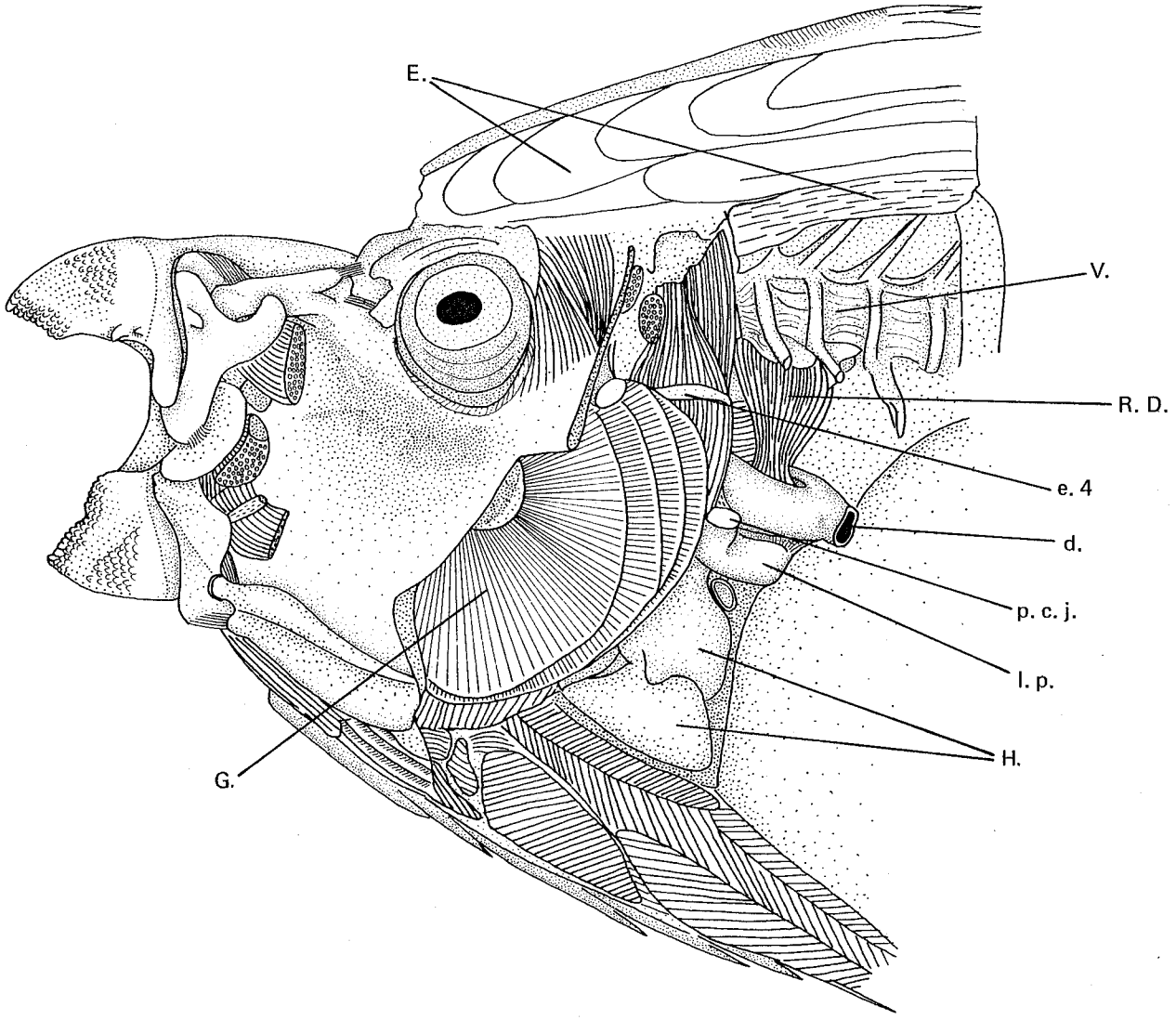
Appendix 1

The head of *S. frenatus* with the integument, nasal, lacrymal, circumorbitals, opercular series, adductor mandibulae, the posterior part of the suspensorium and the pectoral complex, including the cleithrum, removed, to show the position of the jaw apparatus when open and the location of the pharyngeal apparatus.

Abbreviations used in this figure:

d.	Duodenum
E.	Epaxial musculature
e.4	Fourth epibranchial
G.	Gills
H.	Heart
l.p.	Lower pharyngeal bone
p.c.j.	Lower pharyngeal facet of the pharyngocleithral joint
R.D.	Retractor dorsalis
V.	Vertebral column

The individual figured is the same as that used in Chapter 1. The open jaw may be compared with the closed position figured in Figure 1.12 B. The pharyngeal apparatus is figured in Figure 1.15 B.


E.
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APPENDIX 2

NOTES ON THE BIOLOGY OF JUVENILES OF SEVERAL SCARID SPECIES.

