C2. WORLD SQUID RESOURCES

by Paul G. Rodhouse *

INTRODUCTION

Fisheries for cephalopods, especially squid, have attracted interest worldwide over the last two decades. Declining catches in many traditional fisheries have led to increased effort to develop the potential of non-traditional species, especially invertebrates such as the cephalopods. Estimates of global squid consumption by higher predators, especially sperm whales suggest that they consume a greater mass of squid than the total world catch of all marine species combined (Voss, 1973; Clarke, 1983). This is interesting, both because of the commercial potential of squid fisheries, and the role they might have in the provision of high quality protein for human consumption (Caddy, 1983; Roper Sweeney and Nauen, 1984).

There is also some evidence that squid populations have increased in regions where there has been overfishing of groundfish stocks (Caddy and Rodhouse, 1998). It has been suggested that this is the inevitable response of populations of short-lived, semeleparous (i.e. individuals die after reproduction), ecological opportunists to both the reduction in predation pressure by predatory groundfish and the creation of vacant trophic niches.

Squid catches have increased substantially worldwide and this has highlighted the fact that their populations are highly variable. The *Illex illecebrosus* fishery in the northwest Atlantic which was developed very rapidly by the east Asian squid jigging fleet in the late 1970s and early 1980s, following a decline of *Todarodes pacificus* in the northwest Pacific, collapsed suddenly and led to a rapid switching of effort to the southwest Atlantic in the early 1980s to target *Illex argentinus.* Subsequently catches of *Todarodes pacificus* have continued to fluctuate but the fishery for *Illex illecebrosus* has never returned to Canadian waters although consistent, but lower, catches are taken off the eastern USA further south. This large scale variability has attracted attention to the likely role of oceanographic variability in driving recruitment processes in squid stocks (O'Dor and Coelho, 1993; Bakun and Csirke, 1998).

This short review provides an overview of the current status of the world squid fisheries and considers the life history and biological characteristics of squid in the context of the management of the fisheries. It briefly reviews the role of squid in marine ecosystems, describes the relationship between squid stocks and major oceanographic systems and introduces current research on the role of oceanographic variability in driving recruitment processes in squid populations. Finally it provides a brief analysis of the current status of the world squid fisheries and considers the potential for future development.

HARVESTED SPECIES

In 2002, 75 percent of the 2.18 million tonnes of reported world squid catch (FAO, 2002) was identified to species. This included 12 species from two families, the Ommastrephidae and Loliginidae (Table C2.1). Of the remaining 25 percent some 11 percent was unidentified ("not elsewhere included" or nei) common squids (loliginids), and another 14 percent was included in a more general unidentified squid category. The fact that about a quarter of the world squid catch was unidentified is a reflection of the fact that there is a major artisanal and small-scale inshore element to the world squid fishing fleet and that large volumes are caught in tropical and subtropical regions where species diversity is high especially among the loliginid squids. In these areas the taxonomy of the squid fauna generally is poorly understood.

Two species of ommastrephid squid, *Illex argentinus* and *Todarodes pacificus*, comprized 46 percent of the world squid catch and the identified ommastrephids taken together contribute about 70 percent of the catch making this the single most important group. *Loligo gahi* has consistently been the most important loliginid squid in the world catch over the decade up to 2002.

In 2002 about 225 000 tonnes of unidentified cephalopods were also caught and an unknown, but probably substantial, proportion of this would have been squid.

