B2.4 Byproduct and bycatch

B2.4.1 Bycatch of target species

Rock lobsters caught in traps consist of legal-sized lobsters, lobsters below the legal minimum size or above the legal maximum size and berried females of legal size. Table B2.8 shows for each of the geographical zones of the fishery, the estimated number of rock lobsters of legal size retained, compared to the number of lobsters discarded annually because they were below the minimum size, beyond the maximum legal size or berried.

Table B2.8 Estimated number of lobsters discarded annually by fishing region, 1999-00 to 2001-02

(Source: G. Liggins, *pers. comm.*)

	<104mmCL DISCARDED	104-200mmCL & Not Berried KEPT	104-200mmCL & Berried DISCARDED	>200mmCL & Berried DISCARDED	>200mmCL & NOT Berried DISCARDED	Total
Far north	346	6,455	292	247	314	7,654
Mid north	91,037	47,819	106	141	252	139,355
Sydney south	55,816	53,220	14	4	28	109,082
Far south	9,199	30,674	1	0	6	39,880
Total	156,398	138,168	413	392	600	295,971
% catch of all classes	52.84	46.68	0.14	0.13	0.2	

The depth distributions are summarised as follows: For undersized lobsters 99% of the catch of undersize lobsters was from depths less than 30m; for berried females 84% of the catch was from depths less than 30m; for oversize lobsters, 10% of the catch was from depths less than 10m, 72% was from depths of 10-30m and 18% was from depths greater than 30m.

The discarding of undersized lobsters may adversely affect their survival and growth. Capture in traps and subsequent discarding can have direct effects through physical damage to the lobsters through contact with the traps, injury or stress through handling, injury or stress through exposure before return to the water as well as increased predation before a discarded lobster returns to its home ground. While the provision of escape gaps would reduce the proportion of undersized lobsters, it would not eliminate the catch of undersized lobsters. Brown and Caputi (1986), in studies of discarded undersized western rock lobster, indicate that with one escape gap of 54mm width, approximately one undersize lobster was retained for each legal-sized lobster, and this 1:1 ratio could be reduced to 0.45:1 with two 55mm escape gaps. The combined effects of damage, displacement and exposure of more than 15 minutes were estimated to produce an additional mortality of 11%. While these trials were on a different species in a different location, the risk factors of exposure, damage and displacement still apply for the NSW Lobster Fishery, and useful data on time of exposure, physical damage and displacement could be collected with relatively small extra effort from future observer studies.

It is possible that the handling of berried and oversized lobsters could have some effect on fecundity. While this is a possible impact, there is no evidence of a significant problem in this regard, and is not considered to be a research priority for NSW Lobster Fishery. While this aspect of discarding of the target species does not fit the risk assessment methodology used in environmental impact assessments for this and other NSW commercial fisheries, an informal risk assessment assigned a low level of risk to the discarding of rock lobsters.

B2.4.2 Byproduct and bycatch species other than rock lobster

The quantity of bycatch and byproduct species caught by this fishery is relatively minor compared to most other commercial fisheries in NSW. Tables B2.9 and B2.10 show the list of species caught and estimated annual quantity of byproduct and bycatch for the Lobster Fishery. The data are based on the results of observer monitoring of the Lobster Fishery for the three years 1999/00 to 2001/2002 (Liggins, 2004 *In Prep*.). Monitoring procedures for byproduct and bycatch species have been limited to ongoing observer studies, which commenced in 1999. Because of the relatively small quantity of bycatch, management measures for the NSW fishery have not included bycatch reduction measures such as escape panels.

There were two constraints in applying the risk assessment to bycatch and byproduct species, namely that species were only considered for the formal risk assessment if the total retained catch was greater than one tonne (from the Lobster Fishery) and if the proportion landed by the Lobster Fishery was greater than 5% of total landings for all commercial fisheries in NSW waters. None of the species in this category are considered rare species, so these limits are quite conservative, and it would be safe to infer that taxa not meeting the criteria would be at low or negligible risk from the Lobster Fishery. Following are summaries of landings data and risk analysis results for individual taxa. More detailed information on the biological characteristics of these taxa is provided below.

B2.4.2.1 Bycatch

Hermit crabs comprise 81% of the total weight of discards, and sharks make up 71% of the remainder. For each teleost fish species caught, the quantity of discards is below one tonne per year, with redfish (851 kg), eastern wirrah (831 kg) and eastern blue groper (717 kg) the only species with an estimated weight of discards exceeding 500 kg (see Table B2.10). It is likely that there is a low mortality associated with the discarding of hermit crabs because of the protection provided by thick shells. The small amounts of discards for all other species indicate a negligible effect of discarding on these populations. The discarding of eastern blue groper is discussed in section B2.6.

Table B2.9 Species list from observer survey of the catch of the commercial trap fishery for eastern rock lobster 1999/00 to 2001/02.

Family	Species	Common name
Finfish		
APLODACTYLIDAE	*Crinodus lophodon*	Rock cale
AULOPIDAE	*Aulopus purpurissatus*	Sergeant baker
BERYCIDAE	*Centroberyx affinis*	Redfish
BRACHAELURIDAE	*Brachaelurus waddi*	Blind shark
CARANGIDAE	*Pseudocaranx dentex*	Silver trevally
CHAETODONTIDAE	*Chelmonops truncatus*	Eastern talma
CHEILODACTYLIDAE	*Cheilodactylus fuscus*	Red morwong
	Cheilodactylus spectabilis	Banded morwong
	Nemadactylus douglasi	Rubberlip morwong
	Nemadactylus macropterus	Jackass morwong
	N. douglasi or *N. macropterus*	Morwong
CHIRONEMIDAE	*Chironemus marmoratus*	Eastern kelpfish
CONGRIDAE	various spp.	Conger eel
DASYATIDIDAE	various spp.	Stingray

Table B2.9 cont.

Family	**Species**	**Common name**
DIODONTIDAE	various spp.	Pufferfish
ENOPLOSIDAE	*Enoplosus armatus*	Old wife
GIRELLIDAE	*Girella elevata*	Rock blackfish
GLAUCOSOMIDAE	*Glaucosoma scapulare*	Pearl perch
HETERODONTIDAE	*Heterodontus portusjacksoni*	Port Jackson shark
HOLOCENTRIDAE	*Ostichthys* spp.	Red squirrelfish
HYPNIDAE	*Hypnos monopterygium*	Numbfish
LABRIDAE	various spp.	Wrasses
	Achoerodus viridis	Eastern blue groper
	Bodianus spp.	Foxfish/Pigfish
	Ophthalmolepis lineolatus	Maori wrasse
LABRIDAE cont.	*Pseudolabrus gymnogenis*	Crimson-banded wrasse
LATRIDIDAE	*Latris lineata*	Tasmanian trumpeter
MONACANTHIDAE	various spp.	Leatherjacket
	Eubalichthys mosaicus	Mosaic leatherjacket
	Meuschenia freycineti	Six-spined leatherjacket
	Meuschenia scaber	Velvet leatherjacket
	Meuschenia trachylepis	Yellow-finned leatherjacket
	Nelusetta ayraudi	Chinaman leatherjacket
MONOCENTRIDAE	*Cleidopus gloriamaris*	Pineapple fish
MONODACTYLIDAE	*Monodactylus argenteus*	Diamond fish
MULLIDAE	*Upeneichthys lineatus*	Goatfish
MURAENIDAE	various spp.	Moray eel
NARCINIDAE	*Narcine tasmaniensis*	Numbfish
OPHIDIIDAE	*Genypterus blacodes*	Pink ling
ORECTOLOBIDAE	*Orectolobus maculatus* & *O. ornatus*	Wobbegong
OSTRACIIDAE	*Anoplocapros inermis*	Eastern smooth boxfish
	Lactoria spp.	Cowfish
PARASCYLLIDAE	*Parascyllium collare*	Collared catshark
PATAECIDAE	*Pataecus fronto*	Red indianfish
PEMPHERIDAE	*Pempheris compressus* & *P. multiradiata*	Bullseye
PLOTOSIDAE	*Cnidoglanis macrocephalus*	Catfish
POMACENTRIDAE	*Abudefduf vaigiensis*	Sergeant major
	Chromis hypsilepis	One spot puller
	Parma spp.	Parma
PRIACANTHIDAE	*Priacanthus macracanthus*	Red bigeye
RHINOBATIDAE	*Trygonorhina fasciata*	Banjo ray
SCARIDAE	various spp.	Parrotfish
SCORPAENIDAE	*Helicolenus percoides*	Inshore ocean perch
	Scorpaena cardinalis	Eastern red scorpioncod
SCORPIDIDAE	*Atypichthys strigatus*	Mado
	Microcanthis strigatus	Stripey
	Scorpis aequipinnis	Sweep
SCYLIORHINIDAE	various spp.	Swellshark

Table B2.9 cont.

Family	Species	Common name
SERRANIDAE	*Acanthistius ocellatus*	Eastern wirrah
	Epinephelus ergastularius	Bar cod
	Epinephelus undulatostriatus	Maori cod
SIGANIDAE	*Siganus fuscescens*	Black spinefoot
SPARIDAE	*Acanthopagrus australis*	Yellowfin bream
	Pagrus auratus	Snapper
TETRAODONTIDAE	various spp.	Toadfish
TRIGLIDAE	*Chelidonichthys kumu*	Red gurnard
UROLOPHIDAE	various spp.	Stingaree
ZEIDAE	*Zeus faber*	John dory
<multiple families>	various spp.	Unidentified Fish
Invertebrates		
DIOGENIDAE	*Dardanus arrosor* & *Trizopagurus strigimanus*	Hermit crab
OCTOPODIDAE	*Octopus* spp.	Octopus
PALINURIDAE	*Jasus edwardsii*	Southern rock lobster
PALINURIDAE	*Panulirus* spp.	Painted crayfish
PORTUNIDAE	*Ovalipes australiensis*	Two-spot crab
	Portunus pelagicus	Blue swimmer crab
	Scylla serrata	Mud crab
SCYLLARIDAE	*Scyllarides haanii* & *S. squammosus*	Slipper lobster
SEPIIDAE	*Sepia* spp.	Cuttlefish
TURBINIDAE	*Turbo* spp.	Turban snail
VOLUTIDAE	*Cymbiolena magnifica* & *Livonia mamilla*	Bailer shell
<multiple families>	various spp.	Unidentified Crab
<multiple families>	various spp.	Sea urchin

Table B2.10 Preliminary estimates of annual quantities of retained catch (byproduct) and discarded catch (bycatch) of non-target species from observer studies of the NSW Lobster Fishery.

