times in other California flatfishes are variable with a tendency toward winter. Fitch and Lavenberg (1971) reported the following spawning periods: *Platichthys stellatus*, November-February; *Microstomus pacificus*, November-March; *Citharichthys sordidus*, July-September; *Paralichthys californicus*, February-July. Goldberg (1981) reported summer spawning in *Symphurus atricauda* and summer-fall spawning (Goldberg 1982) in *Hippoglossina stomata*. Spawning in *Citharichthys stigmaeus* occurs April-September (Ford 1965). *Pleuronichthys verticalis* which was investigated by Fitch (1963) and Goldberg (1982) and *Glyptocephalus zachirus* which Frey (1971) reported on were in spawning condition throughout the year. Such year-round spawning is uncommon among California flatfishes.

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OTTER TRAWL SAMPLING BIAS OF THE GILL PARASITE, *LIRONECA VULGARIS* (ISOPODA, CYMOTHOIDAE), FROM SANDDAB HOSTS, *CITHARICHTHYS* SPP.

Lironeca vulgaris (Crustacea, Isopoda, Cymothoidae) is a common parasite infesting the gill chambers of many marine fish species from the California coast. Both male and female isopods reside in the gill chambers of sanddab hosts. Aspects of the ecology of this parasite and host specificity are given in Brusca (1978, 1981) and Keusink (1979). Both authors discuss the propensity of isopods, particularly males, to abandon hosts in otter trawls, which may cause false host records. Further, if host abandonment occurs during the trawling operation then estimates of prevalence (no. of infested hosts/total no. of hosts), relative parasite density (total no. of parasites/total no. of hosts), and mean parasite intensity (total no. of parasites/no. of infested hosts) will be biased. During a study of the interactions between *L. vulgaris* and two sanddab hosts, *Citharichthys stigmaeus* and *C. sordidus*, I analyzed the efficiency of traditional otter trawl collecting methods. Prevalence, relative parasite density, and mean parasite intensity were compared for samples of a host population gathered by otter trawls and divers utilizing scuba.

Methods

Speckled sanddabs, *Citharichthys stigmaeus*, and Pacific sanddabs, *C. sordidus*, were collected from a site about 0.5 km west of Goleta Point, Santa Barbara County, Calif., just seaward of an extensive bed of giant kelp, *Macrocystis pyrifera*. The depth was 16 m and the substrate consisted of fine sands and silts with occasional stands of the brown alga, *Pterygophora californica*, and patches of eelgrass, *Zostera marina*.

On 6 November 1979, five consecutive otter trawls of 10-min duration each were taken. The 3.7 m otter trawl was equipped with a cod end of 1.8 cm square mesh. Immediately following retrieval of the catch, sanddabs were sorted and placed in sealed plastic bags. Any *L. vulgaris* wandering about the catch were also retained. After the last trawl, four scuba divers entered the water and collected sanddabs by hand net, attracting fish with bait (sea urchin roe). Fish were transferred to sealed plastic bags. Specimens were collected in this manner for approximately 40 min. All fish and isopods collected by both methods were sexed and measured within the next day.

Host sex, total length to the nearest 0.1 cm, and number of parasitic isopods harbored were determined. Isopod total length was measured to the nearest 0.1 mm. Isopod sex was determined by several criteria: 1) Differential allometric relationship of width to length (Montalenti 1941), 2) presence of penes in males, 3) asymmetry of females, i.e., body twisted to the right or left (Brusca 1978), and 4) presence of oostegites in gravid females. Manca and aegathoid stages (see Brusca 1978) were lumped as juveniles.

Results and Discussion

Otter trawl catches consisted only of flatfish, and sanddabs comprised most of the catch. Size-frequency histograms for sanddab hosts collected by otter trawls and scuba divers were not significantly different (Fig. 1, Kolmogorov-Smirnov test, $P>0.05$). Inspection of these histograms indicates that divers are able to sample small fish more efficiently. Consequently, important information regarding the acquisition of isopod parasites by young fish may not be obtained when sampling with otter trawls. A comparison of the percent of fish infested with *L. vulgaris* reveals a highly significant disparity between the two sampling methods. In the trawl, 21 out of 56 hosts (37.5%) were infested versus 54 out of 73 hosts (73.9%) in the diver sample (chi-square = 17.449, $P<0.005$).