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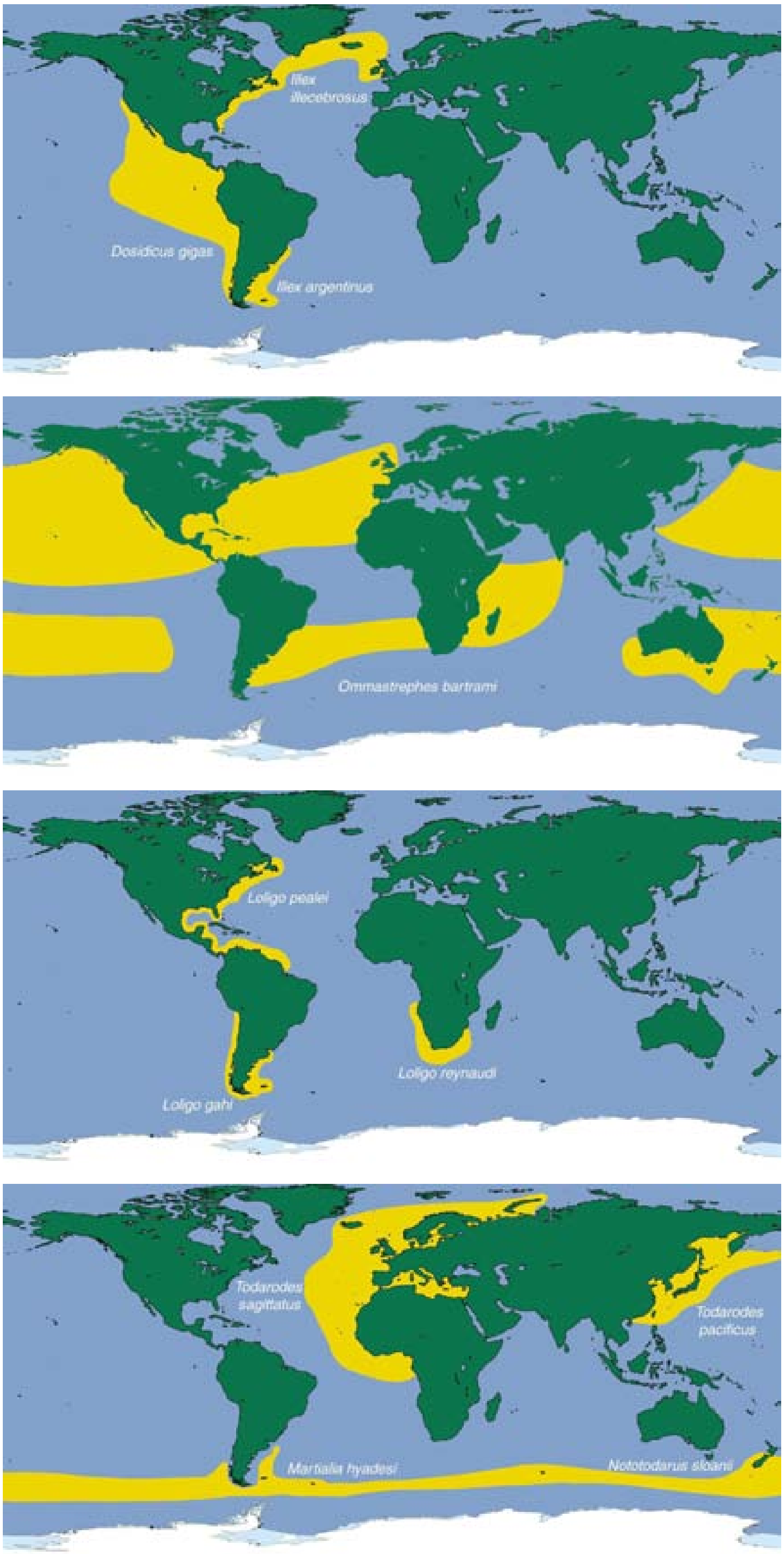
Figure C2.1 - Distribution of the world's major squid stocks exploited by commercial fisheries and reported at species level by FAO



A

Ommastrephidae

B

Ommastrephes bartrami

(Oastrephidae)

C

Loliginidae

D

Flying squids

FISHING METHODS

The ommastrephid squid are almost exclusively caught using jigs (lures) armed with barbless hooks which are fished in series on lines using automatic machines (Suzuki, 1990). The squid are attracted towards the jigs at night with incandescent, metal halide lamps suspended on cables above the deck of the vessel. Small coastal vessels may use a single lamp while the large industrial vessels operate with 150 or more lamps which are typically 2 kW each. The lamps mostly emit white light but small numbers of green lamps are often interspersed in the arrays (Inada and Ogura, 1988). Some industrial vessels will also operate one or two underwater lamps which are raised through the water column, and dimmed, as the squid are attracted towards the vessel. Jiggers typically deploy a large parachute drogue to prevent drifting downwind while fishing, thus enabling the jig lines to operate close to the vertical.

The major fisheries for loliginids mostly use trawls which operate during daytime when the squid are concentrated near the seabed. Conventional otter trawls fish on the bottom but over rough ground pelagic trawls may be fished just off the seabed to avoid fouling the gear. Trawls designed for squid fishing generally have a higher head rope than would be usual for finfish. Outside the major fisheries a wide variety of gear including jigs, traps, nets etc are used to catch loliginid squid (e.g. Chotiyaputa, 1993).

