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Distribution and density of goldsinny wrasse (*Ctenolabrus rupestris*) (Labridae) in the Risør and Arendal areas along the Norwegian Skagerrak coast

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SARSIA

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Samples of fish were collected in the Arendal and Risør areas on the Norwegian Skagerrak coast during the period 1986 to 1990 using a beach seine at 36 different locations. In the Risør area, 131 out of 254 hauls yielded goldsinnies, and in the Arendal area 66 out of 100 hauls. The density of fish estimated for the summer period (June–September) was as follows: Sandnesfjorden 0.9, Sørfjorden 2.8, Nordfjorden 9.8, Risør Skerries 2.0 and Arendal 12.7 fish 1000 m^{-2}. The best catches of goldsinny were taken at stations with medium exposure, but the difference in mean catches between stations with different exposure was not significant. The average number of goldsinny taken at stations was not significantly related to freshwater influence, as inferred from the distance to river outlets. The presence of rock in the substratum significantly increased the average number of goldsinny at a station compared to stations without rock. No similar effect was found for the presence or absence of sand or mud. Bottom with vegetation is highly preferred compared to barren bottom.

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INTRODUCTION

Labridae, mainly goldsinny, *Ctenolabrus rupestris* (L.), are used for cleaning salmon of sea lice (Copepoda: Caligidae) (Bjordal 1988; Costello 1996; Treasurer 1996; Kvenseth 1996). In Norway, directed fishery for goldsinny started in 1988, in Scotland in 1989 and in England and Ireland in 1990 (Bjordal 1991; Darwall & al. 1992). In the Norwegian salmon-farming industry, this use has increased steadily from a total of 1,000 fish in 1988 to an estimated use of 2.5–3 million fish in 1996 and 3.5 million in 1997 (Kvenseth 1997). Commercial fishery started in the early 1990s along the Norwegian Skagerrak coast, and in 1996 about 800,000 goldsinny were caught in southern Norway and sold to salmon farms in Møre, Trøndelag and Nordland, where the natural stocks are too small for exploitation (Kvenseth 1997). As fish mortality during fishing, storing and transport is not recorded, the numbers caught are considerably higher than those reported used in fish farming.

It is known that goldsinny is abundant in coastal areas in South Norway, but few quantitative data are available and little is known about stock structure. These data and data on growth, mortality and reproduction are needed if the stocks of Labridae are to be managed in a rational way.

Distribution and density of goldsinny on the west coast of Scotland were studied by Sayer & al. (1993) and on the Irish coast by Darwall & al. (1992) and Costello & al. (1995). Hiding places seem to be the main limiting factor determining abundance of goldsinny (Costello 1991).

Goldsinny is known to be tolerant to low salinity and to low temperature, but is largely absent at depths likely to be affected by freshwater run-off and in estuarine waters (Costello 1991; Sayer, Gibson & Atkinson 1996; Sayer, Reader & Davenport 1996). The aim of the present article is to describe the distribution of goldsinny in the central part of the Norwegian Skagerrak coast, and how it is influenced by bottom conditions, exposure, fresh water and temperature. Sampling was done before the aimed fishery for goldsinny started in the study area.

MATERIALS AND METHODS

Samples of fish were collected in the Arendal and Risør areas on the Norwegian Skagerrak coast during the period 1986 to 1990 using a beach seine at 36 different locations (Table 1, Fig. 1). The seine was 38.0 m long and 3.8 m deep, with a 20 m rope at each end. The stretched mesh size was 14 mm. Each haul was assumed to sweep a bottom area of up to 700 m^2. Tveite (1971, 1984) has described the operation of the beach seine. Sampling was done primarily to collect juvenile gadoids; and suitability as habitat for Labridae was not considered when the stations were selected.

Table 1. Average number of goldsinny caught per haul at the stations shown in Fig. 1. The table also gives exposure and freshwater influence (index), classification of bottom substratum, maximum depth in the area covered by the haul and a description of vegetation.

