

-A Deadly Dance-

The predator-prey interactions between Norwegian killer whales (*Orcinus orca*) and spring spawning herring. (*Clupea harengus*)

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Introduction

The Vesterålen and Lofoten islands as well as the adjacent fjords in the rugged north of Norway has been the place of overwintering spring spawning herring since 1987. The herring schools follow their principal prey, the copepod *Calanus finmarchius* into the fjords and their deeper overwintering habitat. This yearly migration of herring starts in October

and ends when the spawning migration starts in January.

Just as the herring follows their prey, they are again followed by the killer whales residing in norwegian coastal waters, to which they are the principal prey. A deadly dance for survival is the result - which leads to the question: *What techniques does the killer whales employ to catch their prey, and what antipredator behaviour is exhibited by the herring to avoid being eaten?*

The herring

The herring is also known as the silver of the ocean and was the foundation for many settlements along the norwegian coast in earlier times.

The size of a herring school can vary from a few hundred to several million individuals, and its primary function is to serve as protection from predators - due to the increased dilution and confusion effect. Studies shows that antipredator vigilance increases with school size and that the very large schools are less frequently attacked than smaller ones- as killer whales have been observed to abandon a large school in search of a smaller one.

The herring have been blessed with well developed sight and hearing, which makes them capable of detecting the direction and range of sound and move away from the source. Examples of this has been seen when killer whales enter a fjord with herring and before the whales are in the herrings visual range the school swim to the bottom and hide- likely responding to the sounds made by the whales. Their bodies are camouflaged and built for endurance and their scales reflect the light and can thus exhibit a confusing effect on the predators.

In addition to this, the herring is also capable of fast vertical movements which is hard for the large whales to follow, and which can provide a clean get away. In other words: They might not have the size and teeth of the killer whales but they were not born defenseless.

In summation: the safety provided by high numbers and the herrings physical abilities makes it possible to avoid a predator attack altogether. However, when the herring do find itself in the unfortunate situation of being attacked they have developed several antipredatory strategies to avoid the hungry whales.

Antipredator manouuvres- methods and observations

The investigation of herring antipredator manouveres during attack was done in Tysfjord in the Lofoten region of northern Norway during November 1993. The observations were done night and day in both shallow and deep waters using a 455 kHz SeaBat 6012 multibeam sonar mounted on a 9.8 m motorized vessel.

Rapid changes in school structure and density is important during attacks and is dependent on the individuals ability to assess the danger in time and react fast and coordinated. It takes 0.1 second to transfer information from one herring to neighbouring one hence the reaction time of a herring school is formidable. This is what gives the effect of the fish moving as one - without any leader fish to follow. Individuals who fail to do this will lag behind or be confined to the periphery of the school where they are more vulnerable. To prevent this, the herring was seen organized in a tight ball formation during 80% of killer whale attacks. Mostly the herring remain in this state during 97% of the attack and only 3 % of the time is used on other antipredator manouuvres (school states)

The other antipredator manouuvres that were observed can be divided into two categories:

Movement events:

«**Herd**» : the herring swim rapidly in front of the predator, often observed in small schools chased by the whale

«**Dive**»: Rapid downwards manouvre which allows the herring to escape to deeper water.

