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# OlracRTI

## A Novel Spatiotemporal, Ecosystem-based, Fisheries Management System

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## The Problem

Until the early years of the 20th century, the ocean has been thought of as an infinite resource. However, as fishing efforts around the world continued to surge, mainly after World War II, spurred by rising populations and the need for both employment and food security, significant reductions in marine biodiversity and productivity have taken place. This has demonstrated that the ocean is, in fact, a finite resource and as such needs to be managed carefully.

Large-scale commercial fishing is a major driver of change in marine habitats, modifying its structure and function. Unsustainable fishing practices have a proven negative effect on a population's size, structure, distribution, and abundance within the surrounding environment. Other impacts attributed to unsustainable fishing activities include reduced species diversity, increased variability in catch abundance, and increased by-catch.

We expect that, without introducing some fundamental changes to global approaches to fisheries management, the combination of anthropogenic pressure, consumer-based needs, and technological advancements in securing marine resources will continue to significantly impact fishery resources worldwide.

## What is Needed

Traditional fisheries management has predominantly focused on sustaining or improving fish populations, assuming single-species stocks in isolation from their habitat. However, more recently holistic management has replaced traditional approaches and efforts have been refocused to include the ecosystem as a whole. The biological and economic sustainability of our marine resources can no longer be handled in isolation from the surrounding marine ecosystem. In order to ensure the long-term sustainability of our marine resources, it has become imperative for management to take on a wide-ranging and holistic approach, incorporating all activities and their relative impact on the various assessments and strategies in place.

In response to this need, the development of marine spatial planning management techniques has become increasingly important as a means of facilitating the implementation of ecosystem-based fisheries management.

However, marine spatial planning as a part of fishing resource management is still a relatively new concept and, due to its comprehensive and all-inclusive nature, can be a complex regime that relies significantly on the cooperation of all involved parties. This is an inherently difficult "status" to achieve.

## Introducing RTI

The real-time incentives (RTI) solution is a complete and novel fisheries management approach that aims to avoid unsustainable fishing mortality, minimize ecosystems damage, improve economic efficiency, and empower fishers through technology and data-collection, via a single platform.

This solution applies a holistic approach to fisheries management, which is both responsive and evidence-based, addressing issues prevalent in current management strategies, and preparing us for the new challenges of ecosystem-based fisheries management (EBFM).

The RTI management approach makes use of spatiotemporally explicit management schemes to incentivize skippers to fish in a way that achieves a range of fisheries and ecosystem objectives. At the core of this approach are credit-point allocations and spatiotemporally varying tariffs that reflect the various impacts of fishing on commercial stocks and ecosystems (Figure 1).

Under RTI, management areas will be divided into "grid cells" at a high spatial resolution. Each grid cell will be evaluated in terms of its fishing impact and assigned a "tariff." Areas where the impact on commercial stocks

