Document SPRFMO-III-SWG-10

Information describing *Ommastrephes bartrami* fisheries relevant to the South Pacific Fisheries Management Organisation

REVISED
25 February 2007

Neon flying squid *Ommastrephes bartrami*

1. <u>Overview</u>

Ommastrephes bartrami is the most broadly distributed species in the family Ommastrephidae with a circumglobal distribution. *O. bartrami* is found in subtropical and warm temperate waters of all oceans except the Southeast Pacific. It is most prominent in the North Pacific, off the east coast of Japan and the west coast of USA. Within ocean basins the distribution of *O. bartrami* is patchy and highly aggregated.

O. bartrami is a large oceanic squid commonly observed schooling at the surface at night. Little is known about their spawning behaviour. Spawning in Australian waters is thought to occur in spring to summer and over the continental shelf. *O. bartrami* matures between the age of 7-10 months and has an estimated life span of ~1 year.

There is no information on migratory movements within the South Pacific, however in the North Pacific, *O. bartrami* make an annual round-trip migration between subtropical spawning grounds and northern feeding grounds near the subarctic boundary.

There is no information about population structure within the South Pacific Ocean.

Productivity of *O. bartrami* is very high. The onset of maturity is early, fecundity is high, annual growth rate is relatively rapid and the species is very short lived, which indicates that the proportion of the total biomass that can be harvested is very large.

In contrast to the North Pacific where major fisheries for *O. bartrami* exist, there is currently no known commercial harvest in the South Pacific Ocean. *O. bartrami* has been caught in small quantities as bycatch in the Australian arrow squid jig fishery.

There are currently no management measures in place for trans-boundary, straddling or high seas stocks of *O. bartrami*. The abundance of *O. bartrami* is highly variable and highly correlated with environmental variables. Extremely low squid abundances have been correlated with El Nino events. Due to the ~1 year life span of this species it is not practical to predict future stock size using stock assessments in advance of the fishing season.

Over the last 2 decades the countries fishing *O. bartrami* in the Northern Pacific Ocean have been Japan, Taiwan and South Korea. Since the wide-scale closure of driftnet fishing an increasing number of Chinese vessels have entered the fishery. Recently in the literature there have been reports of complaints about crowded conditions on the fishing grounds. Vessels from Canada and the United States have also recently entered the fishery. As the fishing pressure and the number of fishing nations increase, the potential for expanding fishing grounds into South Pacific grows.

2. Taxonomy

2.1 Phylum
Mollusca

2.2 Class
Cephalopoda

2.3 Order
Teuthida

2.4 Family
Ommastrephidae

2.5 Genus and species
Ommastrephes bartrami (Lesueur, 1821)

2.6 Scientific synonyms

Ommastrephes caroli Furtado, 1887
Loligo bartrami Lesueur, 1821

2.7 Common names

Neon flying squid, Red flying squid, Red ocean squid, Tintenfisch, Kalmar, Pfeilkalmar, Pota saltadora, Encornet volant, Encornet carol, Pota velera, Akaika, Bartram's squid, Aka-ika, Murasaki-ika, Baka-ika.

2.8 Molecular (DNA or biochemical) bar coding

GENBANK accession number for cytochrome c oxidase subunit I (COI) gene is AF000057. GENBANK accession number for clone 49 actin gene is AF234956. GENBANK accession number for clone 6 actin gene is AF234957.