Size-frequency histograms for all isopods recovered by both collecting methods were significantly different (Fig. 2, Kolmogorov-Smirnov test, $P<0.05$). If only male isopods were considered, the difference was very significant ($P<0.01$) while for female isopods there was no difference ($P>0.05$). Apparently male *L. vulgaris* abandon hosts in otter trawls prior to retrieval of

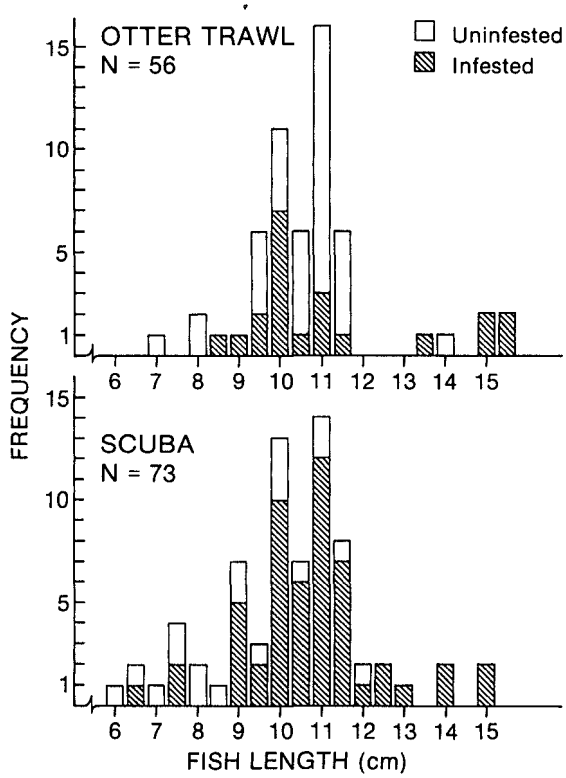

FIGURE 1.—Comparison of size-frequency histograms for *Citharichthys* spp. collected by otter trawl and divers utilizing scuba. Size distributions of sanddab hosts were similar (Kolmogorov-Smirnov test, $P>0.05$) but the percentage of hosts harboring parasitic isopods was significantly different (chi-square test, $P<0.005$).

the catch. This was especially evident for small males (Fisher exact test, $P=0.0057$; small males <10.6 mm vs. large males ≥10.6 mm). Large males may also leave their hosts since a majority of large male isopods were unassociated with hosts in the trawl sample (13 out of 17 males, see Figure 2). In one trawl sample a pod of male isopods was found in the cod end indicating that these individuals did not have sufficient opportunity to escape. Female isopods have feeble crawling abilities (Brusca 1978) and do not appear to abandon hosts in trawls.

Relative parasite density in the diver sample was significantly higher (1.2 isopods per fish) than otter trawl samples (0.4 isopods per fish) (t-test, $P<0.001$) as was mean parasite intensity with 1.6 and 1.1 isopods per infested host, respectively (t-test, $P<0.001$).

In conclusion, otter trawls consistently underestimate prevalence, relative parasite density, and mean parasite intensity of *L. vulgaris* popu-

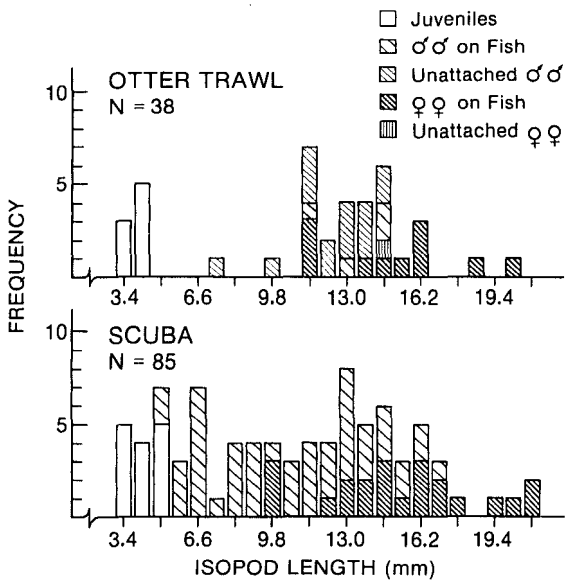

FIGURE 2.—Comparison of size-frequency histograms for the gill parasite, *Lironeca vulgaris*, from sanddab hosts collected by otter trawl and scuba divers. Size distributions of isopods were significantly different between the two samples (Kolmogorov-Smirnov test, $P<0.05$). Small male isopods were notably absent and several isopods were unattached to sanddab hosts in the otter trawl sample.

lations on *C. stigmaeus* and *C. sordidus*. This bias is caused by the abandonment of hosts, particularly by small male isopods. Shorter trawling times may reduce the amount of bias. However, when accuracy is desired, scuba is the preferred sampling method.

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