SHELLED MOLLUSCS

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Contents

Summary

Shelled molluscs are comprised of bivalves and gastropods. They are settled mainly on the continental shelf as benthic and sedentary animals due to their heavy protective shell. They can stand a wide range of environmental conditions. They are found in the whole trophic chain and are particle feeders, herbivorous, carnivorous, and predators.

Exploited mollusc species are numerous. The main groups of gastropods are the whelks, conchs, abalones, tops, and turbans; and those of bivalve species are oysters, mussels, scallops, and clams. They are mainly used for food, but also for ornamental purposes, in shellcraft industries and jewelery. Consumed species are produced by fisheries and aquaculture, the latter representing 75% of the total 11.4 millions metric tons landed worldwide in 1996. Aquaculture, which mainly concerns bivalves (oysters, scallops, and mussels) relies on the simple techniques of producing juveniles, natural spat collection, and hatchery, and the fact that many species are planktivores.

1. Introduction

1.1. Uses of Shellfish: An Overview

Since prehistoric times, humans have exploited molluscan resources for multiple purposes. Shellfish have been traditionally used for such various purposes as currency (e.g., the gold-ring cowry *Cypraea annulus*), magical and religious symbols (in India, the sacred chank *Turbinella pyrum* and especially its rare sinistral form is regarded as a divine symbol of success, peace, and prosperity), horns, containers (large gastropod shells of the genus *Melo* are used as scoops for salt or flour in markets of South East Asia and the Pacific, and to bail out the boats of the native fishermen), or even as tools in some isolated oceanic islands.

However, the search for food has constituted and still continues to form a major reason for shellfish exploitation. These are commonly collected or cultured nowadays to fulfil the high demand of the world market, as well as for local consumption by littoral dwellers. For many coastal populations of tropical areas, shellfish, as a substitute for fish, represents an important dietary component, especially for poor people.

Other reasons for shellfish exploitation include the use of shells as a raw material for mother-of-pearl or for lime in pottery glazes, poultry food additives, or for personal adornment. Some marine species are collected to supply the interests of collectors for beautiful objects, or as a source of pharmaceuticals: a toxin recently extracted from the venomous Caribbean gastropod *Conus ermineus*, could be used to counteract the effects of some myasthenias and of multiple sclerosis on muscle contractility.

1.2. Production

Shellfish landings in 1996 totaled around 11.4 million metric tons. Sixty-two countries worldwide were involved in aquaculture compared to 114 in fisheries for an 8.5 million metric tons aquaculture production (FAO data). The overall shellfish culture has increased by a factor of four in less than 15 years, while total shellfish fisheries landings have remained stable. However, several increases in production by aquaculture followed fisheries collapses (e.g., *Argopecten purpuratus*). Therefore, this has resulted in an increasing share of the total shellfish landings by aquaculture from 46% to 75% in 1984 and 1996, respectively. Among the 128 species of commercial interest, 64 species are produced by aquaculture, most of them being bivalves. However, most of the landings (62%) are based on three species, the Pacific cupped oyster *Crassostrea gigas* (34.4%), the Yesso scallop *Patinopecten yessoensis* (14.9%), and the Japanese carpet shell *Ruditapes philippinarum* (13.1%). Shellfish culture has been established primarily in coastal areas and estuaries that are environmentally sensitive. Therefore, overall landings are correlated with appropriate environmental management as well as cultural practices, production costs, and market demands.

2. Species and Fisheries

2.1. Diversity of Species

2.1.1. Edible Species

Fisheries usually concentrate on a limited number of species [See tables of major and regionally important commercial species of Gastropods and Bivalves]. However, a total of more than 1 500 species of shelled molluscs are currently collected for food in the world (including about 720 gastropods and 790 bivalves), mostly at the craft level. This is especially true in the tropics where biodiversity is highest, with many species typically constituting populations of limited stocks in relatively stable environmental conditions. In temperate areas, a higher food supply, linked with the rather high density of plankton typical of cooler waters, and unstable environments result in large populations of relatively few species of bivalves (like scallops, cockles, Venus clams) or herbivorous gastropods (abalones, periwinkles). This has allowed the development of industrial fisheries.

