

A New Design of an Apparatus for the Observation of *Nautilus*

Yoshiko Kakinuma¹⁾ and Michihiro Tabata²⁾

1) Department of Biology, Faculty of Science, Kagoshima University, Kagoshima 890, Japan

2) Kagoshima Aquarium Public Corporation, Kagoshima 890, Japan

Abstract

It is often seen that when *Nautilus* are kept in an aquarium, the water gets fouled and makes it difficult to maintain good quality of water in the tank. To prolong the recording of the breeding, spawning and predatory behavior of *Nautilus* and to keep good quality of water in the tank, a new design of breeding apparatus was used. By the help of this device, food particles were successfully removed and this made it easier to clean the tank. Also, the water temperature was maintained by a series of *Nautilus*.

Introduction

Breeding and exhibition of the Nautilus, a living fossil, have been recently carried out at several aquaria in Japan. However, because the circumstances of breeding and keeping the nautilus seem not to reach a satisfactory level, every nautilus in these aquaria does not retain its original vitality. We observed that, because the nautilus is an abyssal fauna, the temperature of the sea water must be kept constantly low (below 20°C even in summer) and the sea water soon gets polluted by a great amount of excretion. Accordingly, we set up a new breeding device design to eliminate these problems. By controlling the supply of natural sea water and by cooling the whole apparatus, the water temperature of a compact water tank is kept at 14°C in winter and 18°C in summer. Consequently, we succeeded in observing Nautilus's breeding, spawning, and predation behavior over a long period of time. In the present paper, we would like to report on the design and function of our apparatus.

Breeding device of Nautilus (Shown in Fig 1)

- 1) A breeding box (1) to which a heat insulator is affixed contains the whole breeding device and the box (1) is cooled by an air conditioner II (7)
- 2) The front surface of a breeding tank (2) in the box (1) is covered by transparent plates of vinyl chloride. There are two plates, each 1 mm in thickness, forming a sealed air layer between them which is effective against the misting of the glass, and in heat insulating.
- 3) The natural sea water is supplied to the breeding tank (2) through a tank filter (3) after cooling primarily in a drain tank (4).
- 4) The following parts are all installed outside of the breeding box (1): the radiators of the air conditioners I (6) and II (7), a motor of the pump (5), a

condenser of the lighting equipment, and an air pump.

The above mentioned apparatus made it possible, as shown in (case 1), that, when 1152 ℓ /day (about 7 turns/day and natural sea water at 25°C is supplied, the temperature of the supplied water to the tank filter (3) becomes 22°C (3°C lower) due to the primary cooling in the drain tank (4) and consequently the temperature in the breeding tank (2) is maintained at 14°C the temperature of the natural sea water was 28°C in summer, the temperature in the breeding tank could be maintained at 18°C.

(Case 1) September 27, 1987

amount of supplied water: 800 ml/min. = ℓ /h = 1152 ℓ /day
= 7 turns/day = 165 ℓ /turns

Temperature of supplied water (Natural sea water): 25°C

Temperature of supplied water (after primary cooling): 22°C

Water temperature in the breeding tank: 14°C

(Case 2) October 25, 1987

Amount of supplied water: 1000 ml/min. = 60 ℓ /h = 1440 ℓ /day
= 9 turns/day = 1160 ℓ /turns

Temperature of supplied water (Natural sea water): 24°C

Temperature of supplied water (after primary cooling): 21°C

Water temperature in the breeding tank: 14°C

(Case 3) July, 1988

Pumping water (168 ℓ) in and out of the breeding tank (2)

Amount of supplied water (pump): about 17 ℓ /min. = 1000 ℓ /h
= 24 t/day

Amount of natural sea water supplied: 0.8 ℓ /min. = 48 ℓ /h
= 1152 ℓ /day ~ 2.5 ℓ /min. = 150 ℓ /h = 3600 ℓ /day

The sea water is pumped directly from the sea and filtered through urethane.

The breeding tank contains 168 ℓ of sea water and the specifications are shown above. The changing rate of the water supplied by the pump (5) is approximately 6 turn/h and that of natural sea water is about 7 - 21 turn/day.

The water is supplied downward from a faucet which was placed just inside the water surface at the right- front side of the breeding tank. There are two reasons to do : first, because in the previous experiment we found some Nautili had lost their trim control so in order to avoid this we designed the system to prevent bubbles being generated in the tank. Second this system was also designed to produce currents in the tank. Since the direction of the supplied water is from the down right front, the main stream goes from down to up in the diagonal far left side and consequently a rotational stream is created in the tank.

The water in the breeding tank is drained from an overflow set on the top left corner of the tank Fig. 1 (a).

As has been mentioned above, there is a rotational stream in the tank and therefore excrements and small food - residues are almost completely drained away in twenty or thirty minutes. As a result, only big residue of food, such as fish bones and shells remain in the tank. Thus pollution hardly occurs and it is easy to clean the tank.

