IRISH FISHERIES INVESTIGATIONS

SERIES B (Marine)

No. 12 (1974)

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by

J. Paul Hillis,

A DIVING STUDY ON DUBLIN BAY PRAWNS *NEPHROPS NORVEGICUS* (L) AND THEIR BURROWS OFF THE EAST COAST OF IRELAND.

A diving study on Dublin Bay prawns *Nephrops norvegicus* (L) and their burrows off the east coast of Ireland

by J. P. HILLIS.

Abstract

During 1971 a team of divers studied the structure and numbers of entrances of burrows of *Nephrops norvegicus* in the Irish Sea off Clogherhead and counted their numbers in plots of 28 m^2 area. Numbers of entrances found ranged from one to six with a peak at 3 and the densities of *Nephrops norvegicus* found ranged from 1 per 2.5m^2 downwards.

Introduction

The suggestion that Dublin Bay prawns *Nephrops norvegicus* excavate and inhabit burrows in mud was postulated (though without proof) by Gauss-Garady (1912) as the reason for the swift and dramatic changes observed in numbers taken in the trawl. Burrowing behaviour has been described by Hoglund (1942), from captive observations, Priestly and Thomas (1964), by remote-control under-sea photography, Dybern and Hoisaeter (1965), by diving and captive observations, Crnkovic (1968) by captive observations and by Chapman and Rice (1971) and Rice and Chapman (1971) by diving.

The habit is responsible for the spectacular variations in trawl catch with light conditions described by many authors including Hillis (1971, 1972) dealing with Irish Sea populations.

Method

The place of burrows in the behaviour patterns of *Nephrops* was investigated by programmes of diving carried out in the Irish Sea off Clogherhead in the area shown in Fig. 1, using the research vessels, *Cú na Mara* on 14, 15 and 16 June 1971 and *Cú Feasa* on 6, 7, 8, 13 and 16 September 1971. The divers were J. O. Browne, B.Sc., Fisheries Division, Department of Agriculture and Fisheries, and a team of three from Messrs. Irish Underwater Services Ltd., photography being undertaken on 13 September by C. Craig.

The aims of the programme were as follows:

1. Estimation of the population density.

2. Observations on the behaviour of *Nephrops* and structure and distribution pattern of their burrows, including photographic observations.

3. Observations on the action of the trawl and reaction of *Nephrops* to the trawl.

Estimates of the population density were desirable in view of the variation in trawl catches, but the difficulty was recognised of obtaining meaningful data, due to the fact that only the periphery of the fishing grounds is shallow enough to allow divers adequate working time on the sea bed. Observations on behaviour of *Nephrops* at their burrows proved relatively simple. Considerations of human physiology limit each diver to a period of about 30-45 minutes per day at the relevant depths; each day's work was thus carried out in the afternoon, so that observations and counts could be made in daylight with the *Nephrops* in their burrows and the work could conclude if desired with a trawl haul at dusk for trawl escape reactions.

All the divers and particularly the photographer commented on the turbidity of the water and softness of the bottom sediment, probably a feature inevitable in most *Nephrops* habitats; much the softest and finest bottom encountered was that found at the deepest dive made, at J5.0 F43.0 at 17 fm on the divers' meters, on 13 September, further inside the *Nephrops* inhabited area than any other dive. All positions were fixed by Decca Radio Chain navigational aid.

