Norway lobster (*Nephrops norvegicus*)

MarLIN – Marine Life Information Network
Biology and Sensitivity Key Information Review

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Nephrops norvegicus.
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See online review for distribution map

Distribution data supplied by the Ocean Biogeographic Information System (OBIS). To interrogate UK data visit the NBN Atlas.

Researched by	Marisa Sabatini & Jacqueline Hill	**Refereed by**	Dr Sue Marrs
Authority	(Linnaeus, 1758)		
Other common names	-	**Synonyms**	-

Summary

Description

Nephrops norvegicus is a small lobster, pale orange in colour. It grows to a maximum total length of 25 cm (including the tail and clawed legs), although individuals are normally between 18-20 cm. The head and thorax have a non-segmented cover (the carapace) while the long abdomen is clearly segmented with a broad fan-like tail. The first 3 pairs of legs bear claws. The first pair of legs are very elongated with longitudinal, spiny ridges. There are 2 pairs of antennae, the second pair much longer and thinner than the first. The eyes are large, black, and moveable.

Recorded distribution in Britain and Ireland

Common around most British coasts but not apparently recorded for the English Channel, the Bristol Channel or the Western Approaches. Populations also exist to the north east of Scotland on the Fladen Ground.

Global distribution

Nephrops norvegicus is widely distributed on muddy substrata throughout the north-east Atlantic from Iceland in the north to Morocco in the south. The species is found in the Mediterranean and is abundant in the Adriatic.

Habitat

Found sublittorally in soft sediment, commonly at depths of between 200-800 m, although considerable populations exist at depths <200 m, for example the Clyde Sea. There are many records of *Nephrops norvegicus* populations <20 m in Scottish Sea Lochs. They live in shallow burrows and are common on grounds with fine cohesive mud which is stable enough to support their unlined burrows.

Depth range

20-800m

Identifying features

- The head and thorax are fused and covered with a carapace that has short spines at its anterior end.
- The segments of the long abdomen are grooved transversely.
- The first 3 pairs of limbs possess claws, the first pair being very long and slender with spiny ridges.
- The large, black, kidney-shaped eyes are broader than the eyestalks.
- The terminal appendages are flattened and expanded, forming a tail-fan.

Additional information

Also known as the Dublin Bay prawn, scampi and langoustine.

Listed by

Further information sources

Search on:

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Biology review

Taxonomy

Order	Decapoda	Crabs, shrimps, prawns, crayfish and lobsters
Family	Nephropidae	
Genus	Nephrops	
Authority	(Linnaeus, 1758)	
Recent Synonyms	-	

Biology

Typical abundance	Low density
Male size range	25cm
Male size at maturity	Carapace length 26mm
Female size range	Carapace length 23mm
Female size at maturity	
Growth form	Articulate
Growth rate	See additional information
Body flexibility	Low (10-45 degrees)
Mobility	
Characteristic feeding method	Predator, Scavenger
Diet/food source	
Typically feeds on	*Nephrops* is an opportunistic predator feeding on crustaceans, molluscs and to a lesser extent polychaetes and echinoderms.
Sociability	
Environmental position	Demersal
Dependency	No text entered.
Supports	See additional information for associated species.
Is the species harmful?	No There are large fisheries for the edible *Nephrops norvegicus*.

Biology information

Typical abundance

Early fisheries investigations revealed marked geographical variability in the abundance and size of individual *Nephrops* in trawls (Cole, 1965; Thomas, 1965a). In Loch Torridon, Chapman & Rice (1971) reported densities of *Nephrops* of 1 ind. /7.8 m^2 in 1968, whereas in 1969 it was 1 ind. /5.5 m^2. The density of two populations of *Nephrops norvegicus* was reported for two sites on the west coast of Scotland in the Clyde and the Sound of Jura (Thomas, 1965a). In the Sound of Jura the population of *Nephrops norvegicus* consisted mainly of small *Nephrops* below 30 mm carapace length (CL) at an estimated density of approximately 1 ind. /m^2. The density of *Nephrops* in the Clyde was much lower (approximately 1 ind. /4m^2). Reasons for such variability in density, size and growth rates, are listed below.

- Physical factors such as the nature of the substratum and its suitability for burrowing (Bailey & Chapman, 1983).
- A change in climate could lead to variable recruitment through changes in mortality rates of early life stages, for example, differences in sea temperature and wind induced wave action might affect the survival of larval *Nephrops* either directly or by regulating food supply.
- Patchy settlement of larvae (Bailey & Chapman, 1983).
- Different levels of fishing effort / intensity (Bailey & Chapman, 1983). However variations in fishing effort may only be partly responsible for variations in abundance (Tully & Hillis, 1995) as differences were observed in some areas before the pressure of significant fisheries (Thomas, 1965a).

Mobility
Although *Nephrops norvegicus* is capable of swimming, it is a crawler more than it is a swimmer.

Sociability
Although *Nephrops norvegicus* are essentially solitary animals, multiple occupancy can occur in the burrows (Marrs, pers. comm.).

Growth
Like other crustaceans, *Nephrops norvegicus* must moult, shedding their hard exoskeleton, to grow. *Nephrops* contain no annually marked structures, such as the otoliths found in fish, so the estimation of growth rates, age and maximum age has proved to be particularly difficult in this species.

Growth (and fecundity) in *Nephrops norvegicus* are known to vary geographically and have been shown to be negatively correlated with burrow density (Tuck *et al*., 1997). Thus, growth rate appears to be density-dependent, and is also thought to be related to food availability. For example, Tuck *et al.* (1997) found growth was correlated with infaunal biomass. This suggests that nutritional stress occurs in populations with slower growing individuals. Growth of *Nephrops* may also be influenced at high densities through social behaviour changes (Cobb *et al*., 1982). Parslow-Williams *et al.* (2001) found evidence that nutritional limitation was occurring in *Nephrops norvegicus* from a site in the Clyde Sea with a high population density, compared to another site with a low density of individuals.

