J. Mar. Biol. Ass. U.K. (2001), **81**, 187–188
Printed in the United Kingdom

Unequal sex ratios in longline catches

P. Wirtz and T. Morato

Departamento de Oceanografia e Pescas, Universidade dos Açores, Cais de Santa Cruz, P-9901 Horta, Faial, Azores, Portugal. E-mails: peter@dop.horta.uac.pt, telmo@dop.horta.uac.pt

There is sometimes a significant bias in the sex ratio of fish caught by longline. Usually, more females than males are caught. The possible reasons for unequal sex ratios in longline catches are listed and discussed. One sex could be more common in the area where the fishery takes place because there really is an unequal sex ratio in the population or because the other sex preferentially occurs in different places. Alternatively, longline fishery might preferentially catch one of the sexes. This could be a result of size difference between the sexes and thus a different response to the given hook size or bait size. Finally, sexes could differ in their feeding behaviour. There is growing evidence that females—not only of fish—are 'energy maximizers': they find food faster and spend more time feeding than do males. Thus, fishing methods using bait are likely to catch a higher proportion of females than fishing methods that do not use bait.

Significantly unequal sex ratios are sometimes reported for fish caught by longline. In some catches, males are more frequent than females but in the majority of cases, more females than males are caught. Table 1 gives examples from the fishery literature.

Here are listed and discussed several, non-exclusive reasons for unequal sex ratios in longline catches. In particular, results obtained by ethologists on sex differences in feeding behaviour that predict a catch biased towards a higher proportion of females not only in longline fishery but in any fishery that uses bait are pointed out.

Sex ratios really are unequal

The population sampled could have a sex ratio different from unity (e.g. because of higher mortality of one of the sexes) or one of the two sexes might preferentially occur in different places. Yano (1995), for instance, has reported a much higher proportion of females of black dogfish (*Centroscyllium fabricii*) in deeper depth strata than in shallow depth strata. Munoz-Chapuli (1984) demonstrated spatial segregation of males and females of several species of pelagic sharks during certain times of the year. Thus when fishing takes place in an area preferentially used by one of the sexes, a high proportion of that sex in the catch might be expected.

Longline fishery preferentially catches one of the sexes

To test whether sex ratio data are influenced by the gear used, results from different types of gear, obtained at the same time and place, would have to be compared. Several such comparisons exist in the literature (e.g. Aldebert et al., 1993; Nedreaas et al., 1996; Zhao & McGovern, 1997). They clearly demonstrate an effect of gear type on sex ratio of catch (Table 2).

Longline fishery could bias the sex ratio of the sample if the two sexes of the species in question differ greatly in size. The probability of capturing males or females with a given hook size or bait size might then be different. Thus, when females are the larger sex (as is often the case in fish) and when the gear selects for large size, a high proportion of females in the catch can be expected.

Longline fishery (and any other fishery using bait) might catch unequal numbers of males and females if the sexes differ in feeding behaviour. Schoener (1971) proposed that the females of most species are 'energy maximizers' and spend a larger time foraging than do males because their fitness is principally determined by the net energy acquired, whereas males can increase their reproductive success by other activities, such as courtship, mate guarding, or defence of a reproductive territory, that will detract from feeding time. In accordance with these theoretical considerations, females have indeed been shown to find food faster than males (Laland & Reader, 1999) and have been shown to spend more time feeding than males in animals ranging from fish to mammals (Abrahams, 1993; Schoener, 1971; Wirtz & Oldekop, 1991).

Chance

Hundreds of data sets on longline fishery have been published. By chance alone, the sex ratio in some of them can be expected to differ significantly from unity. The data in many publications are the sum of the results of several fishing seasons. In such cases, we recommend to test if each of the subsets of the data shows the same trend in sex ratio.

Because different gears tend to select different parts of the population as regards length, age, and sex composition, care must be taken when interpreting these results. As pointed out by Nedreaas et al. (1996) and by Zhao & McGovern (1997), the data, in some cases, may differ substantially from the true population composition. Nedreaas et al. (1996) suggested that trawling might be the least selective fishing method. In accordance with the behavioural data described above, longline fishery does indeed catch a higher proportion of females than does trawling in each case where such a comparison is possible (Aldebert et al., 1993; Nedreaas et al., 1996; Zhao & McGovern, 1997).