Gastropods

Scientific name	Common name	Main areas of production
Haliotis asinina*	Donkey's ear abalone	Philippines
*Haliotis corrugata**	Pink abalone	California, Mexico
*Haliotis discus**	Disk abalone	Korea
*Haliotis diversicolor**	Varicoloured abalone	Taiwan, Japan
*Haliotis fulgens**	Southern green abalone	California, Mexico
*Haliotis gigantea**	Giant abalone	Japan
Haliotis iris	Paua abalone	New Zealand
*Haliotis midae**	Perlemoen abalone	South Africa
Haliotis ovina	Oval abalone	Philippines, China
*Haliotis rubra**	Blacklip abalone	Australia
*Haliotis rufescens**	Red abalone	California, Mexico

*Haliotis tuberculata**	European ormer	France
*Trochus niloticus**	Commercial top	Tropical West Pacific
*Turbo cornutus**	Horned turban	Korea, Japan
Turbo marmoratus	Green turban	Indo-West Pacific
*Littorina littorea**	Common periwinkle	France, Ireland, Canada
Strombus galeatus	Giant Pacific conch	Mexico
*Strombus gigas**	Pink conch (Queen conch)	Tropical West Atlantic
Strombus gracilior	Pacific fighting conch	Mexico
Strombus luhuanus	Strawberry conch	Papua N.Guinea, Philippines
*Chicoreus ramosus**	Ramose murex	India
Concholepas concholepas	Barnacle rock-shell	Peru, Chile
Babylonia areolata	Maculated ivory whelk	Thailand, China
Buccinum undatum	European waved whelk	France,Ireland, UK,Canada
Busycon canaliculatus	Channeled whelk	USA, Mexico
Busycon carica	Knobbed whelk	USA, Mexico
Cymbium glans	Elephant's snout volute	Senegal
Cymbium pepo	Neptune volute	Senegal

Mussels

Scientific name	Common name	Main areas of production
*Aulacomya ater**	Cholga mussel	Peru, Chile
*Choromytilus chorus**	Choro mussel	Chile
Modiolus metcalfei	Yellowbanded horse mussel	Taiwan, Philippines
Modiolus philippinarum	Philippine horse mussel	Malaysia, Philippines
Mytilus californianus	Californian mussel	Mexico
*Mytilus coruscus**	Korean mussel	Korea, China
*Mytilus edulis**	Common blue mussel	Netherland, Spain,
*Mytilus galloprovincialis**	Mediterranean mussel	France, UK
Mytilus trossulus	Northern blue mussel	Italy, Greece, France
*Perna canaliculus**	Greenlip mussel	Canada, Alaska, Russia
Perna indica	Indian brown mussel	New Zealand
*Perna perna**	South American rock mussel	India
*Perna viridis**	Asian green mussel	Venezuela
		India, China, Taiwan, SE Asia

Oysters

Scientific name	Common name	Main areas of production
*Alectryonella plicatula**	Fingerprint oyster	China
Crassostrea belcheri	Belcher's cupped oyster	South East Asia
*Crassostrea columbiensis**	Cortez cupped oyster	Mexico, Panama
Crassostrea cuttackensis	Indian cupped oyster	India, Sri Lanka
Crassostrea gasar	African mangrove oyster	West Africa
*Crassostrea gigas**	Pacific cupped oyster	China, Japan, Taiwan,