Because of the within-species and between-location variability in the behaviour of juvenile scarids, and the large between-species differences in their biology, the results of Chapter 6 are partially summarized here as accounts of the biology of each species in a given location. These accounts are based primarily on the results outlined in Chapter 6 B in addition to notes made during the study period (@ 400 hours of underwater observations). They are intended to clarify some of the results in Chapter 6 B and to try and indicate some of the factors which may be important in the biology of juvenile scarids.

S. sordidus - At the North Reef study site (n = 80+).

In the reef slope region, *S. sordidus* recruited in small numbers in the coral rubble at the base of the reef slope during November and December. In this region, no juveniles were recorded in pomacentrid territories, although in nearby sheltered, rubble strewn pits in the reef top (4 m deep) juveniles were recorded in the territories of *Plectroglyphidodon lacrymatus* and *Stegastes nigricans*. Of the 37 juveniles observed in these pits, between 10.5 and 17 mm T.L., 20 were in pomacentrid territories, 10 on the outskirts and 7 not in a territory. Pomacentrid aggression was only observed towards a single 17 mm T.L. individual. At 10.5 to 17 mm T.L., the juveniles were solitary or in small groups of 3 to 6. On the reef slope, the home ranges of individuals increased with growth. Aggressive interactions were not frequent and were primarily with conspecifics (Table 6.14). As the home range expands, it moves slowly up the reef slope, and typically overlaps with those of several other species. At this stage, up to 60 mm T.L., individuals were solitary or occasionally formed small multi-specific groups. Aggression was most intense towards equally sized conspecifics. Vertical movement of some individuals was limited by the territorial behaviour of *A. lineatus* and juvenile *S. frenatus*. No individuals were followed above 60 mm T.L., although small schools of larger *S. sordidus* were occasionally seen in the reef slope region. Most large juvenile and adult *S. sordidus* were recorded in schools on the nearby reeftop.

S. sordidus - In the lagoon study site (n = 60+).

In the lagoon study site, *S. sordidus* settled in relatively large numbers primarily during November to February. Recently recruited individuals were most frequently recorded in pomacentrid territories and among the branches of arborescent corals near to the reef edge (Table 6.12). Of the 11 recently recruited *S. sordidus* observed in detail, seven were in or near pomacentrid territories (including *Stegastes nigricans*, *S. apicalis*, *Pomacentrus grammorhynchus* and *Plectroglyphidodon lacrymatus*). The remaining four were in arborescent corals. (In transects, 6 of the 9 newly recruited *S. sordidus* were in pomacentrid territories). With growth, the home ranges steadily increased in area. Solitary or paired individuals continued to feed in pomacentrid territories, unmolested, although some individuals at 15 - 15.5 mm T.L. began to

hide when the pomacentrid approached. Pomacentrids first attacked juvenile scarids at about 15.5 mm T.L. and by 16 to 20 mm T.L. they were excluded from the pomacentrid territories (16 - 18 mm T.L. from *S. apicalis* territories; 18.5 to 20 from *S. nigricans* territories). These juvenile scarids and those from live corals moved to nearby pomacentrid-free areas of rock or rubble. They typically formed small schools and were often attacked by pomacentrids (Tables 6.13, 6.14, Fig. 6.9 A). Inter- or intra-specific aggression by the scarids was primarily towards equally sized conspecifics. Individuals continued to behave in this manner, slowly enlarging their home ranges up until 102 mm T.L. Above this size, however, it appears that some *S. sordidus* abandoned their home ranges and join large (up to 105 individuals) mobile schools which forage over extensive areas of the reef flat (over 400 m^2). It is during this phase, above 110 mm T.L., that *S. sordidus* begins to feed as a 'biter' (Chapter 6A). Despite recruitment of *S. sordidus* in the lagoon study site region for the three recruitment periods observed in this study (*i.e.* summer 1981, 1982, 1983) and in previous years (1979, 1980; H. Sweatman and G. Anderson, pers. comm.), and the presence of numerous small juvenile *S. sordidus*, the largest *S. sordidus* recorded was 113 mm T.L. No large IP or TP individuals were present. This suggests that larger S. sordidus migrate from the lagoon study site area during the late juvenile phase. Large *S. sordidus* were also absent from other areas of the lagoon.

The observed behaviour of *S. sordidus* in the lagoon study site was also true in other scarid species found in the area, although these were some slight differences as noted below:

S. brevifilis (n=3) was not observed to recruit into pomacentrid territories. They remained solitary throughout the juvenile phase and were aggressive to other scarids. Some IP's were recorded in the lagoon.

S. dimidiatus (n=5) and *S. oviceps* (n=3), both recruited to large stands of live arborescent corals. They had few antagonistic interactions and remained solitary. The largest *S. dimidiatus* observed in the lagoon study site region was approximately 105 mm T.L., and the largest *S. oviceps* approximately 94 mm T.L.

