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Introduction

Although we often admire our cool sea, we usually do so as tourists, failing to notice the richness of life hidden in the water. Because of its significant levels of pollution, the Baltic is commonly perceived to be “dead”: surely it is almost impossible for any life to exist in such a “dirty” water body, in which the salinity is low and the environment hostile? But in fact, the very reverse is the case: the Baltic is inhabited by several hundred species of crustaceans, a very important taxonomic group in the functioning of the natural environment, and many of them lead a very intense life in the sea’s coastal waters. They are mostly brackish water species. The sea’s low salinity is the reason why both marine and freshwater organisms can flourish there.

Many crustacean species are benthic, that is, they live on the seabed, some buried in the sediments, while others go about their daily (or nightly) activities on top of sandy or muddy bottoms, while a few attach themselves to hard substrates. Some relict species have lived in the Baltic for thousands of years, others have appeared in its waters within the past few decades, and a few even more recently. Human activities are of particular importance in this respect: live organisms get carried from place to place, often accidentally, but sometimes deliberately, the consequence being that they colonize new water bodies. Among the Baltic crustaceans, there are also species that have infiltrated from the North Sea to the Baltic, thereby expanding their distribution range.

Crustaceans make up a very important component of the Baltic Sea’s ecosystem, playing a significant part in the food web. They provide food for many animal species, at the same time playing a certain role in the human economy. Because of their small size and the absence of relevant culinary traditions, Baltic crustaceans are not caught for food, nor are they harvested for the pharmaceutical, cosmetic, and biotechnological industries, which in Poland have never before used crustaceans. Overcoming certain mental barriers and the development of knowledge will certainly contribute to a better understanding of the role of crustaceans in the Baltic Sea and their application in the economy.

Having studied Baltic invertebrates for many years, and crustaceans in particular, I have decided to focus here on the most numerous group of crustaceans in this sea, the so-called higher crustaceans (Malacostraca), many of which live in its coastal zone. One can come across these animals during a stroll along the beach or a swim in the sea. I hope that the information and photographs contained in this book will make it easier to identify the species and allow a moment of reflection. The Baltic is not as rich in fauna and flora as the “salty seas”, but many species have found it an optimal place to live in—an ecological niche in which they can reproduce and create populations.

We should do all we can to prevent Baltic crustaceans from becoming extinct. We humans have an impact on many aspects of nature, especially those arising from our activities, such as pollution, eutrophication, or the maritime economy and management. Even so, while not relinquishing the privilege of water management, we should always strive to find a balance between our economic needs and the demands of the natural environment. Information and environmental education are highly significant in this respect. With an adequate level of knowledge and awareness, the continued existence of crustacean populations in the Baltic Sea should be secure.

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Chapter 1
Crustaceans in the History of the Baltic Sea

The Baltic Sea has a relatively short history. Yet nearly 20 thousand years ago, its present position was occupied by a huge ice sheet. After the glacial period it went through a series of phases, in which freshwater and salt water mingled together. These changes were the reason why the present Baltic Sea ultimately became a brackish water body. As a consequence of all those transformations and processes, species of both marine and freshwater origin now live in the Baltic. About 10 thousand years ago, when the Baltic Lake merged with the North Sea, many crustacean species were able to swim into the then sea, the so-called Yoldia Sea. Some of these relict species from that arctic period still inhabit the Baltic (Fig. 1.1).

Around 18 thousand years ago, the ice sheet covering the area occupied by today's Baltic Sea had spread over present-day Scandinavia and northern Poland. Subsequent climate warming caused the ice sheet to start melting. The surface of the oceans at that time was about 130 m below the current level.

About 13.5 thousand years ago, ice melting led to the formation of the Skagerrak and Kattegat, the "gateways" to the Baltic Sea. It was then that the present natural connection with the North Sea came into existence. At that time the level of the oceans was about 100 m lower than nowadays.

From 12 to 10.5 thousand years ago, a period when the climate was cold and harsh, the ice stopped melting and moraine formed along the ice ridge in the areas of present-day southern Norway and Finland. The Baltic Ice Lake came into being. This climate was unfavourable to the development of living organisms. Mainly freshwater species were present.

About 9.9 thousand years ago, the Yoldia Sea came into existence. Ice melting in the area of present-day southern Sweden led to the emergence of land separating the then Baltic Sea from the North Sea. Subsequently, this land was breached and water flowed from the lake into the ocean, and continued to do so until the water levels had levelled out. Then, sea water from the adjacent North Sea began to flow into the Baltic. The dominant species during this period was the mussel *Yoldia arctica*, from which the name of the sea was derived. The salinity of the water did not exceed 15‰. There is a hypothesis that there used to be a connection between the Baltic

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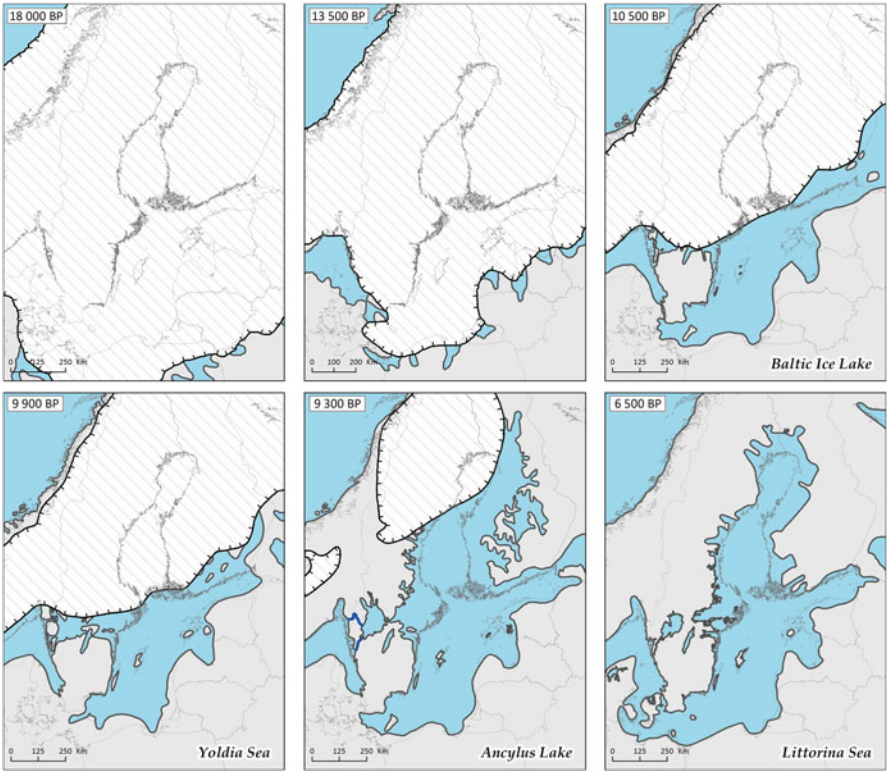

Fig. 1.1 History of the Baltic Sea (L. Szymanek)

and the White Sea, as a result of which many species could have got into the former, e.g. *Mysis relicta*, *Saduria entomon*, *Pontoporeia affinis* and *Limnocalanus grimaldi*.

About 9.3 thousand years ago, as a result of climate warming, the ice sheet over Scandinavia melted almost completely. Scandinavia started to rise, and this was the direct cause of the Baltic Sea becoming cut off from ocean waters. This led to the formation of the so-called Ancylus Lake, the salinity of which was no greater than 3‰. The lake was inhabited by freshwater organisms. As a result of this reduced salinity, some marine species died out, but others survived in deeper waters. The dominant species was the snail *Ancylus fluviatilis*, which gave its name to the lake.

About 6.5 thousand years ago, further climate warming took place. The water temperature was a few degrees Celsius higher than that of today's Baltic Sea, and ocean water levels rose. The Ancylus Lake became connected to the North Sea. The saline waters of the sea turned the area into a water body with a salinity about 6‰ higher than that of the present Baltic Sea. Along with the influx of water from the North Sea, a lot of marine species entered to the Baltic Sea and colonized it. The dominant species was the snail *Littorina littorea*: hence the sea's name—the Littorina Sea.

About 3 thousand years ago, the level of the bottom of the Danish Straits rose, which made the inflow of marine waters into the Baltic Sea more difficult, in consequence lowering the salinity of the Baltic Sea. In this way the present-day Baltic Sea was formed, a typical brackish water body.

Today's Baltic Sea is the perfect habitat for the many species of crustaceans that have entered it in various ways. Those with a wide range of tolerance to low salinity can inhabit it. On the other hand, this factor prevents many typically marine species from colonizing it.

Human cultural changes and ubiquitous globalization in recent decades have led to the appearance in the Baltic Sea of crustacean species that had never before inhabited it. Around 30% of them arrived in ships' ballast waters, others turned up along river systems, and some were introduced deliberately by man with the intention of creating aquacultures. Many of these species, having found suitable ecological niches for living and reproducing in the Baltic, are now a permanent feature of the sea with established populations. One of the first crustaceans described is the bay barnacle *Balanus improvisus*. Nowadays a very common species, growing on ships' bottoms and underwater structures, it was recorded in the Baltic Sea for the first time in 1844. Some species in the colonization phase had a pronounced negative impact on the native fauna and the functioning of communities. Among these are newcomers from regions a long way from Europe. *Rhithropanopeus harrisii* (in the Baltic since 1951) and *Gammarus tigrinus* (in the Baltic since 1991) are originally from the coastal regions of North America. The spinycheek crayfish (*Orconectes limosus*), also from North America, was brought to Europe for breeding purposes and was first recorded in the coastal waters of the Baltic Sea in 1954. Today it is quite common, especially in estuarine waters. Another large group of immigrant species now inhabiting the coastal waters of the Baltic Sea has come from the Ponto-Caspian region (the Black Sea, the Caspian Sea and the Sea of Azov), among them *Cercopagis pengoi*, a highly predatory species feeding on zooplankton. It was first recorded in the Baltic Sea in 1990. Also, *Palaemon elegans*, in the Baltic since 2000, founded a population in the coastal zone and has become an integral part of the ecosystem. Since the 1990s *Hemimysis anomala* and *Chelicorophium curvispinum* have appeared in the Baltic. The Vistula Lagoon, the Szczecin Lagoon, and recently also Baltic coastal waters, are inhabited by several species of Ponto-Caspian gammarids. These are (1) *Pontogammarus robustoides*, in Polish waters since 1988, (2) *Dikerogammarus villosus*, first found in the coastal waters of the Szczecin Lagoon in 2002, (3) *Chaetogammarus ischnus*, in the central Vistula since 1928, later at the mouth of the Vistula on the Gulf of Gdańsk, (4) *Dikerogammarus haemobaphes*, in the Vistula Lagoon since 2001 and (5) *Obesogammarus crassus*, in the Vistula Lagoon since 1999.

Another group of crustaceans to have arrived in the Baltic Sea comes from south-east Asia. Among them is the Chinese mitten crab *Eriocheir sinensis*, first found in Baltic waters in 1940. There are also species that have migrated from the North Sea and expanded their range of distribution. One of them is *Carcinus maenas*, although only mature specimens are found in the Polish coastal zone. Today, all these species are classified as alien, invasive, non-native or non-indigenous. These terms are seemingly all pejorative, but have they perhaps simply taken advantage of vacant ecological niches? Their colonization has taken place very rapidly, because the human agencies aiding this process are much more dynamic than ever before.

The species that in recent years have colonized the Baltic Sea are undoubtedly having an impact on the Baltic ecosystem. However, the function and importance of every such newly appearing crustacean should be examined on their own merits. Many of the species that once entered the Baltic are today an integral part of its fauna and have enhanced its biological diversity.

Chapter 2
The Baltic Sea: A Living Environment

Today's Baltic Sea is the second-largest brackish water body worldwide after the Black Sea. It came into existence as a result of a series of natural transformations that took place over the last few thousand years, since the last European Ice Age. The changes that have been reported in the last 40 or 50 years have been due largely to human activities (Fig. 2.1).

The Baltic is connected to the North Sea through narrow straits; as these limit the flow of water, the rate of water exchange in the Baltic is very slow. The river waters flowing into the Baltic are the reason for the sea's positive water balance, but they are also sources of contaminated waters, carrying nitrogen and phosphorus compounds leached from fields.

The Baltic is a small sea, with an area of ca 415,000 km^2 (including the Kattegat Strait) and a shoreline of about 8100 km. It is also shallow: the greatest depth is 459 m, with an average depth of just 55 m. Its geographical position places it in the cold sea category: this is borne out, for example, by the annual freezing over of the Bothnian Bay.

Seasonal changes affect the biology and ecology of living organisms in the Baltic. In addition, there is a distinct thermal and salinity stratification of its waters. Many parts of the sea suffer from permanent oxygen deficiencies, anoxia being recorded in both the water and the bottom sediments. Hypoxia and/or anoxia are often accompanied by the presence of hydrogen sulphide. The low salinity means that there is a much lower diversity of flora and fauna than in other seas. The number of species falls dramatically with decreasing salinity in a north-easterly direction, from the Danish Straits, through the Baltic Proper, to the Bothnian Bay.

The living conditions for crustaceans in the Baltic Sea are thus difficult. The low salinity, seasonally variable water temperature, oxygen deficiencies and the presence of hydrogen sulphide mean that only very flexible, eurytopic species with a wide range of tolerance in relation to these environmental factors are able to find niches here.

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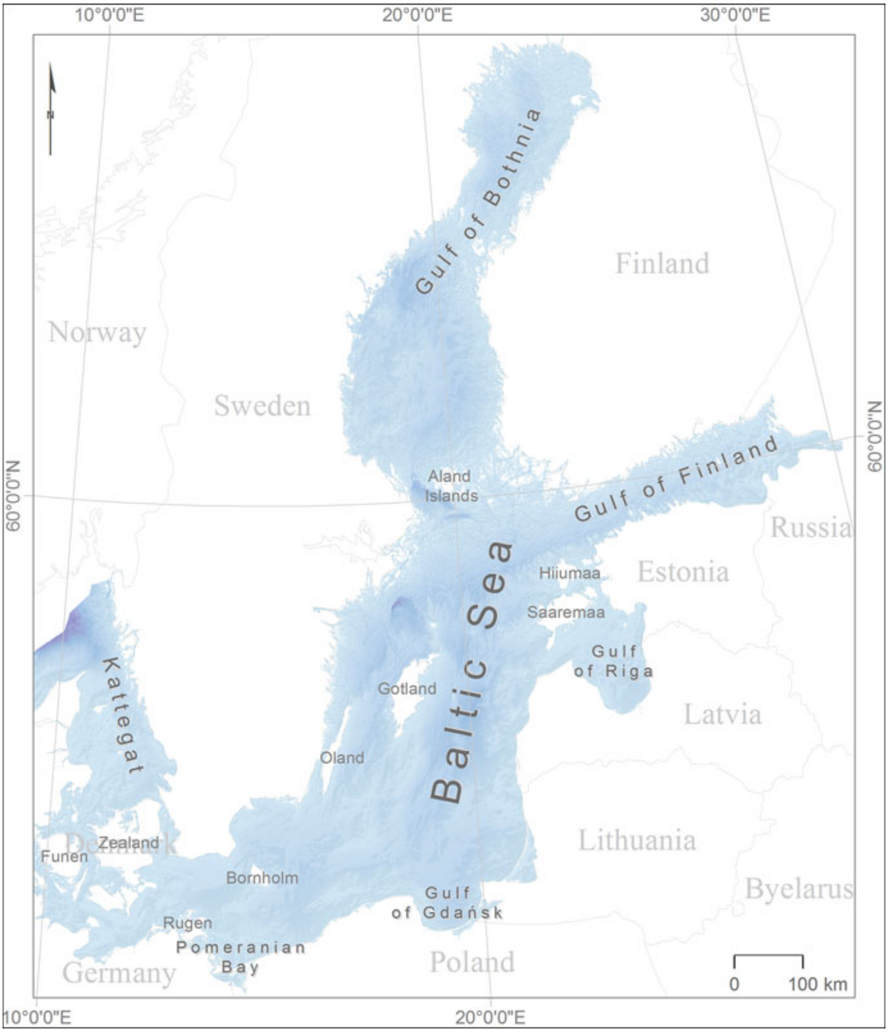

Fig. 2.1 The Baltic Sea (G. Gic-Grusza)

2.1 Salinity

As in other brackish water bodies, species diversity in the Baltic Sea is poor. Most crustaceans colonized the Baltic when the salinity of the water was ca 15‰. The gradual decrease in salinity, changes in ionic composition and low salt concentrations have become key factors in the occurrence of crustaceans. Many Baltic crustaceans are of marine origin, some are typical freshwater species, and yet others are brackish water organisms. Most are euryhaline, that is, they tolerate a wide range of salinity. Along with the Baltic's salinity decrease from west to east, we observe a rapid decrease in the number of species in the same direction. In the Kattegat (where the salinity is 26‰) there are approximately 36 species of crustaceans, including 5 *Isopoda*, 12 *Amphipoda* and 3 *Decapoda*. At a salinity of less than 5‰, such as that in the far north of the Baltic Sea, marine crustaceans are virtually absent. On the other hand, freshwater crustaceans tolerate salinities of up to 10‰, but are only very rarely found in waters of higher salinity. A salinity in the 5–8‰ range is considered to be the threshold value, below which neither marine nor freshwater crustaceans occur. This is because many of the water's physico-chemical properties change at that salinity.

Baltic crustaceans have evolved many adaptations to low salinities. They may be of genetic origin, but may also be the result of long-term physiological adaptation. Salinity influences morphology and behaviour. A reduction in salinity leads to many anomalies in the animal's body structure. Chemically, sea water is very similar to the body fluids of marine crustaceans. To combat dehydration or overhydration, Baltic crustaceans reduce the permeability of the body's outer membranes. For example, *Gammarus duebeni* reduces the permeability of its body shell at low salinities but increases it at high salinities, absorbing ions from water and food. Salinity affects the fundamental life processes of crustaceans, such as growth, osmoregulation, respiration, the absorption and assimilation of food and the elimination of waste products. A change in salinity can lead to differences in the biochemical composition of animals. In the case of many crustacean species, adults can cope better with changes in salinity and tolerate a broader range than juveniles. Osmoregulation is a fundamental physiological process, helping to overcome differences between the osmotic concentrations of body fluids and the external environment. Ionic regulation requires crustaceans to expend energy. But a greater expenditure of energy on metabolic processes forces the animals to spend less assimilated energy on growth processes. Hence, the smaller sizes of Baltic crustaceans, such as common shrimps *Crangon crangon*, *Palaemon adspersus* and *Gammarus oceanicus* in comparison to the same species from more saline water bodies. For example, common shrimps in the southern Baltic are 5–6 cm in length, whereas in the North Sea, where the salinity is above 30‰, they are about 8 cm long. A higher, typically marine salinity lowers the metabolic rate by up to 44% in *G. oceanicus*, by as much as 75% in *Idotea chelipes*, and by 51% in the case of *Rhithropanopeus harrisii*. In *C. crangon* and *Palaemonetes varians*, salinity increases and decreases in the Baltic Sea raise the metabolic rate. In contrast, *Corophium volutator* maintains a constant oxygen consumption, regardless of whether the salinity rises or falls.

Most crustaceans are osmo-conformists, that is, they alter the osmotic pressure of their body fluids in response to changes in external pressure. Some crustaceans, like the Chinese mitten crab *Eriocheir sinensis,* maintain osmotic pressure at a constant level, despite the variations in external pressure; they are referred to as osmoregulators. There are two forms of osmoregulation in this group of crustaceans: hyperosmotic and hypo-osmotic. Hyperosmotic regulation is based on maintaining a higher concentration of body fluid compared to the concentration in the aquatic environment and occurs in freshwater crustaceans, but also in crabs

(*Carcinus maenas*). In crustaceans of freshwater origin, body fluids would become diluted, resulting in hydration, were it not for osmoregulation. *Orconectes limosus*, *Pacifastacus leniusculus*, *Saduria entomon*, *C. crangon*, *Praunus flexuosus*, *G. oceanicus* and *Gammarus salinus* have combined hyper-/hypo-osmotic regulation. In *Mysidacea* and *Palaemonidae* regulation is hypo-osmotic: the osmotic pressure in the body is maintained at a level lower than that of the surroundings. Typical marine crustaceans, but also some euryhaline ones, are iso-osmotic, in which the concentration of body fluid is the same as that of the surrounding water. No osmoregulation occurs in these crustaceans. Crustaceans that are hyperosmotic at lower salinities and iso-osmotic at higher salinities include *C. volutator, Idotea balthica* and *I. granulosa*. *Asellus aquaticus* is hyperosmotic at low salinities, but does not tolerate high levels. Concentrations of body fluids are adjusted by the release of amino acids and peptides into them, and by the production of hypo-osmotic urine. In crustaceans, the ions Na, K, Cl, Ca, Mg play an important part in osmoregulation.

A salinity decrease adversely affects reproductive processes in some crustaceans and can even lead to infertility. At low salinities, crustaceans tend to reproduce only in the warm seasons, but some marine crustaceans, like *E. sinensis* or *C. maenas*, do not reproduce at all during this period, as they require a salinity above 25‰ to breed. Also, freshwater species such as *O. limosus* and *P. leniusculus* do not breed in the brackish waters of the Baltic Sea. In contrast, *G. duebeni* completely loses its ability to reproduce in fresh water: the eggs do not develop when the salinity drops below about 1‰. Some crustaceans, such as *C. crangon*, reproduce throughout the year in the North Sea, but only in summer in the Baltic Sea. The exceptions are the Baltic cold-water crustaceans that breed in the Baltic Sea throughout the year, although reproduction peaks in the summer.. In addition, it has been observed that females of *C. crangon* from fully saline waters have more offspring than their counterparts in the Baltic Sea. In the former waters, bodies are larger, sexual maturity is achieved faster, the animals live longer and large females can carry more eggs. Crustacean eggs and embryos are highly sensitive to changes in salinity, which is why they are laid in brood pouches (marsupia) and fertilization is often internal. Reducing salinity renders crustaceans more sensitive to other environmental factors, such as pollution and oxygen deficiencies. At low salinities, some species, such as *G. duebeni* and *Lekanesphaera hookeri*, are less resistant to temperature changes.

2.2 Temperature

The climate of the Baltic Sea has a significant impact on the lives of crustaceans. In the course of the last millennium the climate has changed considerably. It was the mildestin the sixteenth century, when only four very harsh winters were recorded, and the most severe in the late eighteenth and early nineteenth century, when many areas of the Baltic Sea were covered by ice. Recent winters have been milder. The current climate of the Baltic Sea region is humid-temperate. A typical feature is its variability, and the proximity of the Atlantic makes the winters mild and the summers relatively warm. There have been short-term and long-term changes in hydrographic relations. The cloud cover is quite considerable but poorly differentiated during the year. The prevailing winds are from the north-west to the south-west. In winter, when temperatures are low, some crustaceans migrate into deeper waters, where the environmental conditions are relatively stable and the water temperature is 2–3 °C. Low temperatures slow down the life processes of crustaceans and reduce their metabolic rates: the animals become less active and practically cease feeding. At this time most crustaceans moult or shed their exoskeletons much less frequently than in the warm season. The absence of moulting means that during the cold months of the year crustaceans grow slowly or not at all. At low temperatures, only relict species like *Saduria entomon* are capable of reproducing; nevertheless, they do so more often in summer than in winter. In spring, when the water temperature rises to about 12–15 °C, migratory crustaceans such as *Crangon crangon* return from the deeper regions to the Baltic coastal zone. Their reproduction takes place from May to late September. In summer, crustaceans feed intensively, storing energy primarily in the form of lipids and proteins. In the late summer, therefore, the energy values of these animals are at their highest. Recent climate changes have tended to blur the differences between the four traditional seasons; increasingly we are experiencing two seasons: a warmer and a colder one. These changes have prolonged the breeding period of crustaceans into October and even early November. Even a small-scale rise in water temperatures causes relict species such as *S. entomon*, to migrate into deeper waters, where oxygen shortages and the presence of hydrogen sulphide await them. Climate change can also disturb osmoregulation: as ambient temperatures increase, so do body fluid concentrations in crustaceans, which reduces their ability to regulate ions.

2.3 Stagnation

The deeper waters of the Baltic Sea are cooler and more saline compared to its surface waters. These two layers are separated from each other by the pycnocline, which prevents them from mixing. In many regions of the Baltic Sea, and especially in its deeps, the water is stagnant. As a result, the oxygen content decreases, leading to hypoxia or anoxia, and poisonous hydrogen sulphide is formed. Crustaceans sensitive to oxygen shortages and the presence of hydrogen sulphide abandon such stagnant waters. If this is not possible, the animals perish. This applies not only to crustaceans but also to all other benthic invertebrates. The condition of the Baltic waters, and hence the presence of bottom-dwelling crustaceans and other invertebrates thus depends on inflows from the North Sea, which carry well-oxygenated water of a higher salinity.

2.4 Oxygenation

All the crustaceans described in this book are obligate aerobes, in which oxygen is required for their life processes. Their gills have a large surface covered with a thin epithelium and are used for gas exchange: oxygen uptake and carbon dioxide excretion. In *Decapoda* the gills are located in the gill cavity. In crabs this is connected with the external environment only by small openings (one under each limb). The concentration of oxygen in the water and the residence time in hypoxic conditions, like other stressors, affect crustacean behaviour and metabolism. Changes in water oxygenation cause certain hereditary behaviour patterns to be modified. The first visible response of crustaceans to an oxygen shortage is a change in behaviour. Mobile crustaceans such as *Decapoda* try to get away from the areas under threat. In them we see an increase in metabolism. For example, the metabolic rate of *Crangon crangon* during such a flight may be up to 200% greater than the resting rate. In *Gammarus oceanicus* or *Rhithropanopeus harrisii* the increase in active metabolism is not so great. If the crustaceans do not manage to escape, they try to minimize energy losses by becoming motionless, lowering their metabolic rate, thereby reducing the costs of the most energy-consuming processes. Such processes include protein synthesis. Consequently, oxygen shortages and stressful conditions have a negative impact on the animals' reproduction. In contrast, isopods are relatively resistant to oxygen deficiencies. *Saduria entomon* and *Asellus aquaticus*, which live at the bottom of water bodies, tolerate significant oxygen shortages in the water. For a certain period of time (up to several days) *S. entomon* can live in hypoxic/anoxic conditions by switching to anaerobic metabolism. As a result of anaerobic processes, lactic acid is produced and alanine in the longer term. Because of its resistance to adverse environmental conditions and pollution, *A. aquaticus* is used in tests on toxic compounds. Most crustaceans are slightly resistant to oxygen deficits and die after a relatively short period at oxygenation levels of ca 20%. Deep-water crustaceans of the open waters of the Baltic Sea, such as *Monoporeia affinis, Pontoporeia femorata* and *Diastylis rathkei*, are sensitive to oxygen deficiencies, as are most of the species of the genus *Gammarus* (Figs. 2.2, 2.3, 2.4 and 2.5).

2.5 Bottom Sediments

Most crustaceans are temporarily or permanently associated with the sea bed, which is why the type of sediments is very important for them. The bed and bottom sediments of the Baltic Sea were shaped to a large extent during the last Ice Age. All kinds of moraine structures, boulders of various sizes and pebbles are remnants of the ice sheet. Today, they offer excellent shelter for animals, including crustaceans of the orders *Isopoda, Amphipoda* and *Decapoda*. In the Baltic Sea, a significant proportion of the sediments is terrigenous, with a predominance of alluvial and clay

Fig. 2.2 *Saduria entomon* burrowing in sediment under normal oxygen conditions (Piotr Wysocki)

Fig. 2.3 *Saduria entomon* burrowing in sediment under normal oxygen conditions (Piotr Kendzierski)

sediments: the former occur in the coastal area, the latter in the deeper areas. Sediments are distributed by hydrodynamic processes such as wave action and bottom currents. A significant proportion of the surface sediments of the Baltic Sea bed are relict deposits. Water depth, coastline shape and sea bed topography

Fig. 2.4 *Saduria entomon* burrowing in sediment under normal oxygen conditions (Piotr Wysocki)

Fig. 2.5 *Saduria entomon* burrowing in sediment under normal oxygen conditions (Piotr Wysocki)

formation also affect sediment formation. Beaches are formed by the fine-grained, yellowish-grey sands that dominate in the coastal zone down to a depth of about 10 m. Locally, e.g. at the foot of cliffs, sediments are coarser. At depths of 10–25 m the most common ones are medium- and coarse-grained sands and gravels.

Boulders may appear locally. Deposits of sand from a few to several metres thick may be formed on gravel surfaces. During severe storms, the sand is washed out of these gravelly sediments and is moved over short distances. The deposits become finer with increasing water depth. At about 25–30 m there is a ca 2 m thick layer of fine-grained sand, on which there are visible signs of *Saduria entomon*. By changing its position, this crustacean shifts sediment, thereby contributing to bioturbation.

Around the deeps there are thin sand-silt layers overlying clay sediments. Local elevations are overlain with deposits of sand, gravel and mud, on which ferromanganese concretions may be lying. The bottoms of the deeps consist of mud-clay sediments, usually with some Fe-Mn concretions and some organic matter. *Pontoporeia affinis* and *P. femorata* are found here. At the bottom, laminated deposits are formed under periodically anaerobic conditions; every year more of the sea bed is covered in this way. These deposits do not provide propitious living conditions for crustaceans. In the northern Baltic Sea there are areas of crystalline rocks, clays and gravels. Because of the lack of wave action, muddy sediments cover even shallow areas. The southern and central basins of the Baltic Sea are dominated by layers of mud up to several metres thick. There are sandy deposits along the south-eastern coast of Sweden and in the Danish Straits region. Only in the deeper areas do post-glacial muds dominate.

2.6 The Impact of Human Activities

The crustaceans inhabiting the Baltic Sea occupy specific ecological niches. The changes taking place in the Baltic are largely the results of human activities, so some species are forced to adapt to these processes or limit their distribution ranges. The intensification of tourism is disturbing the biological functioning of the sea and coastal areas and is causing species to abandon the habitats they have hitherto occupied. The destruction of dunes, and the erection of beach infrastructure and other buildings along the coastline all have a negative impact on the occurrence and life processes of crustaceans inhabiting the area. Mechanical cleansing of beaches has contributed to the extinction of species of the family *Talitridae*. Nonetheless, most crustaceans display a wide range of tolerance to environmental factors and are able to adapt to them (Fig. 2.6).

Baltic waters are affected by toxic compounds: the type, concentration and duration of exposure to these are crucial for an organism. There are still significant levels in the Baltic of organochlorine compounds such as DDT (dichlorodiphenyltrichloroethane) and PCBs (polychlorinated biphenyls), which used to be applied by agriculture and industry. Although they have been replaced by other polychlorinated compounds, these too have repeatedly been shown to be harmful to living organisms. Moreover, heavy metals, synthetic hormones, pharmaceutical compounds, municipal and industrial pollutants in sea water all have a negative impact on crustaceans. Toxic compounds penetrate crustaceans directly

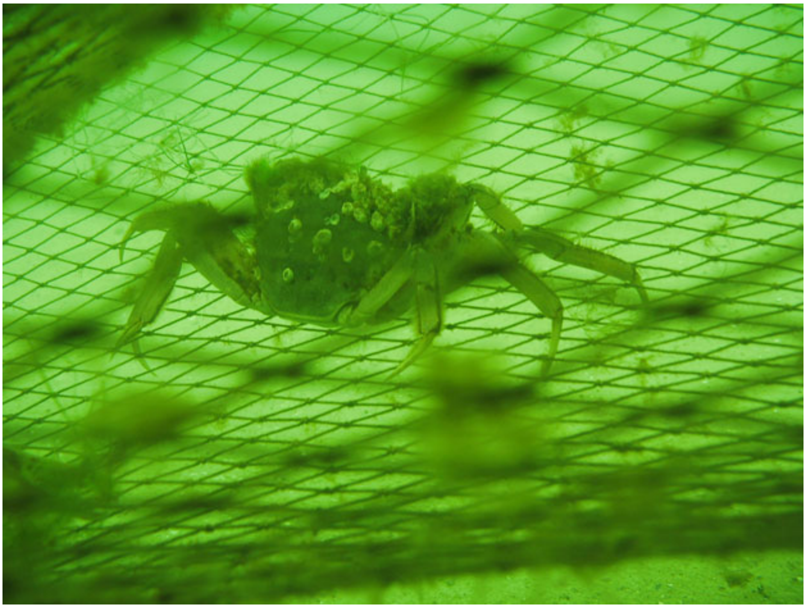

Fig. 2.6 *Eriocheir sinensis* caught in a net (Anna Dziubińska)

from the water through the body's outer skin or with food. They accumulate in the animals and are transmitted along the food web by the process of biomagnification. The first reaction of crustaceans to the contamination of water by toxic compounds is to attempt to escape from the endangered area, which will require an increase in oxygen consumption. Often, however, the animal's sense of balance and orientation are disturbed, which may hamper its departure from the endangered area. Some crustaceans have problems with locating food, so foraging is difficult. If escape is impossible, the animals become motionless and try to wait until the adverse effects disappear. In the case of long-term, low concentrations of toxic compounds, changes take place in the animals' biochemical composition, physiological functions such as breathing, excretion and osmoregulation, and even appearance. Reproduction is hampered by reduced fertility, for example. Moulting is impaired. Under the influence of certain stress factors, some moulting crustaceans gain no weight. Abnormalities occur in individual development. The larval period and the time between moults are prolonged, which also lowers individual production, and slows down their growth.

Eutrophication is one of the more serious problems facing the Baltic Sea. This is the enrichment of the water in nutrients, especially nitrogen and phosphorus in the form of nitrates and phosphates, respectively. Initially, the process appears to be beneficial for the environment, leading to an increase in phytoplankton biomass and subsequently that of the next links in the food web. Over time, however, it leads to the excessive fertility of the aquatic environment. Algal blooms appear, their biomass increases, resulting in a significant increase in the amount of organic matter in the environment. This organic matter falls to the bottom of the sea, where it remains, causing a significant deterioration in oxygen levels and the appearance of hydrogen sulphide. Oxygen shortages cause crustaceans sensitive to hypoxia to leave such areas or die. In addition, structures erected in the sea and the coastal zone are not indifferent to crustaceans, and the location and magnitude of the construction may be crucial to their populations. One solution would be to create protected areas as a means of conserving Baltic crustaceans and their communities: stricter legislation in this respect would be helpful. Otherwise, they will remain endangered.