Information on the growth rate of lobsters is very limited (Thomas,1965c). Despite being one of the most studied decapods, the area of age and growth estimation is still one for which there is no standard methodology (Castro, 1995). A number of studies have estimated the growth rate of *Nephrops norvegicus*:

- Thomas (1960; cited in Thomas, 1965c) estimated an average growth rate of 5.7% for males and 6.2% for female *Nephrops* based on eight moults that occurred in an aquarium;
- Thomas (1965c) estimated an average moult increase in carapace length of 7.1% for male *Nephrops*. Thomas (1965c) suggested that increases in length decreased as male *Nephrops* grew but this was not observed in female *Nephrops* (Thomas, 1965c);
- whereas, Höglund (1942; cited in Farmer, 1975) stated that individuals 10-15 cm in total length grew by 4 mm per moult;
- however, under natural conditions Barnes & Bagenal (1951) concluded that *Nephrops*

moult at least once a year but gave no data for the rates of growth.

Thus mature females about 23 mm CL and mature male *Nephrops* about 26 mm CL are around 2-3 years old in Irish waters (Marine Institute, 2001). The minimum landing size for *Nephrops* in Irish waters is >70 mm (total size) and >20 mm CL therefore individuals would range from 1.5 to 3 years old (Marine Institute, 2003).

Size
Nephrops norvegicus grows to a maximum total length of 25 cm (including the tail, carapace and clawed legs), although is normally between 18-20 cm (Fish & Fish, 1996). The generally recognized standard measurement for *Nephrops norvegicus* is carapace length (CL). The maximum recorded CL of *Nephrops* was 80 mm (Marine Institute, 2001). However, in recent years *Nephrops* with carapaces larger than 60 mm are rare (Marine Institute, 2001).

Environmental position
Nephrops norvegicus construct extensive shallow and branching burrows in soft sediments such as fine or silty mud at depths of 20-800 m. Burrows may be up to 10 cm in diameter, over a metre long and penetrate the sediment to a depth of 20-30 cm (Rice & Chapman, 1981). *Nephrops norvegicus* usually remain within their burrows by day and emerge at sunset to forage during the night but in deeper water this activity is reversed and individuals are more active by day (Chapman & Rice, 1971). In laboratory conditions, large males are less inclined to make burrows than females and small males, which may account for the higher proportion of large males that are caught in small catches (Andersen, 1962; cited in Farmer, 1974a, b).

Feeding
Representatives of most invertebrate phyla have been found in the foregut of *Nephrops norvegicus*. Most studies show that *Nephrops norvegicus* feeds primarily on crustaceans but also molluscs and to a lesser extent polychaetes and echinoderms (Parslow-Williams *et al*., 2002). Although a crustacean diet has a lower energy content that some of the other faunal groups, they do provide a source of essential minerals such as calcium (Ennis, 1973). Any differences in diet appear to be due more to changes in prey abundance than to prey preference (Parslow-Williams *et al*., 2002) indicating that the species is an opportunistic predator. The size range of prey eaten by *Nephrops norvegicus* was investigated by Thomas & Davidson (1962) who found that the minimum food particle size ingested was 1 mm, and the maximum for hard particles such as bits of shells was 5 mm. They also found that larger soft bodied organisms like polychaetes could also be ingested if taken in lengthways.

Loo *et al.* (1993) suggested that *Nephrops* could filter feed, allowing *Nephrops* to extend the size range of its food items. Farmer (1974d) reported that the expodites of the various mouth parts of *Nephrops* in most cases bore plumose setae, which when waved continuously produced water currents. Farmer (1974d) suggested that this behaviour was for cleaning suspended food particles away from the mouth. During another study *Nephrops norvegicus* were kept in small tanks containing fluorescently-marked food particles comprised of the brine shrimp *Artemia salina*. These food particles were found in the gills, stomach and intestine of *Nephrops*. Loo *et al.* (1993) suggested that this provided effective evidence of filter-feeding. However, this feeding may be more 'micro-raptorial' rather than strictly filter-feeding (Parslow-Williams *et al*., 2002). During periods of food scarcity, females spend a prolonged period in their burrows and suspension feeding is thought to occur (Loo *et al*., 1993).

Diel variation in feeding rates have been observed indirectly in *Nephrops norvegicus*. Catch rates of lobsters has always varied depending on the time of day with peak catches at dawn and dusk. Only those lobsters that have emerged from their burrows are caught in the trawls and, since it is assumed that they emerge mostly to forage (Chapman, 1980), catch patterns indicate diel patterns of feeding behaviour. The stomach contents of animals sampled by Parslow-Williams *et al.*, (2002) indicated a feeding peak around dawn but not around dusk, although animals were out of their burrows. Sampling is complicated by the fact that satiated animals will return to their burrows and be unavailable for capture.

Supports which species

The rare British Fries' goby *Lesueurigobius friesii* shares the burrows of *Nephrops norvegicus*. The minute Cycliophoran *Symbion pandora* is a unique sessile animal less than 1 mm long that was found in the mouth parts of *Nephrops* collected in Denmark and the first of its kind to be described. *Symbion pandora* has a basal attachment disc and an anterior ciliated food gathering organ (Conway Morris, 1995).

Barnes & Bagenal (1951) recorded large numbers of *Balanus crenatus* living on *Nephrops norvegicus* in the Clyde area. The following species have been observed on specimens of *Nephrops norvegicus* from the Irish Sea: *Triticella koreni*, *Balanus crenatus*, *Electra pilosa*, *Eudendrium capillare*, *Sabella pavonina*, *Serpula vermicularis* and a forminiferan probably *Cyclogyra* sp. (Farmer, 1972; cited in Farmer, 1975). The polychaete *Histriobdella homari* has been observed on the pleopods of two *Nephrops norvegicus* from the Irish Sea and Clyde Sea (Briggs *et al.*, 1997).

