Observations on the resurfacing behaviour of the whelk Neptunea arthritica

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of the whelk *Neptunea arthritica*

Nand RAM[1] and Yosihiko KAKINUMA[2]

Abstract

Whelks and other molluscs usually response to odor plume and move in the direction of the stimulant. Especially the buried whelks only leave their buried place for search of food or shelter in case of bad weather.

To study their resurfacing behaviour, a simple experiment in the laboratory with time lapse video photography was carried out with continuous flow of fresh sea water. The stimulant used was fresh or frozen mussels.

It was seen that smaller whelks resurfaced faster than larger whelks. On occassions larger whelks which faced down current of the stimulant, kept changing their directions while resurfacing.

Key words: Whelks, burrow, resurface, stimulant

Introduction

Some whelks, especially *Neptunea arthritica* stay buried in their natural habitat[1-3]. When there is a natural stimulant around their area, they respond to the odor plume and resurface themselves. They proceed to crawl in the direction of the stimulance that is present and try to reach it[4-7].

In Hokkaido different species of whelks are being caught by traps and consumed[8-10]. These particular whelks are mostly found buried in sandy bottom and there is a strong effect of Tsugaru warm current which flows in this area and current shift takes place with change in low and high tides.

When an odor plume is present, its only then the whelks resurface. A laboratory experiment was carried out to study the resurfacing behaviour of this particular whelk.

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Materials and methods

All the whelks used in this experiment were brought from Shiriuchi and kept in an aquarium with continuous flow of sea water at Usujiri Experimental Station of Hokkaido University. In this aquarium substratum similar to their natural habitat was used and the temperature ranged from 12°C to 18°C.

A glass aquarium (A) measuring 120cm×45cm×45cm was used. Another small aquarium (B) measuring 90cm×10cm×35cm filled with sand was kept inside the large aquarium (A) and subjected to a continuous flow of sea water. The experimental set up is shown in Fig. 1. Periodical observations and continuous video recording of whelks burrowing and resurfacing were carried out. Resurfacing activity was studied by a video camera (Sony CCD-V900) and time lapse video recorder (Panasonic AG6720A). Individuals were identified by a number on the shell and a tag number of the shell length was placed in front of the aquarium which appeared well on the TV monitor. This was done to avoid confusion in distinguishing the recording of burrowing and resurfacing behaviour of other whelks. Their burrowing position was also noted in the log sheet. Illumination was provided by a 100 Watt bulb.

The recording device consisted of a panel with a reference grid and a watch calendar. The video recordings were later analyzed at 5 sec interval using a video tape recorder (Panasonic AG 7300), with variable frame rate and stop action facilities to record the data on burrowing and resurfacing of whelks. For each burrowing experiments recording was done for two hours. These recordings were later translated into graphics and digitized to obtain a sequential file of individual coordinates and relative data stored in a computer disc.

Prior to the release of whelks, a grid of 5cm×5cm was inserted in the test area and recording done for 5 minutes and then removed. This grid recording was used to locate the position of whelks and later read in the computer to calculate the actual position of whelks. Three sets of grids were taken, ie the front, the middle and the inner back of the aquarium 'B'. Sand in the experimental area was dug and reset for each burrowing of whelks.
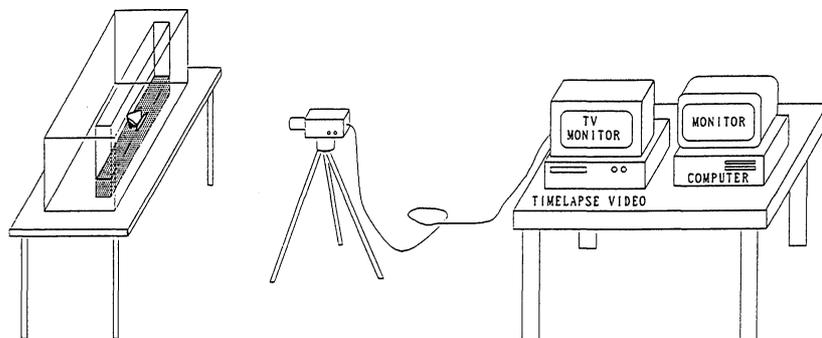

Fig. 1 Schematic diagram of experimental setup for recording the burrowing and resurfacing of whelks.

