and Industry (DTI) from the years 1977 to 1993.

Table 3.3 Reported UKCS diesel spills 1977-1993

Spill category	% spilt by volume	% of spills by number	Mean spill size (bbls)	spill range (bbls)
Drilling	4.5	18	4	0.25-15
Collision	12	3	63	0.1-63
Supply	82	49	26.9	0.5-302
Utilities	1.5	30	0.8	0.1-4

The total amount of diesel spilled from the drilling rigs operating on the UKCS over this 17 year period was less than 525 barrels. Table 3.3 shows that spills during supply to the rig are the most common cause of diesel spills, accounting for 49% of the total number of spills and 82% of the total volume of diesel spilt. The size of these spills is scattered; the majority are small and average <1 barrel, but a single spill of 302 barrels was recorded. Incidents involving rig utilities (e.g. drains) and drilling are much less frequent, and are likely to result in small spills « 15 barrels).

Exceptional spills

The worst case oil spill scenario in any exploration drilling program would be a spillage of crude oil associated with loss of well control or blowout. Maximum loss of crude oil would result from a continuous release of oil. The flow rate and duration of a well blowout is a function of the geology of the reservoir and drilling history of the well. Events of this nature are very rare and have been declining due to modern technology, however historical precedent dictates that they should not be ignored. On the United States offshore continental shelf there have only been 11 recorded platform spills (blowouts and other spills occurring on the platform) > 1,(){)O barrels in the period 1964 -1992, the last being in 1980. Refer to Table 3.4 for incident details (the source data does not distinguish exploration from production installations).

Table 3.4 US OCS platform oil spills > 1,000 bbls 1964-1992

Spill Date	US OCS area and block	Volume $m^{3\,a}$	Cause
4/1964	Eugine Island 208	2,559	Freighter struck platform, fire.
10/1964	Ship Shoal 149 & 199	11,869	Platforms in hurricane, blowout.
7/1965	Ship Shoal 29	1,688[b]	Well blowout.
1/1969	Santa Barbara Channel	80,000	Well blowout.
3/1969	Ship Shoal 72	2,5000	Ship struck platform in storm, blowout.
2/1970	Main pass 41	30,000	Well blowout, fire.
12/1970	South Timbalier 26	53,000	Well blowout, fire.
1/1973	West Delta 79	9,935	Structural failure, storage tank rupture.
1/1973	South Pelto 23	7,000	Stationary storage barge sank.
11/1979	Main pass 151	1,500[c]	Vessel collided with semi-submersible.
11/1989	High Island 206	1,456	Pump failure, tank overflow.

a 1 bbl = 0.159 m^3

b Condensate

c Diesel tank of semi-submersible drilling rig damaged.

Table 3.4 illustrates that various causes have been accessory to the well blowouts occurring, such as ship collision, structural damage and adverse weather conditions. These scenarios must not be discounted. The statistical risk of a blowout occurring world-wide from drilling is 2.5 x 10-3 per well year (based on a 100 well study of offshore blowout causes) (Dahl and Bern, 1983).

Oil spill modelling

The risk of a large spill is very low, but its potential consequences need to be considered. OSRL were commissioned to complete an oil spill modelling exercise for a low risk of occurrence blowout situation, to predict likely trajectory and possible fate of spilled oil (see Appendix E). The spill scenario was based on the situation of an ongoing release of 1,000 m^3 per hour for 12 hours. The model considered two spill release locations representing sites in the north and south of the licensed Tranches. Historical wind speed and direction data, together with wind spell (direction-frequency) data was used to model most realistic Falkland' s conditions.

The results of the modelling are discussed in detail in ' Oil Spill Response Strategy Recommendations for Falkland Islands Exploration Blocks' (see Appendix E). In summary the results indicate that there would not be beaching of the released oil from the most northerly location. In the unlikely event of a blowout scenario at the southerly release location, there is a small probability of oil beaching, i.e. 1 in 2,700 blowout events. That is an overall probability of oil beaching of 6.75 x 10-7 per well year.

Potential impact from an offshore oil spill

The consequences to the environment from a hydrocarbon spill depend on a number of factors including: the type of oil released, the weathering characteristics of oil, the prevailing weather conditions and the receiving environment. The risk of a major spill occurring and that spill beaching on the north coast of the Falkland Islands is very low. In addition a large proportion of the Islands' coast is remote and therefore deployment of oil spill response equipment difficult. The main island group is approximately 160 miles (250 km) east-west by 95 miles (150 km) north-south. There are:

- over 400 islands, many of which are heavily indented;
- few habitations, amounting to isolated farms anti settlements;
- minimal roads or tracks which leave many coastal areas inaccessible;
- limited harbours;
- few airfields or suitable landing areas.

As the risk of an oil spill beaching is very low it is therefore the offshore marine resources that can be considered to be at greatest risk from an oil spill. Offshore flightless birds e.g. penguins will be vulnerable to surface pollution. There may also be limited mortality to krill populations in the immediate vicinity of a spill location.

The operators will have procedures in place to minimise the likelihood of any oil spill event. In the unlikely event there is a spill various options could be available to deal with spilled oil. However there are certain constraints in relation to both weather conditions offshore the Falkland Islands and the remoteness of the Islands which limit the number of realistic options. These are discussed in Appendix E of this report.

3.3 Overall assessment

In summary it can be concluded that from routine operations the effects of drill cuttings discharges have the greatest potential for environmental consequence. However on the basis of past experience in the use of water based muds for single exploration wells, these effects are not considered to be significant. Other environmental effects from routine operations; the physical presence of the rig, atmospheric emissions from well testing and power generation and aqueous/chemical discharges will have a minor or negligible impact.

The greatest, but highly unlikely environmental threat would result from a large oil spill, for example from a well blowout. Analysis has shown that the probability of a blowout event resulting in the oiling of the north Falklands coast is 6.75 x 10-7 per well year. As the risk of oil beaching is low it is therefore the offshore marine resources that can be considered to be at greatest risk from an oil spill.

In light of the low level. of impacts predicted from routine operations, and the management and control measures that are in place/will be adopted, it is considered that the drilling programme proposed by the operators will not have any significant impacts. However in the unlikely event of a large accidental oil spill the potential exists for significant impact

Appendix A

Policy guidelines and legislation

Appendix A Policy guidelines and legislation

A.1 Policy guidelines on the environment

Shell, Amerada Hess, LASMO and IPC are committed to conducting their company' s business in a manner that is compatible with the balanced environmental and economic needs of the communities in which they operate, and to meet legal requirements and consent standards. They recognise their responsibility to ensure operations are carried out with due regard for environmental protection and have established corporate environment policies.

Commitment to environmental protection is lead by senior management and the responsibility of all employees and contractors. The environmental implications for all phases of activities are considered to enable the effective management of any environmental impacts from operations. In addition environmental performance is continually monitored to ensure environmental targets are met.

A.2 Falklands legislative regime regarding offshore exploration drilling operations

The Falkland Islands are among the overseas countries and territories having special relations with the United Kingdom which are included in Annex 4 (as amended) to the European Community Treaty. European law does not, as a result, have any direct effect in the Falkland Islands. Although some provisions of Falkland Islands law (for example the provisions of Schedule 4 to the Offshore Minerals Ordinance 1994 which deal with the contents of environmental impact assessments and environmental impact statements) are modelled on European Community law.

The Islands have a separate legal and legislative system, (including the power to make laws for the islands) administered by the Falkland Islands Government (FIG). However, the UK Government is responsible for matters of defence and external affairs and on other matters prior approval may be required from a UK Secretary of State. Similarly, legislation formed in the UK may be modified and adopted in the Falklands. Planning controls in the Falklands extend to the twelve nautical mile limit of the territorial sea. This is through the administration of planning legislation in the Falkland Islands on a central and national basis, applicable to the whole of the Islands (including the territorial sea) rather than, as in England, on an administrative county or local authority basis where the boundaries cease at the low water mark. As none of the licence Tranches are closer than 50 nautical miles from the coastline of the Islands, such legislation (including onshore legislation) is outwith the scope of this report.

The legal responsibility for exploration and exploitation of petroleum from the Falkland Islands Continental Shelf rests with the Executive branch of Government and is governed by locally enacted legislation. The key details of current environmental legislation and conditions with regard to proposed exploration drilling operations are summarised in Table A.1. However, it should be noted that the Table does not provide a definitive analysis of the law or of the potential liabilities for environmental damage. Environmental legislation in the Falklands is in the early stages of development and further legislation may be required during the potential future development of the offshore hydrocarbon reserves.

Table A.1 Summary of International and Falklands legislation, and conditions relating to environmental protection and provisions controlling offshore exploration drilling operations

International/ UK	Falklands	Development/area activity	Conditions and standards
Exploration drilling operations			
	Offshore Minerals Ordinance 1994 petroleum (OMO 1994)	Exploration/exploitation (and matters connected/ relating to) of minerals in the Continental Shelf and other controlled waters of the Falkland Islands	The Ordinance repeals the Continental Shelf Ordinance of 1991 and provides for exploration and development. The Ordinance sets terms and conditions attached to the activities defined. Of relevance to drilling operations are the following: – Licensing and offences in relation to licences; – Requirements in relation to preparation of environmental impact assessments or environmental impact statements (Sections 64 -67); – 514(1) gives effect to Schedule 1 -strict liability for certain loss or damage (refer to ' accidental discharges').
	Petroleum Survey Licences (Model Clauses) Regulations 1992		The Petroleum Survey Licences (Model Clauses) Regulations 1992 were made under the Continental Shelf Ordinance 1991 and were continued in force by OMO 1994. The Regulations set out the clauses which are deemed to be incorporated in exploration licences, except to the extent that they are excluded or modified by specific provisions of those licences. The 1992 Regulations were amended by OP(L)R 1995. (refer below).
	Offshore Petroleum (Licensing) Regulations 1995 and Model Clauses (OP(L)R 1995)	Exploration/exploitation licences	The Regulations (together with the Offshore Minerals Ordinance 1994): i) regulate the manner in which application may be made for an exploration or exploitation (production) licence; ii) prescribe a form of application (Schedule 1); iii) prescribe Model Clauses for production licences (Schedule 2); and iv) amend the Petroleum Survey Licences (Model Clauses) Regulations 1992 in relation to the Model Clauses for exploration licences.

International/ UK	Falklands	Development/area activity	Conditions and standards
	Offshore Petroleum (Licensing) Regulations 1995 Model Clauses (OP(L)R 1995)	Exploration/exploitation licences	Exploration licences authorise the Licensee to search for minerals specified, in the seabed and subsoil. They do not authorise boring or extraction of any mineral in the course of exploration. Production licences authorise the Licensee to bore and get the minerals specified in the licence. Each production licence comprises four stages; 3 exploration phases and an exploitation phase.
	Model Clauses for Production Licences in Controlled Waters.		The Model Clauses for Production Licences in Controlled Waters, contained in Schedule 2 to OP(L)R 1995, are deemed to be included in any production licence except to the extent that they are excluded or modified by any clause of such a licence. Controlled waters refers to the areas to which the licence relates.
	FIG Environmental Policy Indicative Additional Conditions and Restrictions	Exploration drilling	In addition to the Model Clauses, FIG has produced indicative conditions and restrictions reflecting the environmental policy. These were published to indicate to applicants for licences in the licensing round what conditions, additional to those provided by Model Clauses, might be expected to be included as clauses of the licence. Except insofar as they have actually been included in licensees licences, they do not have effect at all. The indicative conditions and restrictions are divided into 4 categories, 3 of which are relevant to drilling operations: *A)* *General* No more than one rig shall operate in any block at any time without the written consent of the Governor. Restrictions may be imposed on the positions in which the Licensee may drill. At least 3 months notice is required in advance of drilling activity B) *Environmental seismic/drilling.* Conditions which may include consultation with FIG's Director of Fisheries and the Falkland Islands and Environmental Task Group (FENTAG) at least 30 days before exploration drilling work. Prior to commencing drilling operations the proposed drilling mud, any associated chemicals and method of disposal of drill cuttings and spent mud shall be submitted to the Governor and British Geological Survey for review. Also included are indicative conditions relating to the conservation of cetaceans during seismic exploration and other operations under the licence.

International/ UK	Falklands	Development/area activity	Conditions and standards
	FIG Environmental Policy Indicative Additional Conditions and Restrictions	Exploration drilling	C) *Oil-spills.* Refer to ' accidental events' ; D) *Fisheries interests.* The requirement to establish a fisheries liaison officer to promote good working relationships, agree vessel routes, ensure English is spoken on the vessel, take every effort to locate and remove any debris resulting from activities and promptly deal with claims for loss/ damage of gear or loss of fishing time arising from such debris.
	The Continental Shelf Operations Notice No 1	Record and sample requirements for surveys and wells	The Notice details the procedures which should be followed concerning the submission of records and samples from surveys or drilled wells. Section 4 is specific to well data and records, detailing the data to be supplied before permission is given to drill and the data and reports that must be supplied on the completion of the well. Licensees are required to advise the FIG' s Governor, the Attorney General and the British Geological Survey in writing, 28 days before the proposed drilling activity is due to commence. Reports must be supplied within 3 months of the completion of any well.

International/ UK	Falklands	Development/area activity	Conditions and standards
Routine operations and discharges			
	FIG Environmental Policy Indicative Additional Conditions and Restrictions	Discharges	Section B) *Environmental seismic/drilling* establishes conditions imposed on the use and discharge of chemicals during drilling. Water based muds must be used wherever technically possible. Prior to drilling operations, Licensees are required to notify the Governor of FIG and the British Geological Survey of the proposed drilling mud, any associated chemicals and method of disposal of drill cuttings and spent mud. After the completion of each well a written report must be submitted detailing the types, quantities and discharge details of any chemicals used.
Convention for the Prevention of Pollution from Land Based Sources 1974 (Paris Convention)/ Prevention of Oil Pollution Act 1971 (POPA) with amendments	Prevention of Oil Pollution Act(Overseas Territories) Order 1982 Offshore Minerals Ordinance 1994	Discharge of oil and oily mixtures	The Order applies the conditions and standards of POPA 1971 to the Falkland Islands with the exception of Section 3, which relates to the UK Continental Shelf. Section 16 of the Ordnance applies Section 3 of POPA 71 to the designated areas of the Falkland Islands Continental Shelf. The Order states that it is an offence to discharge any oil or mixture containing oil (otherwise than from a ship) as the result of any operation for the exploration of the seabed, subsoil or of their natural resources in a designated area.
Oil in Navigable Waters Act 1958 (UK)	Oil in Territorial Waters Ordinance 1960 (as amended in 1987)	Discharge of oil and oily mixtures	The Ordinance controls the discharge of oil and from vessels oily waters from vessels (including unloading and loading from vessels) within the territorial sea of the Falkland Islands.
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters 1972 (London Convention)/ Food and Environment Protection Act (FEPA) 1985	Marine Environment Protection Ordinance 1995	Discharges	Under Section 3 of the Ordinance a licence is required for deposits in Falkland Island waters or controlled waters. A licence is required for deposits from a range of sources which includes vessels, platforms and other man made structures (excluding pipelines).

International/ UK	Falklands	Development/area activity	Conditions and standards
	Deposits in the Sea(Exemptions) Order 1995	Discharges and atmospheric emissions (exhausts)	Approved under Section 5 of the Marine Protection Ordinance 1995, the Order lists 25 categories of materials which do not require a licence under the Ordinance. Included are the disposal of sewage or domestic waste originating on a vessel or platform, drill cuttings and muds under certain circumstances and the incineration of hydrocarbons. Several of these exemptions are encompassed within other legislation, such as the Offshore Minerals Ordinance and the Merchant Shipping (Oil Pollution) Act.
	FIG Environmental Policy Indicative Additional Conditions and Restrictions	Chemical use	Section B) *Environmental seismic/ drilling* specifies the controls imposed on the use and discharge of chemicals including the requirement to notify the Governor on their use detailing the location and quantities of discharge. The Licensee shall only discharge chemicals which are approved under the UK Harmonised Offshore Chemical Notification Scheme (HOCNS).
Accidental discharges			
	Offshore Minerals Ordinance 1994	Accidental events	Section 14 of the Ordinance imposes on an operator ' strict liability' for loss or dama caused to the environment in defined circumstances (excluding any impact regarded as negligible).
	FIG Environmental Policy Indicative Additional Conditions and Restrictions	Oil spills	Under Section C) Oil-spills., all steps must be taken to prevent the escape of oil. At least 6 months before the implementation of any drilling programme a proposal for an oil spill contingency plan must be submitted to the Governor of FIG for approval. The section details the essential elements that must be provided for within the plan.
Convention on the Prevention of Marine Pollution from Ships (as amended by 1978 Protocol) MARPOL 73/78; International Convention on Civil Liability for Oil Pollution 1969 (CLC)	Merchant Shipping (Oil Pollution) Act 1971; Order in Council SI 1975/2167 (as amended by SI 1976/2143); Merchant Shipping Act 1995	Oil spills from vessels	Stipulates the responsibilities of ship owners for damage caused by oil pollution from their ships. It imposes strict liability for any damage caused by contamination resulting from the escape or discharge of persistent oil carried by a vessel, the cost of pollution prevention measures to minimise the damage and the damage resulting from these measures.

A.3 Future developments in legislation

The level of statutory protection for the offshore environment of the Falklands Islands has increased over recent years with the adoption of UK legislation, such as merchant shipping legislation. Vessels registered in the Falkland Islands must now comply with the regulations of MARPOL 73/78, with the exception of Annex IV (sewage). However, these controls only extend to those vessels registered in the Falkland Islands and to foreign flagged vessels operating within the 12 mile limit of the territorial sea. Currently there is no policy for monitoring pollution by vessels beyond the territorial sea and limited monitoring takes place within territorial limits and Falklands Islands Harbours (FIG, 1996).

Environmental protection in Falkland waters is provided for through the Offshore Minerals Ordinance 1994. Present controls are based mainly on liability for environmental damage, with the responsibility resting with Licensees to show how environmental protection will be achieved, rather than relying on detailed statutory controls. Additional conditions are provided for within subsidiary legislation and conditions attached to production licences. The provisions within current legislation enables the Governor of FIG to incorporate further obligations, conditions or restrictions on Licensees if necessary.

The present and future waste practices and facilities in the Falkland Islands are being addressed through the development of a National Waste Management Strategy. The aim of this programme is to introduce and maintain waste management and disposal systems resulting in environmentally acceptable practices, consistent with relevant international obligations and suitable to the circumstances of the Falkland Islands. This will have future implications for Licensees as FIG will be addressing the facilities that should be provided and requirements which ought to be imposed in relation to wastes arising from the exploration for and exploitation of petroleum in Falkland Island waters.

Recent developments by the UK Government will affect the application of the London Convention, FEPA 1985 and Marine Environment Protection Ordinance 1995 to the Falkland Islands, as stated in Table 2.1. At present the Environment Protection (Overseas Territories) Order 1988 (511988/1084) made under Section 26 of FEPA 1985, does not apply to the Falkland Islands. The Order applies Parts II (Deposits of Substances and Articles at Sea) and IV (general and supplementary purposes) of FEPA, and Schedules 2, 3 and 4 to FEPA, in a modified form to a number of Dependent Territories. In recent correspondence the Foreign and Commonwealth Office have indicated the UK Government' s intention to amend Schedule 2 to the 1988 Order so that it does apply to the Falkland Islands (Lang, 1997). Under Part II of FEPA 1985 a licence is required for the deposit of substances or articles in the sea or under the seabed and for the incineration of substances or articles at sea. These provisions apply to any vessel or marine structure within territorial waters or fishery limits and to any British vessel or British marine structure wherever it may be. Licensing authorities may also issue licences subject to such provisions necessary to protect the marine environment, the living resources which it supports and human health and to prevent interference with legitimate uses of the sea.

In the longer term the 1996 Protocol to the 1972 London Convention will be given effect in the Falkland Islands by a further Order in Council. The Protocol represents a major change of approach to the question of how to regulate the use of the sea as a depository for waste materials. One is to introduce (in Article 3) what is known as the "precautionary approach". This requires that "appropriate preventative measures are taken when there is reason to believe that wastes or other matter introduced into the marine environment are likely to cause harm even when there is no conclusive evidence to prove a casual relation between inputs and their effects." The article also states that "the polluter should, in principle, bear the cost of pollution" and it emphasises that Contracting Parties should ensure that the Protocol should not simply result in pollution being transferred from one part of the environment to another.

The 1972 Convention permits dumping to be carried out provided certain conditions are met. The severity of these conditions varies according to the danger to the environment presented by the materials themselves and there is a "black list" containing materials which may not be dumped at all. The protocol however is much more restrictive. It states (in Article 4) that Contracting Parties "shall prohibit the dumping of any wastes or other matter with the exception of those listed in Annex 1." Of relevance to exploration operations are:

- inert, inorganic geological material;
- organic material of natural origin;
- bulky items primarily comprising iron, steel, concrete and similar unharmful materials for which the concern is physical impact and limited to those circumstances, where such wastes are generated at locations, such as small islands with isolated communities, having no practicable access to disposal options other than dumping.

The only exceptions to this are contained in Article 8 which permits dumping to be carried out "in cases of *force majeure* caused by stress of weather, or in any case which constitutes a danger to human life or a real threat to vessels..." (IMO, 1996).

Incineration of wastes at sea was permitted under the 1972 Convention, but this practice has since been specifically prohibited by Article 5 of the Protocol. Incineration at sea of industrial waste and sewage sludge had already been prohibited under amendments to the 1972 Convention adopted in 1993. Also prohibited by Article 6 of the protocol is the practice of exporting wastes which cannot be dumped at sea under the Convention to non-Contracting Parties. Article 9 requires Contracting Parties to designate an appropriate authority or authorities to issue permits in accordance with the Protocol (IMO, 1996).

A.4 Environmental guidelines

In addition to the legislation specific to the exploration of hydrocarbons in the waters offshore the Falklands Islands, the following sub-section details environmental guidelines which will be incorporated by the operators into the planning of their proposed operations.

A.4.1 Exploration and Production Waste Management Guidelines

This document has been produced by the E&P Forum to provide guidance on exploration and production waste management. The guidelines draw together the know-how of oil and gas E&P companies on the range of waste management options available for wastes generated by their activities.

The document is divided into sections which provide:

- general discussions on waste management principles and the development of waste management plans;
- identification and overview of E&P activities and associated wastes; and
- options for waste reduction, recycling, treatment and responsible disposal.

Whilst not all measures discussed in the guidelines are appropriate for implementation in all geographical areas and conditions, operators should be able to use the guidelines to develop a waste management programme appropriate to their activities and to the ecological sensitivity of the operating location.

A.4.2 United Nations Environment Programme (UNEP) Environmental Guidelines for Oil Exploration and Production

The Guidelines are prepared in association with the E&P Forum and consist of Production and Procedures for Environmental Control, a supplement to the main report, and Technical Guidelines on Environmental Aspects of Oil Exploration. The Production and Procedures for Environmental Control document is divided into sections which consider:

- Policies and approaches to environmental control.
- Regulatory framework for environmental protection during oil exploration and production.
- Environmental Impact Assessment.
- Environmental management within a company; including objectives, responsibilities and accountabilities, standards and targets, monitoring and contingency planning.
- Environmental management application to exploration and production activities. This section addresses waste management, monitoring and records and inspection and maintenance.

The main report, Oil Exploration and the Environment provides a ' Technical Guide to Reducing the Environmental Impacts of Exploration Operations.' The Guide provides a general background and description of the activities, materials used, sources of contaminants and potential impacts from exploration operations from seismic to decommissioning operations and provides the following:

- operational guidelines for surveys and exploratory drilling operations;
- determining factors that should be considered in the working environment (safety, exposure levels and training);
- procedures for environmental control; and
- environmental management within a company.

Appendix B

The environment of the offshore Falklands

Appendix B The environment of the offshore Falklands

B.1 Introduction

The proposed area for exploration drilling operations lies as two main 'areas' in the North Falkland Basin, 200 km north of the Falkland Islands. These areas extend from latitude 49°00' S - 49°40' S, longitude 58°36' W - 59°48' W (Tranches A, B, C, D) and 49°40' S - 50°20' S, 59°00' W - 59°36' W (Tranches F and I) in the Designated Exploration Area of the Falkland Islands continental shelf (refer to Figure 1.1).

This section describes the main characteristics of the offshore marine environment in the area of the northern licence Tranches. Attention is given to the features of the environment that may be sensitive to, or may affect proposed exploration drilling operations. Consideration is also given to the inshore and coastal environment of the Falkland Islands and the key environmental features and sensitivities are identified and described. Figure 4.1 shows the locations of the key places mentioned in the text.

The information presented in this report draws on and expands upon the data produced in the environmental screening studies completed by the operators as part of their licensing round applications and the Environmental Assessment of Sensitivities to Seismic Operations (ERT, 1996). Extensive searches for both published and unpublished literature throughout the world have been undertaken. Communication was also established with key scientists in the Falkland Islands to ensure that all available information was used in the study. Where appropriate gaps in existing knowledge have been identified, and details provided of ongoing and planned environmental studies to address these gaps.

B.2 Meteorological conditions

B.2.1 Synopsis

The South Atlantic Ocean, including the Falkland Islands is exposed to an almost continuous series of depressions and troughs that move east across the area into the South Pacific. The weather is generally cool and oceanic, dominated by westerly winds, a high percentage of which are from the north west.

Offshore, unpredictable violent storms may occur in the study area, although their frequency increases south of 50°S and in inland waters anti passages (Hydrographer of the Navy, 1993). The year round windy climate can be attributed to the fast moving weather systems in the Southern Hemisphere due to the predominance of sea rather than land.

B.2.2 Wind speed and direction

Ships observations made for the sea area 48°00' S - 55°00' S, 58°00' W - 65°00' W, over the period 1854 to 1995 have been compiled by the UK Meteorological Office and are provided in Table 4.1. The results show that the most frequent wind speed throughout the year is force 4 (5.5-7 m/s), representing 22.3% of all observations. 87.4% of observations ranged from force 2 to 7 (2-15 m/s) and 8.1% were gale force 8 (15.5-17.5 m/s) or above. The distribution of wind speeds remains relatively constant throughout the year, although there is a slight increase in observations of higher winds during the winter months.