Predators

Nephrops norvegicus is preyed upon by numerous white fish some of which are listed below.

- In Scotland the stomach contents of cod was examined. Results showed that 80% of cod had *Nephrops norvegicus* amongst their stomach contents (Thomas, 1965b).
- *Nephrops* was also found in 52% of the thornback ray *Raja clavata* that were sampled (Thomas 1965b).
- In the Clyde, *Nephrops* was found in 51% of the small spotted catshark (dogfish) *Scyliorhinus canicula* that were sampled (Gordon & De Silva, 1980).

Habitat preferences

Physiographic preferences	Offshore seabed
Biological zone preferences	Lower circalittoral, Lower infralittoral, Upper circalittoral
Substratum / habitat preferences	Mud, Muddy sand, Sandy mud
Tidal strength preferences	Very Weak (negligible), Weak < 1 knot (<0.5 m/sec.)
Wave exposure preferences	Extremely sheltered, Sheltered, Ultra sheltered, Very sheltered
Salinity preferences	Full (30-40 psu)
Depth range	20-800m
Other preferences	No text entered
Migration Pattern	Non-migratory / resident

Habitat Information

Migration

Tagging experiments have shown that *Nephrops norvegicus* do not migrate large distances (Marine Institute, 2001). In laboratory mesocosms individuals displayed very territorial behaviour, aggressively defending their burrows (Marine Institute, 2001).

Life history

Adult characteristics

Reproductive type	Gonochoristic (dioecious)
Reproductive frequency	Annual episodic
Fecundity (number of eggs)	See additional information
Generation time	See additional information
Age at maturity	See additional information
Season	Summer - Autumn
Life span	5-10 years

Larval characteristics

Larval/propagule type	-
Larval/juvenile development	Planktotrophic
Duration of larval stage	-
Larval dispersal potential	See additional information
Larval settlement period	Insufficient information

Life history information

Longevity

In the Irish Sea, *Nephrops norvegicus* individuals are not thought to live more than 8 or 9 years. In other areas, such as the Porcupine Bank, they may survive over 15 years (Marine Institute, 2001).

Age and size at sexual maturity

Tuck *et al.* (2000) found that, in the Firth of Clyde, age at the onset of sexual maturity was relatively constant between different study sites but varied between sexes. In general, the age at onset of maturity was 4 - 4.5 years in males and 3 - 3.5 years in females. The size (carapace length) at sexual maturity was found to be positively correlated to asymptotic length and negatively correlated to adult density and ranged from 21 - 34 mm in females and 29 - 46 mm in males (Tuck *et al.*, 2000). The authors suggested that there may exist a minimum size threshold under which males may be too small to reproduce.

Reproduction

A full description of reproduction can be found in Jorgensen (1925). Most *Nephrops* stocks in British waters have an annual reproductive cycle (Marine Institute, 2003). Sexually mature *Nephrops* of both sexes moult towards the end of spring and into the summer. Mating takes place while the female is still 'soft' (Farmer, 1975) directly after the female has moulted and before the hardening of the new exoskeleton (Marrs, pers. comm.). Once fertilized the eggs are then carried on the females abdomen for 8-9 months, during which time the females tend to remain in their burrows.

Egg loss
Egg loss is common in crabs, lobsters, shrimps and prawns (Tuck *et al.*, 2000). Reasons for egg loss include failure of the eggs to attach to the pleopods at oviposition, predation, and loss of eggs from the pleopods during the long developmental period (Kuris, 1991). In the Moray Firth a comparison between females with recently spawned eggs and females where the eggs were about to hatch suggested that 32 - 51 % of the eggs are lost during development and that this proportion is larger in smaller individuals (Chapman & Ballantyne, 1980).

Ovary resorption
Ovary resorption has been attributed to a number of factors in other decapods, including lack of fertilization, starvation, hormone deprivation and incorrect photoperiod (Aiken & Waddy, 1980; Sastry, 1983; Adiyodi & Subramoniam, 1983). The timing of ovary resorption after the spawning period, suggests that it occurs in females whose ovaries were not sufficiently developed to spawn at the suitable time. Whatever the cause, resorption is thought to be a mechanism for conserving or recycling nutrients.

Fecundity
The fecundity of *Nephrops norvegicus* is variable and different methods have been used to estimate *Nephrops* fecundity (Abelló & Sardá, 1982) for example:

- Eiriksson (1970) estimated the fecundity of *Nephrops norvegicus* from eggs that were carried on the female abdomen and from the oocytes of mature ovaries. It was also reported (where this method had been used) that the number of eggs carried on the abdomen by the female is lower than the number of oocytes in the ovaries. In an average size female (35 mm CL), it was estimated that around 1,500 eggs were present in the ovaries compared to the 1,000 eggs attached to the pleopods of recently 'berried' females (Eiriksson, 1970). 'Berried' females are those females that carry their eggs on their abdomens.
- Farmer (1974a) and Chapman & Ballantyne (1980) estimated the fecundity of *Nephrops norvegicus* from eggs carried on the abdomen by females.
- Thomas (1964 cited in Abelló & Sardá, 1982) estimated the fecundity from the oocytes of mature ovaries.

In all investigations, the number of eggs was found to be directly proportional to the size of the female. Farmer (1974c) suggested that it was more accurate to estimate the fecundity from the eggs that are carried by the females because very often the oocytes are reabsorbed during the process of sexual maturation. However, it must also be noted that the number of eggs on the abdomen diminishes during incubation mainly due to predation (Morizur, 1979; cited in Abelló & Sardá, 1982).

Egg hatching
During incubation it is generally thought that ovigerous females tend to remain within their burrows (Farmer, 1975). Females *Nephrops* come out of their burrows to allow their eggs to hatch and the larvae to escape from April -June (Farmer, 1974c).