Chapter 3
The Szczecin Lagoon and Pomeranian Bay

Fishing in the Szczecin Lagoon has been carried on for centuries. Moreover, since the eighteenth century, the lagoon has been an important waterway for the transport of people and cargo. Only in the twentieth century did it become a significant tourist and recreational area. The lagoon has a total area of 910 km^2: the smaller, western part lies in Germany, while the larger, eastern part (687 km^2) belongs to Poland. To the north, the lagoon is closed off by the islands of Uznam and Wolin. The prevailing hydrological conditions are largely governed by the River Oder: the river's freshwaters carry large amounts of organic matter and heavy metals to the lagoon, contaminating it. It is a shallow, brackish water body, with an average depth of 3.8 m (max. 8.5 m) (Fig. 3.1).

The sea bed is sandy near to the shores but muddy in the deeper, middle part. The salinity in the central part of the lagoon is low (from 0.5 to 2‰), but can increase to 4‰ when strong westerly winds push water from the open sea back into the lagoon. Waters from the River Oder entering the lagoon decrease the salinity. Since the waters are well mixed, they are oxygenated and there is no hypoxia. The maximum temperature can reach 26 °C, while the annual average is about 11 °C. The winter ice cover can persist for up to 59 days. The significant amounts of nitrogen and phosphorus entering the lagoon, mainly with Oder waters, cause eutrophication. In the cold months, some 50–70% of the nitrogen and phosphorus are carried from the lagoon out into the Baltic. As a result of eutrophication, the lagoon's waters are alkaline, the pH being between 7.4 and 9.5. Both the hydrological conditions and sea transport significantly affect the living conditions of the Szczecin Lagoon. Part of the lagoon is a Natura 2000 conservation area.

The Szczecin Lagoon is connected to the Pomeranian Bay (water volume ca 73,000 m^3), the northern boundary of which is formed by the island of Rügen. A seaway connecting the ports of Szczecin and Świnoujście with the open sea passes through it. With an average depth of about 15 m, the bay is relatively shallow. The eutrophic, polluted waters of the Szczecin Lagoon adversely affect the bay's environment, but on the other hand, fresh water also enters the bay from the same source. The mixing of inland waters with sea waters makes the environmental

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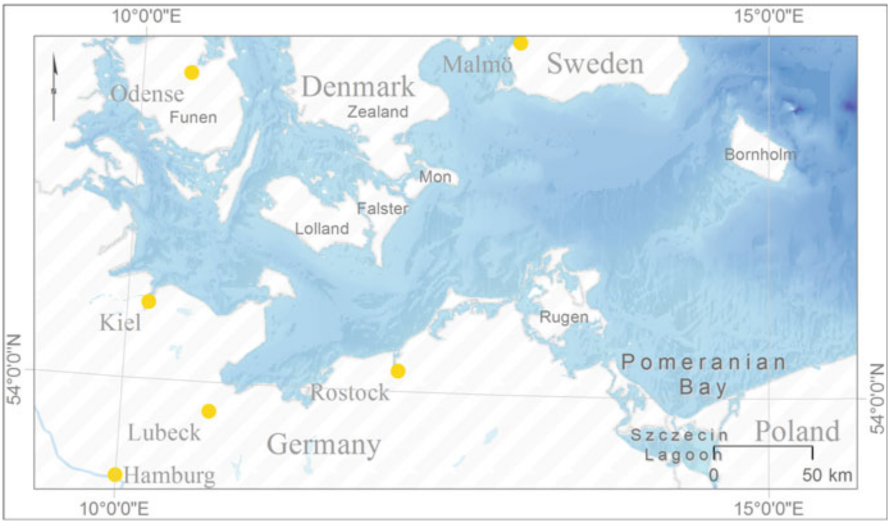

Fig. 3.1 The Szczecin Lagoon and Pomeranian Bay (G. Gic-Grusza)

conditions unstable. The average salinity in the surface layer is about 6‰, but is slightly higher in the near-bottom layer at about 7‰. During algal bloom periods, both bottom and surface waters are well oxygenated, but when phytoplankton decays, there are oxygen shortages. Many parts of the bay bottom are covered with rocks supporting numerous sedentary species of algae. Invertebrates, including several gammarid species, can be found under rocks.

Chapter 4
The Gulf of Gdańsk and Vistula Lagoon

The Gulf of Gdańsk is the south-eastern part of the Baltic Proper and makes up 1.3% of its area. The conventional boundary between the gulf and the Baltic Proper is an imaginary 58 nautical mile line between Cape Rozewie (54°50′N, 18°20′E) and Cape Taran (54°58′N, 19°69′E). Puck Bay is the westernmost part of the Gulf of Gdańsk, while the Vistula Lagoon stretches to the east of it, separated from the open sea by the Vistula Spit. The Gulf of Gdańsk has an area of 4990 km^2 and an average depth of 59 m (Fig. 4.1).

About 760,000 people live around the Gulf of Gdańsk. The so-called Tri-City includes Gdańsk, Gdynia (both port cities) and Sopot, a seaside resort. In addition, there are many smaller towns and villages in the gulf's coastal zone, making it particularly vulnerable to anthropogenic activities. The gulf itself and its shores are beautiful, naturally very valuable areas and a major tourist attraction. Its western part is protected in the form of the Coastal Landscape Park, part of the Natura 2000 European Ecological Network; it is also part of the Baltic Sea Protection Area.

The Gulf of Gdańsk is surrounded by cliffs as well as typical lowland coastlines, and in some places there are sand dunes. Geologically and hydrologically it is very diverse. The climate and the influx of waters from both the open sea and the land, together with the varied depth profile, shape the gulf's environmental conditions. Its bottom is a post-glacial relict, and the sediments may be of sand or silty sand. In Puck Bay there are small vegetated areas of the sea bed that provide breeding and development areas for many species of fish and invertebrates. Sea waters, of higher salinity, and fresh waters entering from rivers mix in the gulf. The water temperature fluctuates during the year. Sea waters flowing into the gulf raise its temperature in winter, but lower it in summer. The much shallower water in Puck Bay is completely mixed. In the deeper parts of the gulf seasonal water stratification takes place. The highest water temperatures are recorded in July and August, sometimes over 20 °C. The River Vistula is the major "supplier" of various pollutants, carried by waters from the whole of Poland. In addition, the tributaries of other rivers, the atmosphere and bottom sediments are sources of nutrients, especially nitrogen and phosphorus. All these aspects have a profound effect on the living conditions and of

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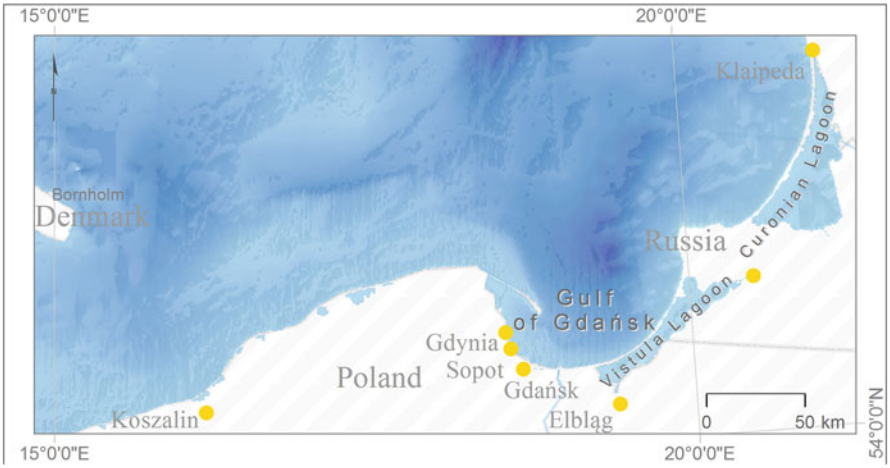

Fig. 4.1 The Gulf of Gdańsk (G.Gic-Grusza)

the plants and animals inhabiting the gulf and its biological diversity. Puck Bay supports a rich phytobenthos, i.e. plants growing on the sea bed, both in quality and quantity. In the 1980s, the vegetated area underwent a dramatic reduction. The maximum depth to which algae grew was reduced, and brown algae from the family *Ectocarpaceae* expanded. Significant levels of nitrogen and phosphorus have made Puck Bay highly eutrophic. This has led to large-scale blooms of algae, especially of cyanobacteria, and the formation of areas with were oxygen is deficient and hydrogen sulphide is present. All these aspects create unfavourable conditions of life for sensitive species of aquatic crustaceans.

The Vistula Lagoon lies at the eastern end of the Polish coast. It is a typical brackish water body with an area of 838 km^2. The larger part (61%) of the lagoon lies in Russia, the remainder in Poland. Separated from the Baltic Sea by a narrow, sandy, forested spit, the Vistula Lagoon is shallow, with an average depth of 2.7 m (maximum 5.2 m). The climate is temperate, though with distinct maritime and continental features. Water temperatures depend on air temperatures, which in summer can be in excess of 24 °C. Winters are mild because of the moderating influence of the Baltic Sea's waters that warmed up in the summer, although in the coldest months the coastal zone can freeze over. In the areas of water exchange with the Gulf of Gdańsk the salinity is relatively high at about 5.5‰, but near Krynica Morska it is only around 3.3‰. The average salinity of the Vistula Lagoon is assumed to be 3.5‰. Because the lagoon is shallow, there is no thermal stratification: the whole water mass has the same temperature and is well oxygenated. The bottom is very little differentiated. There is a lot of organic and inorganic suspended matter in the water, raised from the bottom sediments by wave action. In the warm season, moreover, the shores are well vegetated, and algal blooms occur. All these effects mean that the lagoon's highly eutrophic waters are characterized by poor transparency (no more than 1 m) and a brownish colour. The Vistula Lagoon is inhabited mainly by fresh water and brackish water species. These include a number of alien species that have colonized it in the recent past. The Vistula Lagoon is protected as a Natura 2000 area; it is also part of the Baltic Areas Protection System. There is a well-developed fishery, particularly for European eel *Anguilla anguilla* and pikeperch *Sander lucioperca*.

Chapter 5
The Gulf of Riga

The Gulf of Riga is a relatively narrow and isolated region. In the east and south it borders on the coasts of Estonia and Latvia, while in the north it is sheltered by the islands of Saaremaa and Muhu. It is separated from the waters of the Baltic Proper by numerous shoals and islands. The gulf has an area of 16,330 km^2 and a volume of 424 km^3. It is relatively shallow, its greatest depth being 60 m and the average only 27 m. Over a large area of the relatively flat clay bottom of the bay there are sand deposits, gravels and pebbles. The bottom clay layer is approximately 80 m deep. Saline waters entering the gulf from the open Baltic Sea mix with fresh water brought by the rivers flowing into the bay. The Dźwina River Daugava and the other rivers entering the southern part of the gulf have a substantial impact on the gulf. Their fresh waters reduce the average annual salinity of the surface water in the south of the gulf to 0.5–2.0‰, whereas in the northern parts the salinity is much higher at around 7‰. Most of the gulf waters have a salinity of about 5‰. Below 30 m depth the temperature is about 3 °C and remains almost constant throughout the year. Because the gulf is relatively shallow, there is no permanent halocline. At depths of ca 25 m a thermocline does form, however, but only in winter; it disappears in May. Mixing of the deeper layers with the shallower ones is the reason for the changes in temperature and the relatively poor transparency of the gulf's waters: in the littoral zone the visibility is no more than 3 m. In summer, the surface temperature of the water reaches 17–20 °C, but drops to 5–10 °C in autumn. In winter the coastal waters freeze over. Depending on the area, the ice cover can persist for 80 or as many as 150 days a year. In recent years, the number of days with ice cover has fallen by 5–7 days. Mixing of the water means that it is relatively well oxygenated, the dissolved oxygen content being around 5 ml^{-1} in most parts of the gulf. A seasonal, summer thermocline impairs water mixing, and this can lead to stratification, stagnation and consequently oxygen shortages. This oxygen deficiency disappears in autumn, however. In recent years, oxygen levels have fallen in the deeper parts of the gulf. The gulf's waters are eutrophic: nutrients enter the gulf from the many rivers and also from the Gotland Basin. The Gulf of Riga supports many species of crustaceans that can also be found in other parts of the

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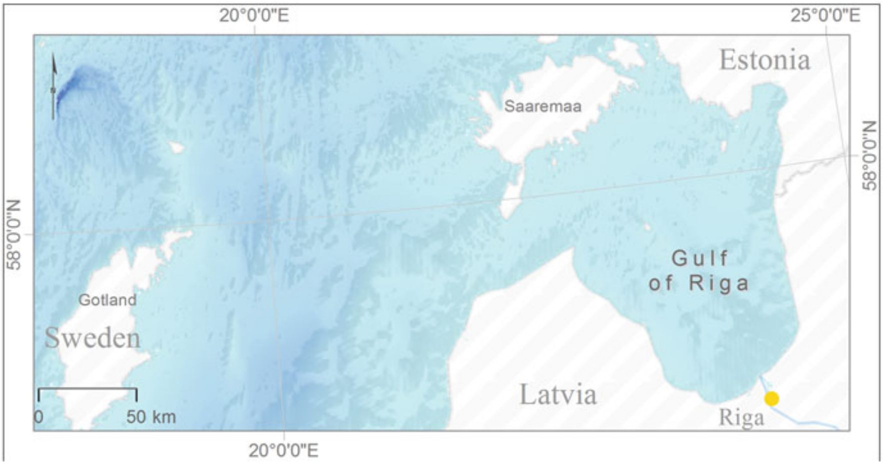

Fig. 5.1 The Gulf of Riga (G. Gic-Grusza)

Baltic Sea. Its well-oxygenated waters create favourable conditions for both pelagic and benthic organisms. many of which have stable populations. The low salinity, sandy sediments and the bottom instability caused by frequent turbulence is the reason for the small number of phytobenthic species. The most common fish species are herring *Clupea harengus* and sprat *Sprattus sprattus*. At the end of the twentieth century a number of works were carried out to reduce the negative impact of humans on the environment, resulting in a definite improvement in water quality and the living conditions of the aquatic organisms (Fig. 5.1).

Chapter 6
The Gulf of Finland

The Gulf of Finland is the easternmost part of the Baltic Sea. To the north, it is bordered by the shores of Finland, to the east by Russia, while its south coast belongs to Estonia. In the west, the boundary between the gulf and the open waters of the Baltic Sea is not clearly marked. The gulf is tubular in shape, with a length of 428 km and a width of 120 km. At the narrowest point the gulf is only 45 km wide. Because of the shallow depth and mixing of waters, it is defined as an estuary. The maximum depth is 123 m and the average is 38 m. The western part is deeper, whereas the eastern end is much shallower. The gulf has an area of 29,498 km^2 and a volume of 1100 km^3. In the northern part of the gulf the bottom consists of alternate areas of crystalline rocks and clays and areas covered with gravel, pebbles and boulders. Only a few depressions in the bottom are filled with clays. In the south, there are larger areas covered with postglacial clays. At the bottom of the gulf there are ferromanganese concretions. The Gulf of Finland has a continental climate, with relatively harsh winters compared with other regions of the Baltic Sea. The water temperature ranges from 0 °C in winter to 17 °C in summer. In winter the gulf freezes over and the ice cover can persist from 30 to 130 days. A significant nutrient load enters the gulf from rivers, the Baltic Proper and the atmosphere, making it one of the most eutrophic regions of the Baltic. Temporary water stratification leads to shortages of oxygen in the deeper areas, or even anoxia. Hypoxia occurs after algal blooms, when dead organic matter sinks to the bottom of the sea (Fig. 6.1).

Even though oxygen conditions are the worst in the western part of the gulf, a significant improvement has taken place since the 1990s. The gulf is the largest recipient of freshwater in the Baltic Sea. About 75% of this flows in with the Neva, which is why the impact of this river on the physical, chemical and biological processes of the gulf is so pronounced. At the mouth of the Neva the surface water salinity is about 0‰, but within 100 m of the shore, the salinity is already around 2.5–3‰. At the western end of the gulf the salinity is higher at about 7‰. The salinity of near-bottom waters is about 5‰ in the east and 10‰ in the west of the gulf. There is a periodic halocline, more pronounced in the west. Oxygen shortages

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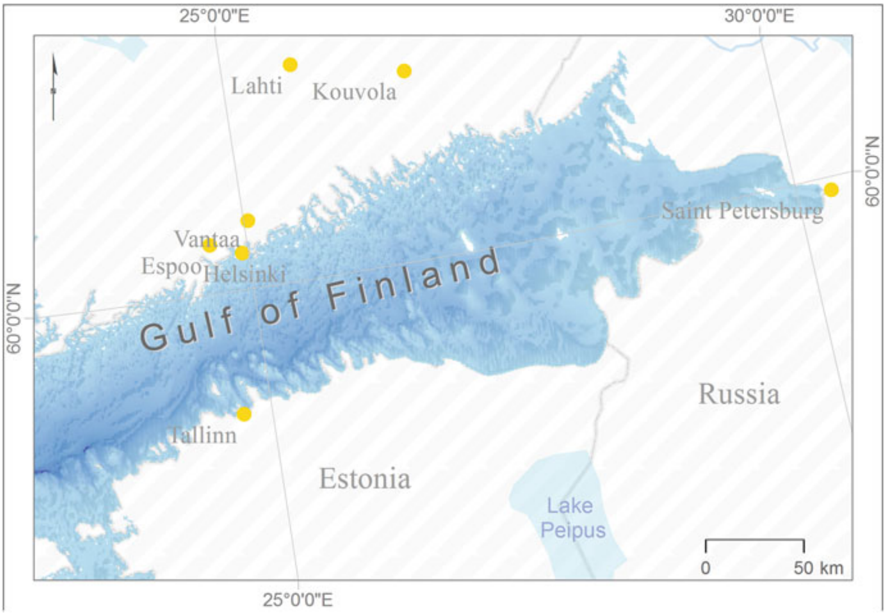

Fig. 6.1 The Gulf of Finland (G. Gic-Grusza)

create difficult conditions for benthic invertebrates, but a rich macrofauna inhabits the gulf's open waters. The coastal zone is dominated by the crustaceans *Monoporeia affinis* and *Corophium volutator*. The gulf is inhabited by about 50 species of marine and fresh water fish, the most numerous being herring *Clupea harengus* and sprat *Sprattus sprattus*.

Chapter 7
The Gulf of Bothnia

This is the northernmost part of the Baltic Sea and also its largest gulf. About 270 km long and some 145 km wide, the gulf is 37,365 km^3 in area and has a volume of 1462 km^2. It lies between the west coast of Finland and the east coast of Sweden. The northern part of the gulf (known as the Bothnian Bay) is shallow, with a maximum depth of 141 m and an average of 42 m. In the south (also known as the Bothnian Sea) the greatest depth is 294 m. The two parts are separated by the 74-km wide Kvarken Strait. To the south the gulf is closed off by the archipelago of the Åland Islands. The seabed is morphologically diverse. The shallower Bothnian Bay is relatively flat, with a number of shoals. In the north-east, there are sands along the shores to a depth of about 50 m. Clay bottoms are overlain by boulders, pebbles and gravels. In the south-east, clays fill small depressions, while and glacial clays overlie elevations on the bottom. In the skerry area there are sedimentation basins and bottom depressions. Ferromanganese concretions are present. The eskers—post-glacial embankments of sandy-gravel sediments—are a characteristic feature. Arctic-continental influences are clearly evident in the climate, leading to very harsh winters. The warm period lasts from June to September. In July, the average temperature is 15 °C. In the warmest period in summer, the water temperature at the bottom is about 1.5 °C, while the surface water temperature is less than 14 °C. In winter the northern part of the gulf freezes over and is covered with ice, sometimes for up to 6–8 months a year. In the 1970s the ice cover persisted into mid-April, with ice floes remaining until May. This gulf is the least saline Baltic basin. In the south the salinity varies between 3 and 5‰, whereas in the north it is approximately 2‰. Herring *Clupea harengus* and cod *Gadus morhua* are caught in the gulf (Fig. 7.1).

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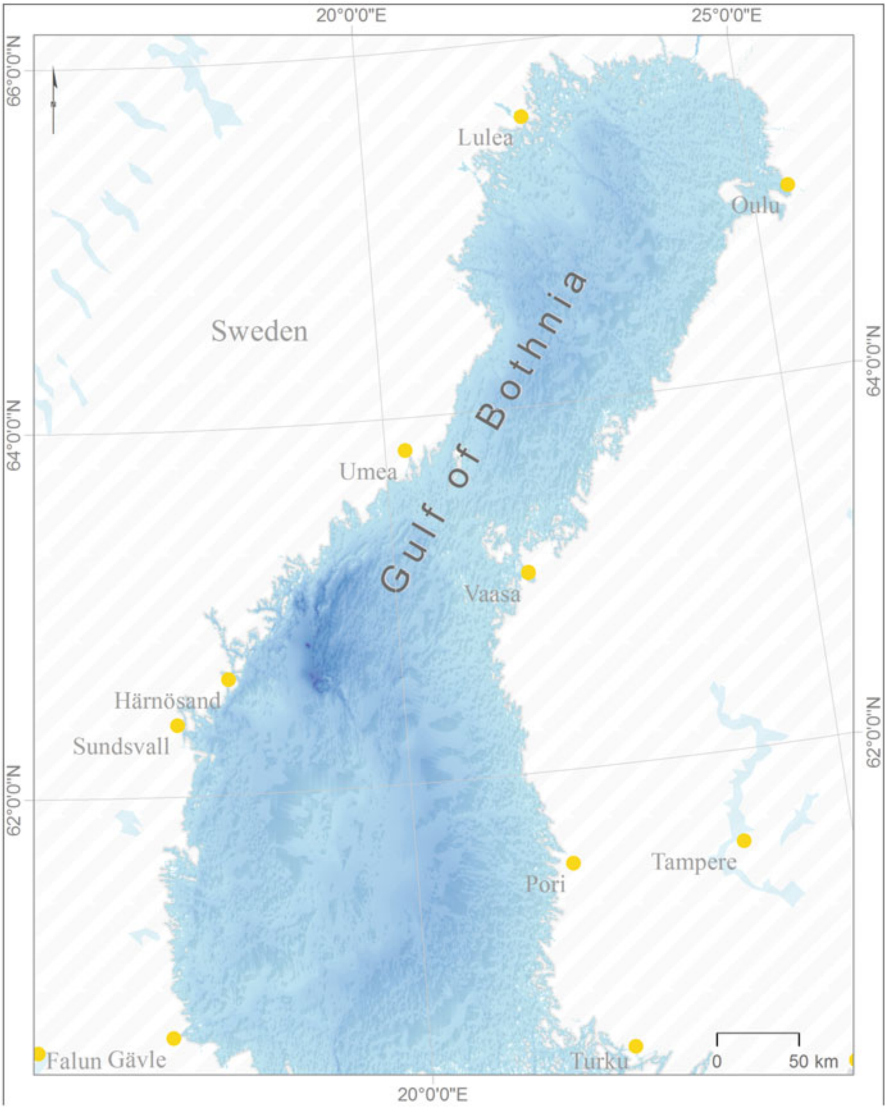

Fig. 7.1 The Gulf of Bothnia (G. Gic-Grusza)

Chapter 8
General Characteristics of Malacostraca

Malacostracans are among one of the most species-rich classes in nature. The crustaceans in this class differ widely in size—from a few millimetres to almost one metre in length. Because of their complex morphological and anatomical structure, they are often referred to as higher crustaceans. The crustacean body is segmented and covered with an exoskeleton that often takes the form of a calcified chitin carapace. Many species are beautifully and brightly coloured, the colours and patterns depending on the substrate against which the animal is seen. They can be found in all types of water bodies, both marine and fresh water. They inhabit both open ocean and sea waters, but also the coastal zone. Many lead a pelagic life in the water column, thus constituting one of the major components of marine zooplankton. They also occur on the muddy and sandy bottoms of water bodies. Some species pairs have symbiotic relationships, while others are commensals, that is, they rely on food supplied by another species (Fig. 8.1).

The crustacean body plan consists of a head (cephalon), thorax (pereon) and abdomen (pleon). In many cases, the head is fused with from 1 to 5 thoracic segments or sometimes with all of them, forming a cephalothorax. The head and thorax are covered with by a massive carapace, which at the front is extended into a rostrum, and in Cumacea, a pseudorostrum. The head bears a pair of stalked, often compound eyes, two pairs of antennae (I—antennules, II—antennae), mandibles (mandibula) and two pairs of jaws (I—the maxillula, II—the maxilla). The thorax normally consists of seven or eight segments, each of which bears a pair of limbs. Some of them are used for locomotion (pereiopods), the others can perform other functions. The first pair of thoracic limbs, and sometimes the next two, are modified into maxillipeds. In some groups, the first pair of walking limbs is much stronger than the others and terminate in chelae or claws. The five pairs of abdominal legs (pleopods) are generally developed to the same extent. They are used for swimming, carrying eggs or gas exchange. In males, the first two pairs of pleopods have been modified into copulatory organs. The sixth pair of abdominal legs, the uropods, are often flattened. The terminal segment of the abdomen is called the

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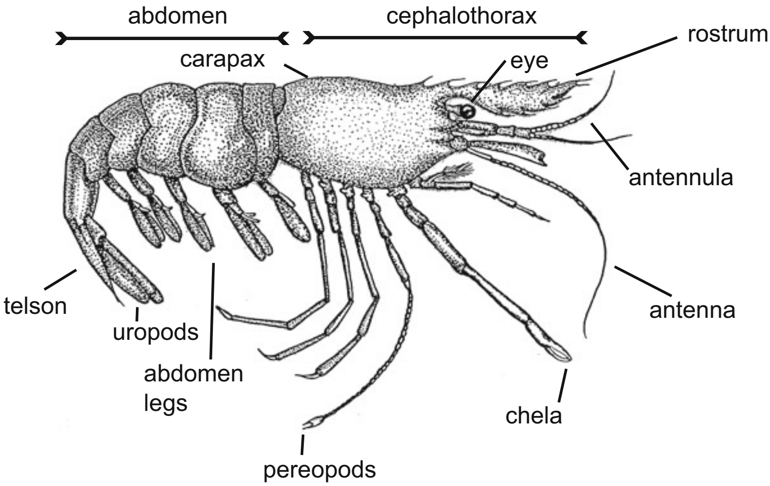

Fig. 8.1 Malacostraca—general habitus (Sylwia Aniszewska)

telson. Together, the telson and uropods form the tail fan, which functions as a rudder.

Gas exchange in crustaceans takes place through the gills and also the whole body surface. The brain is tripartite. The cardiovascular system has a heart of varying length, depending on the taxonomic group. Antennal or maxillary glands act as excretory organs. In some crustacean species balance organs—statocysts—are present.

Higher crustaceans are dioecious, and in many cases sexual dimorphism is pronounced. They are usually oviparous, sometimes ovoviviparous. Most of the crustacean species inhabiting the Baltic Sea do not reproduce throughout the year, but only from spring to autumn. Reproduction involves laying eggs in the brood pouch (marsupium). In most species, there is a linear dependence between the size of a female and the number of eggs she can carry: usually, the larger the female, the more eggs she carries and the more offspring she produces. Large, overwintering females are the first to start breeding; they are followed by the smaller ones, often born earlier in the same year. The animals grow by a series of moults, when the old exoskeleton is shed and replaced by for the initially soft and wrinkled new one.

In view of the very large differentiation among crustacean species, they play a multitude of roles in the environment and the human economy. Some are very important to the sea's food web, by feeding on other plant and animal organisms, but at the same time by serving as food for other animal species. Alien, often invasive, species can pose a threat to native species in that they compete with them for food and ecological niches in newly colonized areas. When colonizing a new area, they may transfer a range of other, often pathogenic, organisms that may threaten the existence of other animals. Consequently, certain crustaceans that have been brought to a new water body can change entire communities, upsetting their equilibrium, and adversely affecting human health and the economy. Against that, however, non-native crustaceans have had many positive impacts on newly colonized areas, at the very least by enhancing their biodiversity. By becoming a component of the food web in such areas, they also become a food resource for predators. Moreover, by inhabiting demersal areas they contribute to the cleaning and oxygenation of near-bottom waters. Many crustacean species are important to the economies of many countries. They are an important food for humans and livestock. Because of their delicious taste, and the valuable protein and mineral compounds they contain, they have become a delicacy in our diet. Many different crustacean species such as crayfish, shrimps and crabs are farmed. Crustaceans or their parts are used in the pharmaceutical, cosmetics and food-processing industries, also in agriculture and medicine. Chitin is recovered from their carapaces. *Saduria entomon*, for example, has particularly large amounts of chitin (12% of the dry weight of an individual). It is used for healing wounds, reducing blood cholesterol, and environmental conservation (for purifying drinking water, removing toxic metals from waste water). The life functions (metabolism, individual reproduction, heart rate, osmoregulation) of some species are used as bioindicators and biomarkers of the state of aquatic environments.

Chapter 9
Species Accounts

The low salinity of the Baltic Sea means that marine, fresh water and brackish water crustacean species can inhabit it. Many are benthic organisms. Some remain buried in the bottom sediments, others occur on sandy or muddy bottoms, and some attach themselves to a hard substrate. In the Baltic Sea, the class Malacostraca is represented by six orders. Five of these—Mysidacea, Cumacea, Tanaidacea, Isopoda, and Amphipoda—belong to the Eumalacostraca, while the Eucarida are represented by one order—Decapoda.

The largest group of malacostracans in Polish Baltic waters are the Amphipoda, of which there are 29 species inhabiting the coastal zone, bays and lagoons. The order Isopoda is represented by 13 species in these waters, and there are 8 decapod species. Some of these species are permanent inhabitants of the coastal zone of the Baltic Sea, whereas others occur only during certain periods of their lives, neither reproducing here nor forming a population. The Mysidacea are represented in the Baltic by six species and the Cumacea and Tanaidacea by one species each.

Species Composition of Crustaceans in the Polish Zone of the Baltic Sea Coast: According to WoRMS (World Register of Marine Species) www.marinespecies.org

Phylum: Arthropoda
  Subphylum: Crustacea
    Class: Malacostraca
      Subclass: Eumalacostraca
        Superorder: Peracarida

1. Order: Mysidacea

    Mysis mixta Liljeborg, 1853
    Mysis relicta Lovén, 1862

(continued)

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Neomysis integer (Leach, 1814)
Hemimysis anomala G.O. Sars, 1907
Praunus flexuosus (Müller, 1776)
Praunus inermis (Rathke, 1843)

2. Order: Cumacea

Diastylis rathkei (Krøyer, 1841)

3. Order: Tanaidacea

Heterotanais oerstedi (Krøyer, 1842)

4. Order: Isopoda

Saduria entomon (Linnaeus, 1758)
Idotea chelipes (Pallas, 1766)
Idotea balthica (Pallas, 1772)
Idotea granulosa Rathke, 1843
Jaera albifrons Leach, 1814
Jaera ischiosetosa Forsman, 1949
Jaera syei Bocquet, 1950
Jaera praehirsuta Forsman, 1949
Lekanesphaera hookeri (Leach, 1814)
Lekanesphaera rugicauda (Leach, 1814)
Eurydice pulchra Leach, 1815
Cyathura carinata (Krøyer, 1847)
Asellus aquaticus Linnaeus, 1758

5. Order: Amphipoda

Hyperia galba (Montagu, 1815)
Gammarus locusta (Linnaeus, 1758)
Gammarus duebeni (Liljeborg, 1852)
Gammarus zaddachi Sexton, 1912
Gammarus oceanicus Segerstråle, 1947
Gammarus inequicauda Stock, 1966
Gammarus salinus Spooner, 1947
Gammarus tigrinus Sexton, 1939
Pontogammarus robustoides (Sars, 1894)
Obesogammarus crassus (G.O. Sars, 1894)
Dikerogammarus haemobaphes (Eichwald, 1841)
Dikerogammarus villosus (Sowinsky, 1894)
Chaetogammarus ischnus (Stebbing, 1899)
Chaetogammarus stoerensis (Reid, 1938)
Calliopius laeviusculus (Krøyer, 1838)

(continued)

Melita palmata (Montagu, 1804)
Monoporeia affinis Lindström, 1855
Pontoporeia femorata Krøyer, 1842
Bathyporeia pilosa Lindström, 1855
Leptocheirus pilosus Zaddach, 1844
*Talitrus saltato*r (Montagu, 1808)
Talorchestia deshayesii (Audouin, 1826)
Orchestia cavimana Heller, 1865
Platorchestia platensis (Krøyer, 1845)
Corophium crassicorne Bruzelius, 1859
Corophium lacustre Vanhöffen, 1911
Corophium volutator (Pallas, 1766)
Corophium multisetosum Stock, 1952
Chelicorophium curvispinum (G.O. Sars, 1895)
Dyopedos monacanthus (Metzger, 1875)

Subclass: Eucarida

6. Order: Decapoda

Crangon crangon (Linnaeus, 1758)
Palaemon adspersus Rathke, 1837
Palaemon elegans Rathke, 1837
Palaemon macrodactylus M. J. Rathbun, 1902
Palaemonetes varians (Leach, 1813)
Rhithropanopeus harrisii (Gould, 1841)
Eriocheir sinensis H. Milne-Edwards, 1853
Carcinus maenas (Linnaeus, 1758)
Orconectes limosus (Rafinesque, 1817)
Pacifastacus leniusculus (Dana, 1852)

9.1 Mysidacea

There are some 780 species in this order. They are small animals, from 2 to 30 mm in length. All are aquatic, inhabiting not only coastal sea waters but also ocean waters down to 3500 m depth. Just a small number occur in fresh water. A few species inhabit moist beach sand. A dozen or so mysid species live in the Baltic, but only six of them occur in the southern part of this sea. Mysids have an elongated, slightly flattened body that is covered with a delicate, almost transparent chitinous carapace. They are usually transparent, but some can be conspicuously spotted. The animals' body colour can change, depending on the environment in which they live: they become darker over a muddy substrate, but are almost transparent in the water column, while on sand their bodies become covered with dark spots. In areas where light is scattered, they turn red.

