ASPECTS OF THE FEEDING ECOLOGY OF THREE COMMON SPARID FISH IN THE LITTORAL ZONE AT CLAYTON'S ROCKS IN THE EASTERN CAPE, WITH NOTES ON THEIR BIOLOGY.

by

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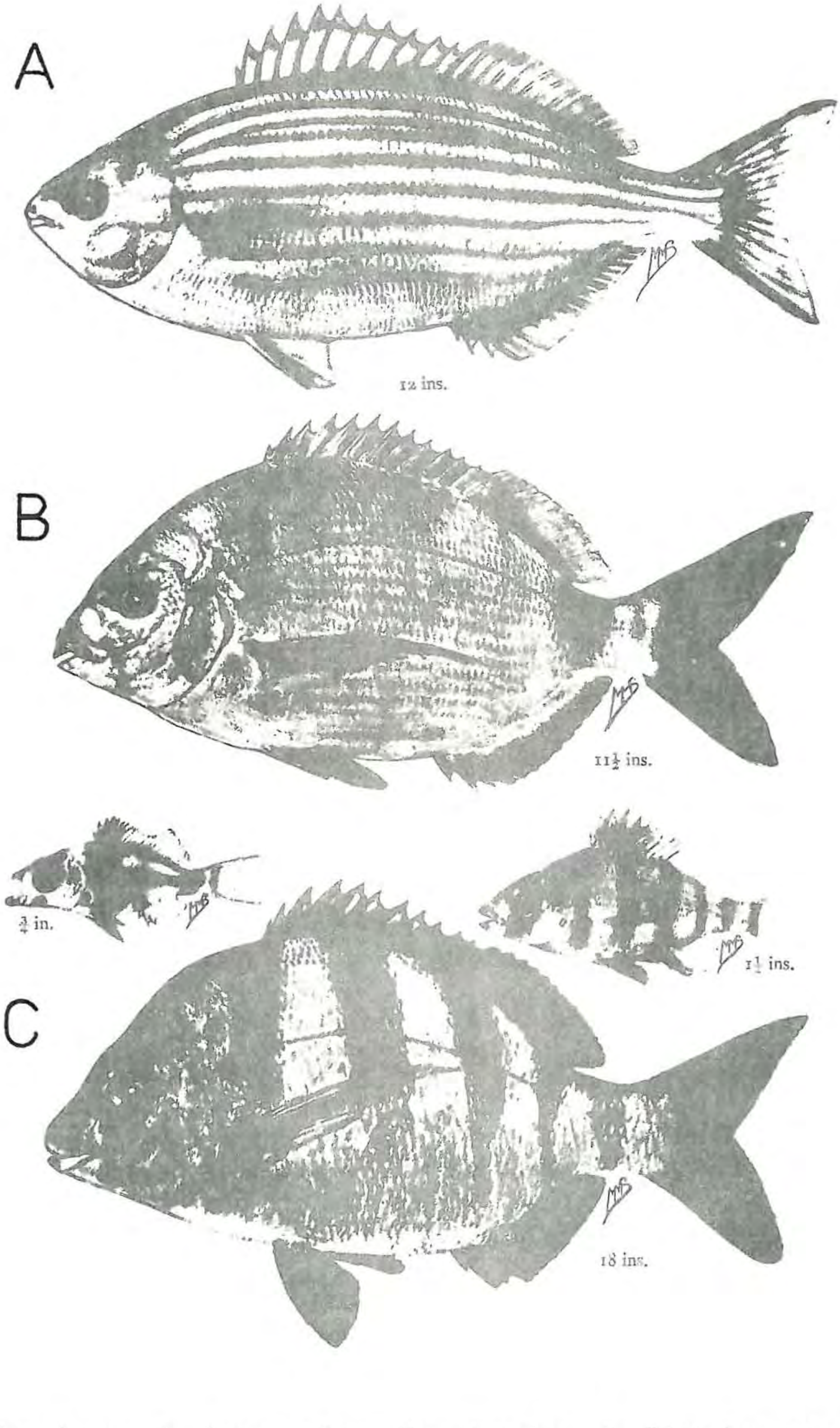

Frontispiece. A. Sarpa salpa, the strepie; B. Diplodus sargus, the blacktail and C. D. cervinus, the zebra

ABSTRACT

The feeding interrelationships of three sparid fish was studied in the littoral zone during low tide at Clayton's Rocks in the Eastern Cape.

The three species appeared in the study area only when between 9 and 10 mm long (SL), and remained resident until a length of approximately 120 mm was reached. No sexually mature specimens occurred in the study area as large adults only use the intertidal zone for feeding purposes at high tide.

From first recruitment into the littoral zone at 9 mm SL until some 35 mm long, the diet of Diplodus sargus consists of harpacticoid copepods and amphipods. Ingestion of amphipods and green algae increases with increased size of fish. Chironomid larvae, cirripede nauplii and an unidentifiable planktonic larva are important food items of small juveniles (50 mm), while diatoms are significant in larger juveniles (25 to 80 mm) in the spring/early summer season. The gut is short and the teeth are incisiform, backed by several rows of molars which increase in size and number with age.

D.cervinus was almost completely carnivorous in the size range studied. The juveniles fed on harpacticoid copepods and chironomid larvae while between 10 and 20 mm long. The diet then consists mainly of the shrimp Palaemon pacificus until the fish are 50 mm long and then amphipods until 100 mm long. All fish larger than this feed predominantly on polychaetes. The gut is short and the teeth are similar to those of D.sargus although there are fewer molars.

From its first appearance at 10 mm, Sarpa salpa feeds mainly on harpacticoid copepods until 25 mm long. Diatoms then predominate in the diet, red algae also being taken until 75 mm long. Larger size classes are herbivores, feeding almost equally on red and green algae. Corresponding changes in gut length and dentition are reported, juveniles having a short gut and conical teeth and adults a long intestine and cuspidate, incisiform teeth.

Marked ecological separation was observed between the three species. Spatial, temporal, behavioural and dietary differences were found. D.sargus has continuous recruitment of juveniles into the littoral zone, S.salpa appears between July and early September and D.cervinus is recruited from late September to November. Competition between small juveniles is reduced by cyclic abundances of food items important to each species and the sub-adults feed on different foods. Some competition exists between large juveniles of D.sargus and D.cervinus, but separation is maintained as individuals of the two species feed at different levels of the water column and in different parts of the littoral zone.

CONTENTS

INTRODUCTION

This report is based mainly on observations and stomach content analyses made between February 1st and December 11th 1975. The study was conducted at Clayton's Rocks in the Eastern Cape, South Africa, a broken rocky area with extensive littoral and subtidal pools (Figures 1, 2 and 3).

The distribution of fish in the littoral zone of the Eastern Cape is largely unknown, although that of invertebrates has been extensively studied by Stephenson (1944). Fish have been largely ignored in the past for a number of reasons. As Stephenson (op. cit., p. 269) states. "the fishes have had to be omitted, except on a very small scale, because a fish survey would involve work of a different type needing special methods and a great deal of time".

The study of ecological collections of the J.L.B. Smith Institute of Ichthyology, Rhodes University (R.U.S.I.) together with field research from February to December 1975 resulted in certain trends being noticed in the littoral fish fauna and these are presented in Tables 2 and 3.

Common tidepool residents at Clayton's Rocks in the E. Cape belong to seven families of fishes, the Gobiidae, Clinidae, Mugilidae, Sparidae, Cheilodactylidae, Gobiesocidae and Serranidae. Of these the Gobiidae are present in sufficient numbers in the upper intertidal zone to allow for a sampling programme, and the Mugilidae and Sparidae are similarly sufficiently abundant in the lower inter-tidal and subtidal zones. The feeding ecology and vertical distribution of the Gobiidae have been fairly extensively studied in the past, for example on the Atlantic coast of France by Gibson (1968, 1970 and 1972), and on the southern coast of South Africa by Pitt-Kennedy (1964).

Similarly in South Africa the feeding ecology has been determined for four species of mullet in the Swartkops estuary by Masson and Marais (1975) and eleven species in the St. Lucia Lake System by Blaber (in press). The food of relatively few of the many sparid species has been studied in detail, notably that of Rhabdosargus globiceps (Talbot, 1954), R. holubi (Blaber, 1974), adult Sarpa salpa and Pachymetopon blochii (Hutchings, 1968) and also Diplodus holbrooki and Lagodon rhomboides (Carr and Adams, 1972, 1973).

The Sparids were chosen for the present study, as none of the three species dominant at Clayton's Rocks have previously been studied in the juvenile and subadult stadia which are common in the littoral zone. The three species are Sarpa salpa (Linnaeus, 1758), Diplodus sargus (L. 1758) and D. cervinus (Lowe, 1838).

These fish are abundant and would be expected to be in competition as they coexist. As Odum (1971, p. 214) puts it, "If they [closely related organisms] do occur in the same places, they use different foods, are active at different times, or are otherwise occupying somewhat different niches," in order to fulfill Gause's principle of competitive exclusion.

With this in mind, one aspect of the ecology of these fish was studied, namely the feeding habits, to determine whether there was any food resource subdivision which would allow the fish to co-exist noncompetitively.

S. salpa (the strepie, see frontispiece) is found from the Black Sea and the Adriatic, through the Mediterranean and along the east coast of the Atlantic from the Bay of Biscay, through Morocco, Madeira and the Azores, to South Africa, as well as on the east coast of Africa as far north as Delagoa Bay (Tortonese, 1973). Barnard (1927) describes it as being primarily a herbivore, as did Smith (1965). In a quantitative study, Hutchings (1968) found that the adult and late juvenile stages were herbivorous, in contradistinction to the results of Talbot (1954), who states that the fish is omnivorous, feeding on algae, angiosperms, crustacea, polychaetes and molluscs. The latter study was carried out in the Klein River estuary where algae are less common than in the sublittoral zone. Little, if anything, is known of the diet of juveniles which appear in great numbers in the tidepools along the coast in late winter/early spring.

D. sargus (the blacktail, frontispiece) is found throughout the range of S. salpa, occurring additionally up the east coast of Africa to the Persian Gulf (Barnard, 1927). This species is mentioned as being an omnivore by Biden (1954), Talbot (1954) and Smith (1965). D. cervinus (the zebra, frontispiece) has similar feeding habits (Talbot, 1954 and Biden 1954) but is of more restricted occurrence, being found in the southern and eastern Mediterranean, Madeira, Cap Blanc, the Canary Islands, the eastern Atlantic and the western Indian

Ocean, as far north as Natal (Barnard, 1927 and Tortonese, 1973).

There is a large literature on the subject of the diet of fishes, particularly of freshwater and marine sublittoral species. In freshwater, ecological research areas are easily defined, e.g., a lake or river, and large samples of single species can be obtained. Most studies have therefore been monospecific and have been quantitative as well as qualitative. Examples are the studies of the trout (Allen, 1951), the blue-gill sunfish (Gerkin, 1962) and the upland bully (Staples, 1975 a, b and c).

Two notable exceptions are the studies made by Keast in Lake Opinicon (1965) and Jones Creek (1966), both in Ontario. These studies were mainly qualitative and enumerated the diets of 14 and 12 fish species respectively. Changes in diet with age and season were found and correlated with seasonal abundances of the food items in the environment with the result that it was found that Gause's principle of competitive exclusion was in operation.

Similar qualitative studies of polyspecific marine communities have been made in the West Indies (Randall, 1967), on the Kona reefs, Hawaii (Hobson, 1974), in the Marshall Islands (Hiatt and Strasburg, 1960), in the Banyuls Region, Mediterranean (Gibson, 1968) and in Brittany, France (Gibson, 1972). Few studies involving large numbers of specimens have been made as these are so often extremely difficult to obtain in the marine environment. Not surprisingly, most are from tidal pools and other easily accessible marine habitats. Examples are the studies of the diet of two gobies and one blenny in

France (Gibson, 1970 and 1972), one goby (Pitt-Kennedy, 1964) and two sparids (Hutchings, 1968) in South Africa and one sparid and one cheilodactylid in New Zealand (Godfriaux, 1974 a and b).

Many methods have been used to analyse stomach contents. After evaluation of these, four were employed in the present study, namely, 1) the percentage occurrence method, 2) the percentage volume method, 3) the points method, and 4) the ranking index method. The four techniques generally gave similar results, although it would appear that the ranking index is most accurate.

The objectives of this study have been to determine 1) the diet of juveniles of three species of sparid fish, 2) how feeding changes with age and season, 3) the relationships between dentition, external gut morphology and diet, 4) the degree of overlap between species possibly resulting in competition, 5) the correlation between diet and invertebrate numbers, if any, 6) recruitment times and approximate growth rates, and 7) which analytical technique is most useful for stomach content analysis in the case of these three fish species.

TAXONOMIC STATUS

As mentioned above three sparid species were studied. Since it is important in ecological work that the species studied should be accurately determined, some systematic work was initially done in order to clarify the confusion surrounding the taxonomic status of two of the three species.

Diplodus sargus: Linnaeus described this species as Sparus sargus in 1758 from the Mediterranean. The species was thought to extend to Angola, and in 1849, Smith described the South African population as a new species (Sargus capensis). Rafinesque (1810) erected a new genus, Diplodus (type Sparus annularis, Linnaeus, by monotypy). Sparus sargus was then described as Sargus rondeleti by Cuvier and Valenciennes (1830) p. 14 (19, pl. 141). This was corrected to D. sargus by Jordan and Fesler (1893). Barnard (1927) placed Smith's capensis as a variety of D. rondeleti. Fowler (1933, p. 175) felt that the two forms were identical, and used Linnaeus' specific name (D. sargus), though subsequently decided that the South African population was separate, and revived Smith's name, as D. capensis. (Fowler, 1936). Smith (1938) agreed with his earlier opinion that the two were identical, and therefore followed Fowler (1933). This is still the current nomenclatural position.

In 1964, Cadenat erected two subspecies, D. sargus typicus and D. sargus insularum, from Dakar and the Cape Verde Islands respectively. D. sargus typicus is stated to have three to five rows of molars on the upper jaw and three to four on the lower, whereas D. sargus insularum has three and two respectively. His diagrams are of individuals of different sizes, D. sargus typicus being almost twice as large as D. sargus insularum. This same changeover is also seen in D. sargus in South Africa (personal observation), in that the older the fish, the more rows of molars are developed. It therefore seems likely that this separation of subspecies is artificial, although this needs further research as there was some overlap in the sizes examined. More recently, de la Paz has recognized two subspecies corresponding to the Mediterranean and South African populations (M.M. Smith, pers. comm.). For the present purposes however, and pending publication of this work, D. sargus is treated as a full species.

D. cervinus: Rafinesque, 1810 described Sparus trifasciatus from the Mediterranean. The Cape Verde population was subsequently described by Valenciennes (1830 p. 59(43)) as Sargus fasciatus. Lowe (1838)[1] described a new species from the Mediterranean as Charax cervinus. Fowler (1936) placed trifasciatus into Diplodus. The Cape Verde population has since been confirmed as a distinct species by Bauchot and Daget (1971), for which the name D. fasciatus is available. Although D. trifasciatus Rafinesque 1810 appears to be the first name available for the Mediterranean, and West and South African populations, the types are lost and the species diagnosis is insufficient for recognition, so the name is a nomen dubium. The next available name is that of Lowe (1838),[1] and hence the specific name of this species is now considered to be D. cervinus.

Sarpa salpa: Linnaeus (1758) described the species as Sparus salpa, and in 1826, Risso[2] described it as Boops salpa. Then in 1830 Valenciennes[2] placed it in the genus Box. Subsequently, Bonaparte[2] erected the genus Sarpa (type: Sparus salpa L., by monotypy), in which the species has since remained.

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1. Cited by Bauchot and Daget (1971)

2. Cited by Tortonese (1973)

STUDY AREA

The study area is situated about 3,2 km north of Kleinemonde in the Eastern Cape, at an area known locally as Clayton's Rocks (Figure 1). The shoreline in the area depicted consists mainly of a gently shelving sandy beach with broken rocky areas of varying extent, such as those at the Three Sisters and Clayton's Rocks. The beach is backed by large shifting sanddunes which run almost perpendicular to the coastline.

The rocks of the study area consists of sandstone striking approximately east-west, and dipping steeply southwards. This configuration has allowed the development of several gullies and pools, partially sheltered by ridges of reistant rock from wave action which is predominantly from the south-east (Figure 2). The maximum collection depth was three metres at the seaward edges of the gullies, at low tide.

Intertidal zonation of both animals and plants is well documented (Branch, 1975;Gibson, 1972 and others) and has resulted in the definition of a number of zones (Stephenson, 1944; Day, 1969 and many others). These zones are based on the distribution of invertebrate animals and were found to bear little relation to the distribution of the size classes of fish studied. Four arbitrary habitats were therefore defined as 1) the upper intertidal zone, 2) shallow pools in the mid-intertidal zone, 3) deep pools in the mid-intertidal zone, and 4) the marginally subtidal zone. The upper zone is submerged for only a few hours at high tide and shows great

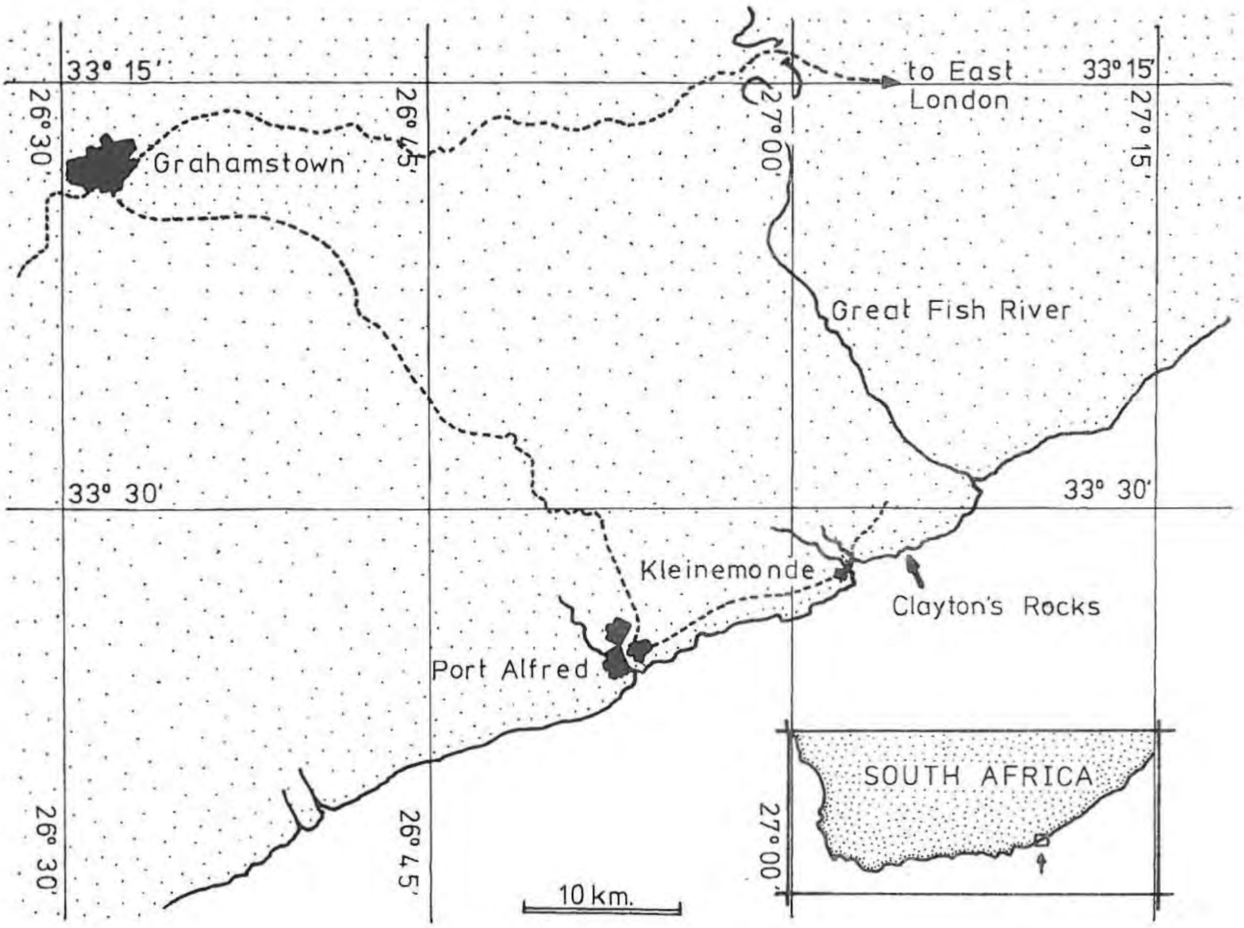


Figure 1. The Eastern Cape coast. Adapted from Topographical Chart 3326 Grahamstown.

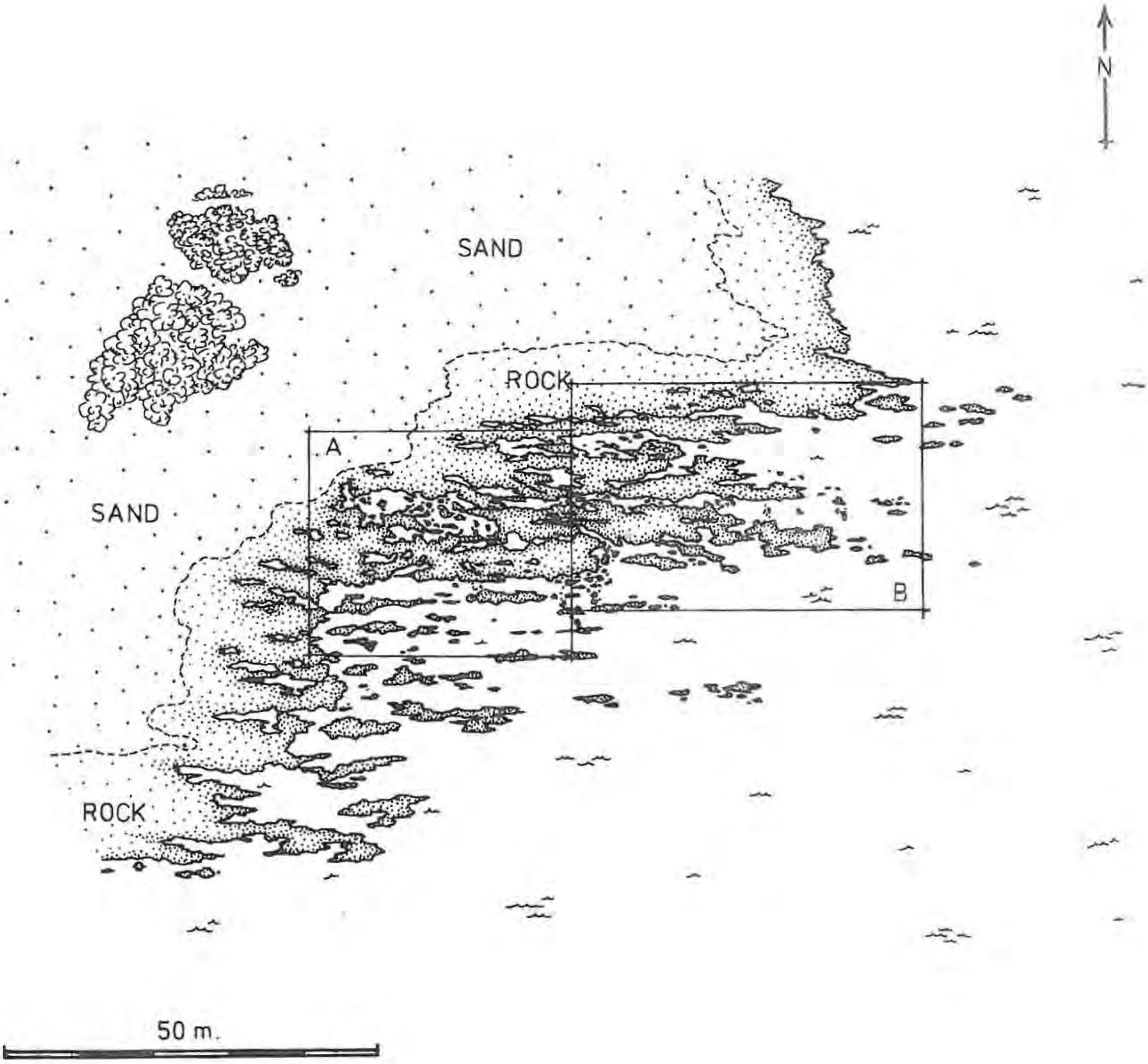
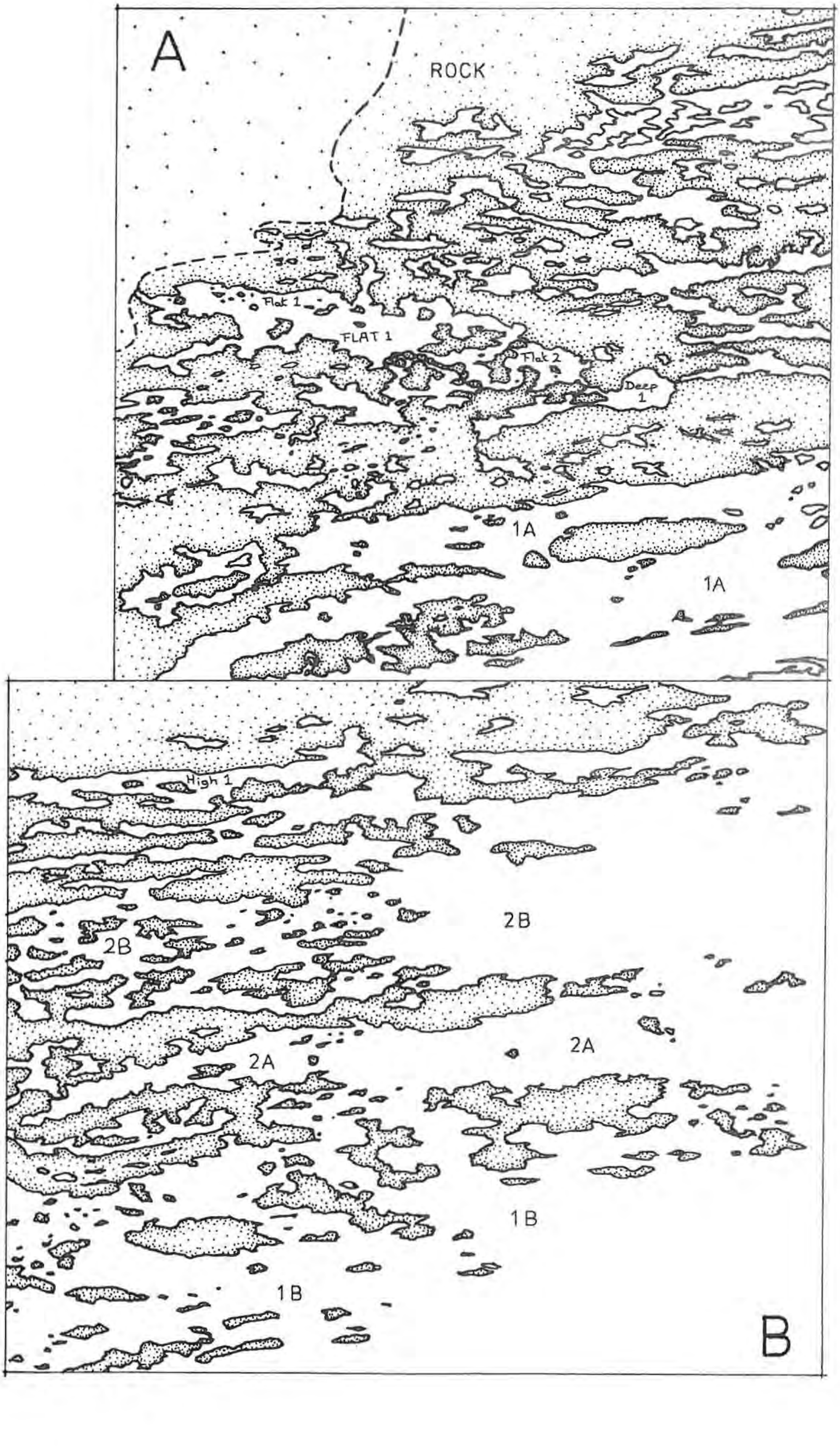


Figure 2. The study area. Adapted from an aerial photograph. The enclosed areas A and B are enlarged overleaf.