Figure B.1 Location of the key places mentioned in text

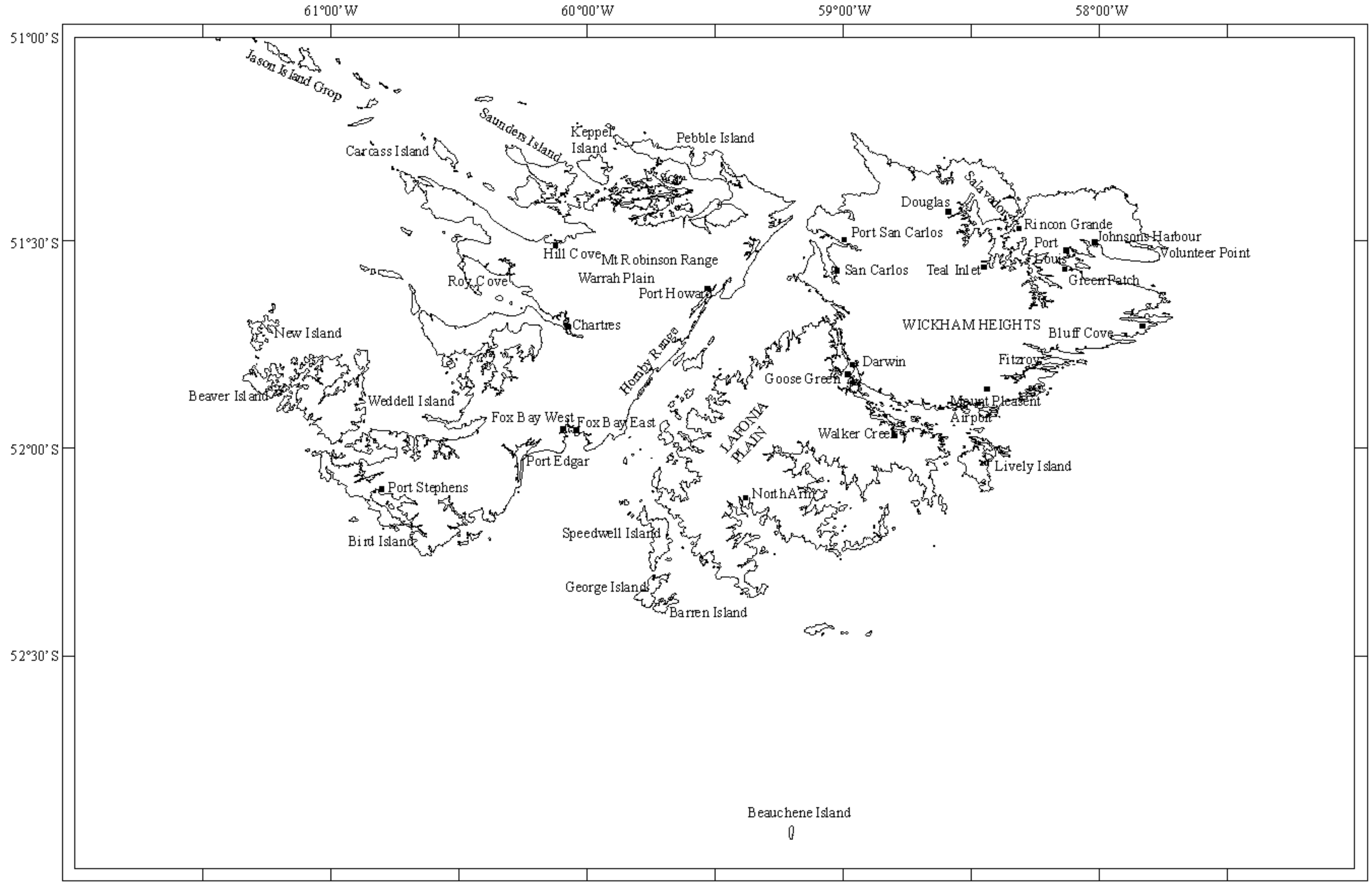


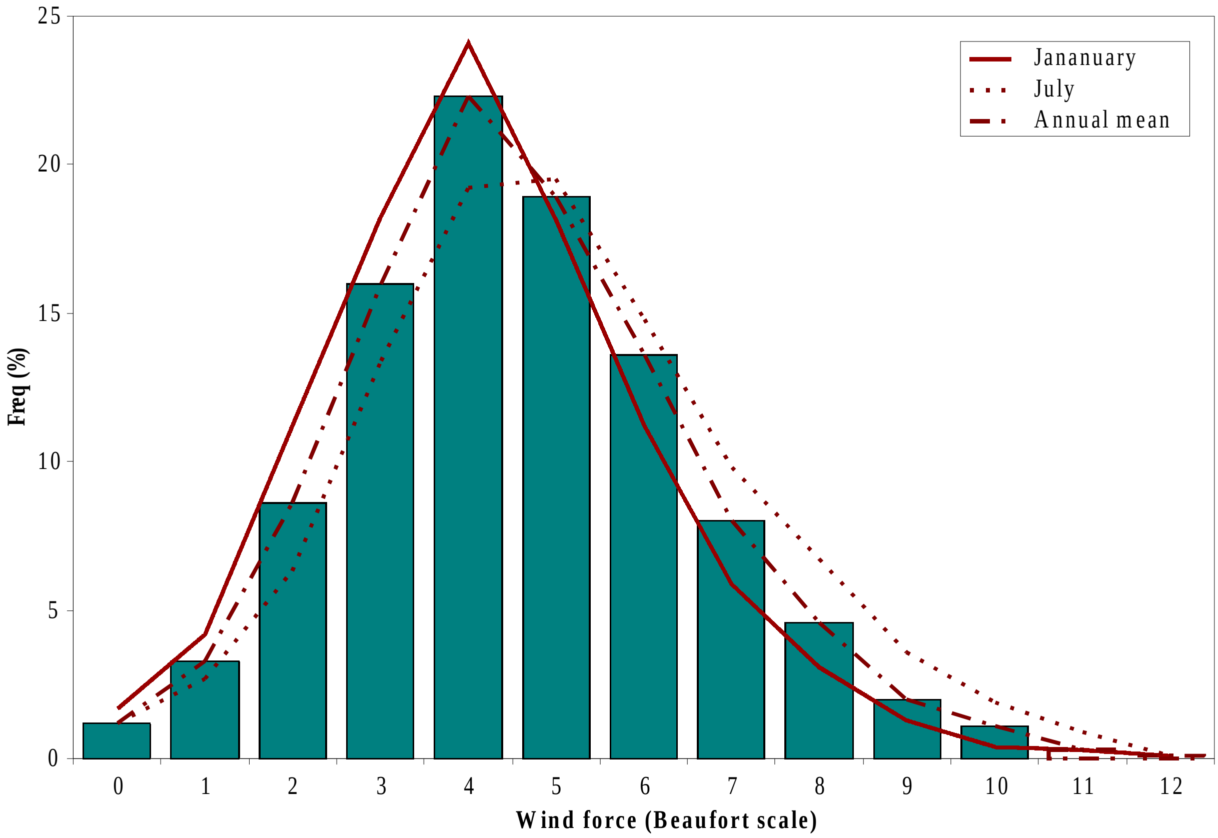
Table B.1 Summary of ships observations of wind speed for sea area 48.05 55.0S, 58.0W 65.0W, from 1854 to 1995 (Data source: Meteorological Office, 1996)

Wind Beaufort Scale	m/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
0	0-0.5	1.7	1.4	1.1	1.3	0.9	0.9	1.2	0.9	1.1	1.0	1.6	1.3	1.2
1	0.5-1.5	4.2	3.3	3.2	3.0	2.9	3.5	2.7	2.8	3.2	3.3	3.9	4.0	3.3
2	2-3	11.2	10.2	8.5	9.0	6.3	7.9	6.3	7.1	8.8	8.9	9.1	10.4	8.6
3	3.5-5	18.3	18.8	16.6	15.9	13.6	14.8	13.4	13.1	14.6	17.0	18.7	18.1	16.0
4	5.5-8	24.1	23.1	23.0	23.2	22.7	22.0	19.2	20.4	20.0	22.5	23.3	24.6	22.3
5	5.5-8	18.2	19.2	19.7	18.2	17.8	17.7	19.5	19.4	19.5	19.4	19.3	18.9	18.9
6	11-13.5	11.2	12.3	13.4	12.9	15.7	14.1	14.8	15.5	14.6	13.8	12.4	12.3	13.6
7	14-16.5	5.9	7.0	7.9	7.9	9.9	9.7	9.8	9.2	8.3	7.5	6.1	5.8	8.0
8	17-20	3.1	2.9	3.8	4.4	6.1	5.7	6.7	5.9	5.4	4.2	3.4	3.5	4.6
9	20.5-23.5	1.3	1.3	1.7	2.1	2.4	1.9	3.6	2.8	2.6	1.5	1.0	1.0	2.0
10	24-27.5	0.4	0.5	0.9	1.4	1.4	1.3	1.9	2.1	1.3	0.9	0.7	0.2	1.1
11	28-31.5	0.3	0.0	0.2	0.6	0.4	0.3	0.9	0.5	0.5	0.1	0.2	0.0	0.3
12	32-35.5	-	0.0	-	0.0	-	0.2	0.1	0.2	0.2	-	0.0	-	0.1

Notes

1. Figures denote percentages of total observations in each month.
2. Period of Data: 1854 to 1995. Total number of observations: 40,760.
3. -indicates zero frequency whilst 0.0 indicates less than 0.05%.

Figure B.2 summarises the annual frequency of occurrence of wind speed for the observation area, over the period described.

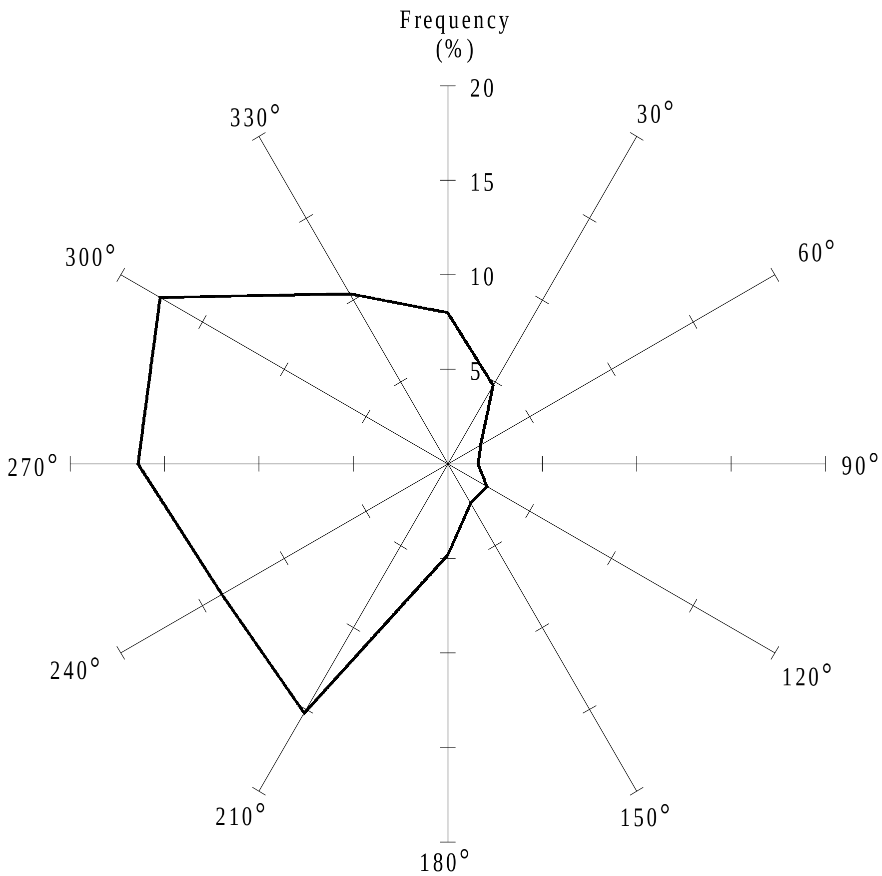


The numerous depressions, ridges and troughs that affect the area produce variable wind directions over the open ocean. The Meteorological Office records show that westerlies (196° - 345°) predominate, representing 71% of observations with little seasonal variation. Figure B.3 shows the annual wind rose for the study area.

Brief unpredictable and violent squalls may occur in the study area at any time, producing gusts in excess of 50 m/ s. In general, such squalls are more frequent south of 500S, especially in inshore waters which are influenced by coastal topography or strong winds over the adjacent sea area.

Inshore, there is no significant seasonal variation in wind direction. The mean wind speed at Port Stanley (west coast of East Falkland) is 16 knots, long periods of calm or no winds are infrequent. Gales occur, on average 4-5 days per month.

Figure B.3 Prevailing wind direction around the Falklands Islands (Meteorological Office, 1996)



B.2.3 Precipitation

Precipitation levels are recorded monthly at several coastal stations in the Falklands. Rainfall can be expected throughout the year in the area, with the greatest levels occurring during the winter and early spring months. Port Stanley (East Falkland) and Port Howard (West Falkland) are two of the wetter places in the islands. Stanley typically experiences 150 days of precipitation annually and an average rainfall of 630 to 650 mm (Hydrographer of the Navy, 1993). Annual precipitation levels at Port Howard average 650 mm (Strange, 1992). To the west precipitation levels are generally lower and West Point Island (to the north west of West Falkland) experiences an average annual rainfall of 431 mm (Strange, 1992).

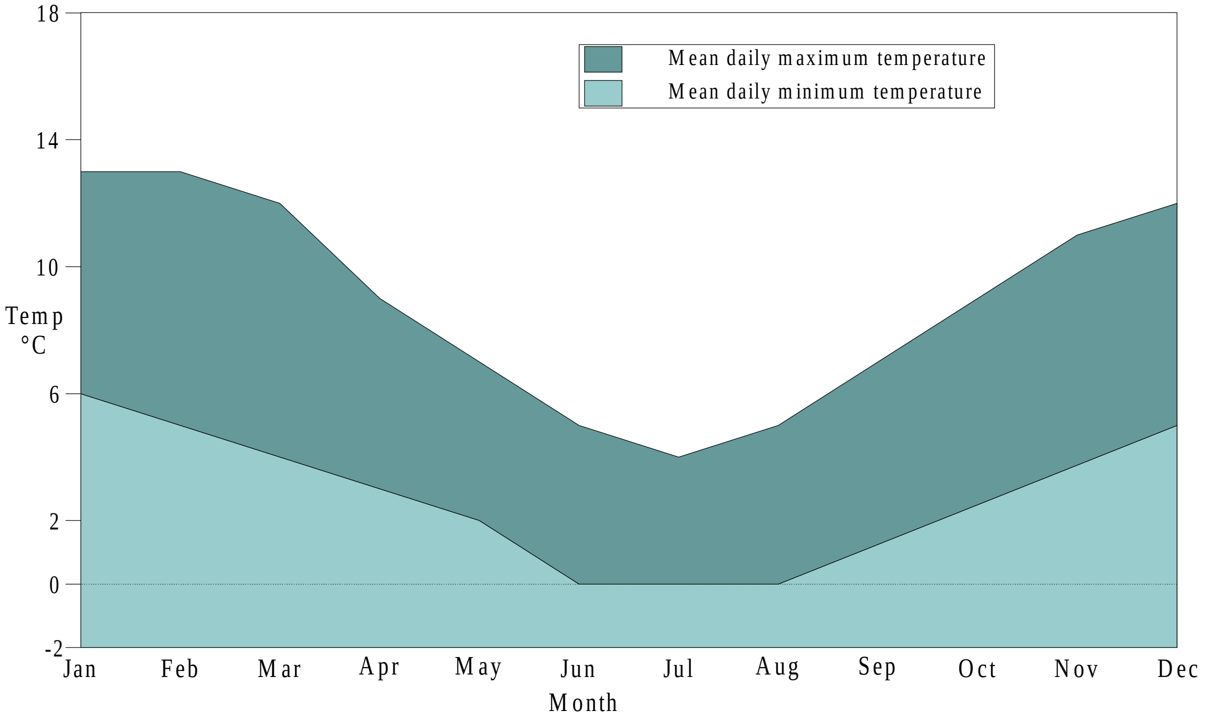
Precipitation levels generally decrease away from the coast to approximately 150 mm in the north, where the seasonal variation is small. Snow fall in the study area commonly occurs from June to October when most of the precipitation over this period falls in the form of snow. The most frequent snowfalls are usually experienced during August when they occur (on average) 11 days out of the month (Hydrographer of the Navy, 1993).

B.2.4 Air temperature

The Falklands climate has a narrow temperature variation range. Onshore air temperature values at Stanley Harbour, taken from 18 to 66 years of observations, are shown in Figure B.4. The mean daily maximum air temperature varies between 4°C to 13°C, from July (winter) to January and February (summer). June, July and August are the coldest months with mean daily minimum temperatures of 0°C, increasing to 6°C in January (Hydrographer of the Navy, 1993).

Temperatures over the open sea are less variable than over the land and are influenced by low sea temperatures and wind chill. The coldest period of the year is from June to September, although temperatures can vary significantly from one day to another. This is particularly true during the winter when the frequent frontal depressions can create rapid airstream changes.

Figure B4 Average temperatures at Port Stanley, over the last 60 years (Hydrographer of the Navy, 1993)



B.2.5 Humidity

Humidity over the sea remains relatively constant as it is closely related to air temperature. Small diurnal variations are observed with highest and lowest values occurring around dawn and in the early afternoon respectively. Seasonal variations are also observed with maximum values in winter. The mean annual relative humidity over the sea is approximately 75% north of 54°S and west of 60°W (Hydrographer of the Navy, 1993).

B.2.6 Cloud, fog and visibility

Cloud cover is represented in units of oktas which correspond to ⅛ of the open sky. Cloud cover over the open sea averages from 5 to 6 oktas. Over coastal areas the average amount of cloud cover is 6 oktas with minimum and maximum amounts around midnight and sunset respectively.

Fog cover over open sea areas is infrequent, averaging 2 to 5%. Visibility in the study area can also be reduced in periods of heavy cloud cover. During deep depressions the cloud base may fall to around 100 m or near sea level and visibility may be reduced to less than 3 km. In addition, rain squalls, drizzle and heavy snow may reduce the visibility further to less than 1 km. However, the fast moving weather systems in the Southern Hemisphere can produce rapid changes in visibility in the study area with the arrival of drier, colder air from higher latitudes.

B.3 Physical offshore characteristics

B.3.1 Bathymetry and topography

The Falkland Islands are located on an extension of the Continental Shelf of Argentina, known as the Falklands Plateau. The plateau is bounded to the north by the steep sloping Falklands Escarpment which leads down to the Argentine Basin, and to the south by a deep east-west trough, the Falklands Trough, which divides the plateau from the Burwood Bank.

The North Falklands Basin is located in a north-east gently sloping area, north of the Falkland Islands as shown in Figure 1.1. The area in which exploration drilling operations are to be conducted is situated at the edge of the Falklands continental shelf where water depths range from approximately 150 m to 500 m.

B.3.2 Geology and seabed sediments

The Falkland Islands are surrounded by four interconnected sedimentary basins of Mesozoic Cenozoic origin; the Falklands Plateau Basin to the east, the South Falklands Basin to the south, the Malvinas Basin to the west and the North Falklands Basin to the north (Ritchards *et al,* 1995).

Little data is available on the seabed sediments types of the continental shelf and slope areas. It is known that the Falklands embayment is included in the Argentine continental shelf which is characterised by a homogeneous layer of fine and medium sand. This constitutes the main component of the sediment and in some areas extends to a depth of 2 m (Bastida, Roux and Martinez, 1992). Other areas are known to have a high percentage of gravel containing small pebbles or bioclasts. Hard substrate areas are believed to be scarce, although it is recognised that these areas may be under represented in the sampling of Bastida *et al* (1992) because of the difficulty of sampling hard substrates.

Prior to the proposed drilling programme the four operators plan to undertake a seabed sampling survey. Results of the analysis of these samples will provide additional data on seabed sediment characteristics in northern licence Tranches.

B.3.3 Seismology

The Falkland Islands do not lie within a known seismic belt, it can therefore be assumed that the study area lies outwith any area of known regular seismic activity.

B.4 Oceanographic conditions

The operators have funded a survey which is presently underway to collect metocean data for the northern Tranches. Measurements of waves and currents are being made two sites, one in Tranche B (490 m water depth) and one in Tranche C (200 m water depth). In addition to wave current data temperature and conductivity profiles are being collected at selected sites and surfacing drifting buoys have been released. Only short term preliminary data is available at present. Further data will be made available in the final report due to be completed in June 1998. These data will be used to confirm the information presented in this Section.

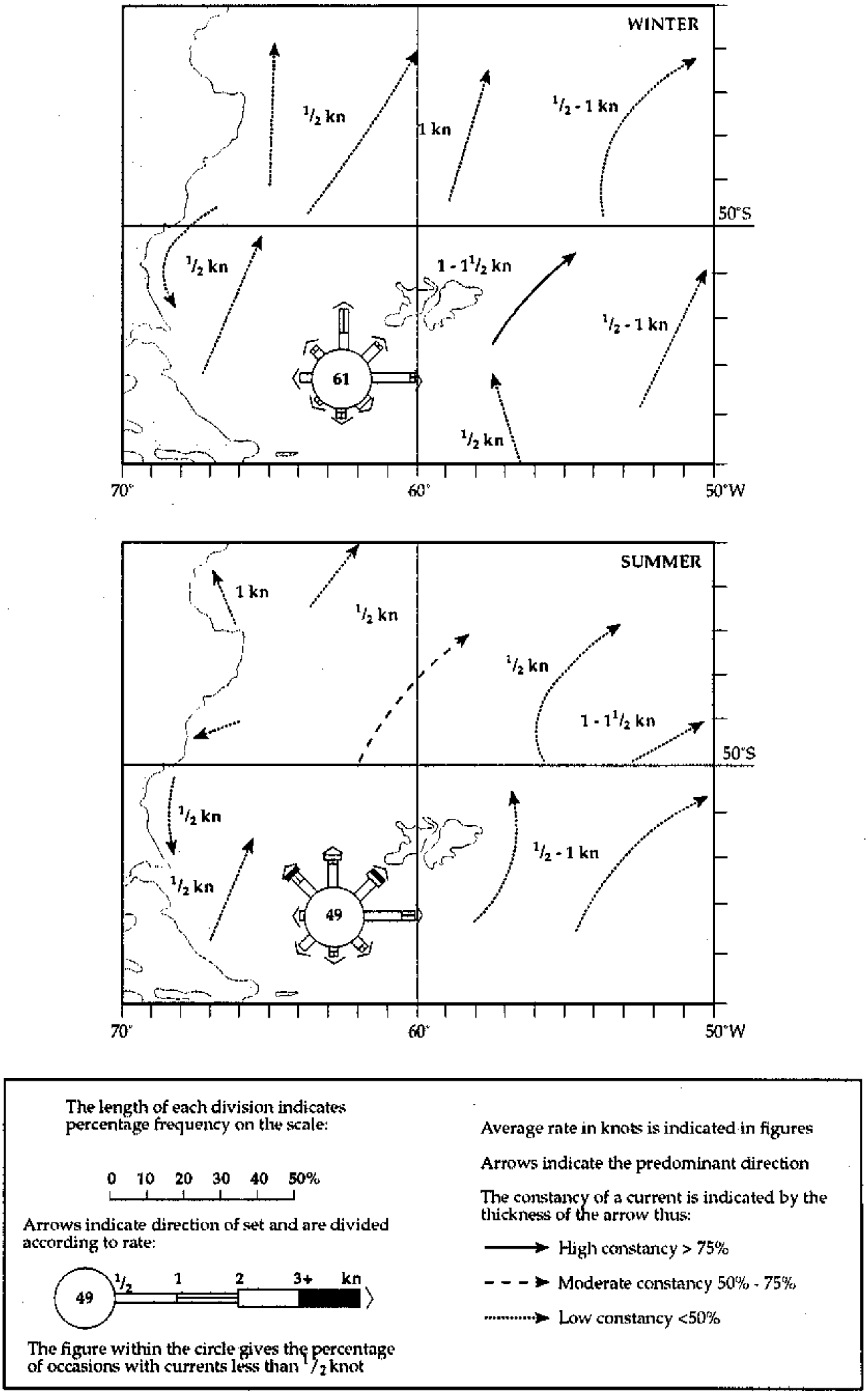
B.4.1 Currents and tides

The current regime in the study area is complex. This is the product of the west to east flow regime through the Southern Ocean, driven primarily by the Antarctic Circumpolar Current (ACC). The northern portion of the ACC is intensified as it flows around Cape Horn before deviating northwards towards Burwood Bank and the Falklands. The velocity of the flow at this point exceeds 60-70 cm/s (Zyranov and Severov, 1979). On meeting the Islands the current flow splits into two branches (east and west Falklands) which pass up either side of the land mass before reuniting in the waters to the north. The splitting of the current flow in this *way* forms an anticyclonic ring current around the Falkland Islands.

The average speeds of the diverging Falklands currents are less than 25 cm/*s* (0.5 knots) and 25-50 cm/s (0.5-1 knots) to the west and east respectively (Hydrographer of the Navy, 1993). From here the waters flow northwards to join the warm waters of the south flowing Brazil current, in a confluence known as the Subtropical front. As the currents converge they divert offshore at high current speeds (Rodhouse *et al* 1992).

The northern licence Tranches lie in the convergence zone of the Falklands currents, in the vicinity of an area of upwelling and high biological productivity on the continental shelf. It is expected that the general flow of the current in the study area is from south-north with a mean velocity of 0.5 knots, little seasonal variation and with a constancy of 50-75% (Figure B.5). A counter current in the area has been observed by Zyranov and Severov (1979), who report an E-W flow in winter of 20-30 cm/sec, and an ESE-WNW flow in summer of over 30 cm/sec.

Figure B.5 Predominant currents and current distribution in the Falklands area (Hydrographer of the navy, 1993



Proudman Oceanographic Institute have developed a current model for the Patagonian Shelf area. The data generated by this report indicates that in the area of the northern Tranches there is only evidence of a residual 0.1 m/s current flow off the edge of the continental shelf in the deeper Tranches. This flows in a north-west direction. In the shallower blocks residual current flow is negligible and water movement is dominated by tidal flows. This data provided by the model appears to confirm the present understanding of water flow in the offshore waters to the north of the Islands. At the time of writing this report metocean measurements are underway in the area of the Tranches to confirm the model predictions (results are likely to be available mid 1998).

In water depths of less than 200 m a considerable part of the water movement is tidal in nature, the proportion of which increases with decreasing depth. The tides around the islands are semi-diurnal with ranges from 0.3 to 3.5 m above chart datum (Hydrographer of the Navy, 1993). Tidal streams vary greatly in strength and direction in different parts of the islands. The main flood stream is NW going and divides off Lively Island (52°02' S, 58°30' W). One part flows WSW and W towards George Island and Cape Meredith (52°16' S, 60°38' W), then NW towards Cape Percival (51°50' 5, 61°21' W). The other flows NE towards Cape Pembroke (51°41' S, 57"43' W), N towards Volunteer Point (51°31' S, 57°45' W), then flows WNW, WSW and finally SSW before rejoining the NW going current (Hydrographer of the Navy, 1993). Flood streams enter the Falkland Sound from the S and N.

B.4.2 Waves

The wind regime in the study area can generate rough sea conditions in any season with waves of variable direction and height. The frequency of rough seas is relatively constant throughout the year, although there is a small increase in overall wave heights during the winter or with the passage of east moving depressions. Figure B.6 shows the wave height for the study area, compiled from ships observations over the period 1949 to 1995, recorded by the Meteorological Office. As can be seen from the Figure, the most frequent wave height over the period was 0-0.5 m, and approximately 70% of all waves recorded were under 2.5 m.

Wind and wave statistics based on satellite data, provided by Satellite Observing Systems Ltd show that although there is little seasonal variation in wind speed over the year, there is a seasonal effect on wave height. Figure B.7 illustrates the chance of exceeding a 2.5 m significant wave height in each month of the year. The Figure shows that the months of January and February are the only two consecutive months where the chance of a wave height greater than 2.5 m is less than 30%.

BA.3 Swell

The swell regime for the study area is shown in Figure B.8. Each swell rose shows the percentage of observations from each direction and the frequency of swell heights. The swell in July and January is from the south-west, to this are added components from the west and north-west during summer, and from the west and south during winter.