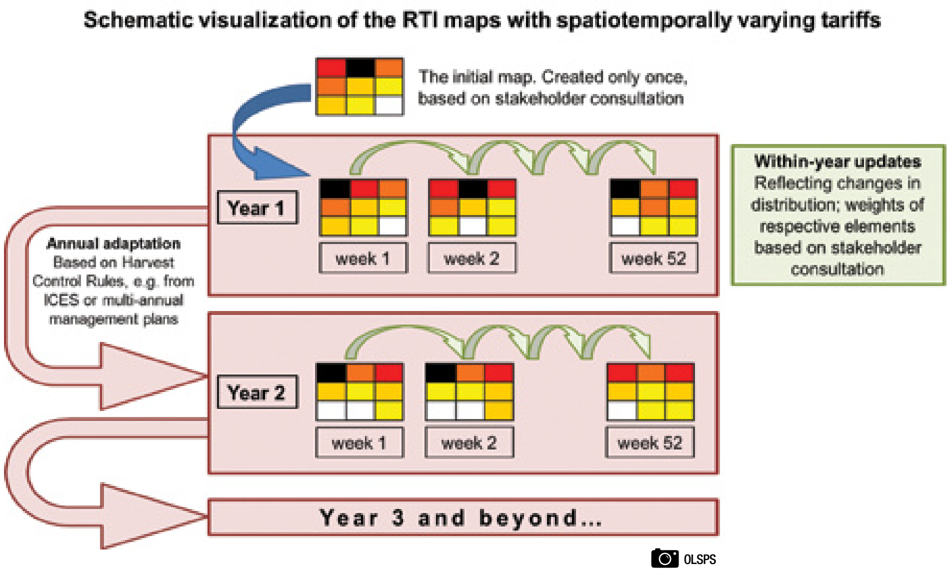



Figure 1: Schematic visualization of the RTI maps with spatiotemporally varying tariffs.

or the ecosystem is deemed high will have higher tariffs than areas where the impact is deemed low. Furthermore, to constrain fishing mortality on a particular species, higher tariffs will be placed in areas where catch per unit effort (CPUE) is higher. It is intended that the annual adaptation and the "real time" updating of these tariff maps will be largely automated. The system therefore allows skippers to independently manage their RTI credits.

In their simplest form, tariff-updates are based on an annual harvest control rule (HCR) and within-year updates informed by recent CPUE data. Fishing opportunities are usually established on an annual time scale, informed by annual stock assessments. As such, it seems reasonable to base the RTI tariffs on an annual HCR, which will determine the overall tariff levels of a management area. Within-year, potentially at time scales as short as weekly, the tariffs of individual cells may change relative to each other based on "real-time" or seasonal data reflecting the actual spatial distribution of the resources and other elements that may be included in the management objectives (e.g., seafloor integrity).

The algorithms used in the RTI approach will be generic so that, on a case by case basis, options can be switched on and off; the species and ecosystem elements included in the tariff-setting can be selected; and the spatial and temporal scales of the system can be specified.

## The Advantages of RTI

We have identified five core advantages of the RTI approach, both in terms of its practical implementation and the tangible impact it is likely to have on sustainable ocean resource management. We have summarized each of these advantages below.

***Bottom-up Inclusion:*** While most management styles tend to focus on a top-down approach, the RTI solution centres on the inclusion of bottom-up management practices, encouraging stakeholder participation from the fishing industry, compliance and enforcement agencies as well as non-governmental organizations. This partnership will not only enhance fishers' support for the system but will also increase their sense of responsibility and empowerment, encouraging compliance and meaningful engagement.

The development of RTI for implementation is based on a stakeholder driven management approach, which includes specifying the objectives and operational details of the system. One of the main factors leading to implementation errors of fisheries management policies is low stakeholder support for top-down regulations. Compliance/acceptability of a management option may also be influenced by social factors such as imitation effects or peer judgement. Fishers are more likely to comply with/accept regulations they perceive as easy to apply and are beneficial. To date, despite the establishment of stakeholder-led advisory councils, the scarce involvement of fishers in the overall policy making process has provided minimal incentive for the sector to act responsibly and be accountable for the sustainable use of a public resource.

Historically, fisheries managers have not prioritized socioeconomic sustainability. Although not identifying specific economic and social objectives, the European Union's Common Fisheries Policy (CFP) specifies that management measures should "contribute to a fair standard of living for those who depend on fishing activities, bearing in mind coastal fisheries and socioeconomic aspects."

However, within the RTI approach, stakeholders will be extensively engaged at the project level. This engagement, combined with conventional socioeconomic data analyses (e.g., projections of the economic performance, cost-benefit analysis, economic incentives), will enable investigations into the socioeconomic consequences of various scenarios of introducing the RTI system. These will then be fed back into the engagement process, leading to the formulation of case-specific socioeconomic objectives of the RTI system.