Figure 3. Enlarged view of the study area adapted from an aerial photograph. A. Includes shallow pools in the midtidal zone (Flat 1 & 2), deep pools in the midtidal zone (Deep 1) and a subtidal gully (1A). B. Includes pools in the high littoral zone (High 1) and a number of gullies (1A,2A & B). The approximate scale is 1 : 300.



A
ROCK
Flat 1
FLAT 1
Flat 2
Deep 1
1A
1A
High 1
2B
2B
2A
2A
1B
1B
B

environmental fluctuations in short time periods. Pool High 1 (Figure 3A) is an example. The shallow mid-intertidal zone includes all the pools between zones one and four with a depth of 60 cm or less, e.g., Pool Flat 1 (Figure 3A). The deep pools of the mid-intertidal zone are between 125 and 250 cm in depth, characterised by Pool Deep 1(Figure 3A). The marginally subtidal zone consists of a number of gullies with variable widths (1 to 10 metres), lengths (5 to 40 metres) and depths (1 to 3 metres). An example of these gullies is Pool 1A (Figure 3A). All measurements have been taken at low spring tide.

Environmental conditions vary greatly, salinities as low as 25°/oo being recorded at low tide. These are caused by substantial freshwater seepage into the pools from springs in the sandy beach. During the day at low tide, surface water temperatures have been recorded ranging from 20°C (Flat 1) and 22°C (open sea) in December to 15°C (Flat 1) and 14°C (open sea) in July.

METHODS AND MATERIALS

FIELD METHODS.

Substrate samples:

Samples were taken of the substrate at irregular intervals in order to quantify any possible relationship between the relative abundance of food items and diet of the fish. Two bottom samplers were developed for use in the subtidal and intertidal areas.

The subtidal sampler consists of a clear perspex box, the inner surfaces being 20 cms wide and long (Figure 4A). Attached to the base is a wide rubber flange to seal off the area being sampled, as it fits the contours of any uneven surfaces. The worker views the inside through the slanted front window. Attached to the box is a cheesecloth bag with two openings. The posterior one fits the mouth of a Consol jar allowing the jar's brass top to be screwed on thus sealing off the hole. The second opening allows the worker's hand and wrist to remain inside while scraping the substrate with a diving knife, the space around the wrist being sealed with string. The intertidal sampler consists of a clear perspex tube (Figure 4B) with an internal diameter of 3,42 cm. The posterior is closed with the exception of an opening through which the handle of a brass scraper protrudes. The "cut-away" section in Figure 4B represents this diagrammatically. A rubber flange is present similar to that of the subtidal sampler.

When a sample was to be taken, a relatively flat surface was selected and the sampler pressed against it. A small amount of rotenone (which kills all animal life in a few minutes) was injected. This minimized damage to the specimens as all leave the substrate when exposed to the drug. The bottom was then scraped with a diving knife or the brass scraper, and when the substrate was clean, an assistant slid a metal plate under the sampler and the whole apparatus lifted out of the water. The contents were either washed down into the consol jar or poured into a collecting bottle, labelled

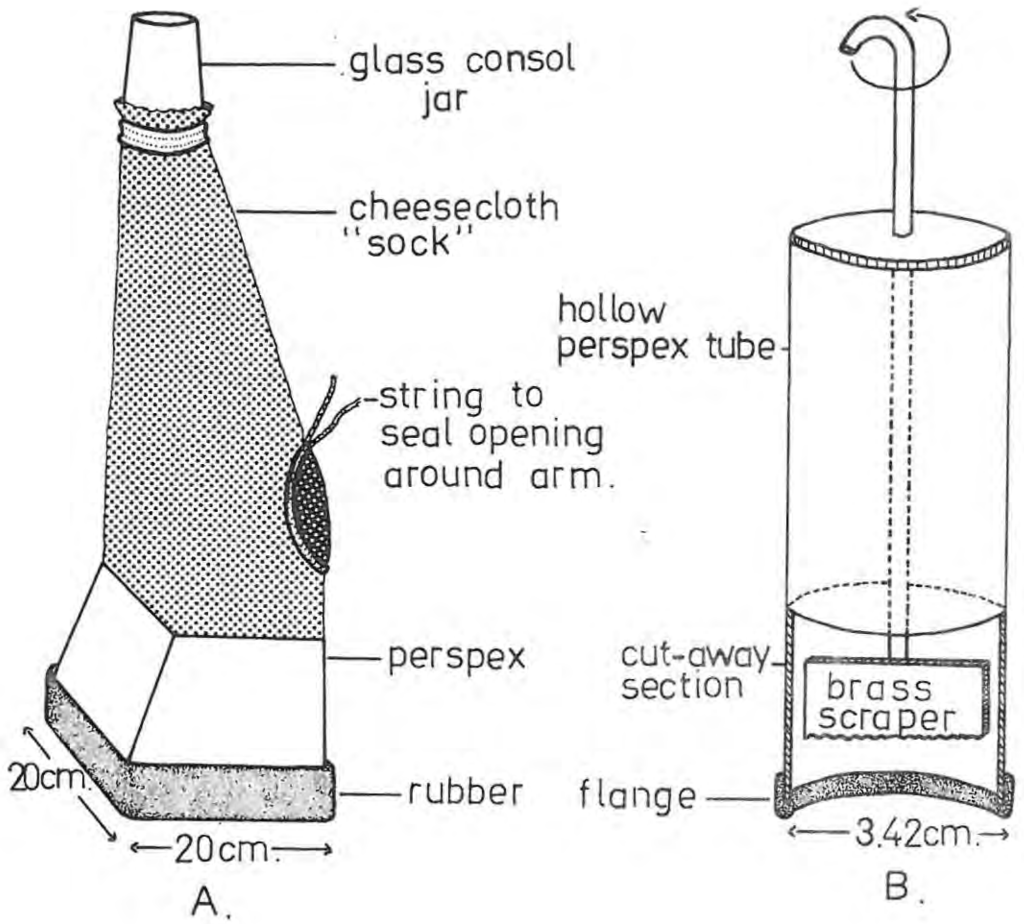


Figure 4. The two substrate samplers. A. Sampler used in the sublittoral region. B. Sampler for use in the intertidal region. For description of method see text.

and formaldehyde added to make a 10% formalin solution.

Fish samples:

Fish were collected at two-week intervals (spring tides) as diving conditions were suitable at that time. The collection of fish was done by a 1) multiprong speargun while diving, and 2) with handnets in shallow intertidal pools. Fish collected with handnets were immediately placed in a 10% formalin solution, whereas this procedure was delayed for up to 1 1/2 hours in the case of those taken by spear. Poison, traps, nets and hook and line were not used for collecting specimens as biases in the feeding habits were thereby introduced, as discussed by Randall (1967).

LABORATORY METHODS.

Identification of invertebrates obtained in substrate samples and as stomach contents was carried out with reference to the work of Sars (1895) and the keys of Barnard, K.H. (1940); Barnard, J.L. (1969) and Day (1967 and 1969). Algae were identified by reference to the works of Taylor (1928), Seagrief (1967) and Day (1969).

Substrate sample analysis:

The samples were placed in a 45% solution of n-propyl alcohol and analysis carried out 1) by counting the numbers of each animal species present, and 2) by estimating the percentage volume of every algal species found.

Fish analysis:

The fish were left in formalin for ten to fourteen days to allow for complete fixation of the tissues. This length of time was kept standard throughout, as formaldehyde can cause changes in the length and weight of up to ± 5% (Royce, 1972 and Staples, 1975a). Any such changes were therefore standardized. After removal, the fish were weighed to the nearest one tenth of a gram, the standard length measured to the nearest millimetre and the stomach removed. To obtain the stomach, an incision in the right side was made and the oesophagus cut immediately posterior to the gills. The abdominal contents were lifted out and the stomach cut anterior to the gut caecae and placed in 45% n-propyl alcohol. The intestine was never analysed as several species of food item are more resistant to digestion than others, with a resultant bias as one moves along the gut (Randall, 1967).

Stomach content analysis:

All analysis was carried out with the use of a Wild M-5 stereoscopic microscope. A major problem encountered in the analysis of gut contents is of the method to be used. Eight methods are available, which may be discussed as followws:

i) Occurrence method: the number of fish in which each food item occurs is expressed as a percentage of the total number of fish examined, e.g., Hida (1973); Perrin et al (1973) Talbot (1954); Omori (1974), Becker (1973) and many others. A similar method was employed by Masson and Marais (1975), who listed the stomach contents by the frequency of occurrence, each food item being listed as absent, present or frequent.

ii) Numbers method: the total number of individuals of each food species is given usually as the mean number or percentage per fish. This method has been used by Wurtsbaugh et al (1975); Merrett and Roe (1974); Becker (1973); Omori (1974), Perrin et al. (1973) and others.

iii) Dominance method: the number of times which a food organism occurs as the dominant item is expressed usually as a percentage of the number of fish examined or of the total number of times dominant food items occur. This method appears to have been used very rarely.

iv) Volume and weights method: here two variations are in use. The percentage volume can be estimated visually by a number of means, e.g., Breder and Crawford (1922); Keast (1965 and 1966) and others. The volumes and weight can be estimated more accurately by graded sieves (Carr and Adams, 1972) or by direct measurement, e.g., Perrin et al. (1973); Wurtsbaugh et al. (1975); Walburg (1975); Staples (1975a), and many others. The results are usually expressed as a percentage of the total mean weight or volume of food per fish.

v) Reconstructed weight/volume method: a standard parameter of the food is measured, e.g., carapace length of a crustacean, volume of an alga, and a regression curve determined for each species of food item of dry weight, calories etc. against this standard parameter. This is an extremely accurate method not commonly used, e.g., Bruton (pers. comm.).

vi) Fullness method: the fullness is estimated and used to determine diet and seasonal feeding periodicities, e.g., Hartley, 1947.

Vii) Points method: this method originally involved the estimation of the frequency of food items, and each category was then allotted points (Swynnerton & Worthington, 1940).

Table 1. Points allotment for stomach contents. The fullness is estimated visually, after removal of the stomach from the body cavity, and a number of points allotted (between 0 and 30). Any intermediate value can be assigned and the figures given below are only used as a rough guide when points are assigned.

FULLNESS INDEX	POINTS
Very Distended	30
Distended	28
Very Full	24
Full	20
7/8ths. Full	17,5
2/3rds. Full	14
1/2 Full	10
1/3 Full	7,5
1/4 Full	4
Empty	0

This was then expanded by Frost (1943) to take the fullness of the stomach into account. In all cases, a full stomach is allotted 20 points and distended one 30. Each food item is then allotted 1,2,4,8 or 16 points depending on the volume occupied by that item. A disadvantage is that a distended stomach should receive 30 points, and if only one food organism is present, only 16 points can be allotted. The method has therefore been slightly modified in the present study as suggested by Hynes (1950), such that points are allotted to the stomach depending on fullness (Table 1), and these are subdivided amongst the food items in the ratio of their volumes.

viii) Ranking index method: this was recommended by Hobson (1974) and is found by multiplying the mean percentage volume of each food item per fish by the ratio of the number of fish containing the item to the total number of fish sampled.

Three of the methods described were not employed in the present study for a number of reasons. The numbers method can be particularily misleading such as in the case of a fish feeding on algae and diatoms, or on polychaetes and copepods. In both cases, the former food item will occur in small numbers and the latter in large numbers. This would lead to a bias in favour of small, numerous food items which may not contribute as much energy to the animal as large food items would. In the same way, the dominance method tends to ignore a food item which occurs regularly but in small volumes, so that a valuable link in a food chain is disregarded. The fullness method is likewise valuable in the determination of feeding periodicities but gives no idea of the diet composition.

For these reasons, it was decided that only the other five methods of analysis would be attempted. It was later, however, found that the fish fed on diatoms at certain stages in their life cycle. The reconstructed-weight method was then discarded for three reasons: 1) The difficulty involved in obtaining a sample of live, monospecific diatoms with no contaminants, e.g., sandgrains, and in large enough numbers to determine either the weight or an energetic value. 2) The uncertainty as to the stage of the life cycle at which a diatom is, whether growing, storing carbohydrates or resting. Energetically, these stages are different and could introduce a bias. 3) The presence of indeterminate numbers of dead frustules in the stomach and in field samples. As Round (1971, p. 83) aptly states, "The persistence of dead frustules also complicates any ecological survey of contemporary biocoenoses since the inclusion of any records of dead cells can be misleading."

The analysis of stomach contents was accordingly done by the remaining four methods: 1) percentage occurrence, 2) percentage volume, 3) points (as modified from Hynes, 1950), and 4) ranking index. In order to estimate the percentage volume of a stomach sample, the contents were identified and spread out on an even surface. The percentages were then estimated with the aid of Data Sheet No. 6 of Geotimes, (available from the American Geological Institute, 2101 Constitution Ave., N.W., Washington 25, D.C.). A copy of this sheet is reproduced here (Figure 5) in order to illustrate this technique.

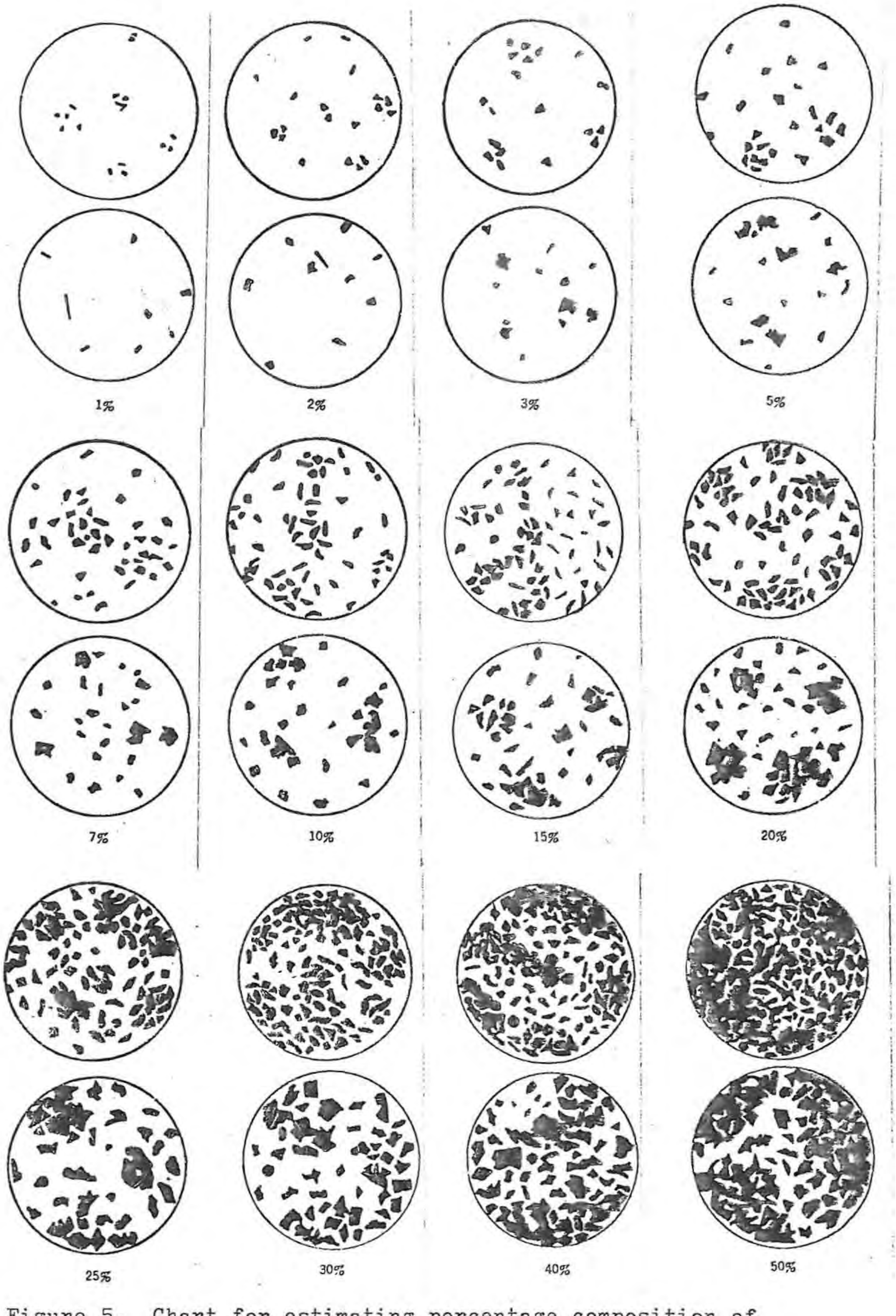


Figure 5. Chart for estimating percentage composition of stomach contents. Originally used for slides of rock and sediment samples.

FAUNA AND FLORA

FISH DISTRIBUTION

The distribution during summer and winter of the more common fish species is given in Tables 2 and 3. These were compiled from the RUSI (Rhodes University, Smith Institute) ecological collections and observations made during 64 hours of diving using snorkel and occasionally aqualung, as well as some 35 hours of direct observation in the intertidal area at low tide. Juveniles of tropical species appear in the intertidal zone mainly during the warmer months, presumably being brought down from the North-east by the warm Agulhas current. These species are not included in the winter list (Table 3) as they are not resident, possibly being killed off by the low winter temperatures. The ratio of the cold to warm water species is 12:13 (Table 2) which is similar to that of 23:28 determined by Stephenson (1944) for the invertebrate population at Kleinemonde. This tends to confirm Stephenson's view (op. cit.) that the area between Port Elizabeth and Port Edward is a faunal transitional zone. One aspect not reported before is the seasonal nature of this fauna, as only 4 species of the warm water component are found at Kleinemonde during winter (Table 3). It thus appears that the transitional zone moves northwards with the onset of winter and southward during summer.

Certain species of fish move in and out of the intertidal area with each tide, presumably in response to the opening up of new food resources or to predation pressure. Some of these species are only seen at high tide, e.g., Pomadasys commersoni

Table 2. Generalized distribution of some of the more common fish observed in the intertidal and immediately subtidal zones at Clayton's Rocks during the summer season.

	Tidal zones			
Species	Upper	Mid	Lower	Sub
GOBIIDAE				
Gobius caffer (C)	OOXX+ OOXX+	OOXX++ OOXX++	X+ X+	- -
G. saldanha (C)	- -	OOXX+ OOXX+	OOXX++ OOXX++	X+ X+
CLINIDAE				
Clinus cottoides (C)	- -	O O	X X	+ +
C. superciliosus (C)	- -	O O	OX+ OX+	X++ X++
SPARIDAE				
Diplodus sargus (C)	- -	OOX OO	OOXX+ OOXX	XX++ OOXXX+
D. cervinus (C)	- -	OOX OO	OOXX+ OOXX	XX++ XX+
Sarpa salpa	- -	OX O	OXX+ OXX	XX++ OXX+
Sparodon durbanensis (W)	- -	OX O	OX OX	X+ X+
Rhabdosargus holubi (C)	- -	OX OX	OX OX	X+ X+
MUGILIDAE				
Myxus capensis (C)	- -	OOXX OOX	OOXX+ OOXX	XX++ OXX++
Liza dumerili (W)	- -	OOXX OOX	OOXX+ OOXX	XX++ OXX++
SERRANIDAE				
Epinephelus guaza (W)	- -	O O	OX OX	+ +
Anthias squamipinnis (W)	- -	O O	- -	- -
CHEILODACTYLIDAE				
Chilodactylus brachydactylus(C)	- -	O O	OOXX OOX	XX++ XX++
Cheirodactylus fasciatus (C)	- -	- -	- -	X++ X++
POMADASYIDAE				
Pomadasys commersoni (W)	- -	- -	- -	+ -
KUHLIIDAE				
Kuhlia taeniurus (W)	- -	O O	OX OX	X+ X+
GOBIESOCIFORMES				
Chorisochismus dentex (C)	- -	OX OX	X+ X+	+ +
SCORPIDAE				
Neoscorpis lithophilus (W)	- -	- -	- -	+ -
CHAETODONTIDAE				
Chaetodon marleyi (W)	- -	O O	O O	X X

Table 2 contd.)

Species	Tidal zones: Upper	Mid	Lower	Sub
LABRIDAE				
Stethojulis albovittata (W)	- -	o o	o o	ox ox
Thalassoma lunare (W)	- -	o o	o o	- -
ACANTHURIDAE				
Acanthurus mata (W)	- -	o o	o o	- -
A. triostegus (W)	- -	o o	o o	- -
POMACANTHIDAE				
Pomacanthodes semicirculatus(W)	- -	- -	o o	- -

ooo	Juveniles	o; x; +	Rare
xxx	Subadults	oo; xx; ++	Common
+++	Adults	ooo; xxx; +++	Abundant
		-	Absent

The upper value in each case represents the distribution at high tide and the lower one, that at low tide. The distributional states of each fish si given in parenthese, being either cold-water (C) or warm-water (W) species, as defined by Stephenson (1944).

Table 3. Generalized distribution of some of the more common fish observed in the intertidal and immediately subtidal zones at Clayton's Rocks during the winter period.

	Tidal zones			
Species	Upper	Mid	Lower	Sub
GOBIIDAE				
Gobius caffer (C)	XX++ XX++	XX++ XX++	X+ X+	- -
G. saldanha (C)	XX++ XX++	XX++ XX++	X+ X+	- -
CLINIDAE				
Clinus cottoides (C)	- -	- -	X X	+ +
C. superciliosus (C)	- -	X -	X+ X+	X++ X++
SPARIDAE				
Diplodus sargus (C)	- -	OOX OO	OOXX+ OOXX	XX++ OOXXX+
D. cervinus (C)	- -	X -	X X	X++ X+
Sarpa salpa	- -	OO OO	OOX OO	++ OOXX+
Sparodon durbanensis (W)	- -	- -	X -	X+ X+
Rhabdosargus holubi (C)	- -	- -	X -	X+ X+
MUGILIDAE				
Myxus capensis (C)	- -	OOXX OOX	OOXX+ OOXX	XX++ OXX++
SERRANIDAE				
Epinephelus guaza (W)	- -	- -	X X	+ +
CHEILODACTYLIDAE				
Chilodactylus brachydactylus(C)	- -	- -	XX X	X++ XX++
Cheirodactylus fasciatus (C)	- -	- -	- -	X+ X+
POMADASYIDAE				
Pomadasys commerconi (W)	- -	- -	- -	+ -
GOBIESOCIFORMES				
Chorisochismus dentex (C)	- -	X X	X+ X+	- -
SCORPIDAE				
Neoscorpis lithophilus (W)	- -	- -	- -	+ -

ooo	Juveniles	o; x; +;	Rare
xxx	Subadults	oo; xx; ++	Common
+++	Adults	oo; xxx; +++	Abundant
		-	Absent

The upper value represents the distribution at high tide and the lower one, that at low tide. The distributional status of each fish is given in parentheses, being either cold-water (C) or warm-water (W) species, as defined by Stephenson (1944).

(spotted grunter) and Neoscorpis lithophilus (stonebream).

INVERTEBRATE AND ALGAL DISTRIBUTION

The generalized constitution of the invertebrate fauna and flora of the intertidal region is given in Table 4. No quantitative results are given as discrepancies have been noted, possibly due to the natural patchiness of animal populations in the environment (Hynes, 1950). The caprellid amphipods are a case in point, Caprella danilevskii and Caprellina longicollis having been obtained in the substrate samples, whereas these together with eight other species have been obtained in stomach contents. As these amphipods are commonly found on hydrozoans (Hutchings, 1968) which have a patchy distribution, it may be that more extensive sampling would obtain the other eight species. Similarly, the sandshrimp Palaemon pacificus was commonly observed in the intertidal area and is a food item, although it was not obtained in the substrate samples. This may be due to the fact that they are wary and move mainly at night.

Some correlations between the abundance of the food items in the stomach contents and the environment have been observed. The larvae of the midge Telmatogeton minor (Chironomidae: Clunioninae) were obtained in large numbers in the substrate samples during the summer period, e.g., they comprised between 11,7 and 27,3% by number of the animal population taken in samples on October 26th. It occurs as a food item of D. sargus and D. cervinus from October to March, indicating that these fish are

Table 4. Generalized distribution of invertebrates and algae commonly obtained in substrate samples taken in the intertidal and immediately subtidal regions at Clayton's Rocks.

	Tidal zones			
Species	Upper	Mid	Lower	Sub
HYDROZOA				
Amphibestia spp.		x		
Thecocarpus formosus		x	xx	xx
POLYCHAETA				
Dodecaceria pulchra				xx
Nereis spp.	x	xx	xx	xx
Onuphis spp.		x	xx	
Pista spp.				x
Spirorbis spp.			xx	xx
CRUSTACEA				
Isopoda				
Cymodocella spp.				xx
Dynamenella spp.			x	xx
Exosphaeroma spp.				x
Gnathia spp.		x	x	x
Ianiropsis spp.				x
Janira spp.				x
Janiropsis spp.		x	xx	xx
Pananthura serricauda				x
Paranthura punctata				x
Stenetrium spp.		x	x	x
Amphipoda				
Aora spp.			x	x
Caprella spp.				x
Caprellina longicollis				x
Corophium spp.				x
Gammaropsis holmesi				x
Jassa spp.				x
Lysianassa ceratina			xx	xxx
L. variegata			x	x
Paramoera capensis		x	x	xx
Parelasmopus suluensis				xx
Podoceras inconspicuus				x

Table 4 contd.)