Figure B.6 Seasonal wave height frequency (Amerada Hess, 1996)

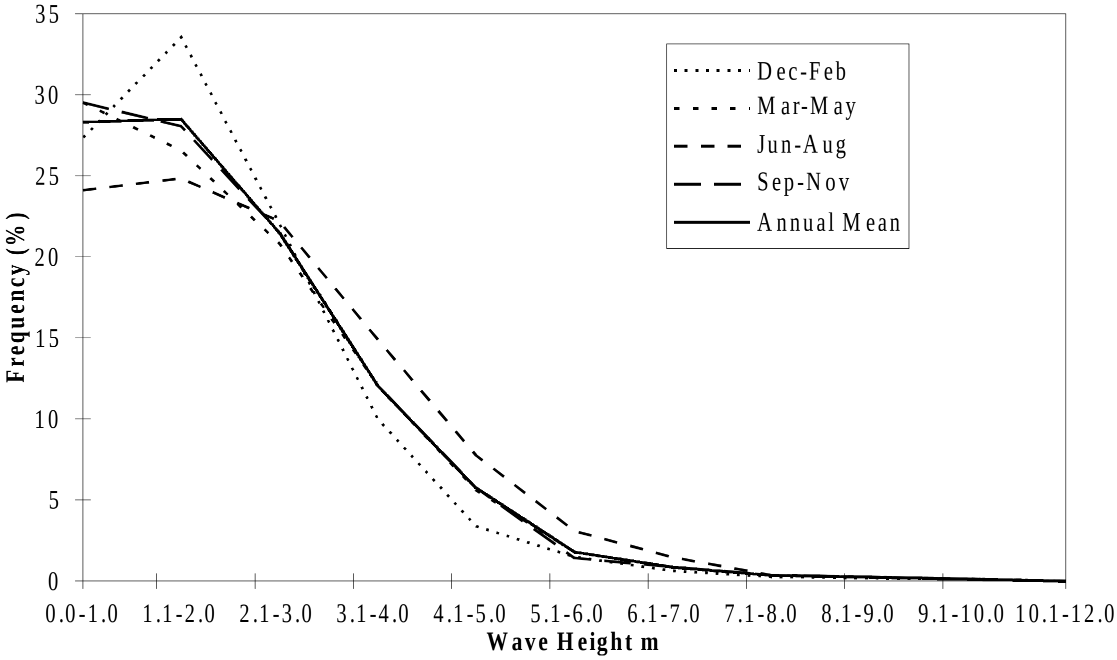


Figure B.6 Monthly exceedence of 2.5 m significant wave height (adapted from Shell, 1996)

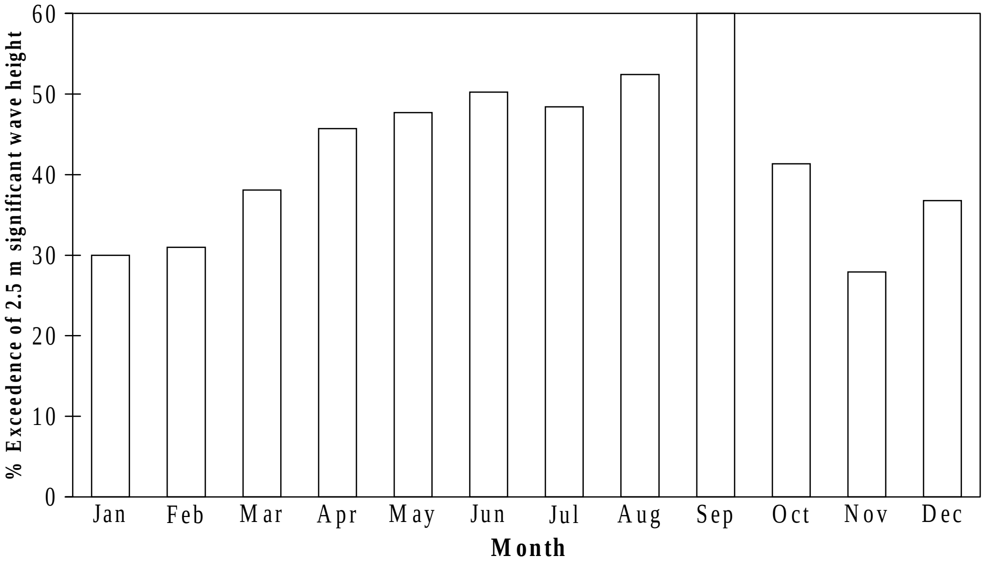
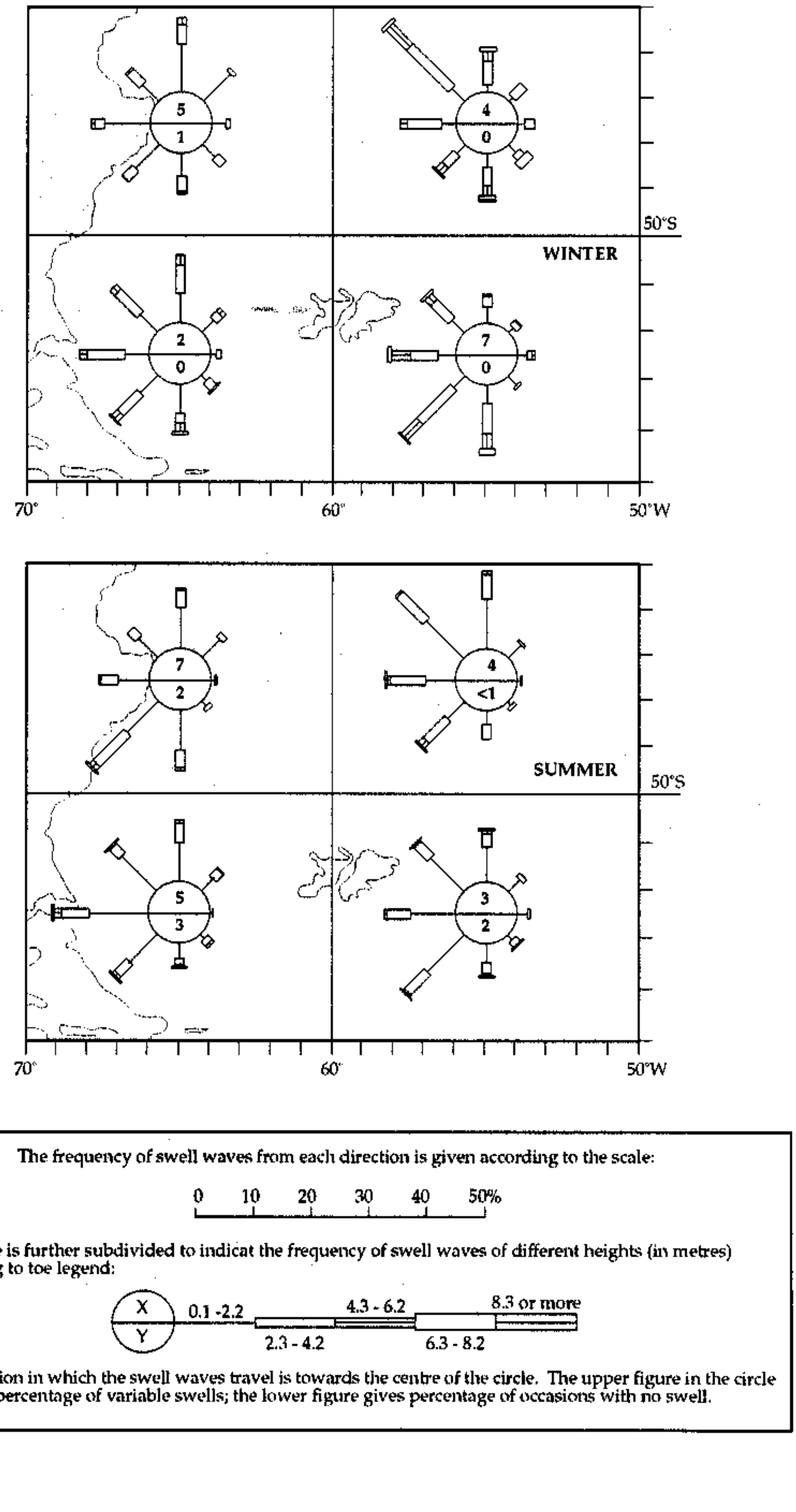


Figure B.8 Swell rose for the Falkland Islands area (Hydrographer for the Navy, 1993)



B.4.4 Sea surface temperature

In general, sea surface temperatures in the northern Tranches are at their lowest in late August and early September when mean temperatures are approximately 4-5 ' C. Temperatures increase during the summer to a maximum of 10 ' c in February. Within these seasons, sea surface temperatures can vary from one period to another, although this variability tends to be less in winter than during the summer. In addition, the current regime (refer to Section B.4.1) influences the sea temperatures in the area, particularly in winter, with the result that from September to March the mean sea surface temperature is approximately 1° C lower than the air temperature. During the summer the reverse is true and from May to August the mean sea surface temperature is approximately 1° C higher than that of the air (Hydrographer of the Navy, 1993).

B.4.5 Salinity

The salinity of the open sea around the Falklands is slightly lower than the mean ocean salinity of 350%◦, varying throughout the year between 33-34 %◦ (Hydrographer of the Navy, 1993).

B.4.6 Sea ice and icebergs

Sea ice is not encountered in the open sea of the northern Tranches. However, the Falkland Islands are situated within the northern limit of iceberg distribution (which extends to 40' 5) and there is a risk in encountering icebergs in the area of proposed exploration drilling operations. The Islands lie outside the limit of icebergs with an average spacing of 45 km, which extends up to approximately 55' 5. Most of the icebergs encountered in the open sea originate from the ice shelves of Antarctica. These become carried by the Southern Ocean Current in a general NE direction. Occasionally an iceberg has been carried by the Falklands current north towards the islands. Data sources on this subject are few although there have been reports in some years of icebergs 20 miles in length observed east of the Falkland Islands (Hydrographer of the Navy, 1993).

B.5 Biological characteristics

Specific research and data on the biological characteristics of the offshore Falkland Islands has tended to concentrate on the biology and lifecycles of the main commercial species. The following subsection provides a general description of the offshore biological environment in the study area, based on the information available at the time of writing this report. Where limitations of data exist, these are indicated in the text.

B.5.1 Plankton and marine algae

Planktonic organisms represent an important part of the marine ecosystem as they form the primary source of food for all higher levels of the marine food chain. The zone of upwelling on the continental shelf, in the vicinity of the northern Tranches, is a region of high biological productivity and of particular ecological interest for marine and coastal habitats.

Research on phytoplankton was carried out in a Discovery expedition which sampled a line of stations between the Falkland Islands and South America; reported in Discovery Report Vol. XVI (Ingram Hendley, 1937; cited in Brown and Root, 1997). This expedition focused on diatom populations. At the nearest station to the Falkland Islands, approximately 2-4 km offshore, 10 species of diatom were recorded. South of 44ºS there were relatively few species and a marked increase in diatoms, in comparison to the dominance of dinoflagellates, ciliates and crustaceans further north.

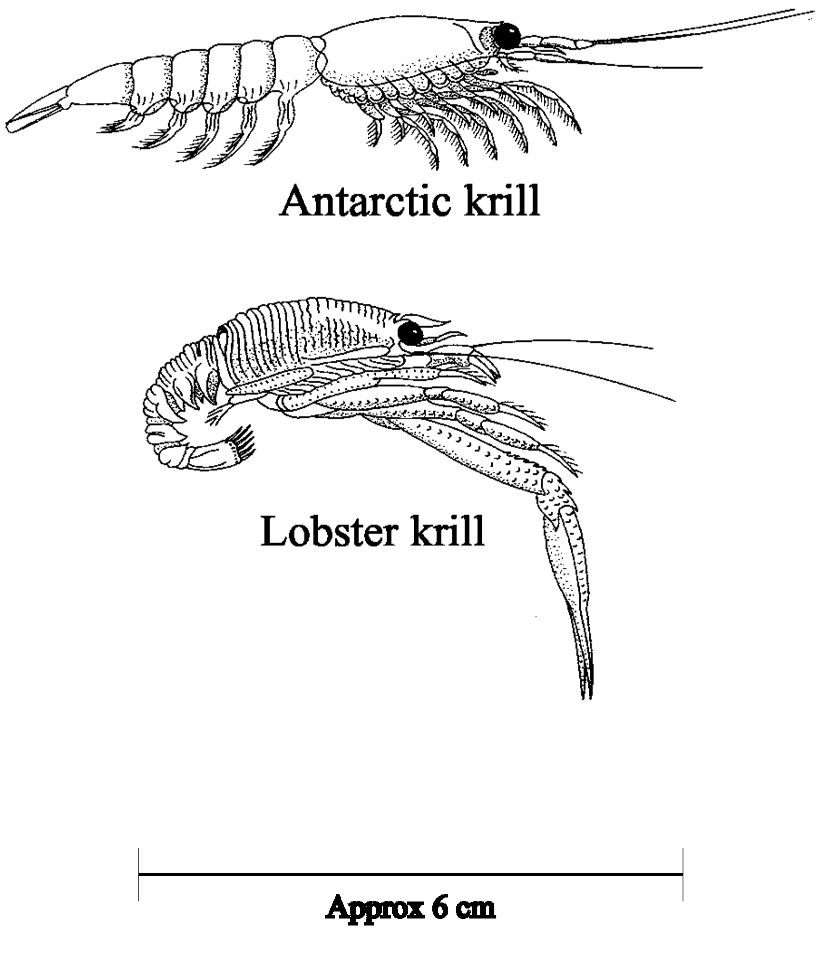
In offshore areas debris can be found on the sea surface, comprising primarily of rafts of floating kelp.

B.5.2 Zooplankton

Recent surveys of zooplankton of the south-west Atlantic Ocean have shown that the lowest zooplankton concentrations are found in the shelf seas surrounding the Falkland Islands (Rodhouse *et al*, 1992).

The key component of the Falklands offshore ecosystem is krill, pink-red pelagic crustaceans similar to shrimp. Within the Falklands ecosystem Antarctic krill (*Euphausia superba*) has become replaced by lobster krill (*Munida* spp). This latter species fills the same ecological niche as the Antarctic species and provides the main food source for the cetaceans, fur seals, penguins and many seabirds in the Falklands. For example, the king cormorant has been found to feed extensively on lobster krill, especially prior to hatching (Thompson, 1989). Lobster krill also represent an important food source for many of the commercial fisheries species, including squid.

Little is known about the distribution of krill populations. Krill are influenced by water circulation which influences their position and also affects nutrient supply and primary production. Hence large concentrations of krill may be found in zones of upwelling, regions of high biological productivity. Lobster krill are present in the waters surrounding the Falklands Islands for most months of the year. Although there is a noticeable increase in the populations of krill in the latter half of summer and in autumn when large swarms in the surface waters can form a reddish tint to the sea. From late March/ April many of the beaches become covered with stranded krill and the sediment becomes stained with a pinky residue (Strange, 1992).



B.5.3 Benthic macrofauna

The benthic macrofauna are animals that live on or within the seabed. They are normally separated from the smaller meiofauna by the definition that they are retained on a 0.5 mm (or sometimes a 1 mm) mesh. Where soft sediments occur, as in offshore sandy areas around the Falklands, they are principally infaunal, i.e. they live within the sediment, either burrowing through it or forming tubes within it. There are indications that in some areas north of the Falkland Islands, coarser gravelly sediments also support a diverse epifauna (animals living on the surface of the seabed).

The infauna is diverse and dominated numerically by polychaete worms, and also includes significant proportions of molluscs and crustaceans. The epifauna includes echinoderms (brittle stars, starfish and sea urchins), bryozoans, corals, sponges, ascidians and crabs. Examination of a photograph of a trawl sample (Figure 4.9b) obtained during the FFS *Walter Herwig* cruise of 1978 from approximately the eastern boundary of Blocks Band D showed it to be dominated by numerous tall sea pens and various echinoderms. Community composition and structure at individual locations is likely to be influenced mainly by depth and sediment type.

An analysis of macrofaunal samples obtained from 75 stations during the period 1978-1979 was used to describe the main assemblages found throughout the Argentine continental shelf, including the seas around the Falkland Islands (Bastida *et al*, 1992). Although fifteen animal phyla were identified over the survey area, analysis of community structure was based only on the molluscs, bryozoans and echinoderms, which were each present in most samples. Polychaetes were noted as being ' relatively abundant' , but were not included due to insufficient taxonomic knowledge. Experience from similar sediments in other shelf areas suggests that polychaetes may make up 50% or more of the macrofauna. Two of the sampling stations are of direct relevance to the present study area, lying to the west of Tranche F in 178 and 188 m water depth. In addition, two stations lie between the northern Tranches and the coast of the Falkland Islands, at depths of 152 and 154 m. The results of a cluster analysis divided the Argentinean continental shelf into three areas (Figure B.9a). The species assemblages at the four stations close to the Falkland Islands showed consistency with others (area C) occupying a large area influenced by the cold and productive waters of the Falkland Current in the deeper waters (generally >1(x) m) of the continental shelf. A total of 152 species were found in this area, although this only represents a part of the fauna, as discussed above. Over 16% of the species found were exclusive to this deep-water area, which was richer in terms of number of species than the shallower areas of the shelf.

Figure B.9a Faunal groupings defined by cluster analysis of stations (Source: Bastida et al, 1992)

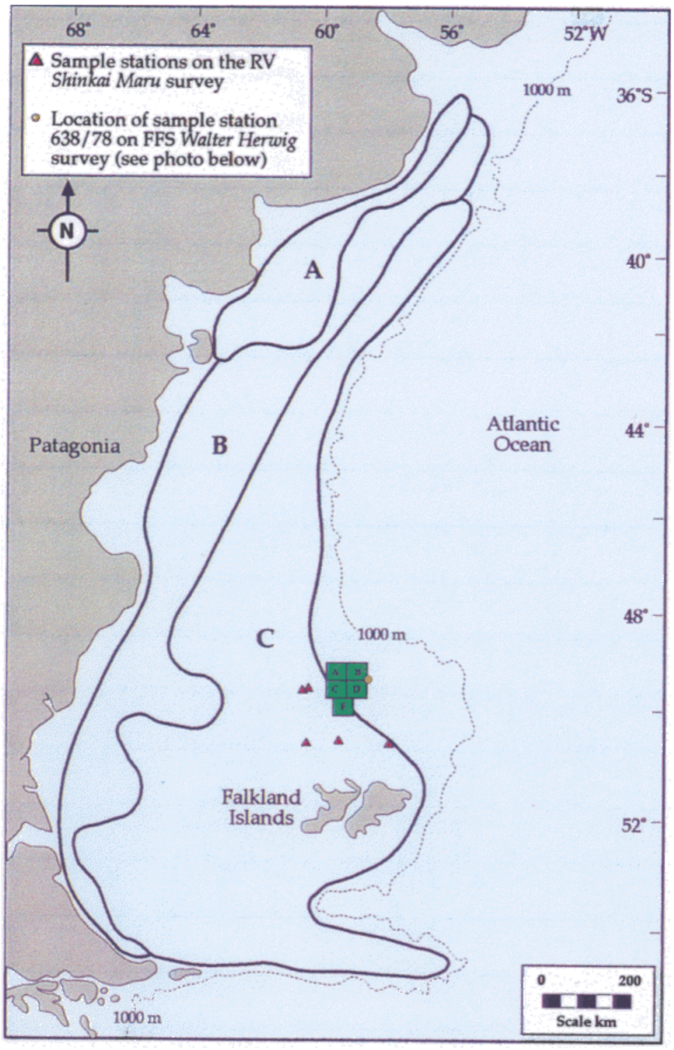
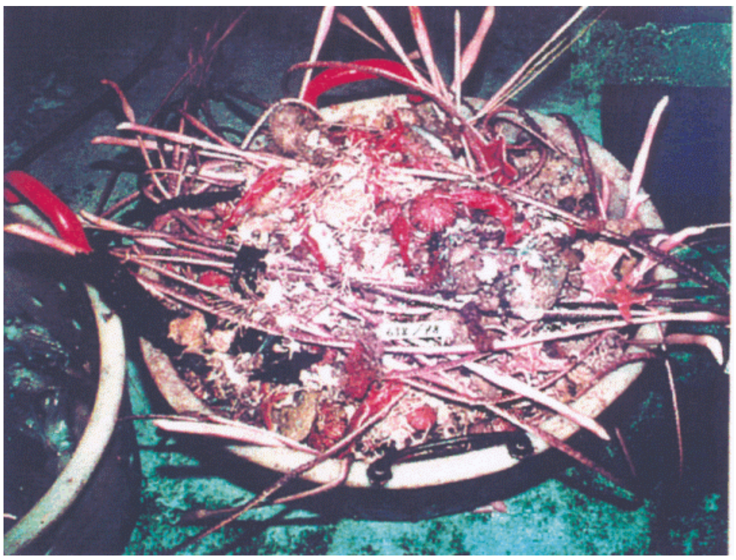


Fig B.9b Epifauna recovered from sample station 638/78 (FPS Walter Herwig survey) Photo by Dieter Walossek)



Qualitative data on larger epifauna are available from six stations sampled in the area of the shelf break (203-232 m) south-east of Tranche F, sampled by Rockhopper trawl during a research cruise conducted in November 1994 by the Falkland Islands Fisheries Department. These suggest a degree of spatial heterogeneity of sediment and community type in this area. Two of the stations yielded catches of the scallop *Chlamys patagonia*, associated with soft seabeds, while another was characterised by the presence of sea urchins and large sponges, indicating hardier (rockier) ground (Conor Nolan, pers comm). Other invertebrate species caught included the crab *Peltarian Spinulosum* and prawn *Thymops birsteini*.

Intensive sampling of the benthos all over the Argentine continental shelf, from Brazil down to the Falklands and from coastal areas down to the beginning of the continental slope, was carried out by benthic trawl during cruises of the German FFS *Walther Herwig* conducted in 1966, 1968, 1971 and 1978. The animal material collected is housed at the Hamburg Zoological Museum, and has given rise to numerous publications on different animal groups encountered, including ascidians, corals, polychaetes and molluscs. ' Antarctic' fauna, including the area up t0 and around the Falkland Islands, has been studied based on collections taken by cruises of the USNS *Eltanin* (1962-66). The work confirmed a high diversity and abundance of polychaetes at all depths, and indicated that they are important in turning over the sediments and in supporting larger animals which are bottom-feeders (Hartman, 1967). Several new genera and species were found only in the Falkland Islands, including the scaleworm *Dilepidonotus falklandicus* and orbiniid polychaete *FaIkIandiella annulata* (both found at depths of between 646 and 845 m), although it is not known to what extent these species may occur further north on the Argentinean shelf. These depths were also characterised by large numbers of the quill worm *Hyalinoecia tubicola.* Abyssal depths (>2,000 m) around the Falklands exhibited a fauna similar to that found in areas further south.

In order to increase the knowledge on the benthic habitats in the vicinity of the Tranches north of the Islands the operators have committed to undertake a joint industry seabed sampling survey around their proposed well locations prior to drilling operations. The samples collected during the survey will be analysed for benthic species in addition to other sediment characteristics.

B.5.4 Fish stocks

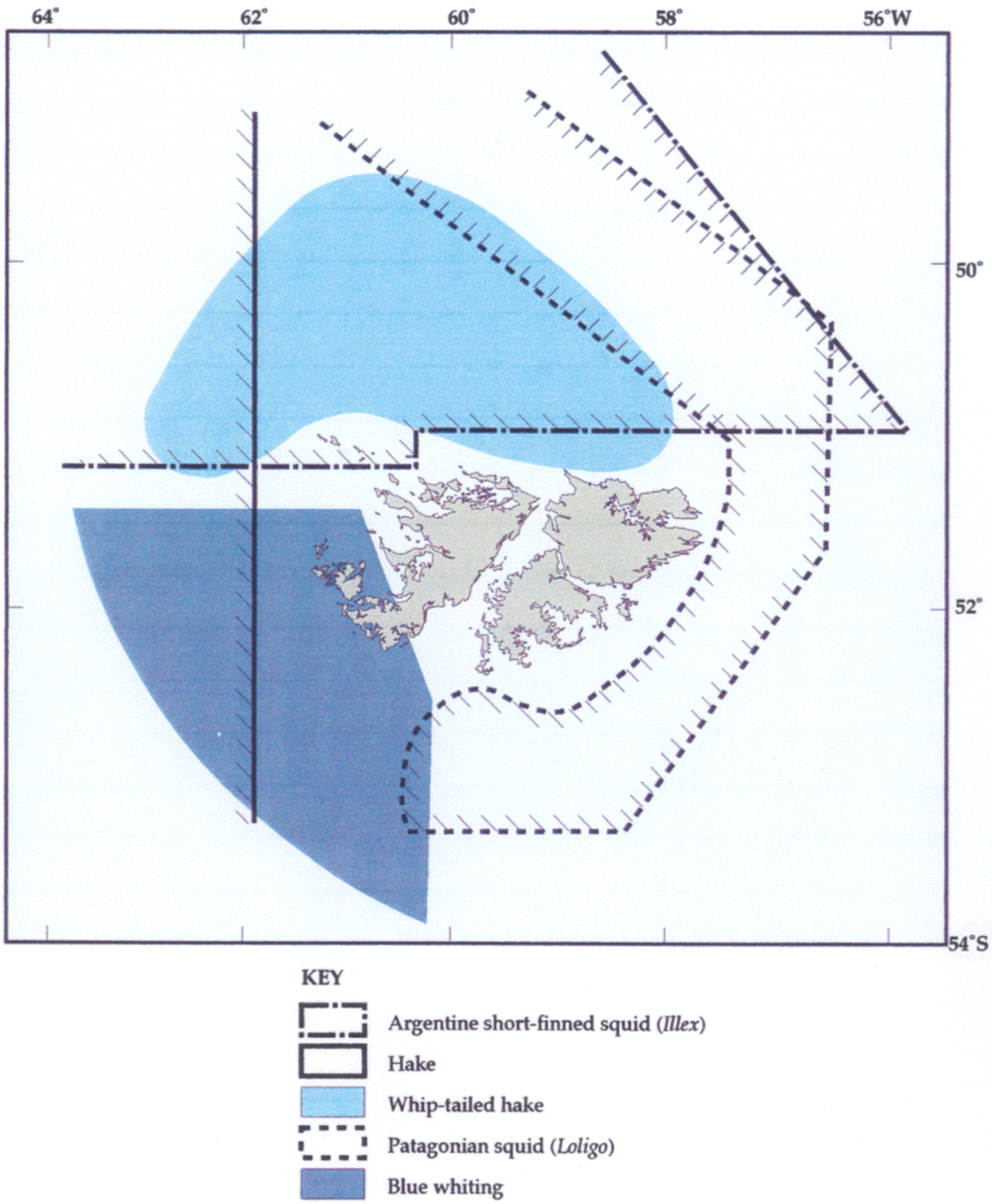
The majority of data on fish stocks in Falklands waters have come from fish catch statistics or relate to those species of commercial value.

Demersal species

Demersal fish stocks in the offshore Falklands and study area are comprised of the common hake (*Merluccius hubbsi*), patagonian hake (*Merluccius aulstraIis*), hoki or whiptail hake (*Macruronus magellanicus*), southern-blue whiting or southern poutassou (*Micromesistius austraIis*), kingclip (*Genypterus blacodes*), skate and ray species, Antarctic cod (*Notothenia* spp) and red cod or salilota (*Salilota austraIis*). Figure B.10 shows the distribution of the main fish species off the Falkland Islands.

Hake

The patagonian hake and the common hake are similar species and often regarded together in catch statistics. The common hake is distributed mainly in the offshore waters to the north of the Falklands as opposed to the Patagonian hake, which is found to the south of the islands. The hoki or whiptail hake population is also concentrated in the open sea to the north of the Falkland Islands. Hake undertake diurnal feeding migrations and are found near the seabed during the day and towards the surface at night. Spawning of the common hake and Patagonian hake is thought to take place from June/ August and September /October respectively. Spawning grounds and nursery areas of the species have not been identified, although it is believed that they lie outside the Falkland Islands Interim Conservation and Management Zone (FICZ) and that recruitment within Falklands waters is based upon migration.


64°
62°
60°
58°
56°W
50°
52°
54°S
KEY
Argentine short-finned squid (*Illex*)
Hake
Whip-tailed hake
Patagonian squid (*Loligo*)
Blue whiting

Blue whiting

Southern blue whiting are a food source for the Patagonian hake and as such the two species show a similar distribution. Like hake, whiting undergo a diurnal migration where they ascend away from the seabed during the night. Southern blue whiting are found extensively around the Falkland Islands from approximately 45.S to 55.S and it is estimated that as much of 90% of the stock is within the FICZ (Grzebielec and Trella, 1994). The fish feed extensively on krill and small crustaceans but also feed on copepods, amphipods, octopus and small fish.

