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DUAL MECHANISMS OF ENERGY INPUT INTO AN OYSTER FARM AT THE PENG-HU ISLANDS

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Lee-Shing Fang and Jiang-Shiou Hwang (1987) Dual mechanisms of energy input into an oyster farm at the Peng-Hu islands. *Bull. Inst. Zool., Academia Sinica* **26**(2): 157-163. Large scale investigations in an ocean farming area had demonstrated that oysters effectively collect plankton and other particulate organic matter from the water flowing through the area and by their fecal deposite transfer material and energy to the benthic communities below. Also, benthic algae was found blooming in waters as deep as 9 to 14 meters directly under the oyster bed which was suggested to help recycling nutrients in the ecosystem and provided a food source for other organisms. Based on these findings, a model proposing dual mechanisms for energy input into the oyster bed system through both filter-feeding oysters and benthic algae is presented for the first time.

The oyster, a filter-feeder, collects the disperse particulate organic matter (POM) in the drifting water, channels energy and nutrients down to the underlying area, amplifies nutrients sink in the local area, promotes the development of benthos, and sustains the biomass at higher trophic levels. However, there is very little *in situ* informations on how the oysters and benthos interact with each other. In this reasearch, concept of the oyster as a "biological concentrator of energy flow" and how this influence the benthos were examined in an experimental ocean farming area at the Peng-Hu Islands.

The Peng-Hu Islands, located in the middle of the Taiwan Strait, are fairly barren land without heavy vegetation and rivers (Fig. 1). The ocean current flowing into the strait is very little influenced by land discharges. A large oyster culture area (650 hectares) was assigned for experimental ocean farm beginning in 1982. The length of the suspended oyster culture rope was about 5 meters below the water surface. Nutrients, chlorophyll a (Weitzel 1981), ATP content (Lumac 1980; Hendzel and Healey 1984), sedimentation rate, POM in the water, organic matter contents of sediment (Meyer-Reil 1983), density and composition of benthos, composition of bottom soil, as well as the conditions of the ocean (e. g. wind velocity, current, tide, D. O., pH, salinity, temperature) were monitored for one to three years. The depth of water in the survey area was 9 to 14 meters.

The amount of chlorophyll a in the water coincided with the rhythm of oyster culture, i. e., highest when there were no oysters during winter and decreased as oysters grew during

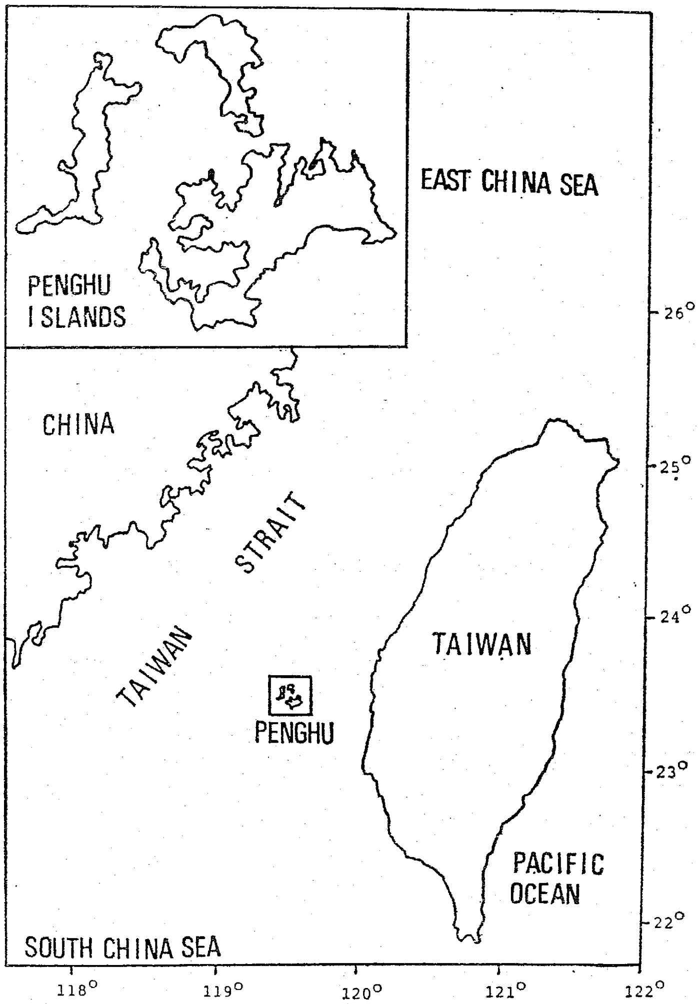


Fig. 1. The location and the study area of the Peng-Hu Islands (Pescadores).

