SEASONAL AND ONTOGENETIC DIET SHIFTS IN AN INTERTIDAL POPULATION OF GOBIUS PAGANELLUS (TELEOSTEI, GOBIIDAE) FROM THE CANTABRIAN COAST

R A Mazé

VIE MILIEU, 2004, 54 (1) : 1-6

SEASONAL AND ONTOGENETIC DIET SHIFTS IN AN INTERTIDAL POPULATION OF *GOBIUS PAGANELLUS* (TELEOSTEI, GOBIIDAE) FROM THE CANTABRIAN COAST

R. A. MAZÉ

Departamento de Biología Animal, Universidad de León, 24071 León, Spain
dbarmg@unileon.es

DIET
GOBIUS PAGANELLUS
SEASONAL CHANGES
ONTOGENETIC CHANGES
PREY SPECIES

ABSTRACT. – The aim of this paper is to describe the diet of an intertidal population of *Gobius paganellus* from the Cantabrian coast, looking at seasonal and ontogenetic shifts and identifying the main prey. *G. paganellus* is an intertidal fish widely distributed on the Iberian Altantic coast. The specimens were captured on the west coast of Asturias (northern Spain). A total of 292 stomach contents were studied. A frequency of occurrence of 99.0% and a numerical composition of 93.0% for arthropods were calculated. The preferential prey items were amphipods and copepods. Isopods, decapods (Natantia), ostracods, leptostracans and acari were secondary prey. So were tanaids, decapods (Brachyura and Anomura) and Diptera larvae, but only for certain sizes and times of the year. A correlation between predator size and the frequency of occurrence of some prey items was found. It was negative for the copepods and ostracods and positive for the leptostracans and decapods, which is obviously related to their respective size. Moreover, a seasonal study of the diet showed significant differences in the contribution of copepods and isopods during certain times of the year, possibly due to larger numbers of smaller sized predators and/or the availability of prey.

RÉGIME ALIMENTAIRE
GOBIUS PAGANELLUS
CHANGEMENTS ONTOGÉNÉTIQUES
ESPÈCES-PROIES
CHANGEMENTS SAISONNIERS

RÉSUMÉ. – Le régime alimentaire d'une population intertidale de *Gobius paganellus* (Gobiidae) de la côte cantabrique est décrit. Les changements saisonniers et ontogénétiques, ainsi que les espèces proies les plus importantes ont été recherchés. *G. paganellus* est un Poisson intertidal qui habite le long de la côte atlantique ibérique. Les individus analysés ont été capturés sur la côte occidentale des Asturies (Nord de l'Espagne). Le contenu d'un échantillon de 292 estomacs a été étudié. L'indice de fréquence des Arthropodes obtenu est de 99 % et le pourcentage numérique de 93 %. Les taxons-proies préférentiels sont les Amphipodes et les Copépodes. Les Isopodes, les Décapodes (Natantia), les Ostracodes, les Leptostracés et les Acariens constituent des proies secondaires. Les Tanaïdacés, les Décapodes (Brachyura et Anomura) et les larves de Diptères sont aussi des proies secondaires, mais seulement certaines tailles et pendant certaines époques de l'année. Une corrélation entre la taille des prédateurs et l'indice de fréquence de quelques proies a été mise en évidence. Cette relation devient négative chez les Copépodes et positive chez les Leptostracés et les Décapodes, en raison de la taille. Enfin, l'étude saisonnière du régime alimentaire a montré des différences qui sont significatives pour la distribution des Copépodes et des Isopodes pendant certaines époques de l'année, elles peuvent être dues à la présence plus importante de prédateurs de petite taille et/ ou à la disponibilité des proies.

INTRODUCTION

Among the major intertidal habitats, the rocky intertidal probably presents the greatest taxonomic breath and functional diversity of potential prey for intertidal fishes. Several previous reviews of the biology of intertidal communities under-rated the importance of fish predation on community structure. However, Norton & Cook (1999) feel that an increasing body of knowledge is emerging which indicates that predation by intertidal fishes can have dramatic effects on their prey.

This paper is part of a wider study whose aim is to establish trophic relationships in ichthyofauna inhabiting the rocky intertidal of the Asturian coast. Most of the species forming part of this taxocenosis are predators of macrofauna, preferring to feed on arthropods, molluscs and polychaetes.