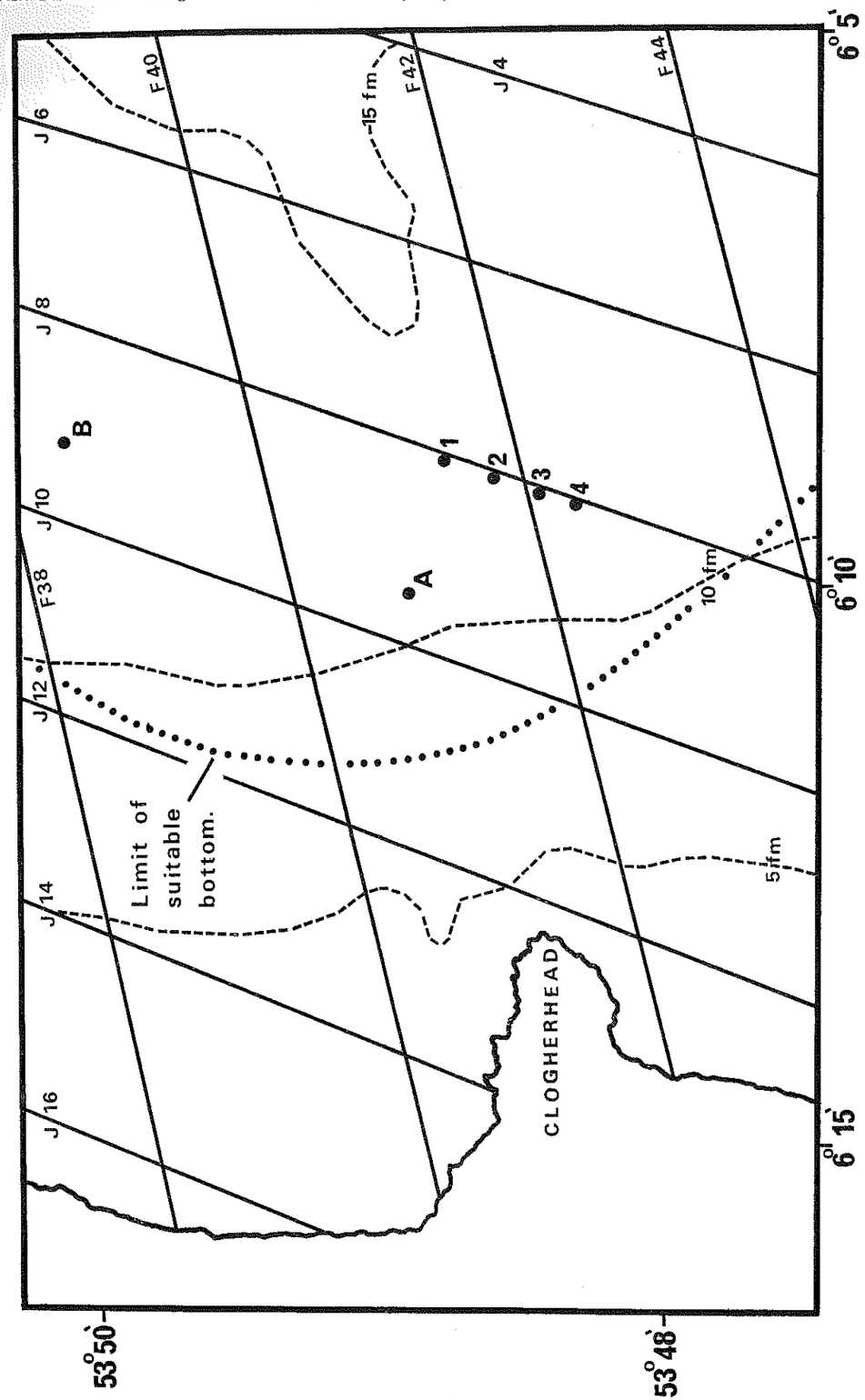

Fig. 1. Area of diving observations off Clogherhead, showing depth contours, Decca grid lines and inshore limit of bottom type suitable for *Nephrops*. Positions of observations as follows:— A = 15 June, B = 16 June, 1, 2, 3, 4, = 16 September.

To count Nephrops it was necessary to extract them from their burrows; to estimate their density it was necessary to mark the extent of the area being surveyed. To drive them from their burrows, three methods were initially tried, namely (1) injection of formalin, (2) injection of compressed air, and (3) use of a small diameter bottle-cleaning brush attached to a 1.2 m flexible nylon rod. For injection of formalin a football bladder was used, attached to a 50 cm length of aquarium tubing which was closed with a spring clamp when out of use, while the formalin was rendered visible by an admixture of gentian violet. This equipment was carried by the diver in a small string bag.

