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Incidental catch and discard of red drum, *Sciaenops ocellatus*, in a large mesh Paralichthyidae gillnet fishery: experimental evaluation of a fisher's experience at limiting bycatch

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Abstract The ability of a commercial fisher to limit red drum, *Sciaenops ocellatus* (Linnaeus), bycatch was evaluated by comparing the catch of directed sets (net site chosen by the commercial fisher) vs randomly placed gillnets during 70 days of gillnetting ($n = 691$ sets). Catch rate did not differ between directed sets and nets set randomly. Thus, fisher experience did not lead to reduced bycatch; however, this may have been influenced by overall low red drum bycatch (0.41 fish net^{-1} for 12 h sets and 0.59 fish net^{-1} for 24 h sets). Catch rates of southern flounder were much higher at 3.97 and 3.37 fish net^{-1} for 12 h and 24 h sets, respectively. Fishing 10 nets per day, the catch of red drum exceeded the daily bag limit of seven red drum on 23% of the days. Of the 326 red drum retrieved from gillnets, 32.5% were dead at the time of retrieval; but only 15 of the 106 dead red drum had to be discarded due to size limits, and six were discarded dead based on bag limits. Current fisheries management regulations (bag limit and window limit of 457–686 mm) are supported by these findings given the conditions (e.g. red drum densities) at which the study was performed.

KEYWORDS: bycatch, discard, gillnet, red drum, southern flounder.

Introduction

It is important to quantify the bycatch and discard mortality of any fishery so that correct information is used when managing a stock (Hall, Alverson & Metuzals 2000). Bycatch of fish, birds, sea turtles and marine mammals have been investigated in gillnet fisheries (Collins, Rogers & Smith 1996; Trent, Parshley & Carlson 1997; Oesterblom, Fransson & Olsson 2002), and efforts to identify ways to reduce gillnet discard mortality are increasing (Buchanan, Farrell, Fraser, Gallaugher, Joy & Routledge 2002). Tools to reduce bycatch include time or area closures, acoustic alarms, highly visible netting and short soak times (Melvin, Parrish & Conquest 1999; Buchanan *et al.* 2002; Cox, Read, Swanner, Urian & Waples 2004).

Red drum, *Sciaenops ocellatus* (Linnaeus), is an estuarine-dependent fish species that is common along the US south Atlantic and Gulf of Mexico coasts. It is

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an economically important recreational and commercial fish species throughout its range. Red drum grows rapidly, reaching 300–400 mm fork length (FL) by its first birthday in September and 550–650 mm FL by age-2 in North Carolina (Ross, Stevens & Vaughan 1995). Estuaries serve as nursery habitat for juveniles (< 550 mm FL) and sub-adults (550–812 mm FL) (Ross *et al.* 1995; Daniel 1998; Collins, Smith, Jenkins & Denson 2002). Management measures to allow increased escapement of these young fish to the adult population have increased.

Similar to user-group conflicts over gillnetting in other areas of the world (Gray 2002), there is concern among recreational fishers in North Carolina that bycatch and discard mortality in gillnet fisheries, particularly in the estuaries, is high. In North Carolina, commercial flounder (Paralichthyidae) fishers use large mesh gillnets (133–152 mm stretched mesh) that incidentally capture red drum. North Carolina Division of Marine Fisheries implemented a daily trip limit of seven fish with a minimum size of 18 inches (457 mm) total length (TL) and maximum size of 27 in (686 mm) TL to reduce the directed effort on juvenile and sub-adult red drum in estuarine and state ocean waters. The daily trip limit was determined based on trip ticket information showing that the bulk of the fishers that sold red drum were catching small amounts as bycatch in their ten, 91-m flounder gillnets (Anonymous 2001; http://www.ncfisheries.net). Time and area closures could be used to further reduce discard mortality in this gillnet fishery if deemed necessary. Many commercial fishers argue that they use their prior experiences to limit bycatch of red drum. This study was undertaken to determine whether experienced commercial fishers set gillnets in a way that minimises bycatch and discard of red drum.