COMMON NAME	Retained Count	Retained Weight (kg)	Discarded Count	Discarded Weight (kg)	Total Count	Total Weight (kg)	%kept (weight)	%kept (number)
Hermit crab	N/A	23395	N/A	115794	N/A	139189	16.8	N/A
Morwong	11737	8020	728	168	12465	8189	97.9	94.2
Wobbegong	1106	7686	1391	5853	2496	13539	56.8	44.3
Redfish	20975	5795	4796	813	25771	6609	87.7	81.4
Chinaman leatherjacket	8530	3627	57	13	8586	3641	99.6	99.3
Rubberlip morwong	3604	2617	1206	313	4809	2929	89.3	74.9
Leatherjacket	3302	1739	496	209	3798	1948	89.3	86.9
Octopus	910	1621	421	374	1331	1996	81.2	68.4
Conger eel	423	1535	69	225	492	1760	87.2	86.0
Jackass morwong	1270	1355	106	19	1376	1374	98.7	92.3
Catshark/Swellshark	927	1321	8088	13906	9014	15227	8.7	10.3

Table B2.10 cont.

COMMON NAME	Retained Count	Retained Weight (kg)	Discarded Count	Discarded Weight (kg)	Total Count	Total Weight (kg)	%kept (weight)	%kept (number)
Blind shark	371	1138	2412	1825	2783	2963	38.4	13.3
Silver trevally	1561	922	22	7	1584	929	99.3	98.6
Snapper	1562	837	1199	278	2760	1115	75.1	56.6
Southern rock lobster	529	786	0	0	529	786	100.0	100.0
Red morwong	1544	765	499	217	2044	982	77.9	75.6
Eastern red scorpion cod	2093	739	820	349	2913	1088	68.0	71.8
Aust. Swellshark (draughtboard)	529	720	0	0	529	720	100.0	100.0
Tasmanian trumpeter	298	619	0	0	298	619	100.0	100.0
Cuttlefish	233	557	194	156	427	714	78.1	54.6
Six-spined leatherjacket	1106	521	44	11	1151	532	97.9	96.2
Eastern wirrah	1212	500	1950	851	3162	1351	37.0	38.3
Yellowfin bream	823	282	783	214	1605	496	56.9	51.3
Slipper lobster	885	279	44	20	929	299	93.3	95.2
Catfish	509	271	606	388	1115	659	41.1	45.6
Eel	53	265	26	185	79	450	58.8	66.7
Yellow-finned leatherjacket	770	171	305	52	1074	223	76.5	71.6
Maori wrasse	376	145	221	73	597	218	66.5	63.0
Unidentified fish	159	139	119	126	278	265	52.4	57.1
Bar cod	61	113	17	3	78	116	97.0	78.0
Velvet leatherjacket	318	98	0	0	318	98	100.0	100.0
Crimson-banded wrasse	349	97	89	22	438	119	81.5	79.8
Parrotfish	199	70	230	67	429	137	51.0	46.4
Mosaic leatherjacket	91	66	34	14	125	80	82.7	72.5
Inshore ocean perch	87	43	303	56	390	99	43.3	22.4
Foxfish/Pigfish	106	42	0	0	106	42	100.0	100.0
Pink ling	26	24	0	0	26	24	100.0	100.0
Mud crab	34	22	0	0	34	22	100.0	100.0
Sweep	44	13	575	81	620	94	14.1	7.1
John dory	26	13	0	0	26	13	100.0	100.0
Maori cod	17	12	0	0	17	12	100.0	100.0
Pearl perch	26	11	17	5	44	16	67.2	60.6
Red gurnard	17	10	0	0	17	10	100.0	100.0
Parma	22	9	850	90	872	99	8.9	2.5
Eastern smooth boxfish	69	9	912	126	981	135	6.4	7.0
Black spinefoot	22	7	22	17	44	23	28.6	50.0
Red indianfish	22	2	0	0	22	2	100.0	100.0

Table B2.10 cont.

COMMON NAME	Retained Count	Retained Weight (kg)	Discarded Count	Discarded Weight (kg)	Total Count	Total Weight (kg)	%kept (weight)	%kept (number)
Bailer shell	0	0	22	9	22	9	0.0	0.0
Banded morwong	0	0	53	16	53	16	0.0	0.0
Banjo ray	0	0	39	67	39	67	0.0	0.0
Blue swimmer crab	0	0	17	3	17	3	0.0	0.0
Common bullseye	0	0	150	12	150	12	0.0	0.0
Coral crab	0	0	17	3	17	3	0.0	0.0
Diamond fish	0	0	39	5	39	5	0.0	0.0
Eastern blue groper	0	0	429	717	429	717	0.0	0.0
Eastern kelpfish	0	0	261	74	261	74	0.0	0.0
Eastern talma	0	0	22	4	22	4	0.0	0.0
Goatfish	0	0	89	65	89	65	0.0	0.0
Mado	0	0	686	47	686	47	0.0	0.0
Moray eel	0	0	119	80	119	80	0.0	0.0
Numbfish	0	0	69	26	69	26	0.0	0.0
Old wife	0	0	752	82	752	82	0.0	0.0
Pineapple fish	0	0	103	20	103	20	0.0	0.0
Port Jackson shark	0	0	385	1208	385	1208	0.0	0.0
Puffer fish	0	0	698	143	698	143	0.0	0.0
Red crab	0	0	261	27	261	27	0.0	0.0
Red squirrelfish	0	0	17	5	17	5	0.0	0.0
Rock blackfish	0	0	53	53	53	53	0.0	0.0
Rock cale	0	0	791	215	791	215	0.0	0.0
Sand crab	0	0	379	43	379	43	0.0	0.0
Sea urchin	0	0	385	78	385	78	0.0	0.0
Sergeant baker	0	0	61	73	61	73	0.0	0.0
Stingray	0	0	22	7	22	7	0.0	0.0
Stripey	0	0	57	5	57	5	0.0	0.0
Turban snail	0	0	66	9	66	9	0.0	0.0
Unid. Crab	0	0	53	11	53	11	0.0	0.0

B2.4.2.2 Byproduct

The estimated quantity of byproduct of various species in the Lobster Fishery is given in Table B2.10. Those taxa with a more than one tonne retained are discussed briefly in this section, and biological information is summarised in Table B2.11. A more detailed risk assessment for three of the species is provided in section B2.4.3.

Table B2.11 Summary of the biological characteristics for the target and main byproduct species of the fishery.

Common name and taxonomic name	Exploitation Status	Distribution	Reproductive strategy	Size at maturity	Age at maturity	Longevity	Growth rate	Stock structure	Stock recruitment relationship
Target species									
Eastern rock lobster	Fully fished	NSW, Vic, Tas,SA, NZ	Eggs attached to female until hatching. Larvae are pelagic. Fecundity 400,000 to 2 million eggs per year.	167 female (size at onset of breeding)	6 - 9 yrs	Long-lived	12 - 20mm/yr at 100mm CL	NSW population is a single stock	Unknown
Byproduct species									
Leatherjackets Monacanthidae (various spp.)	Uncertain	All Australian states, NZ	Demersal eggs - pelagic larvae Fecundity - Max about 2 million*	31 cm (100%)*	3-4 years*	Probably short lived. 9+ years (females)* 7+ years (males)*	Probably fast. Mean growth of 28 cm in 2 years*	Unknown for NSW fish	Unknown
Rubberlip morwong *Nemadactylus douglasii*	Fully fished	Qld, NSW, Vic, Tas, Northern NZ	Pelagic eggs and larvae - congeneric species have an extended pelagic larval stage Fecundity - Unknown	Unknown	Unknown	Long lived >20 years	Slow growth	Unknown	Unknown
Jackass morwong *Nemadactylus macropterus*	Fully fished	Southern Indian and Pacific Oceans NSW, Vic, Tas, S.A., W.A., NZ,	Pelagic eggs and larvae. Specialised pelagic juvenile form. Fecundity - > 1 million eggs (mean for 10 year old fish)	25 cm FL (both sexes)	3 years (both sexes)	Long lived 50+ years in NZ waters 16+ years in Australian waters	Slow growth	NSW/Vic population is a single stock	Unknown
Wobbegong sharks *Orectolobus ornatus* and *O. maculatus*	Uncertain	Qld, NSW, Vic, S.A., W.A. New Guinea	Ovoviviparous Fecundity 20+ pups	*O. ornatus* 63 cm males about 175 cm for females	Unknown	Unknown Probably long lived	Unknown Probably slow growth	Unknown	Unknown
Catsharks, swellsharks *Asymbolus rubiginosus* *Asymbolus analis* *Cephaloscyllium sp A* *Cephaloscyllium laticeps*	Uncertain	All Australian states, NZ	Oviparous (one functional ovary in A rubiginosus)	1. 35cm males 2. 46cm both sexes. 3. Males 70cm. 4. Males 82cm	unknown	unknown	unknown	unknown	Unknown
Hermit crabs *Dardanus arrosor and Trizopagurus strigimanis*	Uncertain	All Australian states, NZ	Eggs carried and brooded in mass attached to abdomen.	unknown	unknown	unknown	unknown	Unknown	Unknown
Octopus *Octopus spp.*	Uncertain	All Australian states, NZ	Gloomy, Maori octopus: benthic eggs, pelagic larvae. Pale, Southern benthic eggs and larvae. Gloomy octopus up to 150K eggs 2.1kg female.	Gloomy: males 100-150g, females larger. Southern females 40-60g. Pale males 5cm ML, females 6cm.	unknown	short-lived 1 to 1.7years	rapid growth	unknown	unknown
Redfish *Centroberyx affinis*	Growth overfished	All Australian states, NZ	Pelagic eggs and larvae. Juveniles form schools, often enter estuaries.	20-25cm	4 yrs	16+ females 11+ males	slow growth	possible single stock NSW	unknown
Conger eels *CONGRIDAE spp*	Uncertain	All Australian states, NZ		unknown	unknown	unknown	unknown	unknown	unknown

Table B2.11 cont.

