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Fishery for goldsinny wrasse (*Ctenolabrus rupestris*) (Labridae) with pots along the Norwegian Skagerrak coast

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Goldsinny wrasse (*Ctenolabrus rupestris*) was captured in pots during the years 1994–98 in the area between Arendal and Homborsund, west of Grimstad, along the Norwegian Skagerrak coast. The pots, made of steel 1 × 1 cm square-meshed netting, were 105 cm in length and 31 cm in diameter. They were baited using various crushed crustaceans. The pots were placed at depths between 5 and 10 m on rocky bottom with a dense cover of *Laminaria* spp. and other macroalgae. A professional fisherman conducted the fishing. Sometimes the pots were hauled once a day, and sometimes twice or three times a day. This did not influence the catch rates. The catch per pot ranked up to 390. The mean catch per pot was 25.8, 18.8, 46.9, 42.7, 55.5 for 1994, 1995, 1996, 1997 and 1998, respectively. Distribution of catch per pot was highly skewed to the left for the first 2 years, while the distribution became progressively more symmetrical for the later years. In 1997, 10% of the pots yielded more than 90 fish, and, in 1998, 9% yielded higher catches. For the other years, this figure ranges from 0.1% to 3%. The proportion of pots yielding fewer than 10 fish decreased from nearly 40% in 1995 to 1% in 1998. The catch rates were dependent on temperature. The data available do not indicate that the fishery had a negative effect on the stock.

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INTRODUCTION

The use of wrasse for cleaning salmon of sea lice (Copepoda: Caligidae) started as a scientific experiment, in tanks and small net-cages, at the Institute of Marine Research at Austevoll in 1987, but even before that, small-scale trials were being conducted by the fish farmers (Bjordal 1988). The use of Labridae, mainly goldsinny (*Ctenolabrus rupestris*) in the Norwegian salmon-farming industry has increased steadily from a total of 1,000 fish in 1988 to 3.5 million in 1997 (Kvenseth 1997).

In Norway, a fishery for goldsinny started in 1988, in Scotland in 1989 and in England and Ireland in 1990 (Darwall & al. 1992; Costello 1996; Treasurer 1996; Kvenseth 1996). Along the Norwegian Skagerrak coast, a commercial fishery started in the early 1990s, and by 1996 about 800,000 goldsinny were being caught in southern Norway and sold to salmon farms from Møre, Trøndelag and Nordland, where the natural stocks are too small for exploitation (Kvenseth 1997). As fish dying during fishing, storage and transport are not recorded, the numbers caught are considerably higher than those reported used in fish farming. Most of the fish are caught in the county of Aust-Agder. Fifteen fishermen are involved in the fishery, and they fish for shorter or longer parts of the season, which may last from May until October. A typical fisherman will catch between 50,000 and 100,000 fish during a season.

Although locally abundant, heavy fishing can have a profound impact on the populations of wrasse. Some studies have shown, for instance, that after 1 or 2 years of experimental fishery the catch per unit effort is reduced by as much as 50–80% (Darwall & al. 1992; Sayer & al. 1996b; Varian & al. 1996). Similar reductions have been observed in some locations in West Norway (Skiftesvik, pers. comm.).

The data series on catch rates of goldsinny in a commercial fishery using specially designed, baited pots along the central part of the Norwegian Skagerrak coast is probably the longest series available. It is therefore worthwhile analysing these data to reveal any trend in the catches and eventually their causes.

Temperature seems to influence the catch rates, and the data are used to describe the extent of this influence.