Materials and methods

The Newport River, NC, USA is a tidally influenced estuary with close proximity to Beaufort Inlet that opens to the Atlantic Ocean (Fig. 1). A directed vs random gillnet set approach similar to that used by Price & Rulifson (2004) was used to determine if a fisher's experience led to reduced bycatch of striped bass *Morone saxatilis* (Walbaum) in a small mesh gillnet fishery. Ten, 91-m long gillnets were fished on 70 days from June to November 2002 by the third author (a local commercial fisher) and one crewmember. North Carolina Division of Marine Fisheries (NCDMF) records all commercial landings data in their trip ticket programme (http://www.ncfisheries.

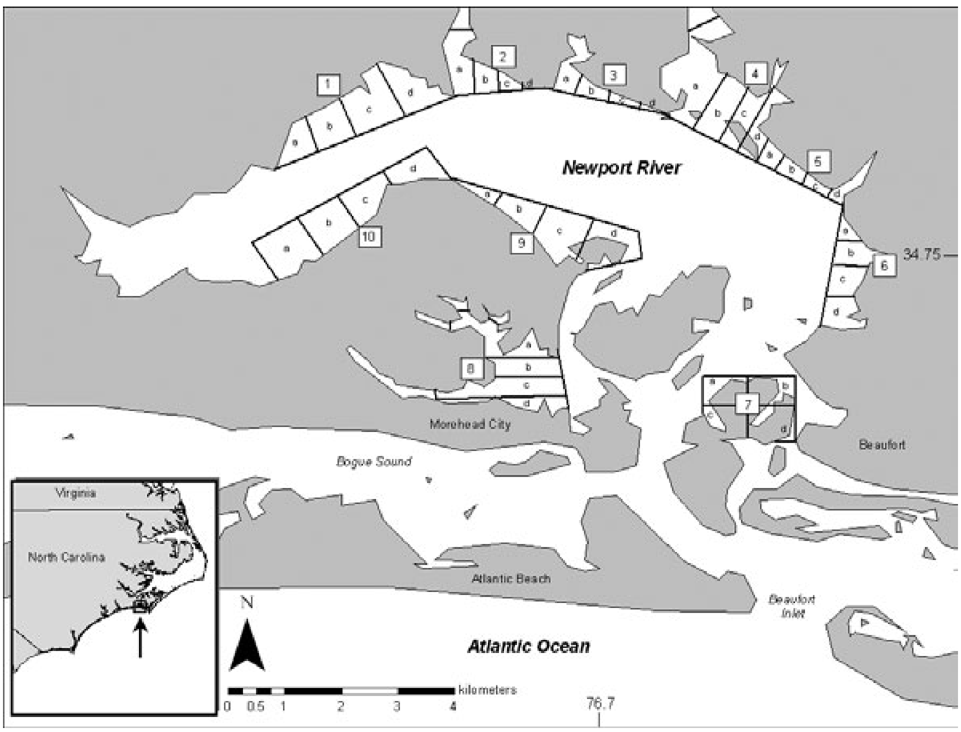

Figure 1. Location of study area in Newport River, North Carolina where large-mesh commercial gillnetting for southern flounder occurs. Numbers denote regions and letters denote sub-regions within a region.

net/statistics/tripticket/index.htm). The trips recorded accounted for 40% of the total number of gillnet trips that had > 50% of the catch being flounder (a criterion used by NCDMF to assign a trip to a large mesh gillnet fisher) in the Newport River during the study period (A. Bianchi & D. Hesselman, NCDMF, unpublished data). Of the 10 nets, three were 13.34-cm, four were 13.97-cm, and three were 15.24-cm stretched mesh; these three mesh sizes were typically used by flounder fishers in summer 2002. All nets were constructed of no. 177 monofilament and were hung 50 meshes deep. Scientific observers accompanied the fisher and recorded data on 53% of net retrieval days; the fisher recorded the data on the other 47% of the trips.