Species	Tidal zones Upper	Mid	Lower	Sub
Tanaidacea				
Leptochelia barnardi				x
Ostracoda	x	xxx	xx	x
Copepoda				
Harpacticoid spp.	x	xx	x	xx
Brachyura				
Rhyncoplax spp.			x	
PYCNOGONIDAE				
Pycnogonum cataphractum				x
INSECTA				
Telmatogeton minor	x	xx		
GASTROPODA				
Cerithiopsis alfredensis		x		
Helcion pruinosus		x	x	
Littorina knysnaensis	x	xx	x	
Oxystele spp.		x	x	
Polineces didyma		xx	x	
Siphonaria spp.		x	x	
ECHINODERMATA				
Parechinus spp.		x	x	x
Ophiarachnella capensis				x
CHLOROPHYTA				
Caulerpa filiformis				
Codium spp.			x	
Enteromorpha spp.	xx	x		
Ulva spp.	x	xx	xx	x
RHODOPHYTA				
Acrosorium spp.			x	
Amphiroa ephedraea		x	x	x x
Ceramium spp.		x	x	x
Champia compressa		x		

Table 4 contd.)

Species	Tidal zones: Upper	Mid	Lower	Sub
RHODOPHYTA contd,)				
Corallina spp.				xx
Hypnea spicifera		x	xx	x
Lithothamnion spp.		x	x	x
Polyzonia elegans				x
Tayloriella tenebrosa		xx	x	x

x Rarely occurs

xx Common

xxx Abundant

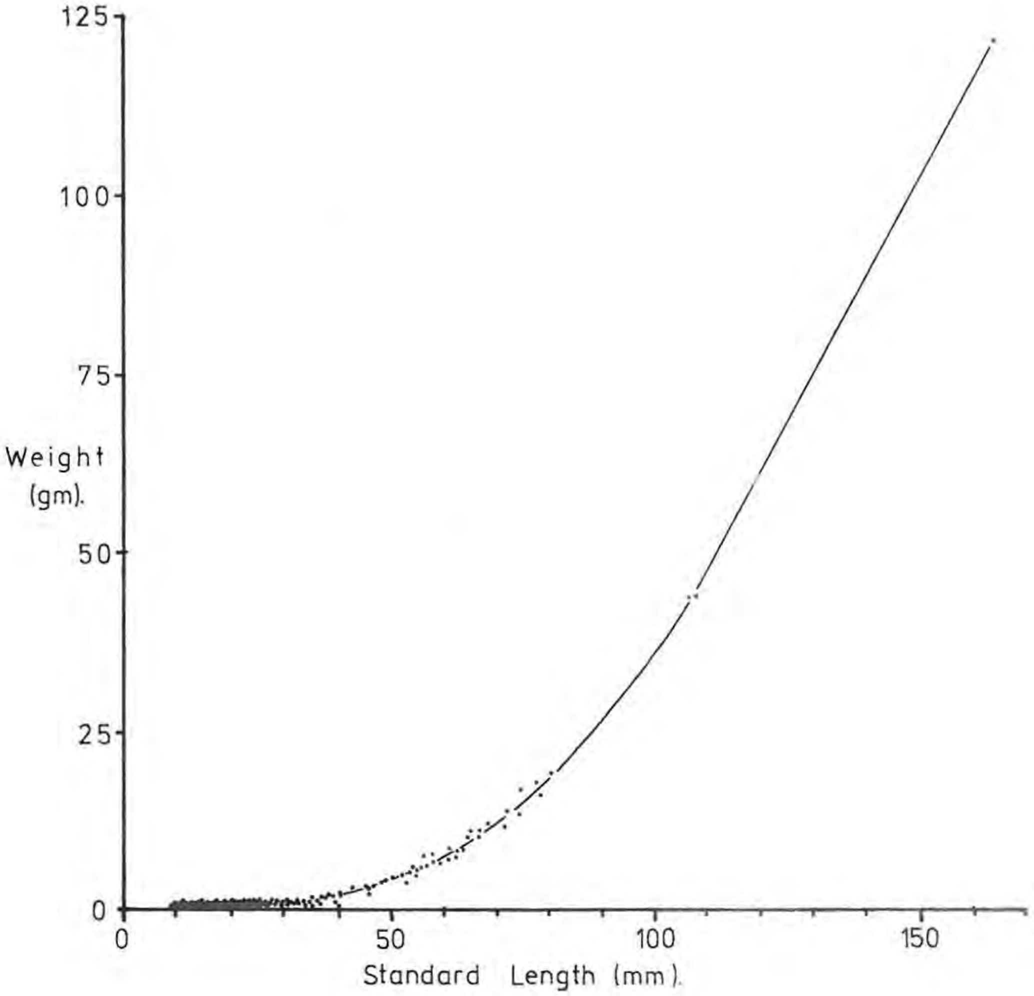
opportunistic. A similar correlation is seen with the amphipods Paramoera capensis, Parelasmopus suluensis and Lysianassa ceratina which occur commonly in the subtidal region (Table 4) and as food items.

POPULATION DYNAMICS

The length-weight relationships, length-frequency distributions and approximate ages were determined for all the fish. The length-weight relationship is of the form $w=a\ell^{b}$ (power regression) which is J-shaped or exponential. When the exponent b=3, growth is isometric, i.e., length and weight increase equally (Royce, 1972). The values obtained for the species studied are between 3,08 and 3,22. Monthly length-frequency distributions were drawn up following the method of Weatherley (1972) in order to determine approximate growth rates from modal distributions. The ages of very small fish were not determined as no rings could be observed in either scales or otoliths. The ages of large fish were determined by the scale method (Hagerman, 1952). The weights of some fish were not determined as the stomachs were removed in the field, with a resultant difference in the numbers recorded for the length-weight and length-frequency distributions.

DIPLODUS SARGUS

The length-weight relationship is given in Figure 6 (n=226). The values of the constants a and b (see above) are 0,024 and 3,19 and the power correlation coefficient is



<u>Figure 6</u>. Estimated length-weight relationship of *Diplodus sargus*. Curve drawn by inspection.

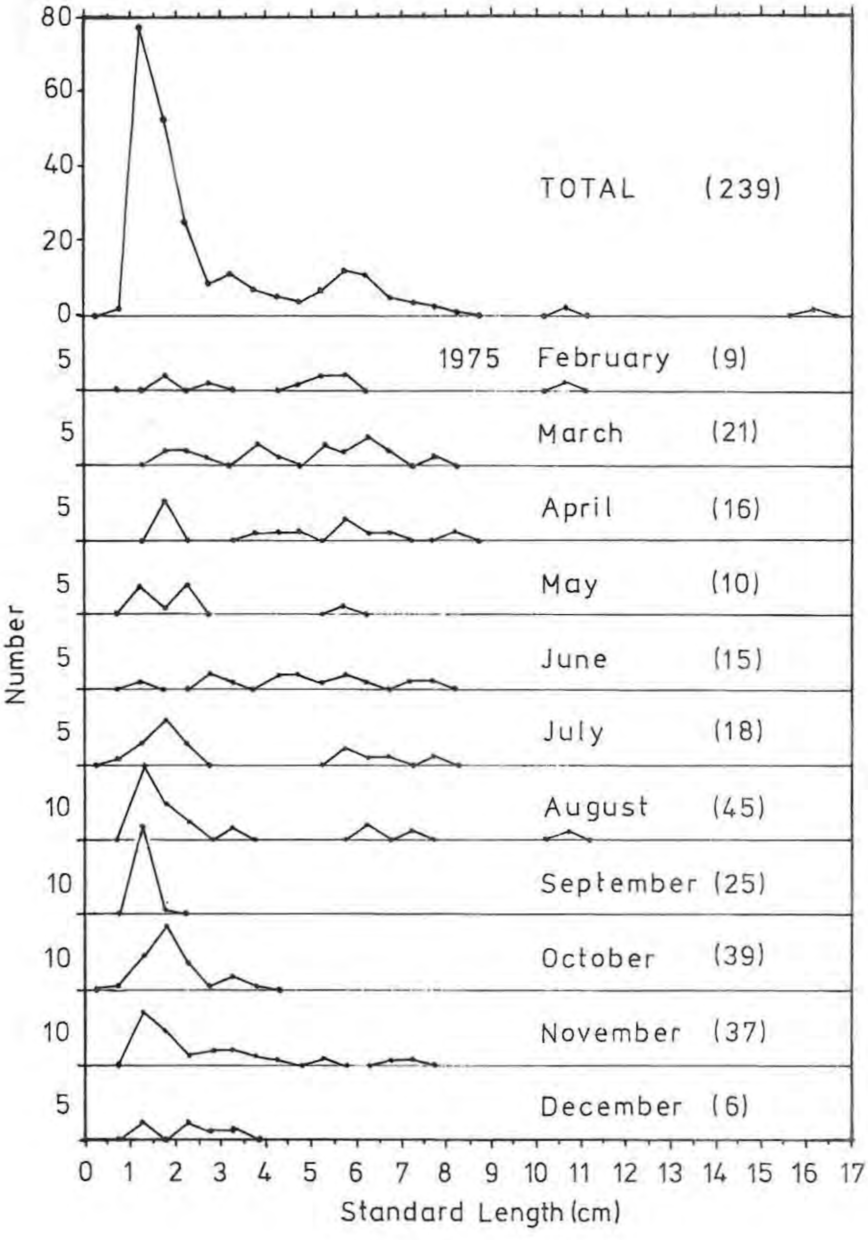


Figure 7. Monthly and total length-frequency distribution of the blacktail, *D. sargus*.

0,976. The monthly and total length-frequency distribution is given in Figure 7. The total lumped sample shows a mode in the 10 to 20 mm size class, indicating that larger fish have to some extent either emigrated to deeper water or died. The juveniles appear in the littoral zone when between 9 and 10 mm long (SL) and leave when about 90 mm long. As the tide rises, larger and larger individuals move into the littoral zone, two individuals (107 and 108 mm SL) being obtained 1 to 2 hours after low tide and one (164 mm SL) about 3 hours after low tide. Visibility in the pools of the research area was very low during September, October and December due to flooding of the Fish River and no fish longer than 40 mm were obtained as no dives were made.

Recruitment of the juveniles into the littoral appeared to be relatively constant, since no monthly peaks of abundance were found during the survey. Biden (1954) has suggested that females of this species spawn throughout the year, though mainly in the summer. A striking fact which has emerged from this survey is that the area under study at no time appears to be used as a breeding area for any of the three fish species studied, even at its deepest point of 3 metres below the spring low water mark. All samples of the population were of immature individuals, the reproductive tracts being so undeveloped that sexing was not possible. At no time were sexually mature fish encountered, and fertilized eggs and newly-hatched larvae of D. sargus, in common with those of most fish of the South African littoral region, remain to be found. The available evidence suggests that the fish breed in deeper water and that there is later a well-marked migration of juveniles to the shallow littoral when they are approximately 9 to 10 mm long.

Further evidence is required as to the age at which this species breeds. However, the age of two specimens of 107 and 108 mm SL was accurately determined to be 1 + years while that of a third specimen 164 mm long was 2 + years. This would suggest that breeding in D. sargus does not take place until at least the third year of life.

D. CERVINUS

The length-weight relationship is given in Figure 8 (n=57) the values of a and b are 0,03 and 3,08 with a power correlation coefficient of 0,994. The length-frequency distribution is given in Figure 9. The total lumped sample shows that the fish first appear in the littoral zone when about 8 mm in standard length and leave again when about 140 mm long. Large fish move in and out of the intertidal zone with the rising and falling tide as was found for D. sargus (Tables 2 and 3).

Monthly modes can be observed, labelled as A, B and C in Figure 9. Recruitment of juveniles into the tide pools is discontinuous, occurring between August and November (mode A) with a peak in October. The mode C represents the third year class of December 1975 (2 +), as analysis of the scales reveals that they were 1 + year old when sampled. The two individuals sampled in August (132 and 129 mm long) had

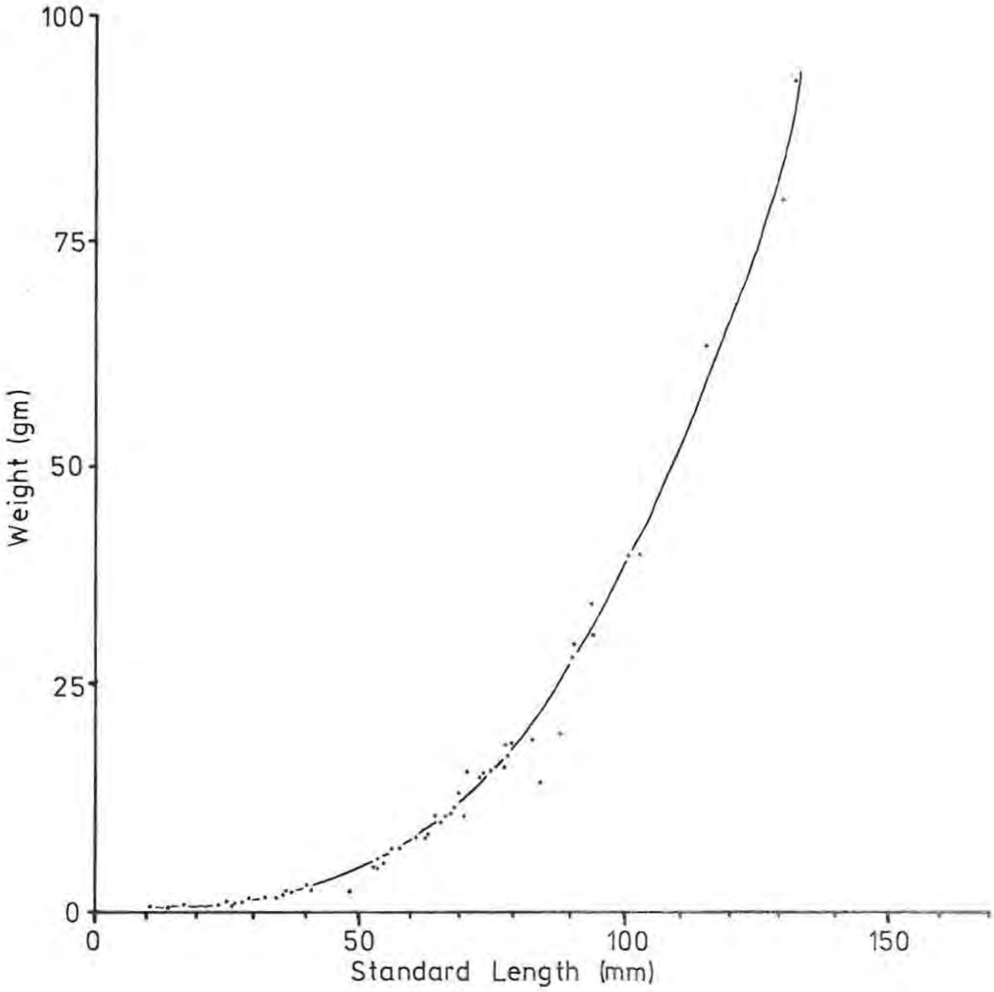


Figure 8. Estimated length-weight relationship of *Diplodus cervinus*. Curve drawn by inspection.

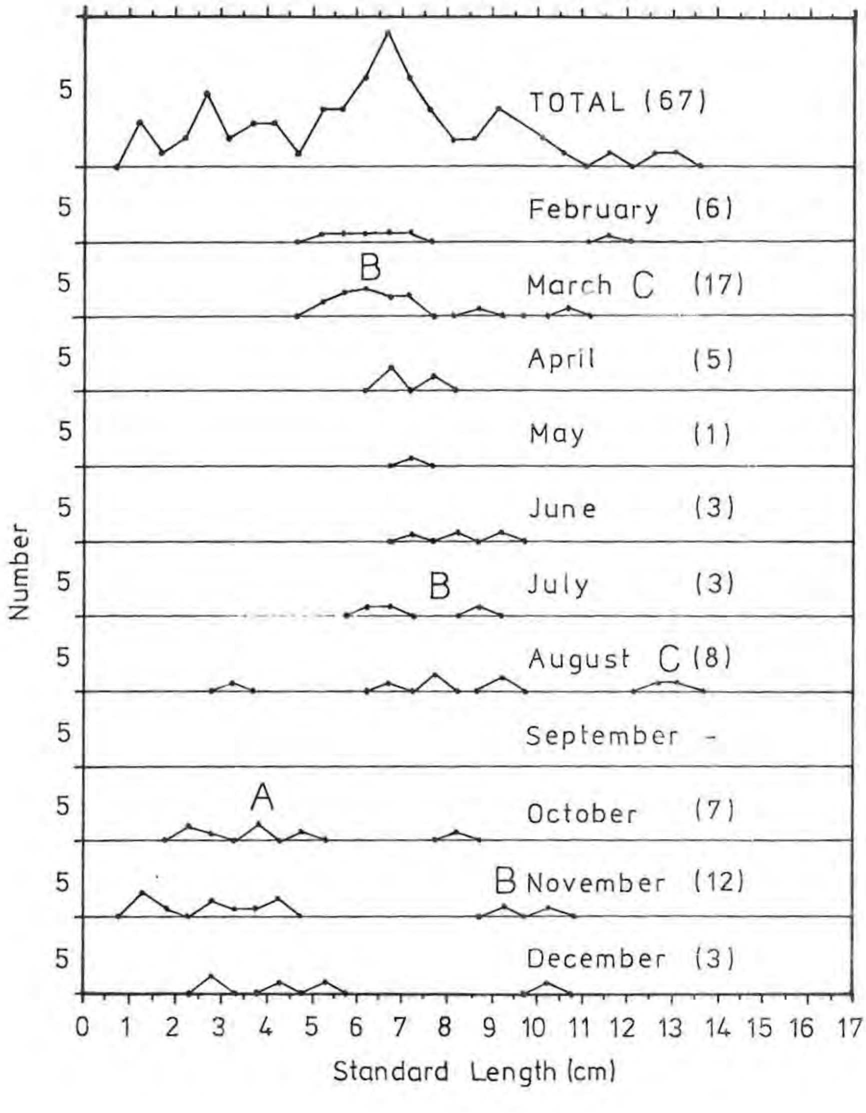


Figure 9. Monthly and total length-frequency distribution of the zebra, D. cervinus, showing modal progression. The modes are labelled A, B and C.

just formed the second ring, giving the approximate time of scale ring formation. The average growth rate determined for mode B is 4,5 mm/month or 54 mm/year (60 to 105 mm from February to December).

SARPA SALPA

The length-weight relationship is given in Figure 10 (n=112). The values for a and b are 0,017 and 3,22, with a power regression of 0,997. The length-frequency distribution is given in Figure 11 , which shows that the majority of the population is from 9 to 45 mm standard length. This may be due either to mortality or emigration. The juveniles appear in the tide pools when they are 9 mm long and fish longer than 100 mm are rarely observed in the littoral zone other than at high tide.

Three monthly modes are observed, labelled as A, B and C. Recruitment of the juveniles into the tidepools is discontinous and occurs between June and September (mode A). Modes B and C were nearly 1 year old and 1 1/2 years old when sampled. It therefore appears that three year classes have been sampled, the 0+ and 1+ of late 1974/early 1975 (modes B and C) and the 0+ of late 1975 (mode A). The time of scale ring formation is likely to have been about June. The average growth rate of mode A is estimated as 6 mm/month or 72 mm/year (10 to 55 mm from June to December).

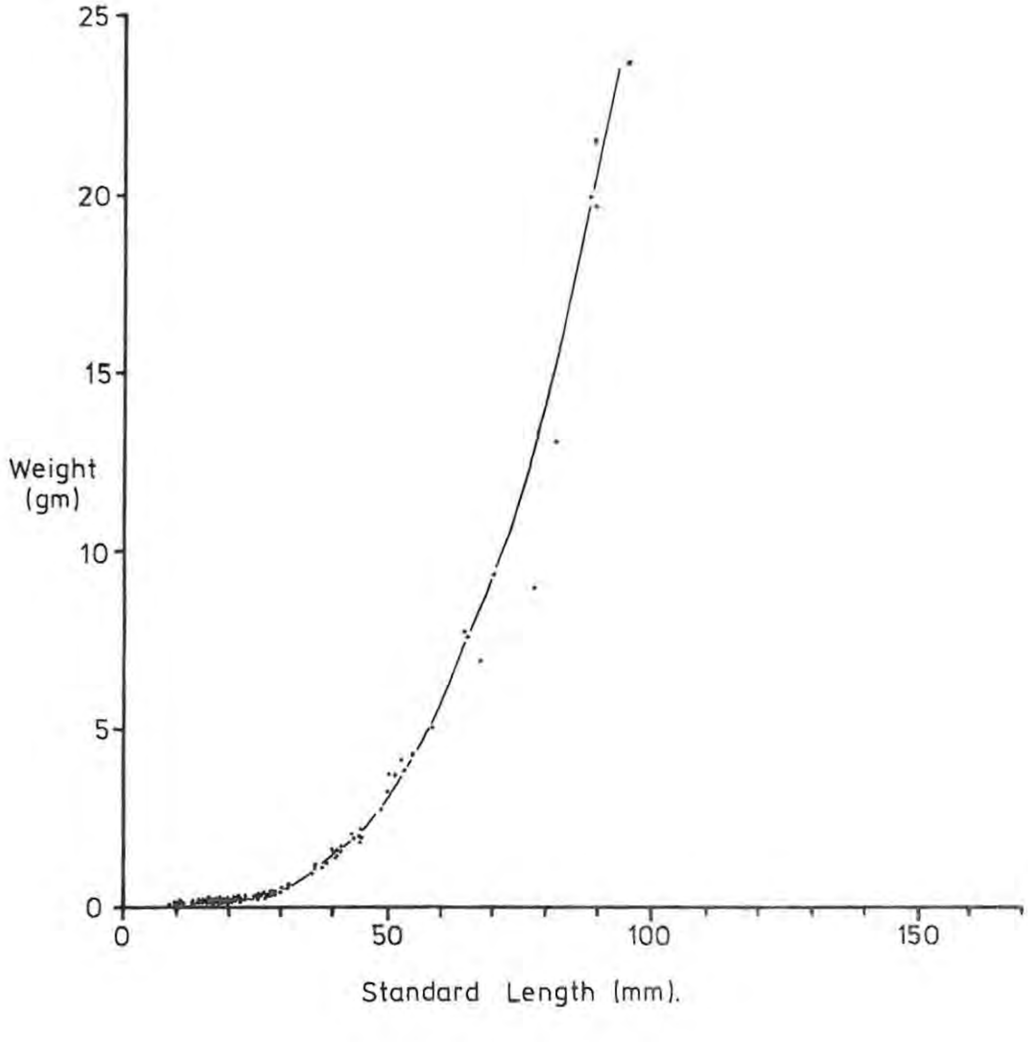


Figure 10. Estimated length-weight relationship of *Sarpa salpa*. Curve drawn by inspection.

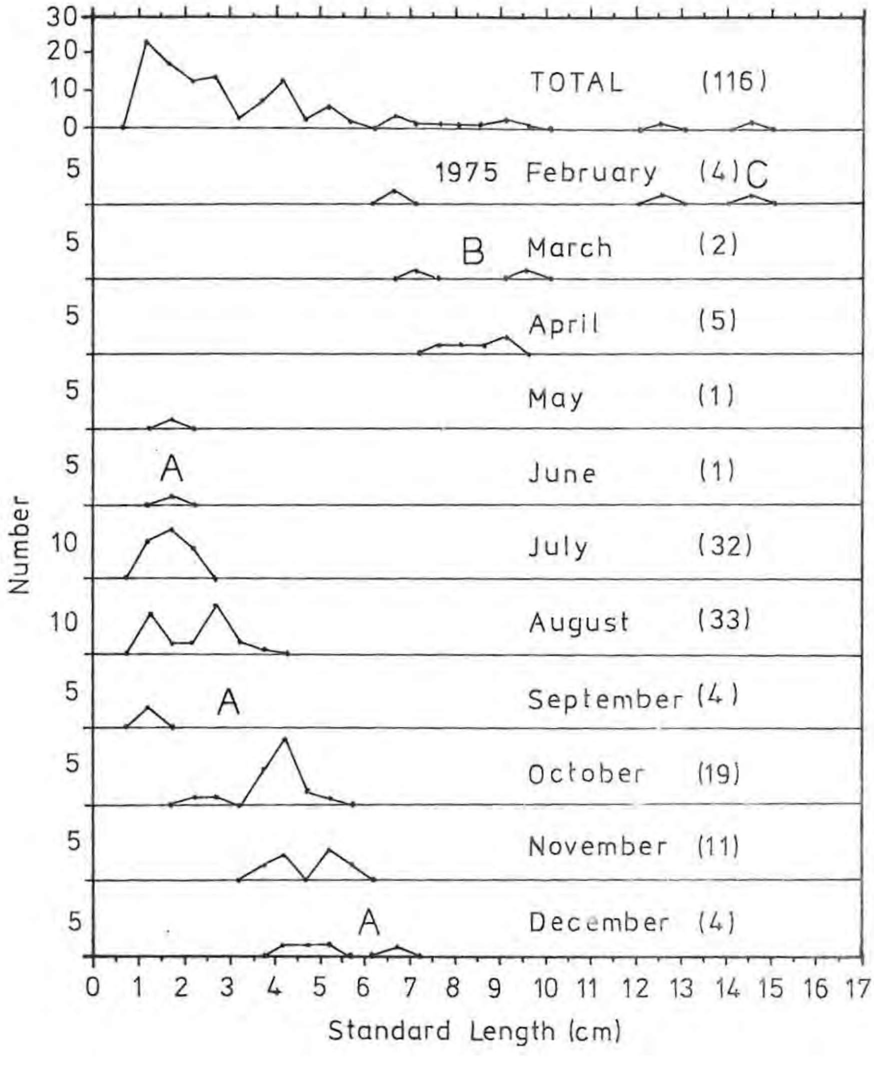


Figure 11. Monthly and total length-frequency distribution of the strepie, S. salpa, showing modal progression. The modes are labelled A, B and C.

FOOD HABITS AND CORRELATED MORPHOLOGY

Two of the four methods of analysis attempted can be considered accurate, these being the points and ranking index methods. The volume and degree of fullness of the stomach are estimated in order to determine the number of points allotted in this study, whereas only the volume is estimated to calculate the ranking index, and so the latter is less subjective. The percentage composition of the diet is therefore calculated for arbitrary size classes using the ranking indices and is illutrated in Figures 12, 13, 15 and 17. The values obtained for the same size classes, using all four analytical methods, are given in Appendices 1 to 32. The diet of *D. sargus* changes with season and the data are therefore presented separately for the months August to December and February to July. No seasonality was observed in the case of the other fish species.