MATERIALS AND METHODS

During the period 1994–98, goldsinny wrasse (*C. rupestris*) were caught in pots 105 cm in length and 31 cm in diameter (Fig. 1). The pots had two funnels, the outer one tapering to an opening 5 cm in diameter

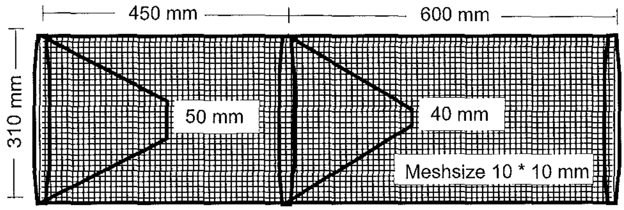

Fig. 1. Pots used in the Goldsinny wrasse fishery along the Norwegian Skagerrak coast.

and the inner one with an opening of 4 cm. The pots were made of steel netting with 1 × 1 cm square meshes. The mesh size was chosen so that most fish smaller than 10 cm in length, which have no commercial value, could escape. The pots were baited using various crushed crustaceans, mainly shrimps and crabs.

A professional fisherman conducted the fishing from a boat about 10 m in length. When the fishery started in 1994 he had no experience in wrasse fishery, although he had a long and varied experience in coastal fishery in general. This fishery was commercial, and not conducted for scientific reasons, but the Institute of Marine Research got all information on number of fish caught in each pot used. The pots were set in the area between Arendal and Homborsund west of Grimstad on the Norwegian Skagerrak coast (Fig. 2). This area consists of open coast with many small islands and skerries. Generally, the pots were placed in the inner and eastern part of the area (i.e. closest to the home base) during the first part of the season, while later they were placed farther out and to the west. Depths at which the pots were placed varied between 5 and 10 m, and always on rocky bottom with dense cover of *Laminaria* spp. and other macroalgae. The pots were hauled, and the fish were removed, and if needed the pots were baited again. Sometimes the pots were hauled once a day, and sometimes twice or three times a day, depending on time available, on the catch rates obtained and on the demand for fish.

Temperatures during this study were measured daily at the Institute of Marine Research Flødevigen Marine Research Station, situated in the fishing area. The temperatures within the geographical area studied are closely correlated (e.g. Ljøen & Sætre 1978), and the measurements from Flødevigen are therefore assumed to be representative.

RESULTS

CATCHES

In 1994, good catches were obtained during the latter part of May (Fig. 3, Table 1). At the end of May, both temperature and catches declined sharply. From the middle of June until the end of July, catches and temperature reflected an increasing trend. During 7 days in August–September, the catch rates were much higher than in May–June. The temperature during this period did not differ much from the latter part of the first period.

In 1995, we fished during most of May up until the beginning of July (Fig. 3). There was a declining tendency both in catches and in temperature during the first 10 days, followed by an increase until the end of June. During the first week of July, both temperature at 1 m depth and catches declined sharply.

In 1996, catches and temperature increased gradually from the middle of May until late July (Fig. 3). During a short fishing operation in mid-September, catches were very high, while mean temperature was only slightly higher than during May–June.

In 1997, catches increased with temperatures from the middle of May until early June, and then stabilized (Fig. 3). During a few days in August, catches were lower, although temperature was the highest observed.

In 1998, catches and temperature increased from the middle of May until the end of May (Fig. 3), when there was a sharp drop in temperature at 1 m and a drop in catches, too. From around 10 June until the fishery ended on 10 July the catches increased slightly.

A Spearman rank correlation analysis of the mean catch per pot versus temperature on the day of fishing was conducted. When several sets were made on one day, these were taken as independent estimates of catch for that day. All correlation, except for that between catch and temperature at 1 m depth in 1994 and between catch and temperature at 19 m depth in 1997, was significant (Table 2).

CATCH RATES IN DIFFERENT SETS

The pots were frequently hauled two or three times a day – the first haul in the morning, the second at mid-