the warm season. Phytoplankton data (5–10 yr) taken extensively from waters of both north and south Taiwan Strait showed the presence of small algal blooms in spring and autumn followed with a winter depression (Su *et al.* 1984a. b.). However, in the present study there were no such blooms in the farm during the oyster season, indicating that the massive oyster assemblage effectively filtered out the phytoplankton. Much of this energy was further transferred to the bottom of the water in the form of fecal pellets (Fig. 2). Data collected from sediment traps under the oyster bed infer a deposition rate of 15 gm/m^2/day of total organic matter during the culture period and 6.5 gm/m^2/day during winter after oyster harvesting. The stronger winter wind (Fig. 2), by resuspending bottom sediments, contributed proportionately more to the winter estimate of deposition rate (Carper and Bachmann 1984). The very high flux of organic matter from surface to bottom in warm seasons, no doubt, resulted from efficient biological activity of the oyster.

Dense benthic algae (*Nevicula* spp.) were found blooming on the sea bottom at 9 to 14 meters deep only directly under the oyster bed from December to March (Fig. 3). The bottom water was turbid, dimly lighted, visibility within 50 cm, temperature around 19°C. The bottom was fairly muddy, composed of 48% sand, 49.5% silt, and 2.5% clay.

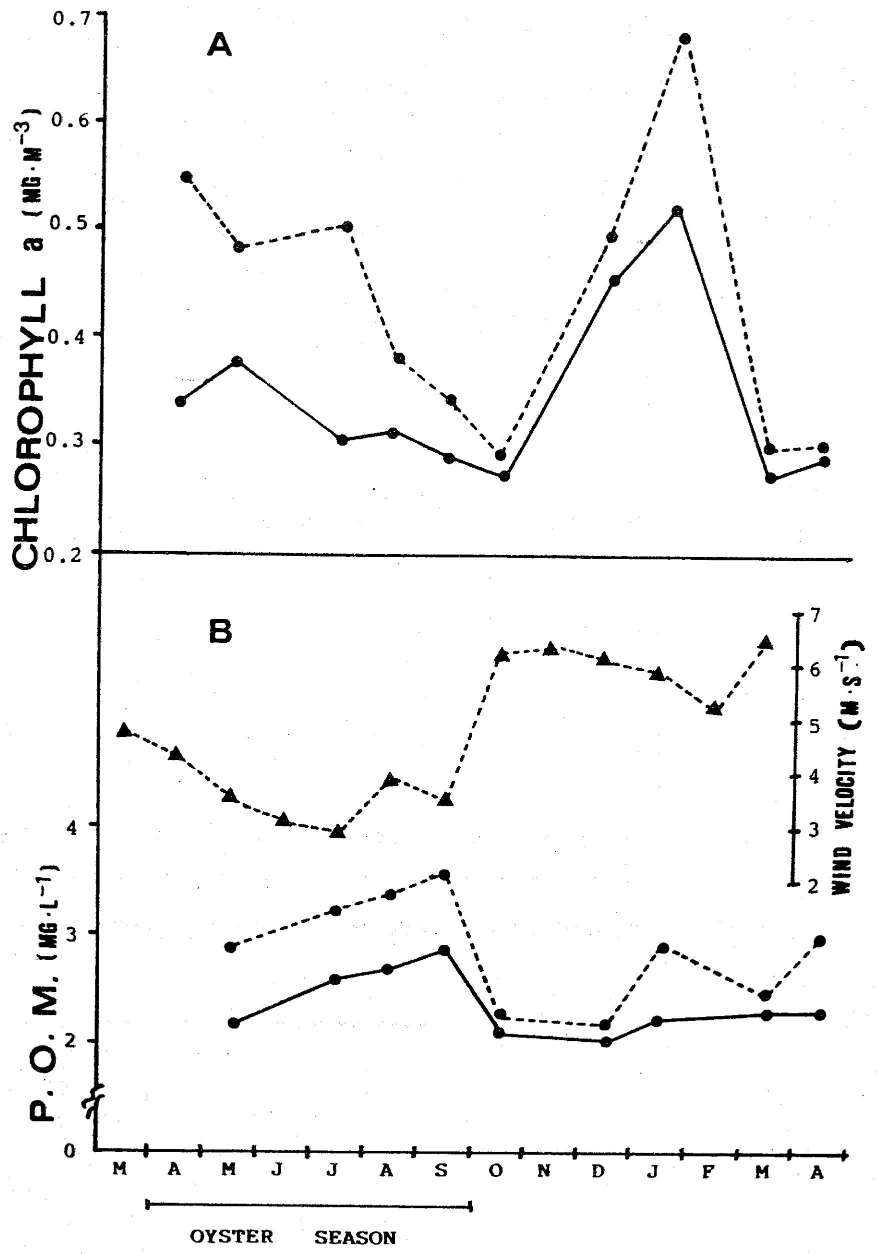
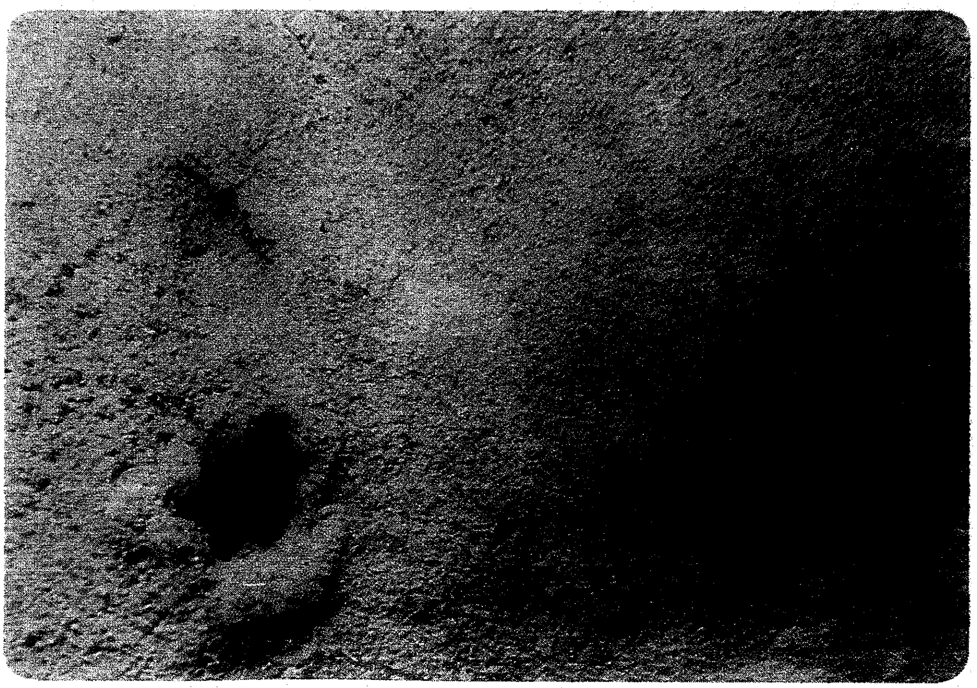