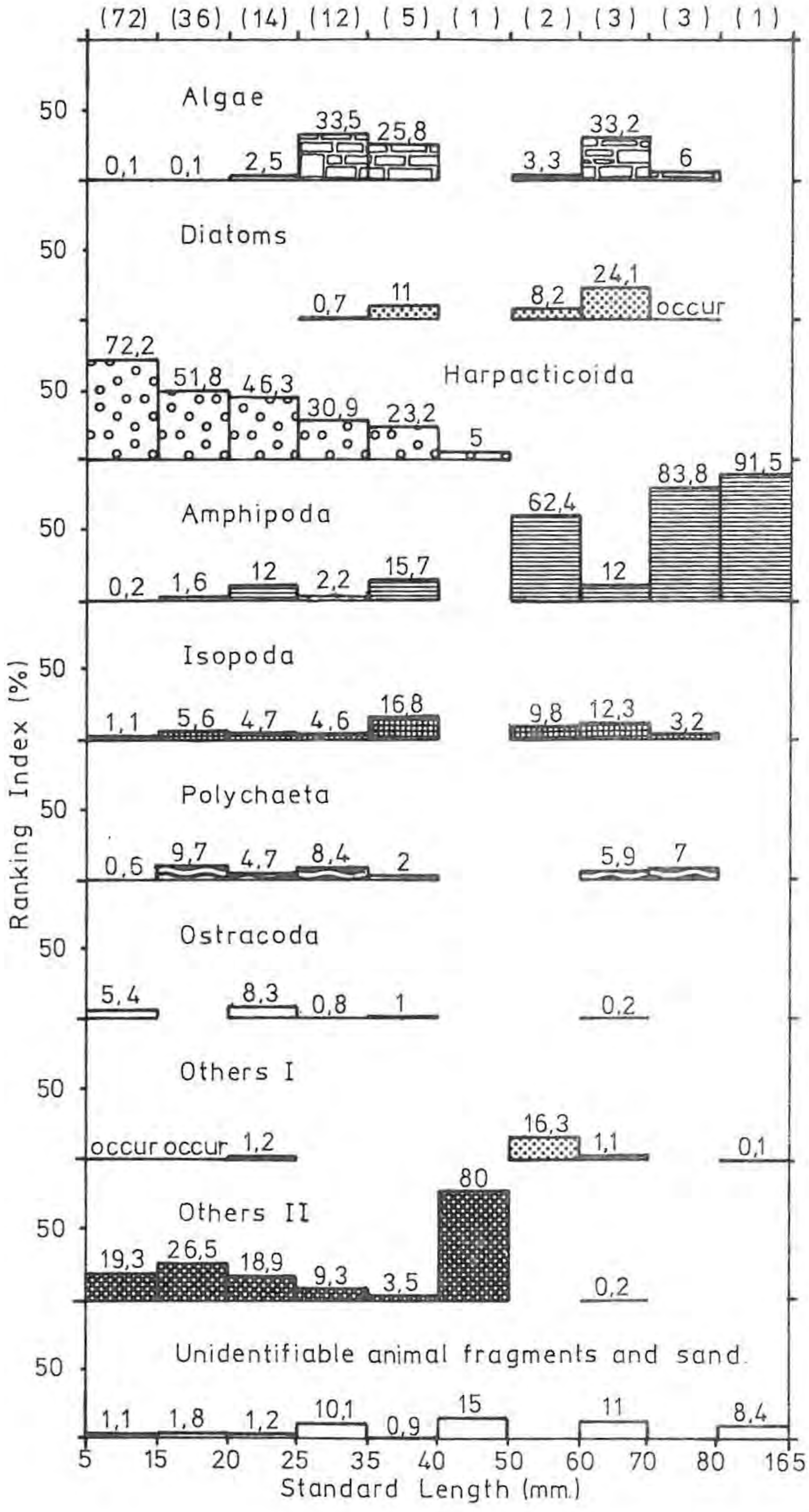
The teeth were examined of fish cleared and stained using the method of Taylor (1967). The gut of the fish was dissected out, drawn and measured, and then the ratio of total gut length to standard length (S.L.) was calculated.

DIPLODUS SARGUS

Summer feeding:

The "summer" period spans the months August to December and the diet is shown in Figure 12 and listed in Appendices 1 to 10 (n=149).

Figure 12. Feeding histogram for successive size classes of *Diplodus sargus* from August to December 1975. The number examined in each size class is given in parentheses. The Others I section includes: brachyura, mollusca, hydrozoa, echinoderms, tanaidacea, *Palaemon pacificus* and mysidacea. The Others II section includes: insecta, cirripede nauplii, zoaea, leptostraca and unidentifiable planktonic larvae.



(72) (36) (14) (12) (5) (1) (2) (3) (3) (1)
Algae
0,1 0,1 2,5 33,5 25,8 3,3 33,2 6
Diatoms
0,7 11 8,2 24,1 occur
Harpacticoida
72,2 51,8 46,3 30,9 23,2 5
Amphipoda
0,2 1,6 12 2,2 15,7 62,4 12 83,8 91,5
Isopoda
1,1 5,6 4,7 4,6 16,8 9,8 12,3 3,2
Polychaeta
0,6 9,7 4,7 8,4 2 5,9 7
Ostracoda
5,4 8,3 0,8 1 0,2
Others I
occur occur 1,2 16,3 1,1 0,1
Others II
19,3 26,5 18,9 9,3 3,5 80 0,2
Unidentifiable animal fragments and sand
1,1 1,8 1,2 10,1 0,9 15 11 8,4
50
Ranking Index (%)
5 15 20 25 35 40 50 60 70 80 165
Standard Length (mm)

The diet of the smallest size class (5 to 15 mm) is composed mainly of harpacticoid copepods (72,2%), cirripede nauplii (8,2%), chironomid larvae (6,5%) ostracods (5,4%) and unidentified planktonic larvae (4,5%). Other food items include isopods (1,1%), polychaetes (0.6%), amphipods (0,2%), algae (0,1%), leptostracans and unidentifiable fragments (1,1%). The next size class (15-20 mm) feeds on a similar diet, although the percentage of harpacticoids taken decreases to 51,8 and that of polychaetes and cirripede nauplii increases to 9,7 and 22,3 respectively (App. 2). These changes are magnified in the 20-25 mm size class (App. 3), harpacticoids only contributing 46,3% of the diet whereas amphipods now contribute 12% and ostracods 8,3% and cirripede nauplii are still important (17,2%).

In the next size class (25-35 mm) there is a sudden change and the green alga, Ulva contributes 32,2% (App. 4). This is also the smallest size class in which diatoms occur, contributing 0,7% and harpacticoid copepods now only contribute 30,9% of the diet. The percentage of Ulva taken remains high in the next size class (24,4%, App. 5) and that of diatoms and amphipods increases to 11 and 15,7 respectively. By this time, the harpacticoid copepods only contribute 23,2% and chironomid larvae, 3,5%.

The poor diving conditions during the months of September, October and December permitted the analysis of the diet of only 10 fish in the size range 40 to 165 mm SL (Apps. 6 to 10). In general, these fish showed an increasing tendency to take amphipods, while algae, diatoms, insects and hydrozoa in general contribute relatively small fractions to the whole.

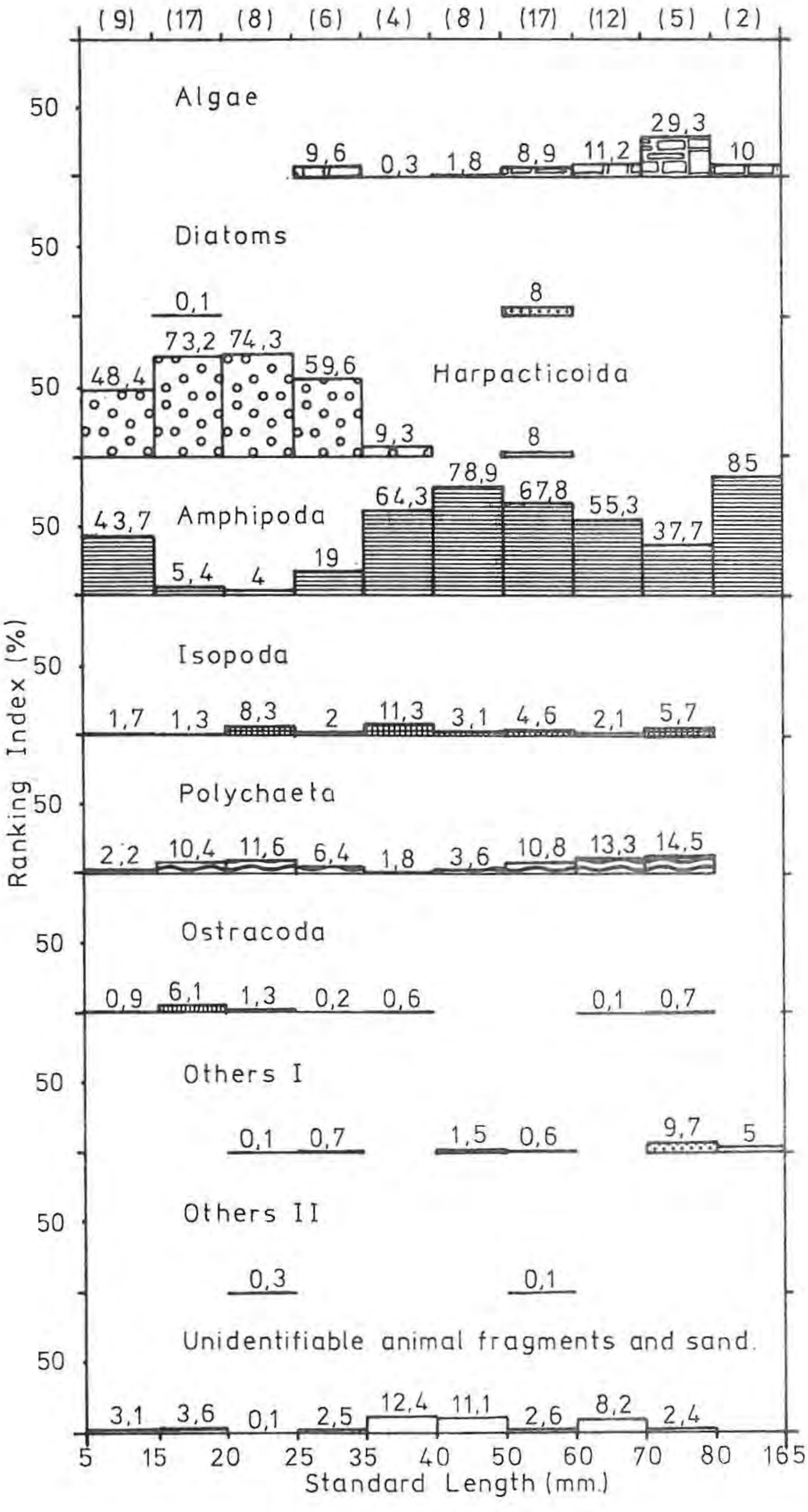
Winter feeding:

The "winter" period spans the months February to July and the diet is shown in Figure 13 and Appendices 11 to 20 (n=88).

The diet of the smallest size class (5 to 15 mm., App.11) is composed almost equally of harpacticoid copepods (48,4%) and amphipods (43,7%). Polychaetes (2,2%), isopods (1,7%) and ostracods (0,9%) contribute a small part to the diet. The percentage of harpacticoid copepods consumed increases to 73,2 in the next size class (15 to 20 mm, App. 12) whereas that of amphipods decreases to 5,4. Diatoms also occur in two fish (0.1%) and polychaetes and ostracods are fairly important (10,4 and 6,1%).

Harpacticoid copepods continue to be important in the 20-25 mm (74,3% App. 13) and 25 to 35 mm (59,6% App. 14) size classes. Otherwise the diet is similar, with the exception of the alga Ulva and amphipods which constituted 9,6 and 19% of the diet in the 25 to 35 mm size class. In the 35 to 40 mm size class (App.15), however, harpacticoid copepods only form 9,3% of the diet. The remainder of the food taken was composed largely of amphipods (64,3%). The situation is similar in the next three size classes, amphipods contributing 78,9, 57,8 and 55,3% to the 40 to 50 mm (App. 16), 50 to 60 mm (App. 17) and 60 to 70 mm (App. 18) size classes. Harpacticoid copepods occur only in the 50 to 60 mm size class (4,6%) and algae and polychaetes become more and more important as the size increases. Amphipods are still the most important food item

Figure 13. Feeding histogram for successive size classes of *Diplodus sargus* from February to July 1975. The number examined in each size class is given in parentheses. Both of the Others sections include the same food items as described for Fig. 12.



(9) (17) (8) (6) (4) (8) (17) (12) (5) (2)
Algae
9,6 0,3 1,8 8,9 11,2 29,3 10
Diatoms
0,1 8
Harpacticoida
48,4 73,2 74,3 59,6 9,3 8
Amphipoda
43,7 5,4 4 19 64,3 78,9 67,8 55,3 37,7 85
Isopoda
1,7 1,3 8,3 2 11,3 3,1 4,6 2,1 5,7
Polychaeta
2,2 10,4 11,6 6,4 1,8 3,6 10,8 13,3 14,5
Ostracoda
0,9 6,1 1,3 0,2 0,6 0,1 0,7
Others I
0,1 0,7 1,5 0,6 9,7 5
Others II
0,3 0,1
Unidentifiable animal fragments and sand.
3,1 3,6 0,1 2,5 12,4 11,1 2,6 8,2 2,4
50
Ranking Index (%)
5 15 20 25 35 40 50 60 70 80 165
Standard Length (mm.)

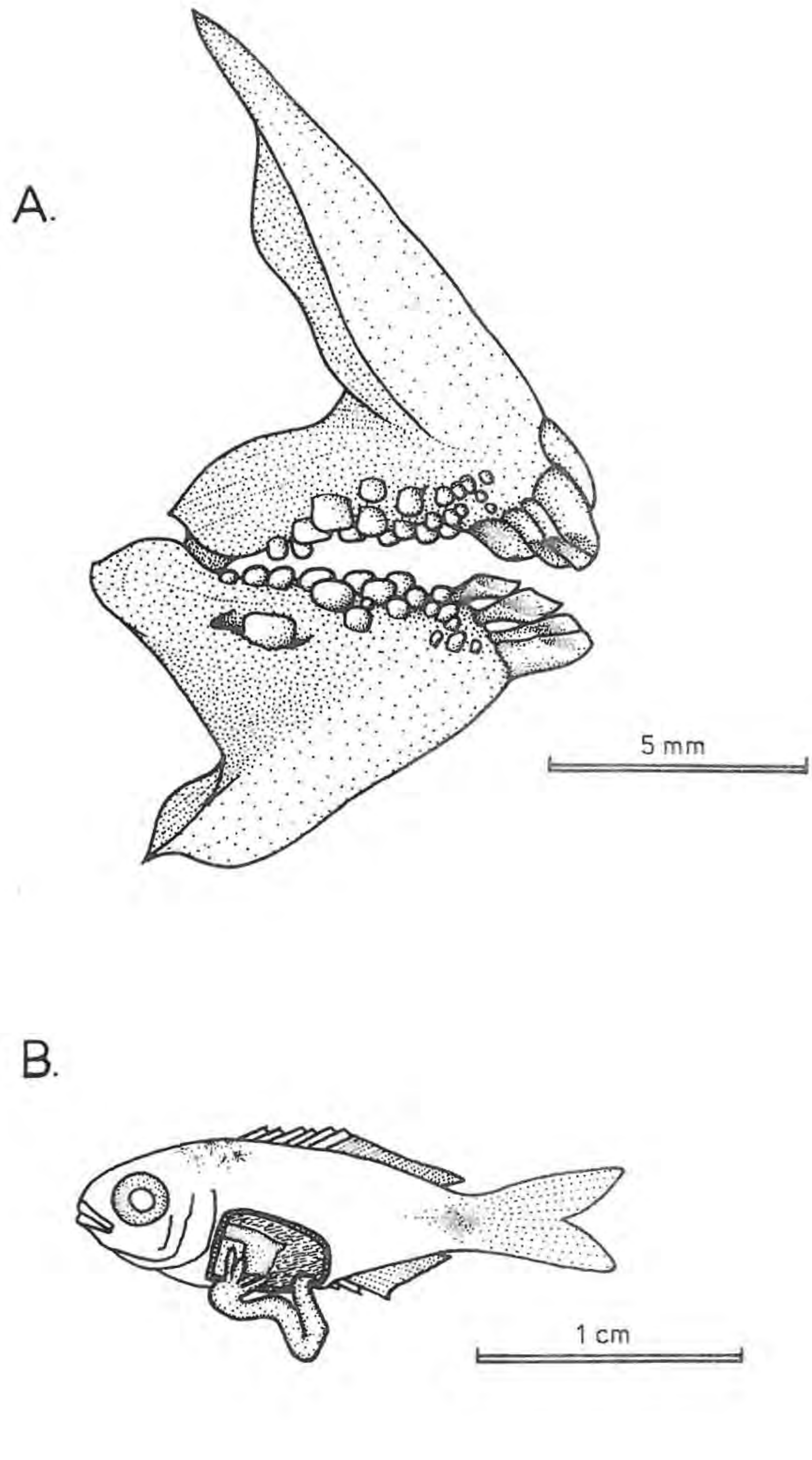


Figure 14. A. Medial view of upper and lower jaws of D. sargus (MSC 75-34, 107 mm SL). B. Lateral view of the left side of D. sargus (MSC 75-37, 16,5 mm SL) with the stomach and intestine dissected out.

in the largest size classes, contributing 37,7% to the 70 to 80 mm size class (App. 19) and 85% to the 80 to 165 mm size class (App.20). The chlorophytan algae Ulva and Caulerpa filiformis are also important, the diet of the two size classes consisting of 29,3% and 10% algae respectively. Molluscs are also eaten, contributing to 6,5 and 1,2% of the diet of the 70 to 80 mm and 80 to 165 mm size classes (App. 19 to 20). The rhaciglossid molluscs could not be identified further as the shells were not found in the stomachs. This is in contrast to the small limpets which were ingested entire. The sea urchin of the genus Parechinus contributed 1,8% (App. 19) and a crab 1,4% (App. 19) to the diet of the 70 to 80 mm size class.

Dentition and external gut morphology:

The medial view of the upper and lower jaws of a fish 107 mm long is shown in Figure 14A. The teeth consist of 4 incisors in both jaws and 3 rows of molars in the upper and lower jaws respectively. The number and size of these molars increases with age. These teeth are those of a typical omnivore (Weatherly, 1972), as is the gut which is short (Figure 14b) with a total gut length to standard length ratio of 0,76 in a 16,5 mm individual.

DIPLODUS CERVINUS

Diet:

The composition of the diet is illustrated in Figure 15 and given in Appendices 21 to 26 (n=67).

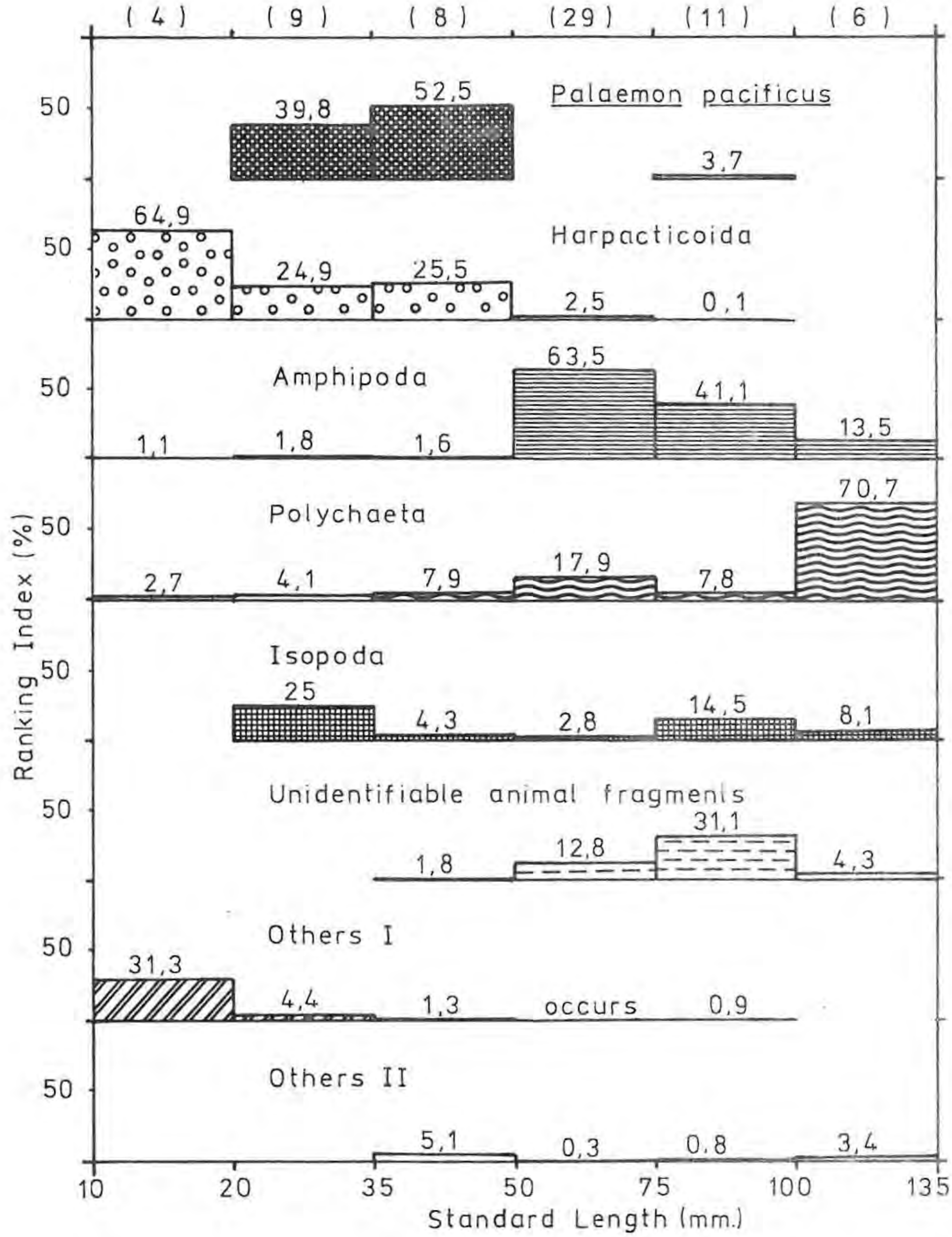
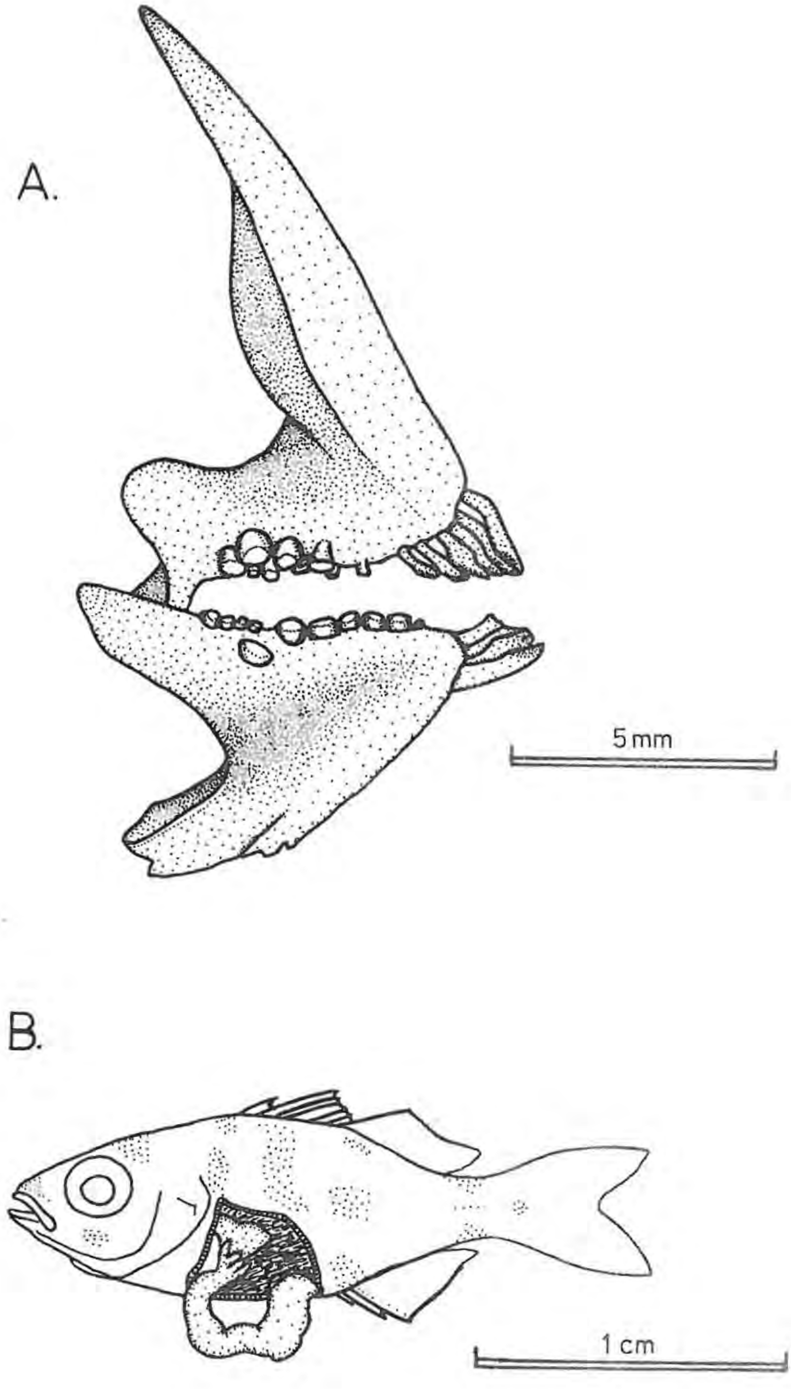


Figure 15. Feeding histogram of successive size classes of D.cervinus from February to December 1975. The number examined in each size class is given in parentheses. The Others I section includes: Insecta, ostracoda, cirripede nauplii and unidentifiable planktonic larvae. Others II includes: Chlorophyta, corallines, mysidacea, tanaidacea and mollusca.

The juveniles (10 to 20 mm, App. 21) feed mainly on harpacticoid copepods (64,9%) and chironomid larvae (31%). Polychaetes (2,7%), amphipods (1,1%) and unidentified planktonic larvae (o,3%) comprise the rest of the diet. In the next size class (20 - 35 mm, App. 22) there is a changeover, the sandshrimp, Palaemon pacificus, (39,8%), isopods (25%) and harpacticoid copepods (24,9%) contributing almost equally. Chironomid larvae, polychaetes and amphipods are present in small amounts. This trend continues in the next size class (35 to 50 mm App. 23), the diet being composed of 52,5% Palaemon pacificus, 25,5% harpacticoid copepods but only 4,3% isopods. Polychaetes are more important (7,9%) in this size class. In the next two size classes, there is again a changeover. The percentage composed of amphipods increases to 63,5% (50 to 75 mm App. 24) and 41,1% (75 - 100 mm, App. 25), that of P. pacificus falls to 0 and 3,7 and that of polychaetes is 17,9 and 7,8. Isopods (14,5%) are important in the larger size class and unidentifiable animal fragments comprise 12,8 and 31,1% respectively. This last may be partly explicable in that six of the fish were taken at night and their stomach contents were unidentifiable in most cases. The diet of the largest size class (100 to 135 mm, App.26) is composed mainly of polychaetes (70,7%) as well as amphipods (13,5%), isopods (8,1%) amd corallines (3,4%).

Dentition and external gut morphology:

A medial view of the upper and lower jaws of a 94 mm long fish is shown in figure 16A. There are six upper and four lower incisors and fewer molars than are found in D. sargus, although they are typically those of an omnivore (Weatherly, 1972).