In conclusion, there are several, non-exclusive variables that may affect the sex ratio in commercial catches. Fishing methods using bait are likely to catch a higher proportion of females than fishing methods that do not use bait.

Table 1. *Sex ratio of longline catches (*P *values calculated by* χ^2*-tests).*

Species	% female	% male	N	*P*	Reference
Thunnus albacares	37	63	420	<0.0001	Faure & Bablet, 1982
Reinhardtius hippoglossoides	66.6	33.4	996	<0.0001	Nedreaas et al., 1996
Helicolenus dactylopterus	46.1	53.9	2293	<0.0002	Estácio et al., in press
Lepidopus caudatus	63.5	36.5	909	<0.0001	Estácio et al., in press
Pontinus kuhlii	64	36	456	<0.0001	Estácio et al., in press

Table 2. *Sex ratios obtained by different types of gear (differences between gear types tested by* χ^2*-tests). Note that Aldebert et al. (1993) report their data as weights captured and no statistical comparison can therefore be made in this case.*

Species	Gear	%female	%male	N	*P*	Reference
Merluccius merluccius	French trawl	49.8	50.2			
	Spanish trawl	47.2	52.6			
	Gillnet	61.2	38.8			
	Longline	86.7	13.3			Aldebert et al., 1993
Reinhardtius hippoglossoides	Trawl 1	51.0	49.0	1009		
	Trawl 2	48.4	51.6	946		
	Gillnet	86.5	13.5	443		
	Longline	66.6	33.4	996	<0.00001	Nedreaas et al., 1996
Rhomboplites aurorubens	Baited traps	72.1	279	1786		
	Hook and line	66.2	33.8	1395		
	Trawl	61.0	39.0	415	<0.001	Zhao & McGovern, 1997

Thanks to Irene Huse for suggesting appropriate references. P.W. is grateful to the director of the Department of Oceanography and Fisheries of the University of the Azores, Dr Ricardo Serrão Santos and to the Fundação para a Ciência e Tecnologia for a grant as an invited scientist (Praxis XXI/BCC/16435/98). Thanks to Alan Southward for checking the English.

REFERENCES

Abrahams, M.V., 1993. The trade-off between foraging and courting in male guppies. *Animal Behaviour*, **45**, 673–681.

Aldebert, Y., Recasens, L. & Lleonart, J., 1993. Analysis of gear interactions in a hake fishery: the case of the Gulf of Lions (NW Mediterranean). *Scientia Marina*, **57**, 207–217.

Estácio, S., Mendonça, A., Krug, H., Menezes, G., Branco, J. & Pinho, M.R., in press. Aspects of the reproduction of six demersal species captured in the Azores Archipelago. *Arquipélago. Life and Marine Sciences*, supplement 2 part B.

Faure, E. & Bablet, J. P., 1982. Contribution à l'étude des caractères biometriques du thon a nagoires jaunes du pacifique *Thunnus albacares* (Bonnaterre, 1788). *Cybium*, **6/4**, 31–55.

Laland, K.N. & Reader, S.M., 1999. Foraging innovation in the guppy. *Animal Behaviour*, **57**, 331–340.

Munoz-Chapuli, R., 1984. Ethologie de la reproduction chez quelques requins de l'Atlantique nord-est. *Cybium* (3è ser), **8/3**, 1–14.

Nedreaas, K., Soldal, A.V. & Bjordal, Å., 1996. Performance and biological implications of a multi-gear fishery for Greenland halibut (*Reinhardtius hippoglossoides*). *Journal of Northwest Atlantic Fishery Science*, **19**, 59–72.

Schoener, T.W., 1971. Theory of feeding strategies. *Annual Review of Ecology and Systematics*, **11**, 369–404.

Wirtz, P. & Oldekop, G., 1991. Time budgets of waterbuck (*Kobus ellipsiprymnus*) of different age, sex, and social status. *Zeitschrift für Säugetierkunde*, **56**, 48–58.

Yano, K., 1995. Reproductive biology of the black dogfish, *Centroscyllium fabricii*, collected from waters off western Greenland. *Journal of the Marine Biological Association of the United Kingdom*, **75**, 285–310.

Zhao, B. & McGovern, J.C., 1997. Temporal variation in sexual maturity and gear specific sex ratio of the vermilion snapper. *Rhomboplites aurorubens*, in the South Atlantic Bight. *Fishery Bulletin*, **95**, 837–848.

Submitted 5 July 2000. Accepted 11 December 2000.