This study describes the diet of *Gobius paganellus* (L.), a species widely distributed on the Iberian coast (Nieto & Alberto 1994a), located in rock pools, preferably with algae and beds of sand (Gibson 1972, Nieto & Alberto 1994b). It is found abundantly in the study area, accounting for 10.1%

of the total number of over 2000 specimens detected, belonging to 19 fish species.

Up to date two studies about the diet of populations of *G. paganellus* from the intertidal habitat were done in France (Gibson 1972) and in Ireland (Dunne 1978). Lately, new data were published on the diet of sublittoral populations from the Tagus estuary (Costa 1988) and the Azores (Azevedo & Simas 2000). No data about seasonal and ontogenetic shifts were indicated by the above-mentioned authors.

The aim of this paper is to describe the diet of an intertidal population of *G. paganellus* from the Cantabrian coast, looking at seasonal and ontogenetic shifts and identifying the main prey species.

MATERIAL AND METHODS

The specimens were caught on the west coast of Asturias, in Figueras, on the right bank of the mouth of the river Eo, and in Ortiguera, on the left bank of the mouth of the river Navia, in 1988 (Fig. 1). Samples were taken from 15 intertidal pools, most of them at least seasonally, distributed between the upper and lower intertidal aeras and varying in size between 0.5 and 50 m^3. The fishes were caught during the lowest tide of each month and the pools were emptied using a motor suction pump. Specimens of *G. paganellus* were found in 3 of the 4 pools sampled in Ortiguera and in 7 of the 11 pools in Figueras.

The individuals were then fixed and sent to the laboratory, where their total length was measured and digestive tracts removed for examination of the contents. The prey were recorded and identified to the lowest taxonomical level possible.

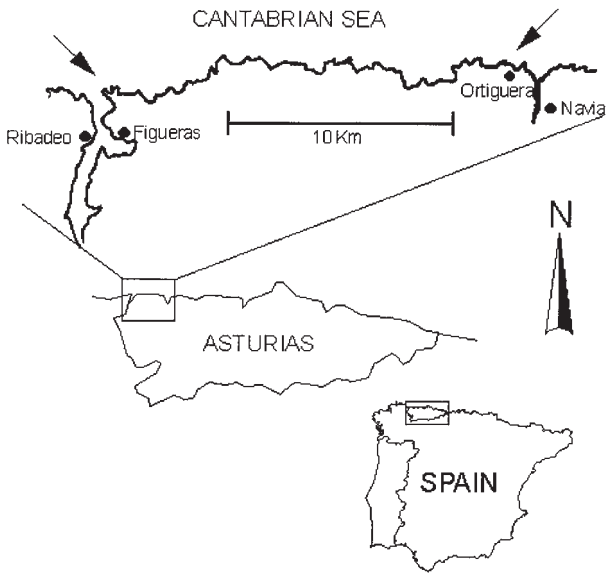

Fig. 1. – Map showing the location of sampling areas.

The contribution of each prey item to the diet was described by the percentage of frequency of occurrence (%F) and numerical composition (%N) (Hyslop 1980).

Taking frequency of occurrence into account, the preys were classified as preferential ($F \geqslant 50\%$), secondary ($10\% \leqslant F < 50\%$) and occasional ($F < 10\%$), following the classification proposed by Hureau (1970).

To evaluate differences between the type of arthropod ingested and predator size the fishes were divided into three size groups (Table I, top) and a chi-square test was applied after grouping the main prey items into 6 categories: copepods, isopods, amphipods, leptostracans, decapods and other arthropods. Significant differences were confirmed by calculating Pearson's correlation coefficient between the frequency of occurrence of a prey item and predator size, which was grouped for every interval 5 mm.

A chi-square test was also used to establish possible significant seasonal differences ($p<0.001$) and the data obtained in the samplings classified into spring, summer, autumn and winter.

RESULTS

A total of 292 stomach contents were studied. A frequency of occurrence of 99.0% and a numerical composition of 93.0% were calculated for arthropods. Both data are higher than those calculated for other species including predators of macrobenthos captured in the same study area (Table I, middle). Therefore, arthropods, and in particular crustaceans, form the most representative group in the diet of *G. paganellus.* This is the reason why this group is preferentially analysed. Other prey items present in the diet were molluscs (N=3,8%), polychaetes (N=2,4%) and others such as cnidarians, sipunculans and echinoderms (N=2,8%).

The list of the Appendix contains the identified prey items. Table I, below and Fig. 2 show how main prey groups contribute to the diet of *G. paganellus* depending on the season and the size group considered. The following is an analysis of the contribution of each prey group.

