Harmful Algal Blooms and their Global Expansion

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Two types of harmful algal blooms (HABs) by unicellular microalgae have been known to occur in coastal waters and impact marine environments and development of utilization of coastal area. The first one is noxious algal blooms which kill marine organisms, especially fish in aquaculture cages and shellfish hanged from rafts. The other is contamination of fish and shellfish by toxins produced by microalgae, which can sometimes causes human poisoning.

HAB occurrences and their ill consequences have increased in frequency, intensity and geographic distribution in the last two decades. The cause of the expansion has been suspected due to;

1. Expansion of harmful microalgae;
2. Increase in cell numbers during the blooming of previously hidden flora;
3. Development of fish and shellfish aquaculture, providing more chances of harmful impacts;
4. Increase of information concerning ill consequences of harmful algae; and
5. Advance in methodology, leading to the detection of new harmful events.

The No. 1 cause, invasion to new areas, is brought by natural mechanisms such as water current, but rather quick recent expansions suggest the implication of anthropogenic activities. Transfer of catch and seedling in fisheries may be one of the important mechanisms, as harmful microalgae attach to them. Discharge of ballast water by cargo ships during their voyage and at ports may also enhance invasion. The No. 2 cause, bloom of hidden flora, may be caused by changes of environmental conditions such as nutrient levels by man-made activities or global long-term environmental changes such as El Nino -Southern Oscillation (ENSO).

The main cause of occurrence and recurrence of certain species in certain areas may vary by the topology of the area and the nature of the species. In eastern and southeastern Pacific countries, there are several harmful microalgae occurring widely throughout the area such as *Pyrodinium bahamense*, *Alexandrium* spp. *Gymnodinium catenatum* and *Gambierdiscus toxicus*. International cooperative scientific research has just started with the initiative of Ocean Research Institute (ORI) to address their blooming mechanism and driving environmental factors.

Osmoregulation during Early Life Stages of Fish

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In my presentation, recent advances in the study of osmoregulation in early life stages of fish are reviewed with special reference to extrabranchial chloride cells. Teleost fish maintain ion concentrations and osmolality of the body fluid at levels different from external environments. In adult fish, the gills, kidney and intestine are important osmoregulatory organs, creating ionic and osmotic gradients between the body fluid and external environments. In particular, gill chloride cells function as the salt-secreting site in seawater (SW) fish, and probably as the ion-absorbing site in freshwater (FW) fish. In fish embryos and larvae, however, those osmoregulatory organs in adult fish are not yet developed or not fully functional. Nevertheless, embryos and larvae are also able to maintain ionic and osmotic gradients. In early life stages of fish when the gills are not yet developed, chloride cells are mainly distributed in the yolk-sac membrane, which covers the yolk. As the fish develop, the functional site of chloride cells shifts from the yolk-sac membrane to the gills.

Numerous chloride cells are present in the yolk-sac membrane of Mozambique tilapia embryos and larvae adapted to FW and SW. Chloride cells in SW often form multicellular complexes together with adjacent accessory cells, whereas chloride cells exist individually in FW. The chloride test and X-ray microanalysis have shown that the SW-type, chloride cell complexes have a definitive function of chloride secretion. According to *in vivo* sequential observations of chloride cells in the yolk-sac membrane of tilapia, single FW-type chloride cells are transformed into multicellular SW-type cells in response to SW transfer, suggesting plasticity in the ion-transporting functions of chloride cells. Recently, we have established a unique *in vitro* experimental model named a "yolk-ball" incubation system, in which the yolk sac is separated from the embryonic body and subjected to *in vitro* incubation. In the yolk balls prepared from FW tilapia embryos, chloride cells form multicellular complexes after SW transfer, indicating that chloride cells are equipped with an autonomous mechanism of functional differentiation, independent of embryonic endocrine and nerve systems. The yolk-ball incubation system definitely serves as an excellent experimental model for further studies on chloride cell differentiation and functions.