The grids taken prior to the experiment were used to record the actual position of whelks by converting the grid dots to the actual distance moved. The average of these three grids intervals were taken to calculate the actual value of X-axis. The dot corresponding to position A was x=94 and y=23, at position B was x_1=547 and y_1=190, so on a 5cm×5cm grid, the position B at X was 400mm (8cm×5cm) and Y was 350mm (7cm×5cm). So in terms of distance travelled in dots, large X=(x_b - x_o) and dots travelled in Y=(y_1 - y_2). Using this formula X=453 dots and Y=167dots. It was then converted to actual distance as follows:

$$\text{If X dot} = 453$$
$$\text{then 1 dot} = 400\text{mm}/453$$
$$= 0.88\text{mm}$$
$$\text{ie} \quad 0.88\text{mm/dot}$$

So the actual distance that the whelk moved horizontally was taken as 0.88mm per dot.

$$\text{and if Y dot} = 167$$
$$\text{then 1 dot} = 350\text{ mm}/167$$
$$= 2.09\text{mm}$$
$$\text{ie} \quad 2.09\text{mm/dot}$$

So the actual distance that the whelk moved vertically was taken as 2.09mm per dot.

To record the position of whelk inside the sand, a piano rod measuring 55mm in length and 0.9mm in diameter was used. The weight of the rod in air was 0.26g. Reliable recording was made by attaching a piano rod to the highest position of the shell, by keeping the whelks on a flat surface with its aperture side facing down. This position on the whelks' shell was cleaned by sand paper and an adhesive was used to fix the rod. From the upper end of the rod, 25mm was coated with white paint. Further details of rod attachment has been illustrated in Fig. 2. The actual attachement of rod is shown in Fig. 3. Rod attachement was possible by keeping the whelks partly submerged in a tray of sea water. It took less than 30 minutes for the adhesive to dry and later the whelks attached with piano rod were transferred to a large aquarium with continuous flow of sea water with three quarters of the shell remaining below the water for a 24 hour period. This enabled the
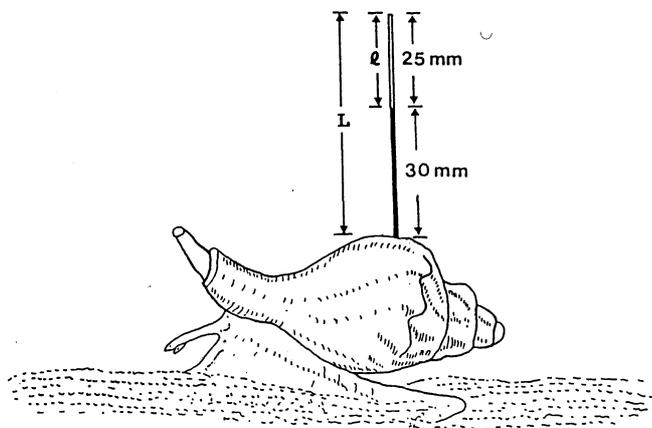

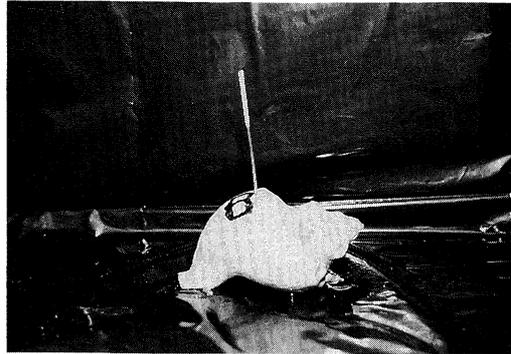Fig. 2 The piano rod attachment details shown on a whelk's shell.

Fig. 3 Attachment of piano rod on the whelk's shell for the burrowing and
        resurfacing experiments.

adhesive to get firmly dried and maintain the rigidity of the piano rod attachment.

Identification of whelks were made both visually and on TV monitor and the data recorded. Part of the shell was cleaned and marked with a quick drying indelible white pental pen. After marking, the whelks were kept slightly submerged in a container of sea water for a short period to prevent the stressing of whelks. White colour was chosen for its brightness and also it appeared clearly in the T.V. monitor. In the test area a black back ground was provided at the back of the sand to give a better image of the whelks on the TV monitor and made it easier to carry out analyses work.