Copepod harpacticoids

Copepods were detected in 49.7% of the examined digestive tracts, accounting for 68% of the total of arthropods.

Seasonally, the high frequency of occurrence of this group is noteworthy, especially the numerical composition in summer (Table I, below), which showed considerable differences in comparison with other seasons.

The frequency of occurrence of copepods in the digestive tracts of *G. paganellus* grouped according to size and season (Fig. 2) showed no significant differences in Group III throughout the year,

Table I. – Top, Number of guts in which arthropods occur. Data are arranged seasonally and per size classes of fishes. Lt=total length (mm). Middle, frequency of occurrence (F) and numerical composition (N) of arthropods in the diet of 5 species of intertidal fishes from the coast of Asturias. *present study, **unpublished data, *** Mazé *et al* 1999. Below, seasonal variation of frequency of occurrence (F) and numerical composition (N) of prey items.

	spring	summer	autumn	winter	Total
Group I (Lt≤35)	-	18	-	-	18
Group II (36 <Lt<65)	11	55	65	40	171
Group III (Lt≥66)	9	18	32	41	100
Total	20	91	97	81	289

	F (%)	N (%)
Gobius paganellus *	99.0	93.0
Gobius cobitis **	91.6	92.0
*Coryphoblennius galerita***	80.6	92.5
Lipophrys pholis ***	80.2	26.1
*Parablennius gattorugine***	45.3	14.0

	spring		summer		autumn		winter	
	F(%)	N(%)	F(%)	N(%)	F(%)	N(%)	F(%)	N(%)
Copepoda	35.0	9.8	78.0	90.8	51.5	37.7	22.2	7.9
Isopoda	55.0	12.5	23.1	0.9	43.3	7.4	43.2	17.0
Amphipoda	100	62.1	86.8	5.4	99.0	50.0	99.0	63.3
Leptostraca	15.0	2.2	13.2	0.4	9.3	1.1	23.5	5.0
Decapoda	10.0	0.9	28.6	0.7	24.7	2.7	18.5	2.2
Others Arthropoda	65.0	12.5	37.4	1.9	26.8	3.4	18.5	4.6

whereas in Group II, they were significantly more frequent in summer than in autumn. Also, the species in this group ingested copepods more often than the larger ones. In Group I, the smallest size group, the frequency of copepods was 100%.

The relationship between higher frequency of occurrence of copepods and smaller predators is well known (Gibson & Yoshiyama 1999), as confirmed by calculating the correlation coefficient ($p<0.01$).

Leptostracans

Nebalia bipes is a secondary species in the diet of *G. paganellus*. Seasonal differences were not observed, but differences in the size of the predator were found, leptostracans being more frequent in larger fishes ($p<0.01$). No specimens measuring less than 43 mm were detected. There were no significant differences between the frequencies of Groups II and III, except during autumn.

Isopods

This group is a secondary prey (F=28.4%) representing a numerical composition of 3.5%. Significant seasonal differences were observed between spring and summer only, when the frequency of appearance is maximum and minimum, respectively (Table I, below).

An analysis of the size groups revealed that isopods were preferred by larger specimens (except in summer and there were no significant seasonal differences) and by Group II in winter and spring (Fig. 2).

The most frequent and abundant isopod in the diet of *G. paganellus* was *Idotea chelipes* and several species of Sphaeromatidae were occasional prey, including two species belonging to the genus *Campecopea*, *C. hirsuta* and *C. lusitanica*.

Amphipods

They were the preferential prey items. They were the most frequent (93.5%) and took second place in numerical composition (20.8%).