Of these methods, all demonstrated the extent of a single burrow system, dyed formalin and compressed air emerging from all holes in a burrow-system and particles of mud moved by currents set up by the brush doing likewise. The coloured formalin, however, was found to be the only effective agent in expelling the inmates and accordingly it was used for all work after the first day.

Plate 1A shows a *Nephrops* emerging from its burrow, with two other burrows visible in the right background, the natural darkness of the burrows being enhanced by the presence of dyed formalin therein. Plate 1B shows more clearly the presence of a cloud of formalin, also showing, especially at the top left hand corner of the plate, part of the suspension of mud particles, which makes the sea in this area turbid. These appear as pale spots, rather out of focus.

To demarcate a known area on the sea-bed it was considered best for divers to survey an area of considerable length, but narrow enough for full examination to be effected by moving along its length once. This avoided difficulties due to clouds of mud stirred up by the divers and departure of *Nephrops* from parts of the area disturbed prior to being examined. A plot of 1.8 m x 15.2 m was laid out by starting from two weights separated by a 1.8 m line; from each of these weights 15.2 m of line was paid out by a diver swimming away at rightangles to the 1.8 m line paying out 15.2 m by means of two spear-fishing gun reels mounted 1.8 m apart on a tubular steel rod which itself became the fourth side of the rectangular area when the line was fully paid out. The orientation of the long axis of the rectangle was diagonally across the tidal current and the diver swam diagonally against it, so that any silt stirred up by the operation was removed from his field of view and from the plot with maximum speed. For ease of location from the surface, and recovery of the equipment on completion of work, one of the original two weights was linked by a slack line to a heavy weight anchoring a marker buoy.

For distribution patterns of burrow systems and the behaviour of *Nephrops*, including when evicted by formalin and when threatened by the trawl, observations were simply made by the divers and recorded in writing on return to the surface. After the day's diving programme was completed, these observations were discussed and the divers compared their experiences, a process which assisted in eliminating any discrepancies from the preliminary reports.

Results

The basic type of burrow was found to have a wide-mouthed entrance into a crater with a rampart and another smaller, more vertical entrance, but elaborations were frequent and from one to six entrances were recorded with the addition of a number of very small roughly circular holes without any depression surrounding them and having short roughly vertical shafts. Plate 1C shows a *Nephrops* in the entrance to its burrow, and illustrates the nature of the crater very clearly. It was noticed that holes of large diameter tended to be more closely grouped than small holes, i.e. they appeared to appertain to shorter burrows or smaller complexes, possibly because the necessity for protection was less among larger *Nephrops*.

The number of entrances and approximate extent of burrows are given in Table 1, showing more than half the burrows at each location to have 3 or more entrances (the over-all percentage was 69%). It is of interest to note that the two burrow systems found with more than 4 entrances both harboured two Nephrops, of which one was tiny in each case.

Table 2 gives observations on the density of burrows and of *Nephrops* observed in the survey plots. One of the observations was made in June and the other four in September. The latter emphasises the closeness of the diving area to the margin of the *Nephrops* area with uninterrupted decrease in numbers in the columns for September from left to right. This evidence implies the confinement of the population to areas of soft substrate.

Table 1. Divers' Observations of Numbers and Distance apart of Entrance, June 1971.

Date Position (see Fig. 1) Divers	Number of Entrances	Estimated "inter-entrance" distance (cm)	General observations	
			Inhabitant *Nephrops*	Other observations
15 June	3	36, 28, 18	One small*	
A	3	74, 56, 28	—	
(J. 9.5	2	36	—	
F 40.9)	3	38, ?, ?	—	
	1	—	None	
JB, BC	2	28	—	
	3	38	—	"Blowhole" 53 cm. away
	1	—	None	
	3	137, ?, ?	—	
16 June				
B	2	15		Compact system
	3	46, 10, ?		
(J 9.2	3	max. 46		
F 38.5)	6	max. 51	2 of which 1 tiny*	
	4	max. 56		
JB, JM	2	20	1	
	5	max. 107	2 of which 1 tiny*	Long system
	4	15, 15, 15, 15	1	Compact system
	2	18		
	4	"Very close"		
	4	max. 33		
	4	max. 56		
	4	max. 53		
	3	?	2	Long system

Summary :— numbers of burrows with N entrances.