Most Baltic mysids inhabit the coastal zone, and many undertake seasonal or diurnal migrations. In spring and summer most species gather in coastal areas at night, where their numbers can reach several thousand per square metre. Some species stay close to the seabed during the day, but move up to the surface at night.

The head and thorax are fused to form the cephalothorax, and this is covered by a carapace. Only one or two body segments of the body may be free, not covered by the carapace. This is usually attached to one, or at most the first three body segments. There may be a cleft at the rear of the carapace. At the front, the carapace projects into a rostrum. There are two pairs of biramous antennae on the head. The antenna of the first pair—the antennule—consists of a scape and two flagella of varying length. In the adult male a setose "male appendage" grows out of the top of the scape. The antenna of the second pair consists of a scape and branches. The antennae bear sense organs. The brown or dark grey eyes are stalked. The mouthparts consist of mandibles and two pairs of jaws. Each thoracic segment bears a pair of legs. The first pair function as maxillipeds and help to take up and grind food. The other seven pairs of thoracic legs consist of an oar-shaped femur, bifurcating into multisegmented limbs (pereopods) richly covered with setae for swimming and wafting water under the carapace, thereby facilitating breathing and the uptake of food.

The thin, cylindrical abdomen consists of six segments ending in a tail plate, the telson. Together with the last pair of abdominal legs, the uropods, the telson forms a broad tail fan. Along the inner margin of the uropods are the statocysts, the basic organs of balance. The other five pairs of abdominal legs (pleopods), if present, are reduced. The telson is large, often covered with setae.

Mysids are dioecious. In general, males are larger and have longer antennae. Two generations usually occur in the Baltic Sea. The body size of the winter generation is larger than that of the summer generation. They reproduce twice or three times during their lifetime. Female fertility is not high, ranging from 5 to 120 eggs. Females lay their eggs in the brood pouch or marsupium, where the young develop. In some species, eggs and embryos at different stages of development may be present at the same time. In the Baltic mysids live from 6 to 14 months.

Mysids play an important part in the Baltic food web. On the one hand they feed on small organisms and organic matter, on the other they constitute food for many species of fish, such as herring (*Clupea harengus*), flounder (*Platichthys flesus*), black goby (*Gobius niger*), sand goby (*Pomatoschistus minutus*) and young cod (*Gadus morhua*) (Fig. 9.1).

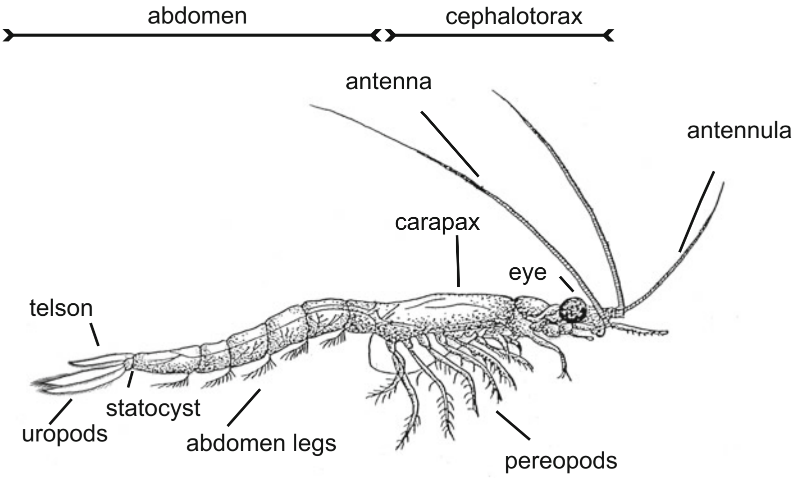


Fig. 9.1 Mysidacea—general habitus (drawing by Sylwia Aniszewska)

9.1.1 Mysis mixta

Mysis mixta Liljeborg, 1853
Order: Mysidacea
Family: Mysidae

Basic Morphological Features

Mysis mixta is the largest representative of the Mysidacea in the Baltic Sea, reaching 30 mm in length. There are numerous brown chromatophores on the transparent body. The rostrum is strongly elongated, almost six times longer than wide, with a sharp, lancet-like end. The greenish, stalked eyes are pear-shaped. The telson at the rear is deeply cleft over 25% of its length. There are 30 spines along its outer margin, and numerous small ones along the inner margin.

Occurrence

It occurs along the coast of North America and around the poles. It is found in the waters of northern Europe as far as the White Sea. It occurs throughout the Baltic and is the most abundant mysid species, increasing in numbers from west to east. It inhabits the deeper waters of the Gulf of Gdańsk and also occurs in Puck Bay.

Biology and Ecology

A euryhaline species, it prefers water with a salinity of less than 6‰. It is also stenothermic, i.e. it inhabits cold waters (3–4 °C). In some parts of the Baltic Sea at depths of 25–40 m its numbers can be as high as 100 and more individuals per square metre. Anoxia in the deeper waters of the Baltic prevents their being colonized by this species. The largest aggregations occur in June, but decline markedly in October. Diurnal migrations are characteristic. During the day, the animals remain in colder, deeper waters, rising towards the surface at night. Young individuals migrate closer to the surface than adults. *M. mixta* is omnivorous: the main component of the diet is zooplankton, particularly small copepods, but it also feeds on phytoplankton, detritus and even small organisms inhabiting the sediments. It is thus an important though indirect link between the bottom of the water body and the water above. Reproduction takes place in autumn or winter. A single female can carry up to 70 eggs in her brood pouch. The young hatch in early spring. By May they reach a length of about 4 mm, and in December, having reached a length of 15–20 mm, they become sexually mature.

Impact

M. mixta plays an important role in the food web in that it significantly affects the abundance of zooplankton by foraging on it. It is a dietary component of sprat *Sprattus sprattus*, twaite shad *Alosa fallax*, cod *Gadus morhua*, European smelt *Osmerus eperlanus*, sand goby *Pomatoschistus minutus,* black goby *Gobius niger*, turbot *Scophthalmus maximus* and herring *Clupea harengus* (Fig. 9.2).

Fig. 9.2 *Mysis mixta* (Piotr Kendzierski)

9.1.2 *Mysis relicta*

Mysis relicta Lovén, 1862
Order: Mysidacea
Family: Mysidae

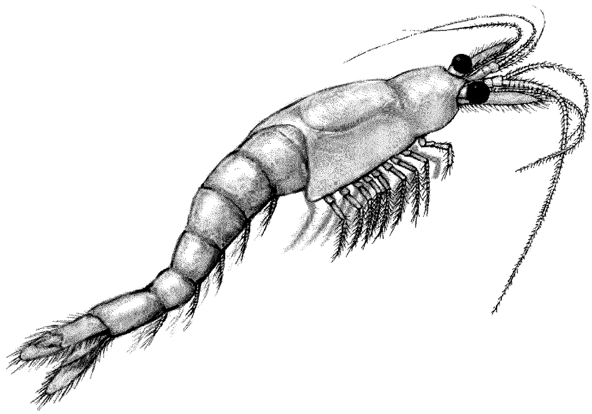
Basic Morphological Features
Specimens are small, not exceeding 25 mm in length. The body, like the other species in this family, is transparent, with just a few scattered chromatophores. The rostrum is lancet-like, about four times longer than wide and devoid of chromatophores. The animals have large, pear-shaped, stalked eyes. The end of the telson is cleft at right angles. There are 20–30 small spines along outer margins of the telson.

Occurrence
The species is not numerous and represents only 10% of all Mysidacea. It is rare in the Gulf of Gdańsk, where it inhabits only the deeper waters. It occurs mainly in the northern Baltic, where numbers can reach 16 individuals per square metre. It is most numerous in June and July. It is also present in some deep, clear European lakes with low water temperatures, for example, Lakes Drawsko or Northern Mamry in Poland.

Biology and Ecology
A euryhaline species, it tolerates water with a very low salinity and even occurs in fresh water bodies. At the same time, it is stenothermic, preferring cold water. Being a Baltic relict, dating from the time of the sea's glaciation, it prefers water temperatures of 3–4 °C. It is omnivorous, foraging on small animals as well as animal and plant detritus. It is dioecious, and reproduction takes place in winter. Females carry their eggs for several months in their marsupia. Juveniles are 3–4 mm in length when they hatch in June; by July they are already 6 mm in length, and by December 15 mm. They live no longer than 1.5 years.

Impact
In the food web this species provides a link between the sea bed and the water above. It is fed on by many fish species: sprat *Sprattus sprattus*, twaite shad *Alosa fallax*, cod *Gadus morhua*, European smelt *Osmerus eperlanus*, sand goby *Pomatoschistus minutus,* black goby *Gobius niger*, turbot *Scophthalmus maximus* and herring *Clupea harengus* (Fig. 9.3).

Fig. 9.3 *Mysis relicta* (Stanisław Węsławski)



9.1.3 *Neomysis integer*

Neomysis integer (Leach, 1814)
Order: Mysidacea
Family: Mysidae

Basic Morphological Features
In the Polish coastal zone of the Baltic Sea specimens reach a maximum length of 23 mm, with females being slightly larger than males. The largest specimens caught in the Gulf of Gdańsk were 15.5 mm long. Their body is almost transparent—any colour is due to a few scattered chromatophores. The antennules are divided into two flagella, the second into a flagellum and an annulus. The species is are characterized by a very long, pointed rostrum, almost ten times longer than wide. The stalked eyes are large, black and pear-shaped. The telson is elongated, clearly tapering, and slightly cleft at the rear, forming the tail fan. The margins of the telson bear between 15 and 20 spines.

Occurrence
The species occurs throughout the Baltic Sea, including the Gulf of Bothnia and the Gulf of Finland. It inhabits coastal bays, lagoons and lakes. It is numerous in the Szczecin and Vistula Lagoons. It usually occurs in the warmer, shallow waters close to the shore, down to a depth of about 1 m. In such environments, there may be up to several tens of individuals per square metre.

Biology and Ecology
It is a brackish water, euryhaline species of marine origin. Low salinities of 1–2‰ do not pose any obstacle to its occurrence. A eurythermic species, it tolerates a wide range of ambient temperatures. It undergoes seasonal and diurnal migrations. In

spring and summer, it congregates closer to the shore, in the emergent plant zone. Its preferred areas of occurrence are shallow waters near breakwaters, jetties and ports. In late summer, it migrates from the coastal zone to a depth of 30–40 m. In March, when the water temperature rises, it returns to the coastal zone. It is found in numerous single-generation shoals. Juveniles prefer deeper waters, older animals somewhat shallower ones. This segregation probably protects the young from cannibalism. During the day these mysids occur in large numbers closer to the shore, migrating at night into deeper waters. They are omnivorous, feeding on phytoplankton, zooplankton and organic detritus. Reproduction takes place from April to October, with 2–3 generations being produced in the course of the year. Overwintering animals start reproducing in early spring, and the reproduction peak is in June. A female carries from a few to several dozen eggs. A temperature of ca 15 °C and a salinity of 14–17‰ are the optimum conditions for embryonic development. The smallest females caught carrying eggs, i.e. ovigerous females, were 9.5 mm long. The larger the female, the more eggs she carries in her brood pouch, but no more than 74. Hatchlings leaving the brood pouch are about 2–3 mm long, are fully developed and resemble adults in appearance.

Impact

This species is a source of food for planktivorous fish, like European smelt *Osmerus eperlanus* as well as other crustaceans like *Crangon crangon* and some snails. It is primarily the food of commercially important fish such as cod *Gadus morhua, sprat Sprattus sprattus,* pike-perch *Stizostedion lucioperca, herring Clupea harengus*, flounder *Platichthys flesus,* plaice *Pleuronectes platessa,* European perch *Perca fluviatili*s, twaite shad *Alosa fallax,* sand goby *Pomatoschistus minutus,* common goby *P. microps* and brown trout *Salmo trutta* (Figs. 9.4, 9.5 and 9.6).

Fig. 9.4 *Neomysis integer* (Piotr Wysocki)

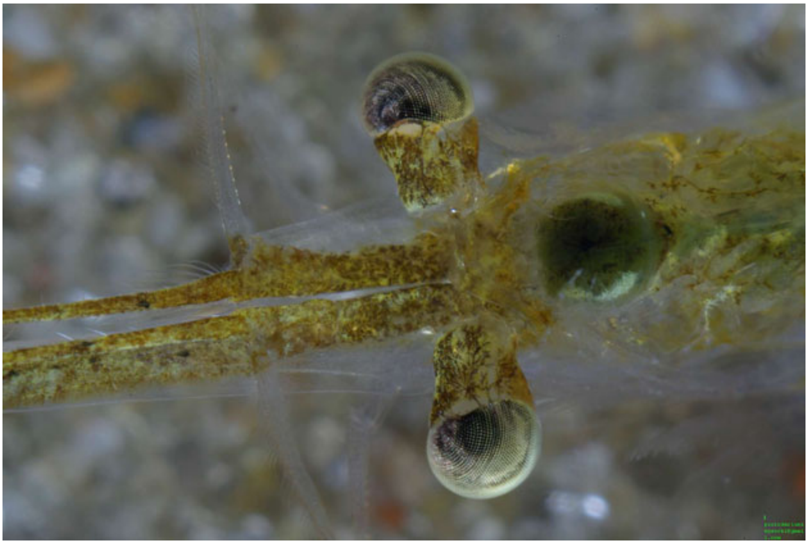


Fig. 9.5 Eyes of *Neomysis integer* (Piotr Wysocki)

Fig. 9.6 Shoal of *Neomysis integer* (Piotr Wysocki)

9.1.4 *Hemimysis anomala*

Hemimysis anomala G.O. Sars, 1907
Order: Mysidacea
Family: Mysidae

Basic Morphological Features
In the Black Sea individuals of this species are 8–10 mm long. In fresh water they reach a slightly smaller size—6.7–8.5 mm. The cephalothorax is relatively broad and short. The rostrum is elongated into an oval shape, being about three times as long as wide. The eyes are very large, round and on short stalks. Characteristic of this species are the red spots covering the body and its ability to change colour. In deeper waters they can turn completely red.

Occurrence
This is a species from the Ponto-Caspian region, where it is present in estuarine and coastal waters of the Sea of Azov and the Black Sea, and also the Caspian Sea, where it inhabits rocky coasts. In the 1950s the species was introduced to the Rivers Dnieper and Volga, and also to the Baltic Sea's catchment areas, i.e. the River Niemen and even the vicinity of St. Petersburg. In the 1980s and 1990s it reached the Curonian Lagoon. It was first recorded in the Baltic in 1962, off the coast of Estonia, having probably got there in the ballast waters of ships. Migration was the cause of its further spread in the northern Baltic, where it was able to create populations. In Polish waters it was first noted in 2002, in the Oder estuary. It presumably arrived there in river waters. It was first recorded in the Gulf of Gdańsk in 2004. An alien species, it also occurs in Puck Bay and in the shallower parts of the Gulf of Gdańsk.

Biology and Ecology
A euryhaline species, it occurs in waters of salinity 0.5–18‰. It is also eurythermic. Although it is omnivorous, it can also be a predator. It has a nekto-benthic lifestyle. It prefers hard substrates. It spends the day near the sea bed, hidden among boulders and pebbles, and after dusk moves into the open water, where it forms shoals.

Impact
In the waters in which it is present, it may be an important food component for fish, which is the reason why in the 1990s it was taken to Lithuanian waters for fish farming purposes (Figs. 9.7 and 9.8).

Fig. 9.7 *Hemimysis anomala* (Piotr Wysocki)

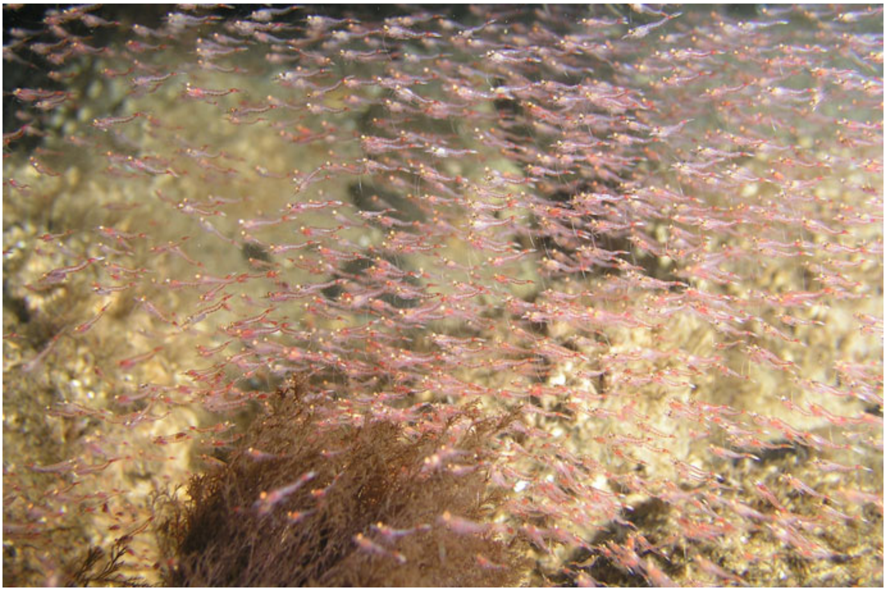


Fig. 9.8 Shoal of *Hemimysis anomala* (Piotr Wysocki)

9.1.5 *Praunus flexuosus*

Praunus flexuosus (Müller, 1776)
Order: Mysidacea
Family: Mysidae

Basic Morphological Features
The species is small, the largest specimens reaching a length of 25 mm. It has large, black eyes, protruding from both sides of the head. A characteristic feature is the elongated rostrum, the inner margin of which is smooth, without setae. The telson has a deep cleft bearing 30 tiny spines. The body is almost transparent; only along the dorsal line, on each abdominal segment, are there distinct, double clusters of chromatophores. Single chromatophores are also visible on the sides of the thorax not covered by the carapace. The body can take on many different colours, depending on the surroundings.

Occurrence
It occurs in the bays and lagoons of the Baltic Sea, including the Gulfs of Bothniaand Finland. It is also common in Puck Bay and the shallower waters of the Gulf of Gdańsk.

Biology and Ecology
It is a marine, euryhaline species, typical of the boreal zone. It inhabits coastal waters of the Baltic Sea where the salinity does not fall below 3–6‰. It is found in ports, near breakwaters, and vegetated areas. In autumn, when the coastal waters cool down, it migrates into the deeper parts of the sea. It is eurythermic, that is, it is tolerant of a broad range of ambient temperatures. It is omnivorous. Reproduction takes place from spring to autumn, two generations being produced during the year. The smallest females start breeding, when they are at least 12.5 mm long. A female of medium body size can carry only a dozen or so eggs. The largest number of eggs found in a female was 40.

Impact
It serves as food for many fish species (Fig. 9.9).

Fig. 9.9 *Praunus flexuosus* (Piotr Wysocki)

9.1.6 Praunus inermis

Praunus inermis (Rathke, 1843)
Order: Mysidacea
Family: Mysidae

Basic Morphological Features

A generally small crustacean, the largest specimens caught in the Gulf of Gdańsk were only 13 mm in length. The rostrum—four times as long as wide—is a characteristic feature of the species. The large, black eyes protrude to the sides.

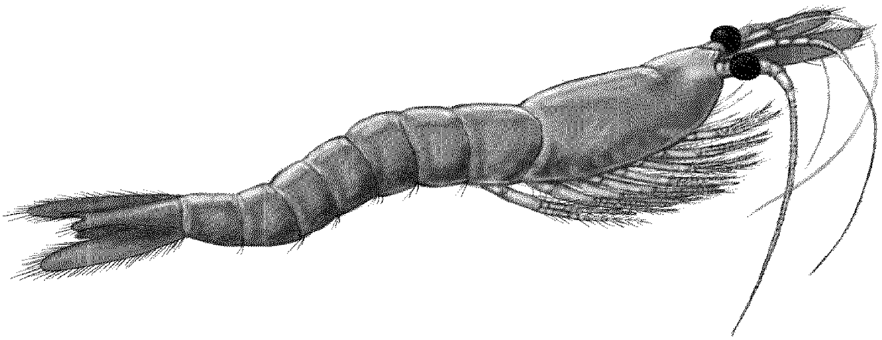


Fig. 9.10 *Praunus inermis* (Stanisław Węsławski)

The cleft in the telson is narrow with 16 small spines. The body is transparent; only along the dorsal line are there clearly visible double clusters of chromatophores. There are similar clusters on the last, unexposed segment of the body. The colour is dependent on the surroundings.

Occurrence
The species is rather rarely seen. Its abundance is the largest in spring, summer and early autumn. It lives among the vegetation in the coastal waters of the Baltic Sea, but avoiding the surface layer. It rarely occurs in the shallows down to 1 m depth, preferring depths from 5 to 10 m. In autumn, when the water cools down, it migrates into deeper parts of the sea.

Biology and Ecology
It is a euryhaline, marine species, occurring in water with a salinity of at least 6‰. It is eurythermic. Reproduction takes place from May to October. The minimum length of reproducing females is 8 mm. A female can lay up to 30 eggs at a time.

Impact
It is a food resource for many fish species (Fig. 9.10).

9.2 Cumacea

About 1300 species of this order have been described, the large majority of which live in sea waters. Representatives of only 21 genera occur in fresh water, and these are concentrated mainly in the Ponto-Caspian region. Many species are euryhaline, so they can be found in littoral lagoons and estuarine waters. Cumaceans have been known since 1780, when the species *Diastylis scorpioides* was first described. It was previously thought that they were larval stages of Decapoda. These animals are small, no longer than 18 mm, and look like a large “comma”. The first three segments of the body are fused with the head, forming a convex cephalothorax. At the front this terminates in a biramous pseudorostrum, unique to this order. It is covered by a carapace, which partially covers the gill chamber. The upper part of

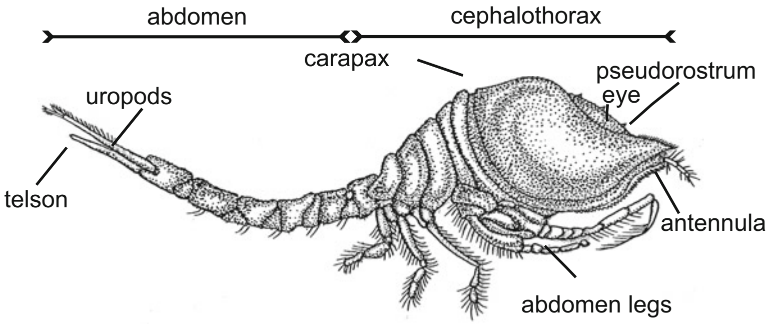


Fig. 9.11 Cumacea (Sylwia Aniszewska)

the carapace bears various kinds of ornamentation, such as setae, knobs, ridges and furrows. The abdomen is relatively slim. On the head there are eyes, often merged into a single eye in the middle of the head. Cumaceans inhabiting deeper waters have no eyes. In females the second pair of antennae is reduced, whereas in males they are very long and point towards the gill chamber, so as to waft water on to the gills. Cumaceans have three pairs of maxillipeds. The first pair, directing water into the gill chamber, assists breathing. Only males have abdominal legs. The elongated telson is flanked on either side by a pair of uropods. Many species inhabit deeper regions of the oceans. Cumaceans are eurybathic animals, i.e. they are very tolerant to changes in water pressure. They lead a benthic life, buried in the sediments of the sea bed, while at night they swim in the water. They feed on detritus and microorganisms. Populations often consist of more females than males. Sexual dimorphism is pronounced: males are larger and during the breeding period they become brightly coloured. The brood pouch (marsupium) in the female is formed by oostegites located at the base of the third pair of maxillipeds. The female lays her eggs in the marsupium where they are inseminated. Freshly-hatched young do not possess the last pair of thoracic legs. This stage is referred to as a manca. Only one species is present in the Baltic Sea—*Diastylis rathkei* (Fig. 9.11).

9.2.1 *Diastylis rathkei*

Diastylis rathkei (Krøyer, 1841)
Order: Cumacea
Family: Diastylidae

Basic Morphological Features

In the Baltic Sea this species may reach a length of 18 mm. The body resembles a large comma. The carapace is extended and clearly separated from the pleon (abdomen), which is relatively long, slim and terminates in an elongated wedge-shaped telson, on either side of this are the biramous uropods. The thoracic legs are small.

Occurrence

Common in the deeper regions of the Baltic Sea, it is present in the Gulf of Gdańsk at depths below 10 m.

Biology and Ecology

The species spends the day buried in the bottom sediments, becoming active at night. It undergoes a diurnal vertical migration to the sea surface. It prefers cold waters, inhabits deeper waters, where the salinity is around 15‰. It can tolerate considerable levels of anoxia. It consumes zooplankton and also detritus. The species reproduce in winter. A single female can carry up to 100 eggs in her marsupium.

Impact

The species is involved in bioturbation, i.e. the mixing of bottom sediments. It is the food of some fish species such as sand goby *Pomatoschistus minutus* (Fig. 9.12).

Fig. 9.12 *Diastylis rathkei* (Piotr Wysocki)

9.3 Tanaidacea

About 900 species belong to this order, most of which are marine. Only four fresh water species are known. Tanaids have recently been found near hydrothermal springs and underwater methane outflows. During the Galathea ocean expedition in 1950–1952, three tanaid species were found at depths greater than 6000 m. In the Baltic Sea, including the Gulf of Gdańsk, there is only one species, *Heterotanais oerstedi*. Tanaids are small, from 2 to 7 mm in length, and most are cylindrical in shape. They spend their lives buried in the bottom sediments of coastal sea waters. From secreted mucus they build tubular cases which they attach to aquatic vegetation and all kinds of other solid substrates in the water. The carapace covers the head and the first two segments of the thorax. The head bears two pairs of antennae. The antennules may be branched or unbranched and is larger than the second pair. Some species have immobile eyes, but most are blind. A characteristic feature is the second pair of maxillipeds, modified into clawed gnathopods. The third pair of pereopods is adapted to burrowing in bottom sediments, while the other thoracic legs are unbranched. The pleopods are reduced. The terminal pleopods, the

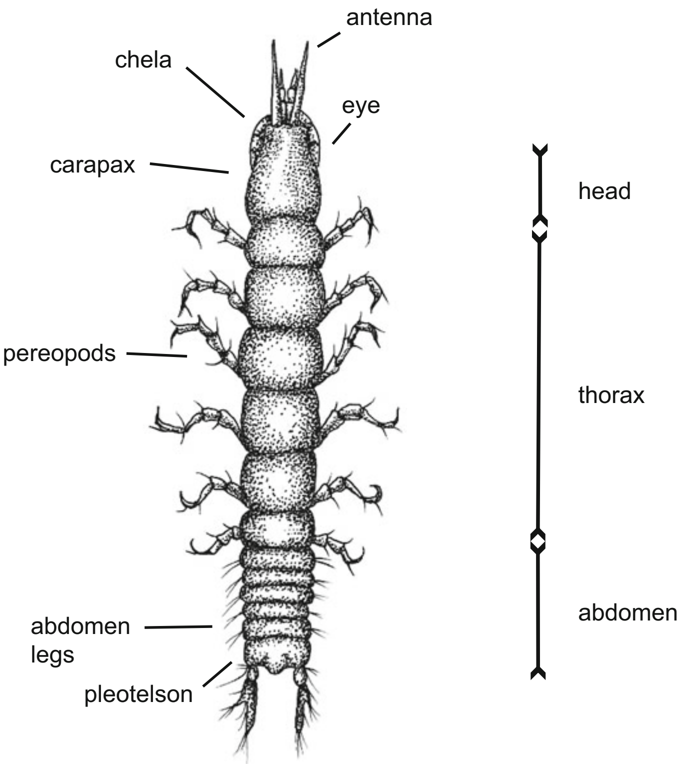


Fig. 9.13 Tanaidacea (Sylwia Aniszewska)

uropods, are biramous. The last body segment is fused with the telson, forming the pleotelson. The crustaceans belonging to this order have not developed separate respiratory organs and the inner part of the carapace has become adapted to gas exchange. They feed on detritus, small plants and animals, such as nematodes and diatoms. They are an important component of the food web. All known species are dioecious. Sexual dimorphism is pronounced, obvious even in the different claw structure and eye size. The marsupium may be formed from just one pair of oostegites. A female lays eggs in the marsupium, where they are fertilized by a male. The juvenile stage is very similar to the adult stage. There is also a manca stage, in which juveniles do not have the last pair of thoracic legs (Fig. 9.13).

9.3.1 Heterotanais oerstedi

Heterotanais oerstedi (Krøyer, 1842)
Order: Tanaidacea
Family: Leptocheliidae

Basic Morphological Features
The length does not exceed 2 mm. The body is cylindrical, terminating in a short, oval pleon (abdomen). Eyes are visible in both sexes. Males have massive chelae (claws). Because of its small size, the biology and ecology of this species is not very well known.

Occurrence
The species is not numerous in the Baltic Sea but is does inhabit its easternmost regions. It occurs in the Vistula Lagoon, the Gulf of Gdańsk and Puck Bay. It is found in shallow estuarine waters and many tideless, coastal zones of seas, to depths of about 10 m. It forms shoals, which in the coastal areas of north-west Europe can exceed 5000 specimens per square metre. In the 1960s numbers of this species in some parts of the Vistula Lagoon reached 8000 per square metre.

Biology and Ecology
The species inhabits sandy bottoms and filamentous algae, on which it builds a U-shaped tube of mud and sand, which it attaches to the solid substrates. A brackish water species, it tolerates low and variable salinities, but no higher than 4‰. It is a eurythermic species. It feeds on tiny animals and plants. It reproduces twice a year, first in late spring and again in autumn. A change of sex has been recorded: some animals, born as females in spring and which reproduced in autumn, become males, which breed the next spring. Hermaphrodites have also been reported. They live for about a year.

Impact
They are involved in bottom sediment bioturbation (Figs. 9.14, 9.15 and 9.16).

Fig. 9.14 *Heterotanais oerstedi* (L. Marszewska)

Fig. 9.15 *Heterotanais oerstedi* (L. Marszewska)

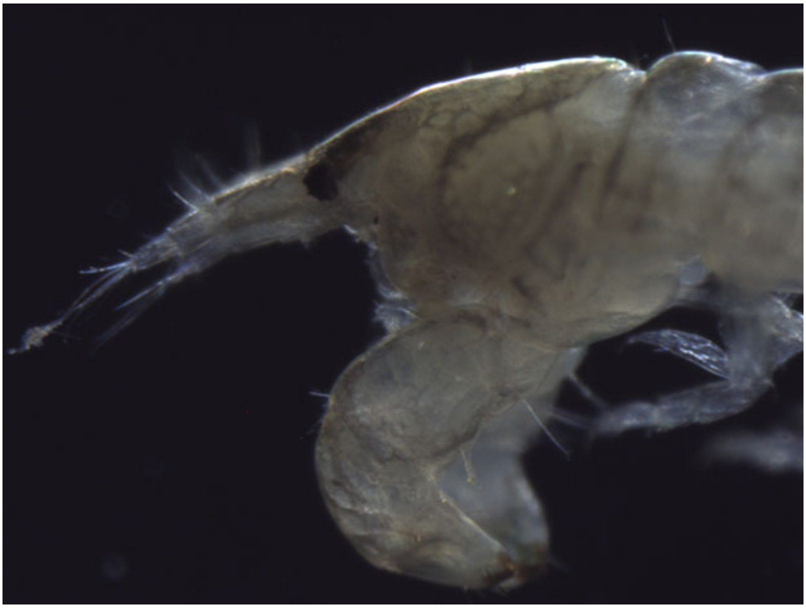


Fig. 9.16 *Heterotanais oerstedi* (L. Marszewska)

9.4 Isopoda

There are about 10 thousand species in this order. Isopods occur in all kinds of water bodies: seas, deep oceans, coastal brackish waters and inland fresh waters. Some inhabit terrestrial environments. Their lifestyles are highly differentiated. Aquatic isopods are mostly benthic, living on the bottom or buried in the sediments. A few species are pelagic and some parasitize marine animals. Some occur in ground waters. Those living on land choose a wide range of environments, from wet to dry.

Most species are very small, reaching a length of only a dozen or so millimetres, although certain deep-sea species can be several tens of centimetres long.

The isopod body plan consists of a head, a distinctly outlined thorax and pleon (abdomen). They are of different shapes, but most are flattened dorsoventrally. They have no carapace. The head segments are fused with the first or second thoracic segment. The next seven segments are free, all bearing unbranched pairs of pereopods (thoracic legs). The last abdominal segments may be fused with the telson, forming a pleotelson. The terminal pairs of abdominal legs (pleopods) are uropods of varying shape. Most species have eyes, but some do not. The antennules are short, the antennae are a little longer. The first pair of thoracic legs is modified into maxillipeds, the others are used for locomotion. The pleopods are biramous, with an inner branch known as an endopodite, and an outer one known as an exopodite. These may play an important function in gas exchange. Often the first

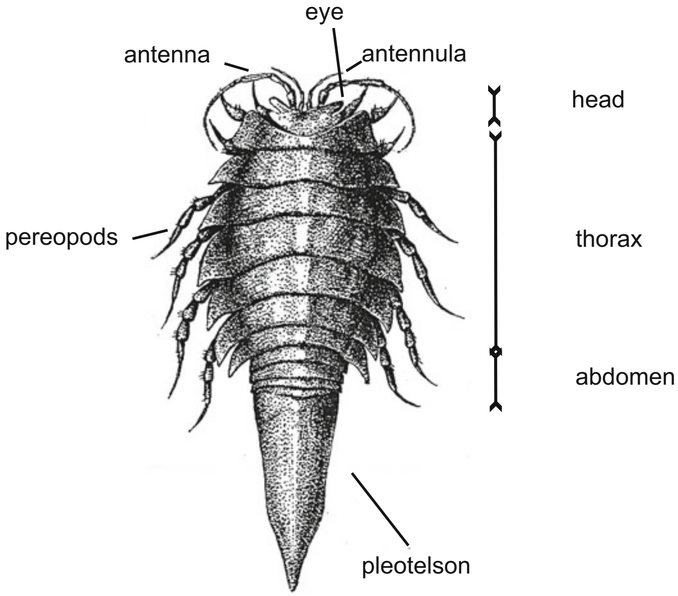


Fig. 9.17 Isopoda—general habitus (Stanisław Węsławski)

pair is broad and protects the gills. By moving the mantle and legs, isopods ensure a constant flow of water that carries oxygen to the body.