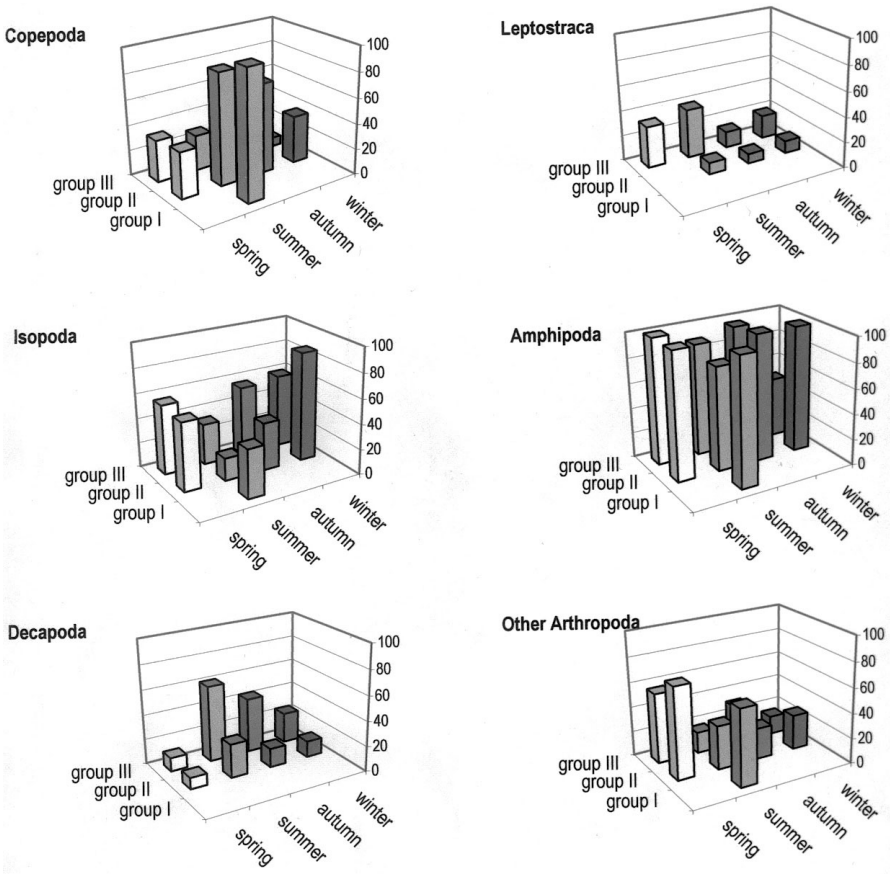

Fig. 2. – Frequency of occurrence of prey items arranged seasonally and per size classes of fishes (Table I).

Significant seasonal differences were only observed in abundance for the summer (Table I, below) and no differences in size were noted (Fig. 2).

A total of 65% of the amphipods detected in the digestive tracts were identified at least to family level. Amongst them, the most frequent species during the whole year were *Gammarella fucicola* and *Melita palmata.* Also worth mentioning as occasional prey were 3 species of *Atylus* and 2 species of *Microdeutopus*.

Decapods

Larval stages (zoea and megalopa) have occasionally been found, as well as hermit crabs in their shells, Brachyura (generally fragments), and Caridea, though less frequently (15.4%). On the whole, decapods were a secondary prey during the year (Table I, below), with significant differences in frequency of occurrence in Groups II and III, which was nearly always higher in the latter (positive correlation) and reached the rank of preferential prey during the summer (Fig. 2).

Other arthropods

The heterogeneous group of prey mentioned below was especially important in spring and showed significant differences in frequency of occurrence in comparison with autumn and winter (Table I, below). Its importance in the diet of smaller fishes should also be noted (Fig. 2) as ostracods were the preferred prey and acarians and Diptera larvae secondary prey.

Tanaidacea, Cirripedia, Mysidacea, Pycnogonida and Myriapoda specimens were found occasionally.

DISCUSSION

Arthropods, especially crustaceans, form the largest group in the diet of *G. paganellus*, in accord with data obtained by other authors for populations on the French Atlantic coast (Gibson 1972), the Irish coast (Dunne 1978) and the Azores (Azevedo & Simas 2000). On the other hand Costa (1988) found a larger contribution of the polychaetes in the Tagus estuary. This may be due to the peculiarities of this estuarine habitat. No data about sea-

sonal and ontogenetic shifts were given by the above-mentioned authors.

The preferential prey items were amphipods (Gammaridea) and copepods. Amongst the first, the most frequent species all year round are *Gammarella fucicola* and *Melita palmata,* which was not surprising as both are very common on the coast of the Iberian Peninsula, generally found in abundance with *Zostera,* amongst algae and in soft substrates (Marques & Bellan-Santini 1985, 1987, Arresti *et al.* 1986, Junoy & Viéitez 1988, Marques *et al.* 1989, Marques *et al.* 1993).

Isopods, decapods (Natantia), ostracods, leptostracans and acarians were secondary preys. Also, tanaids, decapods (Brachyura and Anomura) and Diptera larvae, but only for fishes of certain sizes and at certain times of the year. Tanaids and anomurans are recorded for the first time as part of this diet.