The southern blue whiting of the Falkland-Patagonian region are characterised by the fact that the females are larger than the males and grow more rapidly to reach sexual maturity at a larger size (Lisovenko, Barabanov and Yefremenko, 1980). The species migrate from deeper to shallower waters to spawn in the winter to spring period, from August to September. In recent years it has been observed that the greatest concentration of young fish have been found from August to October in the region south-east of the Falkland Islands. This suggests that the spawning and nursery areas are located to the south-east of the Falklands outwith the present study area (Lisovenko, Barabanov and Yefremenko, 1980). After spawning the fish migrate to deeper water, dispersing south and west over the Patagonian shelf.

Cod

Antarctic cod are one of the most common fish in Antarctic and subantarctic waters, and 16 species have been recorded in Falklands waters. Of these the dominant species are *Notothenia ramsayii* (no common name) and yellow belly (*Notothenia macrocephala*). These species are common in nearshore waters in summer, but migrate to deeper waters during the winter.

Pelagic species

Little data is available on pelagic fish stocks offshore the Falkland Islands.

The Falkland herring (*Sprattus fuegensis*) is known to be present, although there are no biomass estimates available for the population of either of these species. It is also believed that small numbers of tuna (*Thunnus* spp) may pass through Falklands waters. Little is known about the movement of this species although the stranding of individuals suggests that relatively large populations are present and may travel along migratory routes close to the islands.

Important fish stocks can be present in the northern Tranches, and that at times these stocks can include commercially important species. Fishing effort in the study area of the northern Tranches is discussed in Section B.9.1.

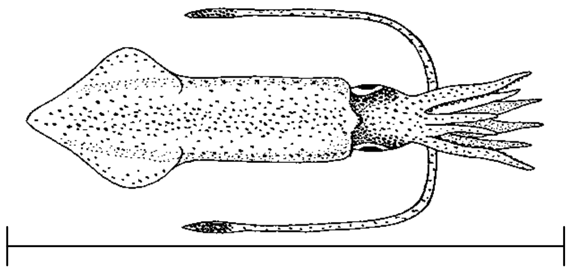
B.5.5 Squid

Three main species of squid are found in Falklands waters; the Patagonian or common squid (*Loligo gahi*), Argentine short-finned squid (*lllex argentinus*) and the Short fin, Sevenstar flying or redsquid (*Martialia hyadeshi*). Generally cephalopods are short lived with a life span of approximately one year and a monocyclic sexual system. This means that if breeding is synchronous, the generations may not overlap and no spawning stock of animals is carried over from one year to the next. In this case annual recruitment contributes almost the entire stock of squid, the abundance of which may vary significantly from year to year (Pierce and Guerra, 1994).

Patagonian squid (*Loligo*)

Patagonian squid and are common in waters off the east coast of the Falklands and throughout the study area, to depths of about 400 m (Strange, 1992). Studies on the food type of the Patagonian squid has shown that they feed primarily on one species of crustacean, belonging to the genus Euphasia (Guerra, Castro and Nixon, 1990). The squid collect in very large numbers and are one of the smallest squid species, reaching a maximum size of 32 cm. The maximum life span of this species is a little over one year for males and approximately one year for females (Hatfield, 1990).

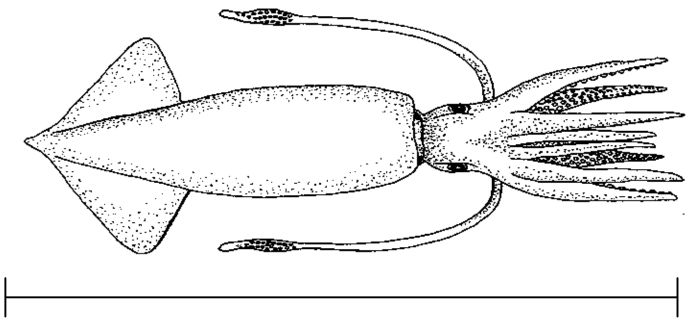
There are two main populations of Patagonian squid, distinguished by their spawning period. One population spawns around March/April (autumn) and the other in September /October (spring). Of the two populations the spring spawning group is the larger. There is evidence to suggest that the species spawns in shallow waters where the female squid produce large amounts of gelatinous spawn on the sea bottom, after which both adults die. Once hatched the next generation migrate offshore in schools, where they feed grow and mature before returning to the shallow spawning grounds to complete the life cycle (Hatfield, 1996).



approx. 32 cm (Strange, 1992)

Argentine short-finned squid (*Illex*)

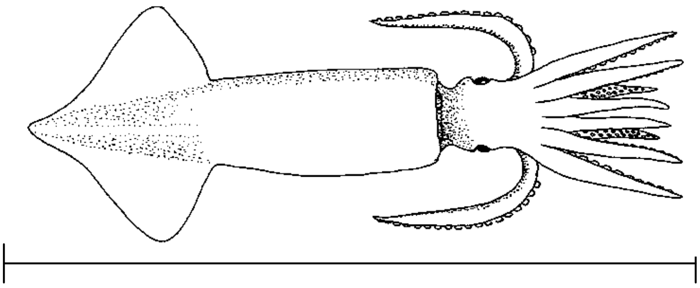
The Argentine short-finned squid are active predators feeding on krill, fish and other squid. Like the Southern blue whiting their distribution is closely connected to that of the hake, their main predator. The squid spawn in the winter months in grounds to the north of the Patagonian shelf. The juveniles develop in the Falklands current or Brazil current and feed over the shelf area. In late summer the squid migrate south to the northern Falkland waters, against the flow of the Falkland current. In the summer/early winter the squid return north to spawn in May after which they die at around one year old.



approx. 40 cm (Strange, 1992)

Short-fin squid

The short-fin squid species may also be found in Falklands waters in the study area. The population is believed to be particularly numerous near South Georgia (south of 50.S) and in waters south of Tierra del Fuego (55.S) (Strange, 1992). The species is of a similar size to *Illex* with a mantle length of approximately 40 cm. Little is known about the life cycle of the species.



approx. 40 cm (Strange, 1992)

B.5.6 Shellfish

Little data exists on the distribution and abundance of shellfish species of the Falkland Islands. Species within the shallow inshore waters of the islands include the softshell red crab (*Paralomis granulosa*) and the king crab (*Lithodes antarcticus*). Red crab inhabit relatively shallow water ranging from 10-40 m depth. The species prefers sheltered environments and occurs over a wide variety of sediments from hard mud to stones and mussel beds, although it generally avoids soft mud and rocky substrates (Hoggarth, 1993 cited in Brown and Root, 1997).

The greatest concentrations of red crab are found in kelp beds along the south-east coast of the Falkland Islands on Lafonia. The species are believed to move from the shallow water environment to deeper waters in spring to moult and then mate. The eggs of the red crab are thought to hatch between August and October in the summer (Hoggarth, 1993 cited in Brown and Root, 1997).

B.5.7 Marine mammals

The waters of the Falkland Islands host a wide variety of marine mammals which belong to two main groups, cetaceans (whales, dolphins and porpoises) and pinnipeds (seals). The cetaceans are comprised of seven species or subspecies of the sub-order Mysticeti (whalebone whales) and 16 species of the sub- order Ordontoceti (toothed whales, dolphins and porpoises) which are listed in Table B2.

There are no complete studies or data available which detail the offshore abundance or distribution of cetaceans in the South Atlantic. The most comprehensive accounts of whales and dolphin movements have been compiled from ships sightings, strandings and commercial whaling records.

It is probable that small cetaceans (such as dolphins and porpoises) may be found all around the Falklands as they feed upon squid and fish. Baleen whales (Mysticeti) feed on small shoaling fish or swarms of krill and may be found where high concentrations of lobster krill are located, such as the continental shelf edge including the area of the northern licence Tranches. Large toothed whales, such as the sperm whale feed on large squid and are likely to frequent deeper water off the continental shelf.

The distribution of some species may be seasonal and dependant upon the movement of their prey or migration patterns. For example, pods of killer whales have been observed to follow the breeding stages of seal colonies. It is also known that humpback whales (a large baleen whale species) frequent the waters of the Falklands as they migrate to and from their calving grounds off Brazil and Africa in spring and autumn.

In view of the absence of any detailed data and the location of the northern Tranches the operators plan to undertake a seabird and cetacean survey covering the area licensed.

B.5.8 Offshore concentrations of seabirds

The Falkland Islands have a rich seabird avifauna comprising 22 species (excluding ducks and waders but including gulls and terns) which have an affinity with the Subantarctic and adjacent cold temperate regions (Croxall, McInnes and Prince, 1984). There is however, virtually no data detailing the distribution or behaviour of seabird species in the offshore waters of the Falkland Islands. Many of the data sources are concerned with the location and status of onshore breeding locations within the Islands with little information available on the species once they have left the inshore sites.

In order to increase the understanding of the offshore distribution of seabird species, the Falkland Islands Exploration and Production Environmental Forum is considering an offshore seabird and cetacean survey.

In the absence of any such data at the present time Section B.6.2 of this report describes coastal sites of importance for the main bird species, the status and significance of these birds and provides general details of the species which may be encountered in the offshore study area.

B.6 Coastal and inshore characteristics

Coastal and inshore areas of the Falkland Islands will not be subject to impact from routine exploration drilling activities. The only potential impact would be in the unlikely event of a large oil spill.

B.6.1 Nearshore and coastal habitats

The Falkland Islands are situated in the South Atlantic, between 51° 00'S -53°00'S and 57°00' W-62°00' W approximately 300 miles (483 km) from the South American mainland. The archipelago comprises two main Islands (East and West Falkland) and over 700 smaller islands, with a total area of approximately 4,700 square miles (12,173 km^2) (FIG, 1995). An environmental baseline survey of coastal and shallow marine habitats of the Falkland Islands was undertaken during 1995 and 1996. The following sub-sections details the main environmental features of the coastal and nearshore habitats.

Morphology and topography

The Falkland Islands are composed of Palaeozoic and Mesozoic sediments which have undergone considerable folding to produce a generally rugged and hilly landscape. The ridges of hills are bounded by generally low and rocky coasts. The coastline of the islands is deeply indented and has a number of submerged coastal valleys (rias) and inland waters which provide well sheltered natural harbours with good holding ground. The shoreline of West Falkland is bounded by steep cliffs to form a ridge which runs along the Falkland Sound.

Table B.2 Cetaceans of the Falkland Islands

Sub-order	**Mysticeti: Whalebone whales**		**Status**	**(1)**
Family	**Neobalaenidae: pygmy right whales**	*Caperea marginata*		
	pygmy right whale			K
Family	**Balaenidae: right whales**			
	southern right whale	*Eulabaena australis*	breeding	V
Family	**Balaenidae: rorquals**			
	blue whale	*Balaenoptera musculus*		E
	fin whale	*B.physalus*		V
	sei whale	*B.borealis*	migrant	V
	minke whale	*B.acutorostrata*		K
	humpback whale	*Megaptera novaeangline*	migrant	V
Sub-order	**Ordontoceti: Toothed whales and dolphins**			
Family	**Physeteridae: sperm whales**			
	sperm whale	*Physeter catodon*	migrant	K
Family	**Ziphiidae: beaked whales**			
	Arnoux's beaked whale	*Beradius arnuxi*		K
	southern bottlenosed whale	*Hyperoödon planifrons*		K
	Cuvier's beaked-whale	*Ziphius cavirostris*		K
	Layard's strap-toothed whale	*Mesoplodon layardii*		K
	Gray's beaked whale	*M.grayi*		K
	Hector's beaked whale	*M.hectori*		K
Family	**Delphinidae: dolphins**			
	killer whale	*Orcinus orca*	breeding	K
	long-finned pilot whale	*Globicephala melas*	breeding	K
	dusky dolphin	*Lagenorhynchus obscurus*		K
	hourglass dolphin	*L.cruciger*		K
	Peale's dolphin	*L.australis*	breeding	K
	bottlenosed dolphin	*Tursiops truncatus*		K
	southern right whale dolphin	*Lissodelphis peronii*		K
	Commerson's dolphin	*Cephalorhynchus commersonii*	breeding	K
Family	**Phocoenidae: porpoises**			
	spectacled porpoise	*Phococena diopdtrica*		K

(1) IUCN Category.
E Endangered. Survival unlikely if casual factors continue.
V Vulnerable. Likely to become endangered if casual factors continue.
K Insufficiently known. Suspected to be rare, vulnerable or endangered.

Intertidal habitats

The intertidal habitats of the Falkland Islands range from rocky shorelines and boulder shores which are subjected to high energy waves, moderately exposed stony shores, sandy and muddy shorelines characteristic of low energy environments. With the exception of seaweed flora, little information exists on the shallow marine environment of the Falkland Islands. To date there has not been a complete survey of the coastline around the islands, although Falklands Conservation have surveyed selected locations around the islands.

Exposed shores

The high energy, exposed nature of the rocky shores, boulder shores and steeply sloping cliff shorelines excludes many of the species which inhabit the lower energy environments. The substrate provides a secure attachment for species such as mussels and limpets and for marine algae. Boulder shores and rockpools provide shelter for and prevent desiccation of marine organisms at low tide, and thus foraging grounds for bird species. High energy environments do not provide suitable nesting sites for birds, except at upper shore levels or on steep cliffs where exposure is reduced.

On more sheltered coastlines stony shorelines with an average diameter of between 2- 300 mm occur. The smaller stones are highly mobile and the shifting nature of the beach prevents many organisms or algae from securing a foothold as well as reducing the availability of shelter. The lower degree of exposure enables some bird species to nest on the upper shore, although the majority prefer more sheltered locations.

Sheltered shores

Low energy environments characterised by sandy and muddy shores can support a wide variety of marine organisms and provide rich feeding grounds and nesting areas for bird species. Sandy beaches are found along the northern and eastern coasts of East and West Falkland and are often backed by dune systems which form the transition into the terrestrial environment. lakes and ponds are also often found inland of these beaches and there are numerous inland freshwater bodies, especially in poorly drained areas.

Nearshore vegetation

Marine algae

The sublittoral environment of the Falkland Islands is relatively rich in species and can be divided into three main zones, each supporting a number of different marine algae. The first of these, the offshore zone, extends from depths of 4-30 m (Strange, 1992). This zone supports two of the most common forms of macroalgae in the islands, the Tree Kelp (*Lessonia flavicans*) and the Giant Kelp or Basket Kelp (*Macrocyctis pyrifera*). The Giant Kelp is the most widespread and most common species of marine algae in the Falkland Islands. It forms a wide belt of growth in the offshore zone and in some regions may extend up to 0.6 miles (1 km) or more (Strange, 1992). The plant attaches itself to boulders and rocky substrates by hold fasts and has small gas filled bladders in the long fronds that maintain buoyancy. These fronds may grow to over 60 m in length and can act as a buffer for the shore by dissipating wave and current energy (Strange, 1992). The kelp forms a very important habitat and nursery area for marine species and a feeding and foraging area for a variety of birds and mammals, including penguin and seal species (refer to Sections B.6.7 and B.6.8).

Tree Kelp is an abundant kelp found on most open coasts. The algae is represented in the Falkland Islands by three species; *L.flavicans, L.frutescens* and *L.nigrecens.* The distribution of these species is not known, although it is believed that *L.flavicans* is the most common (Strange, 1992). In general *L.flavicans* is found in deeper water and is the only species that is not visible from the shore. Mature plants may reach several metres in height with a large trunk-like stem. Beds of Tree Kelp are often composed of dense masses of stems and leaves which form a fringe zone between the low water mark and the zone occupied by Giant Kelp. Like the Giant Kelp, Tree Kelp provides a valuable habitat for marine life.

The fringe zone extends from the extreme low water mark to offshore waters about 3-4 m deep. Two large forms of seaweed grow within this zone, *Lessonia* and *Durvillea* spp. The seaweed growing on the upper reaches of the fringe zone is frequently exposed at low tide.

The intertidal zone extends from the fringe zone and consists of the middle shore between average high and low water levels. This area supports some of the smaller algal species which are exposed during each tidal cycle (Strange, 1992). This zone also supports other seaweed species such as *Iridaea* spp, a brown- black algae which forms dense patches or beds on stony substrates and Ulva spp, a green algae commonly known as sea lettuce. These species provide a valuable food source for grazing bird species such as Kelp Geese and occasionally Vpland Geese.

Coastal vegetation

The flora of the Falkland Islands is diverse, comprising 92 introduced species and 164 flowering plants and vascular flora known to be native to the islands, 12 of which are endemic (WCMC, 1994). The following subsections describe the main coastal vegetation types of the Islands.

Tussock grass

Tussock grass (*Poa flabella*) is the most important vegetation type in the littoral zone, that is the area extending from the high water mark of normal tides, inland. Much of this area is influenced by the sea and is subject to sea spray, occasional flooding and storm action. Tussock grass is of considerable ecological importance in the islands. The vegetation is crucial to the breeding activities of many of the seabird species and forms a valuable habitat for many others, as well as for some seal species and invertebrate fauna (Croxall, McInnes and Prince 1984).

Originally all coasts of the Falkland Islands had an extensive belt of tussock grass standing 3-4 m high (Croxall, McInnes and Prince, 1984). However, the introduction of species such as rabbits, cattle, sheep, feral goats and pigs to the main islands has resulted in the large scale destruction of this habitat. Today tussock grass is typical of the smaller, offshore islands. The plant is generally restricted to areas below 200 m elevation and within 300 m of the coast (Croxall, McInnes and Prince, 1984). Strange, 1992 estimates that of an original area of tussock grass believed to be 54,788 acres (22,181 ha) prior to settlement of the islands, only 10,272 acres (4,159 ha) remains. This represents a loss of over 80% of this type of habitat.

Two main plants may be found growing in association with tussock grass, sword grass or cornflag (*Carex trifida*) and wild celery (*Apium australe*). Sword grass is usually confined to the outer perimeter of tussock grass, growing to a height of between 0.5-1 m (Strange, 1992). The abundance of sword grass in the Falklands has been reduced to its present rare status, probably through the introduction of livestock and is only found on some of the outer tussock islands. Wild celery is a perennial herb which prefers damp coastal regions and commonly grows with tussock grass. Within the shelter of tussock the herb may reach heights of up to 1 m. In exposed situations it is generally grows to only 10-30 cm high (Strange, 1992).

Tussock heath formation

This plant community is formed where open or sparse tussock grass is interrupted by plants of oceanic heath formation and is typical of the smaller offshore islands. These communities generally lack dwarf shrubs, ferns and White Grass which may be found in some oceanic heath formations. The plants that may be present within tussock heath formation include species such as native woodrush (*Luzula alopecurus*), yellow daisy (*Senecio littoralis*) and creeping pratia (*Pratia repens*) which may be dominant or co-dominant. Less commonly, Mountain Blue Grass (*Poa alopecurus*), Blue couch-grass (*Agropyron magellanicum*), Marsh Daisy (*Aster vahlii*) and Wild Strawberry (*Rubus geoides*) may also be found depending upon environmental conditions.

Oceanic heath

Oceanic heath is the dominant vegetation type in the Falklands and most of the islands are covered by some plant communities from this formation. The heath provides shelter for a variety of flowering plants, invertebrate species and inland birds and may colonise areas where tussock grass has been destroyed. The majority of the plants integrate and produce a complex variety of facies however, the communities can be generally divided into two types depending upon the dominant vegetation; dwarf shrub heath and grass heath.

Dwarf shrub heath appears as irregular patches of dark brown vegetation, generally formed by Diddle-dee or Red Crowberry vegetation (*Empetrum rubrum*) on well-drained, drier areas such as hard peat. Diddle-dee is commonly associated with other shrubs such as Mountain berry (*Pernettya pumilla*), Christmas bush (*Baccharis magellanica*),*dark* green mats of *Astelia* and ferns (*Blechnum* sp.).

Grass heath is dominated by rough grasses such as the light yellow White Grass. White grass is the most common and widespread of the vegetation types below 100 m forming dense meadows on level and undulating land.

B.6.2 Coastal concentrations of seabirds

In general, seabirds are more abundant on West Falkland than on East Falkland, particularly if the southern island of Beauchene is excluded. The large number of small, undisturbed islands in the area host important populations of Black-browed albatross, thin-billed prion and most other Procellariiformes. Petrels, such as White-chinned petrel, great shearwater and Grey-backed storm petrel, as well as gull and tern species are confined to or more abundant on East Falkland, many with important breeding sites to the east or north-east of the Islands. This may be due to the greater extent of flat coastal land which is preferred by the species (Croxall, McInnes and Prince, 1984).

Shags, Gentoo penguins and Magellanic penguins feed predominantly inshore and are fairly widely and evenly distributed along the coast. Most of the remaining breeding species of the islands, with the exception of Southern Giant petrels and Falkland Skuas which are linked to seal and penguin colonies, are highly colonial and relatively pelagic away from the coast (Croxall, McInnes and Prince, 1984). The abundance of these species along the west coast of West Falkland may be linked to the distribution of suitable feeding grounds and the productive marine shelf communities of the Falkland Islands and South America. These shelf communities are located within 10o km of New Island and approximately 50 km north of Steeple Jason Island (Croxall, McInnes and Prince, 1984).

In summary, the most important breeding sites of the seabird species are shown in Figure B.12. Of the sites illustrated, many are important for one or two breeding species. The sites of Kidney Island, New Island and the Jason Islands group are of importance for many species and thus represent the most important sites for breeding seabirds in the Falkland Islands.

A summary of the main characteristics of the main species is provided below.

As discussed in Section B.5.8 of this report the likely bird species to be present offshore the Falkland Islands can be indicated by examining existing data on the known coastal concentrations of seabirds. The main breeding sites are illustrated in Figures B.11 and B.12.

Penguins

Of the seabirds found in the Falkland Islands, the particular group of interest are the penguins. Sixteen species of penguin are found in the Southern Hemisphere, occurring mainly between 45°S and 60°S. Of these species five breed on the Falkland Islands; the King penguin (*Aptenodytes patagonicus*), Rockhopper penguin (*Eudyptes chrysocome*), Gentoo penguin (*Phygoscelis papua*), Magellanic penguin (*Spheniscus magellanicus*) and Macaroni penguin (*Eudyptes chrysolophus*).

Monitoring data collected by Falklands Conservation had suggested a decline in the number of breeding populations of Gentoo and Rockhopper penguins. In response to this a complete survey was conducted to record the size and location of rockhopper, king and gentoo penguin populations over the summer of 1995/96 (Bingham, 1996a). The aim of the census was to determine the overall status of the Falkland populations for the species and to record the current size and location of each of the individual breeding colonies. The results of the survey are referred to under the following descriptions of the individual species.

Rockhopper penguin

The Falklands rockhopper penguin is one of three recognised sub-species of rockhopper found in sub-Antarctic islands. They are the most common of the Falklands penguins, breeding at 35 sites around the islands, concentrating mainly on rocky cliffs with deep water approaches, on the west coast of the archipelago (Strange, 1992).

Rockhopper penguins are highly pelagic species which leave coastal breeding sites and migrate offshore during the non-breeding season. The birds are opportunistic feeders and consume varying proportions of crustacean, squid and some fish. Feeding is concentrated where these species are abundant. Rockhopper penguins may therefore be encountered in the area of proposed exploration drilling operations, particularly around the shelf edge. .

Male rockhopper penguins return to breeding sites in early October and are followed by the females approximately 10 days later. During this time colonies are very large and can contain many thousands of breeding pairs. The nests are usually a depression between rocks or tussac and are occasionally lined with grass, mud or peat. Egg laying begins in the first week of November, although variations do exist between colonies on the south-east of the islands (Beauchene Island) and those on the west (Steeple Jason Island). The chicks moult during February and leave the colonies by late February or early March. The adults temporarily move offshore to feed for a couple of weeks before returning to the sites to moult. After the annual moult the adults return to sea around mid April. Figure B.13 shows the chronology of rockhopper activities during the year.

The 1995/96 survey of rockhopper penguins over the 36 breeding sites in the Falkland Islands showed the present population to be around 300,000 pairs, over half of the global population and therefore the most important site in the world for this sub-species. Of the population, 21,000 pairs were recorded on East Falkland, 11,000 pairs on West Falkland and 265,000 pairs on the outer islands (Bingham, 1996a). The most important breeding sites within the islands are found at Steeple Jason, Beauchene Island and Grand Jason as the three sites support 38%, 25% and 11% of the total Falkland population, respectively (Bingham, 1996a). The locations of these breeding colonies are shown in Figure B.14.