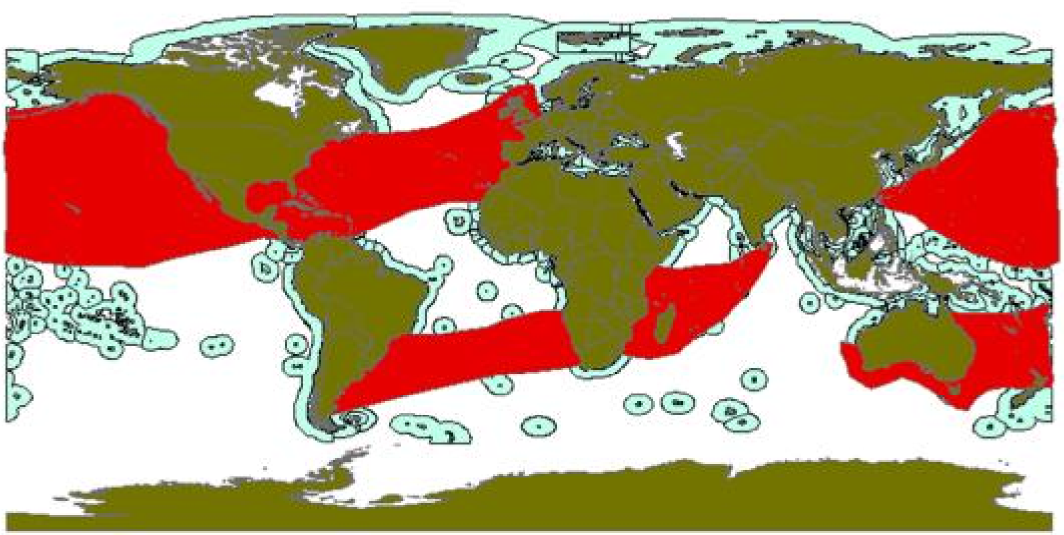
3. Species characteristics

3.1 Global distribution and depth range

O. bartrami is the most broadly distributed species in the family Ommastrephidae with a circumglobal distribution (Murata 1990) (Figure 1). *O. bartrami* is found in subtropical and warm temperate waters of all oceans except the Southeast Pacific. It is most prominent in the North Pacific, off the east coast of Japan and the west coast of USA. Distributions of *O. bartrami* are patchy and highly aggregated (Chen & Chiu 1999).

In the North Pacific (42 - 45˚ N) *O. bartrami* have been observed between 0 - 40 m at night and between 150 – 300 m during the day (Murata & Nakamura 1998). Further south (26-28˚ N) *O. bartrami* has been observed between 40 - 70 m at night and between 400 - 700 m during the day (Nakamura 1991). In the North Atlantic submersible observations of *O. bartrami* were between 540 – 1 050 m during the day and in surface waters at night (Moiseev 1991). Smaller squid spend more time at the surface where they have been observed flying across the water.

Figure 1: Distribution of *Ommastrephes bartrami*. *Source: Adapted from: Roper C.F.E., M.J. Sweeney and C.E. Nauen 1984. Cephalopods of the world. Food and Agriculture Organization, Rome,* Italy. Vol. 3: 277 pp. See also note below about distribution in the South Pacific.



3.2 Distribution within South Pacific area

O. bartrami has been recorded in temperate and subtropical waters along the south, east and west coasts of Australia. *O. bartrami's* distribution extends across the Tasman Sea to Norfolk Island and at least as far south as south-east Tasmania. In the South Pacific it is also present on the high seas to the east of the Peruvian current (Alexeyev 1994).

3.2.1 Inter-annual and/or seasonal variations in distribution

No information is available for the South Pacific. In the North Pacific, however, *O. bartrami* displays large variability in abundance and distribution depending on environmental variables. In particular, high abundances are linked to relatively low temperature and low salinity (Chen & Chui 1999).

In the North Pacific *O. bartrami* have been observed to undertake extensive migrations between subarctic and subtropical waters, where they spawn (Murata 1990; Seki 1993). Araya (1983) proposed that sub adult *O. bartrami* migrate northwards toward the sub-arctic frontal zone for feeding, and mature individuals migrate southward to subtropical waters for spawning. Average swimming speeds while migrating have been recorded between 19- 27 cm/s, averaging speeds of 23.1 km/day (Nakamura 1991).

3.2.2 Other potential areas where the species may be found

None known.

3.3 General habitat

O. bartrami is an oceanic squid that lives in the water column and undergoes vertical migrations.

3.4 Biological characteristics

Spawning in Australian waters is thought to occur in spring to summer and over the continental shelf (Dunning & Brandt 1985). In the North Pacific spawning occurs between winter and summer (Araya 1983). Many details related to spawning remain unknown. It has been suggested that *O. bartrami* is a continuous spawner like its close relative *Sthenoteuthis oualaniensis*, however, evidence is not conclusive.