Gillnets were fished near and parallel to the shoreline in water depths ranging from 0.31 to 2.13 m (mean = 1.08 m depth), which is typical for local flounder gillnetters. The potential gillnet set locations for random nets were determined by dividing the Newport River into regions representative of areas that commercial flounder gillnetters fish (Fig. 1); each region was divided into four sub-regions. The protocol for the net set location was as follows. The fisher determined the regions where nine of the 10 nets would be set for each day of fishing. One of the regions was randomly selected for the randomly set net. The random gillnet (always 13.97-cm stretched mesh) was set near the shoreline (as described above) at the centre of a sub-region in which a directed net (always 13.97 cm) for the selected region was being fished; these two nets (the directed and the random net) were then considered the paired nets for the statistical comparisons for these two treatments (see below). In 11 of 66 trials, presence of obstructions prevented setting the random net at the centre of the sub-region. In these trials, the random net was placed in the centre of the adjacent sub-region. Only one random net was fished each trip, because random nets had the potential to have a negative influence on flounder catch and the cooperating fisher's profit.

Soak times of gillnet sets were distributed around modes of 12 or 24 h (Fig. 2a). Shorter soak times (one tidal cycle; $n = 443$) occurred in warm summer months, and nets were fished for longer periods (two tidal cycles; $n = 248$) in early June (one date), October, and November; the month of September had a mean soak time of approximately 17 hours as a result of switching from 12 to 24 soak times (Fig. 2b). For the 66 paired comparisons, 23 paired sets were approximately 24 h; of the 43 paired 12 h sets, 18 were at night, 12 were during the day, and 13 spanned day and night. The catch (number of fish per set, 1n transformed to stabilise variances) of southern flounder did not differ between the 12 and 24 h soak times ($t = 1.916$, d.f. = 689, $P = 0.056$), but the catch of red drum did ($t = 2.538$, d.f. = 689, $P = 0.011$). Catch was analysed separately for 12 and 24 h soak times.

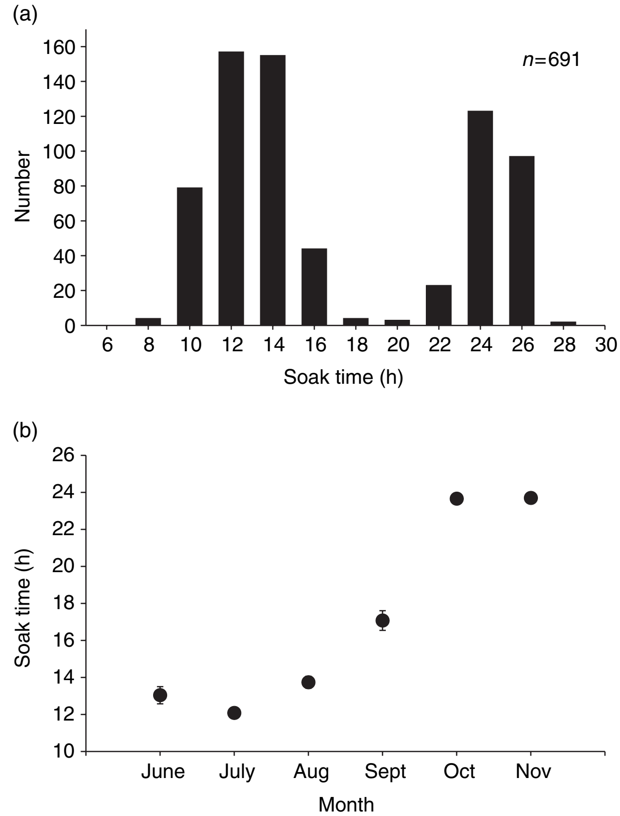

Figure 2. (a) Soak times for gillnets fished from June to November 2002 ($n = 691$ nets) in the Newport River, North Carolina. (b) Mean (± SE) gillnet soak time.

The random net comparisons addressed the question of whether an experienced commercial fisher could successfully set a gillnet to minimise the bycatch of red drum. First, the effect of observer presence on reported red drum catch was tested using a *t*-test. Secondly, the effects of random sets on catch of red drum and southern flounder were compared using paired *t*-tests; the paired *t*-tests were performed using all 66 pairs since each pair was within same region.