A key difficulty identified by fishers is the introduction of new fishing technology regulations; in particular, gear-based technical conservation measures. Within the RTI system, development and inclusion of innovative fishing technologies and behaviour is facilitated and incentivized. Fishers can propose and trial gears and/or methods that help achieve the stated fisheries management or ecosystem objectives. Fishers who wish to deploy "smart" technologies will access benefits (e.g., a reduced tariff regime) once they can demonstrate effective implementation. Furthermore, the need to demonstrate what gears are used (i.e., reversing the burden of proof) would increase remote-monitoring and accuracy of fisheries data, while improving gear compliance and credibility. Together, the system empowers fishers to use technological improvements to their economic advantage while simultaneously undertaking activities in a responsible and sustainable manner.

***Internalizing Costs:*** The RTI system leads to the internalization of costs – costs to the commercial stocks, in terms of overfishing, as well as ecosystem costs as fishers would have to take them into account in their business decisions, i.e., where, when, and how to fish. There would be no need for traditional landings/catch quotas or effort limitations for the fleets while operating under the scheme. Monitoring, principally via the vessel monitoring system (VMS), coupled with results-based adaptive management should ensure that specified targets and objectives are achieved. Adaptive management would act to increase or decrease tariffs according to the stock status (e.g., desired fishing mortality rate, F) or other ecosystem objectives (e.g., by-catch of protected species), with rapid responses made possible by the real-time nature of the system. The amount of RTI credits made available annually could be set in relation to agreed objectives or target fishing mortality rates of the stock(s) of interest. Different métiers, gear, or mesh-size groups could each have their own set of tariff maps, based on differential impacts on target and by-catch stocks and other ecosystem components.

***Addressing the Mixed-Fishery Problem:*** A key advantage of the RTI system is that it addresses the mixed-fishery problem. Classically this occurs when the fishing effort needed to catch the agreed quantity for one species, termed the "choke" species, is considerably smaller than that required for other species caught in the same fishery. If fishing is controlled by total allowable catch (TAC) and implemented as landings quotas, choking will be avoided through continued fishing until all valuable quotas are exhausted and over-quota catches will be discarded leading to over-exploitation of the respective species. Under the Landing Obligation, TACs imply that fishing should stop when the first TAC is exhausted, thus constraining ("choking") the fishery for other species whose TACs are not exhausted. RTI management, even if only applied to the choke species, should alleviate this problem as it restricts effort only in areas where the choke species is abundant while allowing fishers to deploy high effort levels to target other species in areas where the choke species is rare. Multiple species and ecosystem objectives can be included in the tariff setting making it possible to design tariff maps to protect both exploited species and ecosystem components that managers wish to protect.

***Ecosystem-based Fisheries Management Solution:*** The RTI approach will be the first fisheries management system that specifically addresses EBFM in an integrated way, such that one management measure – RTI credit points to be spent according to spatiotemporal tariffs – regulates fishing activity with respect to multiple objectives. The two major pressures through which fishing impacts the ecosystem are catch mortality of both target and non-target species and physical damage to seafloor habitats and their associated benthic invertebrate communities. Thus far, the RTI concept has focused on the former; the possibility of incorporating habitat integrity as an objective directly into the RTI system has not yet been fully explored. Rather than the rigid, all-or-nothing approach of closed areas, RTI offers a flexible middle ground, allowing it to be more or less "expensive" to fish in certain areas. Building on methodology developed in earlier projects (BENTHIS), we will be able to develop a framework that quantifies the impact of fishing on the seafloor habitat and will subsequently develop an approach aimed at reducing the impact on vulnerable parts of the seafloor by including these parameters in the RTI tariff setting.

***Deployment Technology:*** The RTI approach is a technological solution, providing a system that enables rapid reporting, facilitates remote monitoring, and supports higher fleet coverage. The reporting system allows the recording, transmission, and collation of fisheries and ecosystem data in "real time," facilitating the flagging of non-compliance remotely. This, coupled with the development of relevant built-in compliance incentives, supports both the aims and objectives of the current CFP as well as the monitoring requirements of the Marine Strategy Framework Directive (MSFD) by including explicit MSFD targets, while providing options for the adoption of alternative, holistic management in future policy reviews.