Twenty whelks were starved for seven days prior to the experiment and kept without sand in another aquarium with continuous flow of sea water. Continuous recording of whelks burrowing into the substrate were taken for two hours and then stimulant in the form of frozen mussel was introduced into the water column. Recording was continued prior to the release of stimulant into the aquarium. Resurfacing of whelks took place once the stimulant was detected by the buried whelks. Recording of the resurfacing of the whelks continued till they were seen completely above the sand surface. A continuous flow of fresh sea water was provided which created a weak current above the surface of the substrate where the whelks were burrowed. The water in the tank flowed at a rate of 21.5 liters per minute. With this weak current the stimulant from the bait was carried across the burrowing place of whelks in stimulation them to resurface. In the burrowing experiment it was seen that whelks took less than two hours to burrow[11]. After two hours bait was released at a distance of 15cm from the burrowing place.

After each experiment the bait was removed and the tank was flushed for 30 minutes with no bait inside the experimental tank. Then 3 whelks were kept inside the inner aquarium above the surface of sand and allowed to burrow. The shell length, width and weight of whelks used for resurfacing experiments ranged from 35.2 to 93.0mm. Details of the shell length, width and weights are given in Table 1.

The temperature during the resurfacing experiment ranged from 15℃ to 20℃. Frozen mussels were released into the water column and continuous recording of the resurfacing of

Table 1. Shell length, width and weight of whelks used for resurfacing experiment.

Length (mm)	Width (mm)	Weight (g)
35.2	26.6	8.0
36.2	21.6	6.7
37.4	22.0	8.4
37.5	22.0	8.4
38.7	26.6	8.5
40.4	25.0	13.2
47.3	31.0	14.2
50.9	34.8	14.9
53.3	30.7	14.8
57.0	34.2	16.8
58.0	34.0	22.6
58.2	36.9	26.4
64.8	44.1	38.0
68.2	46.4	44.8
76.4	51.8	64.2
83.8	60.3	83.5
88.3	57.2	84.8
90.0	60.6	94.3
91.0	61.0	103.9
93.0	61.6	107.8

whelks were carried out. When recording the data of whelk movement by computer, the time (t_0) taken at burrowing depth (d_0) was taken when the piano rod moved and the recording was started.

Experiments on burrowing of whelks were kept with their opercular side facing the sand. The sand particle distribution was almost the same as that of their habitat and the sand particle diameter of the two substrate is shown in Fig. 4. Prior to the burrowing activity of the whelks, the position of the whelk on the sand surface was recorded since the upper layer of the sand got disturbed when burrowing took place.

A 8mm Sony camera was kept horizontally at a distance of 240cm from the glass tank. This camera was connected to a time lapse video tape recorder. A VHS cassette was inserted and recording was taken before the whelks were released into the burrowing area. Three whelks were kept simultaneously into the glass tank above the sand and the recording of their burrowing mechanism as well as observations were carried out.

The analyses work for the burrowing and resurfacing of whelks were carried out as shown in Fig. 5.

As illustrated in Fig. 2 a 55mm ("L"), 25mm (" ℓ ") of the piano rod was coated with white paint. The projected length for small ℓ was read as ℓ' and the projected length for large L was read as L′. The calculation procedure used was as follows:

$$1' = \sqrt{(X_1 - x_2)^2 + (Y_1 - Y_2)^2} \qquad (1-1)$$

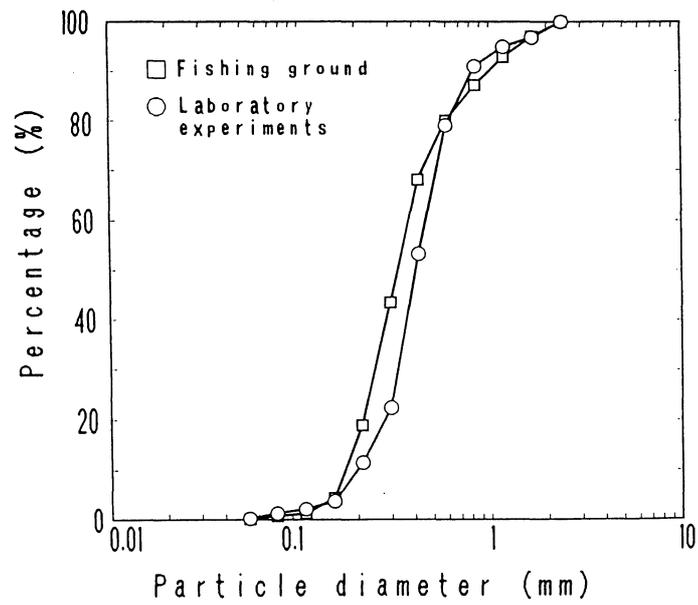$$1' = \sqrt{(X_1 - x_3)^2 + (Y_1 - Y_3)^2} \qquad (1-2)$$