Fig. 2. Seasonal changes in parameters of water samples taken from the oyster farm at a depth of 1 meter (●——●) and 6 meters (●----●)
(A) Chlorophyll a (B) Particulate Organic Matter

The finding of thick benetic algae blooming in such deep water provides direct evidence for the speculation by Graf *et al.* (1982) that an estimation of annual budget of benetic activity in the shallow water ecosystem requires other sources of organic carbon such as benthic primary production in addition to vertical transport of particulate organic matter.

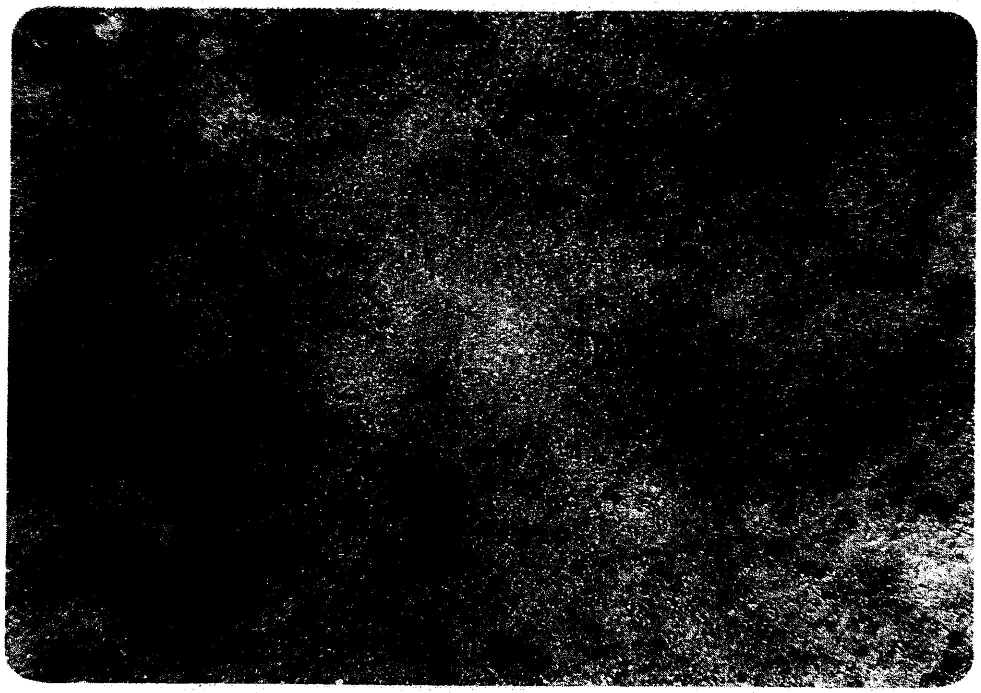
The density of macrobenthic crustaceans and gastropods was positively correlated with sedimentation rate of organic matter, decreasing during the winter. On the other hand, the number of polychaetes increased during the