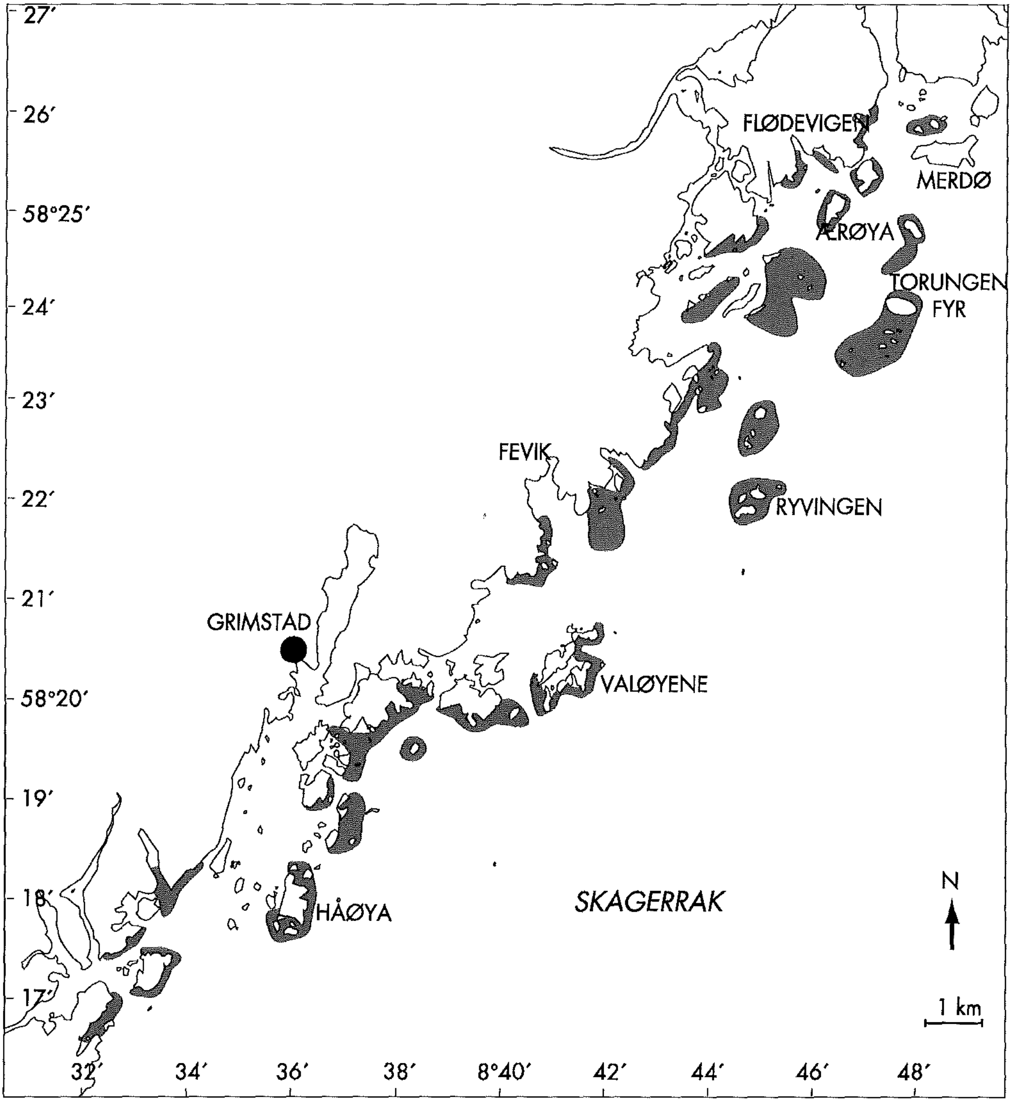

Fig. 2. Map showing fishing areas (shaded) visited during fishing operations 1994–98.

day and the third in the afternoon. When the pots were hauled only once, they usually remained in the sea for 6–8 h.

On 93 days when pots were hauled twice a day, the average catch was 32.3 wrasse per haul in the first set of hauls and 31.0 in the second. A comparison using a Mann-Whitney test showed that the two sets of hauls did not differ significantly in number of fish caught ($p = 0.25$).

Pots were hauled three times a day on 22 days, giving an average of 21.6, 22.5 and 21.2 wrasse per haul. A Kruskal-Wallis test showed that catches of wrasse in the three sets of hauls were not significantly different ($p = 0.83$).