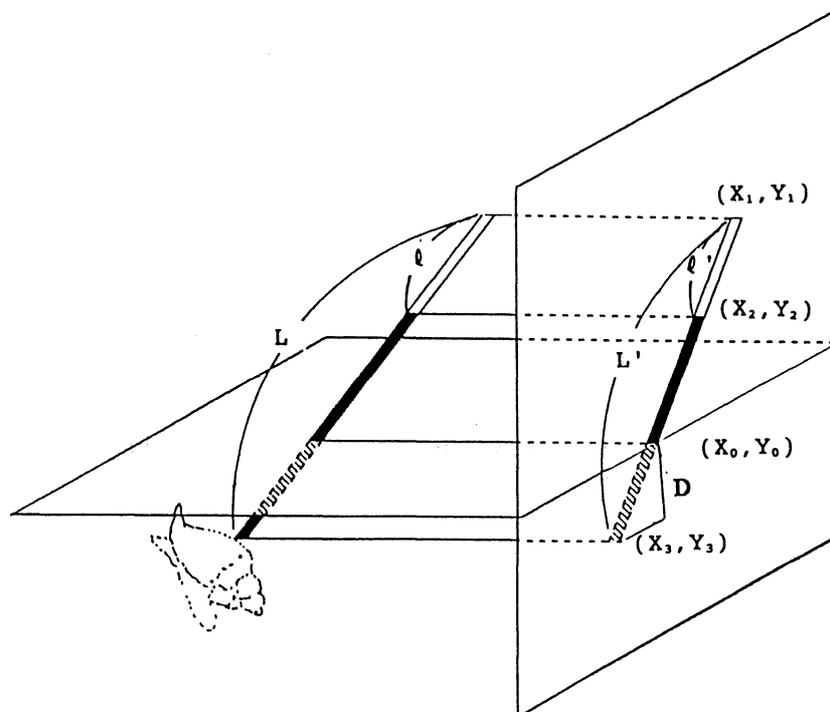Fig. 4 Diameter of sand particle used to carry out experiments on burrowing
of whelks.

Fig. 5 Illustration showing the measuring method for penetration depth of
whelks.

$$\frac{1}{L} = \frac{1'}{L'} \qquad (1-3)$$

$$(Y_1 - Y_3) : (Y_1 - Y_2) = L' : 1 \qquad (1-4)$$

$$Y_3 = \frac{L'}{1'}(Y_2 - Y_1) + Y_1 \qquad (1-5)$$

$$= \frac{L}{1}Y_2 - (\frac{L}{1} - 1)Y_1 \qquad (1-6)$$

$$Y_3 = \frac{11}{5}Y_2 - \frac{6}{5}Y_1 \qquad (1-7)$$

$$D = \frac{11}{5}Y_2 + \frac{6}{5}Y_1 \qquad (1-8)$$

Results

Buried whelks emerged from the sand and moved towards the direction of the frozen mussel. As they emerged there was a displacement of sand laterally. It was also seen that whelks made a series of digging up cycles while resurfacing. A typical example of a whelk resurfacing behaviour is illustrated in Fig. 6. The position of whelk (a, b) is seen with its siphon well protruded above the sand surface, at position (c) when the odour plume is detected the siphon gets well protruded and the whelk prepares to leave the burrowing place, (d) the first lifting of shell takes place and sand gets displaced, (e) surfacing up cycle continues, (f) the shell part is well above the substrate, however, the metapodium end remains well below the sand (g) slipping back of shell takes place and (h) siphon is well orientated in the direction of ordor plume. This resurfacing behavior was seen with all the whelks that were used for the resurfacing experiments. The relationship of whelks shell length and their resurfacing cycle is shown in Fig. 7. The procedure for measuring the resurfacing time and speed of whelk is shown in Fig. 8. The time, t_0 was taken when the resurfacing took place at distance d_0 and t_1 was taken at distance d_1 when the whelks were completely above the sand. This was visually taken and recorded in the log sheet. The resurfacing speed were calculated as follows:

$$\textit{Resurfacing time} = t_1 - t_0 \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots(1-9)$$

$$\textit{Resurfacing time} = \frac{d_1 - d_0}{t_1 - t_0} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots(1-10)$$