Aquatic isopods consume a variety of food; hence they can be classified as omnivores. They include detritus feeders, predators and parasites, though most of them prefer food of animal origin.

The isopods occurring in the Gulf of Gdańsk are dioecious. The marsupia in females consist of 3–5 pairs of oostegites. The lifecycle includes a manca stage, which differs from the adult form in the lack of the seventh pair of pereopods. The animals grow as a result of a two-phase moulting process: the rear end of the exoskeleton is shed first, then the fore part. Isopods are a food resource for many fish species (Fig. 9.17).

9.4.1 *Saduria entomon*

Saduria entomon (Linnaeus, 1758)
Synonym—*Mesidotea entomon* (Richardson, 1905)
Order: Isopoda
Family: Idoteidae

Basic Morphological Features

This is a Baltic relict species of Arctic origin. Individuals can reach a length of up to 80 mm. The thorax is large, oval, with characteristic indented edges. The head is small with round, black eyes. The pleon is massive, and ends in a tapering, wedge-shaped telson. The whole animal is pale brown or pale yellow in colour.

Occurrence

It lives in the Arctic and the boreal zone of the northern hemisphere. It is a common component of the benthic fauna of the central Baltic Sea as well as the Gulfs of Bothnia, Finland and Riga. It inhabits the Baltic only as far west as the island of Bornholm; it is not found beyond this limit, nor does it occur in the North Sea. It inhabits many lakes and seas in the Arctic and temperate zones of the northern hemisphere. It is encountered in the White Sea, the estuary of the River Daugava and the coastal waters of northern Siberia all the way to the Bering Straits. It also inhabits the west coast of North America, from Alaska to central California.

Biology and Ecology

It prefers a sandy-muddy bottom, although one can come across it on peaty substrates, too. It spends a significant part of its life buried in sediments, although the movements of its pleopods make it perfectly capable of swimming. It is a euryhaline species, very tolerant of salinity changes. It occurs in waters of salinity 0–33‰, but the Baltic population does not live beyond the 15‰ isohaline. Fresh water populations also exist. Because of its origin, it is a stenothermic species, tolerating only small changes in ambient temperatures. Preferring colder waters, it populates areas where temperatures do not exceed 6 °C. It is very resistant to oxygen deficiencies. Because of its environmental requirements, it lives in deeper parts of the sea, though more and more often one comes across it nowadays in shallower waters: the deteriorating environmental conditions in the deeper areas of the Baltic Sea are forcing these crustaceans to move there. In adverse environmental conditions, the animals emerge from the sediments and bend in order to facilitate the flow of water through their bodies. They raise the end of the abdomen, moving their pleopods more quickly. At the same time the heart rate increases, enhancing oxygen assimilation. Under hypoxic conditions, they lower their metabolic rate, while at the same time deriving energy from anaerobic metabolism. With these capabilities, they can survive adverse environmental conditions for a long period. The species is an omnivorous scavenger, feeding on the dead remains of molluscs, crustaceans, fish and other organisms that happen to be in the bottom sediments. It can lead a predatory life, but also feed on plants and detritus. Cannibalism has also been observed. The species is dioecious, with distinct sexual dimorphism. It reproduces throughout the year, with a peak in summer. Females are much larger than males.

Impact

It is an important component of the food web. On the one hand, it helps to cleanse water bodies by feeding on dead animal remains, on the other it is an important food resource for fish, e.g. cod *Gadus morhua,* European eel *Anguilla anquilla,* fourhorn sculpin *Myoxocephalus quadricornis,* common dab *Limanda limanda,* sand goby *Pomatoschistus minutus* and flounder *Platichthys flesus* (Figs. 9.18, 9.19, 9.20 and 9.21).

Fig. 9.18 *S. entomon* (Piotr Wysocki)

Fig. 9.19 *S. entomon* copulation (Piotr Wysocki)

Fig. 9.20 *S. entomon* female with eggs (Piotr Wysocki)

Fig. 9.21 Juveniles in marsupium (Piotr Wysocki)

9.4.2 *Idotea chelipes*

Idotea chelipes (Pallas, 1766)
Order: Isopoda
Family: Idoteidae

Basic Morphological Features

In Puck Bay specimens reach a length of 19 mm. As in the case of other Isopoda, the body is symmetrical and dorsoventrally flattened. The species is slim, five times as long as wide. On the head, there are the eyes and two pairs of antennae of different lengths. All the body segments except for the first one have a coxal plate. In the first four segments these are shorter than the segments. The first abdominal segment is shorter than the thoracic segments. The abdomen terminates in a small tail plate with a wedge-shaped telson. The animals are green or brown in colour, sometimes with small white spots. The colouration depends on the substrate, and females are often darker than males.

Occurrence

The species is typical of the boreal zone. It is found in the North Atlantic. In European waters, it extends from the coast of Norway to the Mediterranean Sea. It is present almost throughout the Baltic Sea, though not in the inner parts of the Gulfs of Finland and Bothnia. It is relatively numerous. It is widespread in the Polish coastal zone, occurring in Puck Bay, along Wolin Island and at the mouth of the River Świna. In smaller numbers it inhabits the coastal zone of the Gulf of Gdańsk. It lives in calm, sheltered waters with aquatic vegetation, underwater meadows for preference. In the 1970s it achieved densities of 5 thousand individuals per square metre.

Biology and Ecology

It is a euryhaline, brackish water species, preferring tideless coastal waters of salinity no less than 4‰. It can tolerate short periods of lower salinity. In the Baltic Sea, it has been caught in areas where the water salinity is only 2‰, but it is also found in the seas where the salinity is 32–39‰. A eurythermic species, it tolerates a wide range of temperatures, but is relatively little resistant to low temperatures. It prefers well-oxygenated waters. It has been found no deeper than 20 m in the Gulf of Gdańsk and 40 m in the open Baltic Sea. In deeper waters the amount of dissolved oxygen decreases, which is presumably why the species does not inhabit them. It forages on plant and animal detritus, hence it has been classified as a necrophage. Its food may include epiphytic diatoms. These animals have been observed to consume their own exuvia and dead conspecifics. They are dioecious, like the other species of this order. Males are larger than females. In Puck Bay reproduction lasts from April to October, marsupia forming at the beginning of this period. After mating and fertilization, most males die. During the reproductive period more than half the females have their marsupia filled with eggs. The number of eggs they carry depends on their size: the larger the female, the more eggs she carries. During the breeding period a female carries an average of 75 eggs and a maximum of 95. In Puck Bay reproductive females have been found to carry from only 3 to 47 eggs. Juveniles do not reach sexual maturity until the spring of the following year. They live for about a year.

Impact

The species is locally important in the food web, being fed upon by many species of fish, e.g. European plaice *Pleuronectes platessa*, garfish *Belone belone*, three-spined stickleback *Gasterosteus aculeatus*, turbot *Scophthalmus maximus* and sea stickleback *Spinachia spinachia* (Figs. 9.22, 9.23 and 9.24).

Fig. 9.22 *Idotea chelipes* (Piotr Wysocki)

Fig. 9.23 *Idotea chelipes* (Piotr Wysocki)

Fig. 9.24 *Idotea chelipes* (Piotr Wysocki)

9.4.3 *Idotea balthica*

Idotea balthica (Pallas, 1772)
Order: Isopoda
Family: Idoteidae

Basic Morphological Features
It is as slim as but slightly larger than *I. chelipes*. In the Baltic Sea, it reaches a length of 22 mm. Off the coast of Great Britain, where the salinity exceeds 32‰, males may be up to 30 mm and females up to 18 mm long. All the coxal plates are the same length as the body segments. It is greenish or brownish in colour, often with white spots. Females are usually darker than males.

Occurrence
It occurs in shallow European waters, and is widespread in the north-eastern Atlantic. It inhabits the Baltic Sea, including Puck Bay. It is not numerous. It prefers underwater meadows and shallow sandy areas. Together with *I. chelipes* and *I. granulosa* it forms the so-called Idotea complex in the Baltic Sea. It inhabits the estuarine and littoral zones of seas. It is most numerous in underwater meadows where the dominant brown algae species is *Fucus vesiculosus*. Females often inhabit the lower parts of the algae, and males the upper parts, which explains their different colours.

Fig. 9.25 *Idotea balthica* (Piotr Wysocki)

Fig. 9.26 *Idotea balthica* (Piotr Wysocki)

Biology and Ecology

It is a eurythermic species, with a wide range of tolerance to changes in water temperature. Because it is also tolerant to salinity changes, it is classified as euryhaline. The lowest salinity at which it occurs in the Baltic Sea is 3.5‰, whereas in northern European waters it turns up in coastal zones where the salinity may be greater than 18‰. It prefers clean, well-oxygenated water. It is a typical herbivore, but it also feeds on plants and animal detritus, and zooplankton. Individuals from the Baltic Sea have a shorter reproductive period than those living in waters of higher salinity. Males are slightly larger than females. Breeding takes place from

May to October. Females living in water of salinity 32–33‰ carry a maximum of about 170 eggs. Up to 144 eggs have been found in marsupia (brood pouches) in the Puck Bay population. There is only one generation per year, although hatching may take place twice a year. The lifespan is about 1 year.

Impact
Like *I. chelipes*, it is a local a source of food for coastal zone fish, such as garfish *Belone belone* and long-spined bullhead *Taurulus baublis* (Figs. 9.25 and 9.26).

9.4.4 *Idotea granulosa*

Idotea granulosa (Rathke, 1843)
Order: Isopoda
Family: Idoteidae

Basic Morphological Features
It is slightly smaller than *I. balthica* and has a characteristically stocky build. In waters of salinity 32–33‰, males are from 5 to 18 mm long, females from 6 to 13 mm; in the Sea Baltic it reaches lengths of 14 mm. The coxal plates of the second and third segments are shorter than the segments themselves. It is brown, red or greenish in colour, depending on the colour of the background substrate. It may have white spots on the dorsal surface of the body.

Occurrence
It occurs along rather sheltered sea coasts, in tidal areas, in estuaries, among the algae growing on the sea bed. It inhabits offshore areas from Great Britain to Arctic Norway. It is common in the coastal zone of France. In the Baltic it is found mainly in its western regions, being numerous in the Bornholm and Arkona basins. It also occurs in Puck Bay and the shallower parts of the Gulf of Gdańsk.

Biology and Ecology
It shows little tolerance to salinity changes in the environment. More stenohaline than the other species belonging to this order, it prefers waters of low, preferably unchanging, salinity, but no less than 6–8‰. It is also eurythermic. It is a typical herbivore. Reproduction takes place once a year, from late April–early May to July; females can carry up to 92 eggs in their marsupia.

Impact
It is a food resource for fish inhabiting the coastal zone (Fig. 9.27).

Fig. 9.27 *Idotea granulosa* (Anna Dziubińska)

9.4.5 *Jaera albifrons*

Jaera albifrons Leach, 1814
Order: Isopoda
Family: Janiridae

Owing to the considerable level of polymorphism of specimens identified as *J. albifrons*, the species is often regarded as a super-species or a species group. In the Baltic, there are three species belonging to this group, namely, *Jaera ischiosetosa, J. syei* and *J. praehirsuta*, which differ from one another in colour. In some parts of the Gulf of Gdańsk the three species occur concurrently. They all have very similar life cycles. Hybridization between the species is possible.

9.4.6 *Jaera ischiosetosa*

Jaera ischiosetosa Forsman, 1949
Order: Isopoda
Family: Janiridae

Basic Morphological Features

This is the most numerous and the most common of all the *Jaera* species occurring in the Baltic Sea. Its very distinctive appearance makes it very difficult to be mistaken for another *Jaera* species. Males, reaching a maximum length of 1.5–2.8 mm, are smaller than females which can grow to 4.7 mm in length. In adult males curved bristles are present at the base of two pairs of walking legs. The body colour depends on the substrate on which the animal happens to be.

Occurrence

It is common along the coasts of Europe, all the way to the European shores of the seas around Russia. It occurs in the Polish coastal zone of the Baltic Sea. It inhabits estuarine waters and lagoons supporting underwater meadows, but it can also be found among the stones on the sea bed down to a depth of ca 2 m. It is found in shallow waters at river mouths, where fresh water flows into the sea.

Biology and Ecology

A euryhaline species, it is very tolerant of low water salinities. The lowest salinity at which it occurs is scarcely 2‰. It is also eurythermic. It feeds on plant and animal detritus. Reproduction starts in May. Shortly after copulation the males die. The new generation can begin reproducing already in July.

Impact

It is a food resource for many fish species. Its own role involves cleansing water bodies of dead organic matter.

9.4.7 Jaera syei

Jaera syei Bocquet, 1950
Order: Isopoda
Family: Janiridae

Basic Morphological Features

It has a stocky body and is slightly smaller than the other *Jaera* species. Males grow to a length of about 2.3 mm, females to 3 mm. The two rear pairs of walking legs in the males have pectinate bristles. The colouration is very distinctive. The front part of the body is pale, while the remainder is covered with brown spots aligned in horizontal stripes.

Occurrence

In the coastal zone of European seas it occurs most often at depths of 0.5–3 m. While it prefers vegetated bottoms, it can also be found under stones, in shoals of mussels *(Mytilus trossulus)*.

Biology and Ecology

A euryhaline species, it occurs in waters of both high and low salinity. It is also eurythermic. It feeds on the remains of plants and animals. Reproduction takes place in the warm months of the year.

Impact

Its function in the food web is to remove dead organic matter from water bodies.

9.4.8 Jaera praehirsuta

Jaera praehirsuta Forsman, 1949
Order: Isopoda
Family: Janiridae

Basic Morphological Features

It reaches a maximum length of 3 mm, females being slightly larger than males. The rearpart of the body is slightly wider than the front. The ends of the front four pairs of walking legs in adult males are setose.

Fig. 9.28 *Jaera albifrons* (Piotr Wysocki)

Occurrence
It inhabits the coastal zone of the Baltic Sea, living in underwater meadows of calm, sheltered estuarine waters.

Biology and Ecology
It is a euryhaline species, tolerating salinities as low as 2‰. It is also eurythermic. It feeds on plant and animal detritus. Reproduction takes place in the warm months of the year.

Impact
Like other species of the genus *Jaera*, its main function in the food web is to remove organic matter from water bodies (Fig. 9.28).

9.4.9 Lekanesphaera hookeri

Lekanesphaera hookeri (Leach, 1814)
Order: Isopoda
Family: Sphaeromatidae

Basic Morphological Features
Until recently, this species used to be known as *Sphaeroma hookeri*. In appearanceit is very similar to *Lekanesphaera rugicauda*. Males attain lengths of 11 mm; females are somewhat smaller, growing to only 8 mm. The body is grey, with a yellow stripe crossing the middle part of the dorsum. Characteristic of this species is the first pair of thoracic legs, which are covered by about 20 setae, and two rows of papillae along the telson. When disturbed or stressed, the animals roll up into a ball.

Occurrence
It occurs in estuaries in Great Britain and France. In the Baltic Sea, it is found off the coasts of Denmark, Germany and Sweden. It inhabits the Gulf of Gdańsk, Puck Bay and the Vistula Lagoon. It inhabits sheltered waters in coastal areas; it has also been found in port waters. It usually occurs in the sediments or among the vegetation growing on the sea bed. It does not avoid areas with large quantities of detritus.

Biology and Ecology
It is most common at salinities of 1–10‰ and very rare in more saline waters. It is more tolerant of lower salinities than *L. rugicauda*. Reproduction takes place in summer, when females can carry up to 160 eggs.

Impact
It feeds mostly on detritus (Figs. 9.29 and 9.30).

Fig. 9.29 *Lekanesphaera hookeri (*Piotr Wysocki)

Fig. 9.30 *Lekanesphaera hookeri* (Piotr Kendzierski)

9.4.10 *Lekanesphaera rugicauda*

Lekanesphaera rugicauda (Leach, 1814)
Synonym—*Sphaeroma rugicauda* (Leach, 1814)
Order: Isopoda
Family: Sphaeromatidae

Basic Morphological Features
This species used to be known as *Sphaeroma rugicauda*. Individuals are no longer than 10 mm. Numerous papillae are situated asymmetrically on the telson.

Occurrence
It inhabits the Baltic Sea, including the Vistula Lagoon and Puck Bay. It is typical of open estuarine waters and lagoons, localities that are somewhat farther offshore than those typical of *L. hookeri*. It prefers rocky substrates, and has been recorded on coastal fortifications. It inhabits muddy-sandy but also vegetated bottoms.

Biology and Ecology
A brackish water species, it occurs in waters of salinity no lower than 8‰. It is very rarely come across in localities where the salinity is less than 4‰. It feeds mostly on detritus.

Impact
Principally a detritus feeder (Fig. 9.31).

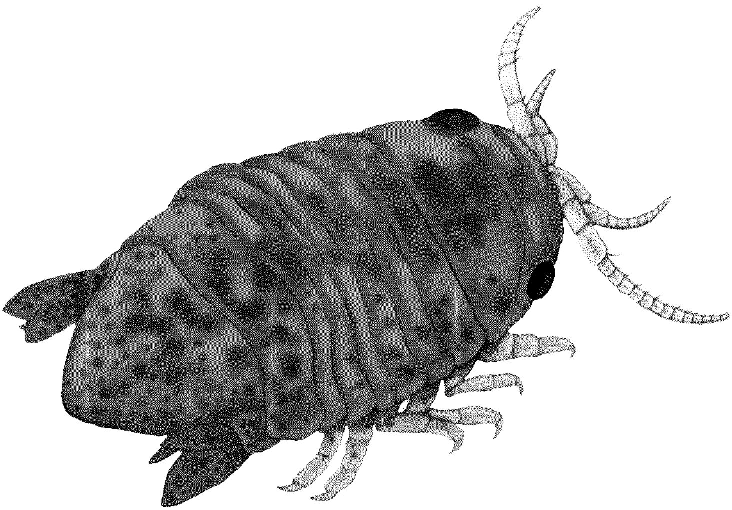


Fig. 9.31 *Lekanesphaera rugicauda* (Stanisław Węsławski)

9.4.11 *Eurydice pulchra*

Eurydice pulchra Leach, 1815
Order: Isopoda
Family: Cirolanidae

Basic Morphological Features
It is small, with a stocky body. Lengths of males range from 4 to 8.5 mm, those of females from 4 to 6.5 mm. The abdomen is tapered and rounded at the end, with four small teeth. The body is dark in colour, speckled with many black chromatophores on the dorsal and lateral side of the body.

Occurrence
It lives in the bottom sediments, in which it buries itself. At the same time, it is a very good swimmer, thanks to the four pairs of thoracic legs. It is common on all the coasts of Great Britain. It inhabits the coastal zone from Norway to Morocco. It does not occur in the Mediterranean Sea. Rare in the Baltic, it has been recorded, for example, on the open sea side of the Hel Peninsula. It dwells in coastal areas of seas to depths down to about 180 m, though more often in shallower waters.

Biology and Ecology
It tolerates salinities no greater than 18‰.

Fig. 9.32 *Eurydice pulchra* (Halina Kendzierska)

Impact
Principally a detritivore, it cleanses sediments of organic matter and participates in bioturbation (Fig. 9.32).

9.4.12 Cyathura carinata

Cyathura carinata (Krøyer, 1847)
Order: Isopoda
Family: Anthuridae

Basic Morphological Features
Individuals inhabiting the Polish coast grow to a length of 15 mm. It has small eyes and is whitish in colour with reddish-brown spots. The antennules and antennae are both short.

Occurrence
It is found from Ireland to the southern regions of the Mediterranean. It is rare in the coastal zone of the Baltic Sea, but it does inhabit Puck Bay and shallow waters in the Gulf of Gdańsk. In some areas of the seas off north-west Europe its densities can be as high as 3000 specimens per square metre. It lives in self-made tubes in the sandy and muddy bottom sediments of estuaries and littoral lagoons.

Fig. 9.33 *Cyathura carinata* (Piotr Wysocki)

Biology and Ecology
It is a euryhaline, brackish water species. It prefers waters, the salinity of which is not less than 1–2‰, but can tolerate salinities as high as 35‰. Reproduction takes place in June and July; females can carry from 18 to 63 eggs. Pre-hatching egg development lasts about 3–4 weeks. The females die after reproduction.

Impact
It is an important dietary component of dunlins *Calidris alpina*, migrating wading birds, in European estuaries. It is also consumed by *Corophium volutator* (Fig. 9.33).

9.4.13 Asellus aquaticus aquaticus

Asellus aquaticus aquaticus Linnaeus, 1758
Order: Isopoda
Family: Asellidae

Basic Morphological Features
Females achieve lengths of 20 mm, while males grow to no longer than 15 mm. In Puck Bay the maximum length is 12 mm. They run very fast over the bottom of the water body.

Occurrence
This is a fresh water species, also found in coastal bays and lakes. It is often be found in river mouths. It has been found in the Gulf of Gdańsk.

Biology and Ecology
This species is highly resistant to environmental changes. It tolerates salinities of up to 15‰. In the Baltic Sea, the highest salinity at which it occurs is 7‰. It feeds on the remains of animals and plants, but also on detritus. It is a dioecious species. The female lays her eggs in the marsupium: the larger the female, the more eggs she can carry. Embryonic development in the marsupium lasts for 1–2 months, after which the 1 mm long young hatch. There are two generations a year, in spring and autumn. In Polish waters these animals do not live longer than 1 year. This species is very sensitive to all kinds of pollution, which is why it is often used as a laboratory indicator for in determining acceptable survival standards in relation to a specific chemical compound.

Impact
It plays an important function in that it helps to remove organic debris, e.g. leaves, from water bodies. It is a food resource for many fish species (Fig. 9.34).

Fig. 9.34 *Asellus aquaticus aquaticus* (Piotr Wysocki)

9.5 Amphipoda

About 5.5 thousand species belonging to this order are known, but oceanographic research constantly brings fresh information on new amphipod species inhabiting the deep waters of seas and oceans. Most amphipods are marine, with a small number occurring in fresh water and just a few in ground water. They lead very diverse lifestyles. They are components of the plankton, but they also inhabit near-bottom waters. They swim, jump, crawl, burrow in mud, build tunnels and cases from grains of sands and plant/animal detritus. Some live in the sand of coastal beaches, others can survive beyond an aquatic environment for a period of time. Many species occur on a large scale, thereby becoming an important link in the food web. Some deep-water species are brilliantly coloured yellow, red, purple or blue. Amphipods inhabiting the coastal zone are usually less strikingly coloured in various shades of green, grey or brown.

They vary widely in size, from 1 mm to 25 cm. The body is segmented and consists of a head, thorax (pereon) and abdomen (pleon). The first thoracic segment is fused with the head and terminates in a rostrum. They do not have a carapace. Swimming amphipods are relatively long, arched and laterally compressed. The body of crawling amphipods is short, as the abdomen is reduced. Amphipods living in the sand have a cylindrical body. Some species have eyes, others not. The antennules are biramous, the antennae (the second pair) are uniramous. The mouthparts are mostly for biting. Some species possess well-developed jaws, in which case the two first pair of thoracic legs are modified into maxillipeds. The thoracic legs are uniramous but differentiated into two types, hence the name of the order,

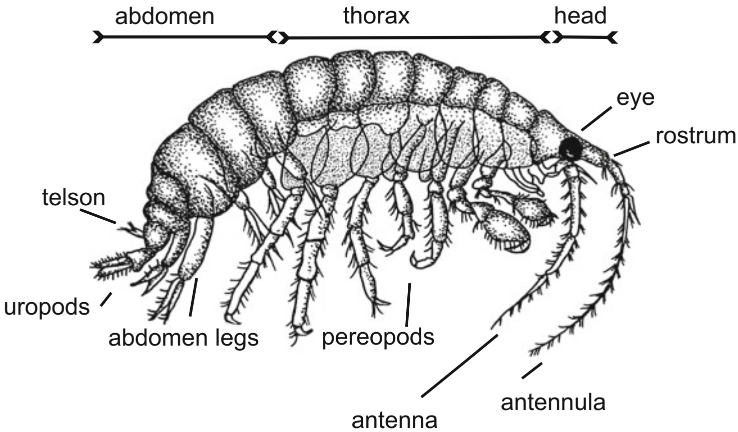


Fig. 9.35 Amphipoda—general habitus (Sylwia Aniszewska)

amphipods. The first four pairs of legs are slightly shorter and are directed forwards. The other three pairs are directed backwards, but their terminal tarsomeres forwards. Gills are present on the thoracic legs. The abdominal legs are biramous and of two kinds. The abdomen is divided into two parts, the pleosome and the urosome. The pleosome bears the first three pairs of legs, which are used for swimming. The urosome bears three pairs of short, stiff legs known as uropods that serve to propel the animal from the ground, and the telson, which is short and forms a small tail.

Amphipods are predators or omnivores. Some species forage on plant food or detritus. Others are parasitic on fish, cetaceans, sponges, jellyfish and ascidians. The entire lives of these parasitic species are associated with their hosts. A few species are commensals of sponges, cnidarians, comb jellies, echinoderms and tunicates.

Amphipods are dioecious, with pronounced sexual dimorphism. Males are usually larger, bearing longer antennae and more strongly armed legs. Testicles and ovaries are coiled and very long. Females possess oval oostegites, attached to the inner surface of thoracic segments II, II and IV. Fully developed oostegites bear long, dense bristles which are intertwined with the oostegites on the opposite side, forming a brood pouch (marsupium) into which the eggs are laid. Amphipods have no gonadopodites, that is, abdominal legs that function as copulatory organs. There are no larval stages. Newly hatched juveniles closely resemble adults. Amphipods can be hermaphroditic.

Many of them play a very important role in the environment as food for many species of fish and birds. Some are indirect hosts for tapeworms, roundworms or acanthocephalans, parasites of fish and birds. Species that scavenge on the remains of plants and animals contribute to the faster mineralization of organic matter present in the water body (Fig. 9.35).

9.5.1 *Hyperia galba*

Hyperia galba (Montagu, 1815)
Order: Amphipoda
Family: Hyperiidae

Basic Morphological Features
The species owes its name to its yellow body colour [galbus (Latin) = yellow]. Individuals living in the Baltic Sea are small, with body lengths no greater than 5 mm. But in seas where the salinity is about 34‰, it can attain lengths of 20 mm. Males are slightly smaller than females. The orange eyes are very large, occupying almost the entire surface of the head.

Occurrence
The species is defined as subarctic-boreal, occurring as it does in the cooler regions of the Atlantic Ocean and in the North Sea. Considerable numbers live in the Arctic. It inhabits the South Atlantic, Antarctic and Indian Oceans. In European waters it occurs off the coast of Great Britain, France and Spain. It is the only species of the family Hyperiidae inhabiting the Baltic Sea. It is a component of the plankton, inhabiting mainly open waters. It undergoes diurnal migrations, rising to the surface at night and moving into deeper waters during the day.

Fig. 9.36 *Hyperia galba* (Piotr Wysocki)

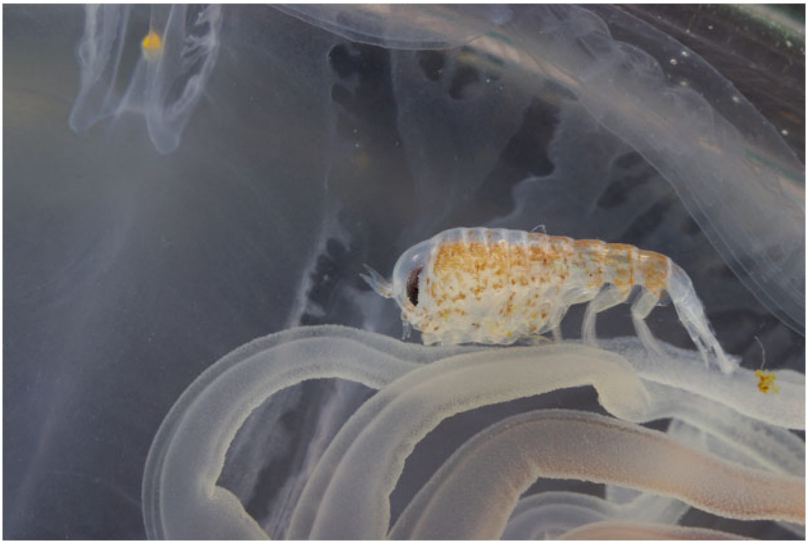


Fig. 9.37 *Hyperia galba* (Piotr Wysocki)

Biology and Ecology
It prefers low temperatures and higher salinities. From time to time it parasitizes the common jellyfish *Aurelia aurita*, attaching itself to its hind legs and feeding on the tissues.

Impact
It is part of the diet of some fish species, including herring *Clupea harengus* (Figs. 9.36 and 9.37).

9.5.2 Gammarus locusta

Gammarus locusta (Linnaeus, 1758)
Order: Amphipoda
Family: Gammaridae

Basic Morphological Features
In the Baltic Sea, males reach a length of 17 mm, while the slightly smaller females grow to 14 mm. In the North Sea, individuals are much larger, attaining lengths of

up to 33 mm. These animals have large kidney-shaped eyes. The spines on the last three pairs of thoracic legs are setose. On the dorsal side of urosome there are large protuberances with setose spines.

Occurrence

It occurs all along the coast of Europe from Portugal to Norway. In the Baltic Sea, it has been recorded everywhere except in the Gulfs of Riga and Finland. In the 1950s and 1960s it was common in the eastern part of Puck Bay, among the underwater meadows and river mouths. Compared with other gammarids, however, it has recently become very scarce.

Biology and Ecology

It is an omnivorous, marine, euryhaline species, occurring at salinities of no less than 5.5‰. It is most often encountered at a depth of a few metres, but not close to the shore. For preference, it inhabits sandy bottoms, but it does not shun substrates covered with algae. It is very sensitive to water pollution. There are two reproductive peaks during the warm months of the year, one in spring and the other in September. A female can carry up to 29 eggs, which is evidence for the low fertility of this species.

Impact

It is foraged on by many species of fish, for example, garfish *Belone belone* and perch *Perca fluviatilis* (Fig. 9.38).

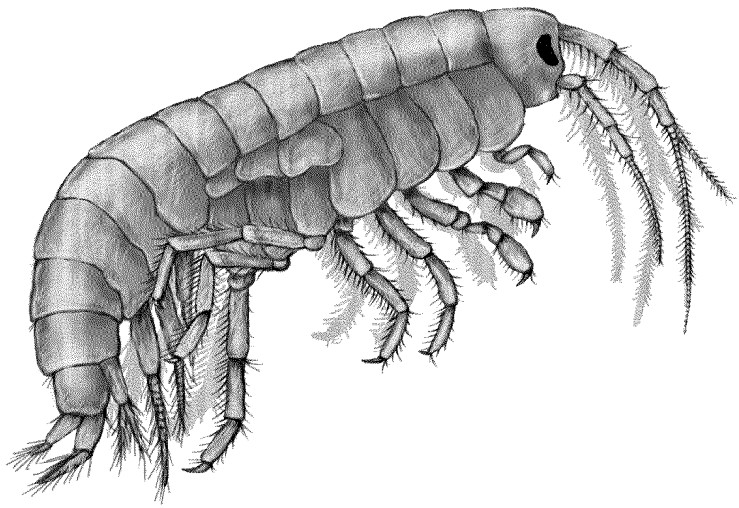


Fig. 9.38 *Gammarus locusta* (Stanisław Węsławski)

9.5.3 *Gammarus duebeni*

Gammarus duebeni Liljeborg, 1852
Order: Amphipoda
Family: Gammaridae

Basic Morphological Features
In the Baltic Sea, it reaches a maximum length of 23 mm. The body is olive-green and brown in colour. dotted red along the side. It has large kidney-shaped eyes. The mandibular palps bear setae of equal length. The fifth, sixth and seventh pair of walking legs, urosome and telson are also strongly setose.

Occurrence
A subarctic-boreal species, it has been recorded along the coasts of Europe and North America (Atlantic Ocean). Although it is relatively common in the Baltic Sea, it is scarce in the Gulf of Gdańsk and Puck Bay. It lives in a variety of environments, from coastal sea waters, river mouths to small standing bodies of fresh water. It is found in the spray zone, where it conceals itself under rocks or among aquatic vegetation. It does not usually occur below a depth of a few metres. Its numbers have declined in recent years.

Biology and Ecology
It is a typical eurytopic organism: it is euryhaline, tolerating a very wide range of salinity variations, as evidenced by its presence in some fresh water bodies, and eurythermic, displaying a considerable resistance to changes in water temperature. It exhibits the greatest tolerance to oxygen shortages of all the native gammarids, being capable of surviving in anoxic conditions for up to 18 h, so long as the temperature is low. It displays negative phototaxis, so during the day it seeks out nooks and crannies in order to avoid excessive sunlight. It tolerates quite high levels of water pollution. It is omnivorous. Females are slightly smaller than males (their maximum length is 16 mm). Breeding takes place twice a year, once in May-June and again in late August. On attaining a length of 12 mm in length, females can start breeding. Up to 78 eggs have been found in the marsupium of a single female, which testifies to the low level of fertility of this species. The larger the female, the more eggs she can carry in her brood pouch.

Impact
It is foraged on by such fish species as perch *Perca fluviatilis,* garfish *Belone belone* and long-spined bullhead *Taurulus baublis* (Fig. 9.39).

Fig. 9.39 *Gammarus duebeni* (Piotr Wysocki)

9.5.4 Gammarus zaddachi

Gammarus zaddachi Sexton, 1912
Order: Amphipoda
Family: Gammaridae

Basic Morphological Features

It can grow to a length of 30 mm, females being smaller than males (no longer than 15 mm). The body is olive-green or yellowish-brown, the sides of the thorax being mottled. The species is identifiable from the dense setae of unequal length on the mandibular palps and the numerous, long bristles on the hind thoracic legs and on the end of the abdomen (Jęczmień 2004; Lincoln 1979).