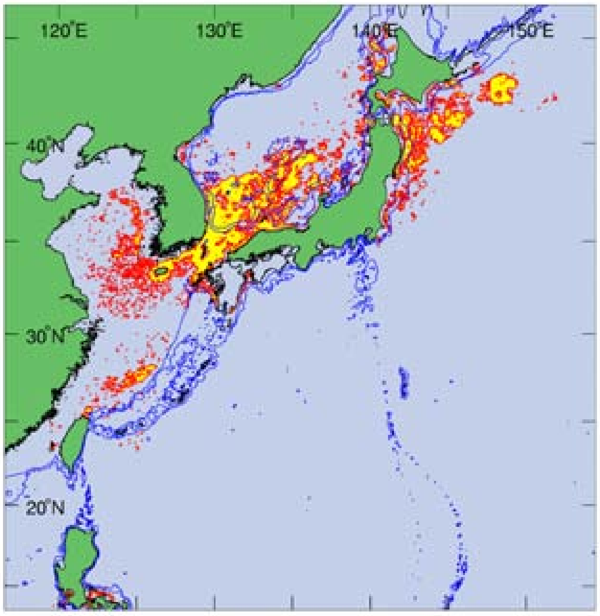
GLOBAL DISTRIBUTION OF STOCKS

Distribution of the major squid stocks is shown in Figure C2.1. The ommastrephids are caught offshore over continental shelves and off-shelf over the deep ocean. They all come close to the surface at night but may migrate down to depths of 1 000 m during the day (Yatsu *et al.,* 1999). The light fisheries for members of this squid family can be visualized through their light emissions by orbiting satellites of the US Defense Meteorological Satellite Programme (http://dmsp.ngdc.noaa.gov/dmsp.html) (Rodhouse *et al.*, 2001) (Figure C2.2). *Todarodes pacificus* is distributed at the margins of the northwest Pacific from 20°N to 60°N and the major fisheries are around Japan, especially in the southern part of the Sea of Japan and in the Tsushima Strait (Figure C2.2a). *I. argentinus* is a southwest Atlantic species extending from about 30°S to 52°S. The fishery is mostly concentrated along the edge of the Patagonian Shelf but extends over the shelf to the north of the Falkland Islands (Malvinas) (Figure C2.2b). *Illex illecebrosus* occurs in the north Atlantic from 25°N off Florida to about 60°N. Its habitat is similar to that of *I. argentinus* being concentrated near the shelf edge but extending over the shelf and into deeper water to a depth of about 1000 m. Since the early 1980s, when the East Asian jig fishery for the species off Canada collapsed, it has largely been exploited by trawlers off the US coast so the fishery cannot be visualized through their light emissions by satellite. *Nototodarus sloanii* and *Martialia hyadesi* are southern hemisphere species, the former is exploited in sub-Antarctic waters over the shelf of the south island of New Zealand (Figure C2.2c) and gives way to the smaller stock of *N. gouldi* in the subtropical waters around the north island. *M. hyadesi* has a circumpolar distribution in the Southern Ocean but is only exploited commercially

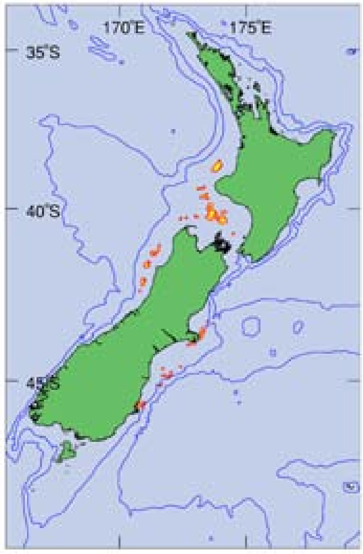
Table C2.1. Summary of the world squid catch in 2002 (FAO 2003).

Species	Family	Common name	Nominal catch tonnes	percent of world cephalopod catch
Loligo gahi	Loliginidae	Patagonian squid	24 976	0.8
Loligo pealei	Loliginidae	Longfin squid	16 684	0.5
Loligo reynaudi	Loliginidae	Cape Hope squid	7 406	0.2
Common squids nei	Loliginidae		225 958	7.5
Ommastrephes bartrami	Ommastrephidae	Neon flying squid	22 483	0.7
Illex illecebrosus	Ommastrephidae	Northern shortfin squid	5 525	0.2
Illex argentinus	Ommastrephidae	Argentine shortfin squid	511 087	16.1
Illex coindetii	Ommastrephidae	Broadtail shortfin squid	527	<0.1
Dosidicus gigas	Ommastrephidae	Jumbo flying squid	406 356	12.8
Todarodes sagittatus	Ommastrephidae	European flying squid	5 197	0.2
Todarodes pacificus	Ommastrephidae	Japanese flying squid	504 438	15.9
Nototodarus sloani	Ommastrephidae	Wellington flying squid	62 234	1.9
Martialia hyadesi	Ommastrephidae	Sevenstar flying squid	-	-
Squids nei	Various		311 450	9.8
Total squids			2 189 206	75.8
Total Cephalopods			3 173 272	100.0

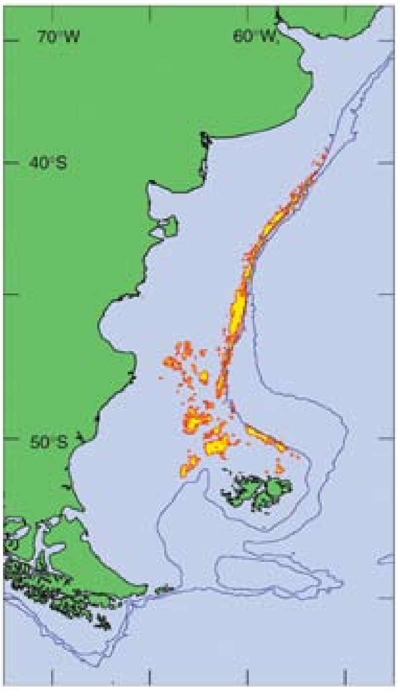
Figure C2.2 - Distribution of the world's light fisheries for ommastrephids (from Rodhouse *et al*., 2001)



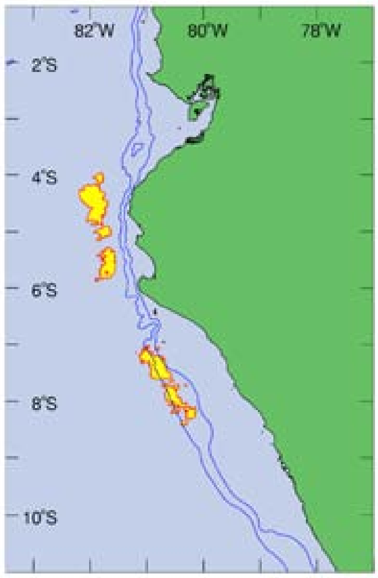
A Kuroshio Current province
(*Todarodes pacificus* and *Ommastrephes bartrami*)



