STOMACH CONTENT ANALYSES OF MULLET FROM THE SWARTKOPS ESTUARY

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ABSTRACT

The stomach content of four species of mullet (*Mugil cephalus, Liza dumerili, Liza richardsonii* and *Liza tricuspidens*), was analyzed. The nature of the stomach content gave some indication of the areas in which each species of mullet had been feeding, the type of substratum from which each had been feeding and the diatom species which each ate.

INTRODUCTION

The stomach content of four species of mullet from four stations on the Swartkops Estuary was analyzed for the purpose of identification of food items. Sediment particles obtained at the same time from the same localities were compared with sediment particles in the stomach contents of the fish. It is stated by Thomson (1966) that *M. cephalus* takes in a proportion of sand, which is believed to assist in the grinding of diatoms and other food in the muscular gizzard-like stomach. One of the aims of this study was to determine any peculiarities of a few mullet species in this respect. The four stations from which the fish were collected are situated between the upper reaches and the mouth of the Swartkops estuary near Port Elizabeth (Figure 1).

The life-forms and the habitats of the benthic algae, particularly the diatoms, which had been eaten by the fish were investigated. It is hoped that these together with the sediment particles ingested by the fish would give some idea of the type of substratum from which the fish fed.

There are two life forms of diatoms in the benthic habitats. These are the motile free-living forms which live as a film on and in sandy or muddy substrata, and the non-motile diatoms which grow attached to rocks and other aquatic plants by means of mucous stipes or pads. A more detailed description of the habitats and life-forms of benthic diatoms is given by Round (1971).

The size of the motile diatoms was noted, as differences in the sizes of diatoms living on sand and silt has been noted by Brockman (1935) and Hustedt (1939). Round (1971) has recorded that small diatoms lived on the fine sticky silt of the Dee Estuary while larger diatoms lived on the sand. The importance of the motile free-living algae for animals feeding on the sediments was recognized by Mare (1942) who made algal population estimates on the sediments.

Mullet names used in this text are after Thomson (in press).

MATERIALS AND METHODS

Liza dumerili (Steindachner 1869), referred to as *Strializa canaliculatus* (Smith) in Smith (1965), was collected at all four stations. *Mugil cephalus* Linnaeus 1758 was collected from Stations 1, 2 and 3. *Liza richardsonii* (A. Smith 1846), referred to as *Liza ramada* (Risso) in Smith (1965), was collected from Stations 2, 3 and 4. *Liza tricuspidens* (Smith 1935), referred to as *Heteromugil tricuspidens* (Smith) in Smith (1965), was collected from Stations 4a and 4b on opposite banks of the river.

The fish were collected with a 35 × 1,7 m trek-net, about halfway between mid- and high-tide. Two to three hauls were taken at each station. A throw-net was used to catch fish at Amsterdamhoek where the substratum was rocky and the flow of the river too strong for the use of a trek-net. Representative temperature and salinity values were obtained from each locality (Table 1). The mullet were then measured and identified. Within 30 minutes of the fish being caught, the abdomens were cut open and the stomachs and oesophagi were removed and preserved in 5 per cent formalin.

In the laboratory the stomach was cut open and a portion of the contents removed and examined microscopically. If the stomach was empty or if the contents were too broken up to examine, the oesophageal contents were examined.

Where possible the diatom species were identified, otherwise the genus is named except for the very small pennate diatoms measuring less than 10μ, which are too small to identify under the ordinary light microscope. These are grouped under the heading of 'Naviculoid diatoms'. Desmids and dinoflagellates were identified as far as genera. Algae other than the above-mentioned, *i.e.* filamentous and colonial green and blue-green algae, are grouped as such. Other animal material was identified as far as possible. Food items in the foreguts of four species of mullet appear in Tables 2–5. The tables indicate the frequency of occurrence in fish stomachs as 'present', or 'frequent' (present in more than 75 per cent of the stomachs).

