Using Underwater Acoustics to Conserve Wild Fisheries and Aquaculture

Words by Ryan Mowat, Director of Fisheries & Research, RS Aqua
As detailed in ECO’s recent Special Issue on Ocean Sound, the measurement of active and passive acoustics in the marine environment is one of the fastest growing areas of marine science. Recent innovations in acoustic telemetry have revolutionized the work we do at RS Aqua with the fisheries and aquaculture sectors, both for conservation and environmental monitoring solutions.

Six years ago, RS Aqua began an exclusive relationship with underwater acoustic telemetry experts Innovasea (formerly Vemco) based in Nova Scotia. Innovasea provides complete turnkey aquaculture solutions and has revolutionized the tracking of wild fish populations with their development of a unique fish tracking system. This system originally was based around small acoustic transmitters that could be attached to or surgically inserted into individual fish, and whose ‘pings’ were recorded and logged if heard by an Innovasea listening receiver. While the first transmitters were only suitable for tagging adult fish and pinged out a limited set of unique ID codes, Innovasea’s committed R&D investment over time led to much smaller tags transmitting internationally recognized unique IDs, and tags transmitting environmental parameters, such as temperature and depth. In recent years, this has allowed researchers to tag large samples of endangered fish populations and learn, for the first time, the ancient migration routes they use, and where major mortality events are occurring on that route.

Tracking Endangered Species

For the iconic Atlantic Salmon, Innovasea’s commitment to providing smaller, safer and more advanced tags has been ground-breaking for our ability to monitor and conserve this endangered species. At RS Aqua, we have watched with fascination as the Innovasea equipment we have specified and supplied has tracked migrating Atlantic Salmon through their home river systems in the UK and Ireland and out into their coastal and offshore migratory routes. Each year the developing technology has taught us a little more, and researchers now have a much clearer idea of where the young salmon are at risk from predation and human impacts in the river system, and the coastal routes they take to their northern Arctic feeding grounds as they leave their rivers. Until now, that knowledge simply did not exist, and it is fundamental to us being able to mitigate anthropogenic threats, such as constructed barriers on river systems, and offshore renewable energy sites. The Atlantic Salmon Trust's Missing Salmon Project – on which RS Aqua is a Technical Partner – recently deployed the UK’s largest Innovasea receiver array for this very reason.

The Missing Salmon Project was set up in 2018 to address the alarming statistic that for every 100 Atlantic Salmon that leave UK rivers for the sea, less than five return. This is a decline of nearly 70% in just 25 years. By tracking their progress with acoustic fish tags, the Missing Salmon Project hopes to uncover salmon migration routes from river to sea to help prevent further decline. The Project has deployed over 260 Innovasea
receivers in the Moray Firth and seven river systems which feed into it. The data from these receivers will not only track the progress of the salmon, but also provide an insight into where major mortality events are occurring and what those threats are. For example, natural predation from birds and seals will play a part, but so too will human activity in the form of construction, shipping and offshore energy. The lessons learned in the Moray Firth will provide valuable insights that are transferable to other salmon populations around the UK.

**Measuring Predation**

As numerous studies demonstrate, one of the threats faced by migratory fish species is predation. This threat can be increased due to human activity, for example at pinch points caused by river infrastructure. To help accurately measure predation, Innovasea recently developed one of their most exciting tags: the ‘Digestion’ transmitter. This acoustic tag is the first in the world to actively change its transmission sequence when it ends up in the stomach acid of another fish or mammal. This means that, for the first time, scientists have an actual real measurement of predation, whereas previously we relied on proxy evidence, such as sudden changes in the depth and temperature of the tagged fish. Incredibly, these Digestion tags can be as small as 12.7 millimeters long.

**Fish Tracking in Marine Conservation Zones**

In order to record relevant fish movement information, Innovasea receivers are generally positioned autonomously in locations from which they are later recovered, and their detection data offloaded via Bluetooth. At RS Aqua we have developed the Acoustic Release Canister (ARC) system that works with Innovasea acoustic release receivers and allows researchers to recover their fish tracking equipment and seabed anchors without the need for a surface buoy. This is particularly important in Marine Conservation Zones (MCZs) where no equipment should be left behind, as outlined in EU and UK regulatory guidelines. Since the ARC can carry other sensors in addition to its fish tracking receiver, it has markedly increased our ability to do science in MCZs. In the case of the Missing Salmon Project, RS Aqua developed a larger, deep-water ARC (the BARC – Big ARC!) to allow deployments at over 200 meters depth. The BARC is now in production and being used on other projects throughout the UK and Ireland.