Stn no.	Mean catch	Exp.	Fresh water	Substrate	Vegetation	Max depth (m)	No. of hauls
1	6.8	2	1	Sand	Some patches of algae and grass	8	14
2	3.9	1	0	Rock, pebbles	Mostly covered with algae	6	15
3	10.0	1	3	Rock, sand	Covered with algae	6	13
4	1.2	2	3	Sand/mud	Some patches of algae and grass	5	14
5	12.3	2	3	Sand/mud	Grass, some algae	4	13
6	2.0	0	3	Hard sand	Mostly barren, some algae and blue mussels	9	4
7	0.3	0	3	Hard sand	Mostly barren, some algae and blue mussels	8	4
8	1.3	3	2	Hard sand	Many patches of algae	7	3
9	0.3	3	2	Hard sand	Many patches of algae and grass	6.5	4
10	2.0	2	0	Hard sand	Mostly barren, some patches of algae	12	3
11	2.8	3	0	Hard sand	Patches of algae	12.5	4
12	1.5	0	1	Sand/mud	Some patches of algae and grass	8	4
13	0.8	0	1	Sand/mud	Much grass	4.5	4
14	7.1	2	2	Sand/mud	Grass	7	13
15	3.3	2	2	Sand/mud	Some grass	8	13
16	2.3	2	2	Mud	Algae and blue mussels, some grass	8	11
17	0.0	2	2	Sand/mud	Barren	9	10
18	2.2	0	3	Sand/mud	Mostly barren, some grass	8	12
19	4.8	3	0	Sand, pebbles	Some grass and patches of algae	10	16
20	1.8	3	0	Sand/mud	Some grass and patches of algae	6	14
21	10.0	3	0	Sand	Some large algae	10	11
22	5.8	3	0	Rock/sand	Patches of algae	4.5	12
23	1.5	3	0				2
24	0.7	2	0	Sand/mud	Mostly barren, some algae	9	7
25	0.2	2	0	Sand/mud	Mostly barren, some algae	7.5	6
26	1.7	2	0	Sand	Mostly barren, some algae	4	6
27	0.3	1	0	Mud	Mostly barren	7.5	4
28	1.3	2	0				3
29	12.6	3	0	Rock/sand	Patches of algae and blue mussels	12	14
30	55.5	2	2	Rock/mud	Inner part with grass, outer part barren	12	14
31	2.2	2	0	Mud	Grass	8	11
32	6.1	2	0	Mud	Grass	6	9
33	15.1	1	2	Mud	Grass	5	11
34	1.9	1	3	Sand/mud	Some grass	8	10
35	21.0	2	0	Sand/mud	Some grass	10	9
36	7.8	2	0	Sand/mud	Grass	3.5	6

Selectivity of the beach seine is not known, but unpublished data suggest that very few fish are caught during their first year of life, while more than 50% of 1-year-old fish will be retained by the seine (Institute of Marine Research, unpublished data).

Freshwater influence and degree of exposure were classified in accordance with the following, arbitrary scales:

	Freshwater influence	Degree of exposure
0	No river outflow	Very protected
1	Little freshwater influence	Protected sounds or bays
2	Much freshwater influence	Open sounds or bays
3	Close to river outflow	Open fjord or coast area

Salinity was not measured. Freshwater influence was therefore assessed from the distance from, and the size of, river outflow. The type of vegetation was also used in the assessment.

RESULTS

DISTRIBUTION

Although the best catches of goldsinny were taken at stations with medium exposure (Table 3), a Kruskal-Wallis test showed no significant difference in mean catches between stations with different exposure ($H = 4.26$, $n = 323$, d.f. = 3, $p = 0.19$). The average number of goldsinny taken at stations was not significantly related to freshwater influence (Table 4) (Kruskal-Wallis test $H = 2.09$, $n = 323$, d.f. = 3, $p = 0.51$).

The presence of rock in the substratum significantly increased the average number of goldsinny at a station compared to stations without rock (Table 5) (Mann-Whitney U-test, $U = 8624$, $n = 318$, $p = 0.006$). (The number of observations is lower than above because no