S. ghobban (n=12) was not observed below 55 mm T.L. Above this size, its social behaviour was similar to *S. sordidus* although large IPs were recorded in the study area.

S. psittacus (n=100+), *S. rivulatus* (n=20+) and *Scarus* sp. (n=15+), recruited more frequently in areas of rubble than *S. sordidus*, and were only rarely recorded in pomacentrid territories. The early juvenile phase was comparable to that of *S. sordidus* with individuals joining large mobile schools between 70 and 90 mm T.L. These species tended to shelter among rubble at night rather than in large pieces of coral rubble or in live coral stands which were favored by *S. sordidus*. In *S. psittacus* and *S. rivulatus*, some individuals appear to remain in the lagoon during the initial and terminal phases.

S. spinus (n=15+) recruits were most frequently recorded in live corals although a few were found in pomacentrid territories. The largest specimen recorded in the lagoon study site region was 63 mm T.L.

S. frenatus - At the North Reef study site (n = 45+).

In the study area at North Reef, *S. frenatus* recruits were most often recorded at the base of the reef slope, in either algae or algal covered arborescent coral rubble, often in or near pomacentrid territories. Of the 29 juvenile *S. frenatus* (<30 mm T.L.) recorded in the North Reef region, ten were in *Plectroglyphidodon lacrymatus* territories. (Small *S. frenatus* were also recorded in *Stegastes nigricans* territories at other non-lagoonal sites). Juvenile *S. frenatus* were typically solitary although pairs were occasionally found. The home range of each fish increased with growth and extended rapidly up the reef slope. Individual *S. frenatus* became increasingly aggressive towards other scarids. Some individuals up to 31 mm T.L. had home ranges entirely within the territory of a pomacentrid (*e.g. P. lacrymatus*), others included the pomacentrid as part of a larger home range. The pomacentrids occasionally attacked small resident *S. frenatus*. The frequency and intensite of these attacks increased rapidly when the *S. frenatus* reached approximately 31 mm T.L. Feeding by *S. frenatus* in the pomacentrid territory decreased shortly thereafter. At about 34 mm T.L., *S. frenatus* moved up onto the upper part of the reef crest, often *via* coral covered gullies in the crest region. The home ranges in the reef crest region were intially near to good coral cover, but gradually expanded to include open areas within *Acanthurus lineatus* territories at about 50 mm T.L. The resident *A. lineatus* did not react, although equally sized *S. sordidus* were vigorously attacked. The *S. frenatus* actively defended their home ranges (territories) against other scarids, especially at dusk, shortly before sleeping in the reef crest region. The home ranges/territories were enlarged until they covered several (3-8) *A. lineatus* territories. The territorial *S. frenatus* were occasionally attacked by pomacentrids and *A. lineatus* but they elicited only mild attacks. Attacks by *A. lineatus*, however, bacame intense once the resident *S. frenatus* reached approximately 89 mm T.L. The *S. frenatus* then become wary of the *A. lineatus*. The *S. frenatus* remained close to cover when feeding and swam rapidly across open areas within *A. lineatus* territories. The vigor of the *A. lineatus* aggression slowly increased. Individual *S. frenatus* betwen 90 and 114 mm T.L. reduced their activity in areas occupied by *A. lneatus* and were eventually excluded from most *A. lineatus* territories. Large juvenile *S. frenatus* started to attack or be attacked by resident IP *S. frenatus* at about 109 mm T.L., shortly before they joined the relatively stable harems of IPs and TPs living in the reef crest/reef slope region. The smallest specimen observed to spawn within one of these harems was approximately 164 mm T.L.

S. frenatus - In the Lagoon (n = 12).

S. frenatus occasionally recruited in the lagoon. Recruits (n=6) were observed in arborescent corals or in or near pomacentrid territories (including *P. grammorhynchus*, *S. apicalis* and *P. larymatus*). With growth, the *S. frenatus* expanded their home

ranges. As in other scarid species, pomacentric aggression towards small (<20 mm T.L.) *S. frenatus* was minimal but unlike other species, aggression from pomacentrids did not markedly increase above 20 mm T.L. One 34.5 mm T.L. specimen, for example, had a home range completely covering a *P. grammorhynchus* territory yet elicited no antagonistic reaction. As the home ranges grew, more pomacentrid territories were included, but pomacentrid attack rates remained low. Throughout the juvenile phase, the *S. frenatus* were typically solitary. They occasionally joined samll multispecific schools and were mildly aggressive towards other scarids. The sizes of the home ranges were not quantified but appeared to be comparable to those of similarly sized juveniles of other species in the lagoon. Unlike other lagoonal scarids, *S. frenatus* frequently fed within pomacentrid territories, without iliciting aggression from the resident pomacentrid (including *P. wardi*, *P. lacrymatus*, *P. grammorynchus*, *S. nigricans* and *S. apicalis*). It appears that the *S. frenatus* that recruit to the lagoon remain there throughout the juvenile and adult phases. A few IPs and TPs were observed, both occupying large home ranges.