The numbers of live and dead red drum captured in all nets were recorded. Red drum were judged dead if they were not able to swim away. The effect of month on numbers of dead red drum in gillnets was evaluated using ANCOVA with total (dead plus alive) number of red drum as a covariate to determine if certain months (e.g. summer) had higher levels of mortality; ANCOVA was used because the number of dead red drum was significantly related to the total number of red drum in a given net. If the assumption of homogeneity of slopes was violated, a separate slopes ANCOVA was used. The effect of mesh size on length of red drum and southern flounder was determined by ANOVA. Due to seasonal migration patterns one might expect temporal changes in red drum and southern flounder catch; thus, the effect of month on red drum and southern flounder catch was determined using ANOVA.

Results

Data were recorded from 691 gillnet sets in 70 gillnet trips. Southern flounder, *Paralichthys lethostigma* Jordan and Gilbert, was the dominant species of flounder [total flounder = 2624; *P. lethostigma* = 2611, *P. dentatus* (Linnaeus) = 9, and *P. albigutta* Jordan and Gilbert = 4] and was the only flounder described.

Table 1. Length of red drum and southern flounder caught in three different gillnet mesh sizes from June to November 2002 in the Newport River, North Carolina

Stretched mesh size (mm)	Mean total length (mm)	SE (mm)	*n*
Red drum			
133	543	5.2	120
140	523	7.1	130
152	542	11.4	76
Southern flounder			
133	374	1.5	894
140	381	1.3	1021
152	398	1.8	678

Southern flounder length increased with mesh size ($F = 56.6$, d.f. = 2,2589, $P < 0.001$; Table 1). A total of 326 red drum was captured in the 691 gillnet sets. Mean length of red drum (alive and dead) only varied by approximately 20 mm in the three different mesh sizes, and there was no effect of mesh size on red drum size ($F = 2.35$, d.f. = 2,323, $P = 0.097$).

Catch of red drum did not change significantly throughout the study for either 12 or 24 h sets (12 h: $F = 2.019$, d.f. = 3, 439, $P = 0.110$; 24 h: $F = 1.876$, d.f. = 4,243, $P = 0.115$; Fig. 3); whereas, for flounder there was a significant effect of date on catch in 24-h sets from June to November ($F = 15.616$, d.f. = 4,243, $P < 0.0001$). There was no significant effect of date on flounder CPUE in 12 h sets from June to September ($F = 2.019$, d.f. = 3,439, $P = 0.071$).

Of the 326 red drum caught during the study period, 106 (33%) were dead. There were no significant differences in the numbers of dead red drum in gillnets among months for 12 h ($F = 0.032$, d.f. = 3,435, $P = 0.992$) or 24-h sets ($F = 0.379$, d.f. = 4,238, $P = 0.823$) so months with warmer temperatures did not lead to increased red drum mortality; a separate slopes ANCOVA was required for the 12 h data set because slopes were not homogeneous. Of the 220 live red drum, 178 (81%) were within the legal slot limit of 457–686 mm, and 91 of the 106 dead drum (86%) were within the legal range (Fig. 4). For the drum outside the slot limit, 11 were <457 mm and four were >686 mm for dead red drum and 37 were less than the slot and five were greater than the slot for live red drum.

On average, the catch of red drum in 10 nets was less than the daily legal limit of seven fish. The mean