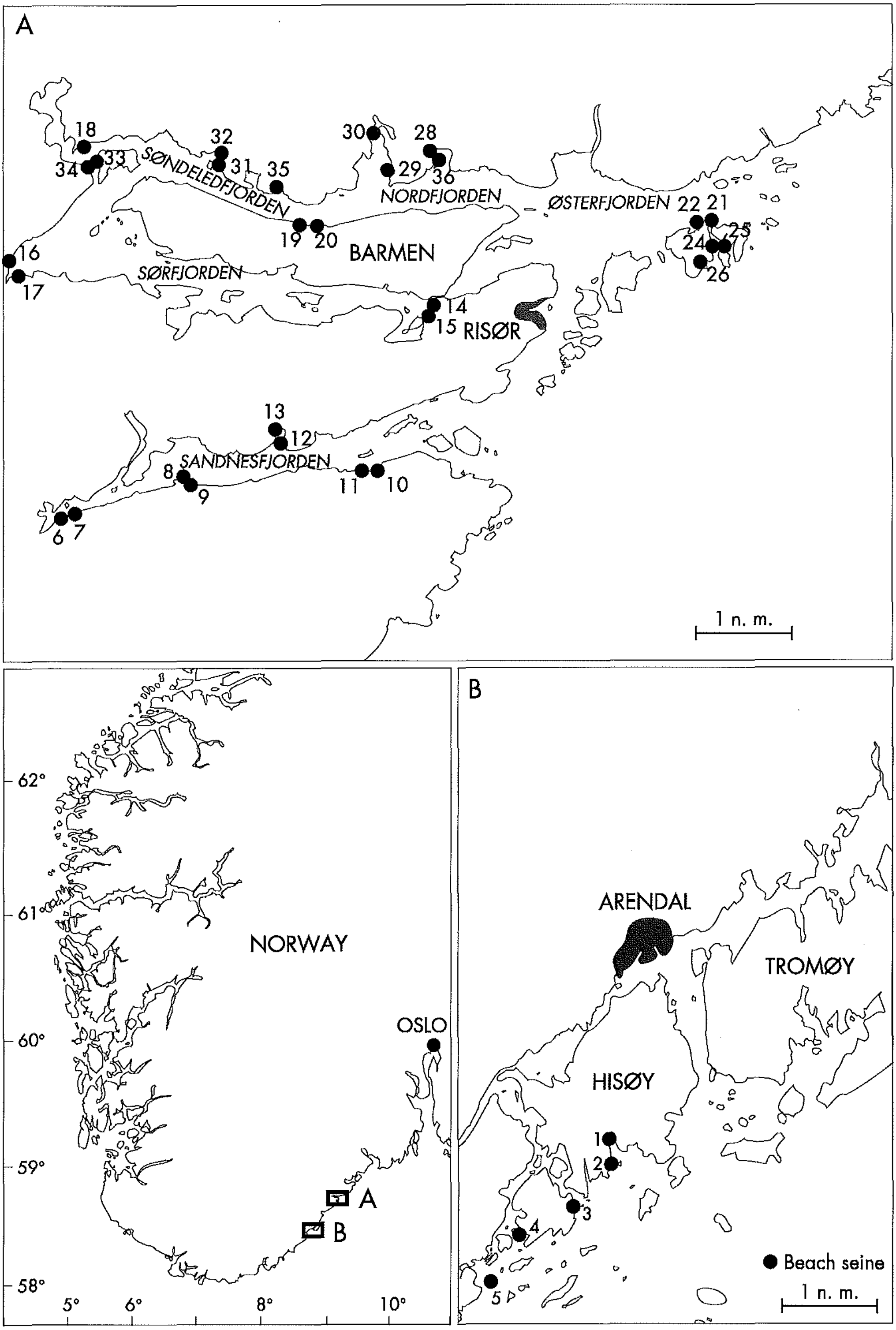

Fig. 1. Fishing locations where the beach seine was hauled. A. The Risør area; B. The Arendal area.

Table 2. Average density of *Ctenolabrus rupestris* for the regions over the period studied. Figures are estimated number of fish per 1000 m^2. A dash (–) indicates that no samples were taken. Average is given for all months sampled and for the summer months (June–September).

	Arendal Stn 1–5	Sandnesfjorden Stn 6–13	Sørfjorden Stn 14–17	Nordfjorden Stn 18–20, 27–36	Risør skerries Stn 21–26
Apr-86	0.0	–	–	–	–
May-86	3.1	–	–	–	–
Jun-86	–	1.8	0.4	0.3	1.8
Jul-86	4.3	–	–	–	–
Aug-86	25.0	–	–	–	–
Sep-86	16.7	–	–	–	–
Nov-86	–	–	0.0	0.3	0.3
Dec-86	0.1	–	–	–	–
May-87	0.9	–	–	–	–
Jun-87	4.6	–	–	–	–
Jul-87	17.3	–	0.3	0.8	1.5
Aug-87	–	–	3.2	22.6	3.5
Sep-87	11.4	–	–	–	–
Nov-87	0.3	0.1	0.0	0.1	0.0
Feb-88	4.3	–	–	–	–
May-88	6.1	–	–	–	–
Jun-88	5.7	–	–	–	–
Jul-88	8.3	0.7	0.3	6.0	1.8
Sep-88	5.0	0.3	0.8	0.0	1.0
Oct-88	3.3	–	–	–	–
Nov-88	–	–	0.0	0.3	0.0
Dec-88	3.9	–	–	–	–
Apr-89	3.9	–	–	–	–
May-89	2.9	–	–	–	–
Jun-89	12.6	–	1.3	3.7	–
Jul-89	–	–	7.5	16.8	3.8
Aug-89	39.1	–	–	–	–
Nov-89	–	–	0.0	8.0	0.2
Jul-90	–	–	8.7	27.1	0.0
Aug-90	–	–	–	11.3	2.7
Average	8.1	0.7	1.8	7.5	1.4
Aver. summer	12.7	0.9	2.8	9.8	2.0