...and Shape changing events

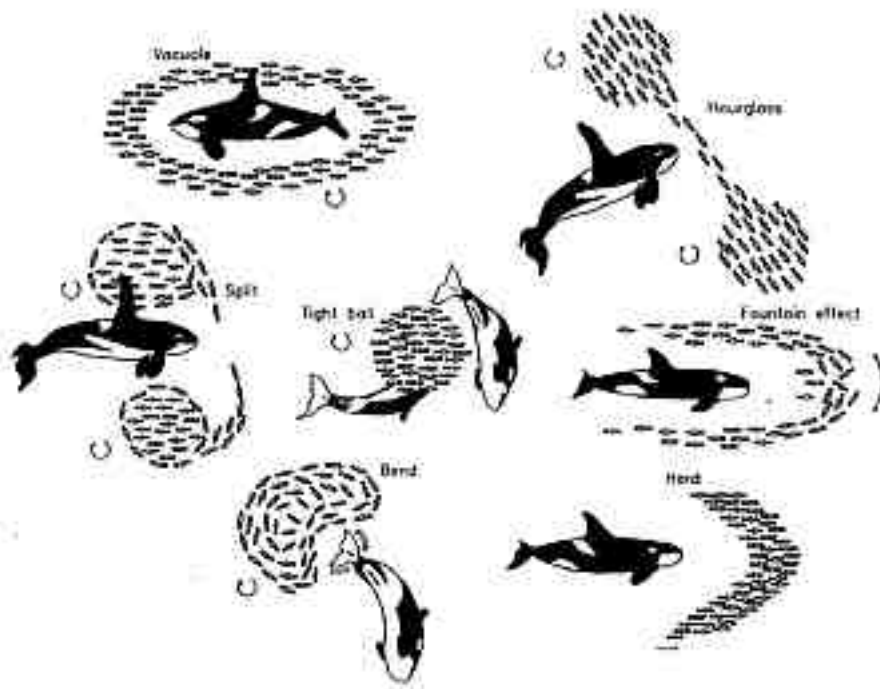
«**Split**»: Fragmentation of the school, frequently used by small schools after 2 or 3 successive strikes by the whale into the school.

«**Bend**» :Inflection of the school

«**Vacuole**»: The predator is situated in an empty space in the middle of the school- typical for large schools.

«**Hourglass**»: Constriction in the centre of the school- exhibited by medium sized schools

«**Fountain**» : Herring turn rapidly in the direction opposite to the predator, often preceded by «herd».



The killer whale

The killer whale (*Orcinus Orca*) is an animal shrouded in myth as seen in the legends of the native americans, and a popular hero as seen in the «Free Willy» films. Also known as orca, the killer whale is a many toothed whale and the largest species of the dolphin family, they can grow up to 8-10 m in length. Their black and white markings are effecient camouflage and are as individual as unique to each individual as our fingermarks

The killer whales are undoubtedly one of the most adaptive cetaceans as they are found in all oceans both in coastal and pelagic waters. The killer whales in Norwegain waters live in relatively stable social groups of 10-50 individuals. This arrangment is thought to have evolved to the accumulation of prey in schools which require a higher degree of cooperation from the whales- as they are known to also hunt in smaller groups or alone in other waters. In these stable groups useful learned traditions like special hunting techniques are effectively passed on- and young individuals are often seen following the older ones and mimicking them during the hunt.

The feeding methods used by the norwegian killer whales have probably evolved as a response to the behaviour of the herring resulting in a special cooperative hunting technique known as carousel feeding. Cooperative feeding is common among social

carnivores and is thought to be a way of increasing hunting success.

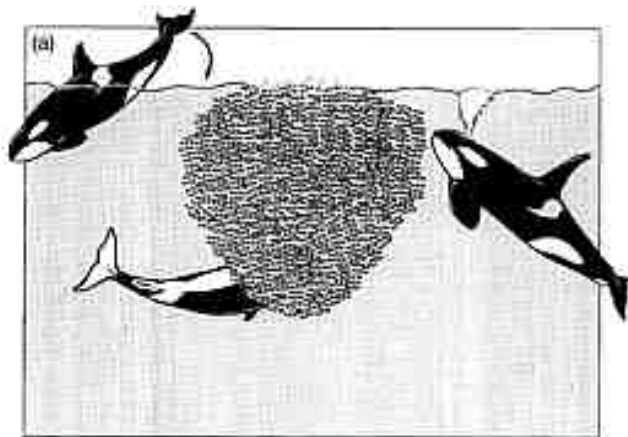
Hunting technique- methods and observations

The study of the cooperative feeding of killer whales hunting herring was conducted in Tysfjord, Ofotfjord and Vestfjord in the north of Norway during 1990-1992. Surface observations were made from several types of vessels including a 100ft research vessel from the university of Tromsø and recorded with a 8mm videocamera. Underwater observations were done with a remote controlled underwater camera mounted on a Zodiac vessel. The use of an outboard engine, which is almost silent, enabled both video and sound recording to be done.