Dispersal potential

Hillis (1968) reported that larvae of *Nephrops norvegicus* in the Irish Sea were dispersed by the local hydrographical conditions but they generally remain in the hatching areas of adults without being transported long distances. The main concentration of larvae in the Irish Sea were found in and near deep water. Hillis (1968) also suggested that there was a more easterly distribution of older larvae.

In the Irish Sea a gyre (circulating water mass) forms during the spring and summer, which coincides with the period when *Nephrops* larvae are present in the plankton. The gyre retained the larvae in the vicinity of the parent population, rather than being carried off by currents into areas of unsuitable substratum (Hill *et al.*, 1996, 1997). This phenomenon has also been observed in the Adriatic and Clyde Sea (Marrs, pers. comm.). In addition to gyres, muddy sediments have also been associated with high densities of *Nephrops norvegicus* (Marrs, pers. comm.).

Sensitivity review

This MarLIN sensitivity assessment has been superseded by the MarESA approach to sensitivity assessment. MarLIN assessments used an approach that has now been modified to reflect the most recent conservation imperatives and terminology and are due to be updated by 2016/17.

Physical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Substratum Loss	High	Moderate	Moderate	High

Although *Nephrops norvegicus* is mobile, if disturbed it is likely to seek refuge within a burrow within the substratum and so are also likely to be removed. Therefore intolerance has been assessed as high. This species does not reach sexual maturity for several years and recovery has been assessed to be moderate.

Smothering	Tolerant	Not relevant	Not sensitive	High

Nephrops norvegicus lives in burrows in sandy mud habitats. Its burrows can be large, consisting of tunnels over a metre long by 10 cm in diameter and penetrate 20-30 cm into the sediment (Rice & Chapman, 1981). Burrows vary in complexity from a simple tunnel to complex systems as juveniles construct burrows off those of adults (Tuck *et al*., 1994). Therefore, it is unlikely to be adversely affected by smothering by 5 cm of sediment (see benchmark). *Nephrops* has been assessed as tolerant at the benchmark level. However, the species may be sensitive to smothering by other materials.

Increase in suspended sediment	Tolerant	Not relevant	Not sensitive	Low

Nephrops norvegicus is probably tolerant of changes in suspended sediment. *Nephrops* are not dependent on increased suspended sediment for food availability as *Nephrops* is a carnivore and feeds by predation and scavenging. The species is also able to move to more suitable conditions if necessary. Therefore *Nephrops* has been assessed as tolerant to this factor.

Decrease in suspended sediment	Tolerant	Not relevant	Not sensitive	Low

This species is probably tolerant of decreases in suspended sediment as it feeds by predation and scavenging and is not reliant on food uptake through the sediments however, its prey may be affected. Therefore an assessment of tolerant is given.

Dessication	Not relevant	Not relevant	Not relevant	High

Nephrops norvegicus is a deep water species so a change in the level of desiccation is not relevant.

Increase in emergence regime	Not relevant	Not relevant	Not relevant	High

Nephrops norvegicus is a deep water species so a change in the amount of emergence is not relevant.

Decrease in emergence regime	Not relevant	Not relevant	Not relevant	High

Nephrops norvegicus is a sub-tidal species so a change in the amount of emergence is not relevant.

Increase in water flow rate	Intermediate	High	Low	Moderate

Following an increase in water flow rate only the surface sediments are likely to be winnowed away in a unidirectional flow. However, the settlement of the planktonic larvae of *Nephrops norvegicus* may be inhibited owing to re-suspension along with particulate matter. Consequently the viability of the population may be reduced. On return to prior conditions, specimens of the characterizing species will have remained and are likely to repopulate via successful larval settlement. Therefore intolerance has been assessed as intermediate with a high recoverability.

Decrease in water flow rate	Tolerant	Not relevant	Not sensitive	Low

Nephrops norvegicus is not likely to be directly intolerant of a decrease in water flow rate. Sediments may become muddier owing to increased settlement of particulate matter. The fine muds inhabited by *Nephrops* are characteristic of low energy, sheltered environments such as deep sea lochs. Therefore, tolerant has been recorded.

Increase in temperature	Low	Very high	Very Low	Very low

Nephrops norvegicus is found in the Mediterranean and is also abundant in the Adriatic showing that it can adapt to increases in temperatures. Bottom temperatures from *Nephrops* inhabited areas range from 7-13°C in the Irish Sea and 10-15°C in the Adriatic (Farmer, 1972a and Karlovac, 1953; cited in Farmer, 1975). However, the maximum and minimum temperatures limiting *Nephrops norvegicus* in its natural environment are not known (Farmer, 1975). Temperature may cause considerable variation in the development rate of planktonic *Nephrops* larvae (Dickey-Collas *et al*., 2000b). An increase in temperatures over long periods may increase egg development and halve incubation time. Chapman (1984) noted a correlation between see surface temperature and *Nephrops* landings 3-6 years later, which suggested an effect on recruitment. For most deep burrowing species like *Nephrops norvegicus* temperature changes in the water column are likely to be buffered to some extent by the sediment and may not be affected. Therefore, *Nephrops norvegicus* may have a low intolerance with a very high recoverability.

Decrease in temperature	Low	Very high	Very Low	Low

Nephrops norvegicus is found throughout the British Isles to Icelandic waters. During the very cold winter of 1962-63 a few dead *Nephrops norvegicus* were caught in the North Sea although the majority were caught alive (Crisp, 1964). It has also been suggested that below 5 °C the activity of *Nephrops norvegicus* ceases (Jensen, 1965). Therefore, a decrease in temperature at the benchmark level is unlikely to cause mortality of this species but it can slow down egg development and increase egg incubation time. This may increase the risk of egg predation or abrasion. Therefore intolerance has been assessed as low with a very high recoverability.