N	1	2	3	4	5	6	Total
15 June	2	2	5	—	—	—	9
16 June	—	3	3	6	1	1	14
Total	2	5	8	6	1	1	33
%	9	22	35	26	4	4	100

*Approximate carapace lengths of divers' size groupings:— tiny=up to 22 mm; small=23-28 mm; medium=29-34 mm; large=35 mm and over.

Regarding the action of the trawl, very limited observations indicated a certain variability. On 7 September the ends of the footrope on the port side was seen to be digging into the substrate about one inch, and some fish but no *Nephrops* were seen being caught. On 8th September, however, when the height of the headline was estimated at 0.9 m and the footrope was level with it or if anything slightly forward, the wing ends were engulfed in such clouds of mud that no details could be seen. *Nephrops* were seen to dart back from the footrope several times in vain attempts to escape. On 16 September, however, when the trawl was observed to be moving very slowly, the absence of such an escape reaction was noted.

Minor behavioural observations noted included, on 14 June, the total absence of visible *Nephrops* during 18.12 to 18.50 hours, while during 19.18 to 19.45 hours many Nephrops were observed with antennae and chelae visible at their burrow entrances.

Table 2. Density of Nephrops and Burrows.

Date	15 June	16 Sept.	16 Sept.	16 Sept.	16 Sept.	(Chapman
Position (Fig. 1)	A	1	2	3	4	&
Decca reading	J9.5 F40.9	J8.05 F41.45	J8.05 F41.78	J8.05 F42.08	J8.05 F42.38	Rice, 1971)
Diver	BC, JM	BC	SS	JB	JM	
Substrate type	—	Soft	Fine, soft	Fine, soft	quite hard	
Area dimensions (m)	14.6 x 2.4	15.2 x 1.8	15.2 x 1.8	15.2 x 1.8	15.2 x 1.8	14 x 10 approx.
Area (m^2)	35.6	27.9	27.9	27.9	27.9	140
Number of *Nephrops* tiny	...	1	—	1	—	—
Number of *Nephrops* small	...	6	3	3	—	2
Number of *Nephrops* medium	...	4	—	2	—	1
Number of *Nephrops* large	...	—	4	—	—	14
Number of *Nephrops* Total	4	11	7	6	—	17
Number of burrows	9	14	13	9	3	66
Area (m^2) per *Nephrops*	8.9	2.5	4.0	5.6	—	7.8
Area (m^2) per burrow	4.0	2.0	2.1	3.1	9.3	2.1

Behaviour on eviction from burrows by formalin included a case when introduction of formalin at one entrance caused the inhabiting *Nephrops* to emerge from a second hole and go calmly and without hurry to a third which it entered backwards, but on encountering formalin there it became extremely aggressive and agitated and departed from the area at great speed, thereby indicating the extent to which a choice of entrances is used as an aid to safety.

Animals making burrows similar to those of *Nephrops* were limited to a very few *Goneplax rhomboides* and it is considered that misidentification of untenanted burrows, whilst not impossible, occurred only very seldom if at all.

Dicussion

The powerful backward propulsion of the tail and large chelae of the Astacidea appear well adapted for escape into and defence of entrances of cavities, and in the case of *Nephrops* the animals create their own sanctuary. In captivity, they prefer an artificial refuge to the open aquarium. The practice of excavating burrows is shared, in appropriate habitats, by the American lobster *Homarus americanus* (Cobb, 1971).