The carousel method was first observed in bottlenosed dolphins (*Tursiops truncatus*) in the black sea, and later also in orcas. The method was variable but main phases could be distinguished: Herding and feeding.

The herding phase:

When a school had been located the killer whales proceeded to swim around and under the fish with their white ventral side against the fish, and all whales swimming in the same direction. This resulted in the herring forming a packed ball of high density- which is easier controlled by the whales. The killer



whales would drive the ball towards the surface which would act as a barrier, and herring could often be observed splashing on the surface from the vessels. During this phase the whales were very vocally active, and the sounds distinguished were: echolocation clicks, whistles and other variable calls.

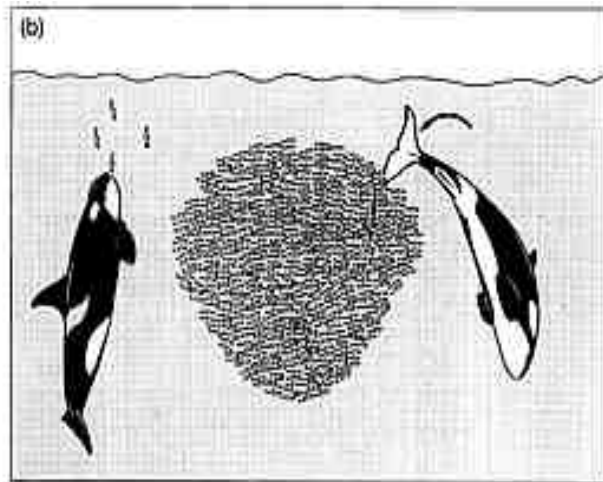
It is thought that due to the good hearing of the herring, acoustic stimuli could be used by

the whales to herd the herring into a tighter ball. The echolocation clicks(0,5-2,5 kHz) emitted by the whales falls into the the sound range detectable to the herring and could aid in the herding of the fish- then again they could also mainly be used to enhance and synchronize the cooperation between the whales. The whales also release air bubbles from their blowholes while circling the fish- the herring is know to show a strong avoidance to bubbles and this may also help in herding the fish closer together.

The feeding phase:

In the feeding phase the whales continued the behaviours described earlier but in a less synchronized manner- and with larger amounts of air bubbles released closer to the school. The whales would also preform tail slaps at the school to stun the fish. The killer whales were apparantly unable to capture herring without stunning them first.

The slaps started by a whale swimming directly towards the school, then following it with the ventral side of their body before arching its body and forcefully slapping the school with the underside of its fluke. A loud bang could be heard as the fluke connected with the school. Wether the herring was stunned by actual physical contact of he fluke,



sound waves or pressure waves is unclear- but only the fish in the immediate vicinity of the fluke were stunned. The whales would then turn back and eat the stunned fish one by one.

More whales were always observed encircling and keeping the school together than feeding, and if the herring tried to escape by a vertical dive one or two whales would swim with their white ventral side up underneath the school and prevent the escape. The whales also ate fish stunned by other individuals of the group.

Conclusion

What techniques does the killer whales employ to catch their prey, and what antipredator behaviour is exhibited by the herring to avoid being eaten?

The carousel method used by the Norwegian killer whales is a prime example on a specialized hunting technique evolved in adaption to living in prey abundant waters.

Cooperation is an important factor to make this technique successful. The herring are herded together in a tight ball by help of synchronized encircling, air bubbles released from the whales blowholes, and maybe also acoustic stimuli. The herring are kept in a tight ball close to the surface and stunned by tail slaps before being eaten.

The herring reacts to attack by forming a tight ball, making it difficult for the whales to attack single peripheral individuals and by providing safety of shelter in the middle of the school. They respond to attack by several amazingly synchronized evasive manoeuvres including: Herd, dive, vacuole, split, hourglass, bend and fountain, and may also avoid an attack altogether by escaping to deeper waters before detection by the whales, as well as aggregating in larger schools that are more difficult for the whales to «pack» and control.

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Illustrations: Svein Spjelkjavik