Increase in turbidity	Tolerant*	Not relevant	Not sensitive*	Moderate

An increase in turbidity would decrease the availability of light, which may benefit *Nephrops norvegicus* as it avoids areas of bright light (Loew, 1976) and prefer the dark. It has been suggested that there is a relationship between the locomotor activity of *Nephrops norvegicus* and environmental illumination (Aréchiga & Atkinson, 1975). Aréchiga & Atkinson (1975) reported that the burrowing activity of *Nephrops norvegicus* is restricted to an optimum range of light intensity from about 10,000 to 10 m-c (meter/candles) (equivalent to approximately, 10% to 0.001% of natural daylight). Therefore in shallow waters *Nephrops norvegicus* is active by night and in deeper water by day, at intermediate depths activity will most likely occur at dusk and dawn (Simpson, 1965).
The compound eye of *Nephrops norvegicus* is well adapted to low levels of light at the sea bed and may assist *Nephrops* in periods of increased turbidity. Therefore an increase in turbidity would increase the activity of *Nephrops norvegicus* and allow colonization of shallower habitats. Therefore increased turbidity may benefit this species and tolerant* has been given.

Decrease in turbidity Low Immediate Not sensitive Moderate

The circadian (daily) rhythm of locomotor activity shown by *Nephrops norvegicus*, with peaks of activity at dawn and dusk, is endogenously (internally) controlled. However, exogenous effects of light are thought to be important in modulating such activity (Aréchiga *et al.*, 1980). For example, in shallow waters *Nephrops norvegicus* is active by night and in deeper water by day. At intermediate depths, activity will most likely occur at dusk and dawn (Simpson, 1965; Farmer, 1974a). However, Hillis (1971) found that at depths greater than 80 m tides exerted a stronger influence on activity than light intensity.

Nephrops avoids bright light and exposure to high intensities causes blindness (Loew, 1976). An increase in light resulting from decreased turbidity may affect the depth at which the species is present or more likely that *Nephrops* will only feed at night.

The sensitivity of *Nephrops* to light also decreases with increasing size (Anderson, 1962: cited in Figueiredo & Thomas, 1967). Females carrying external eggs may be more sensitive than normal to light, although no information on the effects could be found (Figueiredo & Thomas, 1967). Therefore, a decrease in turbidity may increase light illumination that affects the diurnal activity of *Nephrops norvegicus*. Therefore intolerance has been assessed as low with an immediate recoverability.

Increase in wave exposure Not relevant Not relevant Not relevant Moderate

Nephrops populations develop in sheltered areas and the depths at which they are found will be rarely affected by wave disturbance. Although the water movement induced by wave action in a force 8 gale can be 'felt' at 80 m depth (Hiscock, 1983), at the benchmark level, *Nephrops norvegicus* is unlikely to be affected and increased wave exposure is considered to be irrelevant.

Decrease in wave exposure Not relevant Not relevant Not relevant Moderate

The depths at which *Nephrops* are found means that the community is already rarely affected by wave disturbance. A decrease in wave exposure is not relevant.

Noise Not relevant

No information was found concerning the effects of noise on *Nephrops norvegicus* and insufficient information was available to assess sensitivity.

Visual Presence Low Very high Very Low High

Nephrops norvegicus is found in deep water where available light is very low. However *Nephrops norvegicus* are likely to respond to shading and the presence of divers and predators by retreating into their burrows. Therefore intolerance has been assessed as low with an a very high recoverability.

Abrasion & physical disturbance Intermediate High Low Moderate

Abrasion and disturbance from dredges and trawls is likely to crush some individuals. During an experimental study it was reported that trawl caught females had fewer eggs on average than creel caught females from the same area and that it was likely that the eggs may be lost to abrasion (Chapman & Ballantyne, 1980). The proportion of eggs lost to abrasion ranged from 11-22 % in samples taken from the Clyde and West of Kintyre (Chapman & Ballantyne, 1980). Burrows are also likely to be damaged by e.g. trawling. However, Marrs *et al.* (1998) reported that burrows were re-established within 2 days providing that the occupant had remained unharmed (Marrs *et al.*, 1998). Overall, intolerance has been assessed as intermediate with a high recoverability.

Displacement	Low	Very high	Very Low	High

Nephrops norvegicus is tolerant of displacement, such as that caused by a passing trawl that does not kill the species but throws it into suspension, because it can reburrow into suitable substrata. Following displacement to suitable sediments *Nephrops norvegicus* are likely to commence burrowing immediately provided that individuals are not damaged. *Nephrops norvegicus* will be exposed to predators for a short time during such events so intolerance is assessed to be low with an very high recoverability.

Chemical Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Synthetic compound contamination				Not relevant

Due to insufficient information intolerance could not be assessed.

Heavy metal contamination	Intermediate	High	Low	Moderate

In general decapod crustaceans such as *Nephrops norvegicus* tolerate concentrations of heavy metals in their tissues because they are able to regulate the levels which are present in their cells by holding excess metal ions in non toxic forms. This is achieved by binding to blood proteins, metallothioneins, compartmentalization with lysosomes or the formation of insoluble granules (Holmes *et al.*, 1999). Little is known about the effects of heavy metals such as manganese and cobalt in the tissues of crustaceans (Holmes *et al.*, 1999).
However, Baden *et al.* (1994) suggested that *Nephrops* was one of the benthic species most likely to be affected by increased metal concentrations and high concentration of manganese was found in the tissues of specimens living in hypoxic areas (Baden *et al.*, 1994). Baden & Neil (1998) reported that there was no significant reduction in tail flip velocity or flexion force but there was a significant reduction in the maximum post-flip extension force in specimens of *Nephrops* that were exposed to manganese (Baden & Neil, 1998).

