The Population Density of Monsters in Loch Ness[1]

It is well known that there are monsters in Loch Ness. Their most characteristic features are that they are rarely seen and never caught, but there are records of sightings extending back many centuries. The fact that they are rarely seen suggests that the population is small. It is known from direct observation that the animals themselves are large and it follows from this that the population *must* be small. It can be demonstrated quite easily from trophic-dynamic considerations that many large animals could not exist in Loch Ness; but a few could. It has been suggested from time to time that as the monsters are never caught it must therefore follow that they do not exist. This is both irresponsible and illogical.

Many accounts have been written of Loch Ness and its monsters (e.g. Holiday 1968) but very few quantitative observations have been made. We know nothing of their distribution. The population structure of the monster community is also unknown to us. As they are rarely seen and never caught (characteristic features) it is particularly difficult to study their population dynamics. However, it is our purpose to show that it is possible to estimate the number of monsters that can exist in Loch Ness.

The production rate of oceanic organisms is size dependent, but in ecologically stable areas the standing stock is constant at all sizes (Sheldon et al. 1972). It is not unreasonable to assume that similar relationships exist in large bodies of freshwater. If this is so then the standing stock of monsters, taken over logarithmic size intervals, should be similar to that of other organisms (e.g. fish or plankton).

We have not been able to find any information on the standing stocks of Loch Ness, but an estimate of the fish stock can be made if the probable yield is known. A deep oligotrophic lake such as Loch Ness should give an annual yield of rather less than 1 kg ha^{-1} yr^{-1}. This estimate can be refined by calculations based on Ryder's (1964, 1965) morphoedaphic index (total dissolved solids/mean depth). Again, we could not find data from Loch Ness and have used a value for total dissolved solids for the northern part of Loch Lomond (Darling and Boyd 1969). The estimate of mean depth was taken from Hutchinson (1957). By using this information in Ryder's (1964) equation we calculate that Loch Ness should give an average fish yield of 0.55 kg ha^{-1} yr^{-1}. The ratio of biomass to production of a fish producing system will range from about 1 to 5, so that the standing stock of fish in Loch Ness should lie in the range from 0.55 to 2.75 kg ha^{-1}. The concentration of monsters should be similar.

The area of Loch Ness is about 5,700 ha. The total mass of monsters in the loch is therefore in the range 3,135 to 15,675 kg. In Fig. 1 we show the number of monsters the loch could support relative to individual size. The minimum average size is taken arbitrarily as 100 kg; anything smaller is not suitably monstrous. The number of monsters in the loch could vary from 1 to 156 depending on the standing stock and average size. The largest number would occur in the situation where high standing stock and small average monster size coincide; however, we believe that such a situation is unlikely. The smallest number must be more than two if the species is to be maintained. Monsters have been seen in the loch for hundreds of years so that there must be a breeding population. The alternative possibility, a single monster of great age, is unlikely, and *inter alia* is not in keeping with the wide range of size estimates reported in the literature. A viable population could be quite small but probably would not be less than 10. This constraint is indicated by the vertical line in Fig. 1. All the combinations of individual monster weight and population shown by Fig. 1

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are theoretically possible, but we would only consider those to the right of the vertical line to be realistic.

We will now attempt to show that some of the individual monster weight and population combinations are more probable than others. Much of our reasoning is based on observational evidence.

The trophic position of the monsters is probably that of terminal predators feeding on fish (Holiday 1968). The growth efficiency of many aquatic predators is around 10%. If the monsters are similarly efficient and if a major part of the fish production is used by them, then their production must be of the order of 300 kg yr^{-1} or more. The average number of deaths per year is determined in a stable population by the ratio of production to mean size. On this basis monsters weighing 100 kg would have to die at a minimum rate of about 3 per year. Larger monsters would die less frequently.

Two lines of evidence support the view that monsters do not die frequently and must therefore be large. Firstly, corpses are never found. Secondly, a relatively large number of juveniles must exist if adult mortality is high, but although small monsters have been seen from time to time they are not common. It seems therefore that Loch Ness must contain a small number of large monsters. These could weigh as much as 1,500 kg with a population of 10–20 individuals. A 1,500-kg monster could be about 8 m long, a size that agrees well with observational data.

We are aware that in these calculations we have not taken migratory fish into consideration. These will increase the effective standing stock of the loch and this could result in there being either more or larger monsters than we have shown. However, Sheldon et al. (1972) suggest that standing stocks are not absolutely constant. There is probably some decrease at the higher trophic levels which could result in there being either fewer or smaller monsters than we have shown. These two factors are antipathetic, and although we do not know the relative magnitudes, they are both likely to be of the order of a factor of two. They will tend to cancel each other and it is not improbable therefore that the population density that we have described for the monsters in Loch Ness is near to the true value.

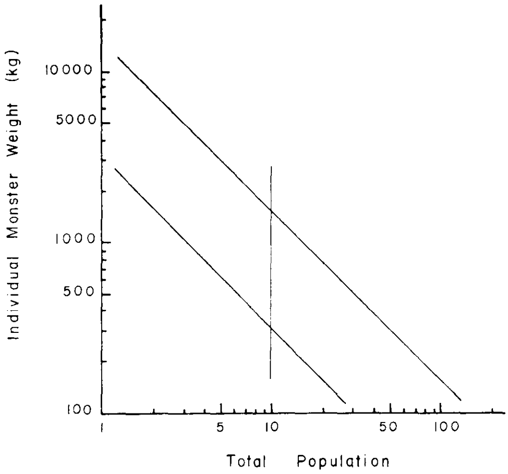

FIG. 1. The probable number of monsters in Loch Ness. Upper curve: at a standing stock of 2.75 kg ha^{-1}; lower curve: at a standing stock of 0.55 kg ha^{-1}. The vertical line indicates the suggested minimum population size.

It is not unknown for sightings of monsters, both in Loch Ness and elsewhere, to go unrecorded (Heuvelmans 1968; Holiday 1968). Fear of ridicule is the main reason why many observers do not make their observations known to science. But it is the skeptics who are at fault. Monster observers should be encouraged. The occurrence of monsters is quite reasonable and is by no means fantastic.

We would like to thank Kate Kranck for drawing our attention to this problem, because until she mentioned it we were unaware that monsters were a problem.

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