

# Mini GPS Fish Tags Contributing To Fisheries Management

## *Reconstructing True Fish Distributions and Migration Routes Give New Insights into Fish Behaviour*

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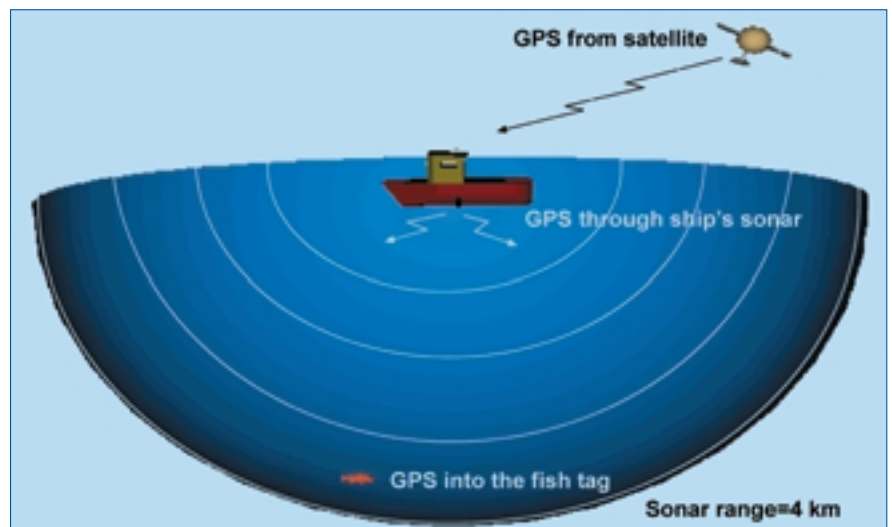
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**K**nowledge concerning fish distribution and migration is of great importance to fisheries management. However, such knowledge is often poor and/or biased because information is mainly derived from fisheries data. Information on the general geographical distribution of fish may be available, but tracking single fish or schools in time and space, other than over short ranges in lochs, lakes and within fjords, has been impossible. Better information as to the migratory pattern of fish in the oceans will be a substantial contribution to a sustainable management of our fish resources. Furthermore, as there is little understanding of the mechanisms of fish orientation and navigation, any technology that will improve this knowledge is extremely valuable.

Star-Oddi of Iceland and Simrad of Norway, in close cooperation with scientists at the Institute of Marine Research (IMR) in Norway and the Marine Research Institute (MRI) of Iceland, have developed a miniature global positioning system (GPS) tag to track fish over great distances.

The tag can be implanted into the body cavity of a fish, or attached to the



*(Top) The system's principal involves linking a GPS satellite, a vessel's GPS receiver, a vessel's sonar and GPS-tagged fish.*

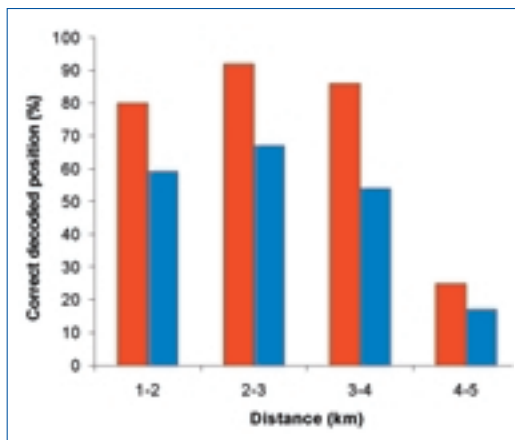
*(Right) The DST GPS tag with user-defined return information text. The tag can be used internally or externally on fish.*



fish's exterior. The tag receives GPS positions transmitted by a vessel's sonar or by a transmitter on a fixed or drifting buoy. Research and fishery vessels carrying Simrad sonar are capable of transmitting the vessel's position, and the GPS tags can receive the signal within a radius of up to four kilometres from the vessel, depending on the acoustic conditions in the area. A vessel sailing at about nine nautical miles per hour will be able to cover an area of approximately 140 square kilometres in only one hour of sailing, ma-

king the system quite effective. The vessel receives its position from a satellite. The vessel's sonar signal is encoded with the position and transmitted underwater to tagged fish in the area. The fish tags receive GPS signals sent by the sonar. Received positions are stored in the tag, and fish movements can be reconstructed after tag recovery.

Marine research institutes carry out several annual surveys covering much of their national exclusive economic zone and, by utilising the GPS tags and Simrad sonar, the surveys can gather additional valuable data with minimal additional cost.