When the whelk burrowed themselves, the surface layer of the substratum was disturbed and before the whelk proceeded to burrow three points were taken along the base of the shell and recorded as initial position prior to burrowing as "0" level. The complete burrowing cycle was recorded in a VHS video tape. This video tape was transfered to a time

a

A 93.4mm whelk seen partly buried with its siphon well protruded above the sand surface.

b

Whelk's shell position before the release of bait.

c

Position of the whelk's shell after the release of stimulant into the water column. The siphon gets protruded and lifting of shell.
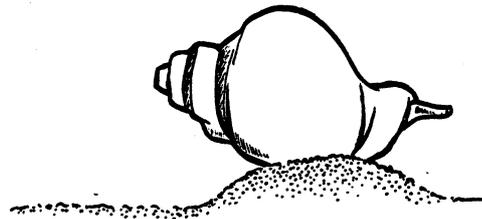
d

Lifting of shell takes place. Sand gets displaced.
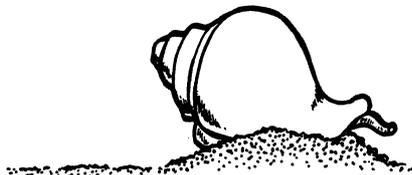
e

Whelks shell seen inclined.

f

Whelk's shell well above the sand and siphon pointing towards the direction of the stimulant.

g

Shell gets slipped backward when probing up took place.

h

The position of the shell and siphon pointing directly towards the stimulant.

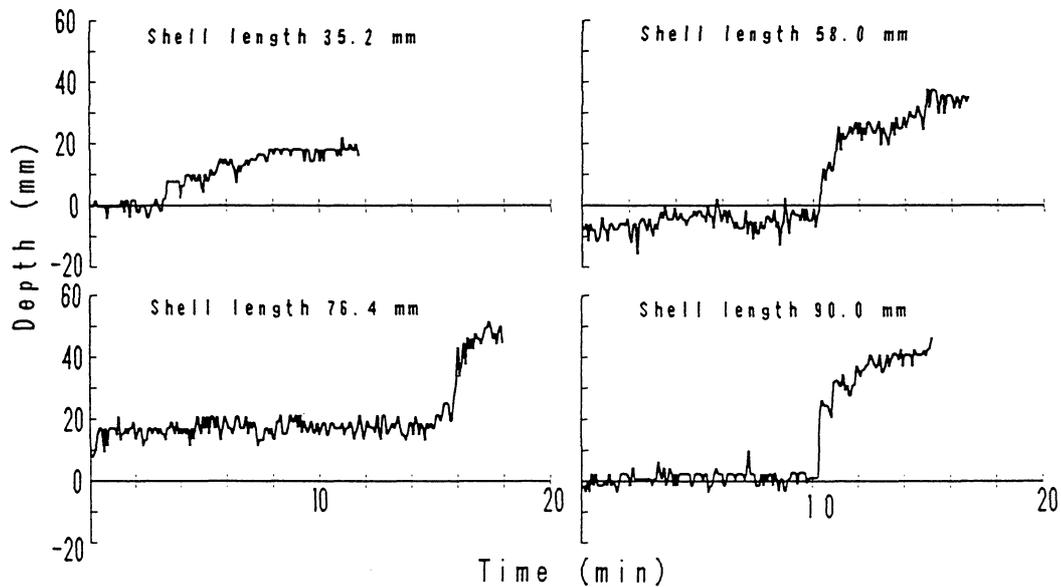Fig. 6 Illustrations showing the resurfacing cycle of a whelk.