Five cylindrical tubes made of transparent polystyrene ($\varnothing 60 \times 100$) with small holes are set, as spawn nests, on the right hand corner of the breeding tank Fig. 1 (a). This place is far from the main rotational stream and free from excrement pollution and small food residues.

Maintenance of the tank filter

All sea water overflowing the breeding tank (2) drains into the first filter in the rear side of the tank filter and the water runs through a net and urethane filter. The same amount as that of the supplied natural sea water drains from the bottom of the first filter into the drain tank (4). The rest of the sea water passes through the first filter, mixes with fresh sea water, runs through urethane and sand filters, and then is cooled by a heat exchanger of the air conditioner I (6). The sea water is finally pumped into the breeding tank (2) through suction filter.

Since lumps of excrement and food residue accumulate in the first filter, the net must be washed with sea water every day (after detaching it from the vessel). On the other hand, the urethane filter may be washed with water once a week.

Cleaning of the whole tank filter is done once a month. In the season when the temperature of the natural sea water is higher, a valve in the breeding-tank-side, one of the two valves in the water-supply - side of the pump (5), will be closed, and a valve in the tank-filter-side, the other valve of the two, will be opened after cleaning; then the pump starts operating

Having established a closed circuit, the sea water circulates in the tank filter. The pump is run until the temperature of the sea water is the same as that in the breeding tank. After cooling, the valves return to their normal position, then the sea water is supplied into the breeding tank (2).

- (1) Breeding box W: 180cm D: 75cm H: 120cm

Material of outer frame: concrete panel, 12mm thick

Material of heat insulator: foam polystyrene, 10mm thick

- (2) Breeding tank W: 56cm D: 47cm H: 64cm

Effective volume: approx. 168 ℓ

(Made of acrylic)

The spawning nest ($\varnothing 60 \times 100$; made of transparent polystyrene with small holes) is set on the upper right corner.