Additional observations of *S. frenatus* were made at a number of sites at Lizard Island and on other reefs. These observations are summarized below:

1) Recently recruitemd individuals (n=4) were recorded in *Halimeda* on the reef slopes of two mid-shelf reefs.
2) Small juvenile *S. frenatus* (n=3) were observed feeding in pomacentrid territories at two Lizard Island sites (Coconut Bay and Watsons Bay). Small juvnile *S. frenatus* (n=11) were observed feeding in areas with no territorial herbivorous pomacentrids at three Lizard Island sites and on two mid-shelf and three outer-shelf reefs.
3) Large juvenile *S. frentus* were observed feeding in *A. lineatus* territories at two Lizard Island reef crest sites (n=5) and on the reef crest of one other mid-shelf reef (Rib reef; n=4). Large juvenile *S. frenatus* (n=14) were observed in reef crest sites but not in *A. lineatus* territories at three Lizard Island sites, two mid- and one outer-shelf reefs. Numerous individuals were also recorded away from *A. lineatus* territories in back-reef areas.

S. gibbus - At the North Reef study site (n = 30+).

S. gibbus recruited at the base of the reef slope, in or near to complex coral rubble. Of the 22 individuals observed at a small size, none were associated with pomacentrid territories. In progressively larger specimens, the home range slowly expanded up the reef slope. In the study area, the reef crest was reached by individuals at approximately 80 mm T.L. but further movement was apparently restricted by territorial *S. frenatus* and *A. lineatus*. The home range continued to expand along the reef slope, into gullies and back reef rubble areas. Although *S. gibbus* occasionally joined small multispecific groups when below 20 mm T.L., it typically remained solitary throughout the juvenile phase. Individual *S. gibbus* first joined small schools of conspecifics at about 250 mm T.L. before moving up onto the main adult feeding areas, on the reef crest and reef flat, at about 300 mm T.L.

This patterns is similar to that of *C. bicolor*, although individuals of *C. bicolor* (n=5) remained in deeper water, over rubble and in gullies, throughout the juvenile phase.

S. niger - At the North Reef study site (n = 80+).

S. niger recruited in relatively large numbers, typically at the base of the reef slope, over coral rubble or coral rock, and not in pomacentrid territories. Once swimming off the substratum, *S. niger* typically joined small multispecific groups which slowly expanded their home ranges up the reef slope. These home ranges eventually extend over most of the reef slope. They were bordered on the top by territorial *S. frenatus* and *A. lineatus*, and on the bottom by areas of open sand or rubble. Within these home ranges, *S. niger* exprienced little aggression from pomacentrids, although pomacentrid aggression twoards *S. niger* was more pronounced than towards *S. frenatus*. Some *S. niger* were vigorously excluded from *P. lacrymatus* territories at 18 mm T.L., whilst similar sized and larger, *S. frenatus* actively fed within the territories. Intraspecific aggression was of a heirarchical nature and mild. The most aggressive encounters were between equally sized individuals, which occupied neighbouring home ranges. Large juvenile *S. niger* eventually joined the resident stable harems in the area.

At night, home range boundaries of juvenile *S. niger* were abandoned and individuals moved down the reef slope to seek shelter. Many individuals, often of similar sizes, formed monospecific groups of four to eight individuals in areas near to complex coral rubble in which they sheltered overnight.

The behaviour of *S niger* at North Reef was comparable to *S. niger* at other sites and was similar to several other species at North Reef. These species are listed below, with a note of any marked discrepancies.

S. brevifilis (n = 7) was comparable to *S. niger* but was more aggressive towards other scarids and favoured upper reef slope areas as a small juvenile. Adults joined large mobile schools.

S. bleekeri (n = 5) differed in that large juveniles and adults typically formed harems in deeper rubble covered areas.

S. rubroviolceus (n = 11) often recruited in shallower regions of the reef slope and as a juvenile was often recorded in the upper reef slope region. Juvenile and small IP individuals remained in this area, whilst pairs of large adults (one IP and TP) occupied large home ranges (defended against conspecific) in the reef crest, upper reef slope and reef top regions.

Scarus sp. (n = 20+) differed from *S. niger* in that large juveniles apparently joined mobile schools and moved away from the reef slope, to feed over more extensive areas including the reef flat.

The behaviour of *S. niger* is similar to that of *S. flavipectoralis* and *S. schlegeli*. These species, however, remain in deeper water. The former is typically solitary, whilst the latter joins small mono- or multi-specific schools. These species

were not observed in detail at the North Reef study site.

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