Juvenile squid are virtually absent from net, jigging or driftnet collections and very little is known about their biology or ecology. Egg masses have never been observed and paralarval distribution suggests hatching occurs somewhere near the sea surface where temperatures range between 21 to 25˚ C (Hayase 1995; Bower 1996). The distribution of paralarvae in the northern hemisphere also suggests that spawning does not occur in near-shore waters (Bower 1996; Yatsu et al. 1998).

In the Northern Pacific age and growth of *O. bartrami* has been investigated based on the examination of statolith microstructure, however, daily increments still remain to be validated. Growth rates were found to vary by sex, geographic region, hatching season, food availability and ambient temperatures (Forsythe 2004). Slower growth rates have been observed in the late spring and summer compared to autumn (Ichii et al. 2004). Female *O. bartrami* grow faster than males with individual growth rates ranging from 1.1 to 2.5 mm day^{-1} and from 1.1 to 2.1 mm day^{-1} respectively. (Yatsu et al., 1997; 1999).

O. bartrami matures between the age of 7-10 months and has an estimated life span of ~1 year (Yatsu et al. 1997; 1998). Size at maturity in Australian waters is thought to be greater than 40 for cm female and greater than 30 cm in males (Dunning & Brandt 1985). Size at maturity in the North Pacific has been reported at about 30-33 cm in males and 40-55 cm in females (Yatsu et al. 1998).

The maximum recorded size in Australian waters for females is 477 mm mantle length and for males, 397 mm mantle length (Dunning & Brandt 1985). Maximum size reported in North Pacific is 406 mm males and 562 mm females (Murata 1990).

There is no information describing migratory movements of *O. bartram*i in the South Pacific. However in the North Pacific, *O. bartrami* make an annual round-trip migration between subtropical spawning grounds and northern feeding grounds near the subarctic boundary (Murata & Nakamura 1998). During spawning migrations *O. bartrami* have been observed to migrate at a rate of up to 17 km day^{-1} (Araya 1983).

O. bartrami have been observed to fly a distance of 10 - 20 m at 1 - 2 m height off the sea surface. It is believed that the gliding-like flying behaviour is analogous to flying fish with the aim of escaping from predators (Murata 1988).

Immature male and female squid school together, but with the onset of sexual maturity sexual segregation occurs. Squid larger then 400 mm are typically found in schools of less than 20 individuals (Dunning & Brandt 1985).

O. bartrami display high variability in abundance. Due to this there is a considerable body of research investigating correlations between squid abundance and environmental variables. Examples of this research, which is predominantly undertaken by the Chinese and Japanese, are spatial and temporal analyses using Grays incidence methods (Chen et al. 2002) and forecast modelling using artificial intelligence (Chen et al. 2003; Cui et al. 2003).

3.5 Population structure

There have been no investigations into the degree of genetic mixing that occurs between populations in different hemispheres. Dunning (1998), however, proposed three separate sub species: North Pacific, North Atlantic and a southern hemisphere subspecies.

Within the South Pacific there is no information about population structure.

Within the North Pacific the population of *O. bartrami* is thought to comprise of two seasonal cohorts and 4 stocks (Yatsu et al. 1998; Bower & Ichii 2005). Yatsu et al. (1998) also divided the North Pacific Ocean into three zones based partly on the occurrence of parasites, however, Yatsu et al. (1998) suggests that the stocks are not genetically separated as hatching dates overlap.

3.6 Stock productivity

Very high – onset of maturity is early, fecundity is high, annual growth rate is relatively rapid and the species is very short lived, which indicates that the proportion of the total biomass that can be harvested is very large.

3.7 Role of species in the ecosystem

O. bartrami are opportunistic predators. Similarly to *S. ouloualensis* and *D. gigas*, *O. bartrami* display ontogenetic changes in diet with growth. Those between 15-19 cm mantle length feed mostly on planktonic crustaceans, whereas larger individuals feed primarily upon myctophids and squid (Murata 1990; Wantanabe et al. 2004).