<u>Figure 16</u>. A. Medial view of the jaws of *D.cervinus* (MSC 75-36, 94mm SL). B. Lateral view of the left side of *D.cervinus* (MSC 75-37, 16,5mm SL) with the stomach and intestine dissected out and displayed.

The gut is short (Figure 16B) as in D. sargus, fish of 16,5 mm and 74 mm length having gut S.L. ratios of 0,7 and 0,95 respectively.

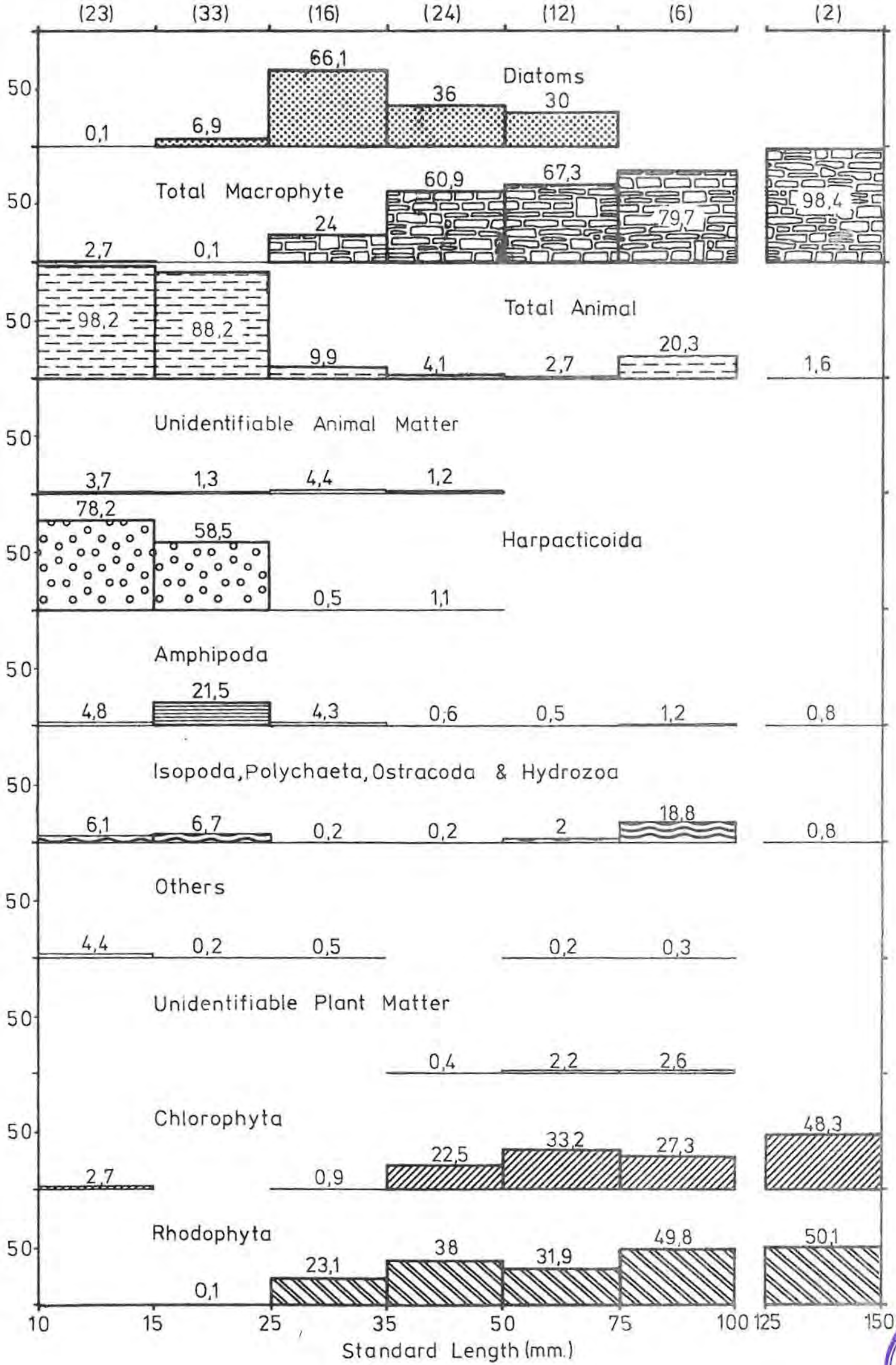
SARPA SALPA

Diet:

The percentage composition of the diet (ranking index) is illustrated in Figure 17 and the values obtained by the four methods of analysis are given in Appendices 27 to 33 (n=116). The total percentages of macrophytic algae and animals are included in Figure 17 in order to emphasise the changeover in diet with age.

The juveniles (10 to 15 mm, App. 27) feed mainly on harpacticoid copepods (78,2%), the remainder of the diet being composed of amphipods (4,8%), other animals (10,5%), chlorophytan algae (2,7%) and diatoms (0,1%). The same trends are observed in the 15 to 25 mm size class (App. 28) as harpacticoid copepods contribute to 58,5% of the diet. The incidence of amphipods (21,5%) and diatoms (6,9%), however, increases. The diet is completely different in the 25 to 35 mm size class (App. 29), being composed of 66,1% diatoms and 23,1% rhodophytan algae, with the total animal contribution being 9,9%. The importance of diatoms (36%) decreases in the 35 to 50 mm size class (App. 30) as that of rhodophytan (38%) and chlorophytan algae (22,5%) increases. This trend is again observed in the 50 to 75 mm size class (App. 31), the diet being composed of 30% diatoms, 33,2% chlorophytan algae and 31,9%

Figure 17. Feeding histogram for successive size classes of *Sarpa salpa* from February to December 1975. The number examined in each size class is given in parentheses. The Others section includes: mysidacea, insects, zoaea, leptostraca, cirripede nauplii, fish muscle, rhaciglossid molluscs, bryozoa and tanaidacea.


(23)
(33)
(16)
(24)
(12)
(6)
(2)
Diatoms
0,1
6,9
66,1
36
30
Total Macrophyte
2,7
0,1
24
60,9
67,3
79,7
98,4
Total Animal
98,2
88,2
9,9
4,1
2,7
20,3
1,6
Unidentifiable Animal Matter
3,7
1,3
4,4
1,2
Harpacticoida
78,2
58,5
0,5
1,1
Amphipoda
4,8
21,5
4,3
0,6
0,5
1,2
0,8
Isopoda, Polychaeta, Ostracoda & Hydrozoa
6,1
6,7
0,2
0,2
2
18,8
0,8
Others
4,4
0,2
0,5
0,2
0,3
Unidentifiable Plant Matter
0,4
2,2
2,6
Chlorophyta
2,7
0,9
22,5
33,2
27,3
48,3
Rhodophyta
0,1
23,1
38
31,9
49,8
50,1
50
10
15
25
35
50
75
100
125
150
Standard Length (mm.)

rhodophytan algae. Almost all of the diet of the two largest size classes is composed of macrophytic algae, the 75 to 100 mm (App. 32) and 125 to 150 mm (App. 33) size classes feeding on 27,3 and 48,3% chlorophytan algae and 49,8 and 50,1% rhodophytan algae respectively. Hydrozoans (Gattya humilis and Thecocarpus formosus)form a fair proportion of the diet (18,6%) of the 75-100 mm size class as well, and no diatoms are eaten by either size class.

Dentition and external gut morphology:

Lateral views of the upper and lower jaws of fish 99 and 20 mm long are shown in Figure 18A and C, as well as a view of a single tooth of an individual 39 mm long. The teeth are initially pointed and conical in the juvenile, and are replaced by incisiform teeth as the fish grows. The anterior incisiform tooth breaks through when the fish is some 20 mm long (Figure 18C) and is multicusped (Figure 18B).All the conical teeth have been replaced by the time the fish is 35 mm long and the multiple cusps are worn away, leaving two cusps when the fish are approximately 65 mm long. This change in dentition is correlated with the diet, as juveniles feed on animal life which can be seized and held by the conical teeth, whereas the adults feed on algae which are nipped off by the incisiform teeth.

The gut of a juvenile is that of a typical omnivore (Weatherly, 1972) with a ratio of 0,86, shown in Figure 19C. As the fish grows longer, the gut-standard length ratio increases, being 1,36 in a fish 39 mm long (Figure 19B) and 2,66 in one 99 mm long (Figure 19A). The diet changes as well,

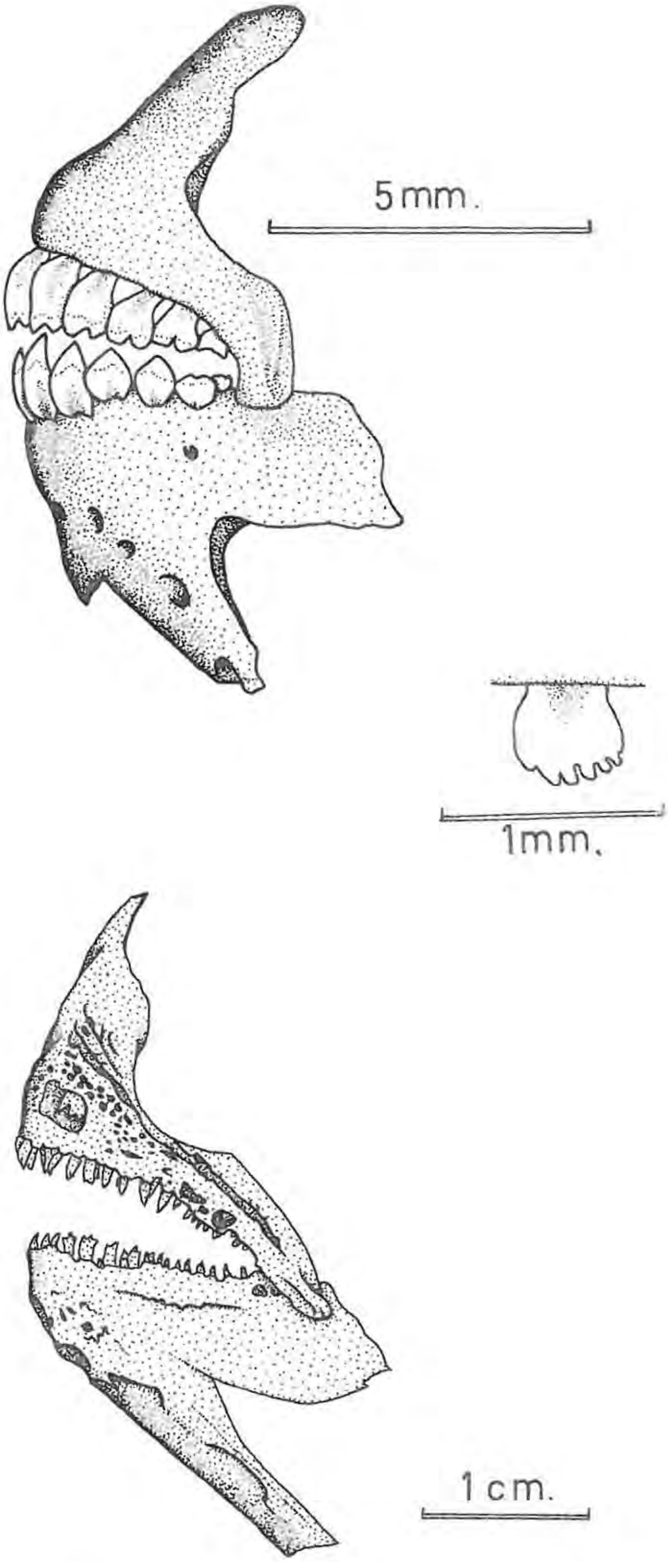


Figure 18. A. Lateral view of the jaws of S.salpa (RUSI 74-323, 99mm SL). B. Lateral view of a single tooth of S.salpa (MSC 75-37, 39mm SL). C. Lateral view of the jaws of S.salpa (MSC 75-39, 20mm SL).

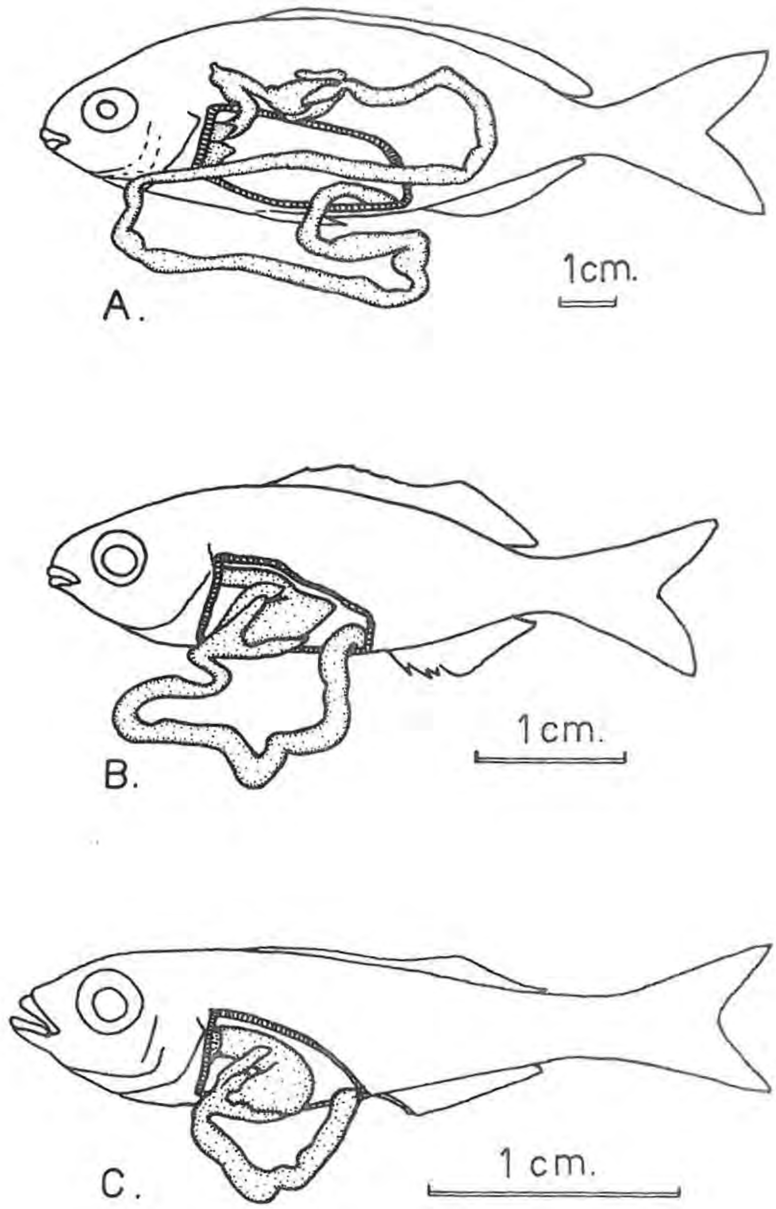


Figure 19. Lateral views of S. salpa with the gut unravelled and displayed. A. 99mm SL (RUSI 74-323). B. 39mm SL (MSC 75-37). C. 20mm SL (MSC 75-39)

being composed of 60,9 and 79,7% macrophytic algae in these two size classes (Figure 16). Similarily the diet of the smallest size class described above is composed of 88,2% animal matter. The change in gut length and dentition is commonly observed in fish that feed on animal life when juvenile and later on become herbivores (Weatherly 1972).

DISCUSSION

The resources at Clayton's Rocks are subdivided in two ways amongst the three cohabiting sparids. Firstly, the fish have several types of feeding behaviour, a fact which is reflected in the diet, and secondly, they are recruited into the tidepools at different times of the year with resultant temporal separation. In very broad studies of the interrelationships of fishes, Hiatt and Strasburg (1960), Keast, (1965 and 1966), Randall, (1967) and Hobson (1974) have observed a distinct separation of groups of fish species into carnivores, omnivores and herbivores, although individual species are either specialized or opportunistic feeders. In the littoral zone, far less obvious separations have been reported from the Atlantic coast of France by Gibson (1968 and 1972) as the fish species were all found to feed mainly on amphipods and other crustacea and to a greater or lesser extent on other food items. This tendency to feed very largely on crustaceans was also found in the present study, with the exception of adult S. salpa which are herbivorous. Juvenile D. sargus, D. cervinus and S. salpa feed mainly on harpacticoid copepods whereas the sub-adults feed on amphipods. This relationship between the size of predator and prey has also been observed by Keast (1966), Wurtsbaugh et al. (1975) and others. Changes in dentition are correlated with the diet as are gut lengths. For the purposes of this discussion the data collected has been categorized as below.

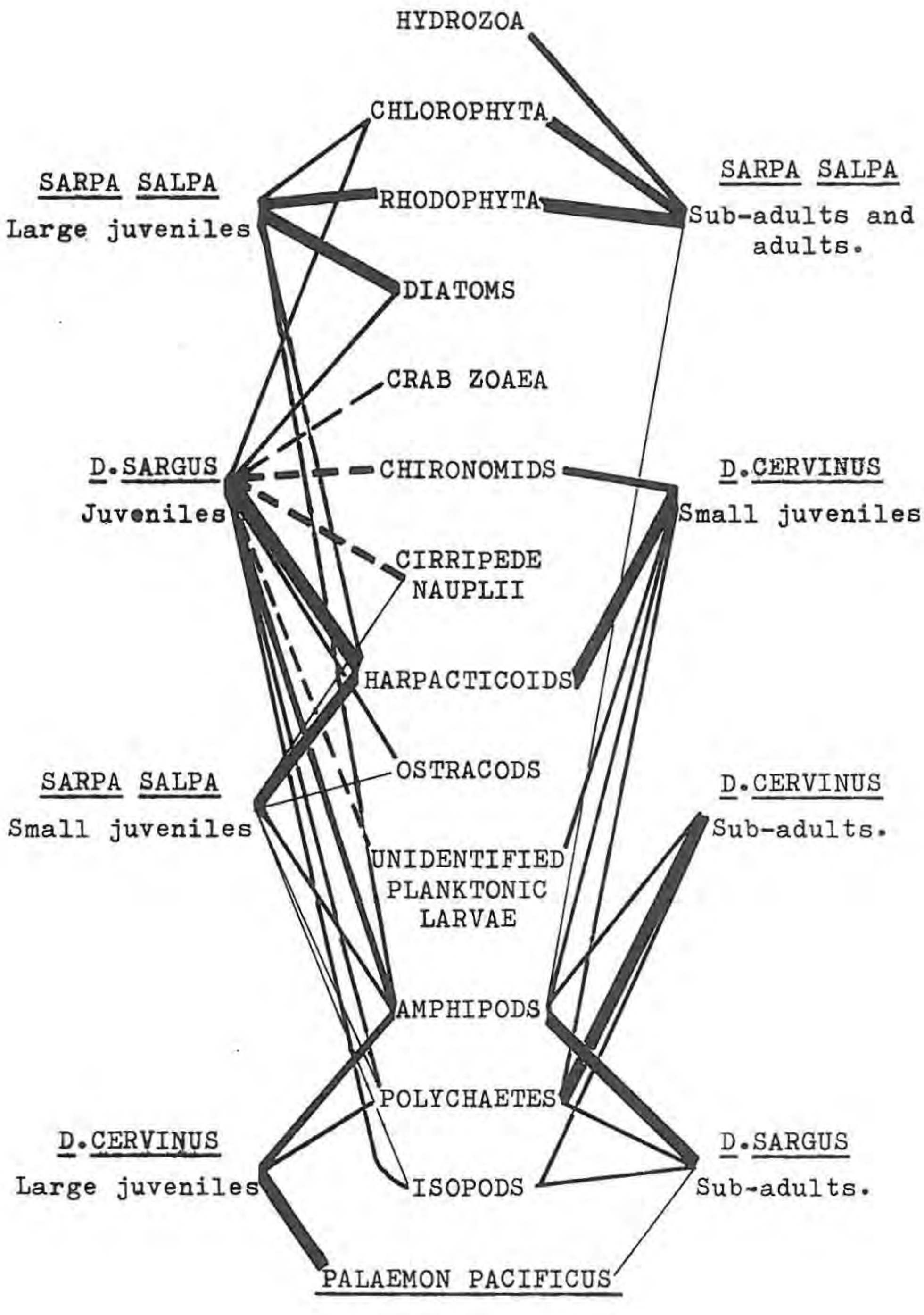
ECOLOGICAL SEPARATION

Subdivision of food resources at Clayton's Rocks:

A simplified food web has been drawn up for the species studied and is shown in Figure 20. Gause's principle of competitive exclusion would appear to operate for all size classes of the fish species studied. Very little, if any, subdivision of food is shown by the smallest size classes of all three species, although there is little competition as the diet is predominantly composed of harpacticoid copepods which appeared to be enormously abundant in this environment. The diet of the three species is, however, very different by the time they are 25 mm long, *D. sargus* feeding on harpacticoid copepods and amphipods as well as cirripede nauplii (in summer), *D. cervinus* feeding on the sandshrimp *Palaemon pacificus*, copepods and isopods, and *S. salpa* ingesting diatoms and rhodophytan algae. This resource subdivision is even more obvious in the sub-adults as then *D. sargus* feeds on amphipods and chlorophytan algae, *D. cervinus* feeds mainly on polychaetes and *S. salpa* is entirely herbivorous.

Thus for most of the year there is no competition, as the large juveniles and sub-adults feed on different foods and the

Figure 20. Simplified food web of the three sparid fish studied at Clayton's Rocks between February and December 1975.



The thickness of lines is an approximate measure of the importance of each food item to that particular fish. The dotted lines indicate those food items only taken in the summer season.

only juveniles present are those of D. sargus. From July to November, however, there is evidence of competition as first S. salpa juveniles, then those of D. cervinus appear in the tide pools. S. salpa feeds mainly on harpacticoid copepods until 25 mm long (App. 27 and 28) which is in competition with D. sargus. But two factors may reduce this interspecific competition. Firstly, the majority of the S. salpa juveniles below 25 mm appear before August (Figure 11) when the juvenile D.sargus of that time-period are feeding on amphipods as well as harpacticoids (Figure 13), and secondly, there may be an abundance of copepods in the environment at this time of year. The two fish species feed in mixed schools at this time and it is therefore possible that the second hypothesis is correct, assuming that the principle of competitive exclusion is operating.

Several alternative food supplies are present by the time the juveniles of D. cervinus appear in October. The competitive pressure between the small juveniles of D. sargus and D. cervinus is reduced by the appearance of cirripede nauplii, chironomid larvae and unidentifiable planktonic larvae in the littoral zone at this time. These are fed on by both species in addition to harpacticoid copepods (Appendices 1, 2 and 21). Later on, the young of the sandshrimp P. pacificus make their appearance in large numbers in the intertidal area and these, together with isopods of the genus Janiropsis, are fed on by the middle-size juveniles of D. cervinus (Apps. 22 & 23).

Competition between large juveniles of the three fish species is reduced by a number of mechanisms. Those of D. sargus feed on diatoms and amphipods while D. cervinus feeds on amphipods and polychaetes, and S. salpa feeds on diatoms and rhodophytan algae. This period of high feeding intensity on diatoms coincides with a period of abundance of the food item. Diatoms of the genus Lycmophora have been obtained in substrate samples taken in October only (peak predation pressure), growing epiphytically on the rhodophytan alga, Hypnea spicifera. S. salpa is a highly specialized feeder at this time, as the algae consumed with the diatoms are largely epiphytic as well, growing on coralline algae. These epiphytes are rarely more than 5 mm long (total length) e.g. Ceramium spp. and Centroceras spp., and yet no corallines are ingested. Fragments of other macrophytes are ingested (App. 29) notably of Hypaea spicifera and Tayloriella spp. on which diatoms grow epiphytically (see above). It therefore seems likely that these fragments are ingested with the diatoms. This is in contrast to the situation found for Rhabdosargus holubi (Blaber, 1974) where algae were eaten specifically for the epiphytic diatoms present.

Similar separation of fish species by specialization of feeding habits has been observed in Jones Creek, Ontario (Keast 1966), where certain fishes exhibited preferences for uncommon food items even when others were common and cohabited with the preferred food. The diet was also found to change with season and age although temporal separation due to discontinuous recruitment of the fish and their food such as was found in the present study was not reported. This evolution of specialized feeding habits is greatest in the tropical seas where a multitude of highly evolved teleosts cohabit on coral reefs (Hiatt and Strasburg, 1960; Randall, 1967 and Hobson, 1974).

Behavioural subdivision of the habitat:

The behaviour of the fishes studied was carefully observed and noted and several important conclusions have been made. The small juveniles of D. sargus and S. salpa feed in discrete or mixed schools of up to 600 individuals whereas D. cervinus is more or less solitary and secretive, no more than 4 individuals feeding together. The two schooling species tend to feed in deep water away from cover while D. cervinus feeds near the substrate such that different parts of the prey population are fed on. These tendencies continue as the fish grow and may serve as ecological separators as the differences in the diet of D. sargus and D. cervinus are not marked. The diet of larger S. salpa is different and this is reflected in the behaviour as individuals of about 30 mm and larger are never found in mixed schools with D. sargus. The behaviour of the large juveniles of D. sargus and D. cervinus reduces competition as D. sargus (midwater) tends to feed on vertical surfaces of gullies and in open water away from cover whereas the secretive D. cervinus feeds on the bottom near cover. (Figure 21)

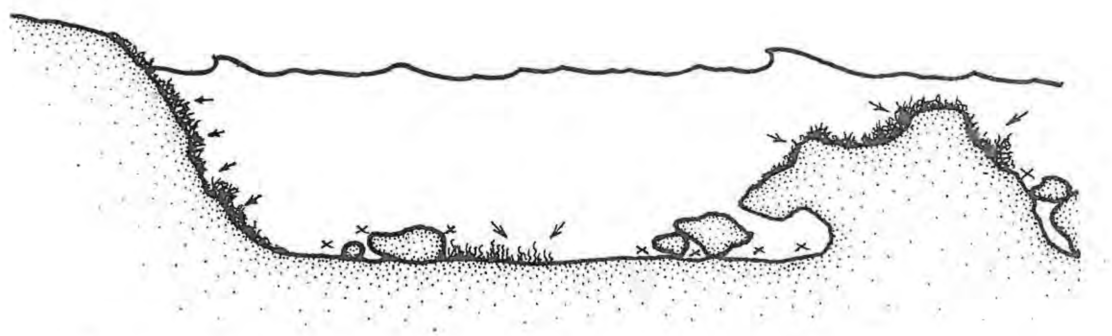


Figure 21. Schematic section of the sub-littoral regions to show the general feeding areas of large juveniles of D. sargus (arrows) and D. cervinus (crosses).

When the fish are adult, the diets are different (Apps. 10, 20 & 26) and no competition exists, which is reflected in the behaviour. Both D. sargus and D. cervinus occur in very small groups (1 to 4 fish) in open water whereas S. salpa feeds in small schools in deeper water where digestible algae predominate, coralline algae being dominant in the inshore region. Similar habitat separation has been reported in freshwater (Keast, 1966) and on coral reefs (Hobson, 1974 and others.)