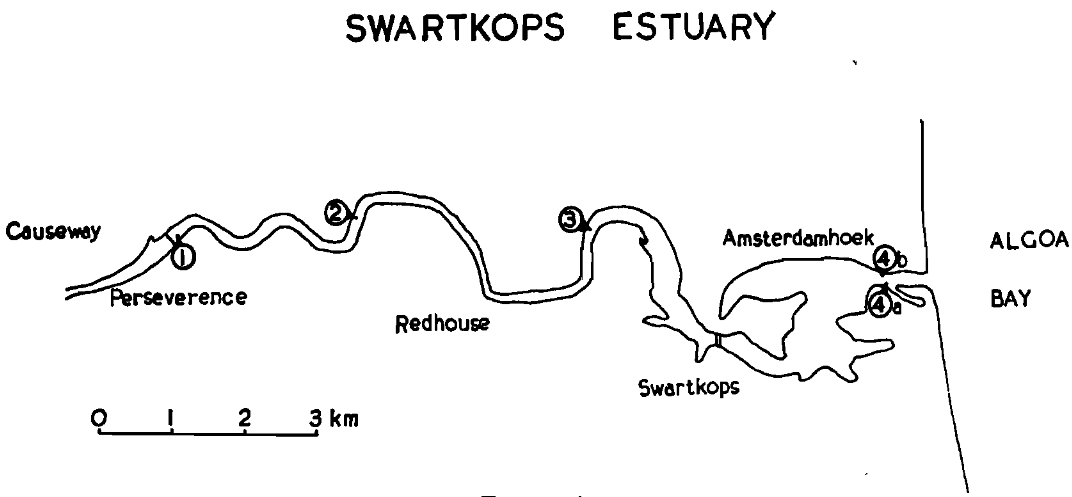

FIGURE 1

Algae in the sediments were identified and compared with those present in the stomach contents (Table 6).

Stomach and oesophageal contents were examined for sediment particle size where a sufficient quantity of stomach content material was available at any of the four stations. Particle size determinations were also performed on a representative sample from the upper 0,5 cm of the substratum at each of the four localities where fish were caught. These samples were preserved in 5 per cent formalin. Particle size was determined by wet sieving according to the method of Morgans (1956), using sieves corresponding to the Wentworth scale. Particle sizes of the sediment and of the stomach contents are shown in Tables 7–10.

TABLE 1

Temperature and salinity values at collecting sites.

Station	*Date*	*Temperature °C*	*Salinity °/oo*
1	10.4.74	22,5	0,26
2	10.4.74	24	2,65
3	11.4.74	25,4	4,75
4a	11.4.74	23,7	22,67
4b	1.3.75	21	32,56

RESULTS

Mugil cephalus

From Table 7 it may be seen that *M. cephalus* selects much finer material than *Liza dumerili* caught at the same locality. Nearly 60 per cent of the dry stomach contents of *M. cephalus* consisted of silt and clay.

Stomach contents of nine specimens of *M. cephalus* taken from Station 1 were examined microscopically. The fish varied in length from 9,1 to 19,7 cm. In all the stomach contents except one, the contents consisted mostly of diatom material. This specimen had ingested more filamentous algae than diatoms and the sand particles were not as numerous. The content of this one specimen was typical of the algal mats growing on rocks in the area.

The diatoms in the stomach contents were mainly very small pennate forms such as *Navicula* and *Nitzschia* and the small centric form *Cyclotella*. *Synedra ulna*, a fresh-water diatom, and *Bacillaria paradoxa*, a euryhaline species, were also plentiful. Other diatoms typically occurring in the area and present in the stomach contents are *Tabellaria flocculosa*, described as a freshwater species by Hustedt (1939–1959), *Coscinodiscus lacustris* and *Amphiprora paludosa* var. *subsalina*, described as living in fresh and brackish water by Hustedt (1930) and Cleve (1894) respectively.