A high incidence of cannibalism, (up to 60% of identified squid material, which made up 50% of stomach contents) has been observed in *O. bartrami* (Seki 1993).

Marine mammals, seabirds, sharks and swordfish prey heavily upon *O. bartrami*. (Aydin et al. 2003; Seki 1993; Stillwell & Kohler 1985; Toll & Hess 1981). In Australian waters the only known predators are pelagic sharks.

4. Fisheries characterisation

4.1 Distribution of fishing activity

At present there is no known commercial harvest of *O. bartrami* in the South Pacific Ocean.

In contrast there are major fisheries in the North Pacific Ocean. The fishing grounds in July are found between 32˚ - 42˚ N and 152˚ - 170˚ E. At the peak of the fishing season (August – October) this region expands both east, west and southwards (Murata et al. 1983; Yatsu et al. 1997; Murata & Nakamura 1998; Chen & Chiu 1999; Chen et al. 2003). These main fishing grounds are associated with the subarctic frontal zone of the Central North Pacific Ocean.

Chinese catch is mainly concentrated in the waters from 42-44˚ N and the main fishing season is from August to September (Chen & Xu 2004).

The central position of the northern fishing grounds (41˚ N and 155˚ E) is located in strong correlation with cold water fronts where surface water temperatures were between 14-21˚ C (Shen et al. 2004), and correlation with the strength of the Kayoshio current (Chen et al. 2003).

Research surveys have been carried out in northern area of Uruguayan sector (Leta 1989), off British Columbia (Jamieson & Heritage 1988), and off the Australian coast (Dunning et al. 1981) with the aim of investigating new fisheries.

4.2 Fishing technology

Japanese jigging vessels pioneered the fishery in 1974, but were displaced by the more efficient driftnet fishing in 1978. Large scale driftnet and gillnet fishing by Japan, Taiwan and Korea began in the 1970’s and stopped at the end of 1992 with the UN global moratorium on large scale drift net fishing. Since then squid have been caught using jigging methods, either mechanical or by hand. In 1996 ~100 Japanese jigging vessels were operating on the high seas.

Some vessels use underwater fishing lights to facilitate daytime jigging operations. These have been shown to work effectively when 5000 W metal-halide and halogen lamps were positioned at 180-200 m depths and jig lines were fished to 300 m depths (Inanda et al. 1995, 1996, as cited by Bower & Ichii 2005).

Japanese studies using echosounders have shown that 28 KHz give the sharpest images of squid distributed in the upper 300 m, and that 50 KHz is effective for picking up dense schools (JAMARC 2001, as cited in Bower & Ichii 2005).

4.3 Catch history

There is no known commercial harvest on the high seas in the South Pacific, however, *O. bartrami* has been caught in small quantities as bycatch in the Australian arrow squid jigging fishery. Exact quantities are unknown. Results from a Japanese research vessel in 1981, showed promising catches of *O. bartrami* within the Australian EEZ (which forms a straddling stock with the high seas) (Dunning et al. 1981).

In the North Pacific Ocean *O. bartrami* has been commercially harvested since the early 1970's and is an important fishery (Chen & Chui 1999). During the 1980s approximately 250 000 t yr^{-1} was harvested by high seas drift netters from Japan, Korea and Taiwan.

A jigging fishery for *O. bartrami* began in 1974 off northeastern Japan after catches of *Todarodes pacificus* dropped sharply. Note that this is a straddling stock. Annual Japanese catch from the jigging fishery ranged between 40 000 to 60 000 t during 1995-1998 and fell to below 24 000 t during 2000-2001 (Bower & Ichii 2005). It has been suggested that this decline is due to environmental conditions and/or due to increased catches. Recent FAO catch data are given in Table 1.

In 1993 three Taiwanese vessels started fishing in the western North Pacific with an annual catch of 15 000 t.