D. sargus and D. cervinus appear to be inactive at night, assuming a colouration different from that observed during the day. D. sargus has faint vertical bars when juvenile and these become very distinct in all size classes at night. The fish are found in schools hovering in midwater or resting on the bottom. D. cervinus is more secretive, being found in algal cover or crevices and the cross-bars are lost, the colour being almost uniform grey. Both species were observed at full and new moons with no major changes in activity. 12 specimens of D. sargus and 6 of D. cervinus were collected between 10 and 11 p.m. and the food was heavily digested and mostly unidentifiable, indicating a cessation of feeding at night. S. salpa was not observed at night.

POPULATION COMPOSITION

The three species are recruited into the littoral zone of the research area when they are between 9 and 10 mm long (SL). The largest numbers of these individuals are found in deep water (2 m) and this suggests that breeding occurs in deeper water and the juveniles then migrate into the littoral zone.

This observation is backed up by the fact that all fish obtained in the study area were sexually immature. The oldest fish obtained were just over 2 years old (2 + year class) and it is therefore likely that the breeding population is at least 3 years old and occurs in the deeper sublittoral regions.

SUMMARY

1. The food and feeding relationships of three species of sparid fish were studied in the littoral zone of Clayton's Rocks in the Eastern Cape from February to December 1975.

2. Only sexually immature specimens occurred in the study area at low tide, larger fish moving into the littoral zone at high tide.

3. D. sargus was found to be an omnivore, feeding on harpacticoid copepods, amphipods and algae in the winter season as well as cirripede nauplii, chironomid larvae, zoaea and an unidentifiable planktonic larva in summer. The diet changed with age, juveniles feeding mainly on harpacticoids and the sub-adults on amphipods.

4. D. cervinus was found to be a carnivore and the diet changed with size, harpacticoid copepods, the sandshrimp Palaemon pacificus, amphipods and polychaetes being eaten by successively larger size classes.

5. The diet of S. salpa changed markedly with age, small juveniles feeding mainly on harpacticoid copepods, large juveniles on diatoms and rhodophytan algae and sub-adults on red and green algae.

6. The diet of all three species was correlated with changes in gut length and dentition.

7. Length-weight relationships and length-frequency distributions are described for the three species.

8. Ecological separation of the three species is maintained in four main ways. The juveniles appear at different times of the year when certain food items are abundant, notably the young of the shrimp P.*pacificus* and chironomid insects (temporal separation). The diet is different in the adults (dietary separation) and the large juveniles feed in different parts of the littoral zone (behavioural and spatial separation).

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LITERATURE CITED

ALLEN, K.R.

1951. The Horokiwi stream, a study of a trout population. Fish. Bull. Wellington, N.Z. 10: 1-231.

BARNARD, K.H.

1927. A Monograph on the marine fishes of South Africa. Ann. S. Afr. Mus. 21(2): 419-1065.

BARNARD, J.L.

1969. The families and genera of marine gammaridean amphipoda. Smith. Inst., Mus. Nat. Hist. Bull. 271: 1-535.

BARNARD, K.H.

1940. Contributions to the crustacean fauna of South Africa, XII: Further additions to the Tanaidacea, Isopoda and Amphipoda together with keys for the identification of hitherto recorded marine and freshwater species. Ann. S.A. Mus. 32: 381-543.

BAUCHOT, M.L. and J. DAGET.

1971. Les Diplodus (Pisces, Sparidae) du groupe Cervinus-fasciatus. Cah. O.R.S.T.O.M., sér. Océanogr. 9(3): 319-338.

BECKER, C.D.

1973. Food and growth parameters of juvenile chinook salmon, Oncorhynchus tshawytscha, in central Columbia River. Fish. Bull. 71(2): 387-400.

BIDEN, C.L.

1954. Sea-angling fishes of the Cape. Juta and Co., Ltd., Cape Town.

BLABER, S.J.M.

1974. Field studies of the diet of Rhabdosargus holubi (Pisces: Teleostei: Sparidae) J. Zool., Lond. 173: 407-417.

1975. The food and feeding ecology of Mugilidae in the St. Lucia Lake System. (in press).

BRANCH, G.M.

1975. Notes on the ecology of Patella concolor and Cellana capensis, and the effects of human consumption on limpet populations. Zool. Africana 10(1): 75-85.

BREDER, C.M., Jr. and D.R. CRAWFORD.

1922. The food of certain minnows. Zoologica. II (14): 287-327.

CADENAT, J.

1964. Notes d'Ichtyologie ouest-africaine.

XLII. Les "Sars" des genres Puntazzo et Diplodus des eaux tropicales ouest-africaines.

Bulletin de 'I.F.A.N. 26(3): 944-970.

CARR, W.E.S. and C.A. ADAMS.

1972. Food habits of juvenile marine fishes: evidence of the cleaning habit in the leather jacket, Oligoplites saurus, and the spottail pinfish, Diplodus holbrooki. Fish. Bull. 70(4): 1111-1120.

1973. Food habits of juvenile marine fishes occupying seagrass beds in the estuarine zone near Crystal River, Florida. Trans. Am. Fish. Soc. 102(3): 511-540.

DAY, J.H.

1967. A monograph on the polychaeta of southern Africa. Brit. Mus. (Nat. Hist.), London 878 pp.

1969. A guide to marine life on South African shores. A.A. Balkema, Cape Town.

FOWLER, H.W.

1933. Fishes of the Phillipine Seas and adjacent waters. Bull. U.S. Nat. Mus. (100) 12: i-vi 1-465. 22 figs.

1936. The marine fishes of West Africa. Bull. Am. Mus. Nat. Hist. LXX(2): 607-1493.

FROST, W.E.

1943. The natural history of the minnow, Phoxinus phoxinus. J. Anim. Ecol. 12: 139-162.

GERKIN, S.D.

1962. Production and food utilization in a population of bluegill sunfish. Ecol. Monogr. 32: 31-78.

GIBSON, R.N.

1968. The food and feeding relationships of littoral fish in the Banyuls Region. Vie Milieu 19: 447-456.

1970. Observations on the biology of the giant goby Gobius cobitis Pallas. J. Fish Biol. 2: 281-288.

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

GODFRIAUX, B.L.

1974a. Food of snapper in western Bay of Plenty, New Zealand. N.Z.J. Mar. Freshwater Res. 8(3): 473-504.

1974b. Food of tarakihi in western Bay of Plenty, New Zealand. N.Z.J. Mar. Freshwater Res. 8(1): 111-153.

HAGERMAN, F.B.

1952. The biology of the Dover sole, Microstomus pacificus (Lockington). Calif. Dept. Fish and Game, Fish Bull., 85: 1-48.

HARTLEY, P.H.T.

1947. The natural history of some British freshwater fishes. Proc. Zool. Soc. Lond. 117: 129-206.

HIATT, R.W. and D.W. STRASBURG.

1960. Ecological relationships of the fish fauna on coral reefs of the Marshall Islands. Ecol. Monogr. 30: 65-127.

HIDA, T.S.

1973. Food of tunas and dolphins (Pisces: Scombridae and Coryphaenidae) with emphasis on the distribution and biology of their prey Stolephorus buccaneeri (Engraulidae). Fish. Bull. 71(1): 135-143.

HOBSON, E.S.

1974. Feeding relationships of teleostean fishes on coral reefs in Kona, Hawaii. Fish. Bull. 72(4): 915-1031.

HUTCHINGS, L.

1968. A preliminary investigation into the diets of two littoral teleosts, Sarpa salpa (Linnaeus) and Pachymetopon blochii (Valenciennes), with notes on their biology. Unpublished Honours Project, Zoology Department, University of Cape Town, South Africa.

HYNES, H.B.N.

1950. The food of freshwater sticklebacks (Gasterosteus aculeatus and Pygosteus pungitius) with a review of methods used in studies of the food of fishes. J. Anim. Ecol. 19: 36-58.

JORDAN, D.S. and B. FESLER.

1893. A review of the sparoid fishes of America and Europe. Government Printers Officer, Washington.

KEAST, A.

1965. Resource subdivision amongst cohabiting fish species in a bay, Lake Opinicon, Ontario. Univ. Michigan, Great Lakes Res. Div. Pub. 13:106-132.

1966. Trophic interrelationships in the fish fauna of a small stream. Univ. Michigan, Great Lakes Res. Div. Pub. 15: 51-79.

LINNAEUS, C.

1956. Systema Naturae. Jarrold and Sons Ltd., Norwich. Reprint of Vol.1, 10th. Ed. 1758.

MASSON, H. and J.F.K. MARAIS.

1975. Stomach content analyses of mullet from the Swartkops estuary. Zool. Africana 10(2): 193-207.

MERRETT, N.R. and H.S.J. ROE.

1974. Patterns and selectivity in the feeding of certain mesopelagic fishes. Mar. Biol. 28: 115-126.

ODUM, E.P.

1971. Fundamentals of ecology. W.B. Saunders Company, West Washington Square, Philadelphia, Pa. 19105.

OMORI, M.

1974. On the production ecology of the flatfish, Limanda yokohamae - I Feeding habit and distribution. Bull. Jap. Soc. Sci. Fish. 40(11): 1115-1126.

PERRIN, W.F.; R.R. WARNER; C.H. FISCUS and D.B. HOLTS.

1973. Stomach contents of porpoise, Stenella spp., and yellowfin tuna, Thunnus albacares, in mixed-species aggregations. Fish. Bull. 71(4): 1077-1092.

PITT-KENNEDY, S.

1964. A preliminary investigation of feeding in two gobies Coryphopterous caffer (Günther) and C. nudiceps (C. and V) with notes on their sexual maturity. Unpublished Honours Project, Zoology Department, University of Cape Town, South Africa.

RAFINESQUE-SCHMALTZ, C.S.

1967. Indice d'ittiologia Siciliana. A. Asher and Co., Amsterdam. Reprint of 1810 Edition.

RANDALL, J.E.

1967. Food habits of reef fishes of the West Indies. Stud. Trop. Oceanogr. (Miami) 5: 665-847.

ROUND, F.E.

1971. Benthic marine diatoms. Oceanogr. Mar. Biol. Ann. Rev. 9: 83-139.

ROYCE, W.F.

1972. Introduction to the fishery sciences. Academic Press, Inc., III Fifth Avenue, New York, New York 10003.

SARS, G.O.

1895. An account of the crustacea of Norway with short descriptions and figures of all the species. 8 volumes. Al6 Cammermeyers, Christiania and Copenhagen.

SEAGRIEF, S.C.

1967. The seaweeds of the Tsitsikama coastal national park. National Parks Board of the Republic of South Africa Publ.

SMITH, A.

1849. Pisces: In Illustrations of the zoology of South Africa: 31 Pls. Smith, Elder and Co. 65, Cornhill, London.

SMITH, J.L.B.

1938. The South African fishes of the families Sparidae and Denticidae. Trans. R. Soc. S.A. 26(3): 225-305.

1965. The Sea-fishes of southern Africa. Cape and Transvaal Printers Ltd., Cape Town.

STAPLES, D.J.

1975. Production biology of the upland bully Philypnodon breviceps Stokell in a small New Zealand Lake.

I Life-history, food, feeding and activity rhythms. J. Fish Biol. 7: 1-24.

II Population dynamics. J. Fish Biol. 7: 25-45.

III Production, food consumption and efficiency of food utilization. J. Fish Biol. 7: 47-69.

STEPHENSON, T.A.

1944. The constitution of the intertidal fauna and flora of South Africa. Part II Ann. Natal Mus. 10(3): 261-358.

SWYNNERTON, G.H. and E.B. WORTHINGTON.

1940. Note on the food of fish in Haweswater (Westmorland). J. Anim. Ecol. 9:183-187.

TALBOT, F.H.

1954. Notes on the biology of the white stumpnose, Rhabdosargus globiceps (Cuvier), and on the fish fauna of the Klein River estuary. Trans. R. Soc. S.A. 34(3): 387-407.

TAYLOR, W.R.

1928. The marine algae of Florida with special reference to the Dry Tortugas. Papers Tortugas Lab., Carnegie Inst. Wash., 25: 1-219.

1967. An enzyme method of clearing and staining small vertebrates. Proc. U.S. Nat. Mus. 122 (3596): 1-17.

TORTONESE, E.

1973. Sparidae. In: Check-list of the fishes of the north-eastern Atlantic and of the Mediterranean. J.C. Hureau and Th. Monod. Eds. Presses Universitaires de France, Vendôme, pp. 405-415.

VALENCIENNES, A. in CUVIER, G and A. VALENCIENNES.

1830. Histoire naturelles des poissons. 6: 1-559 (1-420, pls. 141-169).

WALBURG, C.H.

1975. Food of young-of-year Channel catfish in Lewis and Clark Lake, a Missouri River reservoir. Am. Midl. Nat. 93(1): 218-221.

WEATHERLY, A.H.

1972. Growth and ecology of fish populations. Academic Press Inc. (London) Ltd., 24/28 Oval Road, London NW1.

WURTSBAUGH, W.A.; R.W. BROCKSEN and C.R. GOLDMAN

1975. Food and distribution of underyearling brook and rainbow trout in Castle Lake, California. Trans. Am. Fish. Soc. 104(1): 88-95.

Appendix 1. Diet from August to December of juvenile D. sargus in the 5 to 15 mm size class (n=72).

Food Species	Percentage occurence	Percentage volume	Points	Ranking index
CHLOROPHYTA				
Ulva species	4,17	1,74	0,34	0,07 (0,1)
RHODOPHYTA				
Polysiphonia species	1,39	0,07	0,01	-
Tayloriella species	1,39	0,07	0,01	-
TOTALS	2,78	0,14	0,02	- (-)
POLYCHAETA				
Dodecaceria pulchra	1,39	0,13	0,01	-
Nereis species (small)	9,72	2,40	0,50	0,23
Nereis species (large)	11,11	1,88	0,21	0,07
Onuphis species	1,39	1,39	0,08	0,02
Terebellidae (tentacles)	1,39	0,14	0,04	-
Terebellidae spp.	1,39	0.11	0.03	-
TOTALS	26,39	6.05	0.87	0,32 (0,6)
CRUSTACEA				
Cirripedia				
Nauplius larvae	36,11	11,51	1,61	4,16 (8,2)
Isopoda				
Dynamenella macrocephala	1,39	0,03	0,01	-
Gnathia species	16,67	3,08	0,38	0,51
Pananthura species	4,17	0,35	0,04	0,01
TOTALS	22,23	3,46	0,43	0,52 (1,1)

Appendix 1 contd.)

Food Species	Percentage occurence	Percentage volume	Points	Ranking index	
Amphipoda					
Cerapus species	2,78	0,42	0,08	0,01	
Gammaropsis species	2,78	0,42	0,04	0,01	
Jassa species	1,39	0,28	0,08	0,01	
Parelasmopus suluensis	2,78	0,39	0,07	0,01	
Urothöe species	6,94	1,05	0,15	0,07	
TOTALS	16,67	2,56	0,42	0,11	(0,2)
Leptostraca	1,39	0,21	0,03	-	(-)
Ostracoda	37,50	7,24	1,06	2,72	(5,4)
Crab zoaea	5,56	0,67	0,11	0,04	(0,1)
Harpacticoida					
Species A	11,11	3,82	0,44	0,42	
Species B	86,11	41,83	5,12	36,02	
Species C	8,33	0,61	0,07	0,05	
Species D	1,39	0,14	0,03	-	
Species E	1,39	0,63	0,08	0,01	
Species F	1,39	0,03	0,01	-	
TOTALS	109,72	47,06	5,75	36,50	(72,2)
Insecta					
Telmatogeton minor	36,11	11,51	1,61	4,16	(6,5)
Unidentifiable planktonic larvae	30,56	7,39	1,00	2,26	(4,5)
Unidentifiable fragments	20,83	2,81	0,41	0,58	(1,1)
GRANT TOTALS	237,40	100,00	13,18	50,57	(100)

Appendix 2. Diet from August to December of juvenile *D. sargus* in the 15 to 20 mm size class (n=36).

Food species	Percentage occurence	Percentage volume	Points	Ranking index	
CHLOROPHYTA					
Ulva spp.	8,33	0,42	0,64	0,03	(0,1)
POLYCHAETA					
Nereis spp. (small)	47,22	11,58	2,11	5,47	
Nereis spp. (large)	8,33	1,67	0,13	0,14	
TOTALS	55,55	13,25	2,24	5,61	(9,7)
CRUSTACEA					
Cirripedia					
Nauplius larvae	66,67	19,36	2,02	12,91	(12,9)
Isopoda					
Gnathia spp.	25,00	6,53	0,78	1,63	
Janiropsis spp.	5,56	0,33	0,07	0,02	
Panathura spp.	8,33	0,36	0,05	0,03	
Stenetrium spp.	2,78	0,14	0,01	-	
TOTALS	41,67	7,36	0,91	1,68	(2,9)
Amphipoda					
Cerapus spp.	2,78	0,22	0,07	0,01	
Gammaropsis spp.	2,78	0,42	0,02	0,01	
Maera spp.	8,33	0,58	0,07	0,05	
Paramoera capensis	27,78	3,03	0,56	0,84	
Parelasmopus suluensis	5,56	0,36	0,08	0,02	
TOTALS	47,23	4,61	0,80	0,93	(1,6)

Appendix 2 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
Leptostraca	5,56	2,50	0,59	0,14 (0,1)
Ostracoda	55,56	5,89	0,95	3,27 (5,6)
Mysidacea	2,78	0,28	0,04	0,01 (-)
Harpacticoida				
Species B	94,44	31,61	5,92	29,85
Species C	11,11	0,97	0,11	0,11
Species E	2,78	0,97	0,24	0,03
Species G	2,78	0,14	0,01	—
Species H	2,78	0,03	0,01	—
TOTALS	113,89	33,72	6,29	29,99 (51,8)
INSECTA				
Telmatogeton minor	27,78	8,14	1,66	2,26 (3,9)
Unidentifiable planktonic larvae	5,56	2,50	0,59	0,14 (0,2)
Unidentifiable fragments	30,56	3,50	0,73	1,07 (1,8)
GRAND TOTAL		100,00	17,00	57,95 (100)

Appendix 3. Diet from August to December of juvenile *D. sargus* in the 20 to 25 mm size class (n=14).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
CHLOROPHYTA					
Ulva spp.	28,57	4,29	0,98	1,22	(2,5)
POLYCHAETA					
Nereis spp. (small)	14,28	4,64	1,15	0,66	
Nereis spp. (large)	35,71	4,45	0,62	1,59	
TOTALS	49,99	9,09	1,77	2,25	(4,7)
CRUSTACEA					
Cirripedia					
Nauplius larvae	42,85	19,33	4,79	8,28	(17,2)
Isopoda					
Gnathia spp.	42,85	4,34	0,53	1,86	
Janiropsis spp.	14,28	2,43	0,64	0,35	
Panathura spp.	14,28	0,43	0,06	0,06	
TOTALS	71,41	7,20	1,23	2,27	(4,7)
Amphipoda					
Gammaropsis spp.	7,14	0,21	0,05	0,02	
Jassa spp.	7,14	1,07	0,02	0,08	
Paramoera capensis	50,00	10,07	2,48	5,04	
Parelasmopus suluensis	21,42	2,86	0,43	0,61	
Photis spp.	7,14	0,57	0,14	0,04	
TOTALS	92,84	14,78	3,12	5,79	(12)

Appendix 3 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
Ostracoda	64,28	6,20	0,96	3,99 (8,3)
Crab zoaea	14,28	0,57	0,16	0,08 (0,2)
Tanaidacea				
Leptochelia barnardi	14,28	0,79	0,15	0,11 (0,2)
Harpacticoida				
Species B	100,00	22,18	3,96	22,18
Species C	7,14	0,14	0,03	0,01
Species E	7,14	0,36	0,07	0,03
Species H	7,14	0,14	0,03	0,01
TOTALS	121,42	23,39	4,20	22,27 (46,3)
Macrura				
Palaemon pacificus	7,14	6,43	0,90	0,46 (1)
INSECTA				
Telmatogeton minor	21,42	1,21	0,23	0,13 (0,3)
Unidentifiable planktonic larvae	14,28	4,72	1,06	0,67 (1,4)
Unidentifiable fragments	28,57	4,29	0,98	1,22 (1,2)
GRAND TOTAL	571,33	100,00	20,04	48,09 (100)

Appendix 4. Diet from August to December of juvenile *D. sargus* in the 25 to 35 mm size class (n=12).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
CHLOROPHYTA					
Ulva spp.	50,00	20,92	2,63	10,46	(32,2)
RHODOPHYTA					
Ceramium spp.	25,00	1,17	0,08	0,29	
Centroceras spp.	8,33	0,42	0,08	0,03	
Polysiphonia spp.	8,33	0,42	0,08	0,03	
Tayloriella spp.	8,33	0,83	0,03	0,07	
TOTALS	49,99	2,84	0,27	0,42	(1,3)
CHRYSOPHYTA (Diatoms)					
Lycmophora spp.	16,67	1,25	0,15	0,21	
Unidentified species A	8,33	0,42	0,03	0,03	(0,7)
POLYCHAETA					
Nereis spp. (small)	8,33	0,83	0,13	0,07	
Nereis spp. (large)	16,67	13,33	3,13	2,22	
Terebellidae (tentacles)	16,67	2,50	0,27	0,42	
TOTALS	41,67	16,66	3,53	2,71	(8,4)
CRUSTACEA					
Cirripedia					
Nauplius larvae	8,33	9,5)	0,55	0,79	(2,4)
Isopoda					
Gnathia spp.	25,00	1,75	0,24	0,44	
Janiropsis spp.	16,67	5,83	0,28	0,97	
Mesanthura ? *catenula*	8,33	0,83	0,12	0,07	
TOTALS	50,00	8,41	0,64	1,48	(4,6)

Appendix 4 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
Amphipoda					
Gammaropsis spp.	8,33	0,08	-	0,01	
Paramoera capensis	25,00	2,58	0,35	0,65	
Parelasmopus suluensis	8,33	0,67	0,10	0,06	
TOTALS	41,66	3,33	0,45	0,72	(2,2)
Ostracoda	16,67	1,50	0,19	0,25	(0,8)
Crab zoaea	8,33	0,42	0,08	0,03	(0,1)
Harpacticoida					
Species B	83,33	11,40	1,35	9,50	
Species C	8,33	0,25	0,2	0,2	
Species H	8,33	6,17	0,31	0,51	
TOTALS	99,99	17,82	1,68	10,03	(30,9)
INSECTA					
Telmatogeton minor	33,33	5,00	0,45	1,67	(5,2)
Unidentifiable planktonic larvae	8,33	4,10	0,58	0,35	(1,1)
Unidentifiable fragments	41,67	7,83	0,77	3,26	(10,1)
GRAND TOTAL	474,97	100,00	12,00	32,41	(100)

Appendix 5. Diet from August to December of juvenile *D. sargus* in the 35 to 40 mm size class (n=5).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
CHLOROPHYTA					
Ulva spp.	40,00	24,40	4,86	9,76	(24,4)
RHODOPHYTA					
Ceramium spp.	20,00	1,00	0,15	0,20	
Polysiphonia spp.	20,00	1,80	0,40	0,36	
TOTALS	40,00	2,80	0,55	0,56	(1,4)
CHRYSOPHYTA (Diatoms)					
Lycmophora spp.	40,00	21,00	3,06	4,20	
Unidentified species A	20,00	1,00	0,14	0,20	
TOTALS	60,00	22,00	3,20	4,40	(11)
POLYCHAETA					
Nereis spp.	20,00	4,00	0,60	0,80	(2)
CRUSTACEA					
Isopoda					
Dynamenella huttoni	20,00	3,50	0,53	0,70	
Gnathia spp.	60,00	10,00	1,48	6,00	
TOTALS	80,00	13,50	2,01	6,70	(16,8)
Amphipoda					
Cerapus spp.	20,00	1,20	0,17	0,24	
Paramoera capensis	60,00	9,20	1,37	5,52	
Parelasmopus suluensis	20,00	2,50	0,38	0,50	
TOTALS	100,00	12,90	1,92	6,26	(15,7)

Appendix 5 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
Ostracoda	20,00	2,00	0,30	0,40	(1)
Harpacticoida					
Species B	100,00	9,20	1,36	9,20	
Species C	20,00	0,40	0,06	0,08	
TOTALS	120,00	9,60	1,42	9,28	(23,2)
INSECTA					
Telmatogeton minor	40,00	7,00	1,05	1,40	(3,5)
Unidentifiable fragments	40,00	1,80	0,31	0,36	(0,9)
GRAND TOTAL	560,00	100,00	16,22	39,92	(100)

Appendix 6. Diet from August to December of juvenile *D. sargus* in the 40 to 50 mm size class (n = 1).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
CRUSTACEA					
Harpacticoida					
Species B	100,00	5,00	0,40	5,00	(5)
INSECTA					
Telmatogeton minor	100,00	80,00	6,40	80,00	(80)
Unidentifiable fragments and sand	100,00	15,00	1,20	15,00	(15)

Appendix 7. Diet from August to December of juvenile *D. sargus* in the 50 to 60 mm size class (n = 2).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
CHLOROPHYTA					
Ulva spp.	50,00	4,00	0,56	2,00	(3,3)
CHRYSOPHYTA (Diatoms)					
Lycmophora spp.	50,00	10,00	2,00	5,00	(8,2)
HYDROZOA					
Symplectoscyphus spp.	50,00	10,00	1,40	5,00	
Thecocarpus formosus	50,00	10,00	1,40	5,00	
TOTALS	100,00	20,00	2,80	10,00	(16,3)
CRUSTACEA					
Isopoda					
Dynamenella macrocephala	50,00	2,00	0,28	1,00	
Gnathia spp.	50,00	10,00	2,00	5,00	
TOTALS	100,00	12,00	2,28	6,00	(9,8)
Amphipoda					
Caprellina longicollis	50,00	14,50	2,78	7,25	
Cerapus spp.	50,00	7,50	1,05	3,75	
Corophium spp.	50,00	2,00	0,28	1,00	
Jassa spp.	50,00	7,50	1,05	3,75	
Paramoera capensis	100,00	22,50	4,20	22,50	
TOTALS	300,00	54,00	9,36	38,25	(62,4)
GRAND TOTAL	600,00	100,00	17,00	61,25	(100)

Appendix 8. Diet from August to December of the juvenile *D. sargus* in the 60 to 70 mm size class (n=3)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
CHLOROPHYTA					
Bryopsis spp	33,33	3,33	0,07	1,11	
Enteromorpha spp.	33,33	3,33	0,07	1,11	
Ulva spp.	66,67	16,67	4,40	11,11	
Valonia spp.	33,33	10,00	3,0C	3,33	
TOTALS	166,66	34,00	8,67	16,88	(33,2)
CHRYSOPHYTA (Diatoms)					
Lycmophora spp.	66,67	18,33	1,77	12,22	(24,1)
POLYCHAETA					
Eulalia trilineata	33,33	3,33	0,80	1,11	
Pomatoleios kraussi	33,33	1,67	0,50	0,56	
Terebellidae spp.	33,33	4,00	0,96	1,33	
TOTALS	99,99	9,00	2,26	3,00	(5,9)
CRUSTACEA					
Cirripedia					
Cirri of adult	33,33	0,33	0,10	0,11	(0,2)
Isopoda					
Dynamenella macrocephala	66,67	8,33	2,10	5,55	
Janiropsis spp.	66,67	1,00	0,26	0,67	
TOTALS	133,34	9,33	2,36	6,22	(12,3)

Appendix 8 contd.)