*Crassostrea iredalei**	Philippine cupped oyster	USA,France
*Crassostrea rhizophorae**	Mangrove cupped oyster	Philippines, Malaysia
*Crassostrea virginica**	Eastern cupped oyster	Cuba, Venezuela
*Ostrea puelchana**	Chilean flat oyster	USA, Canada, Mexico
*Ostrea conchaphila**	Shell-loving oyster	Chile, New Zealand
*Ostrea edulis**	European flat oyster	USA
*Saccostrea cucullata**	Hooded oyster	France, Spain, UK,
		Turkey, Greece
		India, SE Asia,
Hyotissa hyotis	Honeycomb oyster	Australia,W.Africa,
		Philippines,New Zealand
		Philippines, Vietnam

Scallops

Scientific name	Common name	Main areas of production
*Aequipecten opercularis**	Queen scallop	UK, France
Amusium japonicum	Saucer scallop	Japan, Australia, New Caledonia
Amusium pleuronectes	Asian moon scallop	Taiwan
Argopecten gibbus	Calico scallop	USA
*Argopecten irradians**	Atlantic calico	China, USA
*Argopecten purpuratus**	scallop	Peru, Chile
Argopecten ventricosus	Peruvian calico	Eastern Pacific
*Chlamys farreri**	scallop	China, Japan
Chlamys islandica	Pacific calico scallop	Iceland, Norway, Canada
Crassadoma gigantea	Farrer's scallop	Mexico
Mimachlamys nobilis	Iceland scallop	China
Mimachlamys varia	Giant rock scallop	France, UK
Patinopecten caurinus	Noble scallop	USA
*Patinopecten yessoensis**	Variegated scallop	China, Japan, Russia
*Pecten maximus**	Weathervane scallop	France, UK, Ireland
Pecten novaezelandiae	Yesso scallop	New Zealand
Placopecten magellanicus	Geat Atlantic scallop	USA, Canada
Zygochlamys patagonica	(King scallop)	Chile, Argentina
	New Zealand scallop	
	American sea scallop	
	Patagonian scallop	

Pearl oysters

Scientific name	Common name	Main areas of production
Pinctada chemnitzii	Tiled pearl oyster	India
*Pinctada margaritifera**	Blacklip pearl oyster	Indo-West Pacific
*Pinctada maxima**	Goldlip pearl oyster	South East Asia
Pinctada mazatlanica	Mazatlan pearl oyster	Mexico
*Pinctada radiata**	Rayed pearl oyster	Japan, China, India
Pteria avicular	Swift wing oyster	China
Pteria sterna	Western wing oyster	Mexico

Clams

Scientific name	Common name	Main areas of production
Anadara antiquata	Antique ark	Indonesia, Sri Lanka
*Anadara granosa**	Granular ark (Blood	China, Malaysia, Thailand,
*Anadara tuberculosa**	cockle)	Korea

Arca pacifica	Black ark	Mexico
Arca zebra	Chuchoca ark	Mexico
*Scapharca globosa**	Turkey wing	Venezuela
*Scapharca inaequivalvis**	Globose ark	Japan, Philippines
Scapharca indica	Inequivalve ark	Japan, Philippines
*Scapharca subcrenata**	Rudder ark	Indonesia
	Halfcrenate ark	Japan
Atrina pectinata		
	Comb pen shell	Japan, Taiwan, Philippines
*Placuna placenta**		
	Windowpane oyster	Philippines, Bengladesh
*Cerastoderma edule**		
Fulvia mutica	Common edible cockle	UK, Netherlands,France,
	Japanese cockle	Portugal
*Hippopus hippopus**		Japan
*Tridacna derasa**	Bear paw clam	
*Tridacna gigas**	Smooth giant clam	Australia, Philippines, Papua-
	Giant clam	New Guinea, Fiji, Solomon,
Mactra chinensis		Palau, Indonesia
*Mactra veneriformis**	Chinese trough shell	
*Pseudocardium sybillae**	Venuslike mactra	Japan
Spisula polynyma	Imperial surf clam	Korea
Spisula solidissima	Stimpson’s surf clam	Japan, Korea
	Atlantic surf clam	Canada
*Mesodesma donacium**		USA
	Macha clam	
Siliqua patula		Chile, Peru
Siliqua radiata	Pacific razor clam	
	Sunset razor clam	Canada, USA
Donax cuneatus		Myanmar
Donax faba	Cuneate donax	
Donax trunculus	Pacific bean donax	India
	Truncate donax	India, Sri Lanka
Sinonovacula constricta		Italy, Spain, France
	Constricted tagelus	
Arctica islandica		China
	Ocean quahog	
Ameghinomya antiqua		USA,Canada
Chamelea gallina	King’s littleneck	
Gafrarium tumidum	Mediterranean striped	Chile
*Mercenaria mercenaria**	venus	Italy, Turkey, Spain, France
Meretrix casta	Tumid venus	Indonesia, Sri Lanka
*Meretrix lusoria**	Northern quahog	USA, Canada
Meretrix meretrix	Backwater hard clam	India
Paphia undulata	Japanese hard clam	Japan, Korea, Taiwan
*Protothaca thaca**	Asiatic hard clam	India, Korea, China, Taiwan,
*Protothaca staminea**	Undulate venus (Baby	Japan
*Ruditapes decussatus**	clam)	Thailand
*Ruditapes philippinarum**	Greater littleneck (Taca	Chile
*Saxidomus gigantea**	clam)	USA
Venerupis aurea	Common Pacific littleneck	Spain, Portugal, Ireland,
*Venerupis pullastra**	Grooved carpet shell	France