TABLE 2

Stomach contents of *Mugil cephalus*
(O = present, × = frequent)

	Station 1	*Station 2*	*Station 3*
Number of specimens	9	4	1
Size range (cm)	9,1–19,7	8,1–17,5	9,1
Mean S.L. (cm)	11,2	11,2	9,1
Food items	*Frequency of occurrence*		
Naviculoid diatoms	×	×	O
Nitzschia sp.	×	×	O
Synedra ulna	×	×	O
Nitzschia sigma	×	O	—
Cyclotella sp.	O	×	O
Fragilaria sp.	O	×	—
Coscinodiscus lacustris	O	—	—
Bacillaria paradoxa	O	×	—
Pinnularia sp.	O	—	—
Pleurosigma sp.	O	O	—
Stauroneis sp.	O	—	—
Rhopalodia sp.	O	—	—
Tabellaria flocculosa	O	—	—
Achnanthes sp.	O	—	—
Gyrosigma sp.	O	—	—
Amphora sp.	O	—	O
Diploneis sp.	O	—	O
Diploneis bombus	—	—	—
Melosira sp.	—	O	—
Nitzschia transvaalensis	—	O	—
Nitzschia spathulata	—	O	—
Nitzschia longissima	—	—	O
Gyrosigma variipunctatum	—	—	O
Green and blue-green algae	×	×	O
Scendesmus sp.	×	O	—
Pediastrum sp.	O	—	—
Flagellates	O	—	—
Desmids			
Staurastrum sp.	O	O	—
Closterium sp.	×	×	—
Cosmarium sp.	O	—	—
Sponge spicules	—	×	—
Crustacea (fragments)	—	—	O

Four specimens of *M. cephalus* were caught at Station 2. These varied in length from 8,1 to 17,5 cm. Microscopical examination revealed that the stomach contents also contained numerous particles of silt and clay. The tiny naviculoid diatoms which are motile were most abundant. Desmids occurred in the stomach contents of fish from both Stations 1 and 2. These fresh-water organisms were indicative of flooded conditions of the estuary at the time of sampling.

One specimen of *M. cephalus*, 9,1 cm in length, was caught at Station 3. Again the stomach was filled with very small sand particles. Diatoms dominated the food material and the tiny *Navicula*, *Amphora* and *Nitzschia* species formed the main bulk of the material. *Gyrosigma variipunctatum*, a large motile diatom in this part of the estuary, was present in small numbers.

Liza dumerili

From the particle size determinations it is clear that *Liza dumerili* feeds on much coarser sand particles than *Mugil cephalus* (Table 7). It appears that *Liza dumerili* selects sand particles smaller than 500μ (Tables 7–10). Even where the percentage of substrate particles measuring 500μ and more comprised 34,5 per cent of the substratum at Station 2 (Table 8) all three size groups of *Liza dumerili* selected less than 3 per cent of this particular size group.

It is also evident from Tables 7–9 that the smaller size group (6,1–10 cm) of *Liza dumerili* selected finer material than the two larger size groups. It is interesting to note that at Station 3, where silt and clay comprised almost 58 per cent of the substrate, the smaller size group of *Liza dumerili* contained 52 per cent silt and clay in the stomach contents and the stomach contents of the larger size groups contained about 20 per cent silt and clay.

The stomach contents of the largest specimens examined microscopically not only contained the largest sand particles but also the largest variety of diatoms and algal plants. In addition there was more animal material present including ciliates, fragments of crustacea, Rotifera, nematodes, Foraminifera, larval Mollusca and dinoflagellates.

Similar diatoms were dominant in the stomach contents of *Mugil cephalus* and *Liza dumerili* at Station 1. Filamentous green and blue-green algae, typical of the algal mats in the area, were dominant in the stomach contents of two fish and present in the other specimens of *Liza dumerili* caught at Station 1. Desmids occurred most commonly in stomach contents of fish caught at this station where the influence of fresh water on the estuary was greatest.

The stomach contents of *Liza dumerili* caught at Station 2 contained more large diatoms than those of *Mugil cephalus* at the same station. These include *Campylodiscus*, *Hantzschia*, *Gyrosigma*, *Stauroneis*, *Surirella* and *Pleurosigma* species. These diatoms are all motile free-living forms which live on sandy substrata (Hendey 1964; Round 1971).

At Station 3 the large diatom *Gyrosigma variipunctatum*, a free-living motile species, was most common in the stomach contents. Several diatoms which live attached to rocks and plants were also present. These are the *Navicula* and *Gyrosigma* species which live in mucous tubes attached to a substratum. In addition *Grammatophora marina*, *Melosira dubia*, *Paralia sulcata* and *Biddulphia aurita*, all attached forms, were present.