**Fish Tracking Online**

Innovasea receivers can also be cabled to the surface, which allows information about fish detections to be relayed to the Internet in real time using WiFi or the cellular network. This is important when a scientist needs to be immediately alerted to the return of a specific fish to a river system – for example, when an adult salmonid returns carrying sensors which have been recording environmental data throughout its winter migration. The first two of these systems in the UK have very recently been deployed in the Frome and Tamar rivers in the South West of England, and within days of installation a returning sea trout was successfully detected on the Frome.

**From Wild Fish to Aquaculture**

Because these fish tags can transmit environmental conditions such as temperature and pressure over this real-time system, Innovasea soon realized that the live, wireless monitoring of sites of environmental importance was now possible. In their innovative fashion, this led to a new start-up company within Innovasea. Its remit is to develop sensors which can transmit environmental data valuable to aquaculture production – e.g. temperature, dissolved oxygen, harmful algae – wirelessly through the water to a central receiver which makes that information available online to the site manager in real time.

The result of this development is the groundbreaking Innovasea real-time monitoring system, formed of three main technologies: 1) the aquaMeasure wireless subsea sensors; 2) the central aquaHub surface telemetry box which receives and sends sensor data online; and 3) the aquaCurrent cloud software which logs and displays the sensor data online in real time.

While Innovasea’s fish tracking technology changed how scientists monitor wild fish populations, their realtime monitoring system is aimed at revolutionizing how aquaculture producers monitor farmed fish environments. On these farms, it is fundamental that managers know as soon as possible if environmental changes are occurring in fish pens that might be harmful to the fish population. Examples are the recent Harmful Algal Blooms (HABs) that have affected some salmon farms in Scotland and Norway this spring. HABs occur for various reasons – increased water temperatures are often cited as a possible cause – and are formed of concentrated ‘blooms’ of phytoplankton algae, some of which can be harmful to larger animal species. A recent mortality event in Norway was caused by HAB algae damaging the gills of farmed salmon,
meaning the fish were unable to extract oxygen from the sea-
water around them. There is a concern that events like this
may occur more regularly as ocean temperatures rise with cli-
mate change, and innovative monitoring systems are required
to identify and mitigate them. This event in Norway is officially
thought to have cost Norwegian aquaculture at least $82 mil-
lion, with some stakeholders putting the cost far higher.

With the Innovasea realtime monitoring system, site managers
can monitor environmental changes on aquaculture farms as
they occur, but they can also receive automated alerts over
email as soon as conditions move outside safe limits. This
gives managers a much better chance of mitigating the risks
posed by environmental changes. With the wide range of pa-
rameters the aquaMeasures can monitor – e.g. temperature,
dissolved oxygen, salinity, turbidity, chlorophyll, blue-green al-
gae, dissolved organic matter, depth, tilt, pH – and because
multiple aquaMeasures can be deployed wirelessly across
sites one kilometer in diameter, detailed environmental aqua-
culture monitoring is now possible on a scale and resolution
previously unheard of.

Importantly, aquaCurrent not only provides data in real time,
but it also logs all historical site data so that it is available
at the touch of an online button. This means managers can
quickly view time series plots of conditions at a farm loca-
tion running back over weeks, months or even years, allowing
them to pinpoint any past events that have a bearing on cur-
rent environmental or animal health conditions. These data
and plots are available on the aquaCurrent smartphone app,
and so can be viewed anywhere with a mobile internet con-
nection. Historical data logs can also be offloaded in CSV for-
mat, ready to be analyzed with other software if required. All
of this is made possible by the first-of-its-kind wireless moni-
toring system using underwater acoustics.

At RS Aqua, we have been closely involved with the rollout
of Innovasea wild fish tracking technology into the UK and
Ireland over many years, and we hope to be similarly involved
with the introduction of the aquaculture realtime monitoring
system to these islands. Conserving our wild fish stocks while
sustainably growing our aquaculture industry is absolutely
necessary in a world of increasingly limited food resources,
and we’re proud to be working alongside fisheries scientists,
aquaculture producers, and of course Innovasea, to help
make this happen.