The comparisons above are between hauls taken within one day. To compare catches in pots hauled once a day with catches in pots hauled twice a day, consecutive days with one and two hauls were selected. Then 14 days with one haul could be compared to 16 days with two hauls. The mean number of fish per pot was 32.7 and 29.5, respectively. Although the difference is small, it is significant (Mann-Whitney U-test,

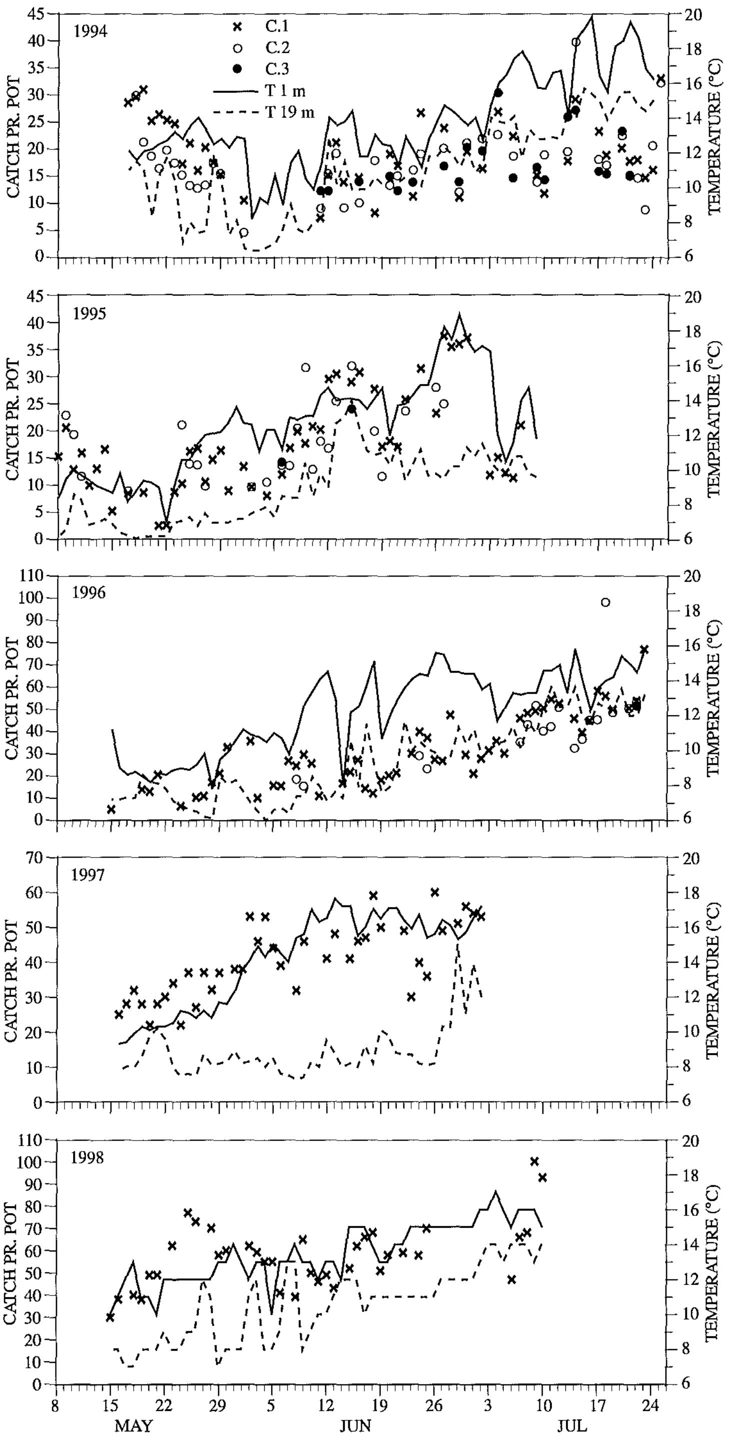

Fig. 3. Average catch per pot for each fishing trip and temperature during the main fishing seasons 1994–98. C1, C2 and C3; catch in the first, second and third haul on one day, respectively. T1m and T19m is temperature measured in °C at 1 m and 19 m depths, respectively.