(A) During oyster season (July)



(B) Early algal bloom (December)

Fig. 3. Photographs of bottom areas under oyster beds.



(C) Peak of algal bloom (February)

(D) Decline in algal bloom and action of benthic fauna (March)

Fig. 3. Photographs of bottom areas under oyster beds. (continued)

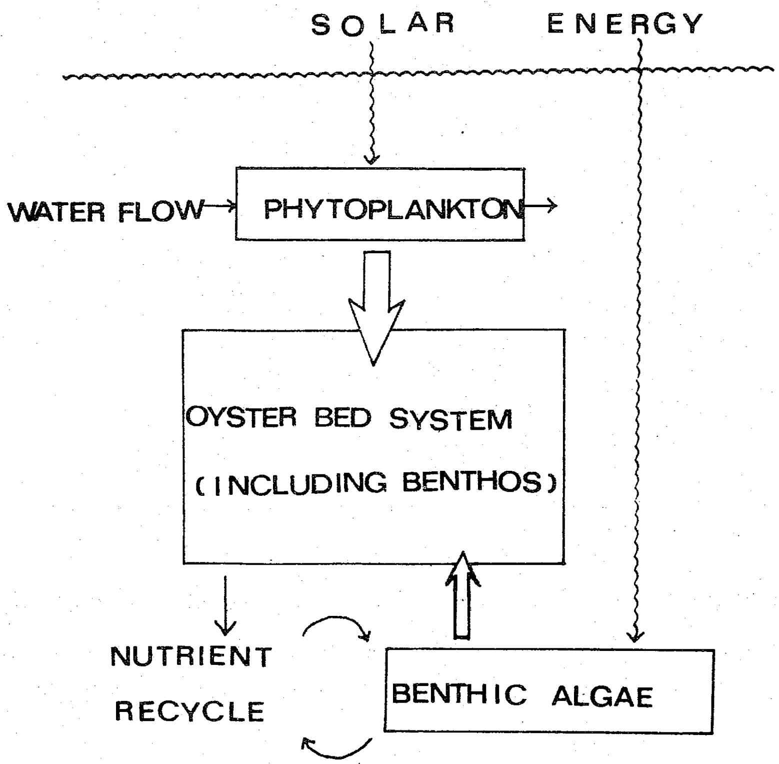


Fig. 4. A model of dual channel energy input system for oyster farm.

winter with blooming of the benthic algae. Polychaetes have been reported to utilize benthic algae (Montagna 1984).

An energy flow model for an oyster reef has been proposed (Dame and Patten 1981; Patten and Higashi 1984). The energy input into this system was suggested to be one channel, i.e., through the filtration of POM by the oysters. However, the present authors proposed a second channel of energy input through the blooming of benthic algae. These algae function like a pump, driven by the dim sunlight, recycling the sedimented nutrients to produce more organic materials (Fig. 4). This do-loop not only makes the most efficient use of the high concentration of nutrients on the sea bottom, but also provides high quality of food for benthic communities. This is especially helpful since the blooming occurs during winter, a time of short food supply. Dame *et al.* (1984) have speculated that there may be a viable feedback loop between the primary producers in the water column and the oyster reef. The finding of the blooming benthic algae have provided the first direct evidence for this speculation.

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澎湖牡蠣養殖區雙向能流模式之研究

方力行　黃將修

在牡蠣養殖區的大型野外調查顯示牡蠣有效的濾取了海水中的植物性浮游生物，並將其有機能量傳導至底部，尤其在調查中首次發現底藻在牡蠣床正下方 9 至 14 公尺深的海水中也能繁茂生長，不但提供了底棲生物糧食，更利用了微弱的陽光，加速了底部營養鹽的循環。根據這些資料，我們首次將牡蠣床能流模式由以往的單向流入改變成雙向能量模式。