**Operation and Implementation**

OLSPS, a company involved in the development of fisheries software solutions, is currently developing the RTI technology needed for basic operation and implementation. This includes the development of software technology for both at-sea and onshore operations.

The technology being used to develop the RTI approach is based on the Olrac Data Management system, an advanced electronic logbook and reporting technology that includes aspects of data management, compliance, and analysis, specifically designed for the global commercial fishing fleet. This system is comprised of two main components that cater for the entire flow of data, from at-sea data collection to the generation and dissemination of reports. These components are the Olrac Dynamic Data Logger (OlracDDL™) and the Olrac Dynamic Data Manager (OlracDDM™).

OlracDDL is a highly customizable vessel-based electronic logbook system. The core

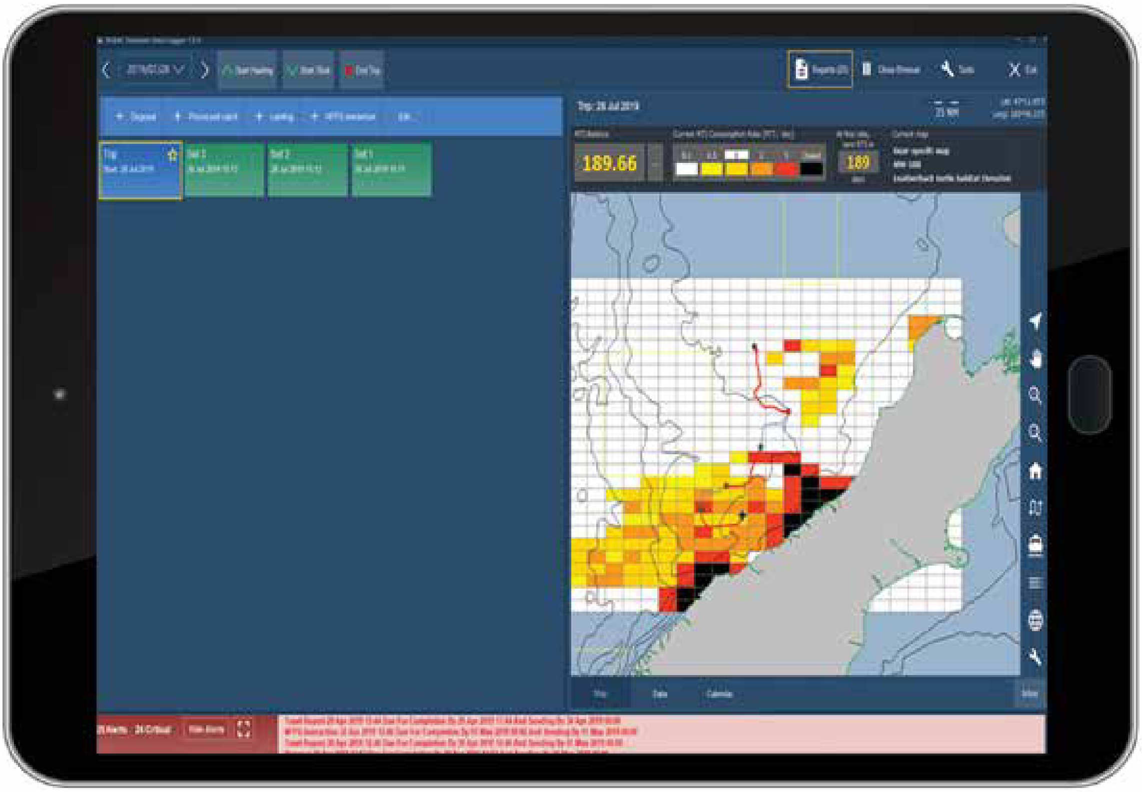



Figure 2: OlracRTI vessel-based dashboard.