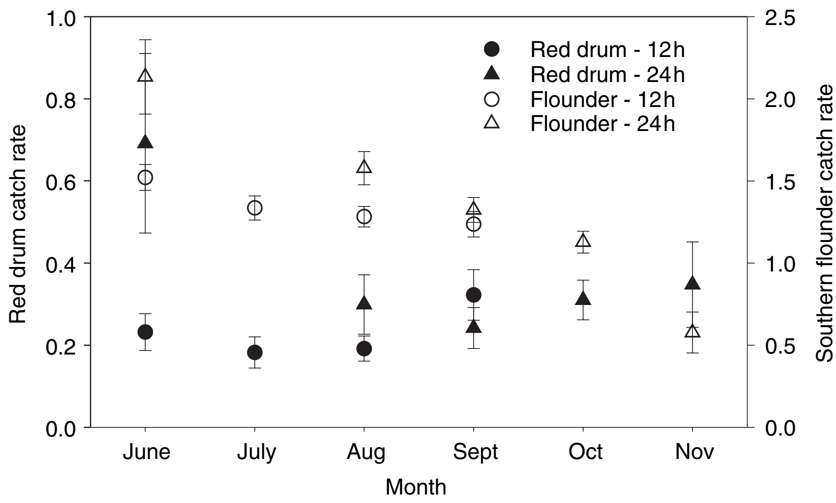

Figure 3. Mean (±SE) catch [ln (catch + 1)/net] of red drum and southern flounder by month for both 12- and 24-h sets in the Newport River, North Carolina.

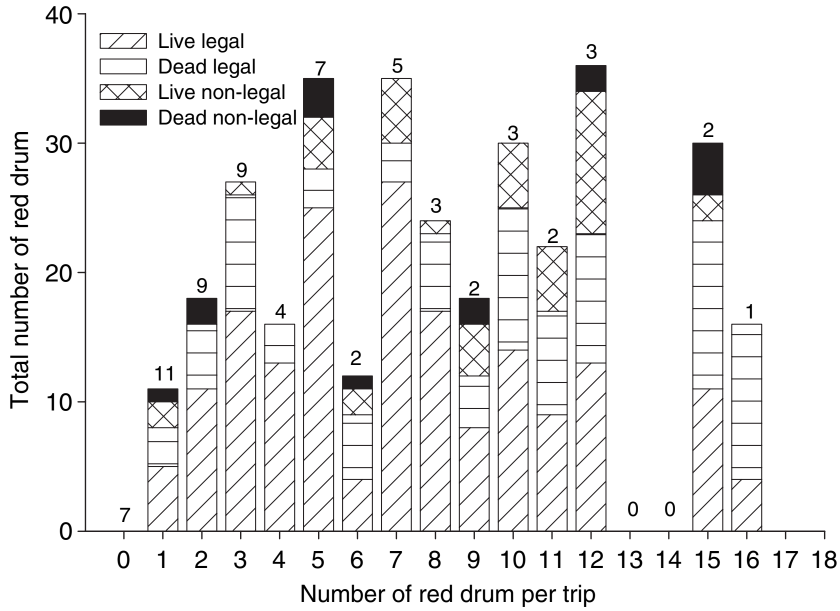

Figure 4. Composition of the catch of red drum by a large-mesh gillnetter in the Newport River, North Carolina. The value at the top of each bar represents the total number of trips at which that number of red drum per trip was caught.

bycatch of red drum for all dates with and without observers was 0.41 red drum gillnet^{-1} during 12 h soaks and 0.59 red drum net^{-1} during 24 h sets. Thus, the daily catch of 10 nets would be about four red drum for 12 h sets and about six for 24 h sets. More than seven red drum were caught on 16 of 70 trips (Fig. 4). Most of the red drum were alive or of legal size.

For the 66 paired nets, red drum catches were not significantly different when observers were present (12 h mean = 0.296; 24 h mean = 0.377) compared with when no observers were present (12 h mean = 0.276; 24 h mean = 0.202) for either 12 h sets (t = 0.176, d.f. = 84, P = 0.860) or 24 h sets (t = 1.195, d.f. = 44, P = 0.238). Given the lack of difference between red drum catch with or without observers, these data were pooled for the random net comparisons. For the 66 paired nets, catch rate did not differ between the directed or randomly set gillnets for southern flounder (t = 1.732, d.f. = 65, P = 0.088) or red drum (t = 0.446, d.f. = 65, P = 0.657; Fig. 5).