Biology and Aquaculture of Bivalves in the Tropical Pacific Region

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Bivalve molluscs (Phylum Mollusca, Class Bivalvia) are common animals in coastal habitats in almost all geographical areas. The group includes oysters, clams, mussels, cockles, arkshells and the like, inhabiting a variety of microhabitats in the coastal zone.

In addition to forming an important part of the coastal ecosystem a large number of these bivalves are fished for human consumption. For many coastal communities, such as those of Pacific islands, they form an integral part of the diet. Due to the demand for these species and the prices they fetch, they are major aquaculture animals around the world. According to Food and Agricultural Organisation data (FAO, 1998) total global production of bivalve molluscs, excluding pearl oysters, in 1998 was 8.02 metric tonnes worth a staggering US$7.9 billion. Table 1. Below shows the level of production of different bivalve groups in 1998 (FAO, 1998).

In the Pacific region, Australia and New Zealand are the major producers of bivalves through aquaculture. Most of the island nations of the Pacific, except Cook Islands and French Polynesia, do not have bivalve aquaculture industries of any significance, however, successful breeding and hatchery rearing of some bivalves has been accomplished by several of these countries. Cook Islands and French Polynesia have been most successful in the culture of Blacklip pearl oysters. New Caledonia is the only country in the Pacific that has been producing edible oysters of the species, *Crassostrea gigas* (Pacific oyster) through aquaculture. Table 2 below lists some of the countries of the Pacific, including Australia and New Zealand, and the bivalve species which are being bred or cultured in these countries.

The aquaculture of most bivalves is based on a very simple principle which involves collecting or gathering naturally produced larvae or juveniles (called spat) and then growing these spat to marketable size. The success of an aquaculture venture

Table 1. World production level of bivalve molluscs in 1998.

Bivalve	Production (metric tonnes)
Oysters	3, 537,830
Mussels	1, 377,830
Scallops, Pectens	874, 255
Clams, Cockles, Arkshells	2, 226, 025
TOTAL	8, 015, 940

Table 2. Some of the bivalve species cultured or hatchery produced in the Pacific Region and 1998 production level.

Countries	Bivalve species cultured or hatchery produced	Production in 1998 metric tonnes
Australia	*Ostrea* sp. (flat oyster)	—
	Crassostrea gigas (Pacific oyster)	3852
	Saccostrea commercialis (Sydney oyster)	5328
	Crassostrea sp. (other oysters)	26
	Mytilus planulatus (Australian mussel)	1482
	Pecten fumatus (scallop)	—
	Pinctada maxima (Silver lip pearl oyster)	—
	Pinctada margaritifera (Blacklip pearl)	—
	Tridacna sp. (Giant clams)	—
New Zealand	*Crassostrea gigas* (Pacific oyster)	13,000
	Perna canaliculus (Green mussel)	75,000
Cook Islands	*Pinctada margaritifera* (Blacklip pearl)	—
Fiji	*Perna viridis* (Mussel)	—
	Tridacna sp. (Giant clams)	—
	Pinctada margaritifera (Blacklip pearl)	—
	Pteria penguin (Winged pearl oyster)	—
Federated States of Micronesia	*Tridacna* sp. (Giant clams)	—
	Pinctada margaritifera (Blacklip pearl)	—
French Polynesia	*Mytilidae* (Mussel)	—
	Pinctada margaritifera (Blacklip pearl)	—
Kiribati	*Pinctada margaritifera* (Blacklip pearl)	—
New Caledonia	*Crassostrea gigas* (Pacific oyster)	45
Papua New Guinea	*Crassostrea rhizophorae* (Mangrove oyster)	5
Samoa	*Tridacna* sp. (Giant clams)	—
Solomon Islands	*Tridacna* sp. (Giant clams)	—
	Pinctada margaritifera (Blacklip pearl)	—
Tonga	*Tridacna* sp. (Giant clams)	—
	Pinctada margaritifera (Blacklip pearl)	—
	Pinctada maxima (Silverlip pearl oyster)	—
	Pteria penguin (Winged pearl oyster)	—