Common name and taxonomic name	**Spawning season**	**Movements and migration**	**Yield per recruit**	**Egg per recruit**	**Natural mortality**	**Fishing mortality**	**Comments**	**References**
Target species								
Eastern rock lobster	Spring Summer	Pre-spawning Northerly migration						Montgomery 1992, Kailola *et al*. 1993, Phillips *et al*. 1980
Byproduct species								
Leatherjackets Monacanthidae (various spp.)	Varied (species dependent) Autumn*	Unknown for most species Chinaman jacket juveniles found in estuaries and inshore bays. Adults found in deep offshore waters*	Unknown for NSW fish	Unknown for NSW fish	Unknown for NSW fish 40-45% in 1989 for South Australian fish*	Unknown for NSW fish Estimated 24% in 1989 for South Australian fish*	* denotes information for the chinaman leatherjacket. Biological characteristics are unknown for most species.	SPCC 1981, Grove-Jones and Burnell 1991, Kailola *et al*. 1993
Rubberlip morwong *Nemadactylus douglasii*	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown		D. Ferrell (unpublished data), Kailola *et al*. 1993
Jackass morwong *Nemadactylus macropterus*	Summer to Autumn	Older juveniles disperse from nursery areas to adult habitats. Little movement by adults.	Unknown	Unknown	Unknown	Unknown	Estimate of total mortality in 1978-79 was about 50%	Vooren 1977, Smith 1982, Smith 1983, Kailola *et al*. 1993
Wobbegong sharks *Orectolobus ornatus* and *O. maculatus*	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Preliminary results of reproductive studies have shown that there are likely to be 3 wobbegong species taken by the Lobster Fishery.	Last and Stevens 1994, Nick Otway personal communication
Catsharks, swellsharks *Asymbolus rubiginosus* *Asymbolus analis* *Cephaloscyllium sp A* *Cephaloscyllium laticeps*	unknown	unknown	Unknown	Unknown	unknown	Unknown		Kailola *et al.* 1993, Last and Stevens 1994, Cavanagh *et al*. 2003. Last 2003
Hermit crabs *Dardanus arrosor and Trizopagurus strigimanis*	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown		
Octopus *Octopus spp.*	unknown	unknown	unknown	unknown	unknown	unknown		Kailola *et al.* 1993
Redfish *Centroberyx affinis*	late summer/ autumn	unknown	unknown	unknown	unknown	unknown		Kailola *et al*. 1993
Conger eels *CONGRIDAE spp*	unknown	unknown	unknown	unknown	unknown	low		Kuiter 1993

Crustaceans

Hermit crabs (23 t retained, 116 t discarded).

Hermit crabs have only been retained by a small number of lobster fishers over recent seasons (one to three fishers in each season), however it is thought that hermit crabs are currently (2004) retained in smaller numbers, if at all. **Given the relatively large catches and discarding of this species in previous years, a more detailed risk assessment is required (see section B2.4.2)**.

Elasmobranchs

Wobbegong Sharks (8t retained, 6t discarded)

The estimated annual catch (retained and discarded) of wobbegong sharks in the Lobster Fishery from the observer surveys was 14 t, of which 8 t was retained. This represents about 12% of the total retained catch of wobbegongs in all NSW commercial fisheries, therefore **a more detailed risk assessment is required (see Section B2.4.2).**

Estimated landings of the following elasmobranch species were below the criteria set for the formal risk assessment, but because of the concern over shark populations generally (e.g. through the National Plan of Action on Sharks), as much detailed information as possible is provided, together with the results of an informal qualitative risk assessment.

Catsharks and swellsharks (1.3t retained, 13.9t discarded)

The species of catsharks, collared catsharks and swellsharks having geographical and depth distributions that overlap with the Lobster Fishery are shown in Table B2.12.

Table B2.12 Summary information for catshark, collared catshark and swellshark species impacted by the Lobster Fishery.

Common Name	Taxonomic Name	Depth (m)	Geographic dist'n in NSW
Orange spotted catshark	*Asymbolus rubiginosus*	25-540	NSW Coast
Grey spotted catshark	*Asymbolus analis*	40-159	From Jervis Bay South
Whitefin swellshark	*Cephaloscyllium* species A	200-550	From Port Macquarie South
Australian swellshark or draughtboard shark	*Cephaloscyllium laticeps*	<60	From Jervis Bay South, rare north of Montague Is.
Collared catshark	*Paracyllium collare*	20-60	NSW Coast

Given the above geographical distributions and depth ranges, the majority of retained catsharks are likely to be orange spotted catshark, while the whitefin swellshark is probably the main swellshark species captured in rock lobster traps. Because of the very small quantity of these species retained by the fishery and the amount of habitat available outside the area fished, **a moderately low level of risk was assigned to these species.**

Blind sharks (1.1 t retained, 8.3 t discarded)

This is a common, widely distributed species which inhabits rocky shorelines and reefs, and nearby seagrass beds from the intertidal zone to 140 m depth. It is not targeted or marketed commercially by other commercial fisheries. It is a very hardy species, and the capture and release of this species from lobster pots is likely to result in negligible mortalities. **The risk assigned to this species was moderately low.**

Port Jackson and Crested horn sharks. (0 retained, 1.2 t discarded)

The Port Jackson shark is abundant in the area subject to the Lobster Fishery, while the crested horn shark is regarded as uncommon. The mortality rate from incidental capture and release of these species from lobster traps is assessed to be negligible. **The risk assigned to these species was negligible.**

Cephalopods

Octopus (1.6 t retained, 0.4 t discarded).

Octopus is a major predator of rock lobsters and is thus attracted to pots by the presence of rock lobsters and possibly by the bait in the pots. The number of octopus retained annually in the NSW Lobster Fishery is estimated at 1400 with a weight of 1.6 t, a very small figure compared to the total catch of octopus for all NSW commercial fisheries of 500 to 600 t over recent years. Given the very short life cycle of octopus species (of the order of one year, see Table B2.11), and also that their known distribution is much more extensive than the waters fished by the Lobster Fishery (Kailola *et al*. 1993), it was concluded that the biological sustainability of octopus is not at risk from the Lobster Fishery.

Octopus landings were below the level set for a detailed risk assessment, and the risk to octopus populations was considered to be low.

Finfish

Following are summaries of landings data and risk analysis results for individual finfish taxa with retained catch of at least one tonne from the Lobster Fishery.

Morwongs

12.8t retained, 0.7t discarded, 12% of retained catch for all NSW commercial fisheries.

The three species of morwong (rubberlip, jackass and red) were not always identified in the observer surveys, with 61% recorded only as 'morwong'. Estimates from the observer studies were:

- Unspecified morwong: 7.8t retained, 0.2t discarded
- Rubberlip morwong: 2.6t retained, 1.2t discarded; Total NSW retained commercial catch: 68t.
- Jackass morwong: 1.4t retained, negligible discarded; Total NSW commercial retained catch: 19t, with a further 796t retained in the Commonwealth Southeast trawl fishery (SETF).
- Red morwong: 0.8t retained, .5t discarded, Total NSW commercial retained catch: 2.9t

The risk from the Lobster Fishery is primarily on rubberlip morwong, as the catches of jackass morwong are very small compared to the catches from the Commonwealth SETF. **Rubberlip morwong meets the criteria for detailed risk assessment (section B2.4.3)**. The rubberlip morwong catch from the Lobster Fishery is relatively small compared to the estimated catch of 96t from the recreational fishery, even if the unspecified catch of 7.8t is added to that of the 2.6t for the specific rubberlip morwong catch from the Lobster Fishery.

Redfish.

5.8t retained, 0.8t discarded.

The retained catch of redfish from the Lobster Fishery amounts to less than 1% of the total NSW commercial retained catch of this species, and thus redfish does not meet the criteria for a detailed risk assessment. Redfish is regarded as growth overfished across the total commercial fishery, which has annual landings of about 800t, so the impact of the Lobster Fishery is a minor part of the total commercial impact on redfish. **A qualitative evaluation indicated a low risk to redfish from the Lobster Fishery.**

Leatherjackets (mixed species)

7.6t retained , 0.3t discarded,

1.5% of retained catch for all NSW commercial fisheries.

The retained catch of leatherjackets from the Lobster Fishery amounts to less than 5% of the total NSW commercial retained catch of this taxon, and thus the species do not meet the criteria for a detailed risk assessment. On the basis of the small proportion of the total commercial catch taken by the Lobster Fishery, **a qualitative evaluation indicated a low risk to leatherjackets from the Lobster Fishery.**

B2.4.3 Detailed risk assessment of selected bycatch and byproduct species

Three of the bycatch and byproduct taxa discussed above were deemed to require a more detailed risk assessment. These were hermit crabs, wobbegong sharks and rubberlip morwong.

The risk analysis procedures described in Section B2.2 produced the following values for resilience ratings (Table B2.13), fishery impact ratings (Table B2.14) and overall risk matrix (Figure B2.7) for byproduct and bycatch taxa in the Lobster Fishery.

Table B2.13. Resilience ratings for byproduct and bycatch species of the NSW Lobster Fishery that met the criteria for detailed risk assessment

Byproduct and bycatch species	Reproductive strategy	Distribution and abundance	Growth rate and longevity	Risk-prone score	Resilience rating
Wobbegongs	2 x Prone	Averse	Prone	3	I-L
Rubberlip morwong	Averse	Averse	Prone	1	H-I
Hermit crabs	Averse	Averse	Prone ?	1	H-I

Table B2.14. Fishery impact ratings for byproduct and bycatch species of the NSW Lobster Fishery that met the criteria for detailed risk assessment

Byproduct and bycatch species	Exploitation status	Fishery impact rating
Wobbegongs	Uncertain	H-I
Rubberlip morwong	Fully fished	I
Hermit crabs	Uncertain	H-I

B2.4.3.1 Hermit crabs

The conclusion of the assessment of bycatch was that a small proportion of the total population of hermit crabs is affected by this fishery, as hermit crabs are generally abundant at shallow inshore depths and across the continental shelf and slope to 400 m depth. From the observer surveys, it was found that 83% of hermit crabs were returned to the water. Given the much larger area of distribution of hermit crabs compared to the area affected by the fishery and the likely high survival rate of hermit crabs returned to the water (G. Liggins, *pers. comm.*), it could be inferred that the impact of the fishery on hermit crab populations is probably small. In a study of the bycatch of the Tasmanian fishery for southern rock lobster (*Jasus edwardsii)*, Frusher (1999) described the bycatch of the Tasmanian fishery. Although there was a large catch of hermit crabs in that fishery, with catch rates (number of hermit crabs/pot lift) more than twice the rate as in the NSW Lobster Fishery, this was not regarded as significant to the population of hermit crabs in Tasmanian waters.