The most frequent and abundant isopod in the diet of *G. paganellus* was *Idotea chelipes*. This species was widely reported in the intertidal area of the Iberian Peninsula (Castelló & Carballo 2001), usually with *Zostera* and algae. Seasonal studies carried out on the Atlantic coast of the Iberian Peninsula showed that it reached the maximum density during the winter months mainly because of the abundance of juvenile specimens that did not appear in summer (Marques *et al.* 1989, Junoy & Viéitez 1990, Marques *et al.* 1993).

Several species of Sphaeromatidae were occasional prey; two of them belong to the genus *Campecopea*, *C. hirsuta* and *C. lusitanica*, which are generally associated with barnacles in the upper region of the intertidal (Bruce & Holdich 2002). This could explain their low incidence in the diet of *G. paganellus* if we compare data obtained in the same study area for *Lipophrys pholis* (Mazé *et al.* 1999), whose diet contained the greatest abundance of barnacles and a higher contribution of the two species belonging to *Campecopea*. *C. lusitanica* has recently been described and is found on the Atlantic, Galician and Portuguese coast (Nolting *et al.* 1998) as well as the Canary Isles and the Azores (Bruce & Holdich 2002). This paper extends its distribution range to the Cantabrian coast.

The decapods, Anomura and Brachyura were noteworthy, as well as the higher frequency of Caridea which are difficult to capture in comparison with amphipods and harpacticoid copepods (Norton & Cook 1999).

A correlation between predator size and the frequency of occurrence of some prey was found. It was negative for copepods and ostracods and positive for leptostracans and decapods, which is obviously related to their size. Many studies on different species of fishes point out that juvenile fishes require harpacticoid copepods for their nutrition; larger specimens ingest macrofauna, mainly peracarid crustaceans (Bodiou 1999).

ACKNOWLEDGEMENTS. – I would like to thank D Pérez-Cardenal and B Fuertes for sampling and identifying the specimens of *G. paganellus*.

REFERENCES

Arresti A, Iturrondobeitia JC, Rallo A 1986. Contribución al conocimiento faunístico y ecológico del orden Amphipoda en el abra de Bilbao (C. Vasca). *Cuad Invest Biol (Bilbao)* 9: 89-125.

Azevedo JMN, Simas AMV 2000. Age and growth, reproduction and diet of a sublittoral population of the rocky goby *Gobius paganellus* (Teleostei, Gobiidae). *Hydrobiologia* 440 (1/3): 129-135

Bodiou JY 1999. Modalités de la prédation des Copépodes benthiques par les Poissons. *Vie Milieu* 49 (4): 301-308.

Bruce NL, Holdich DM 2002. Revision of the isopod crustacean genus *Campecopea* (Flabellifera: Sphaeromatidae) with discussion of the phylogenetic significance of dorsal processes. *J Mar Biol Assoc U K* 82: 51-68.

Castelló J, Carballo JL 2001. Isopod fauna, excluding Epicaridea, from the Strait of Gibraltar and nearby areas (Southern Iberian Peninsula). *Sci Mar* 65 (3): 221-241.

Costa M 1988. Écologie alimentaire des Poissons de l'estuaire du Tage. *Cybium* 12 (4): 301-320.

Dunne J 1978. The biology of the rock goby, *Gobius paganellus* L., at Carna. *Proc R Irish Acad* 78B (12): 179-191.

Gibson RN 1972. The vertical distribution and feeding relationships of intertidal fish on the Atlantic coast of France. *J Anim Ecol* 41: 189-207.

Gibson RN, Yoshiyama RM 1999. Intertidal Fish Communities. *In* Horn MH, Martin KLM, Chotkowski MA eds, Intertidal Fishes: Life in Two Worlds. Academic Press, San Diego: 264-296.

Hureau JC 1970. Biologie comparée de quelques Poissons antarctiques (Nototheniidae). *Bull Inst Océanogr (Monaco)* 68: 1-224.

Hyslop EJ 1980. Stomach contents analysis – a review of methods and their application. *J Fish Biol* 17: 411-429.

Junoy J, Viéitez JM 1990. *Idotea chelipes* (Pallas 1966) (Crustacea, Isopoda) en la Ría de Foz (Lugo, España). *Bol R Soc Hist Nat (Sec Biol)* 85(1-4): 87-97.

Junoy J, Viéitez JM 1988. Crustaceo intermareales de sustrato blando de la ría de Foz (Lugo). Act III Congr Ibér Entom: 529-540.

Marques JC, Nogueira A, Rodríguez LSB 1989. Crustaceos Peracarídeos (Isopoda e Amphipoda) do estuario do Mondego. Inventariacao faunistica e análise da reparticao ecológica das espécies da zona intertidal. *Actas Co Luso-Esp Ecol Bacias Hidrogr e Rec Zoológicos* 253-260.