B New Zealand province
(*Nototodarus sloanii*)



C Southwest Atlantic province
(*Illex argentinus*)



D Humboldt Current province
(*Dosidicus gigas*)

in the Southwest Atlantic sector by the fleet primarily targeting *Illex argentinus*. *Ommastrephes bartrami* is an epipelagic species which occurs over the deep ocean in the Atlantic, Pacific and Indian Oceans. In all three oceans it is absent from equatorial waters and extends from the subtropics to temperate waters in the northern and southern hemispheres. Despite its wide distribution it is only exploited commercially in the northwest Pacific off north east Japan (Figure C2.1b). *Dosidicus gigas* is distributed in the eastern Pacific from 35°N off California to southern Chile extending westwards furthest in the tropics to about 120°W. It is largely an off-shelf species. The major fisheries for *D. gigas* are off Peru (Figure C2.2d) and in the vicinity of the Costa Rica Dome off Central America. *Todarodes sagittatus* is an eastern Atlantic species occurring from the Arctic off northern Norway to about 13°S and westwards to approximately 40°W. It is caught as a by-catch of trawlers although in the early 1980s it occurred at sufficient densities in Norway to generate a short-lived, targeted fishery (Wiborg, 1986).

The most important loliginid squid identified in the world catch is *Loligo gahi* which is distributed in coastal and shelf waters around the coast of South America from southern Peru to northern Argentina. Most of the catch is caught in waters to the south and east of the Falkland Islands (Malvinas) by trawlers. *Loligo pealei* is a western Atlantic species in coastal and shelf waters along the eastern seaboard of the USA, Central and South America from 50°N to 5°N which is also caught by trawlers. *Loligo reynaudi*, as recorded by FAO, is a southern African squid, the distribution of which is poorly known. Augustyn and Grant (1988) have shown that on the basis of morphology, meristics and allozymes, *L. reynaudi* and *L. vulgaris* are, in fact, two sub-species (*L. vulgaris reynaudi* and *L. vulgaris vulgaris*). The fishery for *L. vulgaris reynaudi* is largely pursued by small jigging vessels (ski boats).

In addition to the identified species some 226 000t of unidentified loliginids were reported to FAO in 2002, most of which are from east Asia and the west coast of the USA. The species grouping includes *Loligo opalescens* in California which is fished mostly around the Channel Islands and Monterey Bay by lampara vessels; *L. chinensis* on the shelves of the China Sea (Dong, 1991) caught by large fleets of light fishing vessels detected by DMSP imagery (Rodhouse *et al.*, 2001) and; *L. chinensis* and *L. duvauceli* in the Sunda-Arafura Shelf region which are caught by jigging and a variety of other techniques (Chotiyaputa, 1993).

A further 311 000t of squid not identified to family level was also reported to FAO in 2002. These are mostly caught in East Asia (Rodhouse *et al.* 2001) and would include ommastrephids and loliginids but also some members of other families such as the Thysanoteuthidae (*Thysanoteuthis rhombus*) and Enoploteuthidae (*Watasenia scinitillans*).

LIFE HISTORY AND BIOLOGICAL CHARACTERISTICS

The squids, in common with the other coleoid cephalopods, are semelparous and generally short-lived (Calow, 1987). Most commercially exploited species have a life span of approximately one year at the end of which there is a single spawning event followed by death. The coleoids appear to have evolved from their molluscan ancestors through the process of progenesis which is reflected in the attainment of full sexual maturity while still retaining juvenile characteristics, at least in some respects (Rodhouse, 1998a). In the coleoids, the juvenile characteristics that are still present at full sexual maturity are features of their physiological energetics, and are not morphological.

The short life span and semelparous lifestyle of the squid and other coleoid cephalopods distinguishes them from most, if not all, the fish species that are exploited commercially (Pauly, 1994). These characteristics present particular problems for the management of the fisheries. The essence of the problem is that once the spawners of one generation have reproduced and died it is almost impossible to assess the potential recruitment strength and stock size of the next generation. A meaningful quota cannot therefore be set until the next generation recruits into the fishery. For this reason Caddy (1983) and Csirke (1986) recommended that squid and other cephalopod fisheries should be managed by effort limitation and assessed in real-time.

This approach has been adopted and refined in the case of the fisheries for *Illex argentinus* and *Loligo gahi* in the areas around the Falkland Islands (Malvinas) (Beddington *et al.*, 1990, Rosenberg *et al.*, 1990, Basson *et al.*, 1996). In this fishery, effort is set on the basis of historical information on stock size then, once the fishery is opened, the stock is assessed using a Leslie-Delury depletion analysis and the fishery is closed once it is estimated that the remaining biomass corresponds to the target spawning escapement. When management of the fishery first started in 1987 the target escapement was set at 40 percent of the numbers of squid recruited into the fishery. More recently the escapement target has been an absolute value so as to stabilize the size of the spawning population in the face of variable recruitment. Collaborative pre-recruitment surveys are now also carried out to improve the initial assessment prior to the start of fishing when effort is being set.