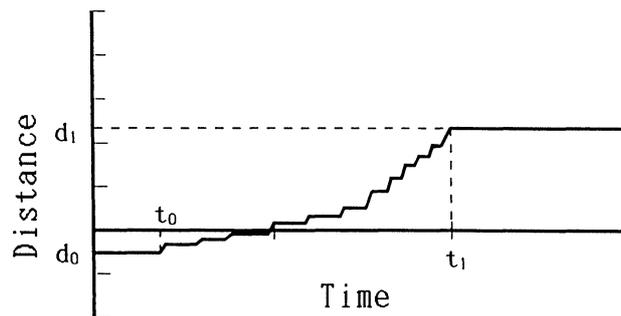Fig. 7 Resurfacing cycles of four different whelks.

Fig. 8 Illustration of calculation method for the resurfacing time
and speed of whelk.

lapse video deck and recording of whelk movement at every five second was clicked and stored in a 3.5 inch floppy disc. The position of whelk at every five seconds was recorded.

Whelks became active as soon as the frozen mussel was released into the water column and when they detected the stimulant, they responded by protrusion and vigorous swinging of their siphon from side to side. Once the direction of the smell was detected, resurfacing was seen with siphon always pointing towards the odor plume.

On one occassion a 90mm whelk was seen buried perpendicular to the water flow and when bait was released, protrusion of the siphon took place followed by resurfacing. This particular whelk kept changing its direction while resurfacing and headed towards the direction of the odor plume. After 5 minutes it completely changed its direction towards the

direction of the plume. When they leave the burrowing place, they kept changing the direction in each digging that took place.

The relationship between shell length and resurfacing time is given in Fig. 9. The relationship between shell length and resurfacing speed is given in Fig. 10. It was seen that when an odor plume was introduced whelks having shell length 60-90mm took 10-15 minutes in resurfacing themselves whereas those with shell lengths between 37 to 45 mm took 5-14 minutes in resurfacing themselves. There were whelks, however, which responded fairly fast, that is within 4 seconds of bait introduction into the tank. A pattern observed for a
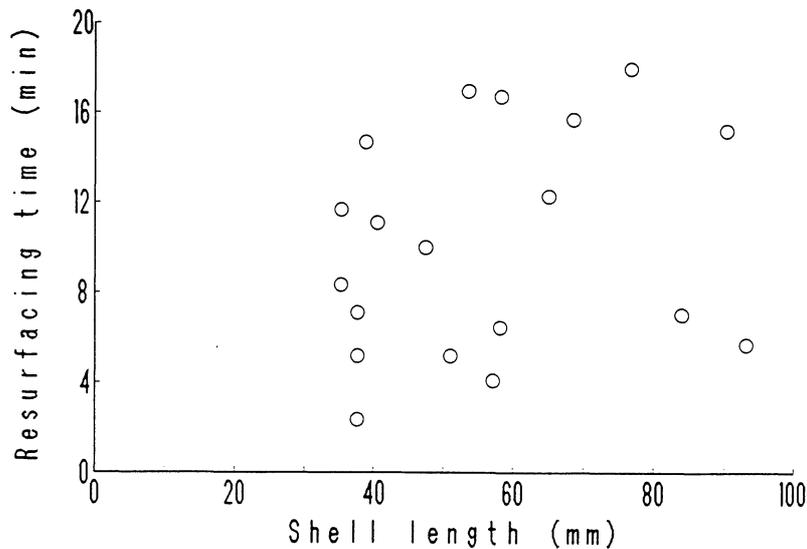

Fig. 9 Relationship between the shell length and resurfacing time of whelks.
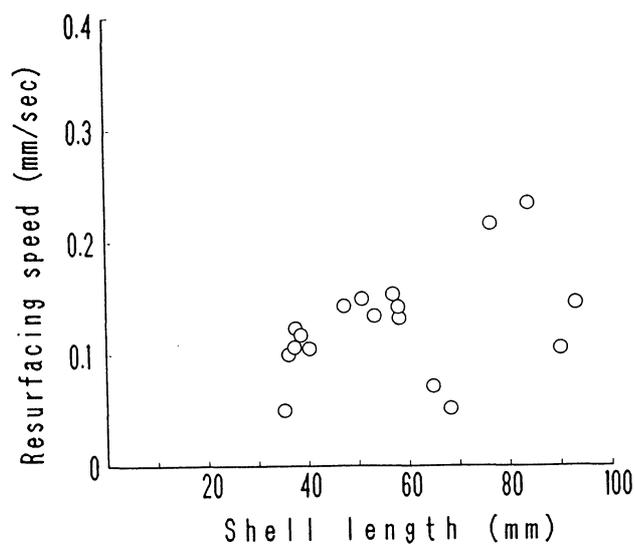

Fig. 10 Relationship between the shell length and resurfacing speed of whelks.

full digging and resurfacing cycle of a 93.4mm and 72.6mm whelk is shown in Fig. 11 and Fig. 12 respectively. For this particular whelk continuous recording was taken. This cycle was recorded when the whelks burrowed themselves and after two hours, bait was released and resurfacing took place. There were cases when some whelks spent more than 4 days at one particular position without showing any movement.