Hermit crabs are considered to have High-Intermediate resilience (Tables B2.11 and B2.13). The lack of information on these species gives rise to an uncertain rating for the stock status, and therefore a fisheries impact rating of High to Intermediate (Table B2.14). **Based on these ratings, the risk to hermit crabs is considered to be moderately high (Figure B2.7).**

The current very small harvest of hermit crabs does not warrant concern for the impact of the current fishery on hermit crab stocks, however there is the potential for changed market conditions to give rise to large amounts of hermit crabs being harvested by the Lobster Fishery in the future. While this is an unlikely scenario, the paucity of biological information on these species indicates the need for cautionary management arrangements to avoid the possibility of significant impacts on these populations.

B2.4.3.2 Wobbegong sharks

Wobbegongs have been classified as Near Vulnerable (A2B) in a report by the IUCN Shark Specialist Group (Cavanagh *et al*. 2003). As with most commercially fished shark species, the basic life history parameters of longevity, growth rate and fecundity place this group in the low resilience category. Specific and immediate action should be given to reduce the high risk on wobbegong sharks. Consequently, management strategies will need to entail such things as providing adequate refuges from fishing mortality and protecting pupping and nursery areas. The draft National Plan of Action for the Conservation and Management of sharks (AFFA, 2002) identifies 18 issues that need to be addressed in the management of sharks in Australia. Of these, five are of direct relevance to the NSW Lobster Fishery. They include the need for validated data sets compatible with other jurisdictions, improvement of shark identification, assessment of harvesting and handling practices of sharks and better understanding of the effects of shark fishing on ecosystem structure. These are important gaps in the information relevant to the environmental performance of the Lobster Fishery.

Two known species of wobbegong are subject to the fishery – the spotted wobbegong (*Orectolobus maculatus*) and the banded wobbegong (*Orectolobus ornatus*). Wobbegong sharks occur on the continental shelf to depths of at least 100 m, but are most common in near-shore waters (Last and Stevens, 1994). Total NSW Commercial Fishery landings declined steadily from about 120 t in 1990/91, to 68 t in 2002/03, although there is some doubt about the scale of the decline as there are a number of problems associated with the accuracy of these data.

A discussion paper on the management of wobbegong sharks in NSW was published in December 2001, but the management arrangements are yet to change. A decline in commercial catches over an extended period, coupled with the low fecundity and high longevity of the species have caused concerns about the status of the population.

Wobbegongs are considered to have Intermediate-Low resilience to fishing (Tables B2.11 and B2.13). Because of their uncertain status, the fisheries impact profile for wobbegongs is High-Intermediate (Table B2.14). **The overall risk to the population of wobbegong sharks was assessed as high (Figure B2.7).**

B2.4.3.3 Rubberlip morwong

The resilience of rubberlip morwong was rated as High-Intermediate (Tables B2.11 and B2.13). The fisheries impact profile was Intermediate, based on the fact that the species is considered to be fully fished. **Given these ratings, the risk to rubberlip morwong is rated at intermediate (Figure B2.7).**

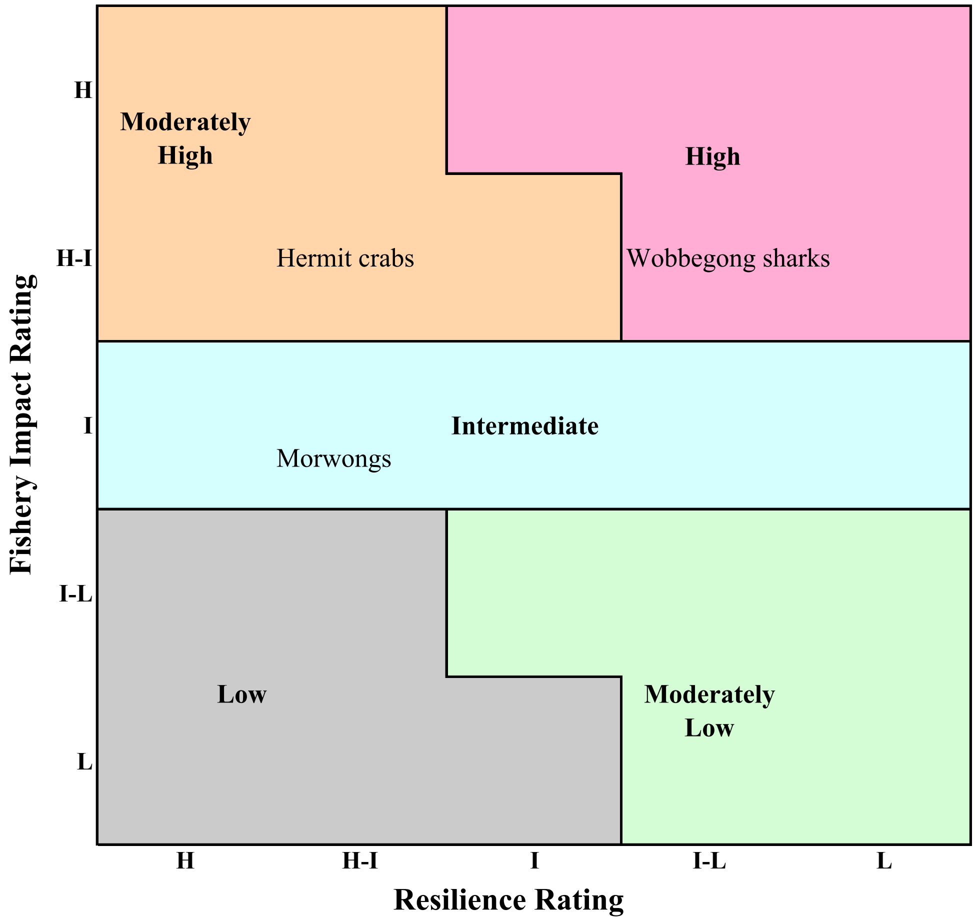

Figure B2.7 Levels of qualitative risk for byproduct and bycatch species taken by the Lobster Fishery.

Fishery impact and resilience ratings: H – High, H-I – High to intermediate, I – intermediate, I-L – intermediate to low, L – low.

B2.5 Bait Species

B2.5.1 Bait use and potential risk for disease introduction

For inshore traps, bait comprises mainly mullet and luderick taken in other NSW commercial fisheries. This is in fresh, salted or dried form. Offshore lobster fishers use fish frames (particularly tuna) and meat products (e.g. bones). The amount of bait used in the fishery is of the order of 200t per annum. Fish products account for a large proportion of the total bait used. As bones are used as bait in the offshore fishery, this component accounts for only a small component of all bait used (of the order of 5%). The possible effect of bones introducing diseases or pathogens into the environment was considered for this assessment. Dr R. Callinan, a veterinary scientist with NSW Department of Primary Industries, advised that there were no known reports of pests or diseases which have been identified as being introduced by use of animal bones in a fishery.

B2.5.2 Effectiveness of existing management regime to minimise risk

It is considered that the present management arrangements adequately minimise the risk of introduction of pests and disease in bait organisms.

B2.5.3 Overall risks

Overall risk was considered low.

B2.6 Protected and Threatened Species

B2.6.1 Species that may be affected by fishing activities

There is the potential for entanglement in pot ropes of cetaceans (mainly common and bottlenose dolphins, Southern Right, Minke and Humpback whales), and marine turtles (green, loggerhead, leatherback, hawksbill). Other cetacean species which may be occasionally sighted in NSW waters have not been listed in Table B2.15, but the risk from the Lobster Fishery on these species is considered to be negligible. There is a potential impact of the fishery on eastern blue groper, which is protected against commercial fishing in NSW. Table B2.15 indicates the protection status and assessed risk from the Lobster Fishery for protected and threatened species subject to impact from the fishery.

Table B2.15. Summary of risks for protected and threatened species.

	common name	scientific name	TSC/FM Status	EPBC Status	Risk
Cetaceans	common dolphin (offshore)	*Tursiops truncatus*	V		low
	common dolphin (inshore)	*Tursiops aduncus*	V		low
	bottlenose dolphin	*Dephinus delphis*	V		low
	Southern Right whale	*Eubalaena australis*	V	E	low
	Minke whale	*Balaenoptera acutorostrata*	P		low
	Humpback whale	*Mergaptera novaeangliae*	V	V	low
Reptiles	Green turtle	*Chelonia mydas*	V	V	low
	Leatherback turtle	*Dermochelys coriacea*	V	V	low
	Loggerhead turtle	*Caretta caretta*	V	V	low
	Hawksbill turtle	*Eretmochelys imbricata*	V	V	low
Finfish	Groper, blue, brown, red	*Achoerodus viridis*	p 20		low

TSC/FM=*Threatened Species Conservation Act* 1995 / *Fisheries Management Act* 1994, EPBC=*Environment Protection and Species Conservation Act* 1999. V=vulnerable, P= Protected, E=endangered, P20=protected from commercial fishing under Section 20 of NSW *Fisheries Management Act* 1994.

B2.6.2 Level of interaction with the fishery

The NSW Department of Environment and Conservation (DEC) maintains a register of stranded and entangled marine mammals and turtles (the Marine Fauna Management Database). The coverage and accuracy of this register depends on reports of incidents. The ongoing observer surveys of the Lobster Fishery are unlikely to provide estimates of cetacean and turtle entanglements with gear in the Lobster Fishery, as these events are rare and the observer surveys cover only a relatively small proportion of fishing effort. There is currently no requirement for fishers to report any incidents of entanglements and as such, this is an important gap in the information relevant to the environmental performance of the Lobster Fishery.