Occurrence

A boreal and subarctic-boreal species, it is widespread along the Atlantic coasts of Europe (Jażdżewski 1975; Lincoln 1979). It is present throughout the Baltic coastal zone, including the Gulf of Gdańsk, Puck Bay and the Vistula Lagoon (Brzeska 2006). It is common at the mouths of rivers, in estuaries and in sheltered coastal bays (Jęczmień and Szaniawska 2000; Pinkster and Broodbakker 1980; Bulnheim and Scholl 1981). It has been observed to migrate up rivers. It lives among underwater vegetation, but also on sandy bottoms with small numbers of algae down to depths of no more than 4 m. It is the dominant gammarid in many areas. In the 1970s the largest aggregations consisted of several thousand individuals per square metre. On the beach one can find it on washed up vegetation or in pools of water left over after storms (Jęczmień and Szaniawska 2000; Jażdżewski 1975; Żmudziński 1990).

Biology and Ecology

It is a euryhaline, omnivorous (Looijenga and Dieleman 1980; Bulnheim and Scholl 1981), brackish water species, preferring waters of low salinity, and is not affected by decreasing salinity. The highest salinity at which it has been found to occur is 18‰. Changes in salinity affect its activity levels (Looijenga and Dieleman 1980). It is also a eurythermic species, tolerating a wide amplitude of water temperatures, for example, from below zero to 21 °C. It prefers clean, well-oxygenated waters. Males are more resistant than females to oxygen shortages in the environment (Cwetkowa 1975). The species is sexually dimorphic. The second pair of thoracic legs in males bears a claw for holding and carrying the female during copulation. They also have two copulatory appendages on the ventral side of the seventh thoracic segment. *G. zaddachi* is a monogamous species and males and females pair off long before copulation. Mating takes place between the female's moulting periods. The female lays eggs in her marsupium, which is where fertilization and early embryonic development take place. The animals grow through a series of moults and are sexually mature on attaining a length of about 7 mm. In the Baltic Sea reproduction takes place throughout the year, with a peak in summer. The lifespan is from a few to a dozen or so months (Cwetkowa 1975; Jęczmień 2004; Kolding and Fenchel 1981).

Impact

It is foraged on by many different fish, such as salmonids and other benthic species (Jażdżewski 1975) (Fig. 9.40).

Fig. 9.40 *Gammarus zaddachi* (Piotr Wysocki)

9.5.5 Gammarus oceanicus

Gammarus oceanicus Segerstråle, 1947
Order: Amphipoda
Family: Gammaridae

Basic Morphological Features
It occurs in the western Baltic and can grow to a length of 33 mm. In the Gulf of Gdańsk it is slightly smaller, achieving a maximum length of 28 mm. Males are larger than females (Jęczmień 2004). It is one of the largest of our native gammarid species. In colour, the body may be grey, yellow, greenish-brown and even dark red. There are red spots on the sides of the body. It has large, kidney-shaped eyes. The palps bear setae of equal length. There are a few tufts of setae on the scape of the antennules. These have accessory flagella consisting of a few segments. The body is sparsely setose. The urosome bears numerous, massive spines and very short setae (Jęczmień 2004).

Occurrence
A cold-water, arctic-boreal species, it inhabits the northern coasts of Europe. It is also present along the southern coast of Greenland and the Atlantic coasts of North America (Segestrale 1959; Steele and Steele 1974). It is common in the whole Baltic Sea, inhabiting its deeper regions (Cwetkowa 1975; Jażdżewski 1973). It has

Fig. 9.41 *Gammarus oceanicus* (Piotr Wysocki)

Fig. 9.42 *Gammarus oceanicus* (Piotr Wysocki)

even been recorded even at a depth of 140 m (Haahtela 1969). In some areas, its population are dense, with up to a few thousand individuals per square metre. It occurs in the Pomeranian Bay, the Gulf of Gdańsk and Puck Bay (Jażdżewski 1971, 1973). In summer, it avoids the warmed up shallow waters along the coast (Jęczmień and Szaniawska 2000).

Biology and Ecology

It is classified as a marine, euryhaline species, the lowest salinity at which it occurs being 2‰ (Segestrale 1959). It is omnivorous. It reproduces in the Baltic Sea reproduces from May to December (Jażdżewski 1970). On reaching a length of 8 mm, females become sexually mature. They can carry a maximum of 168 eggs, which is indicative of the species' considerable fertility. It has a lifespan of 2 years (Jęczmień 2004).

Impact

It plays an important function in the food web in that it serves as food for many fish species (Figs. 9.41 and 9.42).

9.5.6 Gammarus inequicauda

Gammarus inequicauda (Stock, 1966)
Order: Amphipoda
Family: Gammaridae

Basic Morphological Features

Closely resembling *G. locusta*, it is small in size, not exceeding 15 mm in length (Jęczmień 2004). It has large kidney-shaped eyes, and the mandibular palps bear setae that decrease in size towards their bases. The first part of the palp is unarmed. The lower edge of the scape of the antennules has a few tufts of setae. These have accessory flagella, which in adults consist of 4–8 segments. On the prehensile part of the second pleopods males have a blunt, bottle-shaped spine. The hind pleopods in males are setose. The rear edge of the base of the seventh pleopod is armed with 1 or 2 spines (Jęczmień 2004).

Occurrence

This species is widespread, occurring in the coastal zones of European seas, from the Mediterranean, through the English Channel (Stock 1967), right up to the coast of Norway (Stock 1966; Jażdżewski 1971). It also lives in the Black Sea. It inhabits only certain parts of the Baltic, but these include the Gulf of Gdańsk and Puck Bay (Jęczmień and Szaniawska 2000). In the latter it was first found in the 1960s (Jażdżewski 1970a). Nowadays it is rare. The largest aggregations occur at depths of 2–7 m, wherever the seabed is vegetated. Along with disappearance of underwater meadows, so did its natural environment, which caused its numbers to decline (Jażdżewski 1970b).

Biology and Ecology

A euryhaline species, it can tolerate waters of low salinity, about 5‰. It is also a eurythermic species, remaining unaffected by wide amplitudes of water

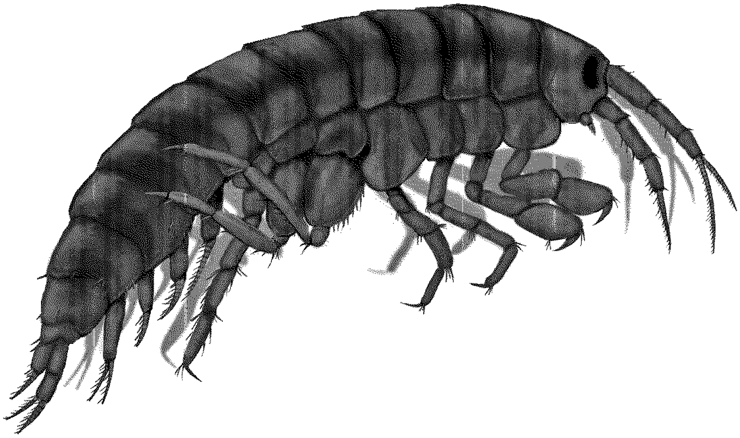


Fig. 9.43 *Gammarus inequicauda* (Stanisław Węsławski)

temperature. It is omnivorous. Breeding takes place from May to October (Jażdżewski 1970a). A female can carry up to 15 eggs in her marsupium. In the Baltic Sea reproduction takes place twice a year: once between April and July, and again in late September–early October, when the young, hatched earlier in that year, begin breeding. The largest number of eggs ever recorded in a female's marsupium is 65, which testifies to the species' considerable fecundity (Jęczmień 2004). It is relatively resistant to environmental pollution.

Impact
It is foraged on by many species of fish, e.g. perch *Perca fluviatilis* and long-spined bullhead *Taurulus baublis* (Fig. 9.43).

9.5.7 Gammarus salinus

Gammarus salinus Spooner, 1947
Order: Amphipoda
Family: Gammaridae

Basic Morphological Features
In the Baltic Sea males reach a length of 27 mm (Jęczmień 2004). Females are slightly smaller, no more than 22 mm long. The body is greenish-brown in colour, with conspicuous horizontal stripes. It has large kidney-shaped eyes. The mandibular palps bear setae of unequal length forming mushroom-shaped tufts. There are also setae on their first segments. The fifth, sixth and seventh pair of walking legs,

the urosome and telson are sparsely setose. The urosome usually has two spines close to one another, which are longer than the surrounding setae. There are also setae on the rear edge of the seventh pair of walking legs (Jażdżewski 1975; Cwetkowa 1975; Jęczmień 2004).

Occurrence

A boreal species, it inhabits the littoral zone of the Atlantic Ocean from the coast of France to southern Norway (Cwetkowa 1975; Salmon 1962). It occurs in many areas of the Baltic Sea (Segerstrale 1959; Jażdżewski 1975). It is common in the Gulf of Gdańsk (Jęczmień and Szaniawska 2000). It usually colonizes sea beds overgrown with aquatic vegetation such as underwater meadows, but it can also be found close to the shore (Cwetkowa 1975; Jęczmień 2004).

Biology and Ecology

Although it is a typical brackish water species, it may also choose waters of a higher salinity. It prefers a depth range of 10–40 m, but one comes across it in shallower waters, too. It avoids sites subject to strong wave action (Spooner 1947). It is an omnivorous species. It reproduces twice a year, first in April–June, and again in August (Jażdżewski 1970). The smallest reproducing females are 6–8 mm long. The female carries about 30 eggs; the larger the female, the more eggs she can carry in her marsupium (Cwetkowa 1975).

Impact

It serves as food for many fish species (Jażdżewski 1975) (Fig. 9.44).

Fig. 9.44 *Gammarus salinus* (Piotr Wysocki)

9.5.8 *Gammarus tigrinus*

Gammarus tigrinus Sexton, 1939
Order: Amphipoda
Family: Gammaridae

Basic Morphological Features
Males reach a length of 12 mm and are slightly larger than females, which grow to a length of 10 mm (Sexton and Cooper 1939). Males are light green or yellowish in colour. The head bears large kidney-shaped eyes. The dark stripes across each body segment are characteristic, resembling those of a tiger, hence the species' name. The antennules have accessory flagella. The last five pairs of thoracic legs are densely setose. The end of the abdomen is also setose (Konopacka 2004). These features make it easy to distinguish from other gammarids.

Occurrence
It originates from the Atlantic coastal waters of North America (Bousfield 1958). It was probably during the First World War that it reached the Irish coast waters in ships' ballast waters (Hynes 1955). In the 1950, it was introduced to brackish waters in Germany as a way of adding variety to fish food. It was first recorded in the Baltic in 1975 and in Polish coastal waters (the Szczecin Lagoon) in 1988 (Gruszka 1999). By the early twenty-first century it had reached the Gulf of Gdańsk, which it proceeded to colonize, along with Puck Bay (Szaniawska et al. 2003). An inhabitant of coastal waters, living both on the sea bed and in the open water, it dwells on sandy or muddy substrates, vegetated sea beds, and also on rocky coasts, where it can be found under stones lying on the bottom (Bousfield 1958). It moves very quickly. When swimming, it strikes its ventral side with its abdomen and then straightens the body out with great force. Individuals of this species can be seen sliding on their sides across the sea bed. The thoracic legs pull and move the body, and the abdomen propels them forwards.

Biology and Ecology
It is a euryhaline species tolerating salinities from 1 to 24‰ (Bousfield 1958); it occurs in both fresh and brackish waters. Being eurythermic, it also tolerates a wide range of temperatures. Though omnivorous, its basic food consists of plant and animal detritus. Breeding takes place in the warm months of the year. Females begin to breed when they have reached a length of 4 mm. They carry up to 50 characteristically dark green eggs (Sexton and Cooper 1939). The incubation period is very short, allowing the female to lay eggs 16 times a year, whereas other species of this genus have four generations at the most. Females achieve sexual maturity very much faster than other gammarid species (Pinkster et al. 1977). Females hatched in April can begin breeding already a few weeks later, in late May. The

Fig. 9.45 *Gammarus tigrinus* (Piotr Wysocki)

species' rapid invasion of European waters and its ability to displace native species is due primarily to its to exceptional fecundity.

Impact

Its role in the environment should not be underestimated. On the one hand, it is an additional source of food for other invertebrates and fish, but on the other it is displacing native gammarids (Konopacka 2004; Gruszka 1999; Grabowski et al. 2009). It has been found to forage on fish caught in nets, and it is capable of transmitting non-native, parasitic species (Ovcharenko et al. 2009). With its exceptional powers of adaption and its resistance to contamination, it is a serious threat to the communities in which it occurs (Fig. 9.45).

9.5.9 Pontogammarus robustoides

Pontogammarus robustoides (Sars, 1894)
Order: Amphipoda
Family: Pontogammaridae

Basic Morphological Features

Males and females grow to similar lengths: the former to 11–18 mm, the latter to 10–16 mm. The body is orange-yellow in colour. The eyes are large and kidney-shaped. The antennae are short: the first segment of the first pair (antennules) is wide and barrel-shaped, while the first two segments of the second pair are setose. The abdomen is short, with three spines and setae on the sides. The seventh pair of pleopods and the urosome are setose, and the latter is armed with 4–6 spines. The characteristic features of the species are well developed in juveniles (Zawisza 2006).

Occurrence

This is an alien species in Polish waters. It originates from the Ponto-Caspian region, where it occurs on a large scale in the coastal waters of the Caspian Sea, the Sea of Azov and the Black Sea, as well as at the mouths of the Rivers Volga, Don, Dnieper and Danube. It is also found in lakes in the Black Sea basin (Konopacka 2004; Dedju 1967; Grabowski 2011). It was first recorded in the coastal waters of the Baltic Sea in 1988, in the Szczecin Lagoon (Gruszka 1999) and at the mouth of the River Oder (Konopacka 2004); subsequently, in 1998, it was found in the Vistula Lagoon (Grabowski and Bącela 2005). By the second half of the 1990s it had reached the Gulf of Finland (Kalinkina and Berezina 2010). It inhabits shallow waters in the Gulf of Gdańsk (Zawisza 2006). In later years it spread very quickly, colonizing new areas with ease and at the same time significantly increasing its numbers. It now occurs in many Polish fresh water bodies. It inhabits vegetated substrates, but it can also occur on sandy and rocky substrates. For preference, it lives in coastal waters no more than a few metres deep. It is often found in eutrophic waters (Dedju 1980).

It probably found its way into Polish waters in ships' ballast waters, but it could also have been introduced to fish ponds a food resource for farmed fish. In the 1960s Ponto-Caspian gammarids were introduced into reservoirs in the countries of the former Soviet Union as a supplementary feed for fish (Grabowski 2011). The construction of canals, connecting basins that had previously been physically isolated from one another, has facilitated the migration of many Ponto-Caspian species. The slight acidification of river waters in recent years as a result of their pollution has additionally assisted the migration of hitherto isolated species (Zawisza 2006).

Biology and Ecology

This is a eurytopic species, capable of adapting to a wide range of new environmental conditions, hence its ability to expand its range and colonize new water bodies (Dedju 1980). It is a fresh water and brackish water species, tolerating low salinities of 0.5–5‰; at the same time it is resistant to salinity changes of several parts per thousand. Under laboratory conditions it can survive at a salinity of 35‰. Although it is a eurythermic species, it prefers warmer waters. Populations reach their largest numbers in summer. It can tolerate a significant reduction in dissolved oxygen concentration. The lethal level of hypoxia is about 60% less than in the case of other Ponto-Caspian species. It is an omnivorous species, foraging on zooplankton and even plant and animal detritus. The diet varies depending on the crustacean's age (Berezina and Panov 2006). When the water temperature exceeds 10 °C, the animals begin breeding (Bącela and Konopacka 2005; Zawisza 2006). This

Fig. 9.46 *Pontogammarus robustoides* (Piotr Wysocki)

Fig. 9.47 *Pontogammarus robustoides* (Piotr Wysocki)

takes place twice or three times a year. A single female can carry up to 65 eggs, which classifies the species as one of the most prolific among the gammarids occurring in our waters (Bącela and Konoppacka 2005).

Impact

It is an important food resource for many fish families, e.g. Gobiidae, Salmonidae, Percidae and Cyprinidae (Konopacka 2004; Zawisza 2006). In freshly colonized regions it effectively displaces native species of Amphipoda, which leads to negative changes in the ecosystem (Grabowski 2011). It can also carry non-native parasitic species such as trematodes (Ovcharenko et al. 2009) (Figs. 9.46 and 9.47).

9.5.10 *Obesogammarus crassus*

Obesogammarus crassus (G.O. Sars, 1894)
Order: Amphipoda
Family: Pontogammaridae

Basic Morphological Features

In appearance, the species is very similar to *Pontogammarus robustoides*, although its body is much slenderer, and the antennae are slightly longer in relation to the body length. Males range in size from 10 to 17 mm, females from 8 to 15 mm. Baltic specimens are slightly shorter (6–10.5 mm). They have elongated, pointed thoracic plates, with few setae. The eyes are large and kidney-shaped. The antennae are relatively short, and the telson is elongated. A characteristic feature of this species is the armed urosome. There is a tuft of a few fine setae in the centre of the first urosomal segment, and two spines in the middle of the second one. The large segment towards the base of the posterior pereopod is expanded and protrudes downwards (Konopacka 2004).

Occurrence

Of Ponto-Caspian origin, this species is alien to Polish waters. It is common in the coastal zones of the Black Sea, the Sea of Azov and the Caspian Sea, and in the lower reaches of the rivers flowing into these seas (Karaman 1953). Like other gammarid species from those regions, it was introduced to many dammed reservoirs. In 1961 it was introduced into a reservoir on the River Niemen, from where it got into the Curonian Lagoon(Arbaciauskas 2002; Gasjunas 1968; Gasjunas 1972), then into Baltic coastal waters and ultimately into the Vistula Lagoon. It was first recorded in Polish waters (Vistula Lagoon) in the late twentieth century (Konopacka and Jażdżewski 2002), and a very short time afterwards in the Szczecin Lagoon. It is present in shallow waters in the Gulf of Gdańsk. No doubt it will not be long before we hear of the first individuals in western Baltic coastal waters. It prefers vegetated substrates, but it can also be found beneath stones (Konopacka 2011).

Fig. 9.48 *Obesogammarus crassus* (Piotr Wysocki)

Biology and Ecology

It is a brackish water species, but tolerates low salinities of up to about 5‰; consequently, it can colonize coastal bays, lagoons and river mouths. It is a eurythermic species, with a broad tolerance to changes in water temperature. It is omnivorous. These features greatly facilitate its expansion and colonization of new water bodies.

Impact

In recently colonized areas it can have an adverse impact on the native fauna. It is a dietary component of some fish species. It may carry non-native parasitic species (Ovcharenko et al. 2008) (Fig. 9.48).

9.5.11 Dikerogammarus haemobaphes

Dikerogammarus haemobaphes (Eichwald, 1841)
Order: Amphipoda
Family: Gammaridae

Basic Morphological Features

The males of this small crustacean are slightly larger than the females, reaching a length of 22 mm. The antennules, bearing few setae, are much longer than the second pair of antennae. Only in the males are there tufts of short setae on the flagella. The base of the seventh pereopod is lobed and protrudes downwards. The outer part of the third pair of uropods is long, covered at the base with dense clusters of setae and spines. The urosome has poorly developed, characteristic protuberances that bear tiny spines and setae (Jażdżewski 2011; Mordukhai-Boltovskoi 1964).

Occurrence

This species reached the waters of central Europe from the Ponto-Caspian region, via the Dnieper (Dedju 1967) and the Vistula basins, and then along the Bydgoszcz Canal and River Noteć to the River Oder. It was first observed in Polish waters in 1996, in the Włocławek Reservoir (Konopacka 1998), and then a little later in the Szczecin and the Vistula Lagoons (Gruszka 2000; Jażdżewski and Konopacka 2002; Grabowski and Bącela 2005). It was first recorded in the south-western Baltic in 2000. It occurs primarily on vegetated substrates, at depths of no more than 1 m.

Biology and Ecology

A eurytopic species, it exhibits a considerable tolerance to a wide range of environmental factors. It is a fresh water and brackish water species: while preferring fresh water, it can also survive in salinities of up to 8‰. It is eurythermic, but prefers warmer waters, and is able to tolerate temperatures of up to 30 °C. The largest aggregations (a dozen or so specimens per square metre) at the Vistula mouth occur in September, when the water is at its warmest. It is very resistant to oxygen deficiencies. It is omnivorous, and an opportunistic necrophage and predator (Kititsyna 1980). After winter, once temperatures have risen substantially, it begins breeding. In Polish waters it produces three generations per annum (Bącela et al. 2009). One female can carry up to 43 eggs. Like many other species of amphipods, hermaphroditic individuals may occur.

Fig. 9.49 *Dikerogammarus haemobaphes* (Piotr Wysocki)

Impact

It serves as food for many fish species, such as gobies *Neogobius* spp. and perch *Perca fluviatilis*. It is a carrier of parasites that may endanger native Amphipoda (Ovcharenko et al. 2009) (Fig. 9.49).

9.5.12 Dikerogammarus villosus

Dikerogammarus villosus (Sowinsky, 1894)
Order: Amphipoda
Family: Gammaridae

Basic Morphological Features

This crustacean grows to a considerable size: females (8–14 mm) are smaller than males (12–22 mm) (Nesemann et al. 1995). It is easily confused with *D. haemobaphes*. The main feature distinguishing the two species are the tall protuberances with spines on the first and second urosomal segments of *D. villosus*. The antennules and antennae are more or less the same length. The first segment of the scape of the antennules is broad. The gnathopods are massive and are used for capturing food (Konopacka 2004).

Occurrence

In the Ponto-Caspian region, the native range of this species, it occurs in rivers and coastal lakes. It is widespread in the less saline parts of the Black Sea and the northern Caspian Sea. In Polish inland waters it was first recorded in the lower reaches of the River Oder in 2001 (Jażdżewski and Konopacka 2002). The first record from the south-western Baltic and the Szczecin Lagoon is from 2002 (Jażdżewski and Konopacka 2002). A relationship exists between the size of the animals and the type of habitat they dwell in. The largest individuals prefer rocky substrates, whereas medium-sized and juvenile individuals can be found on vegetated substrates (Devin et al. 2004).

Biology and Ecology

It is a eurytopic species, exhibiting a wide range of tolerance to environmental factors. Though primarily a fresh water crustacean, it does also occur in brackish waters of low salinity. It tolerates a wide range of temperatures, able to survive in waters as warm as 30 °C. It is omnivorous (Osiecka 2007; Dick and Platvoet 2000, 2001). Reproduction is dependent upon the water temperature and takes place only in the warm months (Kley and Maier 2003). There are two, sometimes three, generations per year, and a single female can carry up to 50 eggs.

Impact

In the areas it inhabits it often has a negative impact on native species (Klotz 2002; Konopacka 2011). Because of its broad nutritional spectrum, it plays an important role in the food web. It serves as a food resource for many fish species. Like other Ponto-Caspian amphipods, it carries non-native parasite species (Ovcharenko et al. 2009). Because of its aggressive behaviour, it has earned the nickname "killer shrimp" (Kley and Maier 2003) (Figs. 9.50 and 9.51).

Fig. 9.50 *Dikerogammarus villosus* (Piotr Kendzierski)

Fig. 9.51 *Dikerogammarus villosus* (Piotr Kendzierski)

9.5.13 Chaetogammarus ischnus

Chaetogammarus ischnus (Stebbing, 1899)
Order: Amphipoda
Family: Gammaridae

Basic Morphological Features

Males grow to a length of 6–10 mm, females to 4–8.5 mm. In the Ponto-Caspian area, from where it originates, it can attain lengths of up to 20 mm. It has large, kidney-shaped eyes. The antennae are shorter than the setose, the setae being longer in males than in females. There are also long setae on the scape of the antennae. The fifth to seventh pereopods are practically devoid of setae. There are four spines on each of the first and the second urosomal segments, and two spines and a small number of setae on the third (Carausu et al. 1955; Micherdzinski 1959).

Occurrence

It lives mainly in fresh waters, and has been found even in the upper reaches of rivers flowing into the Caspian and Black Seas. It has been recorded in the coastal zones of both these seas. It got through to the Baltic Sea via the network of canals (Carausu et al. 1955; Jażdżewski 2011; Mordukhai-Boltovskoi 1964). It is non-indigenous to Polish waters and the first Ponto-Caspian gammarid to have been recorded in the brackish waters along the Polish Baltic coast. The species was first recorded in the middle reaches of the River Vistula in 1928 (Jarocki and Demianowicz 1931). Nowadays it is present at the mouth of the Vistula in the Gulf of Gdańsk. It was recorded in the south-western Baltic as long ago as 1969. In the 1980s and 1990s it was found in several lakes in Mecklenburg, Germany (Kohn and Waterstraat 1990). It also found its way to North America in ballast waters, and by 1995 had reached the Great Lakes. It occurs in bays, lagoons and estuaries, but it is not common (Jażdżewski 2011). At present, it is being superseded by other Ponto-Caspian gammarids in many areas. It lives on both rocky and vegetated substrates.

Biology and Ecology

Although it is a fresh water species, it can tolerate low salinities. It is also a eurythermic species, preferring higher ambient temperatures. It is omnivorous (Dedju 1967).

Impact

It can adversely affect the native fauna in the waters it has colonized. It is part of the food web in that it is a food resource for many fish species (Fig. 9.52).

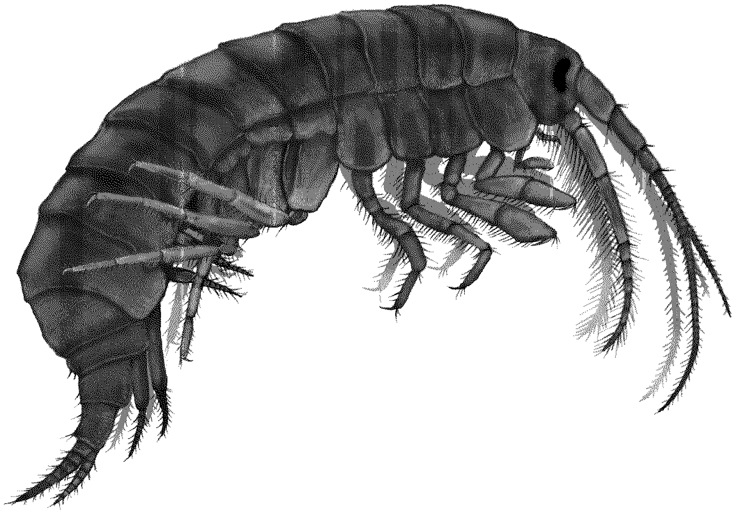


Fig. 9.52 *Chaetogammarus ischnus* (Stanisław Węsławski)

9.5.14 Chaetogammarus stoerensis

Chaetogammarus stoerensis (Reid, 1938)
Order: Amphipoda
Family: Pontogammaridae

Basic Morphological Features

Quite small in size, it is one of the few gammarid species where the female is larger than the male. In the Baltic Sea females grow to a length of 7 mm, males to only 5 mm. It is light green, whitish or greenish-blue in colour. The eyes are large and kidney-shaped. The antennules and antennae are both short and sparsely setose. The last three pairs of pereopods, the urosome and telson are covered with spines. The telson is elongated and is armed with three spines.

Occurrence

It occurs sporadically in the Polish coastal zone of the Baltic Sea (Jażdżewski 1976), principally in river mouths and where the sea bed and beaches are stony (Barnes 1994). In 2004, single specimens were caught near Kołobrzeg.

Biology and Ecology

It is an omnivorous, fresh water species, but can tolerate low salinities. Breeding takes place in spring, up to and including June.

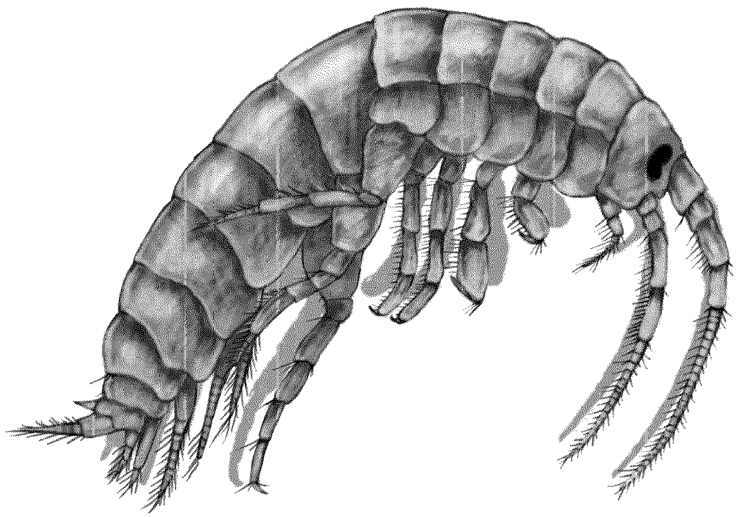


Fig. 9.53 *Chaetogammarus stoerensis* (Stanisław Węsławski)

Impact
In newly colonized areas it can adversely affect other animal species. It is foraged on by various species of fish (Fig. 9.53).

9.5.15 Calliopius laeviusculus

Calliopius laeviusculus (Krøyer, 1838)
Order: Amphipoda
Family: Calliopiidae

Basic Morphological Features
It reaches a length of up to 14 mm, but the largest specimens in the Baltic Sea are only 8 mm long. It is white to greenish in colour, although the body gives the impression of being transparent. The dorsal side is thickly mottled dark red, which makes it appear very colourful. It has a small rostrum, and large, dark brown eyes (Żmudziński 1990). Both pairs of antennae are similarly short and slender. The telson is triangular, but with a rounded end.

Occurrence
It occurs in the arctic-boreal regions of European coasts. It is relatively rare along Polish coasts, but is encountered on all the coasts of the Baltic. At the beginning of the twenty-first century single individuals were caught near Ustroń Morski. It prefers shallow sublittoral waters. The greatest depth at which it has been found

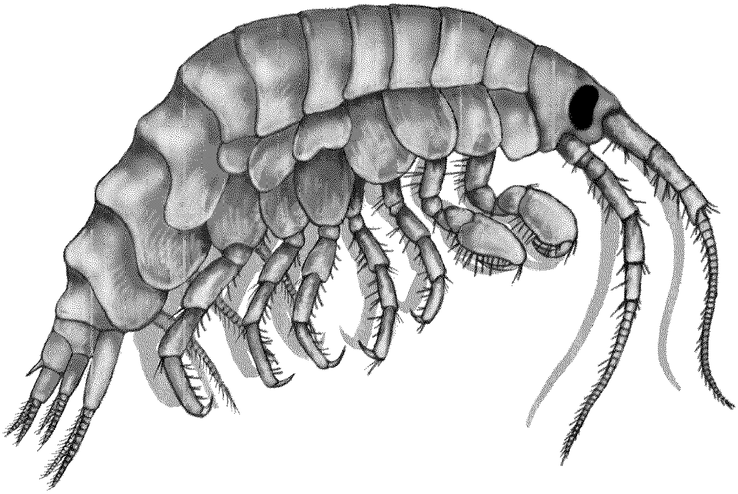


Fig. 9.54 *Calliopius laeviusculus* (Stanisław Węsławski)

in the Baltic Sea is 30 m. It prefers shallow waters with plentiful aquatic vegetation. During the day, it conceals itself among the seaweed, while at night it swims up to the water surface (Żmudziński 1990).

Biology and Ecology
It is a euryhaline species, but can tolerate water salinities of at least 6‰. It is also eurythermic. Breeding takes place in summer and autumn.

Impact
Like all crustaceans, it is an integral part of the food web (Fig. 9.54).

9.5.16 Melita palmata

Melita palmata (Montagu, 1804)
Order: Amphipoda
Family: Melitidae

Basic Morphological Features
In fully saline seas it can grow to a length of 16 mm, but in the Baltic these crustaceans are smaller, no more than 9 mm long (Żmudzinski 1990). The slender body is bright yellow through blue-grey to reddish-brown in colour. The eyes are small, round, with an evident slit beneath. Characteristic are two teeth, located dorsally on the penultimate abdominal segment, and one much bigger tooth on the

segment before. The second pair of pereopods is cleft at the end to form a claw. The uropods are strongly elongated. The telson tail plate is clearly cleft and has several large spines at the end (Żmudzinski 1990).

Occurrence
It lives in the arctic-boreal zone, occurring in the White and Barents Seas. It is rare in the Baltic Sea, inhabiting its western and southern waters (Gic-Grusza et al. 2009). It is found in the Gulf of Gdańsk and occasionally in Puck Bay (Janas and Kendzierska 2014; Klekot 1980; Legeżyńska and Wiktor 1981). In the 1970s numbers reached some 1000 individuals per square metre of sea bed. It lives in the sublittoral of seas and brackish water bodies where underwater meadows flourish, but also on rocky coasts and on muddy bottoms. It is found at depths below 2–3 m (Żmudzinski 1990).

Biology and Ecology
It is a marine and brackish water species. It is not found at salinities less than 6‰ (Barnes 1994). It is eurythermic. It feeds on small plants and detritus. Breeding takes place twice a year, in summer and autumn (Żmudzinski 1990). A single female bears up to 21 eggs.

Impact
Like all crustaceans, it is an integral part of the food web (Fig. 9.55).

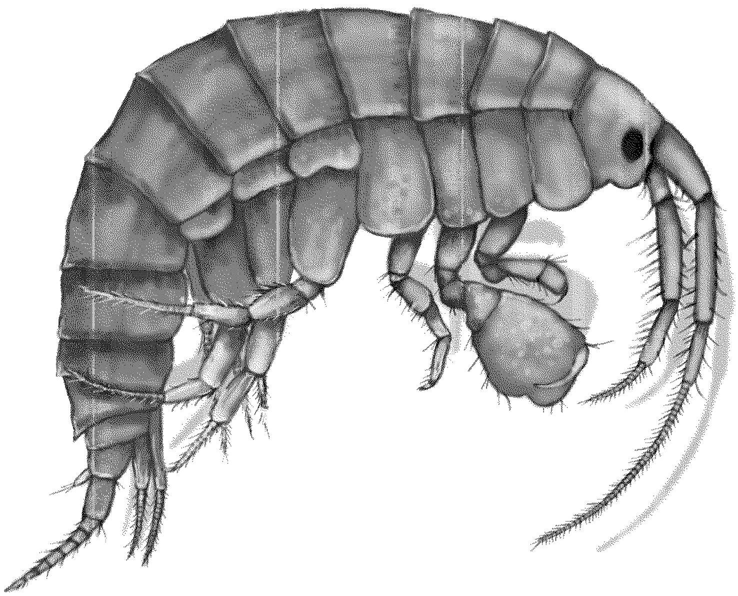


Fig. 9.55 *Melita palmata* (Stanisław Węsławski)

9.5.17 Melita nitida Smith, 1873

Order: Amphipoda
Family: Melitidae

Basic Morphological Features

Species was redescribed by Mills in 1964. Has similar size and shape as *Melita palmata*. Identification based on absence of dorsal teeth on the first urosome segment and presence of a group of dorso–lateral spines on either side of the second urosome segment, and on the shape of the male gnathopod 2. Female gnathopod 2 less powerful and setose than in male. The length of an individual reaches up 8.7 mm. Body is smooth and bright yellow to brown color. The eyes round, normally developed. Antenna 1 longer than antenna 2. Male antenna 2 flagellum with dense setae. Gnathopod 1 smaller than gnathopod 2. Observed, positive correlation between the length of organism and number of articles and variability in ornamentation on urosome segment 2 (Normant-Saremba et al. 2017).