The fish caught at Station 4 had ingested motile diatoms living on the sand such as naviculoid diatoms, *Amphiprora* species, *Nitzschia* species, *Hantzschia* species and *Donkinia* species. *Cocconeis*, a form which can live attached either to sand-grains or to other plants, was a fairly

TABLE 3

Stomach contents of *Liza dumerili*
(○ = present, × = frequent)

	Station 1	*Station 2*	*Station 3*	*Station 4*
Number of specimens	8	16	14	7
Size range (cm)	9,4–13,8	6,9–19,9	7,7–19,5	13,2–18
Mean S.L. (cm)	10,8	12,6	12,3	14,5
Food items		*Frequency of occurrence*		
Naviculoid diatoms	×	×	○	×
Nitzschia sp.	×	×	○	○
Synedra ulna	○	×	○	—
Cyclotella sp.	○	○	○	—
Melosira sp.	○	○	—	—
Coscinodiscus lacustris	○	○	○	—
Nitzschia transvaalensis	○	○	—	○
Gyrosigma sp.	○	—	○	○
Tropidoneis lepidoptera	○	○	—	—
Amphiprora paludosa v. subsalina	○	○	—	—
Surirella sp.	○	○	○	○
Amphora sp.	○	○	○	—
Bacillaria paradoxa	○	○	○	—
Rhopalodia sp.	○	○	○	—
Achnanthes sp.	○	—	○	○
Tabellaria flocculosa	○	○	—	—
Diploneis bombus	—	×	○	—
Fragilaria sp.	—	×	—	—
Nitzschia sigma	—	×	○	○
Pleurosigma sp.	—	○	—	—
Cyclotella meneghiniana	—	○	—	—
Synedra fulgens	—	○	○	—
Stauroneis sp.	—	○	—	—
Campylodiscus daemelianus	—	○	—	—
Caloneis sp.	—	○	—	—
Nitzschia spathulata	—	○	—	○
Eunotia sp.	—	○	—	—
Campylodiscus sp.	—	○	—	—
Actinoptychus splendens	—	○	○	—
Hantzschia sp.	—	○	—	—
Gyrosigma variipunctatum	—	○	×	○
Grammatophora marina	—	○	—	○
Navicula (in tubes)	—	—	○	—
Gyrosigma (in tubes)	—	—	○	—
Melosira dubia	—	—	○	—
Paralia sulcata	—	—	○	○

TABLE 3 (continued)

Stomach contents of *Liza dumerili*
(O = present, × = frequent)

Food items	Station 1	Station 2	Station 3	Station 4
	Frequency of occurrence			
Nitzschia longissima	—	—	O	—
Cocconeis scutellum	—	—	O	—
Biddulphia aurita	—	—	O	O
Amphiprora sp.	—	—	—	×
Nitzschia closterium	—	—	—	O
Chaetoceros sp.	—	—	—	O
Licmophora sp.	—	—	—	O
Hantzschia virgata	—	—	—	O
Rhizosolenia sp.	—	—	—	O
Cocconeis sp.	—	—	—	O
Hemiaulus hauckii	—	—	—	O
Donkinia sp.	—	—	—	O
Nitzschia erosa	—	—	—	O
Algae: greens and blue-greens	×	×	×	×
Pediastrum sp.	—	O	O	—
Scendesmus sp.	O	×	O	—
Desmids				
Closterium sp.	O	O	O	—
Micrasterias sp.	O	—	—	—
Cosmarium sp.	O	—	—	—
Staurastrum sp.	O	—	—	—
Animal				
Ciliates	O	O	—	—
Crustacea (fragments)	O	O	O	O
Rotifera	—	O	O	—
Nematodes	—	O	O	—
Foraminifera	—	O	O	O
Tintinnids	—	—	O	O
Larval molluscs	—	—	O	—
Sponge spicules	—	—	O	O
Dinoflagellates	—	—	O	O

common food item. A few marine planktonic diatoms, *Chaetoceros* species, *Rhizosolenia* species and *Hemiaulus hauckii* appeared in a small percentage of stomach contents. The proximity of the river mouth and the consequent marine influence would account for these marine forms being present in the stomach contents of fish caught at Station 4. *Ditylum brightwellii*, a marine planktonic diatom, was present in the sediment sample taken from this station.