B2.6.3 Existing measures to mitigate impacts

Currently there are no specific obligatory reporting requirements for the entanglement of marine mammals, turtles or seabirds. This should be addressed by the FMS, so that data will be available directly from the fishery. The eastern blue groper is the only protected finfish species subject to impact from the Lobster Fishery. While the impact on this species was assessed as low, it would be prudent to collect extra data to provide information on discarded blue groper. This should be in the form of extra data collected via catch returns, to indicate the condition of fish when discarded (data on barotrauma effects, scale loss, etc). Further information could be collected as part of the observer program.

B2.6.4 Overall risks from the fishery to these species

B2.6.4.1 Risk assessment – cetaceans and marine turtles

Entanglement is considered to be an extremely rare event. The NSW DEC maintains a register of entanglements of marine mammals and turtles. There has been only one entanglement recorded in this register for the Lobster Fishery in the past five years. This involved the entanglement of a humpback whale in the rope attached to a lobster pot. The whale was released unharmed. The register has recorded four instances of entanglements of cetaceans or turtles in crab pot ropes over this period, so there is the potential for a very small number of entanglements of protected species in the Lobster Fishery. A relatively small number of these incidents might result in mortalities of protected species. The NSW Lobster Fishery accounts for approximately 1.6% of the total number of potlifts for all Australian rock lobster fisheries. Environmental assessments for rock lobster fisheries in WA, SA, Tasmania, and Victoria indicate an extremely small number of interactions of the fishery with whales, dolphins or turtles, so considering the relatively small proportion of potlifts attributable to activities in NSW, this frequency of interactions between cetaceans and turtles with the NSW Lobster Fishery would be expected to be extremely rare.

No information is available on interactions of the fishery with protected seabirds in NSW. Given the nature of the lobster traps and the depths at which they are set, it would seem extremely unlikely that interactions would occur with the pots when they are set on the ocean floor or reef. Interactions with birds may occur with birds roosting on vessels, or eating discarded fish. These forms of interaction do not have the potential to cause significant damage to birds. Given the relatively small volume of discarded fish from boats in the Lobster Fishery, the potential impact of the fishery on seabirds is considered to be negligible. Norman (2000) surveyed commercial fishers for a study of the bycatch of marine birds and mammals in inshore commercial fisheries in Victoria, and noted that for the Lobster Fishery, one dolphin, seals and turtles were captured, but no marine birds were recorded from this fishery. Priddel (2003) has reviewed the threats to seabird populations in NSW, and cited longline fishing and plastic ingestion as the most potentially damaging threats.

With an extremely low frequency of incidents involving threatened and protected species in the Lobster Fishery, it is difficult to ensure that there is adequate reporting of interactions. Observer programs obviously cannot cover 100% of the activities of the fishery, and there is an obvious disincentive for fishers to report interactions with threatened and protected species.

Risk to protected and threatened cetaceans and sea turtles was considered to be low.

B2.6.4.2 Risk assessment - protected fish

Eastern blue groper (*Achoerodus viridis*)

Conservation status: The blue groper is protected from commercial fishing under section 20 of the FM Act.

Distribution and decline: Occurs from Hervey Bay, Queensland, to Wilsons Promontory in Victoria (Hutchins and Swainston, 1986). Recreational angling is the only method by which the species can be legally taken, and although there is some evidence that the species is still being overfished in some areas, in others its protected status has allowed it to rebuild numbers to the point where it is commonly seen on rocky reefs throughout its range (Smith *et al*., 1996).

Key Threatening Processes: Hook and line fishing may pose a threat to the blue groper, especially in areas where local fishing pressure is high (Pogonoski *et al.*, 2002).

Other threatening processes: Illegal spearfishing also poses a threat to the blue groper (Pogonoski *et al.*, 2002).

Habitat: Juveniles inhabit seagrass beds until they reach about 10 cm in length, when they move to rocky reefs. Adults may range over large areas of reef in estuaries and offshore to depths of at least 60 m. (Gillanders, 1995a; Kuiter, 1996)

Recovery plans: A recovery plan is not required for this species because it is not listed as vulnerable or endangered.

Assessment of risk to the blue groper

Biological characteristics: The blue groper is a protogynous hermaphrodite, commencing life as a female, with some individuals changing to males after 8-18 years. Females mature at 1-2 years. The sex ratio is heavily biased toward females (1:6.8 - 1:62 (Gillanders, 1995b)). The reproductive characteristics of the species make it particularly susceptible to overfishing of large males (Gillanders, 1995b). Based on this information, the resilience of the species is considered to be low-moderate.

Fishery impact rating: There is considerable spatial overlap between the Lobster Fishery and blue groper, which is indicated in estimates from observer studies of bycatch from the Lobster Fishery. These surveys provide an estimated annual mean count of 429 eastern blue groper caught in lobster traps and discarded (G. Liggins, *In prep*.). There is some risk of barotrauma-induced mortality, as even hauling from a depth of 10m results in a doubling of the gas volume. While eastern blue groper are likely to be more abundant on the very shallow inshore reefs, they may not be as susceptible to the inshore traps, which have smaller entrances, precluding entry from larger fish. The fishery impact rating from the Lobster Fishery was classed as low.

Overall Risk: Given the perceived increase in numbers throughout most of its range, its resilience and limited interaction with the fishery, the **risk from the Lobster Fishery is considered to be low.**

B2.7 Other species and species assemblages

B2.7.1 Other species or assemblages that may be affected by the fishing activity

Species assemblages covered in this section will be confined to macroalgae, benthic motile invertebrates and fish. All vertebrate assemblages have been covered under sections for byproduct and bycatch species (commercial and non-commercial) and threatened and protected species (see Sections B2.4 and B2.6), however additional discussion on the potential effects of lost traps is provided here. Sessile invertebrates are discussed under marine habitats as biogenic habitat (Section B2.8).

A species assemblage is simply a group of organisms that are present in the same place at the same time (Underwood, 1986). The main broad groupings of species assemblages relevant to the Lobster Fishery assessed in this section are macroalgae, benthic motile invertebrates and fish. Determining the types of species assemblages that are present in the area where the Lobster Fishery operates depends on the spatial and temporal scales at which the assemblages are defined (Underwood and Chapman, 1995).

In a general sense species assemblages are associated with different habitats (e.g. sandy substrate, rocky reef) and oceanic environments (e.g. depth, currents) (e.g. Bax and Williams, 2001). As the habitats and/or oceanic environments change the assemblages of species present also change. Spatially there are two main vectors of change in habitats and oceanic environments for the Lobster Fishery – depth, from the coast to the continental slope, and latitude, from north to south. These two spatial vectors were used to identify the types of species assemblages present within the range of the Lobster Fishery.

B2.7.1.1 Macroalgal species assemblages

Macroalgae only occur down to about 50m depth along the NSW coast, being most abundant from the intertidal zone to the shallow subtidal (Underwood and Chapman, 1995). There are four broad groups of macroalgae – foliose (e.g. kelp), turfing (e.g. green filamentose algae *Enteromorpha* spp.), articulated coralline (e.g. *Amphiroa* spp.) and encrusting (e.g. encrusting coralline) (Fowler-Walker and Connell, 2002). Similar groupings have been used extensively in the literature (e.g. Padilla and Allen, 2000). Underwood *et al*. (1991) described several types of habitat which included two with algal species assemblages in their surveys of the NSW coast. 'Turf habitat' was dominated by *Sargassum* and *Dictyopteris* species and "*Pyura* habitat" included large stands of *Ecklonia* or *Sargassum* and filamentous or turfing algae. Harriot *et al*. (1999) in their study of subtidal rocky reefs in northern NSW found diverse and abundant macroalgal species assemblages typical of sub-tropical and temperate environments. There was a difference in the macroalgal assemblages along the inshore to offshore gradient, reflecting a depth related change.

Potential impacts of the Lobster Fishery on macroalgal assemblages

Impacts on macroalgal assemblages are similar to those for habitats (see Section B2.8). The activity of lobster potting has the potential for the greatest impact on macroalgae. Foliose, articulated coralline and turfing algae can be impacted when movement of the trap (when being deployed, retrieved or moved by currents) damages plants and/or completely removes their attachment from the substratum. Damaged fronds may reduce the algal assemblage's ability to photosynthesise, decreasing primary productivity in the damaged area. Furthermore, foliose macroalgae provides habitat and is a source of food for a large variety of motile invertebrates (e.g. amphipods, Poore *et al*., 2000). The loss of macroalgae will therefore impact the species assemblages that are dependent on them. Encrusting algae will be little impacted because of its flat profile and tougher growth form.

The other activities of the Lobster Fishery - harvesting, discarding, lost gear, travel to and from fishing grounds, presence in the area and boat maintenance - have low to negligible impact on macroalgal assemblages because the level of interaction between these activities and macroalgae is extremely minor.

While there is no research to provide data on the impact of lobster traps on macroalgae from the NSW fishery, a study on the physical effects of pots in South Australia (Casement and Svane, 1999) indicated a very small impact of fishing compared to natural disturbances. A study of the impact of lobster pots in the Victorian fishery also concluded that the impact on the ocean floor and on benthic organisms was minimal (Moulton, 1996).

From these studies we can extrapolate a low risk to macroalgal assemblages from the activities of the NSW Lobster Fishery.

B2.7.1.2 Benthic motile invertebrate species assemblages

This section covers impacts on motile invertebrate assemblages. Sessile invertebrates are discussed under marine habitats as biogenic habitat (Section B2.8). Most information about benthic motile invertebrate species assemblages on the coast of NSW is for intertidal and shallow subtidal areas (e.g. Underwood *et al*., 1991; Underwood and Chapman, 1995). Invertebrate groups found at these depths include anemones, echinoderms, worms and molluscs. These can occupy a range of habitat types including rocky reefs, sand, mud and gravel sediment (Underwood and Chapman, 1995).