Table 1. Fishing operations with pots for goldsinny 1994–97, and minimum and maximum temperatures at 1-m depth measured daily at the Flødevigen Marine Research Station.

Year	Period	Days fished	No. of pots	No. of fish	Fish per pot	Temp. °C at 1 m Max–min
1994	18 May–26 June	42	3,292	59,981	18.76	11.2–19.5
1994	23 Aug.–3 Sept.	7	505	37,154	73.57	16.1–18.3
1995	9 May–8 July	60	2,691	49,636	18.45	10.5–18.9
1996	16 May–24 July	69	1,537	52,082	33.89	7.8–15.8
1996	16 Sept.–21 Sept.	6	169	27,864	164.88	14.4–15.5
1997	17 May–3 July	47	1,732	74,009	42.73	9.3–17.6
1997	8 Aug–11 August	4	133	2,936	22.08	21.0–21.3
1998	15 May–10 July	37	928	51,106	55.49	9.5–17.0

$p = 0.005$). In the following, no distinction is made between haul numbers.

FREQUENCY DISTRIBUTION OF CATCHES

The numbers of empty pots are underreported, and so all empty pots were omitted from the following analysis. The catch per pot ranged from 1 to 390 (Table 3). For the first 2 years the distribution was highly skewed to the left, while the distribution became progressively more symmetrical for the later years (Fig. 4).

In 1997, 10% of the pots gave more than 90 fish, and in 1998, 9% gave higher catches. For the other years this figure ranged from 0.1% to 3%. The proportion of pots giving 1 to 10 fish ranged from 37% in 1995 to 1% in 1998. The proportion of pots with 1–5 fish ranged from 11% in 1995 to less than 1% in 1997 and 1998.

DISCUSSION

As empty pots were usually not reported, the catch rates are given as average catch in all pots with at least one fish. This gives an overestimate of the catch, and the more so during the first years when the frequency distributions of the catches suggest that a considerable number of pots have been empty (Fig. 4). According to reports from the fisherman, however, it is assumed that fewer than 10% of the pots were empty, and that disregarding the zero catches does not change the conclusions of this study.

Temperature is clearly one of the factors determining fishing success. At temperatures below 7°C, goldsinny in Ireland are passive (Darwall & al. 1992). Sayer & al. (1993) estimated that goldsinny disappeared at 8.7°C and reappeared at 8.2°C in Scottish waters. It is likely that goldsinny along the Skagerrak coast is adapted to slightly lower temperatures, and even at temperatures at 1 m depth as low as 8°C, catches between 10 and 20 fish per pot were obtained. There is no obvious upper limit, but the low catches in August 1997, when the temperature was up to 21.5°C at 1 m depth, could be an indication that the temperature was above the preferred one. Stone (1996) observed that goldsinny reared at 19°C showed no adverse effects and even had an increased feeding response when exposed to temperatures of 24°C.

The fishing could start when the temperature was assumed to be high enough for the goldsinny to be active. The further development was apparently regulated by two main factors in addition to the sea temperature: 1) the demand for fish, which is highest during spring and 2) the possibility to fish more profitably for other resources, e.g. lobster. The fishery started regularly in the middle of May, with a water temperature at 1 m depth of between 8°C and 12°C. The main fishery ended in July (Fig. 3).

In 1994, 1996 and 1997, an additional fishery was conducted during a short period in August–September. In 1994 and 1996 this fishery yielded very high catch

Table 2. Spearman rank correlation between catch per pot of goldsinny wrasse and temperatures at 1 and 19 m depth.

		Temp. at 1 m		Temp. at 19 m	
Year	N	r	p	r	p
1994	101	0.121	0.230	0.284	0.005
1995	72	0.665	<0.001	0.597	<0.001
1996	73	0.596	<0.001	0.814	<0.001
1997	40	0.776	<0.001	0.256	0.116
1998	37	0.425	0.014	0.369	0.027

Table 3. Some descriptive statistics of catches of Goldsinny in fish pots along the Norwegian Skagerrak coast.