In experimental studies, specimens of *Nephrops norvegicus* were exposed to methyl-mercury (MeHg), mercury (Hg), copper (Cu) and cadmium (Cd) in solution. Results showed that at sub-lethal metal concentrations, the highest concentrations of the metals were recorded in the gill tissues, the hepatopancreas, the carapace, the tail muscles and the ovaries (Canli & Furness, 1993). Results also showed the following:

- 100% mortality after three days when exposed to 100 µg MeHg/l;
  100% mortality after 8 days when exposed to 100 µg Hg/l;

- 85% mortality after 30 days when exposed to 1mg Cd/l, and
- 100% mortality after 14 days when exposed to 100 µg Cu/l (Canli & Furness, 1993).

Therefore, intolerance has been assessed as intermediate with a moderate recoverability level.

Hydrocarbon contamination				Not relevant

No information on the effects of hydrocarbons on *Nephrops norvegicus* could be found therefore intolerance cannot be assessed. However, the *Braer* oil spill released 85,000 tonnes of light crude oil around the Shetland Isles in 1993 and sampling programmes found specimens of *Nephrops norvegicus* tainted with polyaromatic hydrocarbons (PAHs). An exclusion zone was extended shortly after the oil spill as a precautionary measure to prevent contaminated shellfish from reaching the market. Approximately 15 months later the removal of the exclusion order occurred for all crustaceans except *Nephrops norvegicus* as concentration of

PAHs in its tissues was still too high. The removal of the exclusion order for *Nephrops norvegicus* occurred another 6 months later (Topping *et al*., 1997).

Radionuclide contamination Low

Investigations of bioturbation in radionuclide contaminated sediments on the Irish Sea floor near the Sellafield nuclear reprocessing plant found *Nephrops norvegicus* to be present (Hughes & Atkinson, 1997). Even though *Nephrops norvegicus* can be found in areas where radionuclides were present, no information on their effects on this species could be found. Therefore intolerance cannot be assessed.

Changes in nutrient levels Tolerant | Not relevant | Not sensitive | Very low

Hughes (1998b) suggested that burrowing megafauna often flourish in areas where the sediments are naturally rich in organic matter, such as sea lochs. For example, *Nephrops norvegicus* was present in high densities in Loch Sween, Scotland where the organic content was about 5% and as high as 9% in some patches (Atkinson, 1989). Hughes (1998b) reported that burrowing megafauna, including *Nephrops* was abundant in areas of <4% organic carbon around the Garrick Head sewage sludge dumping ground (Firth of Clyde) but absent where organic carbon exceeded 6%.
Eutrophication may cause indirect effects such as the occurrence of hypoxia which may result in toxic metals such as manganese (Mn^{2+}) and cobalt (Co^{2+}) being released from the sediments and become available for accumulation within decapod crustaceans (Holmes *et al*., 1999). (For hypoxia and heavy metal effects see oxygenation below and heavy metals above).

Sheltered, deep water habitats are likely to be sinks for organic matter. Therefore, *Nephrops* is likely be tolerant of high levels of naturally occurring organic matter and only susceptible to extremely high levels, perhaps as the result of sewage sludge dumping or similar activity. Therefore, tolerant has been recorded. However *Nephrops* is probably sensitive to indirect effects of eutrophication such as hypoxia (see below).

Increase in salinity Not relevant | Not relevant | Not sensitive | Low

Nephrops norvegicus is found within fully marine subtidal locations. It is highly unlikely that it would experience conditions of hypersalinity. Therefore this factor is considered not relevant.

Decrease in salinity Intermediate | High | Low

Nephrops norvegicus is found in waters at full salinity. Thompson & Ayers (1989) noted that *Nephrops* larvae were found at salinities of 34-35 ppt in the wild. Farmer (1975) reported that *Nephrops* occurred at salinities of 29-30 ppt in the Kattegat and 35.8-38.7 ppt in the Adriatic. However, Höglund (1942; cited in Farmer, 1975) suggested that the absence of *Nephrops norvegicus* in the Baltic Sea was due to its intolerance to very low salinities. Even though *Nephrops norvegicus* is mobile and some individuals will be able to avoid unfavourable salinity changes, individuals may be affected. Therefore intolerance has been assessed as intermediate with a high recovery rate, albeit with very low confidence.

Changes in oxygenation High | Moderate | Moderate | High

Diaz & Rosenberg (1995) suggested that *Nephrops norvegicus* was sensitive to hypoxia.

Juvenile intolerance
The tolerance of juvenile *Nephrops* to low oxygen concentrations was examined under laboratory conditions.

- Behaviour and mortality changed with lowered oxygen concentrations; energetically costly activities were reduced, and activity in general declined. In normoxia, juveniles initially walked and then burrowed but when exposed to hypoxia they were mainly inactive with occasional outbursts of escape swimming. To increase oxygen availability the juveniles were observed to raise their bodies on stilted legs (similar to adults in hypoxic conditions) but an oxygen saturation of 25% (O_2<2.5 mg/l) were lethal within 24 h (Eriksson & Baden, 1997).

- Burrowing behaviour was tested in post larvae at an oxygen saturation of >80% (O_2< 8 mg/l) for 1 wk. The difference in time taken to complete a V-shaped depression or a U-shaped burrow was measured and showed a strong negative relationship between post larval age and burrowing time but all individuals made a burrow. Eriksson & Baden (1997) suggested that juveniles are therefore more sensitive to hypoxia than adults.

Adult intolerance
In moderately hypoxic conditions 38-43% saturation (3.8-4.3 mg O_2/l) *Nephrops norvegicus* compensates by increasing production of haemocyanin (Baden *et al.*, 1990). In the laboratory, this compensation lasted one week so at the level of the benchmark the species would not be killed. However in severe hypoxia, <20% saturation (<2 mg/l) *Nephrops* became less active and raised their bodies on their legs (Baden *et al.*, 1990).