Knowledge of benthic motile invertebrate assemblages deeper than 20m is very patchy and less detailed than shallower habitats. The major groups of invertebrates occurring at these depths are:

- Meiofauna (very small animals that live interstitially in sediment)
- Crustaceans (e.g. hermit crabs)
- Echinoderms (e.g. starfish, sea urchins)
- Molluscs (e.g. bivalves, limpets, nudibranchs)
- Anemones (e.g. burrowing anemones)
- Worms (e.g. polychaetes, flatworms)

Ponder *et al*. (2002) provides descriptions of all the major marine invertebrate groups found in Australian waters, including the continental shelf and slope and abyssal plain. All of the major groups identified above have families of species that occur from the shallowest to the deepest parts of the ocean and in the widest range of habitats from fine muddy sediment to rocky hard substrata and biogenic structures such as sponges (see Section B2.8). There is virtually no habitat type or ocean depth where some groups of invertebrate assemblages are not found.

Potential impacts of the Lobster Fishery on benthic motile invertebrate assemblages

Benthic motile invertebrate assemblages are associated with habitats that are fished by the Lobster Fishery, hence there is potential for them to be impacted by the fishery. However, there has been very little work done directly on these assemblages on the extent and magnitude of effects of the activities of rock lobster fisheries throughout Australia, but given the studies from other states on how the traps actually settle on the sea floor or reef when deployed, it is likely that there is a very low risk to these assemblages.

2.7.1.3 Potential impacts due to lost traps

Traps are lost due to the effects of weather (heavy seas), bottom snags, entanglement with gear from other fisheries, human error, vandalism and gear failure. When traps are lost, they may continue to catch and retain a variety of species, including lobsters and finfish, and thus cause extraneous mortality. There is currently no reliable quantitative information on the number of traps lost annually in the Lobster Fishery, nor on the hazard-life – the period for which a lost lobster trap poses a hazard to rock lobsters, sharks or finfish species. There are no reliable estimates of mortalities caused by lost traps. Anecdotal information from fishers and researchers is that for the majority of lost gear that is eventually recovered, there are generally no animals remaining in the traps. It seems likely that traps lost in the inshore fishery would persist for a short time before disintegrating as a result of wave action or being washed ashore in heavy seas. The loss of traps in the offshore fishery is likely to give rise to a greater hazard. There is some evidence that rock lobsters and some finfish escape from the traps, so that ghost fishing is unlikely to have a significant impact on these species. Wobbegong sharks occur to depths of at least 100m but are more common inshore (Last and Stevens, 1994), while offshore traps in the Lobster Fishery are deployed in depths of 51m-220m. The partial overlap of depth distributions, combined with the fact that larger wobbegongs occur in the deeper waters, indicates a probable low impact on wobbegongs as a result of ghost fishing.

Studies of lobster fisheries in other countries (Laist, 1996) indicate that the rate of trap loss in these fisheries is usually between 10 and 30% of traps used. Parrish and Kazama (1992) conclude that ghost fishing by lost pots in the Hawaiian Lobster fishery contributes little to the mortality of the population. In September 2002, concerns were raised by NSW Department of Primary Industries (previously NSW Fisheries) with the Eastern TUNAMAC regarding loss of lobster traps in the NSW fishery following entanglement of longlines with offshore lobster traps.

The risk to assemblages from lost traps from the offshore fishery is likely to be low, but because of the paucity of information on number of traps lost, hazard-life of lost traps and mortalities of rock lobster and other species, the FMS should consider steps to redress these information gaps. The other activities of the Lobster Fishery - travel to and from fishing grounds, presence in the area and boat maintenance - have a low to negligible impact on assemblages.

B2.7.2 Potential impacts of the fishery on the species diversity of benthic invertebrate and fish assemblages

There have been no specific studies of the diet of the eastern rock lobster, however it is likely to feed on a range of food items similar to that found for other rock lobster species in Australia, i.e. a wide range of items from coralline algae to molluscs and crustacea (Joll and Phillips 1984, Edgar 1990). Many of these species are known to have high turnover rates, and the impact of the fishery on prey populations was graded as low risk.

No specific research information is available on the major predators of eastern rock lobster, but it is likely that the major predators are octopus and possibly wobbegong sharks on the larger lobsters, and various species of finfish on pueruli and juvenile lobsters. Two factors which lead to a low risk of the eastern rock lobster impacting these predator populations are the decline of populations of these species from other sources of fishing mortality and the fact that eastern rock lobster is only one element of the diet of these species. The effect of removal of rock lobsters over part of their size range is regarded as having an insignificant impact on predator and prey species.

The relatively small biomass of byproduct and bycatch species also indicates that there would be an insignificant impact on the predator and prey populations of these species.

Studies on rock lobster fisheries in South Africa (Mayfield 2000) have indicated relationships between populations of rock lobsters, urchins and juvenile abalone, suggesting that increasing the number of lobsters may reduce numbers of juvenile abalone and urchins. It has been generally accepted that in Australian waters, rock lobsters are not keystone species in the ecosystem, however, a recent study of 'no-take' MPAs in Tasmania (Buxton et al. 2004) has indicated that increases in number of lobsters in the protected zones were associated with reductions in numbers of prey species such as urchins and abalone. It is possible that the effect of lobster fishing in NSW may have a similar cascading effect on the ecosystem.

B2.7.3 Translocation of organisms as a result of the fishery

There are no known organisms translocated as a direct result of catches of target, byproduct and bycatch species. Discarded individuals of both target, byproduct and bycatch species are returned to the water at the same position as the haul location of the trap. Hence there is negligible risk of translocation of target, bycatch and byproduct species.

There is negligible risk of translocation of marine flora. Lobster traps are either placed in similar positions or hauled and subject to substantial drying before redeployment. The invasive marine seaweed *Caulerpa taxifolia* only occurs in estuaries, so is not subject to spread by the Lobster Fishery.

B2.7.4 Ecosystem functions that may be affected by the fishery

There is insufficient scientific information available to provide any rigorous inference concerning ecosystem functions which may be altered as a result of the fishery.

B2.7.5 Overall risks from the fishery on species assemblages

Overall risk was assessed to be low.

B2.8 Aquatic Habitats

B2.8.1 Marine habitats and their importance to biological communities

Marine habitat may be defined as the geological, environmental and biological structure that supports biological communities self-organised from the available species mix (Bax and Williams 2001). This broad definition includes three distinct types of habitat structure: (a) geological structures, which include rocky reefs, sediment deposits, submarine canyons, bedrock outcrops; (b) biogenic structures which consist of living biota and any physical structure they create (e.g. sponges, corals, kelp beds, bryozoans, mollusc beds, worm tubes, ascidians, sea pens and sea whips); and (c) the water column.

Seabed habitat is an important factor that influences the composition and distribution of biological communities (Underwood and Chapman, 1995; Glasby, 1998; Bax and Williams 2001). The distribution and composition of fish and invertebrate communities living on the continental shelf of New South Wales are also influenced by factors such as latitude, depth and hydrology (Gray and Otway, 1994, Connell and Lincoln-Smith, 1999, Bax and Williams, 2000, Williams and Bax, 2001). Biological communities, including commercially targeted stocks of fishes and invertebrates, depend on substratum features (geological and biogenic) to provide spawning sites, feeding areas and refuge areas from marine predators and fishing fleets. Bax and Williams (2001) have suggested that existing physical refuges from fishing activities may play an important role in sustaining the productivity of many commercially fished species.

The water column is also an important part of the three dimensional marine environment. The seawater may vary in salinity, temperature, and density, all of which are important factors that influence the behaviour of marine organisms. The oceanic water mass in which marine biological communities exist also contains currents which bring oxygen and food to many species, disperses the pelagic eggs and larvae of many invertebrates and bony fishes away from spawning sites, and currents are used by many species to assist migratory movements. Therefore, it is essential that the quality of the water column is maintained in order to sustain biological communities in the long-term.

B2.8.2 General Information on Marine Habitats in Oceanic waters of NSW

Despite the importance of habitats to biological communities there has been little work done on describing the spatial distribution of habitat types on the New South Wales continental shelf. Bax and Williams (2001) report the results of a survey designed to map major seabed features and habitats on a megascale (kilometres to tens of kilometres) on the south-eastern Australian continental shelf. The mapped area included a section of the southern New South Wales continental shelf extending from Bermagui southwards to the border with Victoria, and an additional larger area of continental shelf off the Victorian coastline (Bax and Williams, 2001). This part of the south-eastern continental shelf is described as a series of massive sediment flats (soft-grounds - 89%) with reefs and bedrock (prominent hard-grounds – 11%) (Bax and Williams 2000, 2001). The soft-ground habitats included all types of sands, muds and gravels. An important distinction in terms of habitat value was made between hard-grounds having high vertical relief (>2 m) and hard-grounds having low vertical relief (<2 m) because of their different vulnerability to the effects of fishing gear (Bax and Williams, 2001).

Similar soft-ground and hard-ground habitats to those described by Bax and Williams (2001) are found along the entire New South Wales continental shelf. An area off Sydney was mapped for the deep ocean outfall study (Gordon and Hoffman, 1989) but this was confined to a very small area and did not extend into the deep areas of the continental shelf. Unfortunately, there are no comparable data that can be used to describe the spatial distribution or the relative sizes of similar habitats for the rest of the New South Wales continental shelf. The work done by Bax and Williams (2001) provides important insights for understanding the impacts of commercial fishing operations on soft-ground habitats, hard-ground habitats, biogenic structures and the relationship between fish and invertebrate communities and these habitat structures.

B2.8.3 Risk assessment of marine habitats

B2.8.3.1 Risk context

The risks being assessed for marine habitats can be defined as the likelihood that marine habitats will be degraded by the current activities of the Lobster Fishery, such that the populations or stock levels of species associated with these degraded habitats will become ecologically unsustainable within the next 20 years. This definition of risk explicitly describes the consequences for which we wish to mitigate risk as being: (a) the widespread degradation of habitats; and (b) ecologically unsustainable populations and communities of biota associated with these habitats.