Liza richardsonii

Two specimens were caught at Station 2. No sediment size determinations were carried out on the stomach contents as there was not enough material available. Microscopical examination of the stomach contents revealed that small ($<50\mu$) and medium($<250\mu$) sand particles were most abundant. The small naviculoid diatoms dominated in the food contents.

Five stomach contents of fish from Station 4 were analyzed. Diatoms were dominant in the stomach contents, particularly the motile naviculoid forms. In two of the guts examined the diatom *Nitzschia spathulata* formed the main bulk of the food material. This motile species is recorded as being common on beach sand on the Eastern Cape coast by Giffen (1966). The sediment particle sizes examined microscopically were similar to those from Station 2. Subsequent sand particle size determinations executed on stomach contents of *Liza richardsonii* caught at Station 4 revealed that 75 per cent of the total dry mass consisted of silt and clay (Marais, unpublished).

Liza tricuspidens

Six fish were caught at Station 4a with the other species of mullet. Only four stomach contents were examined as the remaining two stomachs were empty.

The fish had ingested filamentous algae, fibrous matter and bits of larger aquatic plants – mainly *Zostera*. Diatoms were not numerous and consisted of the attached forms *Grammatophora*, *Licmophora* and *Achnanthes*. These stomachs contained practically no sand particles. It was thought that these fish had been feeding on a rocky substratum. Subsequent sampling for these fish was carried out from the opposite bank of the river at Amsterdamhoek over a rocky substratum where the fish were found to be more abundant (Marais, unpublished). Diatoms and algae growing on the rocks were compared with those in the stomach contents of the fish (Table 5).

Filamentous algae and attached diatoms constitute the algal mats growing on the rocks. Some motile diatoms and sand particles were caught up in the algal mats having been swept on to the rocks by the water movements.

The fish stomach contents contained mainly filamentous algae and attached diatoms. Several fish had eaten fragments of *Zostera*. The *Zostera* beds are situated on sand banks in other areas of the estuary. However large quantities of this plant are broken off and washed up on the Amsterdamhoek bank of the estuary. *Liza tricuspidens* was observed to be feeding at clumps of *Zostera* floating in the area. Approximately 30 per cent of the stomach contents contained sand particles. Where sand particles were present the quantities were very much less than in the stomach contents of the other three mullet species. This is substantiated by the fact that the stomach contents of *Liza tricuspidens* had an appreciably lower percentage of ash than those of

TABLE 4
Stomach contents of *Liza richardsonii*
(O = present, × = frequent)

	Station 2	Station 4
Number of specimens	2	6
Size range (cm)	13,0–15,5	9,5–14,4
Mean S.L. (cm)	14,3	12,8
Food items	*Frequency of occurrence*	
Naviculoid diatoms	×	×
Synedra ulna	×	—
Nitzschia sp.	×	×
Fragilaria sp.	×	—
Cyclotella meneghiniana	×	—
Nitzschia sigma	×	O
Amphora sp.	×	O
Melosira sp.	×	O
Synedra fulgens	×	O
Eunotia sp.	O	—
Tabellaria flocculosa	O	—
Diploneis bombus	O	—
Hantzschia marina	O	—
Nitzschia spathulata	—	O
Licmophora sp.	—	O
Grammatophora angulosa	—	O
Nitzschia closterium	—	O
Hantzschia virgata	—	O
Chaetoceros sp.	—	O
Achnanthes brevipes	—	O
Grammatophora marina	—	O
Cocconeis sp.	—	O
Licmophora sp.	—	O
Paralia sulcata	—	O
Gyrosigma variipunctatum	—	O
Biddulphia aurita	—	O
Coscinodiscus sp.	—	O
Pleurosigma sp.	—	O
Green and blue-green algae	×	×
Scendesmus sp.	×	—
Desmids		
Closterium sp.	O	—
Animal		
Nematodes	O	—
Foraminifera	—	O
Tintinnids	—	O
Crustacea (fragments)	—	O
Sponge spicules	—	×
Dinoflagellates		
Ceratium sp.	—	O
Peridinium sp.	—	O
Dinophysis sp.	—	O

TABLE 5

Substrate analyses and stomach content analyses of *Liza tricuspidens*

(O = present, × = frequent, † = abundant)