Occurrence

The species is originates from North America (Bousfield 1973). It was originally described from New England (NE America) by Smith in 1873. Was recorded along the Pacific coast of North America (Chapman 1988). N Europe waters is non-native species. Shipping is the most likely vector of introduction to Europe. Probably was transported in ballast water and in fouling on ships hulls. Small boats, such as recreational vessels can transport them in short distances. Many empty niches in European brackish waters make the environment susceptible for this species (Heiman et al. 2008; Gouillieux et al. 2016). In Europe was first found in 1998 in the Netherlands. In 2010 was noted in the Baltic Sea in Kiel Canal (Reichert and Beermann 2011). Later was reported from the Mecklenburg Bay and in Cuxhaven. In 2014 was found in the Gulf of Gdansk. In 2013–2016 was found in the Arcachon Bay, Hosssegor Lake and the Gironde Estuary (SW France) (Normant-Saremba et al. 2017). Base on the clumps of hydroids and ectoprocts, crevice builed by oister reefs, on hard substrates, both natural and artificial. In muddy bottom it can burrow into soft sediment (Chapman 1988; Reichert and Beermann 2011). Co-occur with *Melita palmate* (Faasse and Moorsel 2003).

Biology and Ecology

It lives in relatively brackish waters, in mesohaline regions of estuaries. It shows a broad tolerance of temperature and salinity. It is euryhaline, in salinity range 3–20‰, can tolerate even 30‰. It is a eurythermic. This indicates a tolerance for low as well as high temperatures, found in waters with temperatures up to 32 °C (Jażdżewski and Konopacka 1995; Faasse and Moorsel 2003). It feeds small particle detritus, scraping of small plant surfaces for diatoms and other epiphytic algae (Zimmerman et al. 1979; Borowsky et al. 1997). High tolerance to environment makes it a potential invader of estuaries in other parts of the Baltic Sea.

Fig. 9.56 *Melita palmata* (Lena Marszewska)

Female sexually dimorphic characters based on brooding female. Annual life cycle with several broods. Ovigerous females observed from May to September. A single female bears from 5 to 51 eggs in the marsupium.

Impact
It plays a function in the food web. The population development shows possible expansion to the other estuaries or even the whole Baltic Sea (Fig. 9.56).

9.5.18 Monoporeia affinis

Monoporeia affinis Lindström, 1855
Order: Amphipoda
Family: Pontoporeidae

Basic Morphological Features
Specimens can grow to lengths of 8–12 mm, depending on the environment in which they occur. Males are slightly shorter than females. In the Baltic Sea, the largest specimen ever recorded was 8 mm long. The body is transparent with a yellowish-orange shine. It has large, dark brown, elliptical eyes. The setose legs are

adapted to burrowing in sediments. The last pair of pereopods has a broad base, which also helps the animal to burrow.

Occurrence

A glacial relict in the Baltic, it is common in almost the whole sea and is abundant in open waters (Dziaduch 2012). In some deeper waters it is one of the dominant species, when aggregations can reach up to 20,000 individuals per square metre (Elmgren et al. 2001). It inhabits most post-glacial water bodies in Europe. It is also numerous in the North American Great Lakes. It occurs mainly at depths of 20–60 m, on sandy-muddy bottoms. It spends the day buried in bottom sediments, and at night swims in the water. In winter it moves closer to the shore. It is found in the greatest numbers in September.

Biology and Ecology

It is a euryhaline, brackish water species of marine origin. It prefers water with a salinity of about 10‰. Being a post-glacial relict species, it is stenothermic, well adapted to low temperatures. This is evidenced by the high lipid level in the body, making up to 33% of the dry weight. Although it prefers well-oxygenated water, it can tolerate hypoxia in the water. More than 90% of the food consists of detritus, the remainder of algae, bacteria and organic matter.

Breeding takes place in winter. Females become fecund on reaching a length of 6 mm. Copulation takes place in the water, after which most males die. Reproducing females are on average 9 mm long. They carry an average of 30–40 eggs for 3–4 months until hatching. After the breeding period, the average size of

Fig. 9.57 *Melita palmata* (Lena Marszewska)

individuals in the population clearly falls and does not exceed 2 mm. The growth rate of individuals, the fastest in summer, is slower at greater depths. It has a lifespan of up to 3 years.

Impact
Because of its the large numbers, it is a significant component of the food web in many regions (Ejdung et al. 2000). It is an important food resource for herring *Clupea harengus*, European smelt *Osmerus eperlanus* and cod *Gadus morhua* (Fig. 9.57).

9.5.19 *Pontoporeia femorata*

Pontoporeia femorata Krøyer, 1842
Order: Amphipoda
Family: Pontoporeidae

Basic Morphological Features
Up to 12 mm in length, the body is almost transparent, of a sturdy structure. The slightly elongated eyes are small and light red in colour. Some individuals living in deeper waters have no eyes at all. The dorsal surface of this crustacean is smooth, only the first segment of the tail has a forked spine (Żmudziński 1990).

Occurrence
A glacial relict species, it inhabits the sea around the North Pole, several areas of the North Sea and also the Baltic Sea up to the Gulf of Finland and Gulf of Bothnia. It lives mainly in the open water, down to a depth of 200 m (Mulicki 1957). In some areas, aggregations can comprise as many as 2000 per square metre of the sea bed. It prefers muddy or muddy-sandy sediments (Banasiak 2003). Along with the deterioration in oxygen conditions and the appearance of hydrogen sulphide, its numbers have decreased. In the 1990s declines in numbers were apparent already below 30 m depth. It spends the day buried in sediments, while at night it swims in the water (Mulicki 1957).

Biology and Ecology
It is a euryhaline, brackish water species of marine origin. It prefers water with a salinity of about 10‰. It is stenothermic, with a clear preference for low temperatures: this is associated with its glacial origin. The highest temperature tolerated is 13 °C. Being highly resistant to oxygen shortages, it colonizes deep-water areas (Banasiak 2003). Under hypoxic conditions, it can lower its metabolic rate, temporarily switching to anaerobic metabolism. It feeds on plant and animal detritus (Mulicki 1957). Reproduction takes place mainly in winter, in the deeper parts of the sea. It reaches sexual maturity in autumn. From October onwards, males begin to prepare for the mating season: they do not feed, and change to a pelagic lifestyle. Fertilization takes place in the water. After fertilization, the males die. Females

carry eggs until spring, when the juveniles hatch. These closely resemble adults. Having given birth to the new generation, the females perish, too (Żmudziński 1990). The lifespan of the species in the Baltic Sea is 2 years.

Impact

It is an important component in the diet of predatory species of invertebrates and many fish, such as herring *Clupea harengus* and cod *Gadus morhua* (Banasiak 2003) (Fig. 9.58).

Fig. 9.58 *Pontoporeia femorata* (Piotr Wysocki)

9.5.20 Bathyporeia pilosa

Bathyporeia pilosa Lindström, 1855
Order: Amphipoda
Family: Pontoporeidae

Basic Morphological Features
This is a small crustacean, growing to a length of no more than 6 mm (Żmudziński 1990). The body is transparent, with a whitish hue. The small, red eyes are round in females and kidney-shaped in males. It is distinguishable from other gammarids by the antennules, which are elbowed. There are two or three setae on each scape of the antennules. The telson is deeply cleft and sparsely setose on the side and at the end.

Occurrence
Common in the Baltic Sea, it is very abundant in summer in the shallowest, sandy regions of bays, down to a depth of 0.5–3 m. It is found in Puck Bay and the Gulf of Gdańsk. Aggregations range from a dozen or so to several hundred individuals per square metre of sea bed (Żmudziński 1990). For preference it inhabits the surf zone. In winter, it migrates into deeper waters (Żmudziński 1982). With very fast and agile body movements it can burrow rapidly into the sand, but it is also a good swimmer.

Biology and Ecology
It is a euryhaline, salt water species of marine origin. It cannot survive in waters with a water salinity of less than 6‰. It is also eurythermic. It feeds on algae and diatoms growing on the bottom. Breeding takes place in spring and summer, with two or three generations being produced during the course of the year (Żmudziński 1990). Females carry from half-a-dozen to fifteen or so eggs. Juveniles closely resemble their parents and are about 2 mm in length (Jażdżewski 1970).

Impact
It is an important food resource for many predatory species, such as turbot *Scophthalmus maximus* (Fig. 9.59).

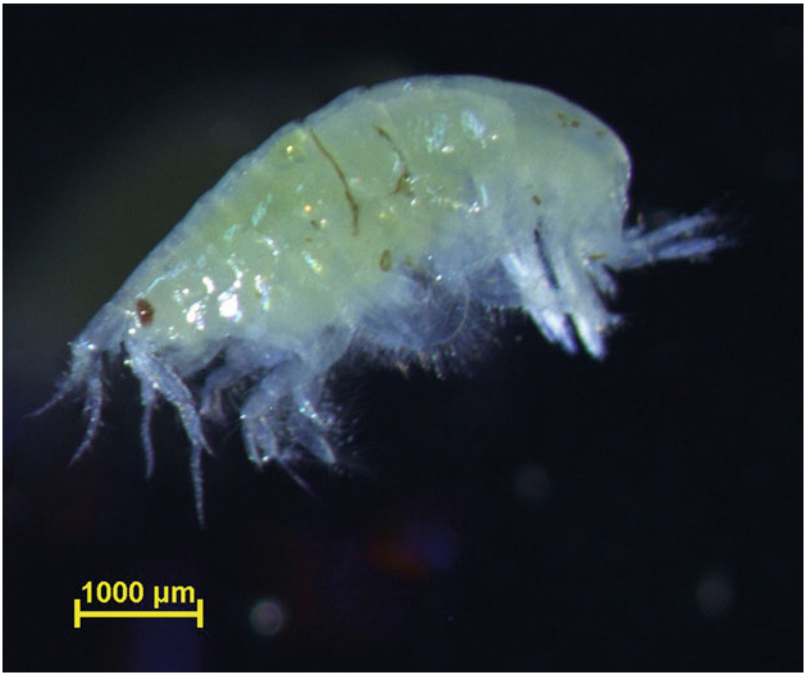


Fig. 9.59 *Bathyporeia pilosa* (Anna Dziubińska)

9.5.21 Leptocheirus pilosus

Leptocheirus pilosus Zaddach, 1844
Order: Amphipoda
Family: Corophiidae

Basic Morphological Features
A small crustacean, no longer than 5.5 mm (Jażdżewski 1970). The body appears to be transparent, although in fact it is gold-yellow in colour with a reddish tinge. The bases of the pleopods are spotted brown. The eyes are black. The antennules are half the length of the body. It is distinguishable from other species of Amphipoda by the extremely long terminal pair of pereopods. A characteristic feature of this species are the elongated coxal plates of the second segment, covering the lower part of the head and the plates of the first segment. The telson is short (Żmudziński 1990).

Occurrence
It is common in brackish waters in most coastal zones of Europe (Barnes 1994), from the Baltic Sea to the Mediterranean Sea. In the 1970s it used to be abundant in the underwater meadows of Puck Bay (Jażdżewski 1970). Nowadays one comes

across it only occasionally (Osowiecki 2000). It lives in self-made cases attached to a hard substrate. It is very a good swimmer and prefers clean, unpolluted water (Żmudziński 1990).

Biology and Ecology
Although it is a brackish water species, it tolerates significant decreases in salinity very well, even to as little as 2‰. It does not occur in waters where the salinity exceeds 15‰. It is a eurythermic species. It has very specific oxygen requirements and is not very resistant to environmental pollution. It feeds on detritus, algae and organic matter in the bottom sediments. Reproduction takes place twice a year (Żmudziński 1990). On average a single female carries 9 eggs. Overwintered animals start breeding in spring, and their offspring themselves reproduce in summer.

Impact
It is a significant component of the food web, like all organisms (Fig. 9.60).

Fig. 9.60 *Leptocheirus pilosus* (Halina Kendzierska)

9.5.22 *Talitrus saltator*

Talitrus saltator (Montagu, 1808)
Order: Amphipoda
Family: Talitridae

Basic Morphological Features
It belongs to a family of crustaceans known as sand hoppers or sand fleas. The name "sand flea" is misleading, however, as they do not bite people. Females reach a length of 16 mm, males grow to 20 mm. The body is transparent, with a greyish-brown tinge and dark brown or blue spots or stripes. It is stocky, with a broad thorax and slightly tapering abdomen. There are round, black eyes on the large head. The antennae are longer and more robust than the antennules. The telson is thick and broad. The last three pairs of pleopods are well developed to enable the animal to burrow into sand, and to make prodigious jumps, often to heights of 50 cm. All the pereopods bear spines (Żmudziński 1990).

Occurrence
It is the most common species of the family Talitridae, occurring on the sandy north-eastern coasts of the Atlantic and the North Sea. It is common along the coasts of Europe, from Norway down to the western shores of the Mediterranean (Lincoln 1979; Żmudziński unpubl.; Adin and Riera 2003). In the Baltic Sea, it inhabits beaches with dunes. It is most easily found in sites not disturbed by humans (Żmudziński 1990). It is the only talitrid species that is afforded complete legal protection in Poland. During the day, it remains buried in sand or hidden among the various objects scattered on the beach (Żmudziński 1990). It occurs in aggregations in the spray zone where the sand is moist. In spring and early summer it is found close to the waterline, but in late summer and autumn somewhat farther away from the shore. On land, it moves using its pereopods, while in water it swims very well.

Biology and Ecology
It is a eurythermic, euryhaline, brackish water species. The lowest tolerable salinity is 6‰. It forages after dusk on organic matter it finds on the beach (Drzycimski and Nawodzińska 1965). Sexual maturity is reached after a year. Breeding takes place from May to September, peaking in July. During the reproductive period, females remain hidden in the sand. There are two generations per year. Juveniles are 4 mm long (Drzycimski and Nawodzińska 1965). They prefer a moist substrate, which is why they tend to congregate by the waterline. In the splash zone, they burrow into sand. When a wave recedes, they emerge from the sand and try to move further up the beach. It is thought that, with its ability to define the sun's position, *T. saltator* "knows" where the waterline is. In autumn, it burrows deep into the base of dunes and remains there until spring. It has mucous glands on the body. When it digs pits in the sand, the mucus helps to clump the sand grains, thus preventing the pit walls

from collapsing (Kozieł 2004). After the animal has passed by, the walls of the pits collapse behind it. It has a lifespan of a year and a half. Beach destruction, construction of beach infrastructure and tourism limits the distribution of this species (Stanek 1999). The presence of tourists is not a direct cause of the animals' extinction: mechanical beach cleaning, the erection of concrete structures, restaurants and other recreational facilities are much more dangerous. It has happened

Fig. 9.61 *Talitrus saltator* (Piotr Wysocki)

Fig. 9.62 *Talitrus saltator* (Piotr Wysocki)

that *Talitrus saltator* disappeared from a beach after it had been mechanically cleaned (Jędrzejczak 2004). It was replaced by *Orchestia cavimana* and *Platorchestia platensis*—species that prefer hard substrates.

Impact
It serves as food for many species of birds and insects (Pank 1997). It plays a part in cleansing beaches of organic matter (Drzycimski and Nawodzińska 1965) (Figs. 9.61 and 9.62).

9.5.23 Talorchestia deshayesii

Talorchestia deshayesii (Audouin, 1826)
Order: Amphipoda
Family: Talitridae

Basic Morphological Features
With a length of just 14 mm, this is one of the smallest talitrids in the Baltic Sea region. Females are smaller than males. It is stocky, with a wide thorax, brown or greenish in colour, although reddish individuals with dark stripes and spots on the body are also quite common. The eyes are large, round and black. The second pair of antennae are three times as long as the first pair (Dettlaff 2006; Żmudziński unpubl.).

Occurrence
It occurs on sandy shores of the north-east Atlantic and North Sea. It is found in the coastal zoneof almost the whole of Europe, in the Mediterranean and the Black Sea (Drzycimski and Nawodzińska 1965). It inhabits sandy coasts on the southern and western Baltic. In Poland it was recorded for the first time in 1965 on a beach on the Puck Bay side of the Hel Peninsula, where it had presumably been carried by birds (Drzycimski and Nawodzińska 1965). Nowadays it can be found on little frequented beaches in and around Jurata and in the former military training area on Hel, where the species has been found in numbers up to 30,000 individuals per square metre. Forty or 50 years ago, one used to find it on beaches all along the Hel Peninsula, but its distribution has become limited by the increasingly intensive recreational use of the beaches. It spends the winter in a state of anabiosis, buried in the sand (Kozieł 2004). It burrows into the sand down to depths of as much as half a metre. It is active from May to September, spending the day buried in the sand, and entering the water after sunset. This mode of life makes it less exposed to intense sunlight and desiccation. When escaping from danger, it can jump to a height of 30 cm (Demel 1965; Żmudziński 1960).

Fig. 9.63 *Talorchestia deshayesii* (Piotr Wysocki)

Biology and Ecology

It is a euryhaline species, occurring in waters of salinity above 6‰. It is also eurythermic. Like other Baltic invertebrates, it lowers its metabolic rate at low ambient temperatures. It feeds on plant and animal detritus in the beach sand. Breeding takes place from May to late summer. During the reproductive period, females remain buried in the sand down to depths of 20 cm. They can carry a maximum of 14 eggs in the marsupium. During the reproductive period a single female can breed several times. Juveniles prefer a moist substrate. They generally reach sexual maturity in the spring of the following year. There are three overlapping generations. They live for about 2 years (Drzycimski and Nawodzińska 1965).

Impact

It is a food resource for other animals. It forages on organic matter on the beach, contributing to its cleansing. Hence, it is often called a "beach cleaner" (Fig. 9.63).

9.5.24 Orchestia cavimana

Orchestia cavimana Heller, 1865
Order: Amphipoda
Family: Talitridae

Basic Morphological Features

With its stocky body, it is one of the largest talitrids. Females (max. length 17 mm) are smaller than males, which may grow to 22 mm. The body is brown with a purple sheen. The eyes are large, round and black. The antennae of the second pair are three times as long as those of the first. The telson is short, distinctly cleft, each lobe bearing a few spines (Żmudziński unpubl.).

Occurrence

It occurs in brackish water lagoons, bays and river mouths of the Baltic Sea, where it was first recorded in 1899. It inhabits the waters around the island of Wolin, the shores of the Szczecin (Utko 1999) and Vistula Lagoons and the banks of the Dead Vistula (Martwa Wisła) (Żmudziński 1990). Elsewhere in Europe it has been found in the Mediterranean and Black Seas, and the seas of northern Europe. It also inhabits the Atlantic coast of North Africa and the Red Sea (Lincoln 1979; Jarvekulg 1979; Kotta 2000). It lives on rocky shores, although it can also be found under piles of seaweed lying on beaches. It spends the day hidden under stones and other objects on beaches, becoming active after dusk (Żmudziński unpubl.).

Biology and Ecology

It is a brackish water species, preferring water of low salinity, about 2‰. It is eurythermic and feeds on plant and animal detritus. With rising spring temperatures, it begins to breed, and reproduction lasts all summer. There is pronounced sexual dimorphism. For example, the second pair of gnathopods in the male is bifurcated into a claw, whereas in females it is straight. Females start breeding when they reach a length of 9 mm. A female can carry a dozen or so eggs at any one

Fig. 9.64 *Orchestia cavimana* (Piotr Wysocki)

time. Incubation lasts only 2 weeks, so several generations are produced during the summer. While breeding, females conceal themselves under rocks (Żmudziński unpubl.).

Impact
It plays an important function in cleansing sediments of organic matter (Drzycimski and Nawodzińska 1965). It is a food resource for other animals (Pank 1997) (Fig. 9.64).

9.5.25 Platorchestia platensis

Platorchestia platensis (Krøyer, 1845)
Order: Amphipoda
Family: Talitridae

Basic Morphological Features
This is one of the smallest talitrids in the Baltic Sea: the largest recorded specimens are no longer than 15 mm. Males are larger than females and have longer antennae. In males, the second pair of legs has a well-developed prehensile claw, in females this leg is straight. *P. platensis* has a stocky body and a broad thorax. There are small black eyes on the small head. The antennae of the second pair are three times as long as those of the first pair. The telson bears a few spines. It can be yellowish, orange, olive and even brown in colour (Żmudziński unpubl.).

Occurrence
It was reported for the first time in the coastal waters of the Baltic Sea in 1940, and near Kuźnice on Puck Bay on the Polish coast in 2005 (Spicer and Janas 2006). Earlier it had colonized the coasts of Germany, Denmark and Sweden. It lives on the coasts of the Mediterranean and North Seas. It is also found in large numbers off the coasts of the Atlantic and Pacific Oceans (Lincoln 1979; Teigsmark 1981; Zettler 1999). It is a typical inhabitant of rocky sea shores (Żmudziński unpubl.). It hides under stones or other objects during the day and is active at night.

Biology and Ecology
A marine species, tolerating a minimum salinity of 6–7‰. It feeds on plant and animal detritus. Breeding takes place from spring to December, peaking in summer. At any one time a female can carry up to 36 eggs in her marsupium. While breeding, females conceal themselves under rocks (Żmudziński unpubl.).

Impact
It is a very important component of beaches. Feeding on the remains of plants and small animals, it contributes to beach cleansing (Drzycimski and Nawodzińska 1965) (Fig. 9.65).

Fig. 9.65 *Platorchestia platensis* (Piotr Kendzierski)

9.5.26 Corophium crassicorne

Corophium crassicorne Bruzelius, 1859
Order: Amphipoda
Family: Corophiidae

Basic Morphological Features

It grows to a length of 6 mm (Żmudzinski 1990). The body can be light brown or orange in colour and is covered with numerous dark spots. The head has a small triangular rostrum. The second pair of antennae in the male are massive. A characteristic feature are the fused segments of the urosome, which are covered by a single plate. The eyes are small. The base of the first pair of antennae has five spines on the ventral side.

Occurrence

It occurs in deeper sea waters, but also in bays and estuarine waters of many European seas. It lives buried in sandy-muddy bottom sediments (Barnes 1994). It inhabits the coastal waters of the western Baltic (Kohn 1996), as far as the Pomeranian Bay, the island of Bornholm and the Słupsk Furrow. In the 1950s it inhabited Puck Bay.

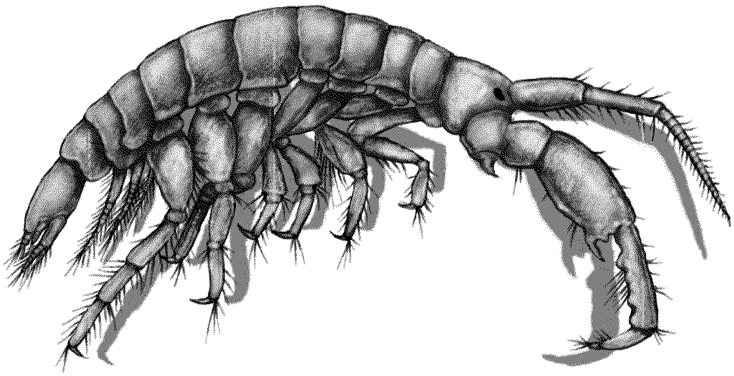


Fig. 9.66 *Corophium crassicorne* (Stanisław Węsławski)

Biology and Ecology
It is a marine species, preferring slightly higher salinities, over 10‰. It is a euryhaline species, feeding on organic matter in sediments. It reproduces in summer.

Impact
It takes an active part in bioturbation and the removal of organic matter from sediments. It is a food resource for some species of fish (Fig. 9.66).

9.5.27 Corophium lacustre

Corophium lacustre Vanhöffen, 1911
Order: Amphipoda
Family: Corophiidae

Basic Morphological Features
It is up to 7 mm in length (Żmudziński 1990). The body is yellowish-white and has a small triangular rostrum on the head. Both pairs of antennae are setose. The urosome is fused into a uniform, rectangular plate with rounded sides.

Occurrence
It has been recorded in many coastal zones worldwide, including the coastal bays and estuarine waters of the Baltic Sea, such as the Vistula and Szczecin Lagoons and the mouths of some rivers. It is also found in shallower waters in the Gulf of Gdańsk (Jażdżewski 1976, 1987). It inhabits sandy and muddy bottoms, though

Fig. 9.67 *Corophium lacustre* (L. Marszewska)

Fig. 9.68 *Corophium lacustre* (L. Marszewska)

preferably among the vegetation covering the sea bed. They construct cases from the sediment which they attach to algae (Żmudziński 1990; Barnes 1994).

Biology and Ecology
It is a euryhaline species, preferring water of low salinity, about 1‰. It is eurythermic and feeds on organic matter deposited in the sediments. Reproduction takes place in summer. Females start breeding on reaching a length of 3 mm. A single female can carry up to 17 eggs. Juveniles leave the marsupium when they are about 1 mm in length.

Impact
It participates in cleansing water bodies of organic matter and also in bioturbation. Individuals of the species have been found in the stomachs of turbot *Scophthalmus maximus* (Figs. 9.67 and 9.68).

9.5.28 Corophium volutator

Corophium volutator (Pallas, 1766)
Order: Amphipoda
Family: Corophiidae

Basic Morphological Features
Small in size, it grows to a maximum length of 10 mm. The body is whitish, with characteristic brown markings. The second pair of antennae of males are exceptionally thick in relation to the body size. The urosome is not fused (Żmudziński 1990).

Occurrence
It is common in shallow bays and estuaries. It is found off the coasts of North America, and of Europe from the Mediterranean as far as Norway, Great Britain and Ireland (Muus 1967; Larsen and Doggett 1991; Hart 1930). It also occurs in the Black Sea and the Sea of Azov. It inhabits muddy-sandy substrates to depths of 30 m (Schellenberg 1942). It constructs special U-shaped tubes from grains of sand, silt and its own secretions, attaching them to hard substrates in the water, like stones, plants, and underwater structures such as piles and piers.

Biology and Ecology
It is a euryhaline species, tolerating a very wide salinity range from 2 to 50‰ (Mclusky 1967; Mills and Fish 1980). It is eurythermic and is found in waters of very different temperatures, even as high as 37 °C. Its tolerance to high ambient temperatures decreases as the salinity does. It is exceptionally resistant to hypoxia and the presence of hydrogen sulphide. Under adverse conditions, it limits its life processes to a minimum and switches to anaerobic metabolism (Dobrzycka-Krahel et al. 2014). The tubes in which it lives can be found in sediments down to depths of

Fig. 9.69 *Corophium volutator* (Piotr Wysocki)

10 cm. It feeds on plant and animal detritus on the bottom of the water body, as well as small, live organisms inhabiting the water column, such as diatoms and other algae. Sexual dimorphism is very pronounced. Breeding takes place from April to November, with the first juveniles appearing in early May. It can produce from 2 to 5 generations a year (Jażdżewski 1970). After hatching, the young remain in the marsupium for about 5 days. The first free-living individuals are from 1.2 to 1.4 mm in length.

Impact
It is consumed by many species of fish, such as perch *Perca fluviatilis*, European plaice *Pleuronectes platessa*, turbot *Scophthalmus maximus*, European eel *Anguilla anguilla* or gobies Gobiidae, other crustaceans like *Crangon crangon*, and many aquatic birds. Itself feeding on plant and animal detritus, it participates in the cleansing of water bodies (Fig. 9.69).

9.5.29 Corophium multisetosum

Corophium multisetosum Stock, 1952
Order: Amphipoda
Family: Corophiidae

Basic Morphological Features

In the Baltic Sea, this species reaches a length of 8 mm. The body is yellowish-white in colour. The head bears a small triangular rostrum. The antennae are setose and bear a number of spines. The urosome is flattened, segmented and not fused. The cleft telson is wider than long (Jażdżewski 1987).

Occurrence

It occurs in the bays and estuarine waters of the Baltic Sea. It is also present in the Dead Vistula and the Gulf of Gdańsk. It constructs tubes from sand to live in (Kendzierska 2016; Jażdżewski 1976, 1987).

Biology and Ecology

This species inhabits mainly fresh water bodies. Occasionally, however, it is found in brackish waters (Barnes 1994), with a salinity of about 6‰. It is a eurythermic species and feeds on organic matter deposited in sediments. It breeds in summer.

Impact

It participates in bioturbation and the removal of dead organic matter from sediments (Fig. 9.70).

Fig. 9.70 *Corophium multisetosum* (Anna Dziubińska)

9.5.30 *Chelicorophium curvispinum*

Chelicorophium curvispinum (G.O. Sars, 1895)
Order: Amphipoda
Family: Corophiidae

Basic Morphological Features
It is small in size, up to 6 mm in length, with a cylindrical body greyish-yellow in colour with transverse dark stripes. The rostrum is located on the head. The second pair of antennae are much longer than the first pair. They have a large, curved tooth and two smaller teeth at the base. These antennae are used for locomotion. The urosome segments are not fused (Schellenberg 1942).

Occurrence
It comes from the Ponto-Caspian region, where it is common. It is numerous in the mouths of the Volga, Dnieper, Dniester and Danube, and in many coastal lakes of the Black and Caspian Seas (Mordukhai-Boltovskoi et al. 1969). It found its way to the North and Baltic Seas via the network of canals (Jażdżewski 2011). It was reported in the River Vistula already in the 1920s (Seligo 1920). Nowadays it occurs in vast numbers in some Polish rivers, such as the Vistula, Oder, Bug and Narew, although it prefers standing waters. It was first recorded in the Baltic Sea in 1926. In recent years, it has colonized the Szczecin and Vistula Lagoons (Jażdżewski 2011; Konopacka 2004). Like other corophiids it constructs tubes for living in. These it places on various kinds of hard objects lying in the water and on the bottom of the water body. It is numerous among the benthos of some rivers.

Biology and Ecology
It feeds on small algae, such as diatoms (Van der Velde et al. 2000). It produces two or three generations per year. Wintering specimens breed in April and May, perishing thereafter. The juveniles of that generation are capable of reproducing as early as July. The next generation appears in autumn. There may be up to 40 eggs in the marsupium (Jażdżewski 2011).

Impact
When it colonizes new water bodies, it has an impact on native species, particularly where it occurs in large numbers. It is an important food for many fish species (Jażdżewski 2011). It covers mechanical equipment in water, clogging filter tubes, for example. It is still expanding its range of distribution (Fig. 9.71).

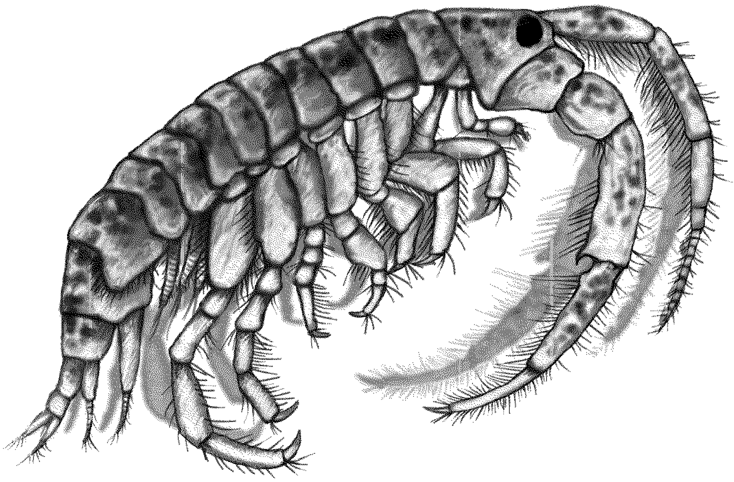


Fig. 9.71 *Chelicorophium curvispinum* (Stanisław Węsławski)

9.5.31 Dyopedos monacanthus (Metzger, 1837)

Order: Amphipoda
Family: Dulichiidae

Basic Morphological Features
Individuals grow to a length of 7.5 mm. Females are smaller than males. Individuals in the Atlantic population can attain large sizes in the cold months of the year when the water temperature is below 8 °C. There is sexual dimorphism. The body is pale yellow, mottled brown. The slightly prolonged head bears large, protruding black eyes. The antennules are slightly longer than the body length; the antennae are about 25% shorter than the first pair. The coxa is prolonged into a long spine, which curves forwards and inwards. The first pair of thoracic legs (gnathopods) is small, while the second pair of these legs in the male is very large and adapted for defence (Dziaduch 2007).

Occurrence
It occurs in the coastal zone of the Atlantic Ocean, off the coasts of North America and Europe, from northern Norway and Iceland to the English Channel and the Danish Straits (Stephensen 1929; Lubitz 1979; Lincoln 1979). It has been recorded in the western Baltic, i.e. in the Arkona and Bornholm Basins and the Gulf of Mecklenburg. In 2006 and the following years, after a 50-year absence, it was recorded in the Slupsk Furrow, where a population of that species has now established itself (Dziaduch 2007). In the Atlantic Ocean, it lives at depths from

15 to 325 m, where in winter its numbers can reach 3000 specimens per m^2. Summer aggregations, however, are much smaller, less than 50 specimens per m^2. It is an epibenthic species, occurring in areas where the bottom is of silt and gravel with some sand. It is found in cool waters that support a lot of microalgae and organic matter (Thiel 1998a).

