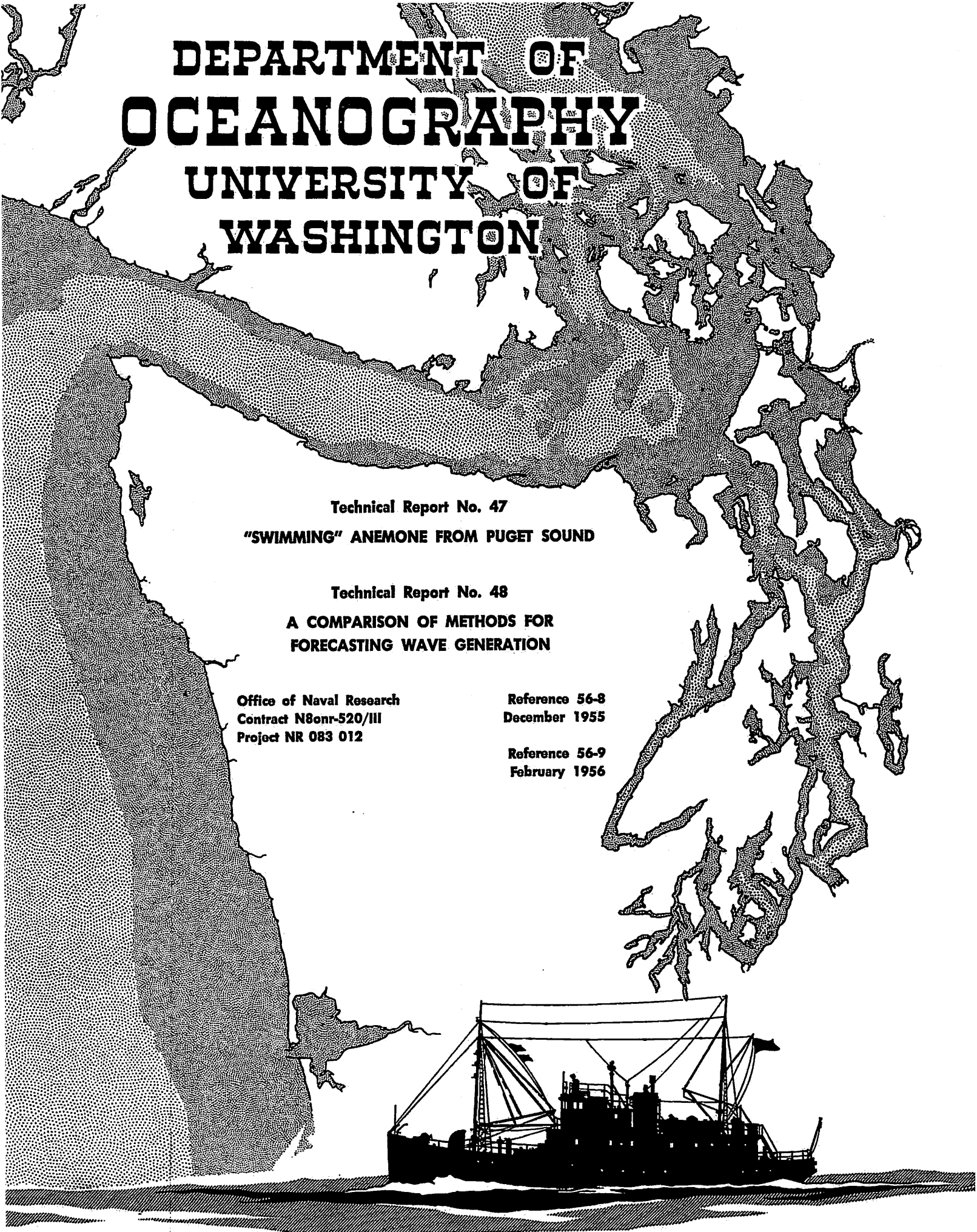
DEPARTMENT OF OCEANOGRAPHY
UNIVERSITY OF WASHINGTON



Technical Report No. 47

"SWIMMING" ANEMONE FROM PUGET SOUND

Technical Report No. 48

A COMPARISON OF METHODS FOR FORECASTING WAVE GENERATION

Office of Naval Research
Contract N8onr-520/III
Project NR 083 012

Reference 56-8
December 1955

Reference 56-9
February 1956

SEATTLE 5, WASHINGTON

UNIVERSITY OF WASHINGTON DEPARTMENT OF OCEANOGRAPHY
Seattle, Washington

Technical Report No. 47

"SWIMMING" ANEMONE FROM PUGET SOUND
by
Charles S. Yentsch and Donald C. Pierce

Technical Report No. 48

A COMPARISON OF METHODS FOR FORECASTING WAVE GENERATION
by
Maurice Rattray, Jr. and Wayne V. Burt