OLSPS

component of this unit is a GIS system where vessel movements are continuously tracked, with their associated activities and observations spatially presented in the form of maps and tables. Data types collected by the eLog system include relevant fisheries, biological, environmental, and human resources data. Once the required data has been collected, it is transmitted, in real time, via Wi-Fi, cellular, or satellite networks to the designated recipients, be it port authorities, compliance agencies, or management officials.

To better manage an entire fleet of fishing vessels, OlracDDM, a web-based application, can house numerous fishery records from an entire national fishing fleet if necessary, as well as manage, store, analyze, and distribute submitted reports (e.g., port departure and entries, catch, vessel movement, sales, and transhipment of fish) on behalf on the skipper. This unit also empowers and informs fishers of their operations by allowing them to view real-time catch reports from several vessels; view, analyze, and summarize all vessel activity data; and view vessel and catch locations via a map interface. In order to prevent any errors or inconsistencies from occurring in submitted reports, an extensive validation, auditing, and crosschecking of data is done.

The OlracRTI unit is fully integrated within the Olrac Data Management system, comprising two components:

**OlracRTI Onboard Unit:** The OlracRTI vessel-based unit tracks and monitors a vessel's location in relation to predefined parameters, such as the RTI grid cells it occupies and its usage of RTI points in real time, for the ongoing calculations of RTI tariffs and their associated tariff maps (Figure 2).

Once calculated and distributed, skippers will be able to view their real-time RTI points balance and make an informed decision on how to direct their fishing operations based