During laboratory studies at <15% O_2 ($O_2$1.5mg/l) specimens of *Nephrops norvegicus* stopped feeding even though there was available food suggesting that hypoxia induces starvation (Baden *et al.*, 1990).

Gill discolouration may also occur in *Nephrops norvegicus*. Specimens from the Kattegat and Skagerrak were examined and the percentage of discoloured gills varied between 10-20% (O_2 1-2 mg/l) for both sexes. Some specimens with black gills also had holes corroded into the carapace about 10 mm in diameter. It should be noted that this area has low levels of oxygen due to eutrophication.

At 12% (<1.2 mg O_2/l) oxygen saturation some specimens of *Nephrops norvegicus* began to 'tip toe'. They supported themselves by elevating the body from the substratum with their claws and telson. The lobsters remained elevated until they became tired and sluggish and barely moved when touched for 2-3 days after which they died (Baden *et al.*, 1990). Catches of *Nephrops norvegicus* were found to be high in hypoxic conditions, probably because the animals are forced out of their burrows (Eriksson & Baden, 1997). However, at 10% saturation (1.0 mg O_2/l) specimens only survived for 2-4 days (Baden *et al.*, 1990). Baden *et al.*, (1990) reported that the *Nephrops* biomass declined from 10.8 kg/hr to zero from October 1984 to September 1989 in the SE Kattegat, an area affected by 1-3 month periods of low oxygen concentrations (< 2ml/l = 2.8 mg/l) during the 1980s. Therefore, intolerance has been assessed as high at the benchmark level with a moderate recovery level.

Biological Pressures

	Intolerance	Recoverability	Sensitivity	Confidence
Introduction of microbial pathogens/parasites	Intermediate	High	Low	High

Infection of *Nephrops norvegicus* by a parasitic dinoflagellate of the genus *Hematodinium* has been known since the mid-1980s (Field *et al.*, 1992). Infected populations have been found in the Irish Sea, Scottish sites in the Clyde Sea area and the west and east coasts. *Hematodinium* has also been reported in *Nephrops* in the German Bight, the Skagerrak and Kattegat (Briggs & McAliskey, 2002). Infected animals are recognized by an opaque vivid body colouration, believed to be due to high densities of parasites in the haemolymph. The muscle of infected animals are said to have a bitter taste. Infection causes a general morbidity of the lobster and a reduction in swimming performance. Death usually occurs when the parasite bursts out of the haemolymph (Marrs, pers. comm.). Recovery of *Hematodinium* infected *Nephrops* has not been observed to date (Stentiford *et al.*, 2001). Results from Irish Sea and Scottish surveys show a seasonal pattern to the level of *Hematodinium* infection in *Nephrops norvegicus*, with peaks in spring (Stentiford *et al.*, 2001; Briggs & McAliskey, 2002). There was also a marked spatial variability in infection rates in animals in the Irish Sea (Briggs & McAliskey, 2002). The prevalence of infection is higher in immature animals though the reasons for this are still unclear. High mortalities seen during some surveys although these values may be an artefact brought about by the increased catchability of infected *Nephrops* as swimming performance falls with severity of infection (Stentiford *et al.*, 2000). This may lead to overestimation of the actual prevalence of infection in fishing stocks. Briggs & McAliskey (2002) report that the disease has been present in populations of *Nephrops* at least since 1994 and despite inflicting juvenile mortality on the *Nephrops* stock, recent assessments indicated a stable situation. Although a correlation was noted with salinity, this and the interrelationships of other environmental factors affecting *Nephrops* stocks needs further investigation. Therefore, intolerance has been assessed as intermediate with a high recoverability level.

Introduction of non-native species Not relevant

No information was found concerning the effects of non-native species on *Nephrops norvegicus*.

Extraction of this species Intermediate High Low High

Catchability of *Nephrops norvegicus* depends on the pattern of emergence from their burrows. This is influenced by the seasonality and the illumination of the sea bed (Hillis, 1996). In British waters, the *Nephrops* fishery has grown rapidly since its inception in the 1950s. *Nephrops* is now one of the most valuable shellfish resources in the north-eastern Atlantic (Hughes, 1998b). However, findings from the western Irish Sea suggest that the structure of some *Nephrops* populations may render them vulnerable to over-exploitation (Hughes, 1998b) because a gyre retains the larvae in the vicinity of the parent population, rather than being carried off by currents into other areas (Hill *et al.*, 1996,1997). The retention of larvae by the gyre may be essential for the maintenance of the local *Nephrops* population and it is possible that over-exploitation of *Nephrops* in this area could lead to a self-perpetuating population decline owing to a reduction in recruitment. However, Hughes (1998b) reports that most stocks have the potential to recover even after heavy fishing pressure. Therefore, intolerance has been assessed as intermediate with a high recovery level.

Extraction of other species Intermediate High Low Very low

No specific information was found concerning the extraction of other species. Any extraction of other species using gear that penetrates the seabed such as scallop dredging is likely to have similar effects as fishing for *Nephrops norvegicus*. However in other forms of demersal fishing where there is little or no penetration of the seabed may leave *Nephrops* unaffected in their burrows. Therefore, intolerance has been assessed as intermediate with a high recoverability.

Additional information

Recoverability

In the Irish Sea, *Nephrops norvegicus* individuals are not thought to live more than 8 or 9 years. However, in deeper waters such as the Porcupine Bank they may survive over 15 years (Marine Institute, 2001). *Nephrops norvegicus* do not reach sexual maturity for 2-3 years. Local populations of *Nephrops norvegicus* may vary considerably in density, size and growth rate (Tuck *et al.*, 1997). The fecundity of *Nephrops norvegicus* is also known to vary geographically (Eiriksson, 1970; Tuck *et al.*, 1997). The percentage of eggs lost during development can range from 32 - 51 % with larval mortalities as high as 87% (Garrod & Harding, 1980) which could reduce recovery rates. As a result *Nephrops norvegicus* do not produce large numbers of offspring. Potential recruitment from other populations of *Nephrops norvegicus* is low as *Nephrops* larvae do not have a high dispersal potential and adult *Nephrops* show no evidence of migration (Marine Institute, 2001).