	Japanese carpet shell	China, Korea, Japan, USA,
Mya arenaria	(Manila clam)	France
	Smooth butter clam	Canada
*Panopea abrupta**	Golden carpet shell	Italy
	Pullet carpet shell	Spain, France
Cyrtopleura costata		
Pholas orientalis	Sand gaper (Soft shell	USA, Canada
	clam)	
		Canada, USA
	Pacific geoduck	
		USA, Mexico
	Angel wing	Philippines
	Oriental angel wing	

Table 1. Major and regionally important commercial shellfish species of the world Species under intensive cultivation or receiving commercial aquaculture attention are indicated by an asterisk. The common vernacular names of species used here are the official English FAO names when they exist.

However, the choice of the exploited species does not always reflect the potential shellfish resources of a given region, but largely depends on the social and cultural habits in area. Moreover, consumers often have very specific requirements regarding shape, color, and taste of the food. For example, shipworms are well known for the severe damage they cause to shipping and wooden harbor structures all around the world. However, coastal people in Thailand and the Philippines have for centuries anchored logs in the sea to favor development of some fleshy species of shipworms, which are considered a delicacy. The North Atlantic slipper limpet *Crepidula fornicata*, accidentally introduced into France from England and the US, has been massively spreading for the last 20 years, resulting in trophic depletion, and space competition in oyster beds, and therefore affecting scallops fisheries. In the Mount Saint Michel Bay (Normandy), its considerable biomass (137 000 metric tons in 1998, i.e., eight times more than the yearly production of mussels and oysters in this area) contributes significantly to increase mud deposition in this site. French fishermen systematically reject this pestilential species, whereas it is considered good to eat in Canada.

Rapid depletion of natural beds due to frequent overexploitation can also lead fisheries to move towards other targets and to exploit species that were traditionally discarded. By way of example, the tree-oyster *Isognomon alatus* is increasingly marketed in northern South America, as a substitute for the true oysters. In France, following the fishery collapse of the highly regarded clam *Venus verrucosa*, exploitation of new species such as the surf-clams *Spisula* spp. and the European common bittersweet *Glycymeris glycymeris* has emerged. However consumers often show unwillingness to change their dietary habits, and the fisheries must also find some other outlets for the newly exploited species.