Fig B.11 Wildlife reserves and important breeding sites for the Falkland seabirds and seals (adapted from Croxall, McInnes and Prince, 1984 and Strange, 1992)

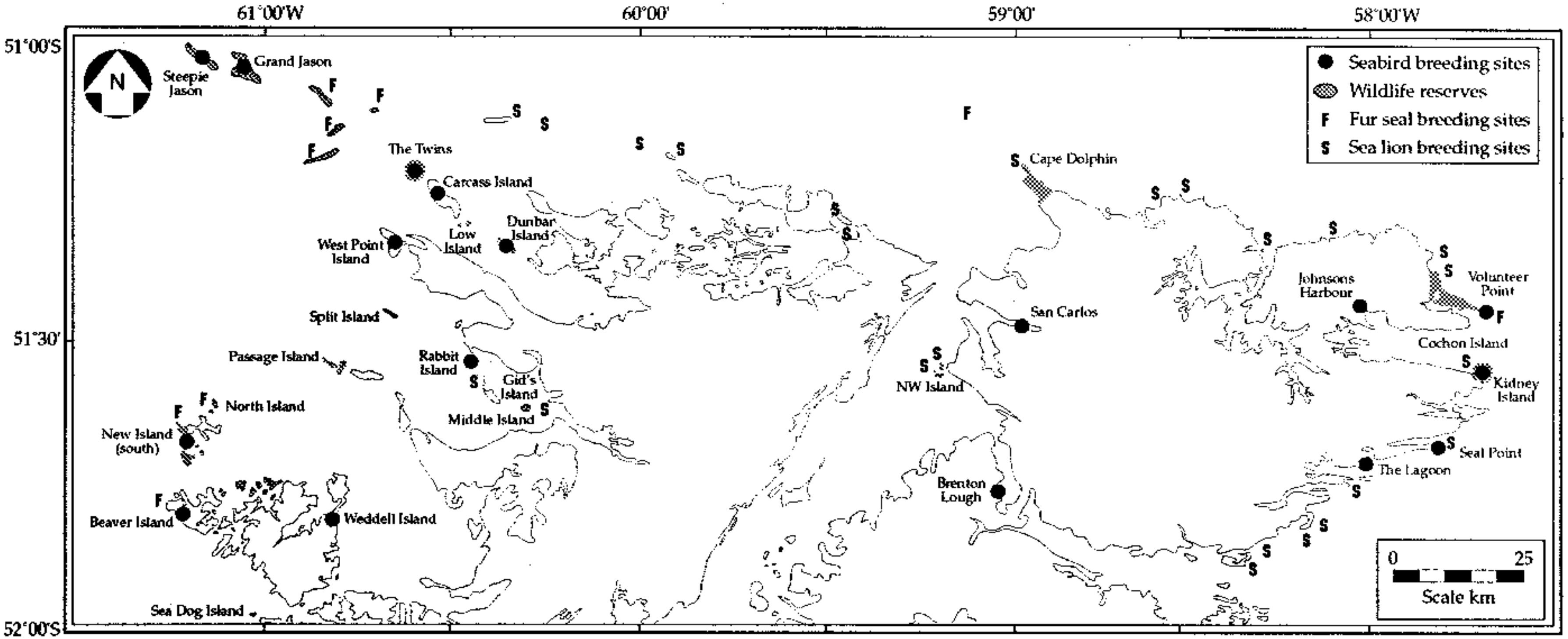


Figure B.12 Breeding sites of seabirds in the Falklands (adapted from Croxall, McInnes and Prince, 1984 and Strange, 1992)

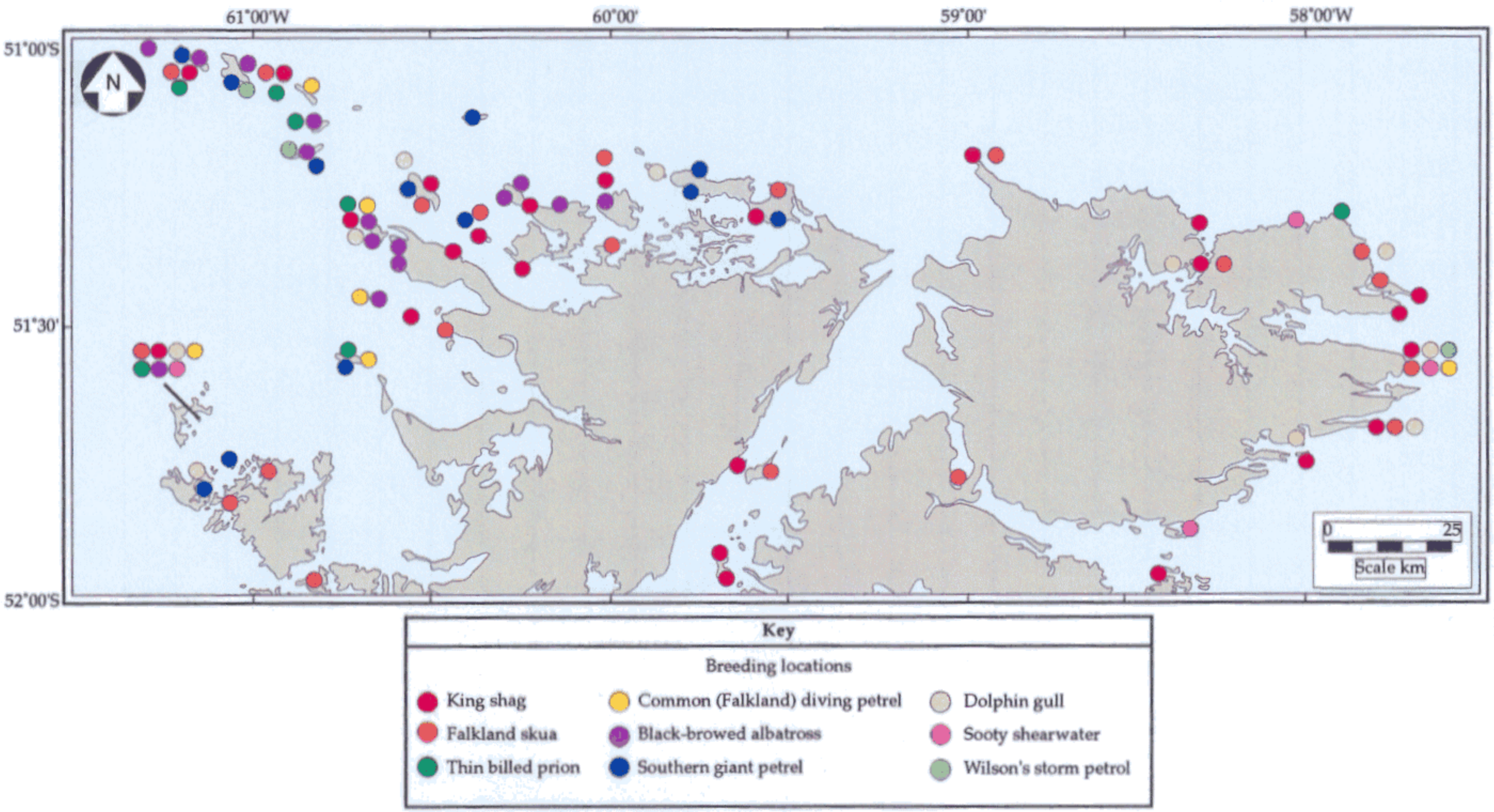
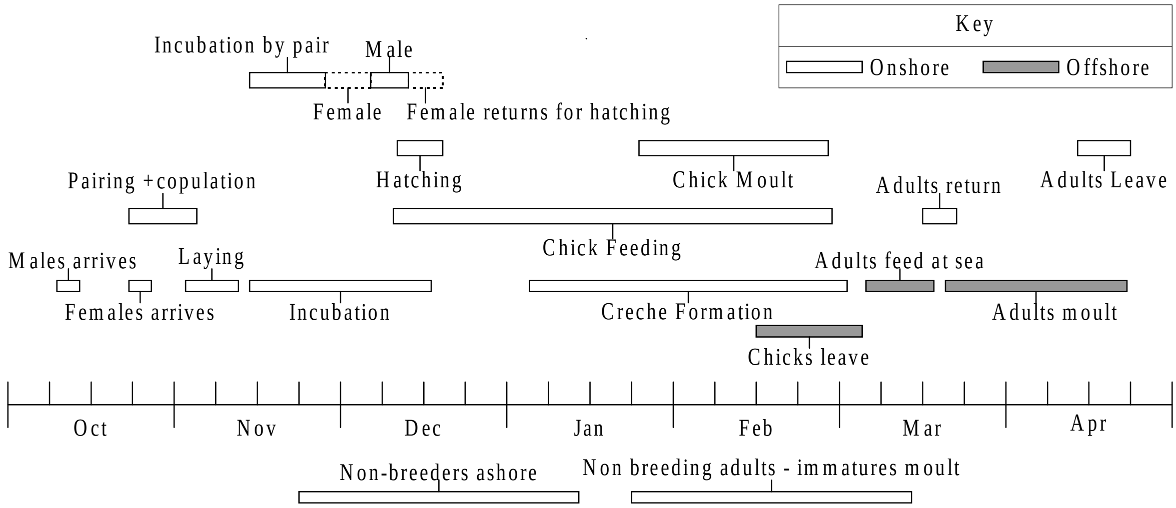


Figure B.13 Chronology of Rockhopper Penguin activities (Adapted from Strange, 1992)



Gentoo penguin

The gentoo penguin is fairly widely distributed in the Falkland Islands and is scattered around the archipelago. Breeding colonies are compact consisting of 300-500 pairs, although in places the colonies may collectively form concentrations of several thousand birds (Strange, 1992). The majority of breeding sites are situated on low coastal plains, fairly close to sandy or shingle beaches which they use to gain access to the open sea. Breeding takes place between September and January. By late January the young undergo a moult into their adult plumage and begin to enter the sea in late February/early March.

Gentoo penguins are opportunistic feeders and take equal proportions of fish, krill and squid. The adults remain around the colonies throughout the year and conduct feeding trips on a daily basis.

The Falkland Islands are of international importance for this species as the most important out of 12 major breeding sites for gentoos (Bingham, 1996b). The 1995/96 population of the Falkland Islands was about 65,000 breeding pairs (22% of the world' s population) comprised of populations ranging from 7 to 5,100 pairs (Bingham, 1996a). Gentoo colonies are widespread throughout the islands. The most important sites were at Bull Point (East Falkland), Albemarle and Carcass Bay (West Falkland) and on the islands of New, Steeple Jason, Grand Jason, Saunders and Speedwell, as shown in Figure B.14. The distribution of the gentoo population was 16,000 pairs on East Falkland, 24,000 pairs on West Falkland and 25,000 pairs on the outer islands (Bingham, 1996a).

Magellanic penguin

The Magellanic penguin is numerous around the coast of the Falkland Islands. The species nests in burrows which it excavates behind the coastline in any soil type. On occasions the penguin utilises natural cracks and hollows in the rocks and the base of cliffs. Breeding takes place September to January. Following this adults leave the colonies to feed at sea before returning to their nests to moult in March. They vacate the nests in April, from when their whereabouts is largely unknown. Magellanic penguins are opportunistic feeders and take varying proportions of fish, squid and lobster krill. They may therefore be encountered in the productive waters of the offshore Tranches.

The Falkland Islands is believed to hold an important proportion of the world population of Magellanic penguin, although not as important as the sites of southern Chile and Argentina (Croxall, McInnes and Prince, 1982). It is however known that large populations exist on the north and north-east coast of East Falkland (Strange, 1992).

King penguin

The Falkland Islands represents the northern extremity in the global range of the king penguin. The king penguin is the largest and most highly coloured of the Falkland breeding species. The species prefer low coastal plain sites close to sheltered sandy beaches. They do not make a nest but lay one egg, which they hold on their feet for the entire incubation period of about 55 days. The chicks overwinter at the breeding colony and are reared over 11-12 months. As the complete breeding cycle takes around 14 months, a pair will only breed twice every three years. This breeding cycle results in individual birds breeding out of phase with their predecessor, producing large chicks and eggs in the same colony at the same time.

The feeding behaviour and diet of the King penguins is not known. It is believed that they feed mainly on small fish and take little squid and have a wide range at sea.

The population study of 1995/96 recorded a population of approximately 400 breeding pairs. The population is of local importance and represents only 0.1% of the world' s population. The only breeding site on the island was found at Volunteer Point (Figure B.14), although individuals were found nesting singly amongst gentoo penguins at other locations.

Macaroni penguin

The macaroni penguin is the rarest of the Falkland Island breeding penguins but of only local importance as the species breeds extensively at other sites outside of the islands. It is thought that less than 300 pairs occur in the archipelago and only 20 pairs of macaroni penguins have been recorded in the Falkland Islands, mainly as single pairs amongst larger numbers of rockhopper penguins (Strange, 1992). Large numbers of macaroni penguins breed in the south of the south Atlantic, although little is known about the breeding, feeding grounds and migratory movements of the species. The diet of the species consists of krill in the breeding season.

Albatross

There are nine species of albatross in the southern ocean, seven of which have been recorded at the Falkland Islands. The wandering albatross (*Diomedea exulans*) and the royal albatross (*Diomedea epomophora*) are very large birds which are regular offshore visitors and may be encountered in the area of proposed exploration drilling operations. The yellow-nosed albatross (*Diomedea chlororhynchos*), sooty albatross (*Phoebetria ftlsca*) and light-mantled sooty albatross (*Phoebetria palpebrata*) are vagrant offshore birds and are not expected to be found in the northern licence Tranches in any significant numbers.

The black-browed albatross (*Diomedea malanophris*) is the only species of albatross that is resident in the Falkland Islands and is regarded as the most common and widespread of all the albatross species. Black-browed albatross breed at approximately 12 sites around the Falklands, often in association with rockhopper penguins. Particularly large colonies are found at the Jason Islands and Beauchene Island. The Falklands are of international importance for the species and have an estimated population of around 55,000 breeding pairs, approximately 85% of the world population (Bingham, 1996b).

Black-browed albatross return to the same nesting site each September to breed. The chicks are abandoned by the adults as they near fledgling and leave the nests in early April to search for food. The birds are scavengers and take a variety of food from the sea surface, notably lobster krill and squid.

Procellariidae

The family Procellariidae include the prions, petrels, fulmars and shearwaters. Of the 15 species found around the Falklands, 6 breed on the islands. The status and significance of these are considered below.

Great shearwater (*Puiffinus gravis*) breed at Kidney Island. The population at this site is small and is the only one confirmed outside the main population at Tristan da Cunha. The species return to breeding grounds in September. The young hatch in late December and depart in late April (Strange, 1992).

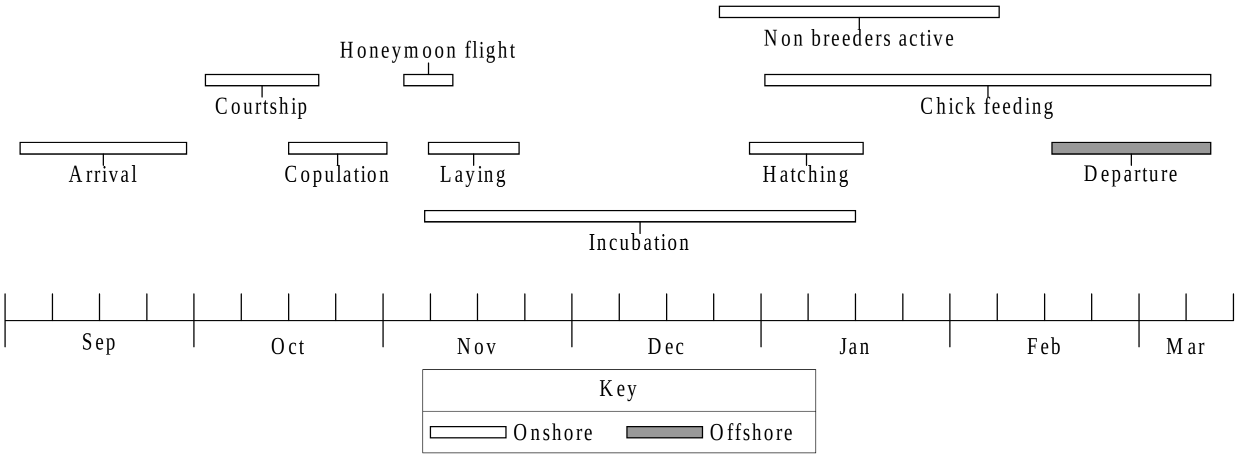
Sooty shearwater (*Puiffinus griseus*) are common in Falkland waters, although few breeding sites have been identified within the islands. The main population within the Falkland Islands breeds at Kidney Island. Smaller populations of the species are found on the north-east coast of East Falkland, New Island and on Beauchene and Sea lion islands to the south of East Falkland. The species return to breeding sites in late September and the eggs hatch in mid-January (Strange, 1992). The majority of the adult birds leave the breeding sites by the end of March, followed by the young in mid /late April.

White chinned petrel (*Procellaria aequinoctialis*) breed at two sites in the Falkland Islands, Kidney Island to the east of East Falkland and New Island, west of West Falkland. The populations at these sites are relatively small, consisting of only a few hundred pairs in total (Strange, 1992). White chinned petrels return to breeding sites in mid October and egg laying commences late November, with hatching beginning in mid-January. Adult birds are most commonly observed at the breeding sites at night, but may also be seen returning during the day, particularly late in the breeding season. The young remain in the burrows for over 100 days and depart after the adults in late April/early May.

Southern Giant petrel (*Macronectes giganteus*) breed in small and locally distributed populations. Breeding begins when the birds return to former sites in September (Figure B.12). The birds lay a single egg in open nesting sites from mid October to early November. The incubation period of the species is around 58-60 days and the young fledge in late March (Strange, 1992). The current population of Southern Giant petrel is estimated at 3,200 pairs (Croxall, McInnes and Prince, *19R4*).

Four species of prion are found in the Falkland Islands, two of these, **thin-billed** (or slender-billed) **prion** (*Pachyptila belcheri*) and **fairy prion** (*Pachyptila turtur*) are breeding species. The thin-billed prion are the most common form of petrel in the Falkland Islands and are very abundant at New Island with populations nearly all confined to West Falkland anti the extreme south-west of East Falkland. No reliable current population estimates are available, but it is likely that the population reaches one million pairs (Croxall, McInnes and Prince, 1984). It is generally accepted that the Falkland Islands are the main global site for this species. The chronology of thin-billed prion activities are shown in Figure B.15. The breeding cycle of the thin-billed prion begins in early September when the birds return to their breeding grounds. The species nest in underground areas varying from 1.5-230 m above sea level (Strange, 1992). Mating takes place in mid-October, egg laying begins in early November and the main hatching of the species takes place between late December and mid January (Strange, 1992). The young birds fledge and leave the colonies by early March.

Figure B.15 Chronology of thin billed prion activities (Adapted from Strange, 1992)



The only known breeding site for fairy prion in the Falkland Islands is Beauchene Island, to the extreme south of East Falkland, where the population is estimated at a few thousand pairs (Croxall, McInnes and Prince, 1984). As the species prefer boulder habitats it is possible that they breed elsewhere on the Falkland Islands however, alternative sites have not been investigated.

Hydrobatidae

The family Hydrobatidae comprise the storm petrels. Of the species breeding in the Falkland Islands, the population of **Grey-backed storm petrel** (*Garrodia nereis*) is believed to be an important one (Croxall, McInnes and Prince, 1984). The species nest in relatively exposed sites and is believed to be numerous at Kidney Island, where it forms shallow nesting burrows in tussock grass. Little is known of the species breeding biology, although it is known that the birds return to their nesting sites in October, begin egg laying in mid December and the newlyborn chicks leave in late March (Strange, 1992).

Wilson's storm petrel (*Oceanites oceanicus*) breed at several sites in the Falkland Islands in a number of different habitats ranging from rocky substrate to tussock grass. The main population is found at Beauchene Island with smaller populations on Grand Jason. The adults return to breeding grounds in early November, begin egg-laying from mid December until early January and the young fledge between mid-February until March (Strange, 1992).

Black bellied storm petrel (*Fregetta tropica*) are believed to breed at a number of offshore tussock islands around the Falkland Islands. Little is known about the breeding behaviour of the species beyond the fact that a single egg is laid that hatches in the second week of January (Strange, 1992).

Other seabirds species

Falkland skua (*Catharacta* (*skua*) *antarctica*) were originally regarded as endemic before a small population was discovered in southern Argentina. The Falkland Islands hold the majority of the world population of the species and are therefore of international importance. The current population of the species is estimated at 3,000-5,000 pairs (Croxall, McInnes and Prince, 1984). The species are widely distributed through the islands.

Common (Falkland) diving petrel (*Pelecanoidcs* (*Urinatrix*) *berard*) is an endemic species to the Falkland Islands. The birds nest in burrows in a variety of habitats from low lying grassland areas, clay slopes and tussock grass but prefer sites close to the ground. The species is widely distributed on offshore islands with extensive populations found on Easterly Island, Sea Lion Island, Beauchene Island, Bird Island, Flat Jason, Elephant Jason and Steeple Jason Islands. Common diving petrels return to their breeding sites in early September to lay from October to November and the young fledge from mid-February (Strange, 1992).

King shag (*Phalacrocorax* (*atriceps*) *albiventer*) and **rock shag** (*Phalacrocorax magellanicus*) are common in the Falkland Islands, particularly in East Falkland. The total population of the species is significant but small in relation to the populations throughout southern Argentina and Chile (Croxall, McInnes and Prince, 1984).

Gull species which breed in the Falkland Islands comprise **Dolphin gull** (*Larus scoresbii*), **Kelp gull** (*Larus dominicanus*) and **Brown-hooded gull** (*Larus maculipennis*). The majority of these species are widespread throughout the southern hemisphere with the exception of Dolphin gull. The Falklands population of Dolphin gull is of importance as the species is restricted in Southern Chile and Argentina.

B.6.3 Shore birds

Several of the birds that frequent the shore of the Falkland Islands are afforded protection through their international status, as discussed in the relevant sub-sections. The international conservation treaties of relevance to the species of the Islands are:

- The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). CITES regulates trade in wild animals and plants which are listed in three appendices. Species listed under Appendix I are currently threatened with extinction (peregrine falcon). Those listed under Appendix II are considered at risk and may become listed under Appendix I unless trade is controlled. Appendix II species are to be protected by the national legislation of the Contracting Parties (coscoroba swan, blacked-necked swan, red-backed buzzard, crested caracara, snowy sheathbill, short-eared owl and barn owl).

- The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention). The Bonn Convention aims to protect migratory species by listing endangered and species at risk under two appendices. The species listed under Appendix I (ruddy-headed goose) are in danger of extinction throughout all, or a part of their range. Those under Appendix II are at risk and require international agreement to improve their conservation status (coscoroba swan, blacked-necked swan, Falkland flightless steamer duck, yellow billed pintail, red-backed buzzard, striated caracara, crested caracara, peregrine falcon, common snipe, white-rumped sandpiper, sanderling, whimbrel). Within the Falkland Islands the Bonn Convention only applies to those species listed in Appendix l, however it is important to note the recognised status of the species outside the Islands.

Anatidae

The Anatidae includes swans, geese and ducks and represents the most numerous family of birds in the Falkland Islands, with 12 species breeding in the islands.

Cinnamon Teal (*Anas cyanoptera*) is a rare species in the Falkland Islands with an estimated population of 12-22 pairs and little is known about the ecology, distribution or population of the species (Woods, 1997).

Black-necked swan (*Cygnus melancoryphus*) is an uncommon Falkland species with an estimated population of 300-600 pairs (Woods, 1997). The species is protected under Appendix II of the Bonn and CITES and Conventions. The birds are mainly restricted to the south of the islands on freshwater ponds outwith the present study area, but may gather on tidal estuaries and in sheltered creeks in winter. In the north the species has been found breeding in large numbers in Pebble Island, Cape Dolphin and to a lesser extent at Keppel Island, Port Egmont and MacBride Head (Woods, 1997). The Black-necked swan breeds from early August to mid-September and nests in solitary pairs close to water. The present population of the Falklands represents a small fraction of the world' s population.

The **Falkland Flightless Steamer Duck** (*Tachyeres brachypterus*) is a protected species under Appendix II of the Bonn Convention. The Falklands are of international importance as the species is endemic to the Islands. The species is common and widespread throughout the Islands and may be found in the shelter of kelp beds and up to 5 km (3 miles) from the shore, where it forages and dives for food. The species is not capable of sustained flight but is capable of rapid movement across the water by paddle-like wingbeats. The birds are very defensive in the breeding season and begin egg-laying in mid-September to mid-October. The birds nest near the shoreline in the cover of heath, brown rush, fern, grassland, and tussock. The young are independent within 15-16 weeks (Strange, 1992). The natural rate of mortality of newly hatched ducklings is high, probably due to predation by kelp gulls and Falkland skuas. The present population of the Falkland Islands is estimated at between 9,000-16,000 pairs (Woods, 1997).

Flying steamer duck (*Tachyeres patachonicus*) are very similar in appearance to the flightless species but are capable of laboured flight over relatively short distances. The species inhabit coastal and inland waters and generally move to freshwater ponds in the breeding season. The birds are widespread throughout the Islands but occur in small numbers, with less than 10 birds being observed at each site (Woods, 1997). The birds nest from September/October and lays from 5-8 eggs at sites similar to the flightless species, including Carcass Island, Keppel Island, Pebble Island and Volunteer Point. Population estimates indicate that the Flying steamer duck is one of the least common water fowl with only 200- 400 pairs inhabiting the Falklands (Woods, 1997).

Yellow-billed pintail or Brown pintail (*Anas georgica spinicauda*) are uncommon in the islands and generally recorded as single pairs. The species is predominantly a freshwater bird and a protected species, listed in Appendix II of the Bonn Convention but may be found in kelp beds in sheltered coastal waters in winter. Important breeding sites on the north coast of the Islands include Pebble Island, Cape Dolphin and to a lesser degree Port Egmont, Carcass Island and Volunteer Point. The present population is estimated at less than 1,000 pairs (Woods, 1997).

The **Ruddy-headed Goose** (*Chloephaga rubidiceps*) is a fairly common resident in coastal areas of the islands. The species is very similar to the upland goose and has a very similar breeding cycle. As the species is listed under Appendix I of the Bonn Convention and the Falkland Islands holds the majority of the world population, the islands are therefore of international importance of this species. The Ruddy- headed Goose breeds throughout the Falkland Islands, often close to the shore in tussock grass, long grass or old Magellanic Penguin burrows. The birds lay 5-8 eggs in early October, 2-3 weeks before the Upland Goose. There are currently around 14,000-27,000 pairs of Ruddy-headed Geese in the Falklands (Woods, 1997).

The **Upland Goose** (*Chloephaga picta leucoptera*) is regarded as being restricted to the Falkland Islands. The species is widely distributed with the largest populations found on extensive greens in coastal and freshwater pond areas. The birds lay from early September through to October. Incubation lasts 30 days and the goslings are usually fully feathered and ready to fly 9-10 weeks after hatching. In December the birds gather in large numbers by ponds and beaches to moult. Surveys have estimated the current population of the Upland Goose to be approximately 46,000-85,000 pairs (Woods, 1997).

Chiloe Wigeon (*Anas sibilatrix*) is an uncommon species in the Falkland Islands, with a population of between 500-900 pairs, but is widely distributed on the coastal waters and larger freshwater ponds and lakes, particularly on south East Falkland. The birds feed amongst kelp patches and tidal estuaries, freshwater ponds and rivers where there is aquatic vegetation. The species breed in September when pairs may double brood. Up to eight eggs may be laid in a well hidden nest of grass construction, some distance from the water.

The **Silver Teal** or **Versicolor Teal** (*Anas versicolor fretensis*) is not widespread but is common within areas of West and East Falkland where it inhabits weedy ponds. The species feeds by dabbling in shallows or foraging on aquatic vegetation and animal life as it swims. Little is known about the breeding cycle of the species. The present population of the species is estimated as consisting of 800-1,500 pairs (Woods, 1997).

The **Kelp Goose** (*Chloephaga hybrida malvinarum*) is a common species (10,000-18,000 pairs) with a wide distribution (Woods, 1997). The species is found on most coastlines where it can graze at low tide on sea lettuce, brown seaweeds and grass. The species nest predominantly near the shore, preferring tussock fringes for nest cover and may migrate to offshore tussock islands to breed. Breeding occurs with egg laying in the third week of October/early November and incubation lasts 30 days. The young birds are capable of flight after approximately ten weeks (Strange, 1992).

Patagonian Crested Duck or **Grey Duck** (*Lophonetta specularioides*) is a common species in the Falkland Islands and has a wide distribution along the coast. The species is particularly abundant in sheltered coves and creeks characterised by tidal reaches and shallows, and on nearshore freshwater ponds where it forages and dabbles on a wide range of marine life. The breeding season of the species is very extended, laying eggs in early August through to April with pairs commonly having two broods. The birds may nest close to the shoreline but often inland and make their nests well hidden in vegetation, sometimes with two males attending one female. The current population of the Islands is estimated at around 7,000- 12,000 pairs (Woods, 1997).

Yellow billed teal or **Speckled teal** (*Anas f1avirostris*) occupies a wide variety of habitats and is common throughout the Falkland Islands in freshwater and marine environments. The species is often found in sheltered coastal areas during the winter. Pairs of the species commonly breed on small streams, coastal ponds and on small stands of water in dense tussock grass cover. The birds begin nesting and egg-laying in August and often rear two broods. The species feeds on a variety of aquatic fauna and flora obtained by straining the water surface and diving. The Falkland Islands holds approximately 6,000-11,000 pairs of the species, a small fraction of the world' s population (Woods, 1997).

Falconifonnes

Five species breed within the islands as summarised below.

Striated caracarra (*Phalcoboenus australis*) is a rare species which is protected under Appendix II of the Bonn and CITES Conventions. The total Falkland population numbers between 500-900 breeding pairs with birds found on a small number offshore tussock islands off West Falkland, such as the Jason Island Group, New Island and to the south on Beuchene Island. The juvenile and immature birds tend to leave the breeding areas in March and often concentrate in large groups in search of food, giving the impression that the species is common. The species feeds on a variety of food including young penguin chicks, small petrels, eggs, insect life and carrion. Survival of the species over the critical winter period is heavily dependant upon the excreta of Gentoo penguin and Fur Seal.

Crested caracarra (*Polyborus p plancus*) are fairly well distributed over the main islands of the Falklands but are not common with only 400-800 breeding pairs (Woods, 1997). The species is protected under Appendix II of the Bonn Convention and is classed as near-threatened by the International Union for the Conservation of Nature (IUCN). The species nest on rocky outcrops, usually preferring high peaks. The birds lay eggs in late September/October in large nests which they use from year to year. Nests are added to at the beginning of each season and may reach large proportions. The Crested Caracarra is an opportunistic scavenger and predator, feeding on a variety of animal life, marine organisms, dead birds and sheep and has historically been regarded as a pest.