ROLE IN MARINE ECOSYSTEMS

The squids are versatile in their ability to capture, subdue and consume a wide variety of prey and they feed voraciously to maintain the active life-style associated with fast growth, short life span and semelparity (Rodhouse and Nigmatullin, 1996). Their prehensile arms and tentacles together with their highly evolved sensory system are adaptations for a broad trophic niche. Many species, especially among the ommastrephids, make large scale migrations enabling them to take advantage of spatial and temporal variations of marine production systems and prey populations. Most juvenile squid prey on small crustaceans and as they grow they gradually switch to fish and other cephalopods. Many, if not all, species are cannibalistic, generally feeding on other members of the same cohort, and this has been suggested to be particularly important during large scale migrations when food resources are scarce (O'Dor and Wells, 1987). Where squid prey on commercially exploited stocks of other species their impact on recruitment to the fisheries is potentially substantial.

The prey of squid caught by the global light fishery, mostly over the world's continental shelves, has recently been reviewed by Rodhouse *et al.*, (2001). The data are not very detailed but confirm the general trend of predation on crustaceans during early life and shift to fish and cephalopods as individuals grow. The oceanic ommastrephids, such as *Ommastrephes bartrami*, currently exploited by light fisheries in the northwest Pacific and *Dosidicus gigas* off Peru, primarily feed on mesopelagic fishes, particularly myctophids. The largely unexploited stocks of oceanic ommastrephids elsewhere in the world's oceans are also known to consume myctophids (Rodhouse and Nigmatullin, 1996). Large stocks of myctophids are present in some areas, particularly the Indian Ocean (northern Arabian Sea) (Shotton, 1997) and in sub-Antarctic waters of the south Atlantic. In these areas they are preyed on by the ommastrephids *Sthenoteuthis oualaniensis* and *Martialia hyadesi* respectively. However, so little is known about the ecology of these oceanic food chains that any future fisheries for these squid species, or their prey, should be developed with caution.

Squid are also important prey for numerous higher predators: fish, seabirds, seals and whales (Clarke, 1996). In areas where groundfish stocks have been depleted by fishing there is evidence in FAO catch data suggesting that populations of short-lived cephalopods might have increased contributing to their increased predominance in fish landings. It has been suggested that this increased squid abundance and the observed rise in cephalopod catches has been, at least partially the response to the relaxation in predation pressure (Caddy and Rodhouse, 1998). Seabirds probably have a smaller impact on squid stocks than the marine mammals but, taken together, global estimates of consumption of squid and other cephalopods by higher predators far exceed global or regional catches by the commercial fisheries (Voss, 1973; Clarke, 1983; Croxall *et al.*, 1985). There are, however, questions about possible bias in these estimates caused by the dynamic nature of cephalopod populations, and hence bias on estimation on standing stock biomass, and the problem of estimating consumption when retention time of remains in predator's gut contents is not well known (Rodhouse *et al.*, 2001).

RELATIONSHIP BETWEEN STOCKS AND OCEANOGRAPHIC SYSTEMS

The large exploited stocks of ommastrephids are mostly associated with the high velocity western boundary current systems of the Atlantic and Pacific Oceans (O'Dor and Coelho, 1993). *Todarodes pacificus*, which for many years has dominated the global ommastrephid squid catch, is distributed in the Kuroshio Current, the western boundary current of the North West Pacific. Its range extends from 20°N to 60°N (Figure C2.1d) but the fishery is concentrated at the latitude of the confluence of the cold, southwards flowing waters of the Oyashio system and the warm, northwards flowing Kuroshio between 35°N to 40°N, east and west of Japan (Figure C2.2a). Similarly *Illex illecebrosus* in the north Atlantic is associated with the warm, northwards flowing Gulf Stream from 25°N to about 60°N (Figure C2.1a), the western boundary current of the northwest Atlantic. In the late 1970s and early 1980s, when *I. illecebrosus* catches by East Asian squid jiggers peaked, the largest catches were taken off Nova Scotia and Newfoundland in the region of the confluence with the cold, southwards flowing Labrador Current. In the south Atlantic, *Illex argentinus* follows the same pattern, being distributed in the southwards flowing Brazil Current, the western boundary current of the south west Atlantic and the opposing, cold northerly flowing Falkands (Malvinas) Current (Haimovici *et al.*1998). Fishing here is concentrated in relatively cool waters to the north of the Falkland Islands (Malvinas) (Figure C2.2a). Catches are greatest in the vicinity of temperature gradients, probably associated with thermal fronts in the wake of the Falkland Islands (Malvinas) (Waluda *et al.*, 2001a). Here the cool waters of the Falkland (Malvinas) Current, a branching loop of the Antarctic Circumpolar Current, meet the warmer water over the Patagonian Shelf. Two other southern hemisphere species, *Nototodarus sloani* and *Martialia hyadesi* are also associated with high velocity, cool waters - in these cases the current being the Antarctic Circumpolar Current at low latitudes in the vicinity of the sub-Antarctic Front (Figure C2.1d).