Edible species of economic importance in the world market of bivalves are highly diverse. They are generally grouped into four broad categories: mussels, scallops, oysters and clams. Each of the three former ones refer almost exclusively to single families of bivalves, respectively the Mytilidae, the Pectinidae, and the Ostreidae (though some oysters from the Eastern and Western Pacific belong in fact to the related family Gryphaeidae). However, clams appear to be a convenient grouping of species, a majority of which are classified under the subclass Heterodonta. Heterodont clams are characterized by hinge dentition with two types of teeth (cardinals and laterals), similar adductor muscles, and equal valves mostly with an elongate, subrectangular, or ovoid shape. They include such diverse groups as cockles, razor shells, or quahogs. In contrast, the clam category is strongly heterogeneous for it also embraces groups not belonging to the heterodonts like the ark shells (Arcidae) or the bittersweets (Glycymerididae). Bivalves looking like true oysters but not strongly related to them, are also usually referred to as clams. Windowpane shells (Placunidae), tree oysters (Isognomonidae), and wing and pearl oysters (Pteriidae) belong to this category. Therefore, the high diversity and heterogeneous composition of the clam category explains why the food market of clams is very complex and splintered into a number of complementary segments.

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Biographical Sketches

Patrick Berthou is a French senior research scientist at Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER). He graduated in 1983 when he wrote a thesis at the University of Brest. He was involved in warty venus fishery studies at the Comité Local des Pêches Maritimes de Granville in France. Since 1985, he has worked in the field of bivalves and small-scale fisheries at IFREMER Fisheries Department, in the laboratory of Brest. His research topics mainly focused on shellfish stocks assessments, fleet dynamics, and coastal management systems. He is concurrently involved in a study about the impact of clam dredge bivalves and an integral management program in the Bay Islands, Honduras, and is heading the Fisheries Information Systems program at IFREMER.

Jean-Maurice Poutiers is a French research scientist associate to the Muséum National d'Histoire Naturelle, Paris. He is also teaching biological and earth sciences in the Paris region. After a thesis on bivalves fauna of the French Mediterranean coast, written in 1978 at the University of Paris, he began to work with the Paris Museum, in the BIMM Laboratory. He mainly studies biodiversity and evolution of marine bivalves of Europe and of deep-sea species from the Indo-Pacific. Since 1986, he also collaborates with the Food and Agriculture Organization of the United Nations (FAO), Rome, on studies of gastropods and bivalves of interest to fisheries. From 1989 onward, he has been an expert at the FAO Fisheries Department, and is involved in the international Species Identification Program for Fisheries Purposes.

Philippe Goulletquer is a French senior research scientist at the Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER). He graduated (PhD) in 1989 from the University of Western Brittany in Brest and in 2000 (HDR) from the University of Caen; he worked as an associate professor between 1989 and 1992 at the University of Maryland, Chesapeake Biological Laboratory, CEES, Solomons, MD (USA). His work focused on the oyster public fishery management in Chesapeake Bay. Since 1992, he has been involved in shellfish aquaculture projects and management in the French IFREMER coastal laboratory in Normandy, then as the head of the coastal laboratory in the leading European oyster production area (Marennes-Oleron Bay, Atlantic Southwest). Since 1999, he has been in charge of co-ordinating the Shellfish aquaculture sector at IFREMER and developing relationships with the industry. His main research objectives concern the shellfish ecosystem management and ICZM, carrying capacity, molluscs ecophysiology, environmental interactions. Meanwhile, he is a French representative at the ICES Introduction and Transfer of Marine organisms (ITMO) working group and at the Mariculture Committee.

Jean-Claude Dao is a French senior research scientist at the Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER). Graduated in 1966 from the Institut National Agronomique de Paris-Grignon (INA PG), he worked between 1968 and 1973 at IFREMER on tuna stock assessment in the north-eastern Atlantic (bluefin and albacore) with the french fishing fleet. He moved to research on pectinids, associating stock assessment, aquaculture and restocking on the king-scallop, and conducted several project on research and development on the French coast. From 1995 to 2000, he lead the "living resources" research group in the IFREMER Center of Brest, with particular interest on artificial reef and stock enhancement. He recently moved to the lesser Antilles in Martinique as the chief of the local IFREMER laboratory.