Hughes (1998b) suggested that the *Nephrops* population in the northwest Irish Sea, in which the larvae were entrained by the gyre, was a self-perpetuating unit but at the same time susceptible to over-exploitation. However, Hughes (1998b) concluded that the above population was probably the exception and that most populations were probably capable of recovery even after heavy fishing pressure. Nevertheless, poor potential larval dispersal and preferential settlement of larvae amongst adults suggests that colonization of new habitats, or recovery of habitats from which the population had been removed, would be prolonged.

Importance review

Policy/legislation

- no data -

Status

National (GB) importance	-	**Global red list (IUCN) category**	-

Non-native

Native	-		
Origin	-	**Date Arrived**	-

Importance information

Fishery Information

In British waters, the *Nephrops* fishery has grown rapidly since it began in the 1950s (Howard, 1989; cited in Hughes, 1998b). *Nephrops norvegicus* forms one of the most important fisheries in the north-east Atlantic. It is the third most valuable fishery in the North Sea. In 2000, North Sea landings of 9,837 tonnes were worth £22.3 million. Whereas, in the west of Scotland 10,733 tonnes of *Nephrops norvegicus* were landed from the International Council for the Exploration of the Sea (ICES) Area VI worth £25.7 million (Fisheries Research Services, 2003a,b).

Nephrops norvegicus is also a very important species for the fish processing industry which uses the tails to produce 'scampi' (see explanation of terms below). The UK Food Labeling Regulations of 1984 specify that the only crustacean permitted to be labeled and sold as 'scampi' is *Nephrops norvegicus* (Ingle, 1997).

Although the *Nephrops* fisheries have great commercial importance the environmental consequences of fishing for the species (using creel pots or more usually for large commercial fisheries with otter trawls) are of concern. Trawls result in large volumes of discards (non-target species and undersized commercial animals) made up of other crustaceans, fish and small *Nephrops*. For example, in the Clyde Sea area 50-90% (by volume) of the catch can be discarded (Bergmann *et al*., 2002a). Wide areas of seabed are also affected as weighted ground lines and heavy otter doors are dragged across the sediment.

Management

Minimum landed sizes of *Nephrops norvegicus* are governed by European Union Council Regulations. Landed sizes vary from 7 cm total length in the Irish Sea and waters of western Scotland, to 13 cm for lobsters fished in the Skagerrak and Kattegat regions of Scandinavia. The fishery is also regulated by permitted net mesh diameters. In the UK a minimum mesh of 7 cm is permitted for fishing *Nephrops norvegicus* (Ingle, 1997). Limits for the Total Allowable Catch (TAC) for individual *Nephrops* stocks have been suggested for the west coast of Scotland (Fisheries Research Service, 2003a). However, to overcome difficulties managing such small units scientists have also suggested grouping some stocks into management areas. For instance, grouping the three Scottish west coast *Nephrops* stocks into a west coast management area, which corresponds to ICES finfish Area VI (Fisheries Research Service, 2003a). The TAC for the three *Nephrops* stocks on the west coast of Scotland was set at 11,340 tonnes in 2002 (Fisheries Research Service, 2003a).

Current exploitation levels are being maintained in the Moray Firth and Noup management areas. A slight recovery in stock size has been reported in the Moray Firth, which resulted in a TAC increase in 2002 to 2000 tonnes (Fisheries Research Service, 2003b). The TAC for the Firth of Forth and Farn Deeps area has remained at 4,170 tonnes. In the Fladden Ground Management Area the TAC has remained at 9,000 tonnes (Fisheries Research Service, 2003b).

Management also applies to the larger ICES finfish areas. The TAC in 2002 for the North Sea *Nephrops* stock (including the management areas above and other not fished by Scottish vessels) has been set to 16,623 tonnes. This is an slight increase for levels set in 2001 but below that advised by ICES. This TAC was based upon advice for *Nephrops* and bycatch concerns for whitefish (Fisheries Research Service, 2003b).

Fishermen and both the EU and the UK managers have also recently agreed to technical measures including mesh size, square mesh panels, twine thickness and bycatch limits to conserve stocks on the west coast (Fisheries Research Services, 2003a).At a local level under the Inshore Fishing (Scotland Act) 1984, various technical and access limitation measures are in place or under consideration (Fisheries Research Service, 2003a).

Some *Nephrops* fisheries terms explained
(Taken from http://www.morayseafoods.co.uk/faq.htm)

- **Langoustine**
  The whole shellfish of the species *Nephrops norvegicus*. Also referred to as Norway lobster, Dublin Bay prawn, in Italy as 'scampo' and to the fisherman of Scotland as 'whole prawns'.
- **Scampi**
  A coined word derived from the Italian 'scampo' and used to describe peeled tails, both plain and coated of the species *Nephrops norvegicus*. In parts of Europe, the phrase with breadcrumbs can also refer to non-*Nephrops* species of shellfish in breadcrumbs.
- **Shrimp & Prawns**
  These two words are often used interchangeably. In Scotland the word prawn is usually used to refer to whole *Nephrops norvegicus* leaving the word shrimp to cover cold water prawns such as *Pandulus borealis* - the North Atlantic prawn.
- **Breaded scampi**
  The peeled tails of *Nephrops* which may be coated in breadcrumbs as a wholetail or for a less costly item made from formed small tails and pieces of peeled *Nephrops*. In the UK only *Nephrops norvegicus* may be put into breaded scampi to ensure that customers are clear what they are purchasing. For further information on terminology refer to the code of conduct published by the United Kingdom Frozen Food Producers Association (UKFFPA).

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