The largest ommastrephid species, *Dosidicus gigas*, is an exception to the general rule of association with high velocity western boundary systems, occurring in the weak northwards flow of the cool Peru (Humboldt) Current in the south eastern Pacific (Figure C2.1a). Although this is the highly productive upwelling system that supports the large but variable anchoveta (*Engraulis ringens*) fishery off Peru, *D. gigas* appears to avoid areas of highest primary production, (Nesis 1983) and preys largely on mesopelgic fishes off the edge of the narrow continental shelf of South America.

The loliginidae are a more diverse family than the ommastrephidae. Roper et al. (1984) list 7 genera and thirty one loliginid species of interest to fisheries. They occur in shelf waters from close inshore to the shelf edge in all regions of the world's oceans apart from the Arctic and Antarctic. They do not appear to make large scale migrations and are not dependent on the large scale current systems in the way that the ommastrephids are. They generally occupy productive coastal waters and because of the presence of a corneal membrane covering the eye (hence suborder Myopsida) they are able to tolerate higher sediment loads than the ommastrephidae. The major fisheries for loliginids are found in a diverse range of habitats including the coastal upwelling system of the narrow Californian Shelf, the productive cool waters of the Patagonian Shelf around the Falkland Islands (Malvinas) and the Sunda-Arafura Shelves of Southeast Asia subject to the reversing wind and current system of the annual monsoon.

RELATIONSHIP BETWEEN OCEANOGRAPHIC AND RECRUITMENT VARIABILITIES

Given that the cephalopods are semelparous, short-lived, ecological opportunists, their populations can be expected to be highly variable with recruitment being driven by variability in the physical and ecological environment. It has been suggested that population size in several cephalopod stocks has probably responded in recent years to changes in the biological environment caused by overexploitation of groundfish stocks (Caddy and Rodhouse, 1998). Furthermore Bakun and Csirke (1998) have developed a conceptual model of how variability in the oceanic environment may drive interannual variability, especially in stocks of the ommastrephid species that depend on the major western boundary current systems. They hypothesize that recruitment variability may be driven by: 1) wind effects, with onshore, wind directed Ekman transport being favourable to both onshore transport of surface dwelling larvae and offshore migration of pre-adults in the sub-pycnocline layers; 2) fluctuations in prey abundance; 3) potential "match-mismatch" effects (Cushing, 1975); 4) variations in predation pressure and 5) disease epidemics.

Recent research in the South Atlantic using remotely sensed sea surface temperature (SST) data (Waluda *et al.*, 2001b) has shown that about 55 percent of the variability in recruitment strength in the Falkland Islands (Malvinas) *Illex argentinus* fishery can be explained by changes in the area of surface waters of putative optimum temperature for larval development on the spawning grounds during the spawning season prior to recruitment. The spawning grounds are near the confluence of the Brazil Current and the Falkland (Malvinas)

Current off the shelf edge at the latitude of the mouth of the Plate River (Rio del Plata). These conditions are associated with a decreased area of ocean surface characterized by steep temperature gradients. Sea surface temperatures in the South Atlantic show teleconnections with ENSO events in the Pacific and it is reasonable to conclude that variability in the *Illex argentinus* population is linked indirectly to the ENSO cycle (Waluda *et al.*, 1999).

Similarly, it has been shown that variability in stock size in the *Todarodes pacificus* fishery in the Sea of Japan is driven by changes in optimum SST for larval development (Sakurai *et al.*, 2000). This variability occurs on decadal scales and is apparently linked to decadal climate changes in the north Pacific basin.

Among the loliginids variability in stock size of the squid *Loligo vulgaris vulgaris* in the English Channel has also been correlated with SST variability (Robin and Denis, 1999). In South Africa the *Loligo vulgaris reynaudii* stock is subject to variability apparently driven by storm events during the spawning season which reduce underwater visibility on the spawning grounds and have negative effect on breeding success (Roberts and Sauer 1994, Roberts 1998). Squid have excellent eyesight and have ritualized mating behaviour dependent on being able to read the "body language" of potential mates (Sauer *et al.*, 1997). When poor visibility prevents the essential mating rituals the spawning success of the population is apparently reduced.

Figure C2.3 - Annual nominal catches ('000t) of all Squids (1982-2002)