Red Backed buzzard (*Buteo polyosoma*) are widely distributed over West and East Falkland and on most larger offshore islands. The birds are a listed species under Appendix II of the CITES and Bonn Conventions. The species use the same breeding sites year after year and nest on high rocky outcrops or coastal cliffs. Breeding begins in early October anti both the male and female incubate. The young leave the nest by late December/early January after a period of 45-50 days (Strange, 1992). The birds feed on a variety of prey including rats and mice as well as small and occasionally larger birds. The current Falklands breeding population of this species is estimated at between 500-1,000 birds (Woods, 1997).

Cassin's or **Peregrine Falcon** (*Falco peregrinus cassini*) is widespread along the north and south of the Falklands but uncommon over the Islands as a whole. The present population is estimated at 500- 900 breeding birds (Woods, 1997). The species is protected under Appendix I of CITES and Appendix 11 of the Bonn Convention. The birds prefer coastal areas and nest on inaccessible coastal cliffs in scrapes and hollows. Egg laying begins in early to mid October and incubation lasts for 30-31 days. The young usually make a first flight in January (Strange, 1992). The species feed on a variety of prey from small mammals and passerines to upland geese. Where prey such as prion is abundant the distribution of feeding birds is high. For example, on New Island where there is a large population of Thin-billed Prion, six breeding birds have been recorded (Strange, 1992). Elsewhere individual birds have been sighted feeding up to 35 miles offshore (Brown and Root, 1997).

Turkey vulture (*Cathartes aura falklandica*) is restricted to the Falklands and is the largest and most common bird of prey in the islands, with an estimated population of 1,900-3,600 breeding pairs (Woods, 1997). The birds begin breeding in September when they commonly nest on tussock grass and in coastal caves. The young normally fledge during January. The birds are important carrion eaters feeding on seal excreta, placenta and dead animal carcasses and have increased in abundance since the development of the sheep industry in the islands.

B.6.4 Pinnipeds

Pinnipeds in the Falklands are comprised of two species of sea lion and three species of seal. These can be divided into two main groups, the Otarioiliea (sea lions, fur seals and walruses) and the Phocoidea (' true' seals such as elephant seals). Otarioidea have external ears, scrota testes and can turn their hind flippers forward to assist movement on land in a rudimentary four-footed method. Phocoidea have no external ear appendages, internal testes and depend on their body muscles for locomotion on land, moving in a rippling form or loping movement. The most complete survey on pinnipeds to date was conducted by the Sea Mammal Research Unit in 1995 on southern sea lions (*Otario flavescens*) in the Falkland Islands.

Southern Elephant seal

Southern Elephant seals (*Mirounga Leonina*) breed mainly in South Georgia and approximately 15% of the population hauls out on the Falkland Islands after the breeding season is completed. Southern elephant seals breed at several small sites around the Falkland Islands, mainly in the north-west, north, east and south-east on sand or shingle beaches. The main breeding colony for the species is found at Sea Lion Island, south of East Falkland and breeding occurs from early September to early October. Colony sizes range from 200-300 animals, comprising a total breeding population of under 4,000 animals (Bingham, 1996b).

No mass migration of elephant seals has been witnessed, although it is possible that the animals may be encountered in the offshore area. It is known that during the winter months of April to June most adults stay at sea to feed largely on squid and fish (Strange, 1992). In support of this, the anatomy of the seal indicates that they can dive to great depths to feed and are not restricted to shallow coastal waters.

Southern sea lion

The southern sea lion is found all around the coasts of South America as far north as Brazil. The Falkland Islands holds approximately 5% of the estimated world population of the species (Bingham, 1996b). The current Falklands population is estimated at 5,534 individuals (Thompson and Duck, 1995). This represents a decline of over 97% in the species over the last 60 years when compared to previous counts.

Southern sea lions breed in small colonies at approximately 60 sites around the Falkland Islands coastline (Strange 1992). The majority of breeding sites occur on offshore tussock islands, north-west of the Falkland mainland, as shown in Figure B.12. Breeding of the southern sea lion takes place in December. After mating the females go to sea to feed up, returning every few days to suckle the pups. The pups gather into pods towards the end of January but may remain dependant upon the cows for up to 12 months. Southern sea lions are shallow benthic feeders which prefer to forage in kelp forests, feeding mainly on squid and octopus, with some lobster krill and fish. Sea lions have been observed feeding in kelp very close to the shore in water depths of only 2.5 m deep (Thomson and Duck, 1995).

Fur seal

The Falkland Islands (or South American) fur seal (*Arctocephalus australis*), like the southern sea lion, prefers rocky coastal sites with steep or shelving rock faces, deep water approaches and access to offshore reefs or kelp beds (Strange, 1992). The animals breed at 15 known sites in the Falklands Islands where they congregates in large numbers to pup, mate and suckle their young. The current population of South American Fur Seal in the Falklands Islands is estimated at over 10,000 adults (Bingham, 1996b). Breeding takes place November to January. After the first departure of the cows the pups begin to wander outside the territories and by mid-January have formed into pods. Older bulls reappear at the coastal sites in March to moult.

Unlike some species of fur seal the animals do not migrate but move to winter hauling out grounds. During this movement pups and cows may travel out to sea for periods of time where they feed on lobster krill, squid and fish.

Leopard seal

The leopard seal (*Hydrurga leptonyx*) is in general a solitary animal. The distribution of the species is usually on the outer edges of the pack ice, although they are known to range widely to most Subantarctic islands, including the Falklands.

Weddel seal

The Weddel seal (*Lephtonychotes weddelli*) is considered an occasional visitor to the Falkland Islands. Regardless of this, it is unlikely that the species will be encountered in the study area as its normal distribution extends from the South Orkneys, where it is common to the northern limit at South Georgia.

B.6.5 Ecologically sensitive areas

The Falkland Islands are rich in biodiversity and known to be internationally important for some of their bird and marine mammal populations. Current legislation makes provision for the designation of Nature Reserves and Sanctuaries within the Falkland Islands on Government land and privately owned land (subject to the owners consent). There are currently 19 Nature Reserves in the Falkland Islands covering 1,460 hectares, all designated on offshore Crown land. A further three Sanctuaries have been officially designated on Crown land and seven on privately owned land. No mainland areas or privately owned land has been given official Nature Reserve status.

In addition to official designations, 27 offshore islands have been declared as private nature reserves (unofficial) by their owners. These private nature reserves have been designated at the request of their owners and thus do not necessarily indicate a high conservation value. The location of the official designations and declarations within the study area are shown in Figure B.12. The size and status of these reserves are provided in Table B.3 below.

Table B.3 Protected areas in the study area of the Falkland Islands (adapted from WCMC, 1994)

Designation and site name	Year Designated	IUCN Category	Location	Area (ha)
Nature Reserve				
Elephant Jason	1973	I	51°09' S 60°51' W	260
Flat Jason	1966	I	51°06' S 60°53' W	375
Gids Island	1966	IV	51°39'S 60°18' W	30
Jason East Cay	1973	I	51°00' 5 61°18' W	20
Jason West Cay	1973	I	50°58' 5 61°25' W	22
Kidney Island	1964	I	51°38'S 57°45' W	32
North Fur	1973	I	51°08'S 60°44' W	75
Sea Dog and Arch Islands	1978	I	52°00' 5 61°06' W	30
Seal Rocks	1973	I	51°07'S 60048' W	22
South Fur	1973	I	51°15' S 60°51 ' W	25
South Jason	1973	I	51°12'S 60052' W	375
The Fridays	1973	I	51°03'S 60°58' W	21
Sanctuary				
Cape Dolphin	1969	IV	51°15' 5 58°57'W	891
Dunbar Island	-	-	51°23'S 60°21' W	225
Low Island	1965	IV	51°19'S 60°27'W	75
Middle Island	1966	IV	51°38'S 60°20' W	155
Stanley Common & Cape Pembroke Peninsula	1973	IV	51°43' 5 57°49' W	2,770
The Twins	1965	IV	51°15'S 60038' W	23
Volunteer and Cow Bay	1969	IV	51°29'S 57°50'W	4,340

Protected Areas Management Categories (IUCN Global Management Category)

I - Strict Nature Reserve/Scientific Reserve
II - National Park
III - Natural Monument/Landmark
IV - Managed Nature Reserve/Wildlife Sanctuary
V - Protected Landscapes and Seascapes
VI - Resource Reserve
VII - Natural Biotic Area/ Anthropological Reserve
VIII - Multiple use Management Area/Managed Resource Area.

B.7 Socio-economic conditions

B.7.1 Fishing activity

The Southwest Atlantic represents one of the richest fishery resources in the world. Largescale commercial fishing of these resources began in the early 1970s. Concern about the level of uncontrolled fishing and the failure of countries to co-operate on conservation led to the introduction of the 150 nautical mile Falkland Islands Interim Conservation and Management Zone (FICZ), in October 1986 (FIG, 1989). Continued concern about the level of fishing effort and the conservation of the fish stocks led to the declaration of the Falkland Islands Outer Conservation Zone (FOCZ) on 26 December 1990 which extends to 200 nautical miles, measured from coastal baselines (FIG, 1997) .

The offshore fishery of the Falklands represents the islands most important economic sector as shown in Figure B.16a. The grounds support a mixed fishery of commercial importance including squid, hake, hoki, blue whiting, cod, herring, kingclip, toothfish, skates and rays. The composition of the islands fishery in terms of fish catch by weight is shown in Figure B.16a.

Figure B.16a Revenue by sector 1994-1995

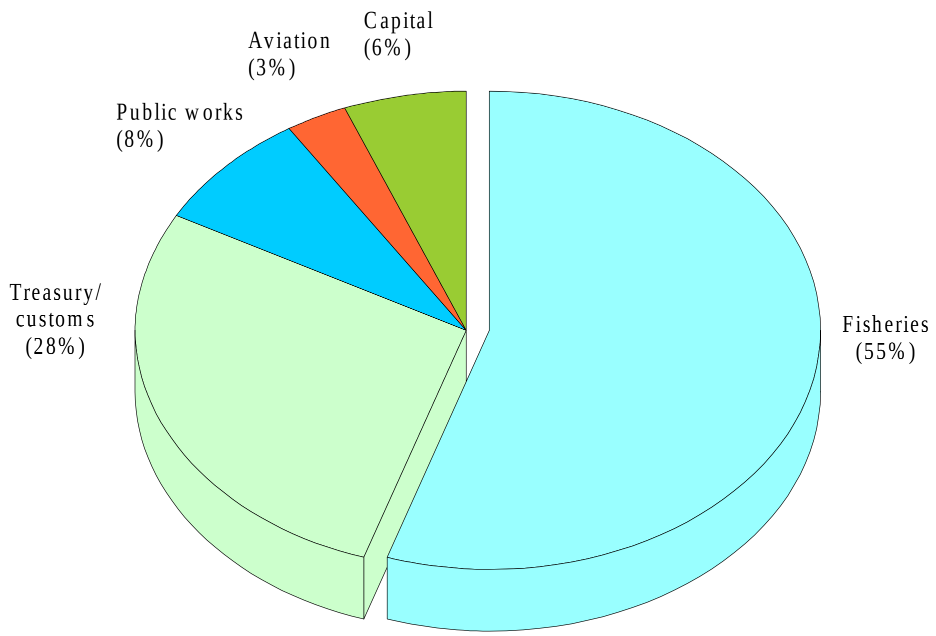
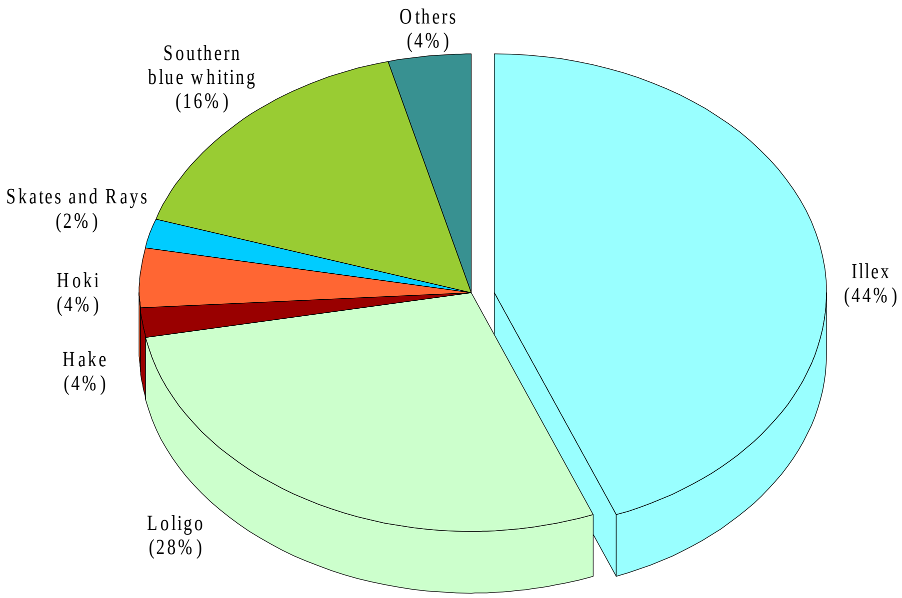


Figure B.16b Fish catch by weight 1990-1996



The fish resources of the Falkland Islands are regulated by effort controls whereby vessels are issued licences to fish within the FICZ for a fixed period. Catch data is collected on a daily basis to ensure the accurate and continuous monitoring of the state of the stocks. As can be seen from Figure B.16b, the squid resources of the continental shelf are the main resource of the Falkland Islands and they support a major international fishery. Over the 10 year history of implementation of controlled fisheries in the Falkland Islands (1987-1997) £245 million has been collected in licence revenue (FIG, 1997). Table B.4 shows the annual license revenue to the Falkland Islands for the period 1989 to 1996.

Table B.4 Annual revenue (Pounds sterling) by licence type in the Falkland Islands (FIG, 1997)

Licence	1989	1990	1991	1992	1993	1994	1995	1996
A	537,775	485,949	300,154	191,586	119,854	125,624	61,008	63,211
B	22,723,027	20,698,011	20,961,399	20,865,023	14,301,237	17,440,342	10,867,548	12,176,224
C	4,028,578	5,077,665	3,286,308	2,904,346	3,558,704	3,305,953	3,473,536	3,915,269
E	3,000	1,000		12,308	12,303	163,607	196,725	118,971
F							74,214	117,243
R						140,664	431,363	446,767
W			113,412	169,895	206,682	413,290	500,679	842,504
X	377,917	613,764	572,085	959,803	1,466,992	2,046,655	2,173,149	2,297,557
Y	939,594	291,531	285,700	187,767	199,798	180,825	164,690	174,748
Z	391,332	774,666	841,843	1,222,974	1,207,635	1,335,812	1,920,068	1,586,520
Total	29,001,223	27,942,586	26,360,901	26,513,702	21,073,205	25,152,772	19,862,980	21,739,014

Note: For licence type see Table B.5.

Table B.5 Licence types, target species and periods of application 1989-1996

	Licence	Target species	Period of application
First season (01 January to 30 June)			
	A	Unrestricted finfish	1989-1996
	B	IlIex squid	1989-1992
		IlIex + Martialia squid	1993-1996
	C	Loligo squid	1989-1996
	F	Skates and rays	1995-1996
	W	Restricted finfish	1994-1996
Second season (01 July to 31 December)			
	R	Skate and rays	1994-1996
	X	All species	1989-1990
		Patagonian squid	1991-1996
	Y	Unrestricted finfish	1989-1996
	Z	Restricted finfish	1989-1996

* Restricted finfish -main target species, southern blue whiting, hoki and hakes.

Fisheries statistics (as mentioned earlier) are collected by FIG Fisheries Department on a daily basis. In February 1997 this Department published fisheries statistics in the second of what is intended to be a series of statistical bulletins describing the performance of the Falkland Islands Fishery. The data presented in this bulletin concentrates on catch statistics, presenting data in terms of total catch by vessel type, month/season and country of origin of fishing fleet. This data together with fishing effort data (obtained from FIG Fisheries Department) has been analysed in order to provide an assessment of the offshore fishery, north of the Falkland Islands.

The data are organised in grid squares as shown in Figure B.17 (data presented for this study concentrates on the offshore area to the north of the Islands). Total trawling and jigging fishing effort for the area north of the Islands is illustrated in Figures B.18-B.22. These figures show that the most heavily fished area is that along the edge of the continental shelf, which is consistently fished for> l,500 though in 1994 some areas were fished> 6,000 hours (see Figure B.18).

In general since the introduction of controlled fisheries in Falkland waters in 1986 the overall pattern of activity within the fishery has remained broadly similar. The squid species *lllex argentinus* has continued to be fished primarily by far eastern jiggers whereas the smaller inshore squid species *Loligo gahi* and finfish species, particularly, hake have been the target of the European bottom trawling fleet. The only major change has been in the blue whiting fishery which has seen the predominantly Polish fleet of the late 1980' s and early 1990' s be replaced by larger factory ships from Japan and Chile. In the area north of the Islands jigging takes place only during the first licence season (01 January to 30 June), as shown in Figures B.22 and B.23. Trawling takes place along the edge of the continental shelf all year, but effort is greatest in the second season (01 July to 31 December), and highest in the months July, August and September, as shown in Figures B.24-B.27. Each of the fisheries of commercial importance are discussed in more detail in the following sections.

Squid fishery

The squid fishery within the FICZ of the Patagonian shelf is regulated by seasons which are species dependant. Squid are fished for by a number of methods; jigging, trawling (single, pair, demersal and mid water), gill netting and seine netting. Of these methods, jigging is the most important in the Falklands, accounting for 40% of the worlds cephalopod catches and 95% of Japanese squid catches (Pierra and Guerra, 1994).

Argentine short-finned squid (*Illex argentinus*)

The fishing season for *Illex* extends from March to June, with peak catches occurring in April and May (Bisbal, 1993). The main fishing countries operating in the area are Poland, Japan, Taiwan and Korea. The main catch areas for the species are to the north and north-west of the Falkland Islands, within the study area from January to June. Low catches of *lllex* took place in the study area during the second season July to December) in 1994 and 1995. No catches of the species were made over this period in 1996.

Patagonian squid (*Loligo gahi*)

There are two fishing periods for *Loligo* extending from February to May and from August to October. The squid are fished for by trawlers from Poland, Spain, the UK and other EC countries which operate to the east and south of the islands (outwith the area of the northern Tranche). A typical European trawler is approximately 1,500 GRT with a crew of 35, and is capable of catching 40-60 tonnes of squid per day (FIG, 1989). There are also a few combination jigging and trawling vessels operating in the fishery and their fishing method is determined by the prevailing conditions. From February to May fishing takes place at the south of the Falklands, moving to the north/north-east from August to October. Catches are made in the study area during this latter period (July to December), although these areas do not represent the main fishing grounds over the year.