Office of Naval Research
Contract N8onr-520/III
Project NR 083 012

Reference 56-8
December 1955

Reference 56-9
February 1956

1/ Richard H. Fleming
Executive Officer

"SWIMMING" ANEMONE FROM PUGET SOUND

by
Charles S. Yentsch and Donald C. Pierce

Abstract

Several specimens of an anemone identified as Stomphia coccinea were found to free themselves and exhibit a spasmodic swimming motion in response to contact with one of the following starfish: Crossaster papposus, Hippasteria spinosa, or Dermasterias sp.. Spasmodic swimming response could also be produced by stimulating the animal with alternating current at 15 to 25 v. and 7.5 amps, or by immersing it in sea water containing mucoid slime of Dermasterias sp.. No swimming response occurred when one of the asteroids Solaster sp., Mediaster aequalis, Henricia leviuscula, Pisaster sp., Evasterias sp. or any ophiuroid, was used.

Reprinted from SCIENCE, December 23, 1955, Vol. 122, No. 3182, pages 1231–1233.

"Swimming" Anemone from Puget Sound

Extensive dredging operations have been carried out in recent years by the department of oceanography of the University of Washington in a study of the distribution and assemblage patterns of plants and animals in Puget Sound. While dredging was being carried out in an area north of Seattle, collections were made of several specimens of an anemone identified by Cadet Hand of the University of California as *Stomphia coccinea* (*1*). These animals were placed in aquariums that are provided with a constant flow of filtered sea water maintained at a temperature of 10°C, the approximate mean surface water temperature in Puget Sound.

By accident it was discovered that the attached anemones would free themselves and exhibit a spasmodic "swimming" motion in response to immediate contact with certain starfish. Preliminary experimentation showed that the swimming response occurred when one of the following starfish—*Crossaster papposus, Hippasteria spinosa,* or *Dermasterias* sp.—was placed in contact with the anemone, whereas no swimming response occurred when one of the asteroids *Solaster* sp., *Mediaster aequalis, Henricia leviuscula, Pisaster* sp., *Evasterias* sp. or any ophiuroid, was used.

Further investigation showed that the spasmodic swimming response could be produced by placing electrodes one on each side of the column and stimulating the animal with alternating current at 15 to 25 v and 7.5 amp. Sea water containing the mucoid slime of *Dermasterias* sp. also elicited the same response. However, parts of other asteroids gave no positive results—for example, direct contact with the amputated arm of *Crossaster* elicited no response. The swimming action has been photographed on 16-mm Kodachrome film (*2*). Figure 1 is a schematic representation of the pertinent activities involved in the swimming response; Fig. 2 is a series of single frames from the film. Briefly described, the swimming procedure is as follows.

1) When the starfish is placed on the oral disk, the anemone partially contracts. This contraction is concentrated in the oral disk and occurs very rapidly (Fig. 1*B*).

2) In 2 to 3 seconds the oral disk, column, and tentacles extend fully.

3) After complete extension, the anemone begins a series of whirling motions, with the oral disk circling around the oral-aboral axis (Fig. 1*C*). One complete rotation takes approximately 1 second. After one or two rotations, the movement changes to a spasmodic, side-to-side movement of the oral disk and the upper part of the column.

4) Detachment from the substratum then generally occurs.

5) The swimming motions of the anemone involve a combination and intensification of undulatory movements of the oral disk, the column, and the base (Fig. 1*D* and Fig. 2*A,B,C*). Considerable thrashing is needed for any extensive progressive movement, suggesting that this mode of "swimming" is very inefficient. The direction moved appeared to be random. The longest distance traveled in a straight line that was observed during one swimming operation was 80 cm. Since this movement lasted 58 seconds, the anemone moved through the water at a rate of about 1.5 cm/sec. While the organism is actively swimming, the base is considerably distended and dome-shaped. At the center of the base is a conspicuous papillalike structure that appears to be important in facilitating quick detachment (Fig. 2*D*). Serial sections are being prepared to reveal whether there is a possible connection between the coelenteron and the underside of the basal disk through an aperture at the end of the papilla.

6) During swimming operations, the base of the anemone will sometimes touch the substratum, evoking an increase in the activity so that the animal may make several such momentary contacts before coming to rest.