observations are available for three stations with a total of five observations). No similar effect was found for presence or absence of sand or mud (Table 5) ($U = 9208$, $p = 0.06$ and $U = 12{,}447$, $p = 0.09$, respectively).

The importance of vegetation, macroalgae and *Zostera* (Table 5) was studied using similar tests, the results suggesting that bottom with vegetation is much preferred compared to barren bottom ($U = 4{,}483$, $n = 318$, $p < 0.001$). Looking at the macroalgae and the *Zostera* separately indicates a significant influence of *Zostera* ($U = 11130$, $p = 0.04$) but not of macro-algae ($U = 1149$, $p = 0.09$).

Temperature

Goldsinnies were caught only once at a temperature below 5° C (4.5° C, Arendal, Feb. 88), and usually the temperature was 10° C or more when catches better than one fish per haul on average were taken (Fig. 2).

Density

Within the regions defined in Table 2 and Fig. 1, the stations were averaged to estimate densities of *C. rupestris* for each survey. The average densities varied from 0 (several areas in November) to 27 per 1000 m^2 (July 1990 in Nordfjorden). Within regions, the average for all surveys varied from 0.7 (Sandnesfjorden) to 7.5 (Nordfjorden) per 1000 m^2 (Table 2).

In the Risør area (Fig. 1A), 131 out of 254 hauls yielded goldsinnies. The maximum catch was 214, and 4 catches were above 100. These catches were taken at Stn 30 and 33 (see Fig. 1) in July 1989 and 1990 and in August 1987.

In the Arendal area (Fig. 1B), 66 out of 100 hauls yielded goldsinnies. The maximum catches were 63 (Stn 5) in August 1989 and 45 (Stn 1) in August 1986.

Other Labridae, such as Ballan wrasse (*Labrus bergylta* Ascanius), corkwing (*Crenilabrus melops* (L.)) and rockcook (*Centrolabrus exoletus* (L.)) were

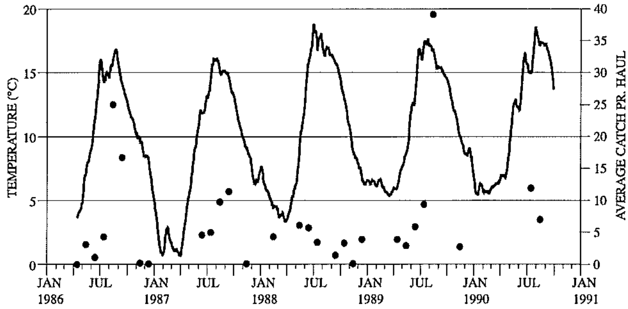

Fig. 2. Temperature at 1 m depth (running average for 14 days, line) at Flødevigen and average number of goldsinnies per haul in beach seine in the Arendal and Risør areas (spots).

caught, but their contribution to the catches was less than one-tenth of that of goldsinny.

DISCUSSION

Goldsinny seem to have a preference for rocks, crevices and boulders (Costello 1991; Sayer & al. 1993), and are often found among dense populations of brown algae (Hilldén 1978). These habitats are generally not readily assessable with a beach seine (e.g. Fosså 1989). Goldsinny seldom move over open sand (Collins & al. 1997), which is a common substratum at beach seine locations. The true number of wrasse in an area is probably underestimated with a beach seine, because wrasse have a habit of hiding when danger approaches. Therefore the figures derived are certainly underestimates. Because of the selectivity of the seine, the young of the year are not caught representatively, and the 1-year-old fish, which have an average size of about 8 cm in late summer, are probably underrepresented (Institute of Marine Research, unpublished data). This also leads to underestimation of the total stock density.