The combined annual catch in the North Pacific by the Japanese, Taiwanese and Korean fisheries for 1985-1990 ranged from 248 000 t to 378 000 t (Murata & Nakamura 1998).

Table 1: Catch data by country and FAO area for *O. bartrami* (t). *Source: FAO 2006.*

Country	FAO Area	1996	1997	1998	1999	2000	2001	2002	2003	2004
Japan	61	-	47 852	53 638	34 551	46 199	21 578	14 082	18 429	18 000 F
Russian Federation	61	-	-	-	-	405	100	483	531	1 420
Japan	67	-	2 008	1 200	1 521	683	2 061	382	4	-
Japan	77	-	10	113	4	81	131	-	-	-
Total		0	49 870	54 951	36 076	47 368	23 870	14 947	18 964	1 420

Source: FAO 2006
F= FAO estimate

4.4 Stock status

Not known or uncertain – Insufficient information is available to make a judgment.

4.5 Threats

None known.

4.6 Fishery value

There is no information available.

5. Current Fishery Status and Trends

5.1 Stock size

There is no information available.

5.2 Estimates of relevant biological reference points

There is no information available.

5.2.1 Fishing mortality

There is no information available.

5.2.2 Biomass

Nigmatullin (2002) estimated that the total world's biomass of *O. bartrami* was between 10 - 13 million tonnes.

5.2.3 Other relevant biological reference points

No information available.

6. Impacts of Fishing

6.1 Incidental catch of associated and dependent species

There is no information available for the jig fishery, but it is assumed to only catch squid. The drift net fishery was banned as a result of serious concerns about the by-catch of a wide range of associated and dependent species.

6.2 Unobserved mortality of associated and dependent species

This is likely to be low due to the selectivity of the jig fishing method.

6.3 Bycatch of commercial species

There is no information available.

6.4 Habitat damage

There is likely to be minimal damage to the habitat due to the fishing methods employed.

7. Management

7.1 Existing management measures

There are currently no management measures in place for trans-boundary, straddling or high seas stocks.

7.2 Fishery management

The abundance of *O. bartrami* is highly variable. Correlations with environmental variables are strong- extremely low abundances with El Nino events have been observed (Yatsu et al. 1999). Due to the ~1 year life span of this species it is not practical to predict future stock size using stock assessments in advance of the fishing season.

Over the last 2 decades the main countries that have fished *O. bartrami* in the Northern Pacific Ocean have been Japan, Taiwan and South Korea. Since the closure of the driftnet fishing an increasing number of Chinese vessels have since entered the fishery. Recently in the literature there have been reports of complaints about the crowded conditions of the fishing grounds and the reckless operations by some vessels (Koganezaki 2002 as cited in Bower & Ichii 2005). Vessels from Canada and the United States have also recently entered the fishery. As the fishing pressure and the number of fishing nations increase, the potential for expanding fishing grounds into South Pacific grows.

7.3 Ecosystem Considerations

Squid jigging is assumed to be a very selective fishing method. The extent of the adverse impacts on the ecosystem from squid fishing is unknown. However, as with any large extraction of resources from the system, changes in community structure are likely. The loss of fishing gear from squid fisheries may also have an adverse effect.

8. Research

8.1 Current and ongoing research

There is currently no known research underway.

8.2 Research needs

More research is required investigating the spawning behaviour of *O. bartrami*. Detailed catch information is also required to effectively manage this species.

9. Additional remarks

Since 1996 the Marine Fisheries Research and Development Department of the Japanese fisheries research agency has conducted annual jigging surveys in the North Pacific to try to develop new jigging grounds. It is unknown whether research cruises for new fishing grounds, by this department, have been conducted on the high seas in the South Pacific.

The distribution of *O. bartrami* also overlaps with another smaller relative in the same subfamily: *Sthenoteuthis oualaniensis*. It has been suggested that where this overlap occurs *O. bartrami* may be an important predator on *S. oualaniensis.* Analyses of diet of both *S. oualaniensis* and *O. bartrami* caught in the same waters showed *S. oualaniensis* to be a more specialised predator than *O. bartrami* thus limiting competition (Parry 2006).

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