Biology and Ecology

It is a marine species and is therefore not present in low salinity waters. It tolerates a wide range of ambient temperatures and is relatively resistant to oxygen deficiencies. The lowest concentration of oxygen at which it has been recorded is 2 ml O_2/l. It is a passive, detritus feeder, consuming mainly seston (organic matter suspended in the water column) (Thiel 1998a; Moore and Earll 1985). It has been observed to migrate to surface waters, particularly in the summer (Thiel 1998a, b). The direct cause of these movements is the greater number of predators, such as fish and benthic shrimps, that feed on *D. monocanthus*. Its numbers increase considerably in the pelagic layer, which is where more predatory species appear. Spawning takes place from April to October in the Baltic Sea (Dziaduch 2007), but all the year round in the Atlantic with variable intensity. Depending on the season from 40 to 100% of females are ovigerous, i.e. carry eggs. They can usually carry about 100 eggs, the number varying, depending on the season and their size. Older, larger females have more eggs than smaller females. There are no developmental stages. Juveniles that have left the marsupium remain in the care of the mother for several days, clinging to mast-like structures on which they grow to a length of about

Fig. 9.72 *Dyopedos monacanthus* (D. Dziaduch)

1.4 mm. Only then do they leave the masts to start a pelagic life. The masts are constructed from micro-algae, dead organic matter and faecal pellets held together by threads of mucous. Larger females build longer and larger masts (Thiel 1998a, b; Dick et al. 1998). These also play a role in the feeding of the young. When the females are perching on the masts, the males are on the lookout for new females. Sometimes males will sit for weeks on end on the masts waiting for a female to moult, lay eggs, after which copulation takes place. A female can reproduce several times per year (Mattson and Cedhagen 1989).

Impact

In the estuarine waters of the Atlantic Ocean it is the main food resource of benthic fish commercially caught there (Fig. 9.72).

9.6 Decapoda

About 10 thousand species are known, differing from each other in appearance, morphology and environmental requirements. These are crustaceans of very different body sizes, from a few millimetres up to 1 m in length (Jura 2007). Decapoda include the largest crustaceans, such as some shrimps, lobsters, crayfish or crabs. However, the majority range in length from 5 to 15 cm. Many species have very specific environmental demands. They inhabit both marine and fresh water bodies, as a consequence of which their external structures are very diverse. Most species are associated with the coastal zones of seas, but there are also deep-sea species. Some swim, others live on the bottom or buried in sediments. Many species migrate daily and seasonally (Jura 2007; Grabowski 2011).

The decapod body plan consists of a head, a thorax and an abdomen of six mobile segments and a telson, forming a kind of tail. The thoracic segments are fused with the head to form the cephalothorax, which is covered by an external, rigid skeleton called the carapace (Hayward et al. 1996; Grabowski 2011). The sides of the carapace protect the gills (Brehm 1968). The external skeleton of lobsters and crabs is reinforced with calcium carbonate. In front the carapace is extended into a rostrum, under which there are the stalked eyes. There are two pairs of antennae. The mouth is located in the lower front side of the cephalothorax. The first three pairs of legs are maxillipeds. The next five pairs of thoracic legs (hence the name decapods)—pereopods—are walking legs. In many species, the first pair of walking legs are armed with powerful chelae (claws), used for capturing food and defence. The other pereopods are used for locomotion. The abdominal legs (pleopods) are much smaller. The abdomen has special appendages—in females for carrying eggs, and in males for copulation. There are pigment cells (chromatophores, melanophores) on the outer body surface (Jura 2007).

Most decapods are predators or scavengers, but there are also herbivorous species, and some that filter plankton from the water for food. A few have symbiotic relationships with other organisms, are commensal or parasitic.

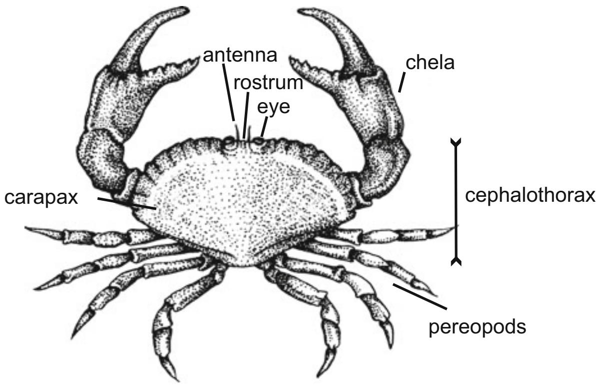


Fig. 9.73 Decapoda—general habitus (Sylwia Aniszewska)

There is distinct sexual dimorphism: males are usually larger than females. Reproducing females carry eggs stuck to their abdominal legs. Most species have larval developmental stages. Decapod fecundity depends on female size and access to food, but also on seasonal changes in temperature and the ability of the animal to adapt to its environment. Growth takes place through a series of moults (Jura 2007; Grabowski 2011; Jażdżewski 1970, 1971).

Decapods are commercially important, and many of them, like shrimps, crabs, lobsters and crayfish, are an irreplaceable component of our diet (Fig. 9.73).

9.6.1 Crangon crangon

Crangon crangon (Linnaeus, 1758)
Synonym—*Crangon vulgaris* (Fabricius, 1798)
Common shrimp, Brown shrimp
Order: Decapoda
Family: Crangonidae

Basic Morphological Features

In the Polish coastal zone, females can grow to lengths of 70 mm and the smaller males to 55 mm (Szaniawska 1991). They are cryptically coloured, that is, they are able to match their colour to that of the substrate on which they happen to be. This is done by means of chromatophores containing black-brown (melanins) and yellow-red (carotenoids) pigments. The body is dorso-ventrally flattened. The well-developed abdomen enables this species to swim well, move over the bottom and burrow into sand (Lloyd and Yonge 1947).

Occurrence
It inhabits offshore sandy and sandy-muddy areas of the Baltic and North Seas, the north and west coasts of Europe and American coastal waters of the North Atlantic (Żmudziński 1967). In the autumn, as temperatures fall, it migrates into deeper waters, and in spring, when the water becomes warmer, it returns to shallower waters (Żmudziński 1961).

Biology and Ecology
It is a marine, euryhaline species, capable of surviving in a wide range of salinity from 5 to 33‰ (Tiews 1970). It is also eurythermic, being tolerant of a wide temperature range from 0 to 30 °C. As it can only live in very well oxygenated waters, it avoids oxygen-deficient areas or where hydrogen sulphide is present (Hagerman and Szaniawska 1989). Under adverse conditions it can switch its metabolism to anaerobic, but only for a very short time: if conditions do not improve, it dies within the hour. It is thus sensitive to environmental pollution. Although it is an omnivore, it prefers food of animal origin (Wiktor et al. 1980). It feeds on small animals, larvae, fish eggs, animal and plant detritus, and is not averse to algae; cannibalism occurs from time to time (Arendarczyk 1974). The dietary composition varies during ontogeny and the annual cycle. It feeds in the evening and at night. It spends the day buried in sand. Only the eyes, the antennules protruding vertically out of the sea bed and the antennae lying flat are visible. It is a dioecious species, with pronounced sexual dimorphism. Females are larger than males, and there are differences in the structures of the antennae and legs and the location of the sexual apertures (Szaniawska 1991). Reproduction lasts from May to the beginning of October. At the beginning of the breeding season the largest females in the population begin breeding, and the smaller ones in subsequent months. Larger females carry more eggs, sometimes as many as 2000. They eat any infertile eggs (Henking 1927). The developmental cycle includes larval stages (Żmudziński 1961).

In the Gulf of Gdańsk this species lives for 2 years (Szaniawska 1991). Common shrimps living in the North Sea reproduce throughout the year and reach a larger body size than those living in the Baltic. This is because of the higher, more favourable salinity of the North Sea and the impoverishment of the Baltic population.

Impact
Common shrimps constitute an important link in the food web, being consumed by such fish as perch *Perca fluviatilis*, small goby *Pomatoschistus minutus*, round goby *Neogobius melanostomus*, shorthorn sculpin *Myoxocephalus scorpius*, European smelt *Osmerus eperlanus* and viviparous eelpout *Zoarces viviparus*. It is also a dietary component of many commercially important fish species, for example, cod *Gadus morrhua,* plaice *Pleuronectes platessa* and turbot *Scophthalmus maximus* (Cięglewicz et al. 1972). It is also an excellent food for farmed fish and is consumed by very many people worldwide. Common shrimps from the Polish coast are not caught: they are too small and there has never been any shrimp-eating tradition among the people of this region (Figs. 9.74 and 9.75).

Fig. 9.74 *Crangon crangon* (Piotr Wysocki)

Fig. 9.75 *Crangon crangon* in sediments (Piotr Wysocki)

9.6.2 *Palaemon adspersus*

Palaemon adspersus Rathke, 1837
Synonym—*Palaemon squilla* (Rathke, 1843)
Baltic prawn
Order: Decapoda
Family: Palaemonidae

Basic Morphological Features

This is a relatively large crustacean, which can attain lengths of up to 80 mm in the Polish zone of the Baltic Sea, though more usually from 36 to 55 mm. Females are larger than males (Dytkowska 1975). The body is laterally flattened and covered with an almost transparent carapace, the front part of which is prolonged into a rostrum. Sometimes it is very beautifully coloured: its chromatophores contain white, blue, red and black pigments. There are black chromatophores on the underside of the rostrum. Its colouration varies depending on the substrate on which it finds itself. Individuals have the ability to regenerate their antennae, maxillipeds, claws on the thoracic legs and telson.

Occurrence

It occurs in the coastal zone of European seas (Schellenberg 1928). It lives in brackish water bays, lagoons and estuaries. It inhabits the Mediterranean Sea, the Sea of Azov, the Caspian Sea, the Aral Sea and practically the entire Baltic Sea (Meyer-Waarden 1935). It lives on sandy and sandy-muddy vegetated bottoms, hence it is often seen in underwater meadows. It spends most of the day hidden among the vegetation. It is omnivorous (Holthuis 1950). It is a very efficient swimmer, moving by thrusts of its abdominal legs. At the same time, it depresses the antennae and thoracic legs against the body and abruptly straightens out its abdomen. In the water, it takes up an upright position. When endangered, it bends the abdomen, thrusts the telson and tail fan against the water and moves forward in a series of jumps. In autumn, as the water cools down, it moves into deeper parts of the sea. In spring, when the water temperature is above 10 °C, it returns to the warmer waters of the coastal zone (Żmudziński 1961; Jensen 1958a, b).

Biology and Ecology

It is a euryhaline species. The lowest salinity in which it has been found, is 6‰, although under experimental conditions it can survive in fresh water for a short period. A eurythermic species, it tolerates a wide range of temperature from 0 to 20 °C (Balss 1926). At salinities above 33‰ (Żmudziński 1961; Berglund and Bengtsson 1981) it can survive at below-zero temperatures. It has high oxygen demands, but under hypoxic conditions it can survive for a brief period by switching from aerobic to anaerobic metabolism (Hagerman and Szaniawska 1989). If the oxygenation remains as low as 20%, it will die very quickly, however. Even though it is omnivorous, it forages mainly at night, consuming algae, small

Fig. 9.76 *Palaemon adspersus* (Piotr Kendzierski)

Fig. 9.77 *Palaemon adspersus* (Piotr Wysocki)

polychaetes, crustaceans, molluscs and detritus. It feeds less often on fish larvae and eggs and the remains of dead fish or other decapods. Cannibalism occurs. The dietary composition varies both during an individual's lifetime and during the year. Sexual maturity is reached in the first year of life. Males use touch and smell to locate females. Breeding takes place from early May to the first days of September.

In spring the biggest females in the population are the first to start breeding. Fertilization is external. Prior to copulation the prawns moult. Females lay from 300 to 2500 eggs. Initially dark green in colour, these later become paler, turning yellow-green and light yellow. After the egg stage, individual development involves five larval stages and one post-larval stage. The larval period lasts 4–5 weeks. The larvae lead planktonic lifestyles in the open waters of the sea. Growth requires a series of moults. They live up to 3 years.

Impact

Like the common shrimp, it plays an important part in the food web and is a food resource for many fish species (Figs. 9.76 and 9.77).

9.6.3 Palaemon elegans

Palaemon elegans Rathke, 1837
Order: Decapoda
Family: Palaemonidae

Basic Morphological Features

The largest specimens recorded in the Polish coastal zone of the Baltic Sea have not exceeded 60 mm in length; most are 35–40 mm long, with females being larger than males. The body is laterally flattened and almost transparent. There are dark yellow-brown stripes on the thorax and abdomen, while the lower part of the rostrum is unpigmented. The second pair of legs has blue or yellow rings. The rostrum is straight or slightly recurved and has 7–9 teeth along its upper edge (Smaldon et al. 1993).

Occurrence

It is widespread in European waters, from the North Sea coasts of Norway to the Mediterranean Sea, Black Sea and Sea of Azov (Grabowski 2011). In the 1950s, the species was introduced to the Aral and Caspian Seas (Zentkevitsch 1963). It was first recorded in the Polish coastal zone of the Baltic Sea in October 2000; by 2002 and 2003 (Kohn and Gosselck 1989; Zettler 2003; Kekkonen 2003) there were considerable numbers of this prawn in the Gulf of Gdańsk (Janas et al. 2004). It also inhabits Puck Bay. It is found swimming, resting on the timber structural elements of piers or in port areas. It has rapidly become the most common prawn species in the Polish coastal zone. When it first made its appearance, there were fears that it might displace the Baltic prawn. Fortunately, these fears turned out to be unfounded and today both species live side by side. Its preferred habitat is a sandy bottom on which algae grow, but it can also be found on bare sandy and rocky sea beds. It often occurs in ports and fishing harbours. It is a highly mobile animal (Dalla Via 1985).

Biology and Ecology

It is a euryhaline species, tolerating a very wide range of salinities from 2.5 to 45‰ (Smaldon et al. 1993). Being a eurythermic species, it can survive in a wide range of temperatures, doing so at high temperatures much more readily than the Baltic prawn. It is not sensitive to oxygen shortages. An omnivore, its diet includes algae, polychaetes, bryozoans, insect larvae, other crustaceans and detritus (Janas and Baranska 2008; Grabowski 2011). Breeding takes place between June and September. During this time, females carry their eggs attached to their swimming legs. Fertility is dependent on ambient conditions such as water temperature or access to food, but also on a female's age. Larger females carry more eggs. Fertilization is external. Sexual maturity is reached in the first year of life (Fincham 1977). They live in the Baltic Sea for up to 3 years.

Impact

It plays an important function in the food web by eating a lot of plant and animal species, while at the same time being a food resource for many fish species, e.g. European eel *Anguilla anguilla,* perch *Perca fluviatilis*, gobies *Pomatoschistus* spp.*,* or viviparous eelpout *Zoarces viviparus.* The planktonic larvae may be consumed by fish fry. By feeding on the parasites of plaice *Pleuronectes platessa* it removes them from the body of the host. Caught in many parts of Europe, it is also eaten by humans (Figs. 9.78, 9.79 and 9.80).

Fig. 9.78 *Palaemon elegans* (Piotr Kendzierski)

Fig. 9.79 *Palaemon elegans* (Piotr Kendzierski)

Fig. 9.80 *Palaemon elegans* (Piotr Wysocki)

9.6.4 Palaemon macrodactylus

Palaemon macrodactylus M. J. Rathbun, 1902
Order: Decapoda
Family: Palaemonidae

Basic Morphological Features

Specimens found in the Wisła Śmiała (southern Baltic Sea) do not exceed a length of 31 mm. In the North Sea they can be as long as 61 mm, and off the coasts of Great Britain they grow to 70 mm long (Janas and Tutak 2014; Ashelby et al. 2004). Individuals from populations outside the species' natural range are smaller than those from its native regions. The body is covered with an almost transparent carapace with random brown maculation. The colouration does not from any recognizable pattern. The legs are fringed yellow. Some individuals have a whitish stripe along the back. The straight, brown-spotted rostrum is armed with 10–11 teeth on its dorsal side and 3–4 teeth on the ventral side. A characteristic feature is the double row of cilia along the ventral margin of the rostrum (Janas and Tutak 2014).

Occurrence

The species is native to the waters of the Far East, i.e. Korea, China, Japan (Newman 1963) and the east coast of Russia. In the 1950s it turned up in many water bodies in different parts of the globe. In 1957 it was found outside its natural range for the first time, in San Francisco Bay. In the 1970s it was first recorded in Australian waters (Newman 1963; Ashelby et al. 2013). Since 1992 it has inhabited Atlantic and North Sea coasts of the UK, Spain, France, Belgium and the Netherlands (Gonzales-Ortegon et al. 2006; Ashelby et al. 2013). In 2002 it appeared for the first time in the Black Sea, and then in 2005, in the Mediterranean Sea, off the coast of Mallorca. The first specimens in the Baltic Sea were observed in the summer of 2014, in the Wisła Śmiała (a short branch of the River Vistula near its mouth) (Janas and Tutak 2014). One of the most commonly reported aquatic alien species, it presumably reached European waters in the ballast water of ships. Often, though, new colonizations take the form of secondary introductions. It could have reached the Baltic in ballast waters, but also under its own propulsion from the North Sea.

Biology and Ecology

This species is tolerant towards a very broad range of environmental changes (Gonzales-Ortegon et al. 2006). It can survive in salinities from almost fresh water (1‰) to 33‰ and over a wide range of ambient temperatures, though avoiding excessively warm waters (Beguer et al. 2011). It is assumed that temperature is a major factor regulating the colonization of new regions. It is resistant to oxygen deficiencies. In many regions, this species reproduces during summer. Fertility is affected by photoperiod. Females begin breeding in the first year of life. A single female can carry about 1000 eggs. Mature females produce between

500 and 2800 eggs. Each age group produces at least two cohorts during a year, and in laboratory conditions as many as 5. The growth rate is very fast. Individuals can be sexed only after they have reached a length of 20 mm. Females grow faster and attain larger sizes than males. This species bears symbiotic bacteria Alteromonas sp., which protect the eggs against fungi. These bacteria have been found only in Palaemon species. It is resistant to a viral disease (WSSV) causing white spots on the animal's body. The larvae are tolerant to environmental changes and they are presumably moved from place to place in ships' ballast waters. They exhibit positive phototaxis, which is why they react to ships' lights and can get into a lighted ship at night. It is an omnivorous species, but 75–95% of its food consists of animals. Under stress conditions, such as large aggregations, cannibalism occurs. Being a pollution resistant species, it can survive in contaminated port waters. All these features have enabled it to successfully colonize new water bodies, to a greater extend than other Palaemon species.

Impact

It plays an important function in the food web, feeding on small crustaceans such as mysids, copepods, amphipods and polychaetes, and also fish larvae (Sitts and Knight 1979). It is in turn eaten by fish and birds. In some areas, it is one of the hosts of the parasite *Odhneria* sp., but does not transfer it to native species. In the areas it inhabits, it has a negative impact on a number of native shrimp species, replacing them in the food web. It can also adversely affect other native species. It has the potential to hybridize with native species, thereby altering the latter's gene pool. At the same time, it can provide additional food for fish and be an indicator of environmental changes (Janas and Tutak 2014) (Figs. 9.81 and 9.82).

Fig. 9.81 *Palaemon macrodactylus* (Piotr Kendzierski)

Fig. 9.82 *Palaemon macrodactylus* (Piotr Kendzierski)

9.6.5 Palaemonetes varians

Palaemonetes varians (Leach, 1813)
Common ditch shrimp
Order: Decapoda
Family: Palaemonidae

Basic Morphological Features
It grows to a length of 50 mm. It is almost transparent, colourless, but with brown mottling. The colouration depends on the background substrate.

Occurrence
It is common in coastal areas of northern and western Europe, from Norway (Dolmen 1997), Scotland and Portugal (Neves 1973) to the Mediterranean Sea, where it inhabits the coasts of Spain and Morocco. It is found in saline waters, tolerating a wide range of salinity (Hagerman and Uglow 1983). It occurs in beech pools, lagoons and bays (Rasmussen 1973). The waters inhabited range from stagnant to rough, with distinct seasonal changes in temperature and salinity. In the Baltic Sea, it is present in many coastal bays in Germany, for example, the Bay of Mecklenburg. It occurs in the Martwa Wisła (Dead Vistula) and the Gulf of Gdańsk (Żmudziński 1961).

Fig. 9.83 *Palaemonetes varians* (Arkadiusz Janas)

Biology and Ecology

It is a typical brackish-water, euryhaline species tolerating salinities from 2 to 45‰. However, it is most frequently recorded in salinities of about 3–5‰ (Dolmen et al. 2004). It does not occur in fresh water. It is a eurythermic species. It is more resistant to oxygen deficiencies than other species of Baltic shrimps (Nielsen and Hagerman 1998; Hagerman and Uglow 1984). It is an omnivore, so its diet consists of both plants and small animals (Escaravage and Castel 1990). It becomes particularly active at dusk when it forages most intensively, although it may also feed during the day (Hagerman and Ostrup 1980).

Impact

It plays a very important role in the food web, being the food of many species of both farmed and wild fish species (Fig. 9.83).

9.6.6 *Rhithropanopeus harrisii*

Rhithropanopeus harrisii (Gould, 1841)
Harris mud crab, Dwarf crab
Order: Decapoda
Family: Xanthidae

Basic Morphological Features

This is a small crab, the carapace width not usually exceeding 20 mm. Its long legs give the impression that it is much bigger. It has a patchy, dark brown colour. The carapace is wider than long, almost oval in shape. It is often covered with sedentary species such as barnacles. The lateral teeth of the carapace are weakly developed and blunt. The leading edge is almost flat and divided down the middle by a shallow furrow. The black eyes are stalked. Relative to the carapace the claws appear to be very powerful and are used for crushing and shredding food. It has the ability to regenerate lost limbs. Loss of the right claw reverses the "handedness" so that the left one becomes the major one: in this way the crab becomes left-handed. The crabs are not hirsute (Ryan 1956).

Occurrence

It originates from brackish coastal waters of North America (Williams 1984). It reached European waters in the ballast waters of ships (Maitland 1874). Because of the slight morphological differences between the crabs occurring in American waters and those found in Europe, the latter were named *Rhithropanopeus harrisii tridentatus* Maitland. It first turned up in European waters in 1874, on the Dutch coast. In the 1930s it was found in the coastal zones of the North Sea, Black Sea, Caspian Sea and Sea of Azov (Szudarski 1963; Kohn and Gosselck 1989; Adema 1991; Hayward and Ryland 1995; Eno et al. 1997; Galil et al. 2002). It was first recorded on the Polish Baltic coast in the 1950s, in the Vistula Lagoon (Demel 1953; Nikolaev 1955). In recent years it has colonized the Gulf of Gdańsk, Puck Bay and the Szczecin Lagoon (Szudarski 1963; Jażdżewski and Konopacka 1993, 2000). Today it is quite common in the Dead Vistula and the Vistula Lagoon. It is regarded as an alien species in 21 countries.

Biology and Ecology

It prefers a muddy or muddy-sandy vegetated bottom, or one covered with fallen branches and other remains of plants and animals. It is also itself a substrate for many representatives of epibiotic flora and fauna. It is eurytopic, euryhaline and eurythermic. As such, it tolerates a very wide range of salinity, from 0.5 to 38‰ (Grabowski 2011), and likewise, a broad range of temperatures, from 0 to 34 °C. It is resistant to oxygen shortages, being capable of surviving for more than a day in anoxic conditions in that it switches to anaerobic metabolism. It is highly resistant to environmental pollution. During the day, it remains buried in the sediments, but after dusk it becomes active and goes in search of food. It feeds on the remains of dead plants and animals, small invertebrates, and even detritus (Turoboyski 1973). During moulting, cannibalism can take place. It uses chemoreceptors to find food, but also to locate other individuals of the same species. It appears to be able to distinguish colours, showing the greatest preference for black, then yellow and green. It is dioecious, and sexual dimorphism is very pronounced. The abdomen of the female consists of seven segments and is much broader than the that of the male. Beneath the female abdomen there are four pairs of pleopods and the sexual apertures. The male abdomen has only five segments and the copulatory organ has evolved from two pairs of pleopods. Immediately after moulting copulation

Fig. 9.84 *Rhithropanopeus harrisii* (Piotr Kendzierski)

Fig. 9.85 *Rhithropanopeus harrisii* (Piotr Kendzierski)

occurs, after which the female buries herself in the sediments. In Polish coastal waters females lay up to 1500 eggs, which are purple-red or yellowish-red in colour, depending on the developmental phase. Egg development takes about 50 days. The animal's life cycle includes larval stages (Grabowski 2011).

Fig. 9.86 *Rhithropanopeus harrisii* (Piotr Wysocki)

Impact

In the food web it competes effectively with other species for food. It is itself an important food resource e.g. for European eel *Anguilla anguilla,* flounder *Platichthys flesus,* gobies *Pomatoschistus* spp., viviparous eelpout *Zoarces viviparus* and cormorant *Phalacrocorax carbo* (Grabowski 2011) (Fig. 9.84, 9.85 and 9.86).

9.6.7 Eriocheir sinensis

Eriocheir sinensis H. Milne-Edwards, 1853
Chinese mitten crab, Shanghai hairy crab
Order: Decapoda
Family: Grapsidae

Basic Morphological Features

This is one of the largest crustaceans inhabiting the Polish coastal waters of the Baltic Sea. The carapace in the biggest individuals can be as wide as 90 mm (Normant et al. 2000) and its wet weight almost 300 g. It is brown in colour. It has a pair of symmetrical claws, which are characterized by dense patches of setae (Grabowski 2011). The two middle pairs of the four pairs of pereopods are twice as long as the carapace. The first three pairs of legs are setose on the outer side. Under stress, an individual may discard one of its legs; a new, though smaller, one subsequently grows in its place.

Occurrence

As its English name implies, this species originates from Chinese waters. It probably reached European waters in the ballast water of ships sailing between Europe and China. The first specimens were caught in German freshwaters in 1912 (Panning 1939). By means of the dense network of rivers and canals, it readily spread and colonized other European waters. After half a century or so, its range of distribution included practically all of Europe. It was first found in Polish waters in 1928 in the Szczecin Lagoon (Kulmatycki 1928). Today, it is still found there and in the nearby Lake Dąbie, and also in the Gulf of Gdańsk and Puck Bay (Normant et al. 2002).

Biology and Ecology

Although the Chinese mitten crab tolerates a wide range of salinity, for breeding it requires a certain range of high water salinities. It also tolerates a wide range of ambient temperatures, though preferring warmer water. It is an omnivorous species, but the dietary composition changes during an individual's lifetime. The young crabs feed primarily on plants, whereas adults consume invertebrates and even small fish (Thiel 1938; Tan 1984). There is pronounced sexual dimorphism. Males have much larger and more powerful chelae (claws), but the most obvious differences are in the shape of the abdomens: the male abdomen is rounded, while the female one is bell-shaped. It is a catadromous species, that is to say, individual animals spend most of their lives in fresh water, but reproducing only in sea waters of salinity above 25‰. The salinity of Polish Baltic waters is lower, which is why this species does not reproduce here. "Our" Chinese mitten crabs breed in the fully saline North Sea. Females can carry up to one million eggs, from which larvae subsequently hatch (Anger 1991; Cohen and Carlton 1995). After reproduction males and females move into shallower sea areas, where they die. Growth takes place through a series of moults. Because of their origin, these crabs require positive environmental temperatures from 7 to 30 °C for breeding.

Impact

Wherever it appears, it successfully competes for food with other species, such as crayfish. It may exert a negative impact on commercial fishing, as it feeds on fish eggs, attacks and consumes fish caught in nets and damages fishing gear (Panning 1939; Ingle 1986). It often rips up vegetation growing on the bottom of a water body, making it difficult for many fish species to lay their eggs. The setae on the claws trap various plant and animal species (nematodes, snails, oligochaetes, mussels and crustaceans), carrying them to new areas which they then colonize (Normant et al. 2007). It is eaten by many species of fish, for example, Wels catfish *Silurus glanis* and some birds, such as black-throated diver *Gavia arctica* and grey heron *Ardea cinerea*. In the seas surrounding Asia it may be the host of the parasite *Paragonium westermani*, which is a threat to human health (Ingle 1986). In some countries, the Chinese mitten crab is a delicacy, especially in Asian cuisine

Fig. 9.87 *Eriocheir sinensis* (Piotr Wysocki)

Fig. 9.88 *Eriocheir sinensis* (M. Jakubowska)

Fig. 9.89 *Eriocheir sinensis* chela (M. Jakubowska)

(Normant et al. 2002). It has been classified as one of the hundred most dangerous invasive species in the world. Combating it involves, among other things, catching it in traps. Its distribution is expected to expand (Figs. 9.87, 9.88 and 9.89).

9.6.8 Carcinus maenas

Carcinus maenas (Linnaeus, 1758)
Green crab
Order: Decapoda
Family: Portunidae

Basic Morphological Features
Adults of this medium-sized crab are 60 mm long and 90 mm wide. The bumpy, wide carapace is therefore broader than long, and has five characteristic teeth on both sides of the front rim. There are three undulations between the eyes. The pereopods are adapted for swimming. The upper parts of the carapace are coloured dark brown or dark green, with small yellow spots, whereas its inner part can take a

variety of colours, from green or yellow to red and even orange; which colour probably depends on the length of time between moults.

Occurrence

The original distribution range of this crab covers the coastal zone and estuaries of Europe and North Africa. Nowadays, it inhabits the Atlantic and Pacific coasts of North and South Americas, southern Africa, Australia and Asia (Fulton and Grant 1900). It occurs in the Baltic Sea, e.g. the Gulf of Gdańsk. These crabs often reach new areas in ships' ballast waters, together with species intended for fish-farming feedstuffs or with fishing gear, rapidly colonizing them. However, in their native environment they move no further than a few kilometres a year. The green crab is considered a model invasive species. It colonizes a variety of environments. It lives on both soft and hard substrates: it is found on rocky coasts and vegetated sea beds, also on muddy and sandy bottoms (Grosholz and Ruiz 1996; LeRoux et al. 1990; Cohen et al. 1995). It is most often found near the sea shore, to depths of 5 m, but it has been caught at 60 m. It undergoes daily and seasonal migrations. In tidal areas it migrates into the deeper waters at low tide. In winter, it moves into deeper, warmer areas of the water body and burrows into the bottom sediments.

Biology and Ecology

A euryhaline species, adults tolerate salinities from 4 to 52‰, but the optimal salinity for its life processes is 10–30‰. The larvae are much less resistant to salinity decreases than adults. Complete larval development takes place at salinities above 20‰, so it does not reproduce along the Polish coast of the Baltic Sea. It is a eurythermic species (Behrens Yamada 2001): adults can survive at temperatures from 0 to 35 °C, though they prefer the 3–26 °C temperature range. When the water temperature drops below 10 °C, the animals stop growing, because moulting ceases. They can live at low temperatures (to −2 °C) by raising the concentrations of body fluids. Below 6 °C the crab consumes much less food. Temperature also affects breeding: above 26 °C the animals stop reproducing. The crab is resistant to hypoxia, but its defensive capabilities are much decreased under such conditions. Outside the aquatic environment, it switches to anaerobic metabolism and can then survive for up to 5 days. It is highly resistant to environmental pollution. It is omnivorous, its diet consisting of mussels, snails, oligochaetes, crustaceans, protozoa and algae (which sometimes constitute up to 306 of the total diet). It is a highly fecund species. A male finds a female as a result of the pheromones she releases before moulting. A male will carry a female for a dozen days or more before copulation, waiting until she moults. Then he deposits his spermatophores on the female, which can remain in place for a few months to a year. Females reproduce twice a year. At any one time a female can produce about 185 thousand eggs. Reproduction is complex and the developmental cycle involves a larval stage. These crabs can reproduce many times during their lifetimes. In fully saline seas there may be as many as 150 larvae per cubic metre of water. It does not breed in the Polish waters of the Baltic because the salinity there is too low. This crab is one of the most successful invasive species, because of its high fecundity, its ability to spread rapidly, fast growth, exceptional adaptive abilities, tolerance to temperature and salinity changes, very broad dietary spectrum, and in many areas the lack of natural enemies such as parasites. It successfully competes with native species. It is classified as an ecosystem engineer, that is, a species that actively modifies its environment.

Fig. 9.90 *Carcinus maenas* (Piotr Wysocki)

Fig. 9.91 *Carcinus maenas* (Piotr Wysocki)

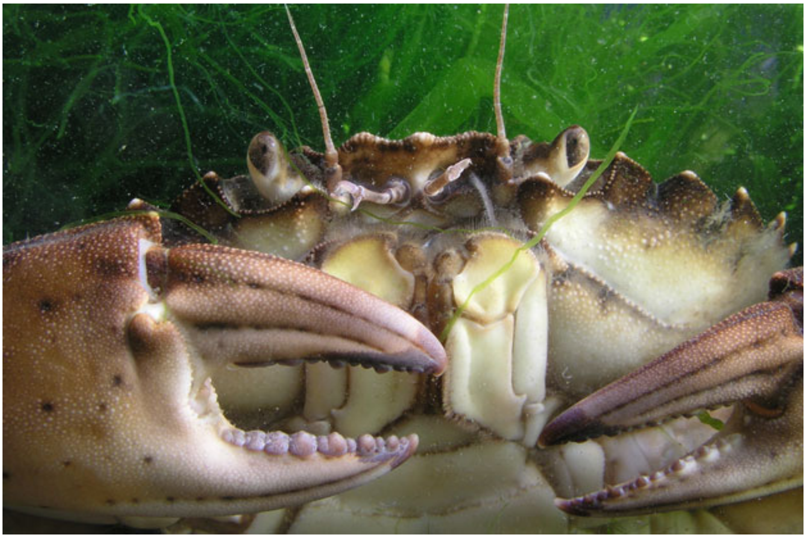


Fig. 9.92 *Carcinus maenas* (Piotr Wysocki)

Impact
It plays an important function in the environment. The crab's early developmental stages are a source of food for many other crustaceans, for example *Crangon crangon* and *Palaemon elegans*, while mature individuals are eaten by other crabs, and some species of fish, birds and seals. For many years, it has been caught for human consumption in Europe, especially in Portugal, Spain and France, where a few hundred tons are sold annually. Elsewhere in the world, it is fished in much smaller quantities (Figs. 9.90, 9.91 and 9.92).