Figure B.17 Total fishing effort for the study area in 1991

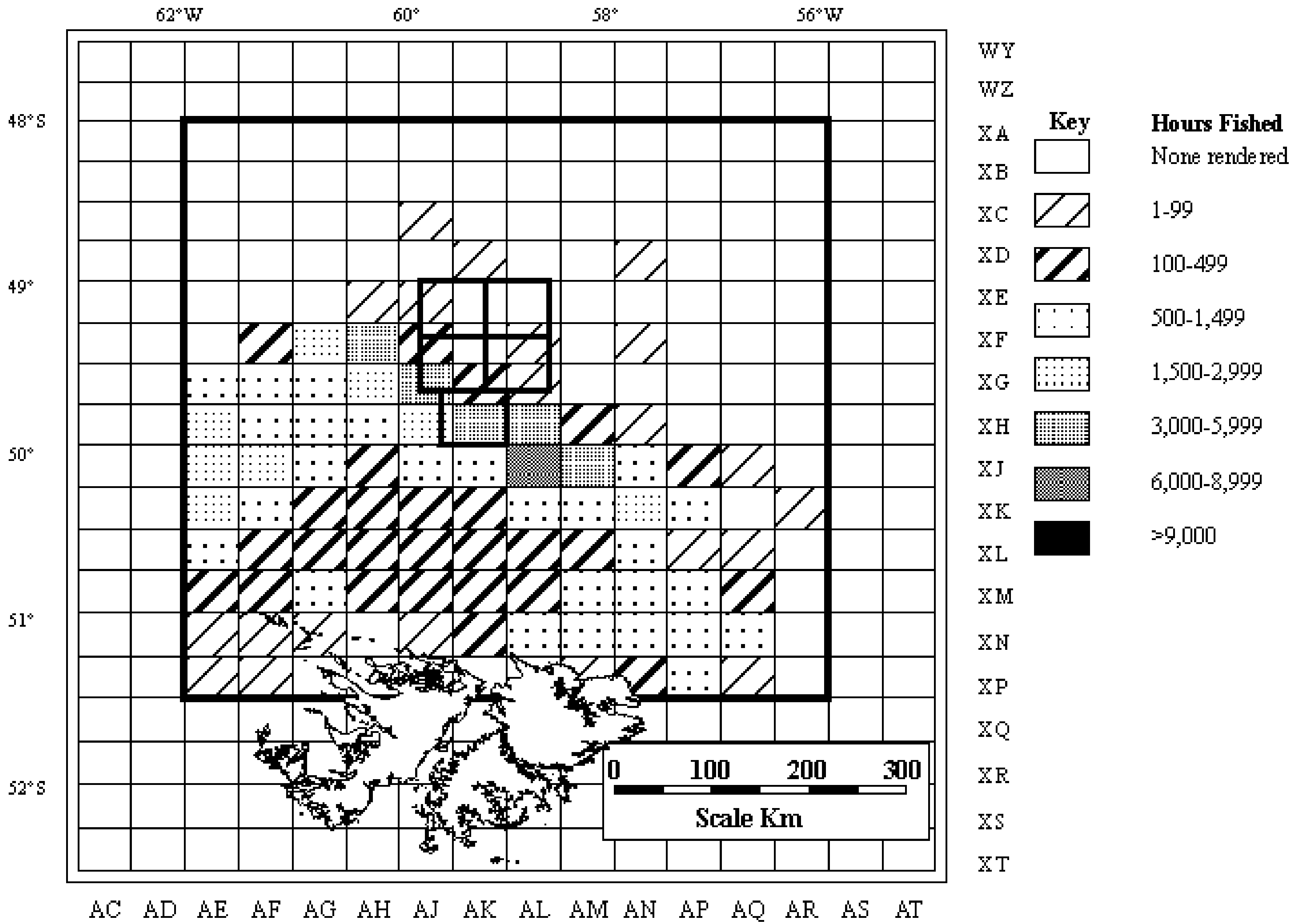


Figure B.18 Total fishing effort for the study area in 1992

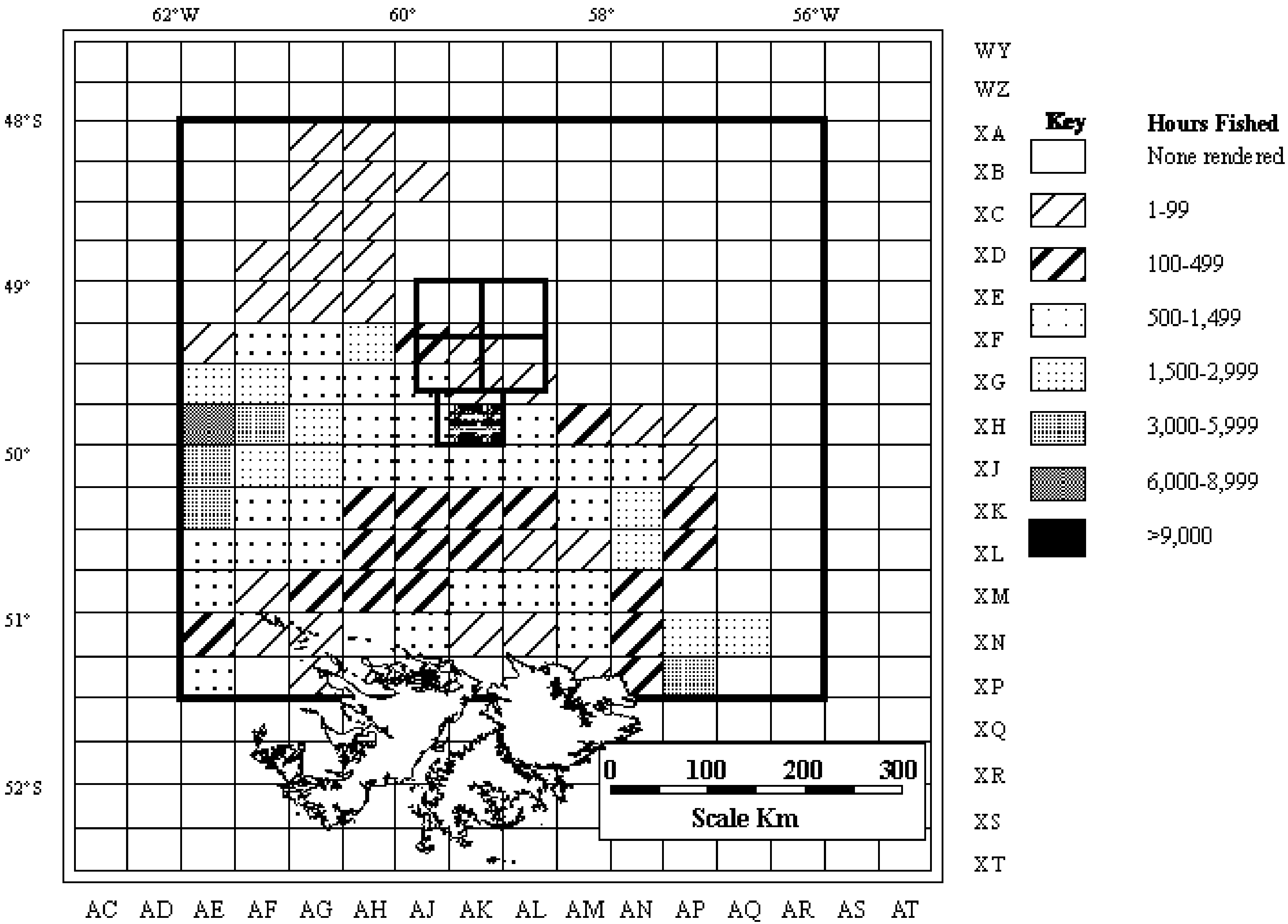


Figure B.19 Total fishing effort for the study area in 1993

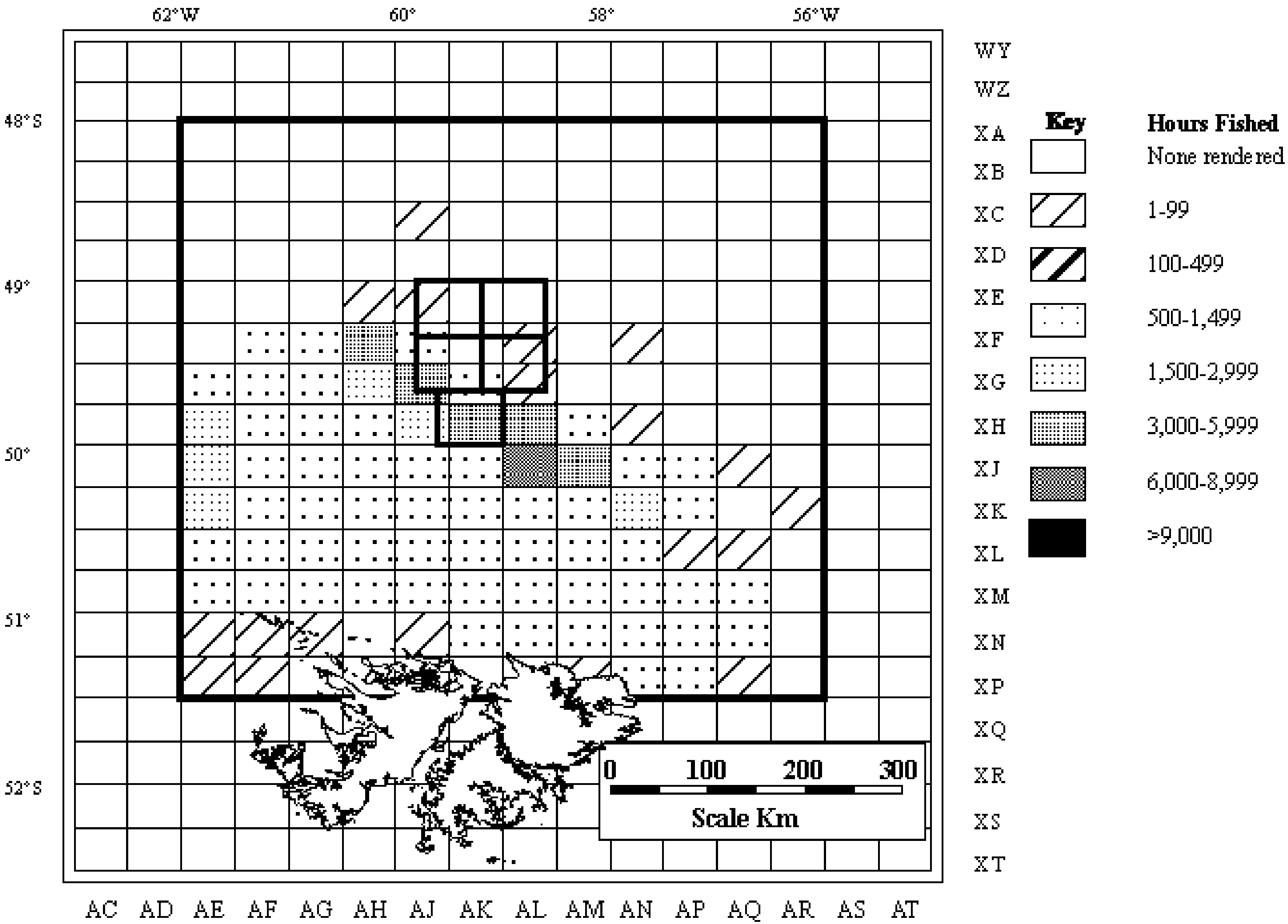


Figure B.20 Total fishing effort for the study area in 1994

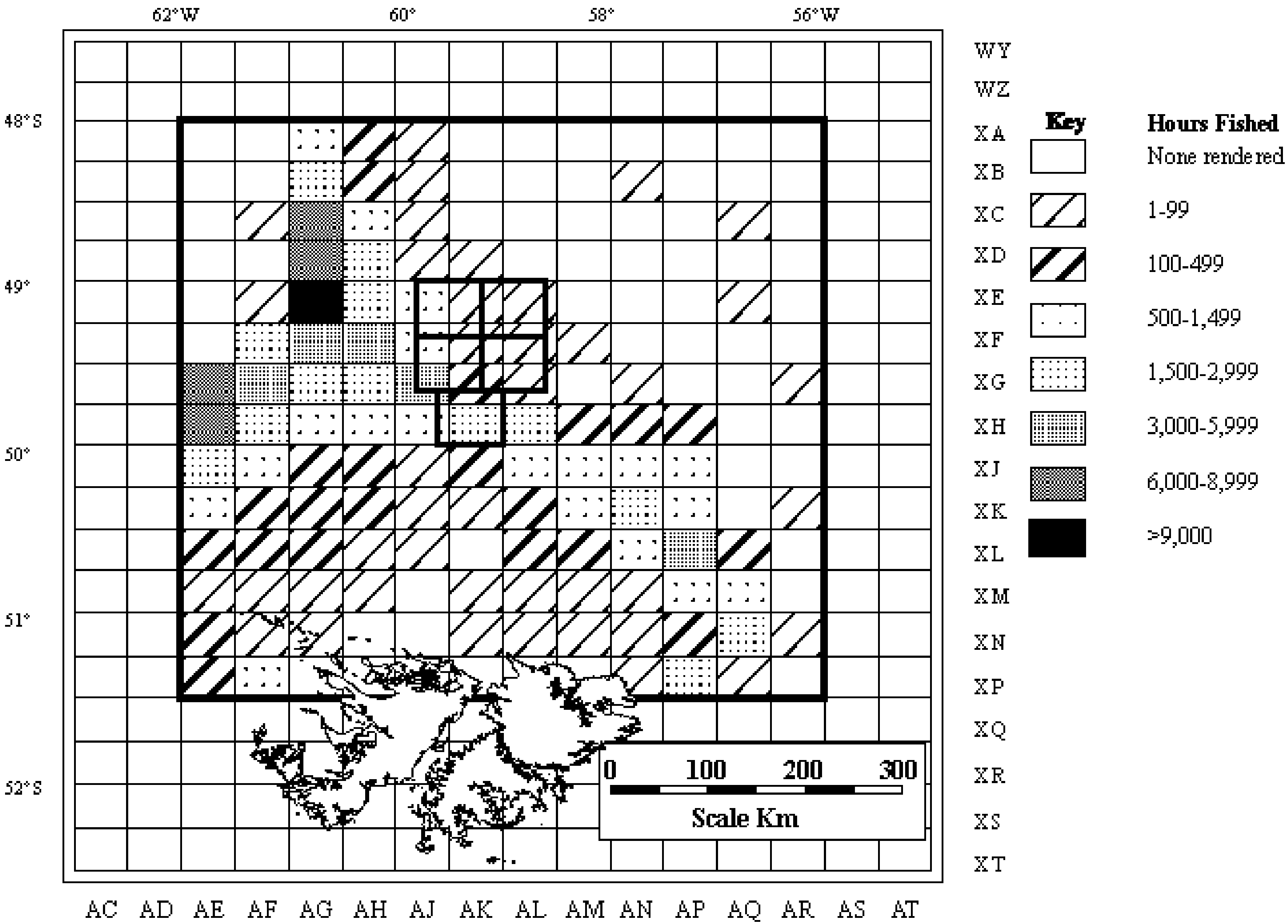


Figure B.21 Total fishing effort for the study area in 1995

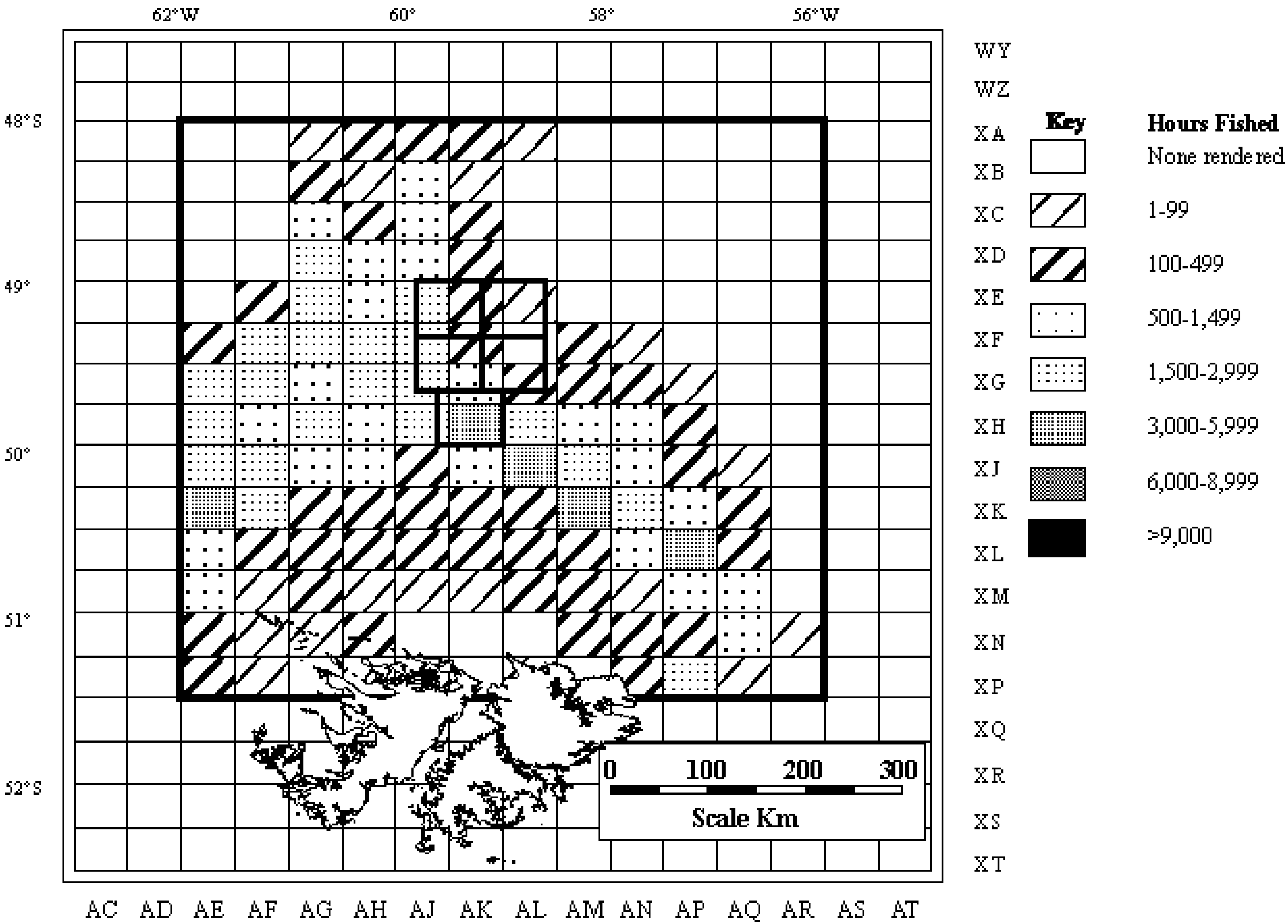


Figure B.22 Total jigging effort for the study area from 1st January – 30th March 1995

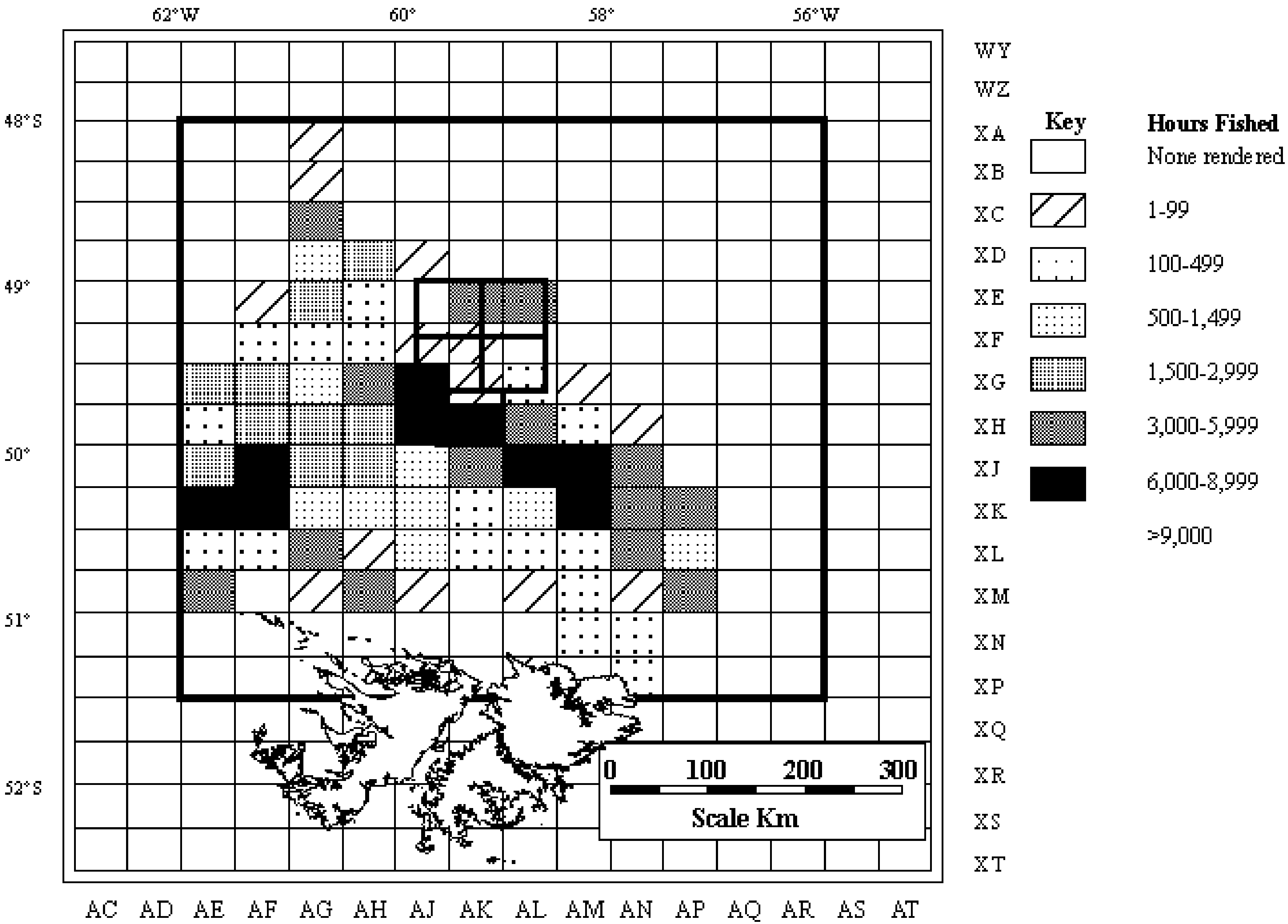


Figure B.23 Total jigging effort for the study area from 1st April – 30th June 1995

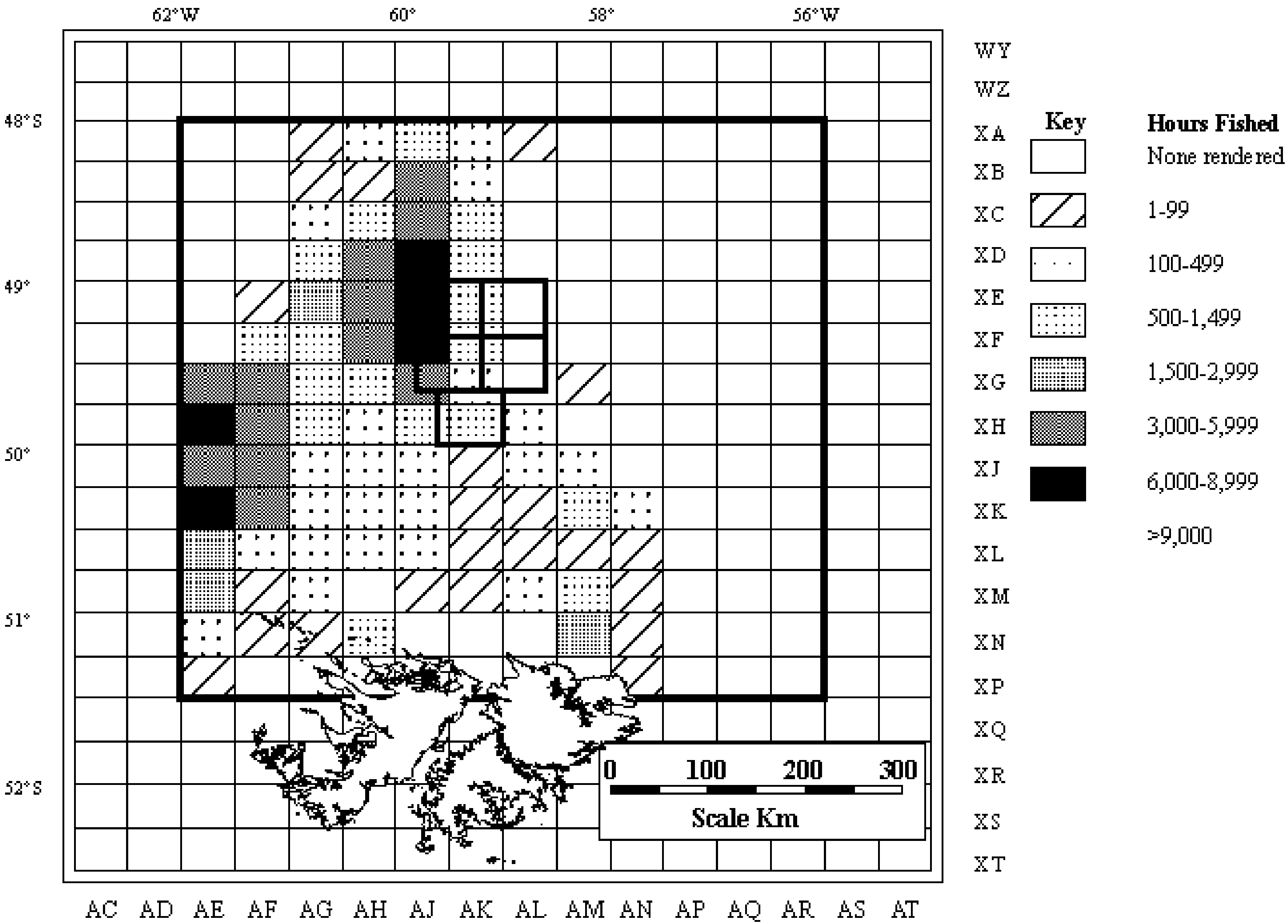


Figure B.24 Total trawling effort for the study area from 1st January – 30th March 1995

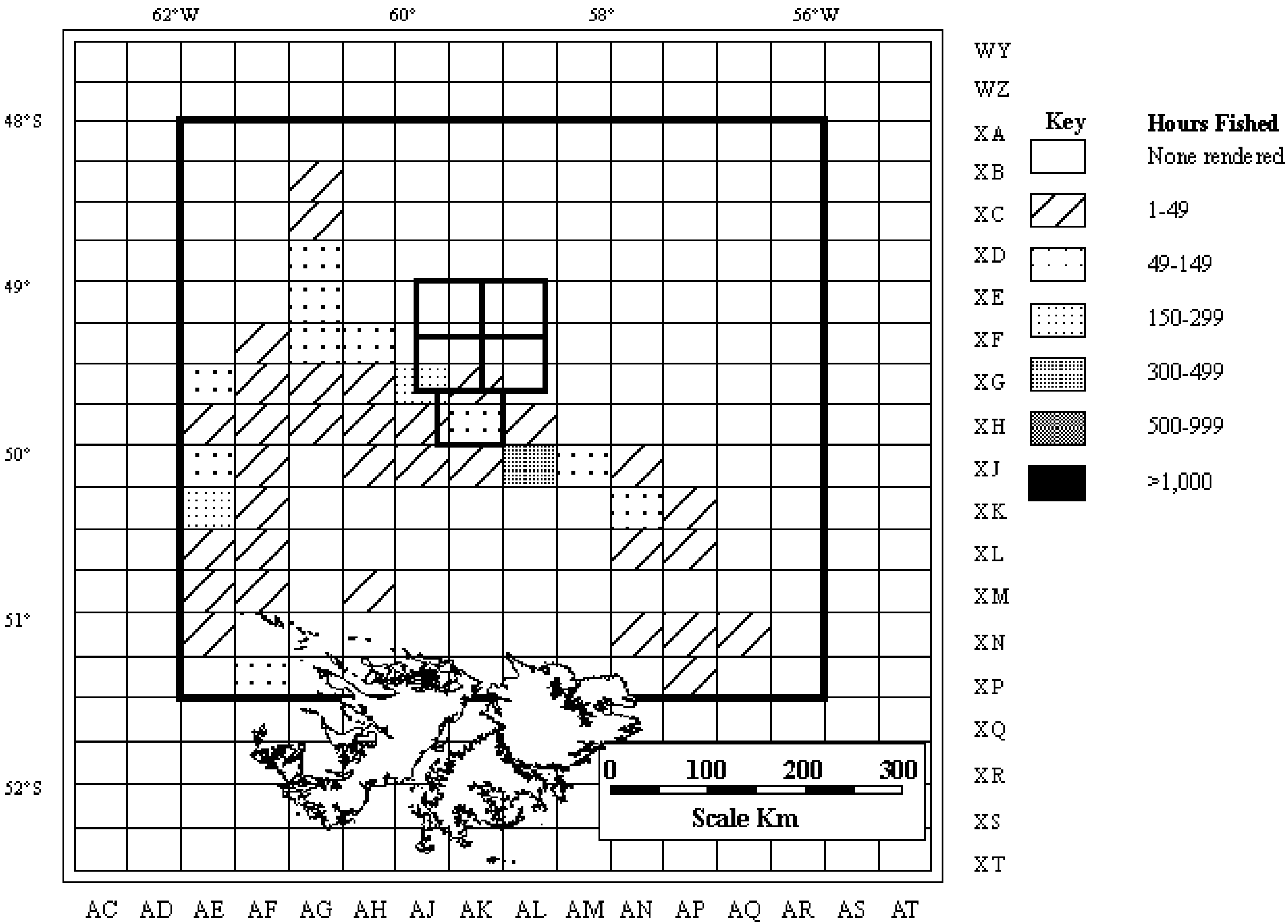


Figure B.25 Total trawling effort for the study area from 1st April – 30th June 1995

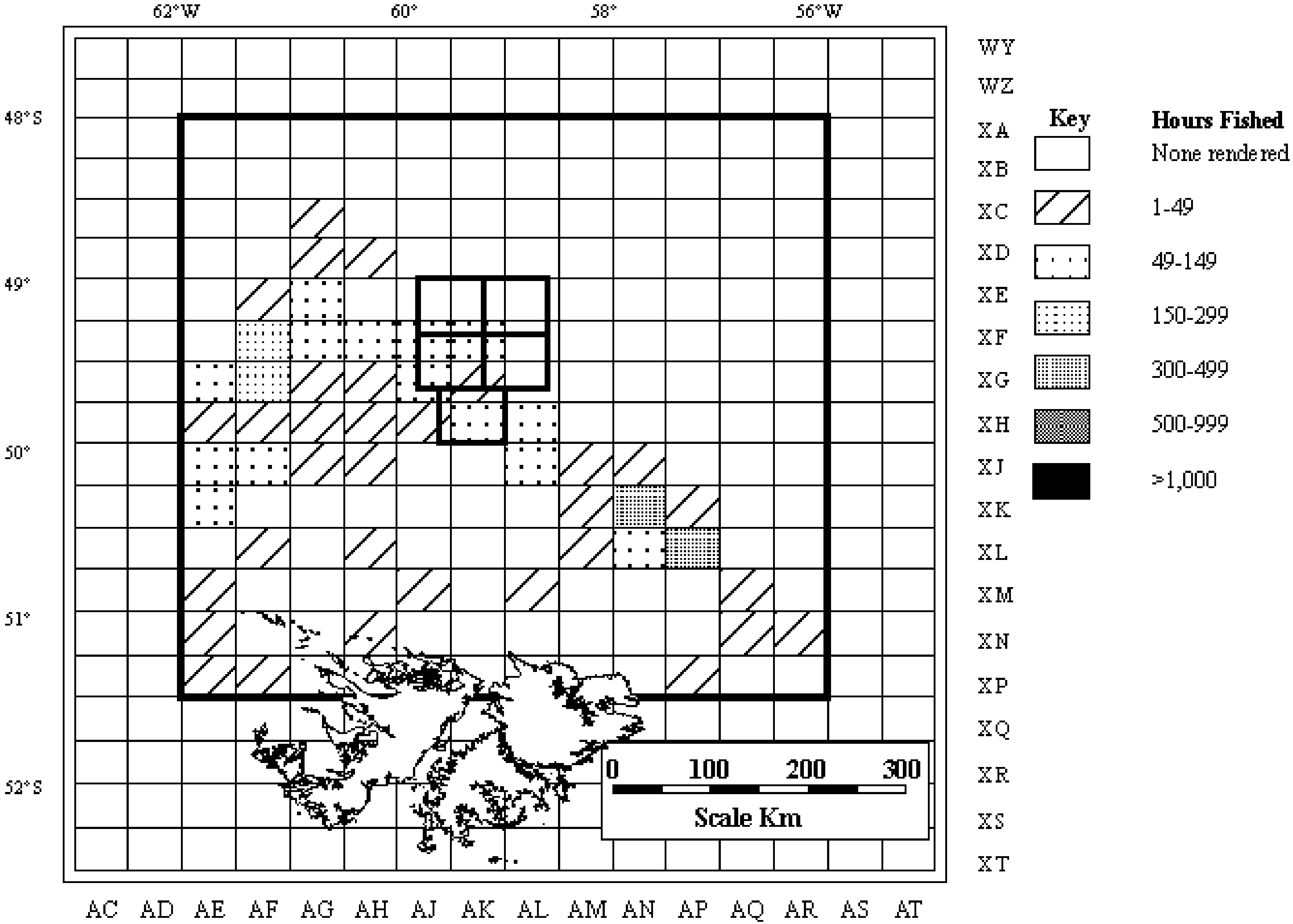


Figure B.26 Total trawling effort for the study area from 1st July – 30th September 1995