		Station 4a	*Station 4b*
Number of specimens		6	9
Size range (cm)		5,1–11,5	5,9–19,1
Mean S.L. (cm)		6,6	15,06
Food items	*Frequency in substrate sample from Station 4b*	*Frequency in fish stomachs*	
Attached diatoms			
Grammatophora marina	†	O	×
Synedra fulgens	×	—	×
Achnanthes brevipes	†	O	×
Melosira dubia	×	O	O
Licmophora sp.	†	O	O
Navicula sp. in tubes	O	×	O
Synedra formosa	×	—	O
Striatella unipunctata	×	—	O
Cocconeis placentula	†	O	O
Licmophora gracilis v. *anglica*	†	—	O
Biddulphia pulchella	O	O	O
Amphora sp. (in tubes)	O	—	O
Mastogloia ciskeiensis	—	O	O
Grammatophora angulosa	O	O	O
Nitzschia sp. (in tubes)	O	O	O
Rhabdonema minutum	O	—	O
Motile and planktonic diatoms			
Nitzschia closterium	O	O	O
Nitzschia pacifica (planktonic)	O	—	O
Naviculoid diatoms	O	O	O
Pleurosigma sp.	O	—	O
Surirella sp.	O	—	O
Navicula sp.	O	—	O
Nitzschia sp.	O	O	O
Fragilaria linearis	—	—	O
Coscinodiscus sp. (planktonic)	—	—	—
Diploneis sp.	—	—	O
Nitzschia sigma	—	O	—
Nitzschia longissima	—	O	—
Hantzschia virgata	—	O	—
Chaetoceros sp. (planktonic)	—	O	—
Amphiprora sp.	—	O	—
Filamentous algae	†	×	×
Zostera sp.	—	O	O
Fragments of Crustacea	—	—	O
Dinoflagellates			
Prorocentrum micans	—	—	O
Dinophysis fortii	—	O	—
Peridinium sp.	—	O	—

the other three species (*L. tricuspidens* 23,6 per cent, *L. dumerili* 49,8 per cent, *M. cephalus* 32 per cent and *L. richardsonii* 35 per cent – expressed on a dry weight basis) (Marais, unpublished data).

CONCLUSION

It appears that there are differences in the feeding of the four species of mullet investigated and that the fish had been feeding in the areas from which they were caught. Fresh-water and euryhaline diatoms and algae occurred in the stomach contents of fish caught at Stations 1 and 2. More littoral marine diatoms and less fresh and brackish water diatoms occurred at Stations 3 and 4. Several neritic marine diatoms occurred in the stomach contents of fish from Station 4.

The life forms of the diatoms which had been eaten by the fish gave some indication of the type of substratum on which the fish fed. In the case of *M. cephalus*, *L. dumerili* and *L. richardsonii* motile benthic diatoms and some attached diatoms occurred most commonly, whereas in the case of *L. tricuspidens* the attached diatoms occurred almost exclusively and few sand particles were present. It appears therefore that the former three species of fish fed on the sediments and occasionally on algal mats attached to rocks or plants, while the latter species fed mainly on algal mats which were attached to rocks and plants. Thomson (1963) published similar findings for *Mugil cephalus*. He states that *M. cephalus* feeds on microscopic organic matter (both living and detrital) on the bottom substrate or grazes on epiphytic diatoms, blue-green and filamentous green algae as well as other Protista.

The three above-mentioned species of fish that fed on the sediments appeared to have ingested different size-groups of sand particles and diatoms. It has already been mentioned that diatom workers have observed a relationship between the size of the sediment particle and the size of the diatoms inhabiting them. It is probable therefore that these three species of mullet fed on areas of the sediment with different particle size composition. *M. cephalus* and *M. richardsonii* ingested the smallest sediment particles and *Liza dumerili* ingested the largest sediment particles. The differences in feeding habits encountered in the different mullet species can possibly be accounted for by differences in stomach structure and length of intestines found in the different species (Marais, unpublished data).