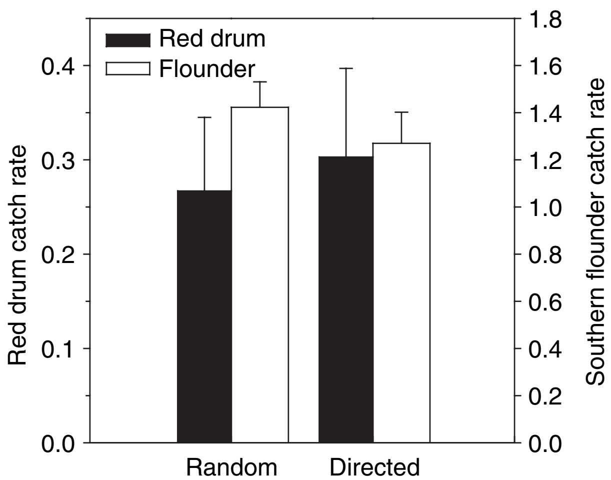

Figure 5. Mean (+SE) catch [ln (catch + 1) net^{-1}] of red drum and southern flounder for random and directed gillnets (12- and 24-h sets combined) in the Newport River, North Carolina.

Discussion

The failure to find a difference in red drum catch between randomly set and directed nets indicates that red drum bycatch was not reduced by exercising judgement in gillnet placement. Using a similar design, Price & Rulifson (2004) examined the bycatch of striped bass in a white perch *Morone americana* (Gmelin) small mesh gillnet fishery during spring and fall in Currituck Sound, North Carolina. Bycatch of striped bass from the two net treatments were not significantly different in the spring, a period when striped bass catch rates were low; however, there was a significantly higher bycatch of striped bass in random compared with non-random nets in autumn when striped bass catches were high (Price & Rulifson 2004). The ability to detect a difference between red drum catch in random and directed gillnets may have been reduced due to relatively low catch rates of red drum.

Bycatch and discard of red drum in large mesh gillnets during this study were low. The daily catch of red drum in flounder nets for the majority of trips was less than the allowable catch (seven fish). The findings are consistent with NCDMF trip ticket landings data for all commercial large mesh gillnet fishers during the June to November 2002 time period in the Newport River area; average monthly landings were 5–8.6 kg of red drum per trip or 3–5 fish per trip (based on our average red drum weight of 1.8 kg). The majority of red drum fell within the slot limit; hence, most red drum that were dead when removed from the net could be legally retained. Larger mesh nets (such as the sizes used in this study) have been suggested as an approach to reduce discards of juvenile fishes in other gillnet fisheries (Ueno 2001; Gray 2002).

When the catch exceeded seven fish (23% of trips) the majority of the discards were released alive. Post-release mortality of red drum captured in large mesh gillnets is unknown. Hook-and-line captured red drum from the nearby Neuse River, North Carolina, had high survival rates (93%) after 3 days retention in net pens (Aguilar 2003). Mortality assessments of gillnetted fish are less common (but see Buchanan *et al.* 2002) and are needed to obtain estimates of survival rate for live discards (Gray, Johnson, Young & Broadhurst 2004).

The number of dead red drum was not related to date. Given previous findings of increased mortality of bycatch at higher temperatures (Davis & Olla 2001; Price & Rulifson 2004), higher mortality was expected during the summer months. This may have been the case if gillnet soak times were consistently > 20 h throughout all months. However, the frequency of soak times longer than 12 h was less during summer months compared with autumn months; commercial gillnetters purposely fish in this manner to reduce spoilage of flounder and reduce discard mortality during summer. Thus, the number of dead red drum did not differ between months because longer soak times did not occur during periods of high summer water temperatures.

Current fisheries management regulations in North Carolina are supported by the findings of this study. This is not surprising since historic commercial landings data for red drum by flounder fishers were considered in developing the 7 fish trip limit implemented in 2001 (L. Paramore, NCDMF, personal communication). This study was limited to one season (2002), and the availability of sub-adult red drum of this size (350–700 mm) and age (age 0–3 based on Ross *et al.* 1995) will be highly dependent on individual year-class abundance. Indeed, the ages captured were from weak year classes (L. Paramore, NCDMF, personal communication). Hence, the North Carolina gillnet fishery should continue to be monitored by observers to confirm that bycatch of red drum remains within sustainable levels.

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