*DST GPS tag test results, depicting the percentage of tags decoding positions correctly taking into account range and probability of repeated reception of a specific position with respect to transmitted distance.*

Recapture of the tagged fish is dependent on commercial fisheries. Fishermen are usually well-informed concerning the scientific value of tags, and receive a reward for returning them. With recapture of a tagged fish, scientists can reconstruct the migration route. In addition to recording its position, these tags also record the depth and temperature of the fish's environment. Timing and frequency of measurements by the tags are user-programmable. By comparing collected data with measured environmental information, the behaviour of fish at defined geographical locations can be further analysed.

### Technical Performance

Scientists have traditionally used acoustic pinging tags for obtaining information about the migratory pattern of fish. These tags transmit an ultrasonic signal, and researchers either track the fish from a vessel using a directional receiver, or use three or more receivers in fixed locations to determine the fish's position by triangulation. However, such methodologies are time-consuming, expensive, can only be used for a short time span and are, thus, not suited for following migrating fish over long distances in the ocean. The Star-Oddi and Simrad GPS system takes advantage of the large areas covered by research vessels and these vessels' equipment, which can transmit acoustic signals over great dis-

tances. The acoustic signals are transmitted through Simrad sonar systems already onboard many vessels. Simrad sonar types SP60, SP70 and SP90 can be used for GPS signal transmission. Using the Simrad sonar SP70, the sonic signal is transmitted in an omnidirectional pattern with an acoustic source level of 205 decibels per one micro Pascal. The GPS system transmits acoustic signals one way, and the tag receives and records the signals. In the Fjord of Oslo, in Norway, the system was tested on tagged cod in cages suspended 60 meters below a drifting buoy. GPS positions transmitted from the SP70 sonar onboard *Simrad Echo* were successfully detected up to four kilometres from the ship. Under better acoustic conditions, ranges up to seven kilometres can theoretically be obtained.

Because of the small size of the GPS tag (diameter 15 millimetres and length 46 millimetres), it can be applied internally or externally on many different species of fish and marine animals.

Tests of the system have shown that the following variables do not affect the performance of the system: fish tagged externally or internally; sonic reflections from coast or ocean bottom, tested in the Fjord of Oslo; vessel speed from zero to nine nautical miles per hour; tags placed pelagic or on the ocean bottom; or other sonar traffic on a neighbouring frequency.

The main influences on the range of

the system, not unexpectedly, are the acoustic conditions in the area at the time of transmission. During the test in the Fjord of Oslo, the same coded GPS position was transmitted continuously. In many situations, each tag has more than one opportunity to receive position data from the same vessel.

Results from the Fjord of Oslo showed that the distance between the tag and a vessel's sonar ranged from zero to 4,000 meters. The percentage of transmitted signals received correctly ranged from 18 to 92 percent.

### Application of the System

These tags may improve intelligence concerning the migratory routes of marine fish, and will, thereby, contribute to increased knowledge of fish migration in general, and migration mechanisms in particular. Since such information is vital for fisheries regulation, the tags could contribute substantially to sustainable management of our fishery resources. Data on fish migratory routes is currently limited to commercial fish resources. There is a growing need for a research tool such as the GPS tag to give new insights into fish behaviour, improved estimates of fish stocks and knowledge of the mechanisms behind orientation and navigation of marine animals, including migratory patterns. Recovered data give researchers a better understanding of distribution and behaviour patterns of species/stocks, and provide data on accessibility and availability to surveys. The tags may supply important key information to migration and assessment models. Furthermore, the link between environment, distribution and migration



*GPS tag implanted into the body cavity of a cod. The tag is implanted with a tube extending to the exterior of the tagged fish to indicate that the fish is carrying a tag.*

***“The tag receives GPS positions transmitted by a vessel’s sonar or by a transmitter on a fixed or drifting buoy.”***

supplied by the tags may play an important role in the development of ecological basis modeling and management approaches.

The system has also been used in Iceland, where 180 cod were tagged in April 2004. When the MRI carries out its annual surveys on research vessels, they transmit GPS positions to the GPS tags.

The GPS tag has also been used on brown trout in Lake Thingvellir in Iceland by Salmon & Trout Research. Star-Oddi offers a small transmitter for use in lakes or oceans, which can be used on smaller boats or in a fixed position, for example on buoys.

### **Conclusions**

The introduction of the GPS tag constitutes a milestone in the field of fish ecology and fisheries science. The GPS tag has the potential to increase our knowledge in fish ecology, thereby, paving the way for improvements in stock assessments and fisheries management.

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