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TABLE 6

Analysis of sediment samples
(O = present, × = frequent, † = abundant)

	Station 1	*Station 2*	*Station 3*	*Station 4*
Diatoms				
Naviculoid diatoms	†	†	†	†
Nitzschia sp.	†	×	†	†
Synedra sp.	×	×	×	—
Synedra ulna	†	†	—	—
Amphora sp.	×	×	†	†
Cyclotella meneghiniana	†	×	—	—
Fragilaria sp.	×	O	—	—
Surirella sp.	O	O	O	—
Amphiprora paludosa var. *subsalina*	×	×	—	—
Nitzschia sigma	×	×	—	—
Nitzschia transvaalensis	O	O	—	—
Stauroneis sp.	O	—	—	—
Coscinodiscus lacustris	O	O	—	—
Tabellaria flocculosa	O	—	—	—
Pinnularia sp.	×	O	—	—
Nitzschia closterium	—	O	—	O
Melosira sp.	—	O	—	—
Pleurosigma sp.	—	O	—	—
Campylodiscus sp.	—	O	—	—
Diploneis bombus	—	O	O	—
Navicula sp. (in tubes)	—	—	O	—
Gyrosigma variipunctatum	—	—	×	—
Navicula humerosa	—	—	O	—
Synedra fulgens	—	—	O	—
Paralia sulcata	—	—	O	—
Biddulphia aurita	—	—	—	O
Nitzschia spathulata	—	—	—	×
Donkinia sp.	—	—	—	×
Amphiprora sp.	—	—	—	O
Cocconeis scutellum	—	—	—	×
Gyrosigma sp. (in tubes)	—	—	—	O
Achnanthes sp.	—	—	—	O
Bacillaria paradoxa	—	—	—	O
Hantzschia virgata	—	—	—	O
Ditylum brightwellii	—	—	—	O
Desmids				
Cosmarium sp.	O	—	—	—
Euastrum sp.	O	—	—	—
Closterium sp.	O	—	—	—
Chlorophyta				
Scendesmus sp.	O	O	—	—
Pediastrum sp.	O	—	—	—
Foraminifera	—	O	—	O

TABLE 7

Particle size of sediment and fish stomach content from Station 1 as a percentage of total dry mass.

Sieve aperture	*Sediment*	*L. dumerili* 10,1–15 cm	*L. dumerili* 6,1–10 cm	*M. cephalus* 6,1–15 cm
1. 2 mm	0,06	0,00	0,00	0,00
2. 1 mm	0,41	0,00	0,00	0,00
3. 500μ	10,26	2,82	1,60	0,99
4. 250μ	68,70	29,61	32,84	3,78
5. 125μ	17,71	28,69	32,25	20,50
6. 63μ	2,16	26,54	18,71	15,81
7. Silt and clay	0,70	12,34	14,60	58,93
Number of fish analyzed		7	3	31
Average S.L. of fish		10,83	9,2	9,32

TABLE 8

Particle size of sediment and fish stomach content from Station 2 as a percentage of total dry mass.

Sieve aperture	*Sediment*	*L. dumerili* > 15,1 cm	*L. dumerili* 10,1–15 cm	*L. dumerili* 6,1–10 cm
1. 2 mm	0,02	0,00	0,00	0,00
1. 2 mm	0,02	0,00	0,00	0,00
2. 1 mm	0,98	0,00	0,00	0,00
3. 500μ	34,50	2,30	1,85	0,24
4. 250μ	53,52	46,84	51,86	41,70
5. 125μ	6,35	28,08	28,85	16,92
6. 63μ	0,70	7,94	7,94	21,32
7. Silt and clay	3,93	14,84	9,50	19,82
Number of fish analyzed		6	14	35
Average S.L. of fish		15,58	12,53	8,71

TABLE 9

Particle size of sediment and fish stomach content from Station 3 as a percentage of total dry mass.

Sieve aperture	*Sediment*	*L. dumerili* > *15,1 cm*	*L. dumerili 10,1–15 cm*	*L. dumerili 6,1–10 cm*
1. 2 mm	0,11	0,00	0,00	0,00
2. 1 mm	0,16	0,00	0,00	0,00
3. 500μ	0,66	0,05	0,06	0,05
4. 250μ	5,77	4,97	5,88	2,55
5. 125μ	19,00	44,54	36,54	18,38
6. 63μ	16,53	30,54	31,48	26,52
7. Silt and clay	57,77	19,90	26,04	52,05
Number of fish analyzed		4	10	11
Average S.L. of fish		15,95	12,22	8,65

TABLE 10

Particle size of sediment and fish stomach content from Station 4 as a percentage of total dry mass.