7) With the cessation of the swimming motions, the anemone settles to the bottom, still fully extended, and comes to rest on its side. After a minute or two the elongated column flexes, the base at-

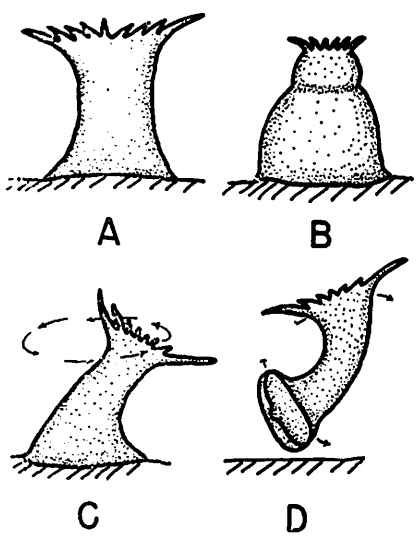


Fig. 1. Pertinent activities involved in detachment and "swimming" by the actinian *Stomphia coccinea.* (*A*) Anemone before contact with the starfish; (*B*) contact with starfish with the anemone partially contracting and a conspicuous sphincter constriction occurring near the oral end of the animal; (*C*) "whirling" motion of the anemone just prior to detachment; (*D*) complete detachment.

Fig. 2. Swimming motion of the anemone *Stomphia coccinea* shown in series of four frames from a motion picture (*2*). The time lapse between the first and third frame is approximately 40 seconds. In bottom frame note protruding pore in the basal disk.

taches to the substratum, the animal rights itself, and the normal resting posture is resumed.

It is interesting to note that the immediate contact of the starfish apparently stimulates the swimming response to completion—there are no partial modifications. It may be that this complex reflex behavior is initiated by the anemone's chemoreceptors after stimulation by some substance from the starfish. This dramatic swimming reaction might be interpreted as an escape mechanism, since it is known that *Crossaster papposus* has been observed to feed on anemones (*3*). However, in the aquariums, during the course of these experiments, none of the species of starfish studied have been observed to feed on this or any other anemone. In addition Stevenson (*4*) observed that *Stomphia* became "restless, jerked and detached" when subjected to adverse conditions, such as the warming of the water within the aquarium.

Periodic locomotion involving creeping motions of portions of the pedal disk is rather common among actinians. Pantin and coworkers have shown that this type of locomotion, termed "walking," may be correlated with some stimulus in *Metridium*. Usually the walking response ensues after the animal has been stimulated adversely (*5*). Because of the long time periods required for this and other actinian responses, Batham and Pantin have termed them phasic.

The swimming response of *Stomphia* has obvious contrasts. (i) The activity is of a much shorter duration. (ii) The swimming activity requires the specific stimulus of the immediate presence of certain starfish or some substance from the starfish. (iii) The site of greater sensitivity of this stimulus appears to be in the region of the oral disk. Electric shocks applied midway on the column evoked the swimming response, but the means by which the sensory apparatus in the oral end of the animal is excited by the electric impulse is not understood. (iv) The swimming response appears to have a rather specific threshold of stimulation. But to divorce this response completely from all phasic activity one would have to establish the existence of a specific receptor-effector mechanism for this response that could operate independently of phasic activities. The existence of such a mechanism in the simple actinian nervous system does not seem probable. A possible answer might be that the swimming response is a combination of accelerated phasic activities.

Figure 1 shows that the general motions of *Stomphia* are the same motions found in slower phasic activity. Likewise, this sequence of movements closely resembles that of the feeding activities of *Metridium senile* as described by Batham and Pantin. Therefore, the swimming response may be all the typical phasic activities in sequence accelerated to a high degree by the presence of the starfish or the starfish substance.

Further work is in progress at these laboratories; special emphasis is being placed on the description of the neuromusculature system of this anemone.

C. S. YENTSCH
D. C. PIERCE

Department of Oceanography, University of Washington, Seattle

References and Notes

1. This work was partly supported by Office of Naval Research contract N8onr-520/III with the University of Washington (Contribution No. 190 from the Department of Oceanography.) Acknowledgment is extended to Richard H. Fleming, executive officer, for the use of the departmental facilities; to M. P. Wennekens and E. E. Collias for their technical assistance, and to L. M. Passano and D. L. Ray for their many helpful suggestions during the preparation of this report.
2. Four copies of this film are available, two at the Department of Oceanography and two at the Department of Zoology, University of Washington, Seattle.
3. H. M. Milligan. *Nature* 96, 619 (1916).
4. T. A. Stephenson. *The British Sea Anemones* (Ray Society, London, 1935), vol. 2.
5. E. J. Batham and D. F. A. Pantin, *J. Exptl. Biol.* 27, 377 (1950).

22 July 1955