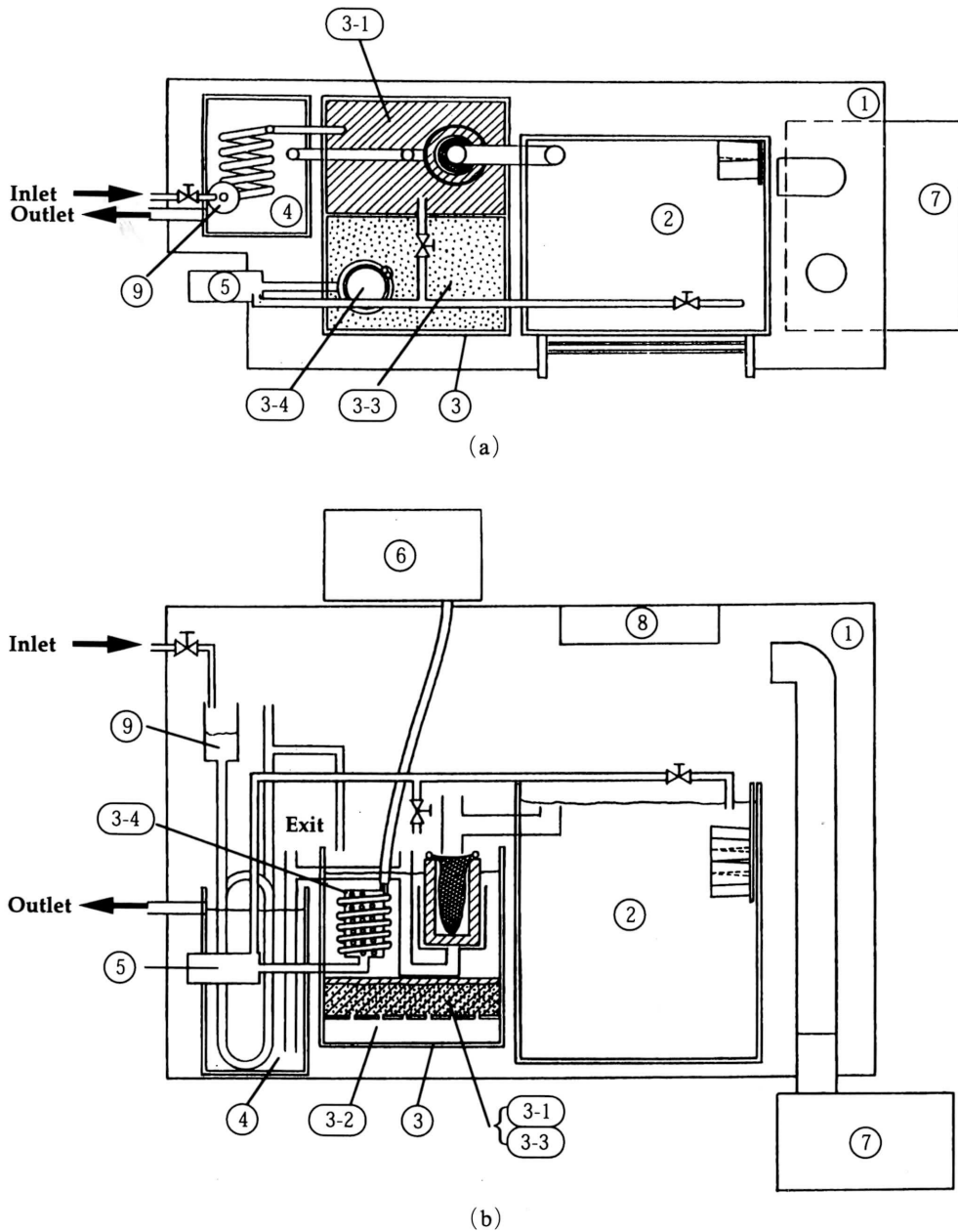


Fig. The breeding apparatus system
(a) A top view (b) A side view

(3) Tank filter W: 45cm D: 60cm H: 50cm

A half (rear) part: urethane filter, 10cm thick, and a cylindrical filter (consists of net and urethane) set on the upper part.

The other half (front) part: quartz sand (2-4mm grain) 5cm deep on the bottom. The air conditioner I, a heat exchanger, and suction filter of the pump are

set on the upper part.

(4) Drain tank W: 25cm D: 35cm H: 47cm

A heat exchanger titanic tube: ($\emptyset 16 \times 10\text{m}$) set in the tank; one end is a receptor and the other leads to the tank filter. The supplied water is cooled primarily by draining.

(5) Pump

REI- SEA

RMD-15 (rated output 10w)

17 ℓ /min. (pressure head ℓ m/hour)

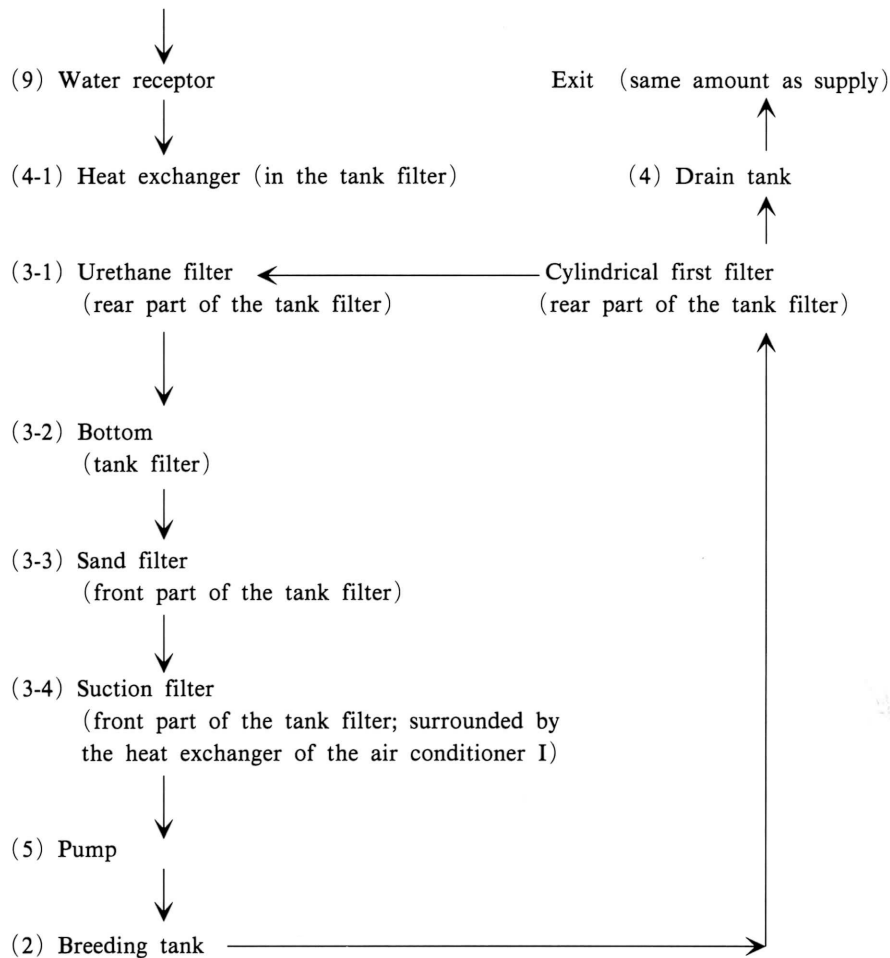
(6) Air conditioner I

TOYO LAB COOL LC - 130E (compressor: 130w)

Used for cooling the sea water in the tank filter (3)

The route of the sea water

(8) Valve for water supply (natural sea water)



- (7) Air conditioner II
Type unknown (for refrigerator) (compressor: 200w)
Used for air conditioning the breeding box (1).
- (8) Lighting equipment
10w fluorescent lamp covered with blue color filter (vinyl chloride plate 1mm thick)
- (9) Valve
for supplying the natural sea water.