9.6.9 *Orconectes limosus*

Orconectes limosus (Rafinesque, 1817)
Spinycheek crayfish
Order: Decapoda
Family: Cambaridae

Basic Morphological Features
This crayfish was previously known as *Astacus limosus* (Rafinesque), *Astacus affinis* (Say), *Cambarus affinis* (Schellenberg) and *Cambarus limosus* (Schindewolf). Specimens grow to lengths of 130 mm, with females being smaller

than males. The body is covered with a chitinous carapace of an uneven brown or yellowish-grey colour. There are reddish-brown streaks on each abdominal segment. The carapace extends into a rostrum, with the eyes on either side (Stańczykowska 1986). The head also bears two pairs of antennae and the mouthparts. The thorax has five pairs of pereopods. The first pair terminates in claws, which are much smaller than those of native crayfish. The tips of the claws are yellow-orange with a black rim. The carapace has numerous spines along the depression separating the head from the thorax. There are also tufts of spines on the sides of the head, hence the English name of this crayfish. The abdominal segments are free; each bears a pair of pleopods. The abdomen terminates in a fan-shaped, five-plated telson.

Occurrence

In 1880, the German ichthyologist Max von den Borne imported one hundred individuals from North America for farming purposes (Pavlovic et al. 2006). The animals were released in fishponds in the area around today's Myslibórz in Western Pomerania. Later, further introductions were made in Poland (Krzywosz 2004; Leńkowa 1962), Germany and France (Machino and Holdich 2006), since when this crayfish has colonized most European fresh water bodies (Lodge et al. 2000). There are also populations in African waters. It also inhabits the Szczecin and Vistula Lagoons, as well as lakes and river mouths along the Polish coast (Krzywosz et al. 2014). Adults can also be found elsewhere in Baltic coastal waters (Jaszczołt 2013; Jaszczołt and Szaniawska 2011).

Biology and Ecology

It is active both during the day and at night, which distinguishes it from our native crayfish, which are active mainly after dusk. When endangered it adopts a defensive position. When escaping from danger, the crayfish moves backwards, although then it loses its balance very quickly and falls on its side. When removed from the water it crosses its dangling claws and tucks its abdomen tightly under the thorax. It can remain in this position for a relatively long time. It is a fresh water species, which is capable of adapting to a variety of environmental conditions, as a result of which it inhabits waters in which no native crayfish occur (Strużyński 1994; Wiktor 1955).

It can live in eutrophic, polluted, as well as clean, oligotrophic waters. These can be either standing or flowing, with various types of sediments. It is also come across in drainage ponds and power station waters. It occurs in salinities of 5–10‰ (Żmudziński 1961). It does not build shelters, but uses natural concealment to hide from predators. In summer, it inhabits the coastal zone, migrating into deeper waters as temperatures fall in the autumn. A eurythermic species, it can survive at both high and low ambient temperatures (Krzywosz et al. 2014). It is also very resistant to oxygen deficiencies: it can survive in waters containing barely 40% dissolved oxygen (Stańczykowska 1986). It is not very sensitive to pollution. It is omnivorous: about 75% of its food consists of plants, the remainder being oligochaetes and molluscs. The dietary composition depends on age, season and habitat (Strużyński 1994). It is dioecious, with distinct sexual dimorphism. Females are smaller, have smaller claws and differ in their leg structure. They have wider abdomens, giving better protection to eggs and hatchlings. They lay up to 400 eggs. Mature females begin breeding in autumn. During courtship, the male touches an encountered female with his claws and antennae, the female responding by extending her claws forwards (Mastyński 1999; Strużyński 1994). Growth takes place via a series of moults. The spinycheek crayfish has a lifespan of 4–5 years. Owing to its considerable flexibility and resistance to many different environmental factors, it spreads easily, threatening native species. It is a significant component of the food web (Śmietana 2011, 2013).

Impact

It is a source of food for fish: perch *Perca fluviatilis,* pike *Esox Lucius,* European eel *Anguilla anguilla,* Wels catfish *Silurus glanis* and burbot *Lota lota*. Caught by fishermen and anglers, it is a luxury delicacy in many cuisines (Holdich and Lowery 1988). It is not a protected species. In some water bodies it has been seen to consume fish roe. In North American waters it is displacing *Orconectes viridis*. It is also a threat to the biodiversity of Europe, where it is effectively displacing the native crayfish *Astacus astacus* and *Pontoastacus leptodactylus* (Mastyński 1999). It is a food source for the American mink *Mustela vison* and the otter *Lutra lutra*. It is a carrier of crayfish plague, caused by the fungus *Aphanomyces astacii*. Despite the many attempts to eradicate it, for example, with the aid of pesticides, its further expansion is to be expected (Figs. 9.93, 9.94 and 9.95).

Fig. 9.93 *Orconectes limosus* (Piotr Wysocki)

Fig. 9.94 *Orconectes limosus* (Tomasz Szyszko)

Fig. 9.95 *Orconectes limosus* (Joanna Jaszczołt)

9.6.10 *Pacifastacus leniusculus* (Dana, 1852)

Signal crayfish
Order: Decapoda
Family: Cambaridae

Basic Morphological Features
This is a large crayfish, growing to lengths of 160 mm, and in some cases to 210 mm (Śmietana 2011). In Polish lakes most females are about 145 mm long and weigh 92 mg; the corresponding figures for males are 148 mm and 96 mg. The carapace has no spines. The rostrum is sharp, becoming suddenly narrower about halfway along its length. Behind the eyes, there are two pairs of antennae. The first pair is elongated, ending in a spine, the second is nodular in shape. The claws are massive, with tiny pits. The inner edges of the chelae (claws) are not adjacent to each other: this is due to two protuberances on the fixed inner edge at 1/4 and 3/4 of its length, and one protuberance on the inner moveable part at 1/3 of its length. The upper surface of the carapace is dark greenish-brown, with a dark-red tinge. The ventral surface is dark grey. The lower surface of the claws may be different shades of red. Characteristic of this species are the white patches near the claw hinge, like the white flags that signalmen used for directing trains—hence the English name (Śmietana 2011; Mastyński and Andrzejewski 2001).

Occurrence
This species is alien to European waters. It originates from coastal fresh water bodies in Oregon and Washington in the western U.S.A (Lewis 2002; Mason 1977). The first specimens were introduced to Europe in 1960, being taken from California (USA) to Sweden for breeding purposes. At that time, it was decided to introduce signal crayfish to the lakes of southern Sweden, where it established populations (Śmietana and Strużyński 1996). This successful introduction was the reason for further introductions to Finland, England, Iceland, Switzerland, Germany, Austria, Italy, France, Luxembourg, the Netherlands, Yugoslavia, Bulgaria, Lithuania, the Czech Republic, Norway and Cyprus (Holdich 2002). To Poland, the first 1000 individuals of this species were imported in 1971, from Simontorp in Sweden. By 1977 approximately 29,000 signal crayfish had been imported to Poland. A further import of these crayfish took place in 1991–1992. It was first found in the Baltic in the Gulf of Bothnia (Anonymous 1999). In the Polish waters it has been observed to migrate seawards. It does not suffer from the crayfish plague caused by fungus *Aphanomyces astaci* but is capable of transmitting its spores (Śmietana 2011). It occurs in all kinds of water bodies, being found in large lakes and ponds, rivers and small streams from the coast to sub-alpine areas. It can dig burrows (Guan 1994), so it inhabits hard bottoms, but also localities where it can find natural shelters; it is often responsible for damaging the shore structure. As it can climb up the banks of a

water body, it easily escapes even from an isolated one. It feels equally at home on land and can migrate for long distances in search of a water body. The rate of migration is estimated at about 1 km per year.

Biology and Ecology

Like other crayfish, it is a fresh water species. However, adult specimens can tolerate salinities of 21‰ (Holdich et al. 1997). It is resistant to high water temperatures: 33 °C (Rutledge and Pritchard 1981) is the highest temperature at which it has been reported to survive. Unlike other alien crayfish, it is not very resistant to oxygen deficits. It is omnivorous, feeding on small invertebrates, fish and their roe, plants and detritus. Sometimes it turns cannibal. Sexual dimorphism is distinct, with males generally being larger than females. In females the abdomen to overall length ratio is about 50%, in males 48%. In addition, the outside edge of the immobile part of the claw is curved. Sexual maturity is achieved in the second or third year, when females reach a length of 60–90 mm. Breeding takes place once a year, beginning in late September, and eggs are laid in October. A female carries about 540 eggs (McGriff 1983). The larger the female, the more eggs she carries. Hatching depends on the water temperature and in many water bodies takes place from March to July; in Poland this occurs from May to mid-June. The growth rate is faster than that of native crayfish. Early maturation means that individual females carry more eggs and produce more young crayfish than native species. Signal crayfish grow faster in recently colonized water bodies that in those waters they have inhabited for generations. The moulting frequency is the same in juveniles as in males and females. On reaching maturity, the females moult frequency depends on her reproductive capacity, since ovigerous females do not moult. At this time, they devote more energy to reproduction than to processes associated with weight gain. Males moult more often than females, and after moulting they grow faster, thereby attaining a larger body size. In older individuals, the moulting frequency is lower (Śmietana 2011). Reproducing females conceal themselves in bottom sediments and are less likely to go hunting, which can also affect their size. The species is long-lived, with a potential lifespan of up to 20 years, but this happens very rarely. Because of its large size, aggressiveness and other characteristics such as the wide range of food it consumes (Mamot et al. 1978), its high reproductive capacity, and faster growth rate and maturation than in the case of the native crayfish, as well as its ability to move over land, in Europe it is considered a highly invasive species (Śmietana 2011).

Impact

In freshly colonized areas it causes changes in natural habitats. Its most dangerous aspect is that it displaces native species of crayfish and transmits crayfish plague to them (Saderback 1993). Like other species of crayfish, it is important in the trophic web, feeding on macroalgae, aquatic insects, molluscs, demersal fish and amphibian larvae (Mamot et al. 1978; Mason 1975). It is eaten by birds, predatory mammals and some fish such as rainbow trout *Oncorhynchus mykiss*, perch *Perca fluviatilis* and European eel *Anguilla anguilla*. In coastal areas, it is also consumed by herring gulls *Larus argentatus*. By feeding on detritus it accelerates the degradation and mineralization of dead organic matter (Lewis 2002). Moreover, by burrowing into the sediments it changes their structure, so it is often classified as an ecosystem engineer. Because of its delicious taste and nutritious value, Europeans enthusiastically embraced its cultivation in the 1970s. However, this enthusiasm waned visibly, once it was realized what damage it was causing to the environment.

Fig. 9.96 *Pacifastacus leniusculus* (Piotr Kendzierski)

Fig. 9.97 *Pacifastacus leniusculus* (Piotr Kendzierski)

Fig. 9.98 *Pacifastacus leniusculus* (Piotr Kendzierski)

Even so, a few hundred tons of signal crayfish are harvested per year in Europe (Holdich 2002). Indeed, as many as 1200 tons were caught in Sweden in 2001 (Figs. 9.96, 9.97 and 9.98).

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Chapter 10
Non-native Crustaceans

The ubiquitous process of globalization is reflected in and affects not only the human economy, but has also given rise to unprecedented environmental changes. The appearance of alien crustaceans is a phenomenon that is very hard to define unequivocally. Newly colonized areas are often inhabited by just a small number of native species, which are susceptible to the effects of human activities. Among invertebrates it is crustaceans that most frequently colonize new water bodies; indeed, freshwater crustaceans are thought to be the most effective invasive non-native species. Species new to the Baltic are often given the negative prefix "xeno" (from the Greek: xenon—foreign), as disruptors of life in that sea. While it is true that most non-indigenous crustaceans have an adverse impact on the newly-colonized environment and that their colonization is invasive, some of them eventually become a regular feature of the ecosystem and an important element of the food web, while others are economically important but with a potential yet to be fully realised. Most new crustacean species are not limited to a specific region but spread very quickly and inhabit further water bodies.

The Baltic Sea is more often colonized by marine crustaceans than by fresh water ones. The connection of the Baltic with the North Sea allows crustaceans to penetrate from adjacent, fully saline seas (e.g. *Palaemon elegans* or *Carcinus maenas*). Others, such as *Gammarus tigrinus* and *Rhithropanopeus harrisii* from the coasts of North America and *Eriocheir sinensis* from Chinese waters got into European waters via ships' ballast waters. *Palaemon macrodactylus* may well have reached the Baltic Sea from the North Sea under its own propulsion, but it could also have got there in ballast waters. Several amphipod species, for example, *Obesogammarus crassus*, *Chaetogammarus ischnus*, *Dikerogammarus haemobaphes* and *D. villosus*, reached the Baltic from the Ponto-Caspian area along rivers and canals. On the other hand, *Hemimysis anomala* owes its secondary spread to sea currents. Floating algal mats may facilitate the movements of crustaceans, some species may be carried by birds, and anglers using crustaceans as bait may disperse them to other localities: this is how *Orconectes limosus* came to expand its range. In addition, just a slight increase in the salinity of inland

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watercourses, as a consequence of the expansion of industry and agriculture, or the discharge into them of urban waste waters, help alien species to spread. The largest number of non-native crustaceans occur in the coastal zone of the Baltic Sea, in its river mouths, bays and lagoons. Most of them come from regions subject to a wide range of environmental changes, similar to those in the waters they have recently colonized.

Crustaceans are able to colonize new water bodies primarily because of their great physiological flexibility. These species are usually eurytopic, broadly tolerant to environmental factors, principally salinity and temperature. They are omnivorous, with high levels of fertility and resistance to contamination. In addition, they owe their success to the lack of natural enemies in the freshly-inhabited areas. In order to colonize the Baltic Sea, crustaceans have to overcome a salinity barrier, the major limiting factor. There are crustaceans, e.g. amphipods, that populated the Baltic Sea several decades ago and whose energy expenditure is still greater than that of species of the same genus but resident in the Baltic for much longer. Other crustaceans inhabiting brackish waters with minimal salinity fluctuations lose their ability to tolerate salinity changes. The main problem faced by these new species is their ability to osmoregulate and to respond to changing ionic ratios in the water. For example, because of the salinity barrier only adult specimens of alien crayfish *O. limosus* and *Pacifastacus leniusculus* are found in the coastal zone of the sea. Some marine crustaceans, such as *E. sinensis*, reproduce in the Baltic Sea only where the salinity is greater than 20‰ (Figs. 10.1 and 10.2).

The direct impact of alien species on biodiversity and the displacement of native species are the most dangerous aspects of such invasions. *Gammarus tigrinus* has gradually replaced the native gammarids *G. duebeni* and *G. zaddachi* and the fresh

Fig. 10.1 *Pacifastacus leniusculus*—a food item of herring gulls *Larus argentatus* (M. Skóra)

Fig. 10.2 *Gammarus tigrinus*—an alien species in the Baltic Sea (Piotr Wysocki)

water *G. pulex*. The American crayfish *O. limosus* and *P. leniusculus* have effectively displaced the native crayfish species *Astacus astacus* and *A. leptodactylus*. *Pontogammarus robustoides* competes with native amphipod species. *Palaemon elegans* may be displacing *P. adspersus*. There is also the possibility of alien crustaceans interbreeding with native species. Alien species enter the food web of the newly colonized water body, feeding on native species and thereby eliminating them, but at the same time competing with them for food. For example, in regions where *E. sinensis* has appeared, there has been a reduction in the number of smaller invertebrates that serve as food for native species that are often of economic importance. Moreover, the role of non-native species in the transmission of their non-indigenous parasites and pathogenic organisms should not be underestimated. Both alien American crayfish species—*O. limosus* and *P. leniusculus*—are carriers of the crayfish plague caused by the fungus *Aphanomyces astaci*. This has no effect on the non-native crayfish but is lethal to entire populations of native European crayfish species like *A. astacus* and *A. leptodactylus*. The Chinese mitten crab *E. sinensis* is the indirect host of the parasite *Paragonimus westermani*, the final host of which can be human. The parasite infects human lungs and causes a disease called paragonimiasis. Consumption of undercooked or raw crab meat may cause the parasite to be transferred to the body of the host. The Ponto-Caspian *P. robustoides* transfers microsporidia. *E. sinensis* is known to have damaged fishing gear in order to get at fish caught in the nets, after which the crabs mutilated the fish, rendering their commercial value minimal. In order to hide from predators and to prevent their drying out, these crabs dig burrows tens of centimetres deep, which weakens sediment stability and accelerates erosion. The Ponto-Caspian species *Ch. ischnus*, *O. crassus* and *D. haemobaphes* are considered to be neutral with respect to the environment (Figs. 10.3 and 10.4).

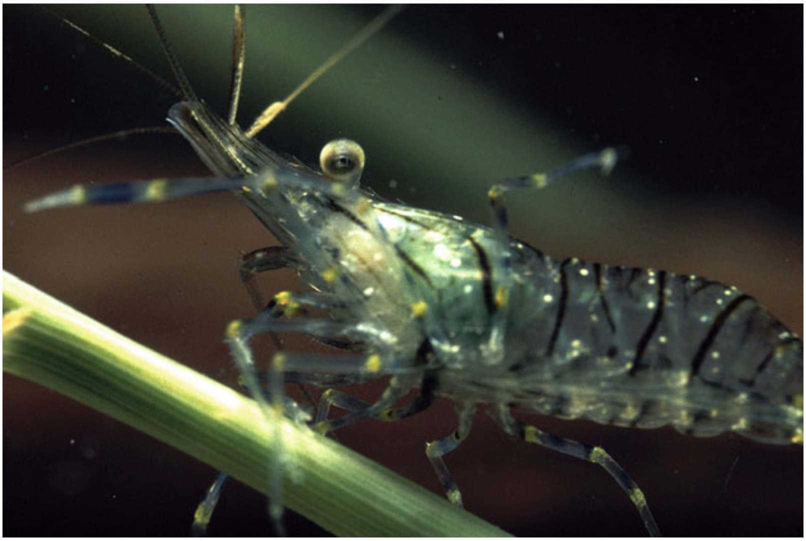

Fig. 10.3 *Palaemon elegans*—an alien species in the Baltic Sea (J. Samsel)

Fig. 10.4 *Rhithropanopeus harrisii*—an alien species in the Baltic Sea (Piotr Kendzierski)

On the other hand, a number of non-indigenous crustaceans may provide an opportunity for the economy and the region in which they appear. Some species, like *P. robustoides*, *D. villosus* and *D. haemobaphes*, were deliberately imported into European waters in order to enhance the food resources of commercially valuable fish. *P. robustoides* is an important component of fish food for gobies

Gobiidae and perch *Percidae*. *E. sinensis*, *G. tigrinus* and *P. macrodactylus* are used as food for farmed commercial fish species. The crayfish *P. leniusculus* and *O. limosus* are caught and sold for human consumption. In Germany, the Chinese mitten crab *E. sinensis* is regarded as a delicacy because of its nutritional value and exquisite taste. It is also used as a feedstuff for other animals and even as a fertilizer. Crabs are known to be ecosystem engineers, which actively modify their habitats. In their hairy claws, they carry certain species of *Nematoda, Bivalvia, Crustacea* (*Harpacticoida*, *Amphipoda*), *Oligochaeta*, *Gastropoda* and *Bryozoa*. Crab claws may carry other organisms, like *Arachnida*, *Insecta*, *Ostracoda* and *Mollusca*. The epibiotic ciliate of the genus *Folliculina* was found on the carapace of *O. limosus*. Some invasive crustaceans, for example, *P. macrodactylus*, are environmental bioindicators. Most crustaceans are beautiful animals, so they can be an inspiration to painters and poets, and larger crustaceans like crabs, crayfish or shrimps are highly decorative.

The Baltic Sea is not very resistant to colonization by non-native crustaceans. Maybe this is because it is a young sea, a difficult environment for many species, in which there are still free ecological niches and habitats waiting to be occupied. The crustaceans that have got into the Baltic Sea by various means have formed their own populations. We know that not all alien crustacean species cause a decrease in native species diversity; on the contrary, some of them enhance it. Therefore, the role and significance of each newly appearing species in the Baltic should be examined on its own merits.

Chapter 11
Function and Importance of Crustaceans

Crustaceans play an important role in the food web, as they are an important link between benthic and pelagic organisms, fish and birds. They are themselves an important dietary component of other invertebrates and for many commercial fish species, such as cod and herring, as well as for those that play a lesser role in the economy. Most are omnivorous, with a broad spectrum of food preferences, thereby contributing to the structure of the ecosystem. Some choose plant food, others are predators, and some are even cannibals. *Saduria entomon*, *Dikerogammarus haemobaphes* and *Rhithropanopeus harrisii* feed on the remains of dead organisms, remove them from the bottom of the water body, thus contributing to the breakdown of organic matter and accelerating mineralization. Species of the genus *Gammarus*, such as *G. salinus*, cleanse coastal waters. Some shrimps are used as food for farmed fish. *Crangon crangon* and *Palaemon elegans* are used as bait for catching such fish as cod and eels. Ponto-Caspian species like *Obesogammarus crassus* and *Pontogammarus robustoides* provide a food source for many species of farmed fish (Figs. 11.1 and 11.2).

The function and importance of species belonging to the *Decapoda* are well-known. Because they are tasty and easily digestible, they are a delicacy in our cooking. The biochemical composition of their bodies, i.e. the high protein and low fat and carbohydrate contents, is similar to that of the flesh of fish. They are an important source of omega-3 fatty acids. They are rich in vitamins A and B (especially niacin and cobalamin 9, vitamins PP and B12). They contain a lot of iodine, selenium and fluorine. All of this means that crustaceans are among the most valuable components of the human diet. However, the small size of Baltic crustaceans, their smaller numbers than in fully saline seas and the pollution of the Baltic Sea make them commercially unattractive. Baltic countries import crustaceans from other parts of the world. Some species of decapods may provide a habitat for other organisms. Numerous organisms such as *Cirripedia*, *Bryozoa*, *Hydrozoa*, *Bivalvia*, algae and bacteria attach themselves to their carapaces and claws.

Since crustaceans are very sensitive to the influence of biotic and abiotic factors, they can be used as indicators of environmental change. Knowing the crustacean

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Fig. 11.1 *Orconectes limosus*—a source of chitin (Piotr Wysocki)

Fig. 11.2 *Asellus aquaticus*—a tool for assessing water quality (Piotr Wysocki)

species composition in a given region, we can anticipate the directions of changes taking place in communities. The behaviour of crustaceans, the course of reproduction, as well as changes in production, respiration, nutrition or in their biochemical composition and energy value provide evidence of the changes taking place in the population and the environment. Thus, crustaceans are used, albeit to an insufficient extent, as environmental bioindicators and biomarkers. Certainly, crustaceans are better indicators of such changes than *Gastropoda* or *Bivalvia*. For example, the presence of *S. entomon* in an environment testifies to low temperatures, potential hypoxia, and even the presence of hydrogen sulphide. Under stressful conditions, arrhythmia of the heart can occur in individuals of this species. The presence of *C. crangon* indicates good environmental conditions, well-oxygenated water and the presence of sandy sediments. The sex ratio in a population of *Gammarus duebeni* is determined by the length of daylight and not water pollution, as is often believed. Non-native crustacean species can also indicate negative changes in the aquatic environment. The appearance and persistence of the invasive, pollution-resistant *G. tigrinus* has caused native gammarid species to be displaced. The native species *Asellus aquaticus* has a high tolerance towards contamination and oxygen shortages and is used as a tool for assessing water quality. *Amphipoda*, which are opportunistic species, are used for assessing sea water quality and as a BOPA (Polychaeta Opportunistic Benthic Amphipoda) indicator.

Crustaceans associated with bottom sediments are typically more exposed to minor changes in environmental factors like temperature than species living in the bulk of the water. This is because of the type of nutritional reserves they store. Crustaceans living in the water itself store more of such reserves because the environmental conditions are less predictable: in general, these are lipids and proteins, less often carbohydrates. Therefore, crustaceans may be an indicator of seasonal changes. In spring, when the water in the Baltic Sea begins to warm up, most crustacean species start breeding and continue to do so until October, in recent years for an even longer period. At this time, crustaceans build up their energy reserves in order to survive the winter.

Very large numbers of crustaceans, such as *Saduria entomon*, can clog fishing nets, much to the annoyance of fishermen. They can be intermediate hosts for parasites, e.g. *Eriocheir sinensis* in the case of the parasitic fluke *Paragonimus westermani*, the final host of which can be human. The crayfish *Orconectes limosus* and *Pacifastacus leniusculus* do not themselves suffer from crayfish plague but can transmit the fungus *Aphanomyces astaci* that causes this disease to other species of crayfish. *Rhithropanopeus harrisii* carries the *Hermes* virus that is lethal to other crustaceans, but is itself immune to it. The "biological engineering" activities of *E. sinensis* are well known: migrating along rivers it burrows into the sediment, exacerbating erosion.

The economic importance of the native and non-native crustaceans present in the Baltic Sea is still too small. Many species living in the Baltic Sea are used by humans, but insufficiently so. The possibility of breeding certain species should be considered. The waste products of crustacean aquaculture (CWP—Crustacean Waste Products) would be a source of protein, an additive to the feed for other farmed species. Waste products, but also whole crayfish, crabs and shrimps can serve as meal for animal feed and as fertilizers. Chitin can be used: it is often bound to proteins and is rich in inorganic compounds like calcium carbonate $CaCO_3$ or in organic compounds such as lipids and pigments. The pigment content in crustaceans ranges from 10 to 50% of their total dry weight. The average chitin content in *O. limosus* is approximately 13% of the dry mass and depends on the size and sex of the crayfish. 12% of the dry mass of *S. entomon* was found to be chitin. Crustaceans can be used, for example, in the pharmaceutical and food industries, due to their moisturizing and antibacterial properties and their ability to capture heavy metals. They may be a source of carotenoid pigments. There thus appear to be good prospects for the industrial uses of Baltic crustaceans.

Glossary

Abiotic factors The non-living components of nature, specific to a particular environment and acting on the organisms occurring in it; they include temperature, salinity, light, pressure, currents and tides.

Acclimation Physiological adaptation, regulating mechanisms of an organism to a specific, usually short-acting environmental factor.

Acclimatization The whole process of physiological, biochemical and morphological changes which reflect an organism's ability to adapt to changing environmental conditions.

Adaptation A change in the structure or function of an organism, increasing its chances of survival and producing offspring in new, permanently changed living conditions.

Algal blooms The large-scale growth of algal phytoplankton, the term usually being applied to a particular species; as a consequence, the water becomes turbid and turns greenish-brown.

Alien species A species introduced outside its normal distribution; also termed non-native or non-indigenous species.

Anabiosis The sudden inhibition of metabolism and life activities of an organism caused by adverse environmental conditions, passing when propitious conditions have been restored.

Anoxia A total depletion in the level of oxygen; anoxic waters are those that are depleted of dissolved oxygen.

Antennae In crustaceans, the second pair of antennae.

Antennules In crustaceans, the first pair of antennae.

Benthos The assemblage of organisms living at the bottom of a water body.

Bioindicator An organism whose presence (or absence) indicates the effect of environmental factors of a predetermined concentration or threshold.

Bioinvasion The rapid expansion of a species into regions where it had not previously existed, often as a result of human agency.

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Biological diversity The diversity of all forms of life, with all their variability in the ecosystem; considered at the level of genes, species, groups of organisms and habitats.

Biomagnification A process taking place in an ecosystem as a result of increasing concentrations of toxic substances in organisms at a higher level in the food web.

Biomarker A biological indicator (e.g. biochemical, physiological or structural change) enabling the qualitative and quantitative assessment of changes in an organism and defining its condition.

Bioturbation The disturbance of the original sediment structure caused by the activities of organisms living at the bottom of a water body—e.g. crawling, feeding, burrowing, tunnelling.

Biotic factors The living components of nature, specific to a given environment; they include interactions between individuals, e.g. competition, predation, parasitism.

Biramous Divided to form two branches, especially the limbs and antennae of crustaceans.

BOPA indicator (**Opportunistic** Polychaeta / Amphipoda) The ratio of the number of opportunistic polychaetes to amphipods used in determining the degree of pollution.

Boreal zone The zoogeographical region lying between the Arctic and tropical zones.

Brood pouch See **marsupium**.

Cannibalism The consumption by animals of members of their own species; common among predatory animals; occurs during famine or when population densities are high.

Carapace Here: the chitinous shield covering the back of a crustacean.

Catadromous species A species of two environments, spending most of its life in fresh waters, but migrating to sea waters to spawn.

Cephalothorax The fused head and thorax of animals such as crustaceans.

Chela (pl. chelae) A claw (claws).

Chitin A polysaccharide with a cellulose-like structure, occurring mainly in the exoskeleton of arthropods.

Chromatophore A cell containing granules of various pigments in the cytoplasm; changes in the concentration or dispersion of these granules alters the colouration and/or its intensity.

Commensalism A form of interaction between two or more species, where one of the species gains an advantage but without harming the other(s).

Community An established assemblage of living organisms inhabiting a particular area; this is a fundamental ecological unit, in a state of equilibrium, characterized by a given species composition and specifically defined quantitative relationships, with the ability to regenerate its structure.

Convergence The similarity of morphological, physiological or biochemical features, occurring in organisms unrelated to each other and caused by their adaptation to performing similar functions.

Detritus Minute fragments of dead organic matter, the shredded remains of dead plants, animals and their excreta, found at the bottom of a water body or in the water column.

Dimorphism (sexual dimorphism) Differences in morphology, appearance and behaviour between males and females of the same species.

Dioecious Having the male and female reproductive organs in separate individuals.

Ecological niche The role and position a species has in its environment; how it meets its needs for food and shelter, how it survives, and how it reproduces; includes all of its interactions with the biotic and abiotic factors of its environment; defines the role and the importance of the organism in the community.

Ecosystem An ecological system consisting of a group of organisms linked by trophic relationships, together with the environment they occupy (an ecosystem integrates community and biotope).

Ecosystem engineer Any organism that creates, significantly modifies, maintains or destroys a habitat.

Estuary A partially enclosed coastal body of brackish water, with one or more streams or rivers flowing into it, with a free connection to the open sea.

Euryhaline Exhibiting tolerance to a wide range of salinity.

Eurythermic Exhibiting tolerance to a wide range of temperature.

Eurytopic species An organism that is characterized by its ability to live in a wide variety of habitats and tolerate a wide range of environmental conditions.

Eutrophication The process of enrichment of water bodies in nutrients, resulting in an increase in the production rate of organic matter, thereby increasing the fertility of waters; this is a natural process, but its intensification as a result of human activities has upset the natural equilibrium of such waters.

Exoskeleton A rigid external covering for the body in some invertebrate animals, such as crustaceans.

Food web A network of food dependences between species; a system of interrelated food chains.

Habitat The physical environment in which an organism occurs; provides numerous ecological niches.

Halocline A well-defined vertical salinity gradient in ocean or other saline water.

Hermaphroditism, bisexuality The presence in an individual animal of reproductive glands or gonads of both sexes, or a single gonad differentiated into male and female parts.

Hypoxia An oxygen deficiency in a biotic environment; hypoxic waters are those with a lower-than-normal level of dissolved oxygen.

Introduction The intentional or accidental import by humans of a species beyond its natural range of distribution.

Invasive species A species rapidly expanding its range of distribution, adversely affecting both the newly colonized environment and the human economy; this term is applicable to both alien and indigenous species.

Invasive alien species A non-native species, the deliberate or accidental introduction of which can endanger the local biodiversity or human economy.

Marsupium (pl. marsupia) Any of several structures in various invertebrates (as a bryozoan, mollusc or crustacean) for enclosing or carrying eggs or young; also known as a brood pouch.

Maxilliped A paired appendage in crustaceans that contributes to the mouthparts.

Native (indigenous, autochthonous) species A species or subspecies occurring within its natural and potentially dispersive range, where it can live without human intervention.

Non-invasive alien species A non-native species that establishes populations in new areas of colonization, but without having any negative impact on local populations and communities.

Nutrients Inorganic salts necessary for the growth of living organisms; the term often implies inorganic nitrogen and phosphorus compounds.

Ontogenesis The development of an organism over its lifetime, from conception until death.

Oostegites The thoracic limb plates found in some crustaceans that form a brood pouch (marsupium).

Osmoregulation The active regulation of the osmotic pressure of an organ organism's body fluids to maintain the homeostasis of its water content; that is, it maintains the fluid balance and the concentration of electro concentration of electrolytes (salts in solution) to keep the fluids from becoming too diluted or too concentrated.

Ovigerous Describes a female carrying eggs.

Pelagial That part of a water body bordering on the coastal and near-bottom zones, the open waters of seas and oceans.

Pereopod Each of the eight walking limbs of a crustacean, growing from the thorax.

Phytobenthos Plants growing at or near the bottom of the sea.

Phytoplankton Plant plankton, i.e. plants floating freely in the water; mostly unicellular algae, blue-green algae and bacteria

Pleopod One of the abdominal limbs of a crustacean; in decapods, pleopods are limbs mainly used for swimming but sometimes used for brooding eggs or catching food.

Ponto-Caspian species Species originating from the biogeographical region including the Caspian Sea, the Black Sea and the Sea of Azov.

Poikilothermy The quality of being cold-blooded, a physiological property characteristic of all invertebrates, in which the body temperature is adapted to that of the environment.

Population A group of organisms of the same species, with a shared genetic pool, able to interbreed freely, occurring in a particular area at the same time.

Pycnocline A layer in an ocean or other body of water in which water density increases rapidly with depth.

Rostrum The beak-like projection of the head in a crustacean.

Setose Bearing bristles or setae.

Statocysts The balance organs of most invertebrates.

Stenohaline Capable of living only within narrow limits of salinity fluctuations, exhibiting no resistance to changes in water salinity.

Stenothermic Capable of living only within narrow limits of temperature fluctuations, exhibiting no resistance to changes in water temperature.

Stenotopic species An organism that is able to tolerate only a restricted range of habitats or ecological conditions.

Symbiosis The interaction between two different organisms living in close physical association, typically to the advantage of both.

Telson The last segment in the abdomen, or a terminal appendage to it, in crustaceans.

Terrigenous Originating on land.

Thermocline An abrupt temperature gradient in a body of water such as a lake, marked by a layer above and below which the water is at different temperatures; this prevents mixing between the surface waters and those beneath the thermocline.

Trophic web The web of food dependence between organisms of different species living in a single community or ecosystem.

Water column A conceptual column of water from the surface of a sea, river or lake to the bottom sediments.

Zoobenthos, benthic fauna An assemblage of animals inhabiting the bottom of a water body, living both on the surface of the sediments and within them.

Zooplankton Animal plankton; tiny animals floating in the water.

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