B2.8.3.2 Risk identification and characterisation

The broad-scale risk analysis (see section B2.2) identified three activities of the Lobster Fishery that could potentially impact on habitats and their capacity to support ecologically sustainable populations of commercially harvested fish and invertebrates and biological communities. Table B2.16 provides an expanded view of these sources of risk and identifies the potential impacts of these fishing related activities on habitats.

Table B2.16 Sources of risk and qualitative risk levels for habitats.

Aspects needed to support ecologically sustainable populations of fish and biological communities associated with these habitats	**Activities of the Lobster Fishery**		
	Potting	Harvesting	Loss of fishing gear
Maintain spatial distribution (coverage) of habitats	-	-	-
Maintain habitat quality (complexity, structure, free of contaminants)	L	L	L
Regenerative processes	-	-	-

H – high; L – Low; Dash - negligible

Current activities of the fishery that could potentially affect habitats

There are currently 149 fishers with endorsements for the Lobster Fishery (January 2004). There is no information collected which would allow an estimate of the number of traps used in this fishery. Trapping may occur anywhere within the area of the fishery, but usually occurs on or adjacent to rocky reef. Traps are generally deployed for a minimum of 24 hours in inshore areas, but may be left for several days before retrieval due to bad weather. In the offshore component, traps are left for up to two weeks or more. Potential impacts from the deployment of traps result from the physical impact of traps hitting the seabed, traps being dragged across the habitat by waves, currents or during fishing operations (retrieval of traps). Movement of traps set under normal operating conditions would be minimised by heavy weights used to anchor the traps, and spikes that anchor the traps into substratum. These measures are used to increase the effectiveness of the traps.

Any lost traps would be rapidly colonised by encrusting marine organisms, and the resulting habitat is also likely to house fish and motile invertebrates. In time, traps would corrode away to nothing. Trap loss in NSW has not been quantified, however a study on the South Australian rock lobster fishery concluded that trap loss was around 18% of the total number of traps used per year, (Casement & Svane, 1999). Overall, the impact of lost traps on habitats is likely to be negligible.

Boat operations and maintenance

This source of risk contains all aspects involved in the operation and maintenance of fishing boats. Potential impacts to biogenic habitats and contamination of the water column could occur when noxious chemicals are introduced into the environment by way of engine emissions, accidental leaks or spills of fuel and/or oil, and chemicals that leach from anti-fouling paints on the hull of fishing boats. There is a low likelihood that the propagules (eggs and/or larvae) derived from biogenic habitats could be adversely impacted by coming into contact with noxious chemicals in the water column. This contact could reduce the survival rate of the propagules and hence the regenerative capacity of biogenic habitats on a local scale. This in turn could lead to localized reductions in habitat complexity and structure.

The likelihood of this type of impact causing widespread degradation of habitats is low because of the relatively small number of operators in the fishery and the high dilution factor of the vast, oceanic, water mass.

B2.8.3.3 Risk on marine habitats from the Lobster Fishery

Risk matrix

The impacts of the Lobster Fishery on habitats were examined and integrated by using a qualitative risk matrix. The x-axis of the risk matrix represents habitat vulnerability, which combines the two characteristics of habitats - resilience and resistance (see section below on vulnerability for a detailed description). Thus, the vulnerability axis provides an integrated measure of biological (for biota) and geological (for rock and sediment types) factors for habitats. The biological and geological factors are independent of the fishery, which means that operational changes in the fishery cannot change the vulnerability rating of a habitat. The y-axis of the risk matrix represents the fishery impact profile for habitats (see section below on fishery impact profile for a detailed description), which provides an integrated measure of the operational factors by combining information on fishery impacts (direct and indirect) and identifying knowledge gaps that need to be addressed in order to mitigate risk levels. Therefore, any operational changes in the fishery that have an impact on habitats or any increases in knowledge that allow a better understanding of impacts on habitats will change the fishery impact profile rating for a fishery.

The area within the risk matrix was divided into 5 levels of risk (see Figure B2.8). Justification of the five levels and their arrangement within the matrix was given in Section B2.1. The definitions for risk levels were identical to those used in the risk analysis of target and byproduct species. The following text provides an explanation on how to interpret levels of risk and how to prioritise management responses for habitats by using their risk levels.

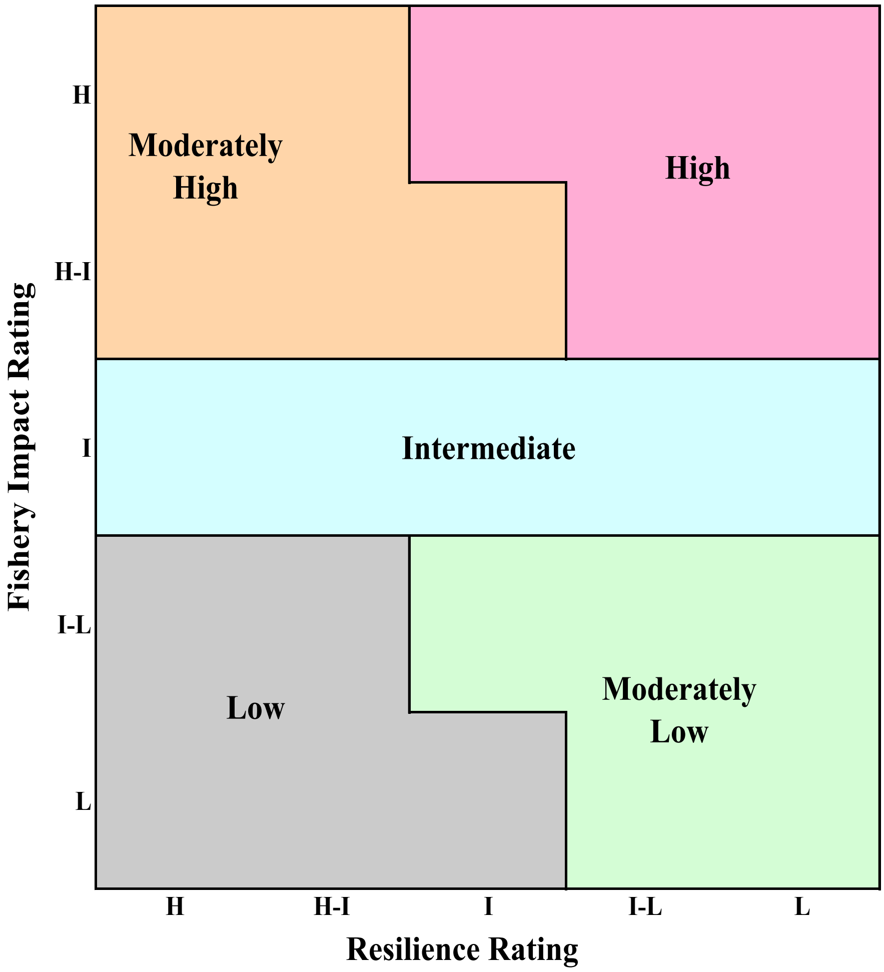

Figure B2.8 Qualitative risk matrix used to determine levels of risk for marine habitats by the Lobster Fishery (this is the same matrix as that used for target, byproduct and bycatch species).

The top right hand corner and the bottom left hand corner of the risk matrix represented the highest and lowest risk levels respectively. High levels of risk indicated habitats with higher vulnerability and largest fishery impact profile ratings, whilst low levels of risk corresponded to habitats with lower vulnerability and lowest impact profile ratings. Managers should give greatest priority to habitats with highest levels of risk. These high risk habitats require direct and immediate action that decreases their fishery impact profile ratings. The area in the top left hand corner of the risk matrix indicates habitats that have moderately-high levels of risk because these habitats have relatively high fishery impact profile ratings but medium to low vulnerability ratings. The focus of management action for habitats at this level of risk should be to make changes in the operation of the fishery to decrease their fishery impact profile rating. These habitats with moderately-high risk levels should be given secondary priority for management action because their vulnerability rating is lower than high risk habitats. Intermediate levels of risk indicate habitats with an intermediate fishery impact profile rating and varying vulnerability ratings, ranging from low to high. The management priority for these habitats of intermediate risk level should be lower than that for habitats having high and moderately-high risk levels. Management measures for these habitats having intermediate risk levels should focus on initiatives that reduce their fishery impact profile ratings. Within this intermediate risk level, management priority should be given to those habitats that have the highest vulnerability ratings. The area in the bottom right hand corner of the risk matrix indicates habitats that have moderately-low levels of risk. These moderately-low levels of risk indicate habitats that have lower fishery impact profile ratings but higher vulnerability ratings. These habitats should be given lower priority for management action than habitats regarded as having high, moderately-high or intermediate risk levels. Any management actions directed towards moderately-low risk level habitats should be focused on ensuring the fishery impact profile ratings do not increase for these habitats. Finally, habitats having the lowest risk levels are characterized by having relatively low fishery impact profile ratings and vulnerability ratings.

Vulnerability

The resilience, resistance and vulnerability of important soft-ground and hard-ground habitats, biogenic habitats, and the water column are summarised in Table B2.17.

Table B2.17 An assessment of the resilience, resistance and vulnerability of important habitats occurring in the operational area of the Lobster Fishery.

Habitats	**Resilience**	**Resistance**	**Vulnerability**
Geological habitats			
Hard-ground substratum (High vertical relief >2m)	Zero	High	Low/Medium
Hard-ground substratum (Low vertical relief <2m)	Zero	High	Low/Medium
Soft-ground substratum (sands, muddy sediments, gravels)	High	Medium	Low
Biogenic habitats			
Biota of hard-ground substratum (High vertical relief >2m)	Variable (ranging from Medium to High)	Low	High
Biota of hard-ground substratum (Low vertical relief <2m)	Variable (ranging from Medium to High)	Low	High
Biota of soft-ground substratum (sands, muddy sediments, gravels)	Variable (ranging from Medium to High)	Low	High
Water Column	High	High	Low

In inshore areas the primary habitat of eastern rock lobster is rocky areas and reefs, commonly with vegetative cover. In offshore waters, traps are generally set on soft-bottom areas between or near hard grounds such as rock outcrops or reefs. There is currently only very broad scale information on areas of habitat in terms of large-scale geological features (e.g. Boyd *et al.* 2003), and given the relatively small value of the fishery, it is unlikely that research on the detailed mapping of rock lobster habitat for the offshore component of the fishery will be a realistic research objective in the short- or medium-term future. It is possible to map fishing areas, but the fine scale mapping of habitats is a difficult and expensive process. Because of the very strong impact of natural climatic events such as storms on reef habitats, the map of an individual habitat may continue to provide a true representation of that habitat for a only a relatively short time. In high relief hard grounds, fishers would generally aim to set traps adjacent to the reef but not directly on it, in order to avoid traps getting snagged, but traps may occasionally land in high relief areas. On low relief hard grounds, traps could be set directly on the reef with much less chance of being snagged. Hard grounds would have high resistance to the impacts of lobster traps (i.e. traps do very little damage), but have zero resilience since they are unable to recover from any damage that does occur. Soft grounds such as those adjacent to reefs would have a medium level of resistance to fishing gear and a high resilience (i.e. they would quickly recover from any damage caused by setting traps).