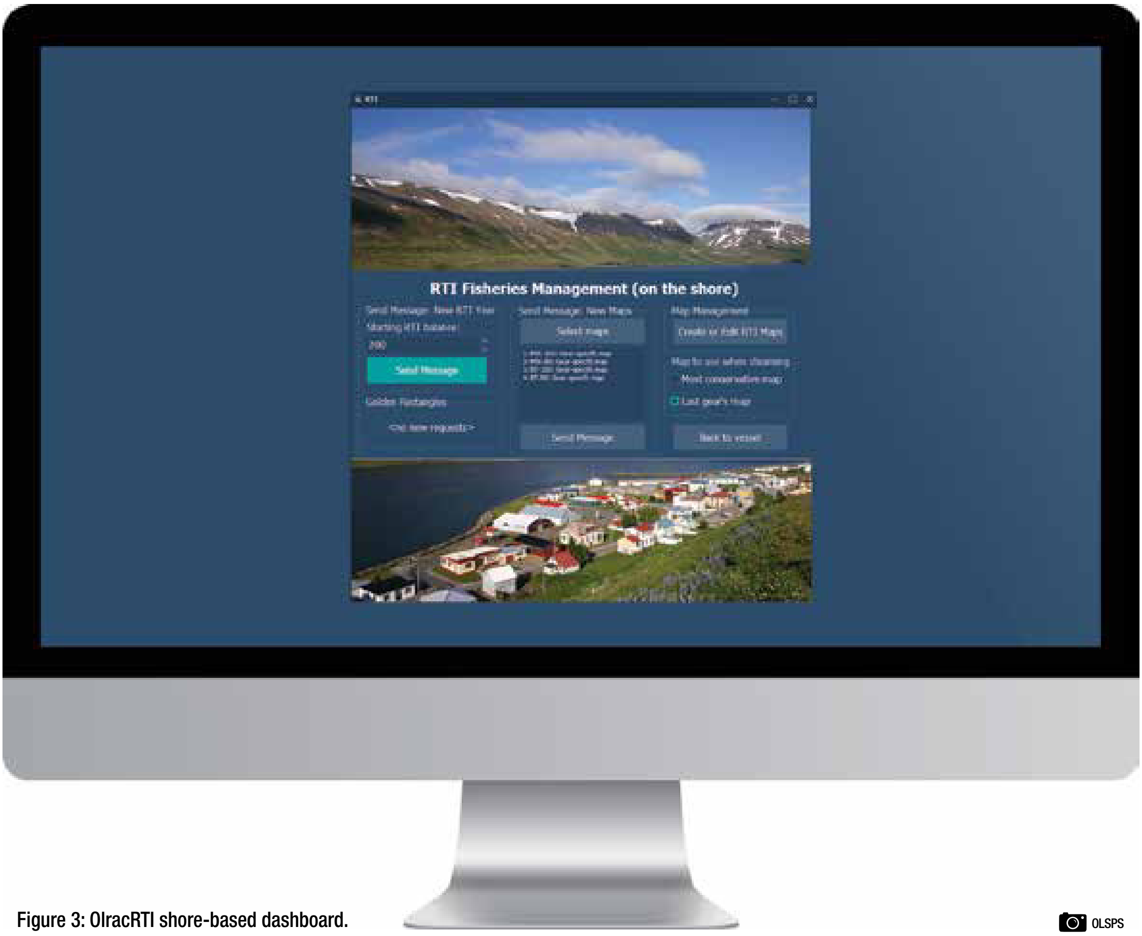



Figure 3: OlracRTI shore-based dashboard.

OLSPS

on the desired RTI points consumption rates (rates associated with the sensitivity of the RTI grid cell in which the vessel is located) they are charged. Furthermore, skippers will be able to integrate electronic tracking, monitoring, and reporting technology for all vessel activities into the software. These electronic monitoring units will serve as both data collectors, in the form of high-resolution videos or images, and as a reports verification system for compliance monitoring, either via random checks or in response to specific flagged activities.

Data collected by the OlracRTI onboard unit and images collected by linked electronic monitoring units can be transmitted to the OlracRTI shore unit where it will be stored and utilized for fleet level analysis and data management, including tariff calculation, data validation, and scientific evaluation.

**OlracRTI Shore-Based Unit:** The OlracRTI web server will use catch, effort, and additional vessel data (e.g., optional ecosystem or weather information) as well as other relevant scientific information (e.g., seafloor habitat indicators, survey indices) to generate tariff maps based on the chosen settings and algorithms developed and selected by the relevant fisheries managers, researchers, authorities, and stakeholders (Figure 3). Once calculated, tariff maps will be automatically distributed to the vessel-based units via various cellular or satellite networks.

After sending the RTI-budgets and tariff maps to the vessel unit, the shore unit will automatically track the spending of RTI credit points for each vessel, calculated based on vessel location and time spent in the grid cells of varying tariffs. Underlying maps of elements that contribute to the combined tariff (e.g., individual species, habitats) will also be made available. Thereafter, the RTI balance will be independently calculated to ensure that the vessel's reported location coincides directly with records submitted to local fishing authorities. In a typical environment, the vessel's location is reported by the onboard GPS. However, if the RTI system is unable to access near-real time, accurate VMS data, the OlracRTI shore unit may act as a full auditor of the vessel's reported location and as a result indicate its RTI point usage.

The RTI approach facilitates the distribution and use of both local and scientific ecological knowledge generated by fishers and managers alike in the management of the resource, through the incorporation of innovative technologies, seamless management of "big data," and the development of intuitive user interfaces.

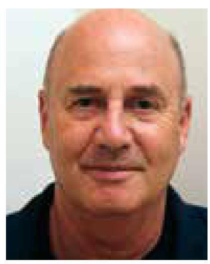
**Conclusion**

Similar spatial approaches to the RTI approach have previously been proposed and explored but they do not display the spatiotemporal dynamics enforced in this solution. The RTI approach surpasses these by explicitly, practically, and dynamically integrating commercial-species targets and ecosystem objectives into fishery management, using one single credit currency. Furthermore, real-time, spatiotemporal approaches are particularly amenable to bottom-up approaches such as co-management or self-governance. In most of these (often industry-led) initiatives, real-time catch and discard information is shared among fishers to incentivize, enable, and encourage vessels to leave areas of high by-catch. Nevertheless, in each case the approach is superimposed on top of the existing management system (often TAC).