Sieve aperture	*Sediment*	*L. dumerili* > *15,1 cm*	*L. dumerili 10,1–15 cm*
1. 2 mm	0,00	0,00	0,00
2. 1 mm	0,00	0,00	0,00
3. 500μ	0,03	0,01	0,00
4. 250μ	5,14	5,67	4,57
5. 125μ	88,32	82,77	83,64
6. 63μ	6,02	6,24	7,41
7. Silt and clay	0,49	5,31	4,38
Number of fish analyzed		6	13
Average S.L. of fish		15,73	12,46

REFERENCES

CLEVE, P. T. 1894. Synopsis of the naviculoid diatoms. Part 1. *K. svenska Vetensk-Akad. Handl.* 26:1–194.

CLEVE, P. T. 1895 Synopsis of the naviculoid diatoms. Part II. *K. svenska Vetensk-Akad. Handl.* 27:1–219.

BROCKMAN, C. 1935. Diatomeen und Schlick im Jade-Gebiet. *Abh. senckenb. naturforsch. Ges.* 430:1–64.

GIFFEN, M. H. 1963. Contributions to the diatom flora of South Africa 1. Diatoms of the estuaries of the Eastern Cape Province. *Hydrobiologia*, 21:201–265.

GIFFEN, M. H. 1966. Contributions to the diatom flora of South Africa. III. Diatoms of the marine littoral regions of Kidd's Beach near East London, Cape Province, South Africa. *Nova Hedwigia*, 13:245–292.

HENDEY, M. I. 1964. An introductory account of the smaller algae of British coastal waters. Bacillariophyceae (diatoms). *Fishery Invest., Lond.* 4:1–317.

HUSTEDT, F. 1927–1930. *Die Kieselalgen Deutschlands Osterreichs und der Schweiz mit Beruchsichtigung der ubrigen Länder Europas sowie der angrenzenden Meeresgebiete.* In Rabenhorst, L.: *Kryptogamen-Flora* 7 (1). Leipzig.

HUSTEDT, F. 1939–1959. *Die Kieselalgen Deutschlands Osterreichs und der Schweiz mit Beruchsichtigung der ubrigen Länder Europas sowie der angrenzenden Meeresgebiete.* In Rabenhorst, L.: *Kryptogamen-Flora* 7 (2). Leipzig.

HUSTEDT, F. 1939. Die Diatomeen Flora des Kustengebietes der Noordsee von Dollart bis zur Elbemünding. *Abh. naturw. Ver. Bremen*, 31:572–677.

MARE, M. F. 1942. A study of a marine benthic community with special reference to the micro-organisms. *J. mar. biol. Ass. U.K.* 25:517–554.

MORGANS, J. F. C. 1956. Notes on the analysis of shallow water soft substrata. *J. Anim. Ecol.* 25:367–387.

ODUM, W. E. 1968. Mullet grazing on a dinoflagellate bloom. *Chesapeka Sci.* 9:202–204.

ODUM, W. E. 1970. Utilization of the direct grazing and plant detritus food chains by the stiped mullet *Mugil cephalus*. In *Marine Food Chains*, Ed. J. H. Steele: 220–240. Edinburgh: Univ. Calif. Press.

ROUND, F. E. 1971. Benthic marine diatoms. *Oceanogr. mar. Biol.* 9:83–139.

SMITH, J. L. B. 1965. *The sea fishes of Southern Africa*. Central News Agency: South Africa.

THOMSON, J. M. 1963. Synopsis of biological data on the grey mullet *Mugil cephalus* Linnaeus, 1758. *Commonw. scient. ind. Res. Org., Melbourne, Australia*: 1–63.

THOMSON, J. M. 1966. The grey mullets. *Oceanogr. mar. Biol. Ann. Rev.* 4:301–335.

THOMSON, J. M. In press. The genera and species of the Mugilidae.

WOOD, E. J. F. 1964. Studies in microbial ecology of the Australian region. *Nova Hedwigia*, 8:461–568.