Hard-ground habitats that have high vertical relief are regarded as having low/medium vulnerability to the impacts of fishing gear (Table B2.17) because high vertical relief reefs tend to be harder and less weathered than low vertical relief reefs making them more physically resistant. Soft-ground habitats are classified as having a low vulnerability to the effects of traps (Table B2.17). The setting of traps on soft sediments would cause a minor disturbance to the sediment over a small area. In most areas where trapping is conducted, the effects of such disturbance are probably short lived. The periodic burial of reefs in high-energy areas can also be caused by natural events, such as storms, making it difficult to separate the effects of fishing from the effects of these natural events (Bax and Williams 2001).

Biogenic habitats have been classified as having high vulnerability to the effects of setting traps (Table B2.16). All biogenic habitats have low ability to withstand contact with traps. It has been observed that traps can dislodge and damage sessile biota from reef habitats (Moran and Jenke 1989, Casement and Svane, 1999) and this is also highly likely to apply to benthic epibiota from soft sediments such as soft corals, sea pens, sponges and ascidians. The resilience of biogenic habitats varies greatly. Some deepwater corals and sponges have very slow growth rates and their recovery rates may be measured in terms of decades or centuries (Sainsbury *et al*., 1997; Bax and Williams, 2001). Conversely, there are also many types of epibenthic biota that have relatively rapid growth rates when compared to the slow growing deep-water species, thereby making them more resilient. Sainsbury *et al*. (1997) found that epibenthic organisms took at least 15 years to grow to 25 cm on the North West Shelf of Australia.

Fishery Impact Profile

The fishery impact profile rating for habitats provides an integrated measure of the operational impacts of a fishery by combining information on known fishery impacts (direct and indirect) and identifying knowledge gaps that need to be addressed in order to mitigate risk levels. Therefore, any operational changes in the fishery that have an impact on habitats or any increases in knowledge that allow a better understanding of impacts on habitats will change the fishery impact profile rating for a fishery. The operational factors and information that are required to reduce the fishery impact profile rating and hence, mitigate risk levels, can be influenced by management changes and research initiatives. This is in stark contrast to the biological and geological characteristics of habitats, used to provide a vulnerability rating, which cannot be changed by management intervention.

A series of five basic questions was used to determine whether the available information describing habitats and the fishery-related impacts on habitats were adequate for assessing and mitigating risk levels in the fishery (Table B2.17). A simple decision rule based on the number of risk prone factors was used to assign the qualitative fishery impact profile rating for a habitat (Table B2.18). Each question required that a qualitative rating of "risk prone" or "risk averse" be made when applied separately to each of the seven broad habitat types (Table B2.19). Each question was given an equal weighting for determining the fishery impact profile rating. In general terms, the more risk prone factors present the higher the fishery impact profile rating. It is recognised that the magnitude of an impact is very important in determining the level of risk (Underwood, 1989). Based on the limited observations in the literature (Moran and Jenke 1989, Casement and Svane 1999), the magnitude of the impacts of traps on habitats was considered to be very small (particularly when viewed within the context of natural disturbance regimes).

The fishery impact profile ratings for habitats are summarised in Table B2.18. The fishery impact profiles were generally at the lower end of the scale. All geological and biogenic substrata were assigned a low-intermediate rating, and the water column was assigned a low impact profile rating. (Table B2.18). In answering the questions in Table B2.19 the lack of knowledge on the first two questions (distribution of habitats and fishing effort) resulted in answers of risk prone. The third question about overlap between the fishing activity and habitats was considered risk averse because the area that could potentially be impacted by the activity is extremely small in comparison to the overall area of the fishery. Habitats for rock lobster were considered to have adequate refuge from the fishery (question 4), because only a very small proportion of the area is likely to be affected at any time, making this factor risk averse. Finally, in answer to question 5, no high impact fishing gear is used in the fishery, making this factor risk averse.

Table B2.18 Fishery impact profile ratings for habitats affected by the Lobster Fishery.

Habitats	Fishery Impact Profile Rating Traps
Geological habitats	
Hard-ground substratum (High vertical relief >2m)	Low-Intermediate
Hard-ground substratum (Low vertical relief <2m)	Low-Intermediate
Soft-ground substratum (sands, muddy sediments, gravels)	Low-Intermediate
Biogenic habitats	
Biota of hard-ground substratum (High vertical relief >2m)	Low-Intermediate
Biota of hard-ground substratum (Low vertical relief <2m)	Low-Intermediate
Biota of soft-ground substratum (sands, muddy sediments, gravels)	Low-Intermediate
Water Column	Low

Risk Levels

The vulnerability and fishery impact profile ratings were plotted on the risk matrix (see Figure B2.8) to determine their qualitative risk level. Geological components of the habitat all had a low risk due to the low vulnerability of this habitat type and low-intermediate fishery impact profile. (Table B2.20). All of the remaining demersal habitats (biogenic) had a low-intermediate risk rating. These results stem from the methods used, which in effect, account for lack of knowledge about the distribution of habitat types and fishing effort by increasing the fishery impact profile (from low to low-intermediate). The water column component of the habitat received a low risk rating because it has low vulnerability and a low fishery impact profile rating.

Table B2.19 Basic questions and information needed to determine the fishery impact profile ratings for habitats impacted by the Lobster Fishery

Basic question	Information needed	Explanation	Rating
1) Where are the habitats?	Spatial distribution of habitat types	Basic knowledge of spatial habitat distributions is needed for risk analysis of fishery-wide impacts on habitats. Habitat mapping is needed at various spatial scales. Megahabitat scale (km to 10s km) for broad habitat types (e.g. submarine canyons, expanses of sediment flats). Mesoscale (10m to km) mapping is the level of resolution necessary for establishing baseline conditions and for monitoring change over time (Bax and Williams 2001).	**Risk prone** - when distribution of habitats is not known. **Risk averse** - when distribution of habitats is known.
2) Where does the fishing occur?	Spatial distribution of fishing effort	A direct measure of where the fishery-related impact is occurring. Mapping of fishing effort is needed at various spatial scales. The location and extent of broad "fishing grounds" is needed as a first step. Vessel monitoring data would provide mesoscale information describing where the fishing impact is happening.	**Risk prone** - when distribution of fishing effort is not known. **Risk averse** - when distribution of fishing effort is known.
3) What overlap is there between the area in which the fishery operates and the distribution of habitat types?	Proportion of available habitat impacted by fishing gear	An indicator of impact effect size on different habitat types. Fishing effort may be concentrated on preferred sub-areas within broad habitat types.	**Risk prone** - when overlap between fishing effort and habitats is not known. **Risk averse** - when overlap between fishing effort and habitats is known.
4) Do habitats have adequate protection (refuge) from fishing impacts?	Proportion of total habitat which is excluded from fishery impacts	An indicator of refuge availability for habitats. Some habitats may be natural refuges because fishing gear cannot operate on them effectively (e.g. high-vertical relief reef areas foul gear and are currently avoided) whilst other areas may be protected by fishing closures or be included within Aquatic Reserves or Marine Parks. It should be noted that fishing is permitted within Marine Parks - the zoning of these Marine Park areas needs to be considered.	Risk prone - When refuge availability cannot be determined or when refuge availability is assessed as being inadequate. Risk averse - When refuge availability of habitats is determined to be adequate.
5) Is the use of "high-impact" fishing gear currently permitted in the fishery?	Knowledge of impacts caused by different gear types used in the fishery	An assessment of the need to exclude or modify certain gear types from the fishery. There are two ways of mitigating risk: (a) modifying the gear to lessen its impacts; or (b) close areas (when gear modification is not possible or impractical).	**Risk prone** - when high-impact gear is used in the fishery. **Risk averse** - when high-impact gear is excluded or not used in the fishery.

Table B2.20 Risk levels for habitats affected by the Lobster Fishery.

Habitats	Risk Levels
Geological habitats	
Hard-ground substratum (High vertical relief >2m)	Low
Hard-ground substratum (Low vertical relief <2m)	Low
Soft-ground substratum (sands, muddy sediments, gravels)	Low
Biogenic habitats	
Biota of hard-ground substratum (High vertical relief >2m)	Moderately-Low
Biota of hard-ground substratum (Low vertical relief <2m)	Moderately-Low
Biota of soft-ground substratum (sands, muddy sediments, gravels)	Moderately-Low
Water Column	Low

B2.8.4 Issues Arising from the Risk Assessment on Habitats

High vulnerability of biogenic habitats was the main reason why risk levels were not negligible or low for these habitats. Despite the high vulnerability, the risk to these habitats was moderately low, due to the very small overlap between the fishery and the available habitat. As a result of the small overlap, there is a considerable amount of "refuge" habitat that is unaffected, therefore the impacts on these habitats do not warrant concern.

Through the risk assessment it also became apparent that there is lack of information relating to the distribution of different habitats and the distribution of fishing effort. Within the framework used for this assessment, this lack of information resulted in low or moderately low risk levels for habitats, but risk levels could potentially have been lower if such information was available. The moderately-low risk level does not, however, warrant a high priority for the collection of this information for the purpose of reducing impacts on habitats in this fishery.

The risk from ghost fishing is low, but action would be warranted to address the issues of information gaps on the number of traps lost in the fishery and the breakdown times of lost traps.