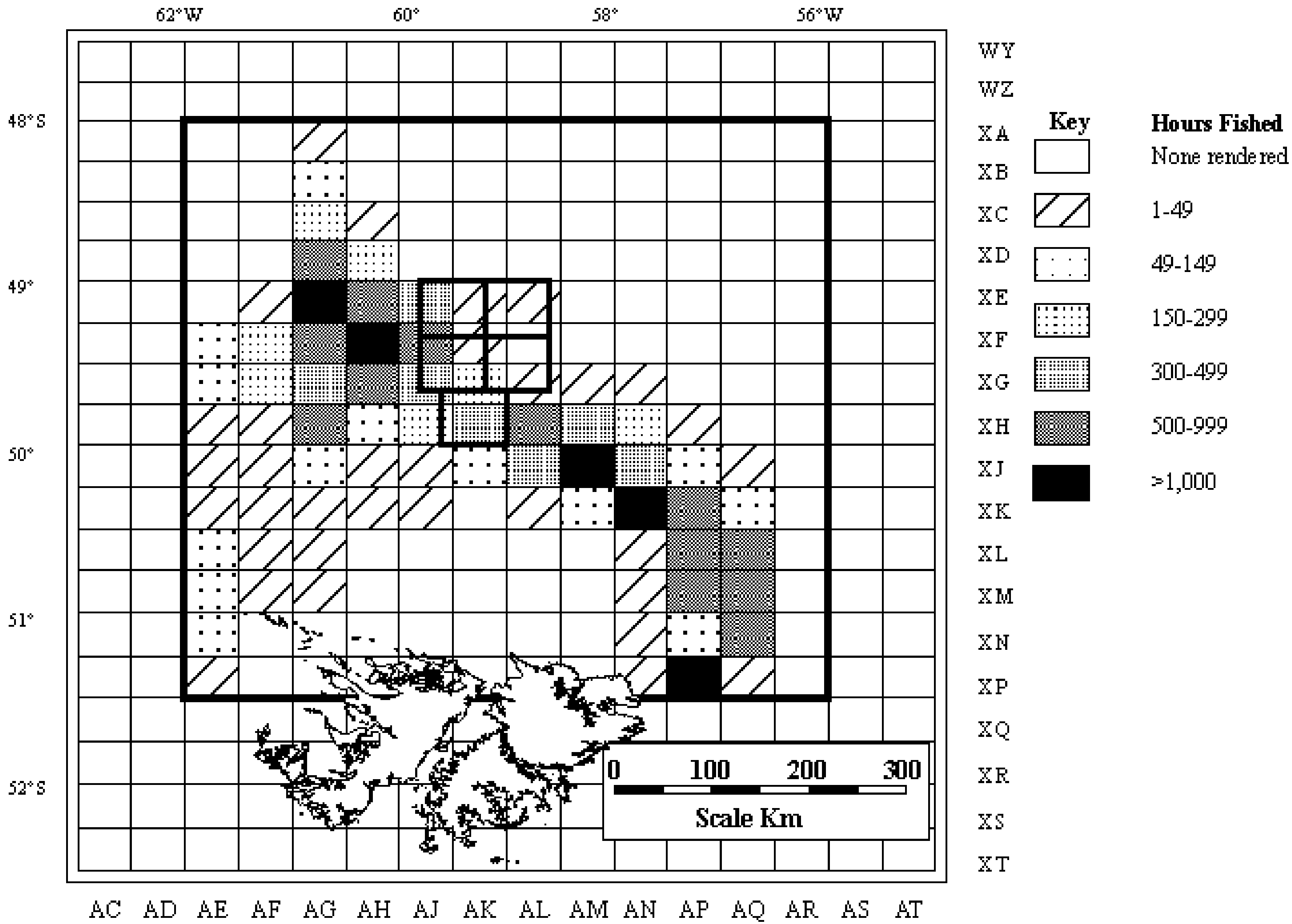
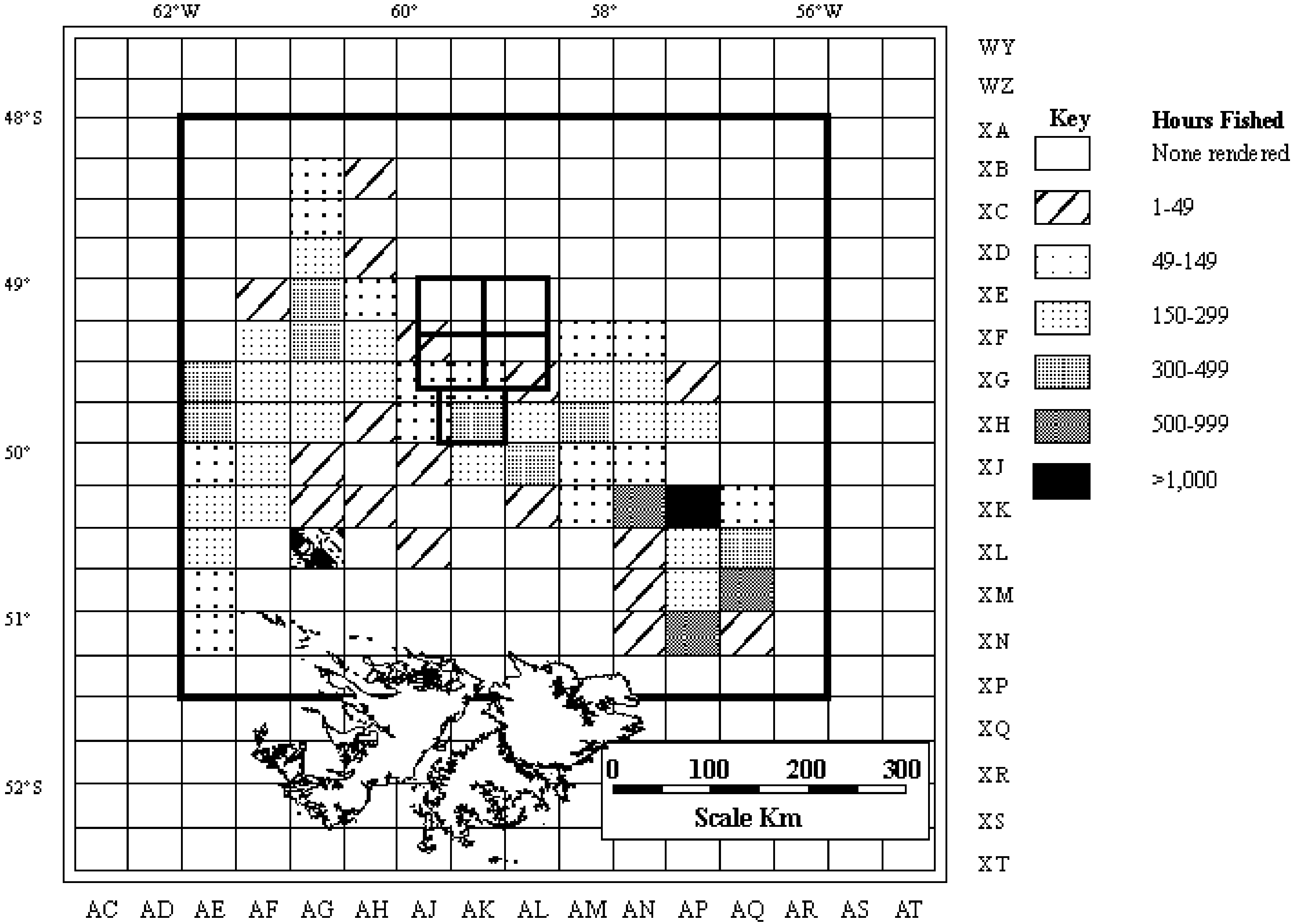


Figure B.27 Total trawling effort for the study area from 1st October – 31st December 1995



Finfish fisheries

Within the study area Tranches A and C represent the most important finfish fishing grounds constituting a main fishing area for hoki and a secondary area for red cod, skate and rays. Catches of kingclip, toothfish, and hake are recorded in the study area throughout the year, although these catches are of a low order (less than 50 tonnes) and represent the lowest finfish catches. Catches of blue whiting have also been recorded in these areas and are greatest during the second season (July to December) in the east of the study area. The main fishing area for the species is to the south-west of the Falkland Islands where the catch rates are high from August to October.

B.7.2 Shipping

The small community of the Falkland Islands is served by two shipping agents Jeppesen Heaton Ltd (formerly Falklands Islands Company) and Hogg Robinson Shipping Services Ltd (HR Shipping Services Ltd). Within the Islands, a local coaster maintains an irregular service between Stanley and other settlements (Hydrographer of the Navy, 1993). Jeppesen Heaton Ltd operate one ship, approximately 3,000 dwt purely for civilian use. This service operates four times a year out of London (Abernethy, 1997).

HR Shipping Services Ltd operate 4 different vessels of 4-5,000 dwt, several larger container vessels and a 10-12,000 dwt hold ship (Abernethy, 1997). These vessels carry both military and civilian freight to the islands and operate 12-13 journeys between the UK and the Falkland Islands each year, equating to approximately one ship per month (Meyer, 1996). With the exception of the 10-12,000 dwt hold ship, all vessels depart from Gravesend and dock at the Ascension Islands (four weeks later) before departing for Port Stanley. The hold ship journeys to the Falkland Islands via South American ports.

In view of the frequency of services and the routes operated by the shipping companies, it is unlikely that these vessels will be encountered in the northern licence Tranches under routine operating conditions. It is generally accepted that vessels do not approach the Falkland Islands via the waters of the license Tranches in preference to routes along coast of South America and to the east of East Falkland (Abernethy, 1997).

B.7.3 Pipelines and cables

There are no piplines or cables in the vicinity of the northern tranches or the wider study are to the north of the Falkland Islands

B.7.4 Wrecks/archaeological interests

There are numerous wrecks in the waters of the Falklands, three of these are located in and around the offshore study area. These wrecks are of unknown identity and have not been awarded special designations (eg war grave status) or restrictions. The Hydrographic Office identification number, co-ordinates and depths of the wrecks are given below.

- Wreck No 129700356, location 49°55' 06"S 58°02' 30"W, depth 300 m;
- Wreck No 140502865, location 50°17' 12"5 60°11 ' 00"W, depth 160 m;
- Wreck No 140503079, location 50°57' 18"5 58°52' 18"W, depth 140 m.

Appendix C

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Appendix C References

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Appendix D

Sources for information on benthic fauna of the Argentine continental shelf

Appendix D Sources for information on benthic fauna of the Argentine continental shelf

Only one published paper (Bastida *et al*, 1992) was found that attempted an overall characterisation of the benthic communities of the Argentine continental shelf, including the present study area, based on dredgings carried out by the RV *Shinkai Maru.* A single large (mean of 50 dm^3) sample of sediment was obtained at each station using a Picard dredge and passed through a 1 mm mesh. After publication of that work, Argentinean benthic studies have continued at the Universidad Nacional de Mar del Plata, but in more restricted areas and concentrated in the coastal zone around Buenos Aires (Bastida, pers comm, 1997). Most of these studies are unpublished to date. The Mar del Plata University has designed, in collaboration with universities in Brazil and Uruguay, a project which aims to study the benthos of the coast and continental shelf. The geographic distributions of the bryozoans sampled during the *Shinkai Maru* cruise were described by Lopez Gappa & Lichtstein (1988). A review of macrobenthic research carried out by Argentinean researchers prior to 1992 along the whole of their coastline and in the Argentinean claim in the Antarctic is provided by Bremec (1992). All of the work was based outwith the present area of interest.

Historically the benthos around the Falkland Islands has been sampled by the RV *Challenger* and *Discovery* expeditions. The United States Antarctic Research Programme since 1948 has involved sampling cruises by the USNS *Eltanin.* The animals collected are the subject of ongoing taxonomic research in the United States and several publications, for example Hartman (1967), Blake (1984). Other major surveys include the Anton Bruun collections around South America from the early 1960's, and surveys conducted by the German FFS *Walther Herwig* between 1966 and 1978 all over the Argentinean shelf from Brazil down to the Falklands and from coastal areas down to the continental slope. Benthic animals were collected by trawls, and the material deposited at the Hamburg Zoological Museum. Professor Dieter Walossek, Leader of the Section for Biosystematic Documentation at the University of Ulm, Germany, provided information about the *Walther Herwig* surveys and also supplied photographs of the trawled samples. Although all of the above-mentioned surveys yielded specimens for taxonomic study, they do not provide quantitative data on species distributions or community structure.

Information on the fauna of the Antarctic including the Falkland .Islands is also to be found in Knox & Lowry (1977), Knox (1977) and Knox (1994).

Dr Jose Orensanz, Associate Research Scientist at the School of Fisheries, University of Washington, maintains a comprehensive electronic biogeographical catalogue of benthic invertebrates from the south-west Atlantic which includes entries for approximately 3,000 species.

Much of the information gathered on benthic surveys for this present report was obtained in response to a general request in ANNELIDA, an electronic newsletter. ERT acknowledges the many individuals world-wide who passed on information that contributed to the wider picture. Information on the work conducted in this area by South American institutions was provided by Dr Ricardo Bastida, Universidad Nacional de Mar del Plata, Argentina and Dr Claudia Bremec, INIDEP, Mar del Plata. Searches for relevant publications records were also conducted using a variety of computerised databases.

Data on larger epibenthos obtained by Rockhopper trawl during a research cruise conducted in November 1994 by the Falkland Islands Fisheries Department was provided by Dr Con or P Nolan, Senior Fisheries Scientist.

An inshore marine survey (from the intertidal zone down to 30 m depth), was conducted in 1996 at 14 sites representative of the Islands' coastal zones (Brown and Root, 1997).

Valuable insights into the benthic communities of the Falkland Islands can be obtained from abstracts of papers presented at IBMANT'97, a workshop on marine biological research in waters around South America and Antarctica. Most of the results presented derived from the *Victor Henson* surveys of the Magellan Straights (southern Chile) conducted during October-November 1994, but the workshop revealed interesting similarities between the marine invertebrate communities of the Falkland Islands and of the southern Pacific coast of Chile (Bingham, 1997).

During the course of this study enquiries were made to the British Antarctic Survey (Dr Andrew Clarke), the British Museum of Natural History (BMNH; Dr David George) and the British Geological Survey (Dr Nigel Fannin). None of these institutions holds survey data for the study area, although some animal specimens collected from the Falklands are likely to be held by the BMNH.

Gaps in offshore benthic data for the Falklands and need for baseline surveys

The description of the benthic communities of the Argentine continental shelf published in 1992 by Bastida *et al* remains a key work for the South-western Atlantic, but work in this area is far from complete and many areas are still completely unknown (Bastida, pers comm, 1997). Although the above-mentioned FFS *Walther Herwig* and USNS *Eltanin* and other surveys yielded specimens for taxonomic study, they do not provide the kind of quantitative data necessary for baseline descriptions or monitoring use.

A general lack of knowledge of the type and distribution of offshore benthic communities around the Falkland Islands prevents a detailed description of such communities in the vicinity of the northern Tranches. There are no relevant data on abundance, diversity or biomass levels. The information available indicates a patchy occurrence of hard sediment. Specific baseline sampling will be of benefit to the understanding of the benthic fauna at the proposed drilling locations. The operators have committed to conduct such a survey prior to the commencement of drilling activities, and the survey design should be adapted as information on sediments in the region becomes available. Sampling will allow characterisation of the key physical, chemical anti biological parameters of the seabed in and around the Tranches. This characterisation will provide a basis for the design of, and comparison with, future monitoring surveys conducted in respect of specific industrial activities, and will support the overall environmental management of the licence areas. Understanding of the seabed sediments, their chemical composition and faunal communities is of particular importance due to their readily quantifiable nature and because any effects from oil development activities are most likely to be detected at the seabed. .

The benthic fauna of this area is not particularly well known, and adequate local identification guides are not available. It is likely that species will be sampled that are new to science. However, a substantial amount of taxonomic work has been carried out and is in progress on species from around the Falklands and other subantarctic areas, and it will be possible for experienced workers to characterise the fauna and monitor impacts of disturbance.

List of taxonomic literature of relevance to the study area

The following list is not intended to be exhaustive, but contains key works of which we are aware.

Hartman O (1967) Polychaetous annelids collected by the USNS *Eltanin* and Staten Island cruises, chiefly from Antarctic seas. *Allan Hancock Monographs in Marine Biology,* No 2. The Allan Hancock Foundation, University of Southern California, Los Angeles, California. 387 pp.

Notes: Contains descriptions and drawings of many deep-water species from the Falkland Islands, including new genera and species described from there.

Blake J A (1984) Polychaeta Oweniidae from Antarctic seas collected by The United States Antarctic Research Programme. *Proceedings of the First International Polychaete Conference, Sydney.* Ed. P A Hutchings, Linnean Society of New South Wales, 112-117.

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Appendix E

Oil spill response strategy recommendations

Appendix E Oil spill response strategy recommendations

Oil Spill Response Strategy for Falkland Islands Exploration Blocks

Introduction

The decision on oil spill response actions that may be utilised in the event of spillage from exploration activities will ultimately depend on a number of factors:

- Type and quantity of oil spilled.
- Pertaining wind and currents (slick trajectory).
- Resources under threat.
- Equipment and trained personnel availability.
- Logistical support availability.
- Political pressures.
- Media pressures.

Good contingency planning practice demands that credible analyses of spill scenarios are undertaken. Such analyses should attempt to encompass the above factors and, where possible, influence the level of response preparedness.

The following outlines various spill response options which the exploration companies considered and the justification for their proposals. The basis of these proposals is the computer simulation model Oil Spill Information System (OSIS) and the particular challenges and constraints faced in the Falkland Islands.

Expectations, Awareness and the Political Climate

Virtually all the organisations with potential input to an oil spill response were consulted during an information gathering visit to the Islands. This round of meetings allows an assessment of current expectations to be made. These may be summarised as:

- A genuine and universal desire to assist in the contingency planning process.
- Existing awareness of the serious constraints to spill response posed within the Falklands. .Willingness to listen to explanations of these serious constraints where appropriate.
- Widespread belief that the northerly licensed areas pose a less serious risk than potential licensing in the Special Area of Co-operation to the south-west. This is based on local knowledge of the prevailing wind and currents coupled with the perception by a number of organisations that shoreline oiling is the worst environmental impact of a spill. There are also some politically sensitive sites in the south-west (e.g. New Island). The ' shoreline oiling impact' was put in context by Falkland Conservation, who pointed out the lack of knowledge of open sea vulnerabilities (notably seabird distributions).
- General understanding that the highest current and future oil spill risk is associated with shipping operations and particularly bunkering within Berkeley Sound.
- A concern was voiced by some that environmental groups outside the Falklands may utilise the forthcoming exploration activities as a means to further wider agendas. This was not seen as a positive factor, but was interpreted as a driver to ensure all possible spill response options should be realistically considered.
- No expectations of industry maintaining a response base in the Falklands to cover the spill risk from forthcoming exploration drilling was apparent.

Strategy Options

Leave alone For spills of light oils and small spills of other oil types, a monitor and evaluate response is justified. This is because the oil will dissipate quickly without serious environmental consequences. This strategy requires aerial surveillance capability to allow any slick to be tracked and its dissipation thus confirmed.

Dispersants These are specifically formulated and licensed products designed to greatly facilitate the formation of dispersed oil droplets in upper surface waters. Dispersants contain surfactant chemicals that reduce the surface tension at the oil-water interface and allow the formation of tiny oil droplets, when some wave energy is present.
The droplets redistribute the oil into the surface water (usually the top few meters), where dilution and biodegradation can occur. Whilst the successful use of dispersants does lead to a transient increase in oil concentrations in the surface waters, there should be no significant increase in the acute toxicity of the oil-dispersant mix compared to the oil alone.

Application of dispersant on to oil at sea can be either from vessels and aircraft.

Contain & *Recover* Containment and recovery involves corralling the oil within a floating barrier (boom) and recovering that oil using various devices (skimmers). Vessels are required to carry and deploy the equipment and successful operations generate a need for temporary oil storage and ultimately disposal.

Protection The use of booms in coastal and shoreline areas as a means to protect sensitive resources can be an effective strategy. This is particular true if the resource is relatively sheltered, away from strong currents and does not require long lengths of booms (i.e. many 100s of metres).

Good planning is required for the effective use of protection measures. This includes the identification and prioritisation of protectable areas and the development of equipment and personnel requirements and procedures.

Shoreline Clean-up Removal of oil from beaches can bring environmental, aesthetic and PR benefits. It can also be hazardous, invasive and require significant logistics and management. Many areas in the Falklands are remote and inaccessible and leaving stranded oil to degrade naturally may be a viable response for many shorelines.

The labour intensive nature of many shoreline clean-up techniques and the generation of waste oil, debris, beach and other materials would present serious logistical and operational challenges.

Response Constraints

The constraints to effective response in the Falklands must be fully understood, as these dictate the response recommendations. The following lists and expands upon the main constraints. Each of these constraints alone could prevent certain response options; in combination they present formidable challenges.

Spilled Oil Behaviour The tendency of most oils to spread rapidly and fragment can lead to large areas of open sea containing thin, floating oil slicks. The ' oil encounter rate' of any countermeasures (e.g. the mouth of a collection boom or the spray pattern from a dispersant application system) may become relatively slow.

Formation of water-in-oil emulsions, with associated increase in viscosity, progressively renders an oil untreatable by dispersants and increasingly difficult to recover and pump if contained in a boom.

Climate

Meteorological records indicate that the Falkland Islands are subject to relative high winds and associated sea states. The mean wind speed at Stanley exceeds 15 knots and prolonged calm periods are rare. On average more than 4 gales a month can be expected. This type of climate severely limits the successful operation of booms to contain oil and allow its collection. Whilst containment may appear desirable, winds above around Beaufort Force 5 (18 knots) lead to such operations becoming ineffectual and potentially dangerous for vessel crews.

Tidal and residual currents also limit the ability of booms to function properly. Any boom perpendicular to a current above about 0.7 knots will begin to fail to contain oil. The Falkland archipelago has a number of sea areas where tidal currents greatly exceed 0.7 knots (though these are away from the licensed areas).

Equipment

Booms can only be handled at sea up to certain lengths. Manoeuvrability is very difficult with lengths above 500 m, even with ideally suited vessels. This maximum length still provides a poor encounter rate as the entrance to a containment formation will be around 150 m and the deployment cannot exceed a relative speed of 0.7 knots.

If oil has been successfully contained, all skimmers have a limited range of oil viscosity capability. Large quantities of water may also be collected along with the oil, generating potential storage problems.

Suitable vessels for boom and skimmer deployment offshore are not readily available in the Falklands. Recovered oil storage vessels are also not likely to be available.

Remoteness

The geographic location of the Islands may be described as internationally remote. The nearest viable seaports and airports are Punta Arenas (Chile) and Montevideo (Uruguay), the former being closest at 480 miles.

In the national context a large proportion of the Archipelago's coast is also remote. The main island group is approximately 160 miles (250 km) east-west by 95 miles (150 km) north-south. There are:

- over 400 islands, many of which are heavily indented. The Islands coastline is many hundreds of miles long;
- few habitations, amounting to isolated stations (farms) and settlements;
- minimal roads or tracks (a road construction programme is underway, but this will still leave many coastal areas inaccessible);
- limited harbours; and
- few airfields or suitable landing areas.

The inaccessibility of much of the coastline is a crucial factor in planning safe and feasible response strategies.

Personnel

The total resident population of the Islands is approximately 2,000. It should be appreciated that this limits the availability of personnel who may be called upon to assist with a spill response effort.

OSIS Modelling

A number of fate and trajectory runs were undertaken, utilising a section of Proudman Oceanographic Laboratory's Patagonian Shelf current model configured for OSIS. The model utilised a tidal component plus a uniform contribution from the Falkland Current. These runs focused on the following parameters:

- Two release sites, representing sites in the north and south of the licensed sea areas. The precise locations of the release sites are as follows:
  Northern location: 49°20' S, 59°12' W (central point of Tranches A-D)
  Southern location: 50°00' S, 59°18' W (central along southern boundary of Tranche F).

- Four oil types, representing the four oil groups (1 to 4) identified on the basis of specific gravity (group 1 being a light, non-persistent oil progressing to group 4, being a very heavy persistent oil). The oil types used and their characteristics when fresh are shown in Table 1.

Group	Oil type	S.G.	Pour point (°C)	Viscosity @ 15°C (cSt)	Asphaltene (%)
1	Kerosene	<0.8	low	2	0
2	Argyll	0.83	9	11	0.95
3	Forties	0.85	0	8	0.24
4	Gamba	>0.95	30	high	0.05

Table 1 Oil types and characteristics used for OSIS runs

The spill scenario was based on an on-going release of 1,000 m3 per hour for 12 hours (i.e. low risk of occurrence).

- Initially runs used a constant wind speed and direction based on monthly historical meteorological information, obtained from The Meteorological Office. This provided a framework for prediction of the oils' weathering, but was not realistic for trajectory (generally winds do not blow continuously from a given direction for long periods). Likely trajectory (specifically the threat of oil beaching) was estimated through reference to historical wind persistence data.

Modelling Results: Weathering

All Group 1 (Kerosene) computer runs indicated total dissipation of the floating slick within 12 hours of release cessation. The processes of evaporation and natural dispersion were jointly responsible for the oil's dissipation.

Of the runs of Groups 2, 3 & 4 oil types there was a prediction of dissipation at sea within a time frame ranging from about 7 to 11 days.

The model predicted rapid emulsification of the group 2, 3 & 4 oils under each monthly weather scenario. This process is a key factor retarding the dissipation of the oil. It also indicates a relatively short 'window of opportunity' for use of chemical dispersants (see later *strategy recommendations* discussions).

Although the characteristics of any oil that may be found in the exploration process remain unknown, it is a fact the many oils do form water-in-oil emulsions. The process is facilitated by the sea states associated with the relatively high wind strengths found in the Falklands.

Modelling Results: Trajectory

The approximate earliest beaching time for the persistent oils (2, 3 and 4) was obtained from OSIS, under four wind speeds (5, 10, 20 and 30 knots). This information has been factored against likelihood of wind persisting from a direction that would lead to beaching The direction criterion was based on the wind blowing towards land from the southerly release point. Table 2 presents this information.

	Wind speed (direction criterion 315° -075° [NW to ENE])			
Duration of spell (hours)	>5 knots	>10 knots	>20 knots	>30 knots
6 or more	118.9	109.1	54.5	9.1
12 or more	72.9	58.3	18.7	1.1
18 or more	42.8	28.5	6.3	0.3
24 or more	23.8	15.2	2.5	0.0
36 or more	7.8	4.1	0.7	0.0
48 or more	2.8	0.9	0.2	0.0
60 or more	1.8	0.6	0.1	0.0
72 or more	0.7	0.6	0.0	0.0
84 or more	0.3	0.1	0.0	0.0
96 or more	0.1	0.1	0.0	0.0
108 or more	0.1	0.1	0.0	0.0
120 or more	0.1	0.1	0.0	0.0
132 or more	0.1	0.1	0.0	0.0
144 or more	0.1	0.0	0.0	0.0

Table 2 *Wind persistence*, *Mount Pleasant* (7/1985 *to* 12/1996)
Entries in the table indicate the average number of 'spells' per year.
Shaded cells are possible beaching scenarios from southerly release point (*i.e. the nearest to land*).

Data interpretation

Table 2 provides an indication of average wind spell frequencies (i.e. wind persistence):

Example: There are on average 4.1 occasions per year when the wind blows between NW and ENE at greater than 10 knots for 36 hours or more.

This wind spells data may be compared against likely beaching times under varying wind speeds. This is shown on Table 2 by the shaded cells.

Reference to the spells data from which the figures in Table 2 are derived indicates that over the 11.5 year recording period there are two occasions that would lead to beaching, of (a) 48 hours and (b) 132 hours duration. Case (a) requires the full 48 hours whilst case (b) requires 96 hours to bring the oil ashore.

Therefore a random oil spill from the southerly release point would have a beaching probability of approximately 1 in 2,700 [37 out of 100,740 hours].

This low risk should be further taken in the context of a statistical likelihood of blow-out of approximately 1 in 4,800 per well month

Strategy Recommendations

The various strategy options listed previously have been put in context by the serious constraints identified. Realistic recommendations follow in this section.

Tier* 1 *Capability

Leave alone

Aerial surveillance capability is likely to be available from the Falkland Islands Government Air Service (FIG AS) Islander aircraft. Two such aircraft are equipped for flying over sea for extended periods and possess the range to cover the oil exploration licensed acreage. These aircraft should be able to confirm the dissipation of either small or light oil spills.

Dispersants

The successful application of dispersants relies on the oil remaining treatable. Above certain viscosity limits, the dispersant become ineffective, as the surfactant cannot penetrate to the oil-water interface. Increase in viscosity is caused primarily by emulsification and evaporation.

The ' window of opportunity' for dispersant use is unlikely to exceed two days. This would be under favourable circumstances, with an oil type that does not readily emulsify. However an on-going oil release would allow on-going dispersant use, with continuous fresh oil present. It is recommended that ' tier l' capability is maintained to provide a first strike dispersant response. Recommended application mode is from a standby vessel.

A typical offshore boat spraying operation could apply around 18m3 of concentrate dispersant per 10 hour day (treating approximately 360m3 of oil). Storage capacity for dispersant on a vessel may be limiting, but the drilling rig should be able to provide additional storage. The correct use of dispersant requires training of operators, availability of application guidelines and aerial support for accurate targeting and assessing effectiveness.

It is recommended that 3 days spraying capability is the tier 1 resource, amounting to 54m3 of concentrate dispersant. After this period it is expected that OSRL would supply back-up dispersant resources.

It is recommended that two days supply (36m) of the dispersant is any of the UK-licensed concentrates, which are likely to be effective on fresh oil. It is suggested that the third day' s supply be the specific product Corexit 9500 (or any forthcoming equivalent), as this dispersant extends the viscosity range of successful operation.

Guidelines have been proposed to FIG regarding areas where dispersant may be used. The National Plan will include such guidelines and it is not expected that use offshore will be prohibited.

Tier* 2 *Capability

National Stockpile

It is expected that FIG will have a relatively small equipment stockpile (inshore boom, sorbent materials & personal protective equipment) and personnel trained in its use operational during the first half of 1998. This could prove effective in mounting a response to relatively small spills associated with fuel transfers and supply in Stanley Harbour / Berkeley Sound.

Tier* 3 *Capability

OSRL

The mobilization time for personnel and equipment from Southampton could be the order of 40 hours. Support envisaged includes a variety of specialised equipment to assist offshore and nearshore strategies, with staff to provide technical advice and extra personnel if a sustained response over a number of days is required.

On-going dispersant application could be supported by OSRL. A feasible supply route would allow the provision of 30m3 concentrate from the UK within 40 hours to maintain boat spraying operations. If further on-going application is needed the ADDSPack aerial system may be mobilized to the Islands.