Food species	Percentage occurrence	Percentage colume	Points	Ranking index	
Amphipoda					
Caprella danilevskii	33,33	0,67	0,20	0,22	
Corophium spp.	33,33	2,67	0,64	0,89	
Gammaropsis spp.	33,33	0,33	0,10	0,11	
Paramoera capensis	100,00	4,00	1,00	4,00	
Parelasmopus suluensis	33,33	0,67	0,16	0.22	
Photis spp.	33,33	2,00	0,48	0,67	
TOTALS	266,65	10,34	2,58	6,11	(12)
Ostracoda	33,33	0,33	0,10	0,11	(0,2)
MOLLUSCA					
Helcion spp.	33,33	1,67	0,50	0,56	(1,1)
Unidentifable fragments	33,33	16,67	0,33	5,56	(11)
GRAND TOTAL	866,64	100,00	18,67	50,77	(100)

Appendix 9. Diet from August to December of sub-adult *D. sargus* in the 70 to 80 mm size class (n=3).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
CHLOROPHYTA					
Caulerpa filiformis	33,33	10,00	2,80	3,33	(6)
CHRYSOPHYTA (Diatoms)					
Lycmophora spp.	33,33	-	-	-	
POLYCHAETA					
Nereis spp. (large)	33,33	6,67	0,67	2,22	
Terebellidae (tentacles)	33,33	5,00	1,40	1,67	
TOTALS	66,66	11,67	2,07	3,89	(7)
CRUSTACEA					
Isopoda					
Dynamenella macrocephala	33,33	3,33	0,93	1,11	
Gnathia spp.	33,33	2,00	0,20	0,67	
TOTALS	99,99	5,33	1,13	1,78	(3,2)
Amphipoda					
Caprella spp.	33,33	23,33	2,33	7,77	
Carapus spp.	100,00	23,00	2,53	23,00	
Cerapus spp. (tubes)	66,66	20,67	3,57	13,78	
Jassa spp.	33,33	1,67	0,47	0,56	
Paramoera capensis	33,33	3,33	0,33	1,11	
TOTALS	209,98	73,00	9,33	46,55	(83,8)
GRAND TOTAL	409,96	100,00	15,33	55,55	(100)

Appendix 10. Diet from August to December of Sub-adult *D.sargus* in the 80 to 110 mm size class (n = 1).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
CHLOROPHYTA				
Caulerpa filiformis	100,00	10,00	2,40	10,00 (10)
CRUSTACEA				
Amphipoda				
Paramoera capensis	100,00	85,00	20,40	85,00 (85)
Brachyura				
Crab gut	100,00	5,00	1,20	5,00 (5)
GRAND TOTAL	300,00	100,00	24,00	100,00 (100)

Appendix 11. Diet from February to July of juvenile *D.sargus* in the 5 to 15 mm size class (n = 9).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
POLYCHAETA				
Nereis spp. (small)	33,33	3,44	0,71	1,15 (2,2)
CRUSTACEA				
Isopoda				
Gnathia spp.	11,11	1,11	0,22	0,12
Janiropsis spp.	11,11	0,56	0,11	0,06
Stenetrium spp.	33,33	2,11	0,26	0,70
TOTALS	55,55	3,78	0,59	0,88 (1,7)

Appendix 11 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Rankinh index	
Amphipoda					
Cerapus spp.	55,56	6,56	1,49	3,39	
Gammaropsis spp.	22,22	3,33	0,84	0,74	
Maera spp.	77,78	20,56	4,24	15,99	
Paramoera capensis	33,33	6.56	1,00	2,18	
Parelasmopus suluensis	22,22	1,00	0,24	0,22	
Photis spp.	22,22	1,00	0,22	0,22	
Unidentifiable spp.	11,11	1,11	0,22	0,12	
TOTALS	255,55	40,02	8,25	22,86	(43,7)
Ostracoda	22,22	2,22	0,24	0,49	(0,9)
Harpacticoida					
Species A	44,44	17,32	2,66	7,70	
Species B	11,11	0,44	0,09	0,05	
Species C	44,44	4,89	0,80	2,17	
Species E	77,78	17,33	3,43	13,48	
Species G	33,33	3,56	0,76	1,19	
Species I	22,22	3,33	0,67	0,74	
TOTALS	233,32	46,87	8,41	24,33	(48,4)
Unidentifiable fragments	44,44	3,67	0,59	1,63	(3,1)
GRAND TOTAL	644,41	100,00	18,79	52,34	(100)

Appendix 12. Diet from February to July of juvenile *D. sargus* in the 15 to 20 mm size class (n=17).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
CHRYSOPHYTA (Diatoms)					
Lycmophora spp.	11,76	0,12	0,04	0,01	(-)
POLYCHAETA					
Nereis spp. (small)	76,47	6,82	1,08	5,22	
Nereis spp. (large)	11,74	-	-	-	
TOTALS	88,21	6,82	1,08	5,22	(10,4)
CRUSTACEA					
Isopoda					
Gnathia spp.	35,29	1,76	0,17	0,62	
Janiropsis spp.	5,88	0,24	0,02	0,01	
Panathura spp.	11,76	0,17	0,05	0,02	
TOTALS	52,93	13,13	2,01	2,72	(1,3)
Amphipoda					
Cerapus spp.	23,52	2,35	0,40	0,55	
Gammaropsis spp.	5,88	0,18	0,02	0,01	
Maera spp.	29,41	2,06	0,24	0,61	
Parelasmopus suluensis	23,52	2,71	0,44	0,64	
Photis spp.	5,88	0,41	0,08	0,02	
Urothöe spp.	17,64	2,18	0,30	0,38	
Unidentifiable spp.	5,88	0,59	0,12	0,03	
Unidentifiable spp.	17,64	2,65	0,41	0,48	
TOTALS	86,37	13,13	2,01	2,72	(5,4)
Ostracoda	58,82	5,24	0,50	3,08	(6,1)

Appendix 12 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
Harpacticoida					
Species A	58,82	9,35	1,48	5,50	
Species B	82,35	11,35	1,61	9,35	
Species C	29,41	2,76	0,20	0,81	
Species E	41,17	20,71	1,19	8,53	
Species G	17,64	0,71	0,02	0,13	
Species I	29,41	0,88	0,08	0,26	
Species J	5,88	—	—	—	
Species K	52,94	23,35	4,56	12,36	
Species L	5,88	—	—	—	
TOTALS	323,50	69,11	9,14	36,94	(73,2)
Unidentifiable fragments	52,94	3,41	0,40	1,81	(3,6)
GRAND TOTAL		100,00	13,41	50,43	(100)

Appendix 13. Diet from February to July of juvenile *D. sargus* in the 20 to 25 mm size class (n=8).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
POLYCHAETA					
Dodecaceria pulchra	25,00	1,88	0,06	0,46	
Nereis spp. (small)	75,00	10,25	1,06	7,69	
TOTALS	100,00	12,13	1,12	8,15	(11,6)
CRUSTACEA					
Isopoda					
Gnathia spp.	75,00	7,75	0,46	5,81	
Janiropsis spp.	12,50	0,63	0,09	0,08	
Stenetrium spp.	12,50	0,25	0,04	0,03	
TOTALS	100,00	8,63	0,59	5,92	(8,3)
Amphipoda					
Caprella spp. F	12,50	0,13	0,01	0,02	
Caprellina longicollis	12,50	1,00	0,18	0,13	
Cerapus spp.	12,50	0,25	0,04	0,03	
Gammaropsis spp.	25,00	6.38	0,33	1,59	
Maera spp.	12,50	0,50	0,08	0,06	
Paramoera capensis	25,00	1,75	0,34	0,44	
Parelasmopus suluensis	12,50	1,00	0,15	0,13	
Photis spp.	12,50	0,13	0,02	0,02	
Urothöe spp.	25,00	1,63	0,08	0,41	
TOTALS	150,00	12,77	1,23	2,83	(4)
Ostracoda	75,00	1,25	0,08	0,94	(1,3)
Crab zoaea	12,50	0,25	0,04	0,03	(-)

Appendix 13 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
Tanaidacea					
Apseudes spp.	12,50	0,63	0,03	0,08	(0,1)
Harpacticoida					
Species B	100,00	28,38	1,50	28,38	
Species C	87,50	2,75	0,16	2,41	
Species D	12,50	0,05	0,01	0,01	
Species E	75,00	26,00	2,20	19,50	
Species G	62,50	3,88	0,14	2,43	
Species I	25,00	0,40	0,04	0,10	
Species M	12,50	0,25	0,01	0,03	
TOTALS	375,00	61,71	4,06	52,86	(74,3)
INSECTA					
Telmatogeton minor	12,50	1,88	0,06	0,23	(0,3)
Unidentifiable fragments	12,50	0,75	0,04	0,03	(0,1)
GRAND TOTAL	850,00	100,00	7,25	71,13	(100)

Appendix 14. Diet from February to July of juvenile *D. sargus* in the 25 to 35 mm size class (n=6).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
CHLOROPHYTA					
Ulva spp.	33,33	6,83	0,38	2,28	(9,6)
POLYCHAETA					
Nereis spp. (small)	33,33	0,33	0,08	0,11	
Nereis spp. (large)	50,00	2,83	0,65	1,41	
TOTALS	83,33	3,16	0,73	1,52	(6,4)
CRUSTACEA					
Isopoda					
Gnathia spp.	50,00	6,00	0,93	3,00	
Janiropsis spp.	16,67	1,00	0,14	0,17	
TOTALS	66,67	7,00	1,07	0,47	(2)
Amphipoda					
Caprella spp. D	16,67	0,50	0,07	0,08	
Caprella spp. E	16,67	0,17	0,03	0,03	
Caprella spp. F	33,33	2.17	0,35	0,72	
Caprellina longicollis	16,67	1,17	0,16	0,19	
Cerapus spp.	16,67	0,17	0,05	0,03	
Corophium spp.	16,67	0,50	0,07	0,08	
Gammaropsis spp.	16,67	0,17	0,03	0,03	
Jassa spp.	16,67	0,50	0,03	0,08	
Maera spp.	50,00	1,00	0,18	0,5o	
Paramoera capensis	50,00	2,83	0,25	1,41	
Parelasmopus suluensis	50,00	2,00	0,56	1,00	
Photis spp.	50,00	0,50	0,14	0,25	
TOTALS	349,82	11,68	1,92	4,40	(19)

Appendix 14 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
Ostracoda	16,67	0,33	0,10	0,05 (0,2)
Mysidacea				
Mysidopsis similis	16,67	0,67	0,13	0,11 (0,5)
Tanaidacea				
Apseudes spp.	16,67	0,17	0,03	0,03 (0,1)
Harpacticoida				
Species A	50,00	43,83	12,87	21,92
Species B	50,00	5,00	0,83	2,50
Species E	50,00	19,16	1,95	8,75
Species K	16,67	0,83	0,04	0,14
TOTALS	166,67	68,82	15,69	14,31 (59,6)
MACRURA				
Palaemon pacificus	16,67	0,17	0,05	0,03 (0,1)
Unidentifiable fragments	50,00	1,17	0,15	0,59 (2,5)
GRAND TOTAL		100,00	20,25	23,79 (100)

Appendix 15. Diet from February to July of Juvenile *D. sargus* in the 35 to 40 mm size class (n=4).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
CHLOROPHYTA					
Ulva spp.	25,00	0,63	0,18	0,16	(0,3)
POLYCHAETA					
Nereis spp. (large)	50,00	2,30	0,29	1,15	(1,8)
CRUSTACEA					
Isopoda					
Gnathia spp.	100,00	6,80	1,25	6,80	
Panathura spp.	25,00	0,25	0,04	0,07	
Stenetrium spp.	25,00	0,68	0,05	0,17	
TOTALS	150,00	7,73	1,34	7,04	(11,3)
Amphipoda					
Caprella spp. B	25,00	5,00	1,00	0,63	
Caprella spp. D	25,00	3,50	0,98	0,88	
Caprella spp. E	25,00	0,50	0,75	0,13	
Caprella spp. F	25,00	3,35	0,33	0,84	
Cerapus spp.	50,00	6,10	0,79	3,05	
Corophium spp.	25,00	2,00	0,30	0,50	
Cymadusa spp.	75,00	3,80	0,61	2,85	
Gammaropsis spp.	25,00	1,00	0,10	0,25	
Jassa spp. A	50,00	5,30	1,20	2,65	
Jassa spp. B	25,00	2,50	0,50	0,63	
Maera spp.	100,00	20,26	5,31	20,26	

Appendix 15 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
Amphipoda contd.)					
Paramoera capensis	25,00	1,50	0,15	0,38	
Parelasmopus suluensis	25,00	1,50	Om15	0,38	
Photis spp.	50,00	1,25	0,17	1,25	
Unidentifiable spp. A	25,00	0,50	0,05	0,13	
Unidentifiable spp. B	25,00	1,50	0,23	0,38	
Urothöe spp.	25,00	10,00	1,20	2,50	
TOTALS	650,00	72,06	14,32	40,20	(64,2)
Ostracoda	25,00	1,50	0,15	0,38	(0,6)
Harpacticoida					
Species B	75,00	7,50	0,83	5,65	
Species E	75,00	0,28	0,06	0,21	
Species I	25,00	0,25	0,04	0,07	
TOTALS	175,00	8,03	0,93	5,91	(9,4)
Unidentifiable fragments	100,00	7,75	1,04	7,75	(12,4)
GRAND TOTAL	1225,00	100,00	18,25	62,59	(100)

Appendix 16. Diet from February to July of juvenile *D. sargus* in the 40 to 50 mm size class (n=8).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
CHLOROPHYTA					
Ulva spp.	25,00	1,88	0,28	0,47	(1,4)
RHODOPHYTA					
Hypnea spicifera	12,50	1,00	0,20	0,13	(0,4)
POLYCHAETA					
Dodecaceria pulchra	12,50	3,75	0,06	0,47	
Nereis spp. (small)	12,50	0,38	0,08	0,05	
Nereis spp. (large)	25,00	3,25	0,19	0,81	
Serpula vermicularis	12,50	1,25	0,02	0,16	
TOTALS	62,50	7,63	0,71	1,24	
CRUSTACEA					
Isopoda					
Dynamenella macrocephala	12,50	0,38	0,11	0,05	
Exosphaeroma antikraussi	25,00	0,88	0,23	0,22	
Janiropsis spp.	25,00	3,25	0,19	0,81	
TOTALS	62,50	4,51	0,53	1,08	(3,1)
Amphipoda					
Caprella danilevskii	25,00	5,11	1,04	1,28	
Caprella penantis	12,50	2,00	0,40	0,25	
Caprella scaura	12,50	0,13	0,04	0,02	
Caprella spp. B	37,50	3,50	0,57	1,31	

Appendix 16 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
Amphipoda contd.)					
Caprella spp. C	12,50	0,38	0,11	0,05	
Caprella spp. D	12,50	0,13	0,04	0,02	
Caprella spp. E	25,00	0,90	0,25	0,23	
Caprella spp. F	12,50	0,26	0,08	0,03	
Caprellina longicollis	12,50	0,13	0,04	0,02	
Cerapus spp.	25,00	5,88	0,28	1,47	
Corophium spp. A	50,00	13,75	2,85	6,88	
Corophium spp. B	25,00	6,88	2,20	1,72	
Gammaropsis holmesi	12,50	0,13	0,03	0,02	
Jassa spp. A	12,50	0,25	0,07	0,03	
Jassa spp. B	12,50	0,13	0,04	0,02	
Jassa spp. C	12,50	0,13	0,04	0,02	
Lysianassa ceratina	12,50	0,13	0,04	0,02	
Lyzianassa variegata	12,50	1,88	0,09	0,03	
Maera spp.	37,50	4,00	0,26	1,50	
Paramoera capensis	50,00	6,50	0,97	3,25	
Parelasmopus suluensis	62,50	2,25	3,00	6,09	
Photis spp.	37,50	2,88	0,34	1,08	
Urothöe spp.	12,50	0,13	0,03	0,02	
Unidentifiable spp.	12,50	2,86	0,56	0,35	
TOTALS	625,00	76,47	13,87	27,12	(78,9)
Tanaidacea					
Leptochelia barnardi	12,50	0,25	0,07	0,03	(0,1)
MACRURA					
Palaemon pacificus	25,00	1,50	0,08	0,38	(1,2)

Appendix 16 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
MOLLUSCA					
Helcion pruinosus	12,50	0,63	0,13	0,08	(0,2)
Unidentifiable fragments	62,50	6,13	0,93	3,83	(11,1)
GRAND TOTAL	924,00	100,00	16,80	34,36	(100)

Appendix 17. Diet from February to July of juvenile *D. sargus* in the 50 to 60 mm size class (n=17).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
CHLOROPHYTA					
Enteromorpha spp.	11,76	2,71	0,54	0,32	
Ulva spp.	29,41	4,71	0,82	1,39	
TOTALS	41,17	7,42	1,36	1,71	(6,9)
RHODOPHYTA					
Ceramium spp.	5,88	0,35	0,07	0,02	
Polysiphonia spp.	11,76	3,29	0,66	0,39	
Tayloriella spp.	11,76	0,71	0,14	0,08	
TOTALS	29,40	4,35	0,87	0,49	(2)
CRUSTACEA					
Isopoda					
Cymodocella pustulata	5,88	0,59	0,12	0,03	

Appendix 17 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
Isopoda contd.)				
Dynamenella macrocephala	11,76	0,94	0,13	0,11
Gnathia spp.	35,29	2,24	0,37	0,79
Stenetrium spp.	17,64	1,12	0,15	0,20
Unidentifiable species	5,88	0,29	0,06	0,02
TOTALS	76,45	5,18	0,73	1,15
Amphipoda				
Caprella danilevskii	11,76	0,53	0,06	0,06
Caprella scaura	5,88	0,12	0,03	0,01
Caprella spp. B	17,64	0,94	0,19	0,17
Caprella spp. C	23,52	1,76	0,28	0,41
Caprella spp. E	5,88	0,71	0,14	0,04
Caprella spp. F	23,52	3,76	0,20	0,88
Cerapus spp.	17,64	2,53	0,33	0,39
Corophium spp. A	23,52	2,00	0,36	0,47
Corophium spp. B	23,52	5,06	0,70	1,19
Cymadusa spp.	35,29	4,71	0,58	1,66
Gammaropsis holmesi	5,88	0,12	0,03	0,01
Gammaropsis spp.	5,88	0,24	0,04	0,02
Jassa spp. A	5,88	0,88	0,04	0,05
Jassa spp. B	5,88	0,35	0,01	0,02
Lysianassa ceratina	5,88	0,24	0,05	0,01
Maera spp.	35,29	8,65	1,04	3,05
Paramoera capensis	35,29	7,95	1,22	2,61

Appendix 17 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
Isopoda contd.)					
Parelasmopus suluensis	52.94	10,65	0,87	5,03	
Photis spp.	17,64	2,65	0,29	0,47	
Unidentifiable spp.	35,29	1,18	0,33	0,30	
Urothöe spp.	5,88	0,71	0,14	0,04	
TOTALS	399,90	55,51	6,93	16,81	(67,8)
Tanaidacea					
Apseudes spp.	5,88	0,24	0,01	0,01	(1-)
Harpacticoida					
Species A	5,88	0,35	0,09	0,02	
Species B	5,88	0,18	0,04	0,01	
Species C	11,76	4,94	0,06	0,58	
Species E	23,52	2,06	0,11	0,48	
Species N	5,88	0,18	0,04	0,01	
TOTALS	52,92	8,02	0,31	1,12	(4,6)
MACRURA					
Palaemon pacificus	11,76	0,59	0,09	0,07	(0,3)
POLYCHAETA					
Eulalia trilineata	17,64	2,40	0,32	0,42	
Nereis spp. (large)	41,17	3,82	0,43	1,57	
Serpulidae spp.	5,88	0,12	0,03	0,01	
Terebellidae (tentacles)	11,76	3,41	0,31	0,40	
Terebellidae spp.	5,88	5,00	1,12	0,29	
TOTALS	82,33	14,75	2,21	2,69	(10,8)

Appendix 17 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
INSECTA					
Telmatogeton minor	5,88	0,59	0,12	0,03	(0,1)
MOLLUSCA					
Philine aperta	5,88	0,29	0,04	0,02	
Rhaciglossa spp.	11,76	0,47	0,10	0,06	
TOTALS	17,64	0,76	0,14	0,08	(0,3)
Unidentifiable fragments	41,17	1,59	0,29	0,65	(2,6)
GRAND TOTAL	693,93	100,00	13,06	24,81	(100)

Appendix 18. Diet from February to July of sub-adult *D. sargus* IN THE 60 to 70 mm size class (n=12).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
CHLOROPHYTA					
Ulva spp.	33,33	11,25	1,48	3,75	(11,2)
CHRYSOPHYTA (Diatoms)					
Lycmophora spp.	8,83	5,42	0,81	2,59	
Unidentified spp. A	8,83	0.83	0.13	0,07	
TOTALS	17,06	6.25	0,94	2,68	(8)

Appendix 18 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
POLYCHAETA					
Dodecaceria pulchra	8.83	1,25	0,01	0,11	
Errantia spp. (elytra)	8,83	0,08	0,02	0,01	
Nereis spp. (large)	41,67	9,17	1,75	3,82	
Pista spp.	8,83	2,08	0,04	0,18	
Pomatoleois kraussi	8,83	1,67	0,03	0,15	
Terebellidae (tentacles)	8,83	1,67	0,03	0,15	
TOTALS	48,82	15,92	1,88	4,42	(13,3)
CRUSTACEA					
Isopoda					
Cymodocella pustulata	8,83	0,83	0,13	0,07	
C. seblevis	16,67	1,08	0,16	0,18	
Dynamenella macrocephala	25,00	1,58	0,13	0,40	
Gnathia spp.	16,67	0,17	0,04	0,03	
Stenetrium spp.	8,83	0,17	0,03	0,02	
TOTALS	53,50	3,83	0,49	0,70	(2,1)
Amphipoda					
Caprella danilevskii	25,00	1,08	0,20	0,27	
Carpella paenantis	16,67	0,25	0,05	0,04	
Carprella scaura	8,83	0,25	0,05	0,02	
Caprella spp. B	25,00	3,67	0,48	0,92	
Caprella spp. C	25,00	1,50	0,24	0,38	
Caprella spp. E	8,83	0,67	0,13	0,06	

Appendix 18 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
Caprella spp. D	8,83	0,25	0,05	0,02	
Cerapus spp.	33,33	3,42	0,68	1,14	
Corophium spp. A	8,83	0,25	0,05	0,02	
Corophium spp. B	16,67	1,08	0,52	0,18	
Gammaropsis spp.	8,83	0,08	0,01	0,01	
Jassa spp.	33,33	3,33	0,19	1,11	
Maera spp.	16,67	5,76	0,41	0,96	
Paramoera capensis	83,33	10,00	0,68	8,33	
Parelasmopus suluensis	33,33	1,75	0,21	0,58	
Photis spp.	16,67	0,83	0,95	0,14	
Temnophlias spp.	8,83	4,42	0,58	0,39	
Urothöe spp.	16,67	2,42	0,28	0,40	
Unidentifiable spp. A	33,33	2,33	0,41	0,78	
Unidentifiable spp. B	33,33	5,00	0,70	1,67	
Unidentifiable spp. C	33,33	3,00	0,52	1,00	
TOTALS	494,64	51,34	7,39	18,42	(55,3)
Ostracoda	8,83	0,41	0,06	0,04	(0,1)
Mysidacea	8,83	0,83	0,16	0,07	(0,2)
MOLLUSCA					
Gibbula rosea	8.83	0.42	0,06	0,04	
Helcion pruinosus	8,83	0,67	0,10	0,06	
Rhaciglossa	8,83	5,00	1,40	0,44	
TOTALS	26,49	6,09	1,56	0,54	(1,6)
Unidentifiable fragments	66,67	4,08	0,32	2,72	(8,2)
GRAND TOTAL		100,00	14,25	33,34	(100)

Appendix 19. Diet from February to July of sub-adult D. sargus in the 70 to 80 mm size class (n=5).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
CHLOROPHYTA					
Caulerpa filiformis	20,00	10,00	1,60	2,00	
Ulva spp.	40,00	12,10	1,16	4,84	
TOTALS	60,00	22,10	2,76	6,84	(20,7)
RHODOPHYTA					
? Acrosorium spp.	20,00	2,20	0,20	0,44	
Hypnea spicifera	20,00	1,00	0,15	0,20	
Polysiphonia spp.	20,00	11,01	1,00	2,22	
TOTALS	60,00	14,30	1,35	2,86	(8,6)
POLYCHAETA					
Dodecaceria pulchra	20,00	2,00	0,37	0,40	
Nereis spp. (large)	40,00	8,00	1,20	3,20	
Terebellidae	20,00	2,00	0,32	0,40	
Terebellidae (tentacles)	20,00	4,00	0,60	0,80	
TOTALS	100,00	16,00	2,49	4,80	(14,5)
CRUSTACEA					
Isopoda					
Dynamenella macrocephala	40,00	4,00	0,63	1,60	
Gnathia spp.	20,00	1,00	0,15	0,20	
Stenetrium spp.	20,00	0,40	0,06	0,08	
TOTALS	80,00	5,40	0,84	1,88	(5,7)

Appendix 19 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
Amphipoda					
Cerapus spp.	20,00	1,20	0,18	0,24	
Corophium spp.	40,00	4,40	0,80	1,76	
Jassa spp.	20,00	6,80	1,13	1,36	
Maera spp.	40,00	2,40	0,36	0,96	
Parelasmopus suluensis	20,00	1,20	0,18	0,24	
Urothöe spp.	80,00	9,90	1,35	7,92	
TOTALS	220,00	25,90	4,00	12,48	(37,7)
Ostracoda	20,00	1,10	0,15	0,22	(0,7)
BRACHYURA					
Rhyncoplax bovis	20,00	2,20	0,30	0,44	(1,4)
MOLLUSCA					
Helcion pruinosus	20,00	3,00	0,45	0,15	
Rhaciglossa spp.?	40,00	5,00	0,68	2,00	
TOTALS	60,00	8,00	1,13	2,15	(6,5)
ECHINODERMATA					
Parechinus spp.	20,00	3,00	0,48	0,60	
Unidentifiable fragments	40,00	2,00	0,30	0,80	(2,4)
GRAND TOTAL	680,00	100,00	13,80	33,07	(100)

Appendix 20. Diet from February to July of sub-adult *D. sargus* in the size class 80 to 165 mm (n=2).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
CRUSTACEA					
Amphipoda					
Caprella spp.	50,00	5,00	0,25	2,40	
Cerapus spp.	100,00	70,00	3,50	70,00	
Cymadusa spp.	50,00	5,00	0,25	2,50	
Maera spp.	50,00	5,00	0,25	2,40	
Urothöe spp.	50,00	5,00	0,25	2,40	
TOTALS	300,00	90,00	4,50	79,70	(90,1)
MOLLUSCA					
Rhaciglossa spp.	50,00	2,50	0,13	1,25	(1,4)
Unidentifiable fragments	100,00	7,50	0,37	7,50	(8,5)
GRAND TOTAL	450,00	100,00	5,00	88,45	(100)