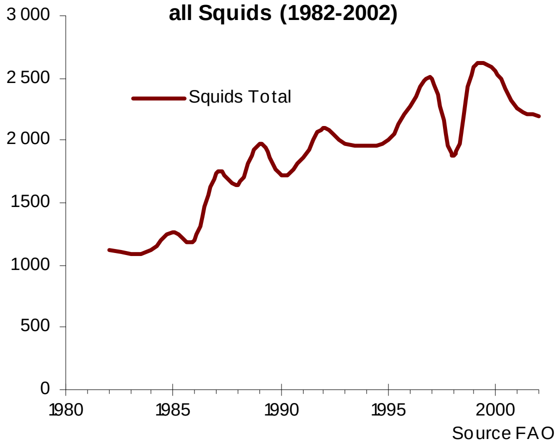
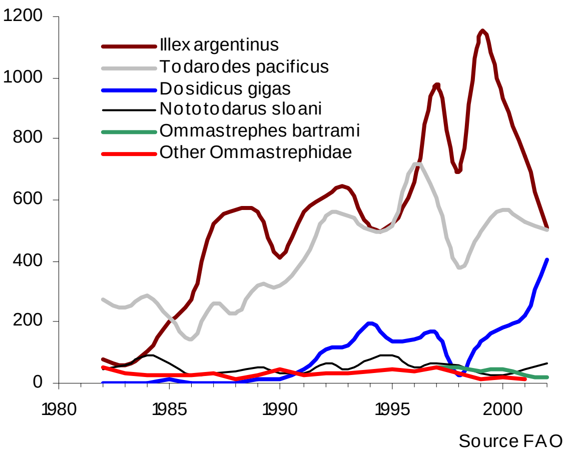


Figure C2.4 - Annual nominal catches ('000t) of Ommastrephidae (1982-2002)



Understanding of the physical forces driving variability in squid populations is at an early stage at the present. But, short lived species, such as squid, provide excellent subjects for analysis of variable recruitment processes because of the semelparous life cycle and hence rapid population response to environmental signals. Their populations are relatively labile compared to the high inertia populations of long-lived fish which are damped by the presence of several year classes living contemporaneously. In the same way that squid populations have been shown to respond to global environmental changes in marine systems driven by overexploitation of fish stocks (Caddy and Rodhouse, 1998), they may also be sensitive biological indicators of global environmental changes in the physical environment of the oceans.

STATE OF EXPLOITATION AND PRODUCTION POTENTIAL

In the decades 1982-2002 squid catches have ranged between 1.1 and 2.6 million tonnes per year (Figure C2.3). Catches of identified squid are dominated by ommastrephids, and mostly by *Illex argentinus* and *Todarodes pacificus*, but between 1991 and 2002 *Dosidicus gigas* made a substantial contribution (Figure C2.4) reaching about 406 356t in 2002. Among the loliginids *Loligo* spp. have consistently contributed nearly 230,000 tonnes per year. From 1985 to 1997 *Loligo gahi* has dominated the identified catch by a considerable margin (Figure C2.5), but in most years since catches of *L. opalescens* have been consistently higher than of *L. gahi*. Records of unidentified squid have declined by a factor of 2.5 from 1989 to 1993, stabilizing at about 300 000t since. (Figure C2.6). Although there has been considerable variability in catches of all species, and in the total squid catch, over the last decade there does not appear to be any consistent trend. It seems likely that the species currently exploited, which have continental shelf or near shelf distributions, are all fully exploited, with the exception of *Ommastrephes bartrami*, and variations in catch rate are driven by environmental variability (see above).

On the other hand there is evidence that stocks of the oceanic squids could make a substantial contribution to increased catches of cephalopods. *Ommastrephes bartrami* is only exploited systematically in the northwest Pacific although its distribution is global in the subtropical and temperate regions. Other ommastrephids, particularly *Sthenoteuthis oualaniensis* in the Indo-Pacific (Yatsu *et al.*, 1998) and *Todarodes filippovae* and *Martialia hyadesi* in the Southern Ocean (Rodhouse, 1997, 1998b) have also been identified as having potential for supporting substantial fisheries. Squid from other families also have potential which is only just being developed. The gonatid *Berryteuthis magister* in high latitude north Pacific waters and *Thysanoteuthis rhombus* in tropical/subtropical waters of all the oceans are lightly exploited and do not appear in FAO data but could probably stand increases in exploitation rate and both have desirable qualities for human consumption (Nesis, 1998; Yatsu, 1998).

Estimates of cephalopod predation by global populations of higher predators, especially sperm whales, have led to very high estimates of the potential for fisheries. Data from the Soviet years of deep ocean resource exploration based on sampling by nets provide more modest estimates of fishery potential but still suggest that cephalopods, especially squid, could support catches of up to 5-10 million tonnes per year (Nigmatullin, 1990). Increases of this order would involve exploiting families such as the Histioteuthidae and Octopoteuthidae for which no markets currently exist but which may be palatable for human consumption.

Exploiting the deep ocean squid, which themselves probably feed in the poorly understood mesopelagic community, would pose serious management problems given the current poor state of knowledge of these ecosystems and the fact that these systems largely lie outside the EEZs of the nation states.