In their extensive field studies on burrowing behaviour and burrow form in Loch Torridon, Chapman and Rice (1971) and Rice and Chapman (1971) found densities of burrows approximately similar to those found in the present work. The most basic form of burrow has a large entrance at one end opening off a crater surrounded by a rampart and a small nearly vertical aperture at the other. However, a very large proportion of burrows in the present investigation had more than two entrances, 69% (Table 1) as opposed to 8% in 1968 and 20% in 1969 in that of Rice and Chapman; in the present studies, three was the most frequent number and up to six was recorded. This difference appears remarkable, but is probably explained by an observation of Dybern and Höisaeter, who note that in the aquarium homeless *Nephrops* try to enter existing burrows, regardless of whether they are already occupied, and if not ejected proceed to make branches and new entrances. It therefore follows that the average burrow system would be expected to be more complex in areas where frequent trawling produces much disturbance of the population, such as the Irish Sea, than in Loch Torridon, where trawling is not carried out on a large scale, if at all. The impression gained in the present work of inverse relationship between burrow length and burrow diameter (the latter indicating the size of the inhabitant) is at variance with the findings of Dybern and Höisaeter; they found a rather consistent positive correlation between *Nephrops* length (above about 27 mm Lc) and burrow length. It may be that the effect observed in the present work is limited to carapace lengths below 27 mm.

Acknowledgment

I wish to acknowledge the assistance received from Mr. John Browne of the Department of Agriculture and Fisheries. Mr. Browne, who is a qualified diver, evolved the underwater techniques used and directed all aspects of work on the sea-bed. My thanks also go to the other divers who participated, Messrs. B. Cusack, J. Murray, L. Clegg, W. Crowley, S. Sheridan and C. Craig, frequently working in conditions of depth and water turbidity considerably severer than those to which they are accustomed. Fig. 1 represents the coast of Ireland by permission of the Ordnance Survey, Permit No. 1833 and nautical data are taken from the Admiralty chart with overlay grid of the Navigational Aid system of Messrs. Decca, Ltd.

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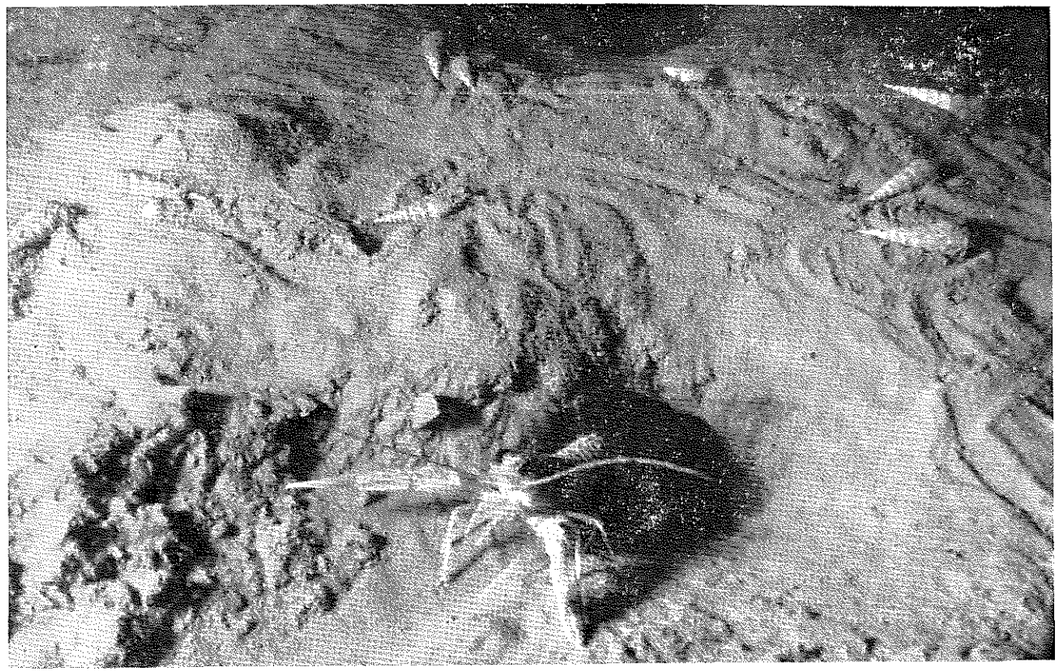

Plate 1. A—*Nephrops* emerging from its burrow, the darkness of which is accentuated by the presence of dyed formalin driving the animal out. B—A cloud of dyed formalin drifting out of a burrow entrance. Pale, poorly focussed spots at top left are particles of sediment suspended in the water. C—*Nephrops* in its burrow entrance, showing clearly the form of the sunken 'crater' at the entrance.

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