Appendix 21. Diet of juvenile *D. cervinus* in the 10 to 20 mm size class (n = 4).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
POLYCHAETA				
Nereis spp. (small)	25,00	0,50	0,05	0,13 (2,7)
CRUSTACEA				
Amphipoda				
Paramoera capensis	25,00	5,00	0,90	0,75 (1,1)
Harpacticoida				
Species B	100,00	44,50	3,08	44,50 (64,9)
INSECTA				
Telmatogeton minor	50,00	42,50	4,25	21,25 (31)
Unidentifiable planktonic larvae	25,00	0,50	0,05	0,13 (0,3)
GRAND TOTALS	225,00	100,00	9,63	68,51 (100)

Appendix 22. Diet of juvenile *D.cervinus* in the 20 to 35 mm size class (n = 9).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
POLYCHAETA				
Nereis spp.	33,33	5,56	1,09	1,85 (4,1)
CRUSTACEA				
Isopoda				
Gnathia spp.	44,44	15,00	0,47	6,60
Janiropsis spp.	11,11	1,88	0,30	0,21
Stenetrium spp.	33,33	13,33	2,18	4,44
TOTALS	88,44	30,21	2,95	11,25 (25)
Amphipoda				
Caprella laevipes	11,11	2,22	0,22	0,25
Caprella spp. F	11,11	2,22	0,22	0,25
Paramoera capensis	22,22	1,33	0,23	0,30
TOTALS	44,44	5,77	0,67	0,80 (1,8)
Ostracoda	22,22	0,78	0,12	0,17 (0,4)
Harpacticoida				
Species B	77,78	14,33	5,16	11,15 (24,9)
Macrura				
Palaemon pacificus	44,44	40,13	8,93	17,82 (39,8)
INSECTA				
Telmatogeton minor	55,56	3,22	0,38	1,79 (4)
GRAND TOTAL	366,21	100,00	19,30	44,83 (100)

Appendix 23. Diet of juvenile *D. cervinus* in the 35 to 50 mm size class (n = 8).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
CHLOROPHYTA				
Ulva spp.	12,50	13,90	0,95	1,74 (5,1)
POLYCHAETA				
Eulalia trilineata	12,50	4,15	0,44	0,52
Nereis spp. (small)	12,50	1,15	0,01	0,14
Nereis spp. (large)	25,00	5,50	0,63	1,38
Onuphis spp.	12,50	3,50	0,35	0,44
Terebellidae (tentacles)	12,50	9,45	1,53	1,18
TOTALS	75,00	23,75	2,96	2,66 (7,9)
CRUSTACEA				
Isopoda				
Gnathia spp.	12,50	2,25	0,09	0,28
Janiropsis spp.	25,00	3,50	0,29	0,88
Stenetrium spp.	12,50	2,25	0,18	0,28
TOTALS	50,00	8,00	0,56	1,44 (4,3)
Amphipoda				
Cerapus spp.	12,50	2,85	0,06	0,36
Paramoera capensis	12,50	1,40	0,02	0,18
TOTALS	25,00	4,25	0,08	0,54 (1,6)
Harpacticoida				
Species B	87,50	9,85	0,48	8,62 (25,5)

Appendix 23 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
Macrura				
Palaemon pacificus	50,00	35,50	2,72	17,75 (52,5)
INSECTA				
Telmatogeton minor	12,50	3,50	0,09	0,44 (1,3)
Unidentifiable fragments	50,00	1,25	0,16	0,63 (1,8)
GRAND TOTAL	362,50	100,00	8,00	33,82 (100)

Appendix 24. Diet of juvenile *D. cervinus* in the 50 to 75 mm size class (n = 29).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
CHLOROPHYTA				
Ulva spp.	6,90	0,84	0,01	0,06 (0,2)
POLYCHAETA				
Eulalia trilineata	17,20	2,65	0,30	0,46
Dodecaceria pulchra	13,80	4,75	0,17	0,66
Nereis spp. (large)	58,60	9,14	0,91	5,36
Onuphis spp.	3,4	1,13	0,04	0,04
Pista spp.	10,30	1,89	0,28	0,19
Pomatoleios kraussi	3,4	1,13	0,24	0,04
Terebellidae (tentacles)	6,90	1,70	0,16	0,12
TOTALS	11,36	22,39	1,83	6,87 (17,9)

Appendix 24 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
CRUSTACEA				
Cirripedia				
Nauplius larvae	6,90	0,70	0,28	0,05 (0,1)
Isopoda				
Dynamenella macrocephala	3,40	0,28	0,01	0,01
Exosphaeroma antikraussi	3,40	0,17	0,02	0,01
Gnathia spp.	13,80	0,41	0,03	0,06
Janiropsis spp.	20,70	3,56	0,01	0,74
Panathura spp.	3,40	—	—	—
Stenetrium spp.	27,60	0,83	0,18	0,23
TOTALS	72,30	5,25	0,25	1,05 (2,8)
Amphipoda				
Caprella danilevskii	3,40	0,11	0,01	0,01
C. penantis	3,40	0,03	0,01	—
Caprella spp. A	3,40	0,18	0,01	0,06
Caprella spp. B	20,70	2,95	0,22	0,61
Caprella spp. C	17,20	1,13	0,09	0,19
Caprella spp. D	17,20	0,79	0,11	0,14
Caprella spp. E	6,90	0,30	0,02	0,02
Caprellina longicollis	3,40	0,15	0,02	0,01
Caprella spp. F	17,20	0,83	0,08	0,14
Cerapus spp. A	24,10	2,36	0,44	0,57
Cerapus spp. B	3,40	0,34	0,01	0,01

Appendix 24 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
Amphipoda contd.)				
Corophium spp. A	37,90	7,05	0,48	2,67
Corophium spp. B	17,20	1,13	0,13	0,19
Corophium spp. C	17,20	0,94	0,11	0,16
Cymadusa spp.	31,00	3,36	0,39	1,04
Gammaropsis spp.	6,90	0,18	0,02	0,01
Jassa spp. A	34,50	4,97	0,57	1,71
Jassa spp. B	10,30	0,60	0,05	0,06
Jassa spp. C	13,80	0,37	0,06	0,05
Lysianassa ceratina	3,40	0,37	0,03	0,01
Maera spp.	62,10	7,66	0,73	4,76
Paramoera capensis	51,70	6,75	0,78	3,49
Parelasmopus suluensis	62,10	8,95	1,00	5,56
Photis spp.	51,70	4,66	0,47	2,41
Phoxostoma spp.	6,90	0,26	0,02	0,02
Temnophlias spp.	6,90	1,55	0,13	0,11
Urothöe spp.	13,80	1,99	0,17	0,27
Unidentified spp. A	10,30	0,10	0,02	0,01
Unidentified spp. B	3,40	0,11	0,01	0,01
Unidentified spp. C	3,40	0,11	0,01	0,01
Unidentified spp. D	3,40	0,22	0,02	0,01
Unidentified spp. E	3,40	0,07	—	—
TOTALS	56,12	60,57	6,22	24,32 (63,5)
Ostracoda	3,40	0,03	0,01	—

Appendix 24 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
Mysidacea				
Mysidopsis similis	3,40	0,79	0,06	0,03 (0,1)
Tanaidacea				
Apseudes spp.	3,40	0,17	0,11	0,01
Leptochelia barnardi	3,40	0,52	0,13	0,02
TOTALS	6,80	0,69	0,24	0,03 (0,1)
Harpacticoida				
Species B	6,90	0,26	0,01	0,02
Species C	3,40	0,26	0,01	0,01
Species E	44,80	2,02	0,18	0,90
Species K	6,90	0,36	0,02	0,02
Species O	3,40	0,26	0,03	0,01
TOTALS	65,40	3,16	0,25	0,96 (2,5)
Unidentifiable Fragments	79,30	6,21	0,61	4,92 (12,8)
GRAND TOTAL	929,50	100,00	9,76	38,29 (100)

Appendix 25. Diet of sub-adult D.cervinus in the 75 to 100 mm size class (n = 11).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
POLYCHAETA				
Nereis spp. (small)	9900	1,73	0,09	0,16
Nereis spp. (large)	9,00	3,73	0,16	0,34
Terebellidae	9,00	8,09	1,20	0,73
Unidentified spp.	9,00	1,10	0,07	0,10
TOTALS	36,00	14,65	1,62	1,33 (7,8)
CRUSTACEA				
Isopoda				
Cymodocella pustulata	18,00	8,91	0,63	1,60
Gnathia spp.	9,00	5,28	0,08	0,48
Janiropsis spp.	9,00	2,36	0,04	0,21
Stenetrium spp.	9,00	1,91	0,09	0,17
TOTALS	45,00	18,46	0,84	2,46 (14,5)
Amphipoda				
Caprella spp. C	18,00	1,91	0,10	0,34
Caprella spp. D	9,00	0,27	0,03	0,02
Cerapus spp.	18,00	3,18	0,15	0,57
Corophium spp. A	9,00	0,77	0,14	0,34
Corophium spp. B	27,00	2,18	0,11	0,59
Cymadusa spp.	9,00	1,91	0,09	0,17
Lysianassa ceratina	18,00	3,91	0,21	0,70
Maera spp.	18,00	6,55	0,21	1,18

Appendix 25 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
Amphipoda contd.)				
Paramoera capensis	9,00	8,50	0,38	0,77
Parelasmopus suluensis	9,00	3,70	0,30	0,33
Photis spp.	18,00	1,09	0,14	0,34
Urothöe spp.	9,00	1,46	0,07	0,13
Unidentified spp.	27,00	6,55	0,24	1,77
TOTALS	198,00	41,98	2,06	6,98 (41,1)
Ostracoda	9,00	1,73	0,08	0,16 (0,9)
Harpacticoida				
Species H	9,00	0,27	0,01	0,02 (0,1)
Macrura				
Palaemon pacificus	9,00	6,91	0,14	0,62 (3,7)
MOLLUSCA				
Littorina knysnaensis	9,00	1,45	0,05	0,13 (0,8)
Unidentifiable fragments	36,00	14,55	1,60	5,20 (31,1)
GRAND TOTAL	351,00	100,00	6,40	16,98 (100)

Appendix 26. Diet of sub-adult D.cervinus in the 100 to 135 mm size class (n = 6).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
CHLOROPHYTA				
Ulva spp.	16,67	—	—	—
RHODOPHYTA				
Corallina spp.	16,67	7,67	0,57	1,27 (3,4)
POLYCHAETA				
Dodecaceria pulchra	16,67	3,87	0,63	0,64
Nereis spp. (large)	66,67	28,83	2,31	19,20
Terebellidae	33,33	18,83	2,00	6,27
Terebellidae (tentacles)	16,67	0,53	0,02	0,09
TOTALS	133,34	52,06	4,96	26,20 (70,7)
CRUSTACEA				
Isopoda				
Cymodocella eutylos	16,67	18,02	0,50	2,99 (8,1)
Amphipoda				
Cerapus spp.	16,67	—	—	—
Corophium spp.	16,67	3,83	0,16	0,64
Lysianassa spp.	16,67	0,93	0,13	0,15
Paramoera capensis	33,33	12,66	0,72	4,22
TOTALS	83,34	17,42	1,01	5,01 (13,5)
MOLLUSCA				
Littorina knysnaensis	16,67	7,67	0,57	1,27 (3,4)
Unidentifiable fragments	33,33	4,83	3,46	1,61 (4,3)
GRAND TOTAL	316,69	100,00	10,50	37,08 (100)

Appendix 27. Diet of juvenile *S. salpa* in the 10 to 15 mm size class (n = 23).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
CHLOROPHYTA				
Enteromorpha spp.	8,70	1,09	0,07	0,95 (2,7)
CHRYSOPHYTA (Diatoms)				
Unidentified spp. A	8,70	0,57	0,06	0,05 (0,1)
POLYCHAETA				
Nereis spp. (small)	17,39	2,61	0,70	0,45 (1,3)
CRUSTACEA				
Isopoda				
Gnathia spp.	8,70	4,87	0,37	0,42
Janiropsis spp.	4,35	0,87	0,04	0,04
Panathura spp.	4,35	0,87	0,10	0,04
Stenetrium spp.	4,35	0,43	0,03	0,02
TOTALS	21,75	7,04	0,54	0,52 (1,5)
Amphipoda				
Gammaropsis spp.	4,35	0,87	0,04	0,04
Lysianassa variegata	8,70	0,87	0,04	0,08
Maera spp.	17,39	4,13	0,40	0,72
Paramoera capensis	8,70	1,09	0,90	0,09
Parelasmopus suluensis	8,70	2,83	0,09	0,25
Unidentified spp. A	13,04	3,26	0,10	0,43
Unidentified spp. B	4,35	0,22	0,02	0,01
TOTALS	65,23	14,14	1,59	1,66 (4,8)

Appendix 27 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
Cirripedia				
Nauplius larvae	22,00	6,65	0,60	1,45 (4,2)
Leptostraca	4,35	0,43	0,04	0,02 (0,1)
Ostracoda	26,09	4,44	0,61	1,16 (3,3)
Harpacticoida				
Species A	43,48	21,63	0,80	9,40
Species B	60,87	25,57	2,01	15,56
Species D	4,35	1,09	0,08	0,05
Species E	30,43	6,39	0,39	1,94
Species G	4,35	1,09	0,05	0,05
SpeciessI	4,35	1,30	0,01	0,06
Species P	4,35	0,22	0,02	0,01
TOTALS	111,18	57,29	3,36	27,07 (78,2)
INSECTA				
Telmatogeton minor	4,35	0,87	0,05	0,04 (0,1)
Unidentifiable fragments	26,09	4,44	0,20	1,27 (3,7)
GRAND TOTAL		100,00	7,82	34,64 (100)

Appendix 28. Diet of juvenile *S. salpa* in the 15 to 25 mm size class (n = 33).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
CHRYSOPHYTA (Diatoms)				
Unidentified spp. A	24,24	9,91	1,26	2,40 (6,9)
RHODOPHYTA				
Ceramium spp.	3,03	0,09	0,02	—
Champia compressa	3,03	0,45	0,34	0,01
Hypnea spicifera	3,03	0,30	0,02	0,01
Polysiphonia spp.	6,06	0,30	0,03	0,02
Tayloriella spp.	3,03	0,15	0,01	0,01
TOTALS	18,18	1,29	0,42	0,05 (0,1)
POLYCHAETA				
Nereis spp.	30,30	5,36	0,28	1,62 (4,7)
CRUSTACEA				
Cirripedia				
Nauplius larvae	18,18	4,76	0,37	0,87 (2,5)
Isopoda				
Gnathia spp.	15,15	0,55	0,05	0,08
Janiropsis spp.	9909	0,48	0,02	0,04
Panathura spp.	3,03	0,21	0,02	0,01
Stenetrium spp.	15,15	1,58	0,13	0,24
TOTALS	42,42	2,82	0,22	0,37 (1,1)

Appendix 28 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
Amphipoda				
Caprella spp. C	3, 3	0,24	0,02	0,01
Cerapus spp.	3,03	0,91	0,05	0,03
Gammaropsis spp.	3,03	0,30	0,05	0,01
Jassa spp.	3,03	0,24	0,02	0,01
Lysianassa ceratina	9,09	0,76	0,	0,07
Maera spp.	18,18	0,94	0,07	0,17
Paramoera capensis	33,33	6,79	0,50	2,26
Parelasmopus suluensis	48,48	9,88	0,79	4,79
Photis spp.	6,06	0,76	0,08	0,05
Unidentified spp. A	6,06	0,42	0,02	0,03
Unidentified spp. B	3,03	0,30	0,03	0,01
TOTALS	62,35	21,54	1,73	7,44 (21,5)
Ostracoda	36,36	2,94	0,13	1,07 (3,1)
Crab zoaea	3,03	0,45	0,05	0,01 (0,1)
Harpacticoida				
Species A	45,45	24,90	2,75	11,32
Species B	51,51	14,00	1,49	7,21
Species C	12,12	3,45	0,17	0,42
Species E	27,27	3,91	0,21	1,07
Species G	18,18	0,94	0,09	0,17
TOTALS	154,63	47,20	4,71	20,19 (58,5)
INSECTA				
Telmatogeton minor	3,03	1,82	0,18	0,06 (0,2)
Unidentifiable animal fragments	24,24	1,91	0,10	0,46 (1,3)
GRAND TOTAL		100,00	9,45	34,54 (100)

Appendix 29. Diet of juvenile *S. salpa* in the 25 to 35 mm size class (n = 16).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
CHLOROPHYTA				
Cladophora spp.	6,25	1,25	0,19	0,08
Enteromorpha spp.	6,25	1,25	0,15	0,08
Ulva spp.	18,75	1,75	0,25	0,33
TOTALS	31,25	4,25	0,59	0,49 (0,9)
CHRYSOPHYTA (Diatoms)				
Lycmophora spp.	6,25	0,13	0,02	0,01
Unidentified spp. A	100,00	36,75	4,92	36,75
TOTALS	106,25	36,88	4,94	36,76 (66,1)
RHODOPHYTA				
Ceramium spp.	50,00	4,25	0,62	2,13
Champia compressa	25,00	6,06	0,93	1,52
Hypnea spicifera	43,75	5,19	0,72	2,27
Polysiphonia spp.	50,00	6,06	0,79	3,03
Polyzonia elegans	18,75	1,38	0,18	0,26
Pterosiphonia cloiophylla	6,25	0,94	0,14	0,06
Tayloriella spp.	50,00	6,56	0,76	3,28
TOTALS	362,50	32,07	4,43	12,86 (23,1)
CRUSTACEA				
Cirripedia				
Nauplius larvae	12,50	0,19	0,01	0,02 (-)
Isopoda				
Dynamenella huttoni	6,25	1,25	0,15	0,08 (0,1)

Appendix 29 contd.)

Food species	Percentage occu rence	Percentage volume	Points	Ranking index
Amphipoda				
Caprella spp. F	6,25	0,75	0,15	0,05
Corophium spp. B	6,25	2,19	0,31	0,14
Gammaropsis spp.	6,25	0,31	0,04	0,02
Paramoera capensis	25,00	1,88	0,22	0,47
Parelasmopus suluensis	6,25	0,31	0,04	0,02
Photis spp.	25,00	6,75	0,97	1,69
TOTALS	75,00	12,19	1,73	2,39 (4,3)
Ostracoda	6,25	0,69	0,11	0,04 (0,1)
Crab zoaea	12,50	0,38	0,05	0,05 (0,1)
Mysidacea	6,25	0,25	0,04	0,02 (-)
Harpacticoida				
Species B	18,75	1,44	0,23	0.27
Species E	6,25	—	—	—
Species G	6,25	0,06	0,01	—
TOTALS	31,25	1,50	0,24	0,27 (0,5)
INSECTA				
Telmatogeton minor	12,50	0,38	0,05	0,05 (0,1)
PISCES				
Fish muscle	6,25	2,19	0,31	0,14 (0,3)
Unidentifiable animal fragments	31,25	7,78	1,10	2,43 (4,4)
GRAND TOTAL		100,00	13,75	55,58 (100)

Appendix 30. Diet of juvenile S.salpa in the 35 to 50 mm size class (n = 24).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
CHLOROPHYTA				
Cladophora spp.	4,00	0,04	0,01	—
Enteromorpha spp.	12,00	0,32	0,05	0,04
Rhizoclonium spp.	12,00	1,16	0,17	1,08
Ulva spp.	64,00	17,36	3,56	11,11
TOTALS	92,00	18,88	3,79	12,23 (22,5)
CHRYSOPHYTA (Diatoms)				
Lycmophora spp.	60,00	4,28	0,79	2,57
Unidentified spp. A	68,00	25,00	2,82	17,00
TOTALS	128,00	29,28	3,61	19,57 (36)
RHODOPHYTA				
Centroceras spp.	36,00	3,00	0,49	1,08
Ceramium spp.	52,00	7,90	1,26	4,11
Champia compressa	36,00	8,72	1,28	3,14
Hypnea spicifera	76,00	7,64	1,28	5,81
Polysiphonia spp.	44,00	7,80	1,25	3,43
Pterosiphonia cloiophylla	12,00	0,68	0,08	0,08
Tayloriella spp.	24,00	2,76	0,46	0,66
TOTALS	328,00	43,42	6,93	20,67 (38)
HYDROZOA				
Thecocarpus formosus	4,00	—	—	—

Appendix 30 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
POLYCHAETA				
Nereis spp. (small)	8,00	0,12	0,02	0,01 (-)
CRUSTACEA				
Isopoda				
Dynamenella macrocephala	4,00	0,04	0,01	0,01
Gnathia spp.	4,00	0,08	0,01	0,01
Janiropsis spp.	4,00	0,08	0,01	0,01
TOTALS	12,00	0,16	0,03	0,03 (0,1)
Amphipoda				
Cerapus spp.	4,00	0,24	0,04	0,01
Corophium spp.	4,00	0,08	0,01	0,01
Paramoera capensis	16,00	0,84	0,14	0,13
Parelasmopus suluensis	16,00	1,32	0,27	0.21
Photis spp.	4,00	0,12	0,02	0,01
TOTALS	44,00	2,60	0,48	0,37 (0,6)
Ostracoda	12,00	0,32	0,05	0,04 (0,1)
Harpacticoida				
Species B	24,00	2,50	0,42	0,60
Species G	8,00	0,04	0,01	0,01
TOTALS	32,00	2,54	0,43	0,61 (1,1)
Unidentifiable animal and plant fragments	32,00	2,68	0,40	0,86 (1,6)
GRAND TOTAL	140,00	100,00	15,74	54,39 (100)

Appendix 31. Diet of juvenile S.salpa in the 50 to 75 mm size class (n = 12).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
CHLOROPHYTA				
Caulerpa filiformis	8,33	0,08	0,01	0,01
Chaemaedoris delphini	8,33	1,25	0,19	0,10
Cladophora spp. A	8,33	0,42	0,06	0,03
Ulva spp.	91,67	22,00	3,29	20,17
TOTALS	116,66	23,75	3,55	20,31 (33,2)
CHRYSOPHYTA (Diatoms)				
Lycmophora spp.	66,66	13,25	2,07	8,82
Unidentified spp. A	66,66	14,33	2,40	9,56
TOTALS	133,32	27,58	4,47	18,38 (30)
RHODOPHYTA				
Centroceras spp.	50,00	3,75	0,56	1,88
Ceramium spp.	33,33	4,58	1,05	1,53
Champia compressa	25,00	2,58	0,39	0,65
Hypnea sp cifera	66,67	14,75	2,48	9,83
Polysiphonia spp.	50,00	8,25	1,75	4,13
Polyzonia elegans	8,33	0,16	0,03	0,01
Pterosiphonia cloiophylla	33,33	2,92	0,51	0,97
TOTALS	291,66	39,07	7,05	19,52 (31,9)
HYDROZOA				
Sertularella spp.	8,33	0,83	0,02	0,69
Thecocarpus formosus	8,33	0,17	0,03	0,14
TOTALS	16,66	1,00	0,05	0,83 (1,4)

Appendix 31 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
POLYCHAETA				
Nereis spp. (large)	8,33	4,58	0,46	0,38 (0,6)
CRUSTACEA				
Amphipoda				
Caprella cicur	8,33	0,17	0,03	0,14
Caprella spp. F	8,33	0,08	0,01	0,01
Cerapus spp.	16,67	0,25	0,04	0,04
Gammaropsis spp.	8,33	0,17	0,03	0.14
Parelasmopus suluensis	8,33	—	—	—
TOTALS	49,99	0,67	0,11	0,33 (0,5)
Tanaidacea				
Leptochelia barnardi	8,33	0,17	0,03	0,14 (0,2)
Unidentifiable plant fragments	41,66	3,18	0,74	1,32 (2,2)
GRAND TOTAL	666,28	100,00	16,46	61,21 (100)

Appendix 32. Diet of sub-adult *S. salpa* in the 75 to 100 mm size class (n = 6).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index	
CHLOROPHYTA					
Caulerpa filiformis	16,67	2,00	0,40	0,33	
Chaemaedoris delphini	16,67	6,67	0,53	1,11	
Cladophora spp. A	16,67	0,50	0,10	0,08	
Ulva spp.	100,00	15,84	2,86	15,70	
TOTALS	150,01	25,01	3,89	17,22	(27,3)
RHODOPHYTA					
?*Acrosorium* spp.	33,33	2,67	0,54	0,89	
Champia compressa	66,67	7,33	1,23	4,89	
Hypnea spicifera	83,33	28,00	3,97	23,33	
Polyzonia elegans	50,00	3,83	0,33	1,92	
Pterosiphonia cloiophylla	16,67	1,67	0,37	0,28	
Tayloriella spp.	16,67	0,33	0,07	0,06	
TOTALS	266,67	44,66	6,74	31,51	(49,8)
HYDROZOA					
Gattya humilis	50,00	23,17	4,03	11,58	
Thecocarpus formosus	16,67	0,83	0,04	0,14	
TOTALS	66,67	24,00	4,07	11,72	(18,6)
POLYCHAETA					
Nereis spp. (large)	16,67	0,83	0,07	0,14	(0,2)

Appendix 32 contd.)

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
CRUSTACEA				
Amphipoda				
Cerapus spp.	16,67	0,33	0,07	0,55
Parelasmopus suluensis	33,33	0,17	0,04	0,14
Photis spp.	16,67	0,83	0,04	0,06
TOTALS	66,67	1,33	0,15	0,75 (1,2)
BRYOZOA	16,67	0,67	0,07	0,11 (0,2)
MOLLUSCA				
Rhaciglossa spp.	16,67	0,17	0,04	0,03
Unidentifiable algal fragments	50,00	3,33	0,47	1,67 (2,6)
GRAND TOTAL	666,70	100,00	15,50	63,15 (100)

Appendix 33. Diet of sub-adult *S.salpa* in the 125 to 150 mm size class (n = 2).

Food species	Percentage occurrence	Percentage volume	Points	Ranking index
CHLOROPHYTA				
Bryopsis spp.	100,00	0,50	0,14	0,50
Caulerpa filiformis	100,00	42,50	11,90	42,50
Cladophora spp. B	50,00	—	—	—
Ulva spp.	50,00	5,00	1,40	2,50
TOTALS	300,00	48,00	13,44	45,50 (48,3)
RHODOPHYTA				
?*Acrosorium* spp.	50,00	1,00	0,28	0,50
Arthrocardia spp.	100,00	1,00	0,28	1,00
Corallina spp.	100,00	1,00	0,28	1,00
Hypnea spicifera	100,00	43,50	12,18	43,50
Polyzonia elegans	50,00	2,50	0,70	1,25
TOTALS	400,00	49,00	13,72	47,25 (50,1)
HYDROZOA				
Thecocarpus formosus	50,00	1,50	0,42	0,75 (0,8)
CRUSTACEA				
Amphipoda				
Cerapus spp.	50,00	1,50	0,42	0,75 (0,8)
GRAND TOTAL	800,00	100,00	28,00	94,25 (100)