	1994	1995	1996	1997	1998
Mean no. fish per pot	25.78	18.76	46.91	42.70	55.49
Count of pots = no. of observations	3770	2646	1706	1777	921
Maximum no. fish per pot	330	170	390	137	150
Variance	787.34	232.20	2321.46	474.24	626.04
Skewness	4.05	2.12	2.63	0.99	0.66
Kurtosis	25.26	8.16	8.45	1.14	0.41
Reported empty pots	27	45	0	88	0

rates, while the catch rate in 1997 was moderate (Table 1).

The frequency distributions of catch rates (Table 3, Fig. 4) show a surprising reduction in the frequency of low catches over the years. One likely explanation is that the fisherman became more experienced and knew better where and how the pots should be placed to get large numbers of fish. The increasing proportion of pots with large numbers of fish also seems to suggest that the fishery does not yet have any serious adverse affect on the stock.

Several types of pots, traps and fyke nets have been used for fishing wrasses (e.g. Bjordal 1993; Maroni & Andersen 1996; Treasurer 1996), but it is not possible to compare the efficiency of these gears because they have not been used in the same areas.

Maroni & Andersen (1996) concluded that the efficiency of baited traps diminished after 2 or 3 h in the sea. Treasurer (1996) also found that catches in pots, fyke nets and various traps decreased markedly with time fished. In the present fishery, the catches in pots hauled once a day were only slightly higher than those hauled twice a day, although they were in the sea for a considerable longer time. This supports the conclusion that the fishing efficiency is reduced over time.

The similarity in the catches among the hauls when the pots were hauled two or three times per day, suggests that catchability does not vary between morning, midday and afternoon, although it is known that the Labridae forage during daytime and are inactive during night (Costello & al. 1995).

Goldsinny has a high fecundity (20,000 eggs per year) and starts spawning at a small size (9.5 cm) (Darwall & al. 1992). Fish smaller than 10 cm are usually not caught with the gears used by commercial fishermen, and if caught they are released. So far, the catch rates in the commercial fishery in the area studied do not suggest any overexploitation, although studies from other areas have shown decreased catch rates after intensive fishing (Sayer & al. 1996; Treasurer 1996; Varian & al. 1996). Therefore, the goldsinny population along the Norwegian Skagerrak coast may probably be

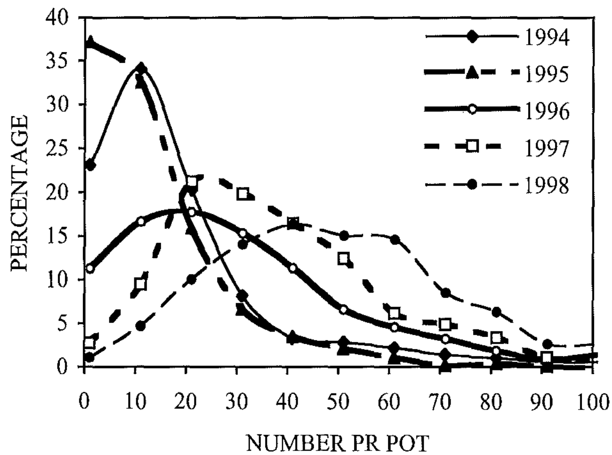

Fig. 4. Frequency distribution of catch rates (number per pot) of Goldsinny along the Norwegian Skagerrak coast for each of the years 1994–98.

resilient to the current exploitation regime. However, the proportion of larger fish (i.e. above 10 cm) may soon become radically reduced; hence, given the relatively low growth rate of goldsinny beyond 10 cm of length (<1 cm.year^{-1}; Treasurer 1994; Sayer & al. 1995), the commercial fishery on goldsinny should be followed closely to detect any adverse effects on the populations.

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