The RTI approach and its deployment platform, however, are a unique and novel management system that incorporates, improves, and simplifies previous management efforts. While the basic RTI framework has been previously delineated, many of the choices made in setting up the system will be decided in partnership with stakeholders. These include, but are not limited to, the spatiotemporal scale of the operation, the design of the tariff maps, the necessary objectives, and the fishery and ecosystem trade-offs.

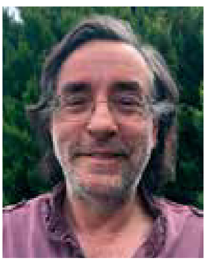
The RTI concept and deployment technology can be used for any type of fishery and can easily be adapted to any level of development and data availability. While the RTI approach may be more attractive or easily implemented in areas where fisheries management is less developed, and it does not face the challenge of replacing a working system, we believe that through successful demonstration and implementation the RTI approach will be adopted by managers and regulatory bodies where fisheries regulation already exists.

Ultimately, we envision the RTI approach being used to facilitate better marine ecosystem management in Europe; thereafter, throughout the world's ocean. By significantly modernizing and simplifying fisheries data management systems and processes, the RTI approach has the potential to make a dramatic and positive impact on the blue economy.



Dr. Amos Barkai graduated in 1981 with a B.Sc. from Tel Aviv University. He obtained his PhD in marine biology at the University of Cape Town in 1987, focusing on the population dynamics and predator-prey interactions in benthic populations. His PhD work, which was published in *Science Magazine*, has been aired by the BBC, and is a regular feature in marine ecology textbooks. Dr. Barkai founded OLSPS in 1989 with Dr. Mike Bergh to provide support to the South African and international fishing industry. OLSPS specializes in the development and implementation of sophisticated quantitative and predictive analytic software tools in fisheries management and other commercial sectors. In 2012, OLSPS was awarded two prestigious IBM awards for its successful establishment of several complex and analytical software solutions. OLSPS developed the OLRAC eLog software, an advanced system for the electronic collection, transmission, and tracing of commercial fishing data, now installed on hundreds of fishing vessels and used by many fisheries around the world.

Dr. Sarah B. M. Kraak trained in general, marine, evolutionary, and behavioural biology. She acquired her PhD degree in 1994 followed by two periods of postdoctoral research (1995-1998 in Switzerland and 1998-2002 in the UK). Since 2002, Dr. Kraak has worked as a fisheries scientist, initially in the Netherlands; from 2008 to 2015 in Ireland; and currently in Germany at the Thuenen Institute of Baltic Sea Fisheries in Rostock. Her areas of expertise include mixed fisheries, management strategy evaluation, spatial management, fisheries-induced evolutionary change, and behavioural economics in the context of compliance to fisheries management regulations. She is a member of the Scientific, Technical and Economic Committee for Fisheries and is on the editorial board of the ICES *Journal of Marine Science*. She has participated in numerous research projects and has an extensive publication record, currently with an h-index of 25. Together with Professor David Reid, she is the originator of the RTI approach. She is currently developing RTI approaches for the Baltic Sea.



Dr. David Reid has been working in fisheries science for 25 years, initially at what is now Marine Scotland Science and since 2009 at the Marine Institute in Ireland. His experience ranges from the development of fisheries surveys, fishing gear technology, and all aspects of the ecosystem approach to fisheries management (EAFM). He has a strong interest in engaging industry stakeholders in the EAFM and has worked closely with them on how to realize an EAFM in an environment of inflexible single species management. Together with Dr. Sarah Kraak, he is the originator of the RTI approach. Dr. Reid has been coordinator or work package leader in a wide range of international collaborative research projects, and has over 100 peer reviewed publications. He is heavily involved in the leadership of the International Council for Exploration of the Seas where he is currently chair of the Steering Group on Integrated Ecosystem Assessment. Since 2010 he has been an adjunct professor at University College Cork, Ireland.