GIANT SQUIDS

As well as being the subject of myth and legend giant squid appear from time to time on the ocean surface, stranded on the shore or caught by accident. The largest known squids belong to the genus *Architeuthis*, and they occur throughout the world's oceans except perhaps in the polar regions. There may be several species but the taxonomy is poorly known. Although accounts of truly enormous squid exist there are few well documented records of specimens of *Architeuthis* exceeding about 2 m mantle length. As well as *Architeuthis* there are also a number of other squid species that reach large sizes (>1 m mantle length) including the Antarctic cranchiid, *Mesonychoteuthis hamiltoni*, the Antarctic onychoteuthid *Kondakovia longimana*, the Pacific onychoteuthid *Moroteuthis robusta* and the widespread *Taningia danae*. The ommastrephid

Figure C2.5 - Annual nominal catches ('000t) of Loliginidae (1982-2002)

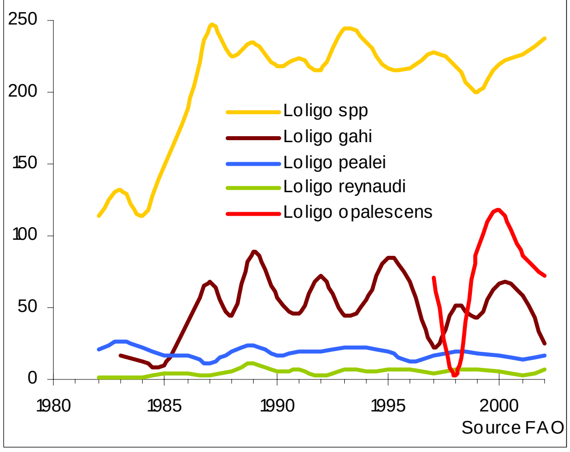
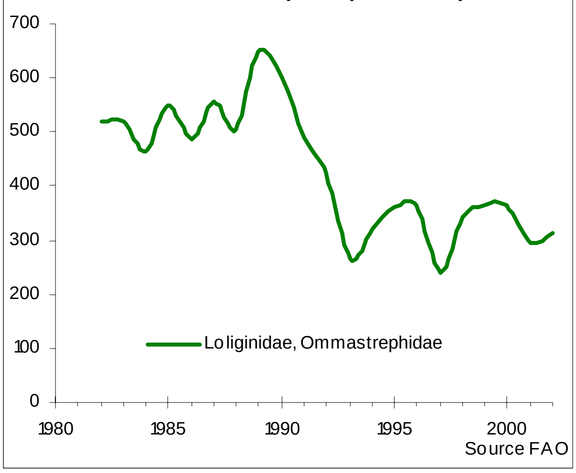


Figure C2.6 - Annual nominal catches ('000t) of non identified squids (1982-2002)



Dosidicus gigas, dealt with elsewhere in this chapter, grows to about 1 m mantle length.

Apart from *D. gigas*, these very large squids are unlikely to ever be of interest to fisheries. They are too rare to be exploited and some species, notably *Architeuthis*, are ammoniacal and hence distasteful to the human palate. There are however ways in which they may interact with fisheries. Several *Architeuthis* have been caught over the years in the orange roughy fishery off New Zealand and there is also some evidence that growing numbers are becoming stranded on shores in the region. Could it be that increasing numbers of giant squid are being discarded from trawlers and, because they are ammoniacal and hence buoyant, they are floating ashore? Elsewhere the very large squid *Mesonychteuthis hamiltoni* is known to be a common species in the diet of sperm whales at South Georgia (Clarke, 1980) and so the species is presumably present in substantial numbers in the deep waters off the shelf in this part of the Scotia Sea. The area is now the location of a deepwater fishery for the Patagonian toothfish, *Dissostichus eleginoides*. Is *Dissostichus* an important prey species for *Mesonychteuthis*? The armament of hooks on the arms and tentacles certainly indicate that this squid is adapted for preying on large prey of some sort.

DISCUSSION

Because the world squid stocks currently being fished over the continental shelves and near-shelf regions of the oceans are likely to be close to fully exploited, variability in recruitment strength and abundance is probably largely environmentally driven. It is questionable to what extent fishing effort might drive changes in recruitment and in this respect the squids could perhaps be compared with insect plague pests such as the desert locust. Populations of these species are difficult to control and respond to environmental variability and change, on scales generally far greater than can be achieved by human intervention (Skaf *et al.*, 1990; Zick, 1990).

Environmentally driven variability in abundance has caused large shifts in effort between the major ommastrephid stocks which do not seem to cycle synchronously. When catches have been generally low worldwide this has led to attempts to locate new fisheries such as in the mid 1990s when *Illex argentinus* abundance was particularly low on the Patagonian Shelf and exploratory fishing for *Martialia hyadesi* took place in CCAMLR waters south of the Antarctic Polar Front. This led to recommendations for precautionary measures to protect dependent species of higher predators (Rodhouse, 1997). Future changes in abundance of the currently exploited species are likely to increase the likelihood of development of new fisheries and extend exploitation offshore of the shelf regions. This will create several new challenges for management, both for ecological and socioeconomic reasons. The dynamics of mesopelagic systems are poorly understood and squid may be keystone species in some areas such as the Antarctic Polar Frontal Zone (Rodhouse and White, 1995) and possibly elsewhere such as the Indian Ocean. Some populations may lie entirely outside EEZs of nation states.

Although there are unexploited stocks and the variability in abundance of exploited stocks may not be primarily driven by the effects of exploitation there is every reason to apply strict precautionary principles to all fisheries given their potential for production of high quality protein for human consumption and also the role of squid populations in marine food webs. Squid stocks present new challenges for fisheries management but the apparent relationship between variability in abundance and environmental variability means that these short-lived species may prove to be more predictable and amenable to fishery forecasting than the longer lived species exploited by the traditional fisheries.

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