From this experiment it was seen that smaller whelks resurfaced faster than the larger ones.
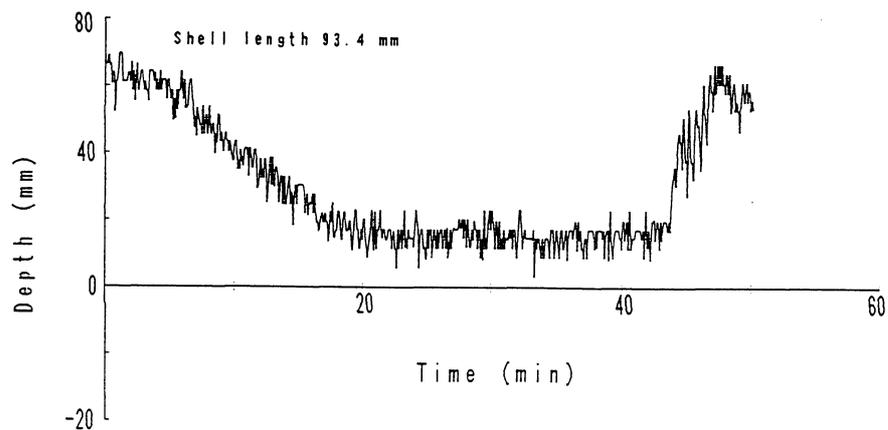
Fig. 11 Complete digging and resurfacing cycle of a 93.4mm whelk.
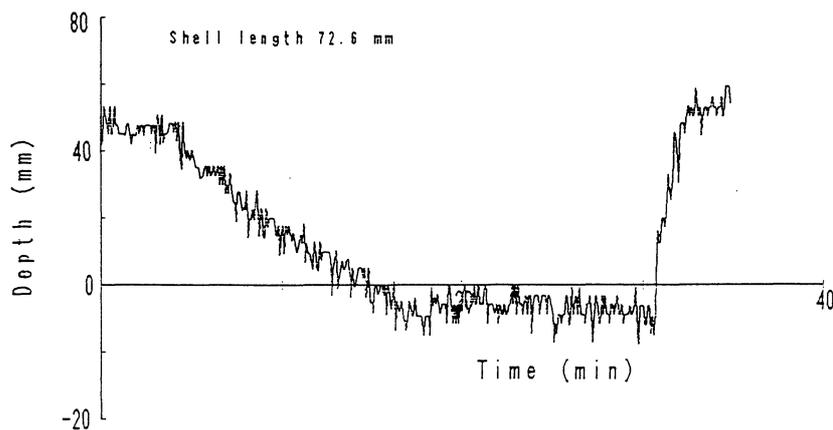
Fig. 12 Complete digging and resurfacing cycle of a 72.6mm whelk.

Discussion

Indepth studies have been undertaken for the burrowing mechanism of bivalves and gastropods, however, the resurfacing mechanism of bivalves or gastropod have not been widely covered. Hydrostatic mechanism, string method[14], and clampers method have been used in studying burrowing mechanism of mollusks.

In the resurfacing of whelks it was seen that even though large whelks were partly buried, the surfacing speed was slower than that of whelks less that 40mm in shell length. On occasions, however, whelks of shell length 60-70mm had resurfacing speed of less than 0.1 mm/sec.

When the odour plume was present at a distance of 15cm from the buried place of whelks, the fastest response to resurface was 4 seconds made by a 93.4mm whelk. With the increase in area of attraction the whelk will have to overcome the different conditions of sea bed as well as the drag. This resurfacing data could be used to minimize the ingress time of whelks with baited traps. The environmental factors could not be altered, however, the trap could be improved so that the attracted whelks spend the least time available to get into the trap.

From the laboratory experiment it was seen that whelks responded to the odour plume within seconds of bait release in the water column and began to resurface.

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