Marques JC, Rodríguez LSB, Nogueira A 1993. Intertidal macrobenthic communities structure in the Mondego estuary (Western Portugal): reference situation. *Vie Milieu* 43(2-3): 177-187.

Marques JC, Bellan-Santini D 1985. Contribution à l'étude systématique et écologique des Amphipodes (Crustacea-Amphipoda) des côtes du Portugal. Premier inventaire des espèces (Gammaridiens et Caprelliens). *Ciênc Biol Ecol Syst* (Portugal) 5: 299-353.

Marques JC, Bellan-Santini D 1987. Crustacés Amphipodes des côtes du Portugal: faune de l'estuaire du Mira (Alentejo, côte sud-ouest). *Cah Biol Mar* 28: 465-480.

Mazé RA, Domínguez J, Pérez-Cardenal D 1999. Diet *of Lipophrys pholis* (L.) (Teleostei, Blennidae) in Cantabrian coastal waters (Spain). *Acta Oecologica* 20 (4): 435-448.

Nieto P, Alberto LJ 1994a. Gobiidae y Blennidae de la zona intermareal de la costa suroccidental de Andalucía (España). *Misc Zool* 17: 179-188.

Nieto P, Alberto LJ 1994b. Relación entre las características de pozas intermareales y las especies ícticas que albergan. Le Système Littoral Méditerranéen, Actes Coll Sci: 182-185.

Nolting C, Reboreda P, Wägele JW 1998. Systematic revision of the genus *Anoplocopea* Racovitza, 1907 (Crustacea: Isopoda) with a description of a new species from the Atlantic Coast of the Iberian Peninsula. *Mitt Mus Nat kd Ber Zool Reihe* 74 (1): 19-41.

Norton SF, Cook AE 1999. Predation by Fishes in the intertidal. *In* Horn MH, Martin KLM, Chotkowski MA eds, Intertidal Fishes: Life in Two Worlds. Academic Press, San Diego: 223-263.

Reçu le 28 février 2003; received February 28, 2003
Accepté le 14 octobre 2003; accepted October 14, 2003

APPENDIX – Prey items of *Gobius Paganellus*

CNIDARIA
SIPUNCULA

ANNELIDA
POLYCHAETA

MOLLUSCA
GASTROPODA
POLYPLACOPHORA

ARTHROPODA
CHELICERATA
Arachnida
Acarina

PYCNOGONIDA
Phoxichilidiidae
Anoplodactylus angulatus (Dorhn)
Others

CRUSTACEA
Ostracoda
Copepoda
Harpacticoida
Porcellidium viride (Philippi)
Others
Cirripedia
Balanomorpha
Malacostraca
Tanaidacea
Mysidacea
Leptostraca
Nebalia bipes (Fabricius)
Isopoda
Gnathiidae
Anthuridae
Paranthura costana (Bate &Westwood)
Anthura gracilis (Montagu)
Sphaeromatidae
Campecopea hirsuta (Montagu)
C. lusitanica (Nolting, Reboreda & Wagele)
Dynamene edwarsii (Lucas)
D. bidentatus (Adams)
Dynamene sp.
Cymodoce truncata Leach
Idoteidae
Idotea emarginata (Fabricius)
Idotea chelipes (Pallas)
Idotea sp.
Others
Amphipoda
Caprellidea
Phtisicidae
Phtisica marina Slabber
Others
Gammaridea
Ampithoidae
Ampithoe sp.
Aoridae
Microdeutopus chelifer (Bate)
Microdeutopus sp.
Atylidae
Atylus guttatus (Costa)
A. swammerdami (Milne-Edwards)
A. vedlomensis (Bate & Westwood)
Calliopiidae
Apherusa bispinosa (Bate)
Gammaridae
Ischyroceridae
Jassa ocia (Bate)
Melitidae
Gammarella fucicola (Leach)
Melita palmata (Montagu)
Phliantidae
Perionotus testudo (Montagu)
Sthenothoidae
Sthenothoe monoculoides (Montagu)
Talitridae
Hyale sp.
Others
Decapoda
Caridea
Palaemonidae
Palaemonetes varians (Leach)
Alpheidae
Athanas nitescens (Leach)
Others
Anomura
Brachyura

MYRIAPODA
Chilopoda

INSECTA
Diptera

ECHINODERMATA