In spite of serious limitations in the sampling method, the data support previous observations both from nature (Hilldén 1978; Sayer & al. 1993) and from aquaria (Gjøsæter 1987) that goldsinny prefer rocky bottom and vegetation (Table 5). There are several reasons for this selection of habitats; they find most of their food there (Hilldén 1978; Fjøsne & Gjøsæter 1996), they seek shelter from predators (Gjøsæter 1988b), and they find places to hide during winter (Sayer, Reader & Davenport 1996).

The statistical analyses must be treated with caution. Rock, sand and mud are not mutually exclusive, nor are macroalgae and Zostera, although while barren is exclusive from those two (see Table 1). Furthermore, distribution of the vegetation is dependent on the substratum. For example, macroalgae were present in 79% of the hauls with rock and in 41% of the hauls without rock, while Zostera was present in 84% of the hauls with mud, while in only 21% of the hauls was rock observed. Therefore, only the unconditional relation between number of goldsinny caught and the presence or absence of each of the characters observed was analysed.

The degree of exposure in the study area varies from open, uncovered coast to narrow fjord areas, but the data show that this does not influence the abundance of goldsinny significantly (Table 3). Hilldén (1978) found that goldsinny preferred exposed areas at the Swedish west coast. The influence of fresh water varied from none to stations situated close to big river outlets, but again no influence could be found on the abundance of the wrasse (Table 4). The results therefore show that goldsinnies have a wide tolerance both for exposure and for fresh water. This agrees with the conclusion of Sayer, Reader & Davenport (1996) that goldsinnies are tolerant to low salinity, but may contrast with the observation of Sayer, Gibson & Atkinson (1996) that they avoid areas with direct freshwater influence. It should be noted, however, that salinity was not measured, and the arbitrary classification based on size of river outlets and distance from them may not give an

Table 3. Average, minimum and maximum number of goldsinny caught per haul at stations with different index of exposure.

Exposure	No. of stations	No. of observations	Mean	Min–max
0	5	28	1.57	0–12
1	5	53	4.87	0–122
2	17	162	9.11	0–214
3	9	80	5.95	0–50

Table 4. Average, minimum and maximum number of goldsinny caught per haul at the stations with different index of freshwater influence.

Freshwater nfluence	No. of stations	No. of observations	Mean	Min–max
0	18	152	5.76	0–82
1	3	22	1.95	0–10
2	8	79	14.02	0–217
3	7	70	2.24	0–63

Table 5. Mean number of goldsinny caught per haul at stations with different types of substratum and vegetation. The Mann-Whitney U-test with corrections for ties is used to test the significance of the difference between stations with and without each factor.

	Present		Absent			
Factor	No. obs.	Mean	No. obs.	Mean	U	p
Sand	233	4.85	85	13.14	9,208	0.063
Mud	185	8.98	133	4.40	12,447	0.085
Rock	68	16.09	250	4.61	6,885	**0.006**
Vegetation	262	8.36	56	1.04	4,483	**<0.001**
Macroalgae	160	9.24	158	4.86	11,649	0.085
Zostera	186	9.39	132	3.80	11,130	**0.041**

accurate picture of the salinity at the depth were the fish were caught.

Goldsinnies are caught during all months (Table 2, Fig. 2), although generally they are much more available during summer (June–September) than during the other seasons. This is obviously related to temperature, and the best catches are always taken when temperature is above 10° C. Sayer & Reader (1996) and Sayer, Reader & Davenport (1996) found that goldsinny entered a hypometabolic state at temperatures below 6° C.

Sayer & al. (1993) found densities between 1 and 4 fish m^{-2} on the West Coast of Scotland during summer months. Costello & al. (1995) also indicate that divers observed up to 4 goldsinnies m^{-2} during surveys in Ireland, Shetland and Norway. These figures are much higher than those derived from the Norwegian Skagerrak coast, but it is not possible to conclude whether there is a real difference in fish density, or if it is caused by methodical differences. We assume that the stock at the time of sampling was unexploited. However, in May 1988 the bloom of *Chrysochromulina polylepis* killed extensive numbers of goldsinny (Gjøsæter 1988a; Granéli & al. 1993). The catches in 1988 were generally low, but the following years do not seem to be markedly different from those in preceding years (see Gjøsæter & al. (2000) for a detailed analysis of the effects of this bloom).

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