Advanced Catch Systems for increased efficiency and financial gain

2011/2012 v.1

ScanTrack – Full control at a glance!

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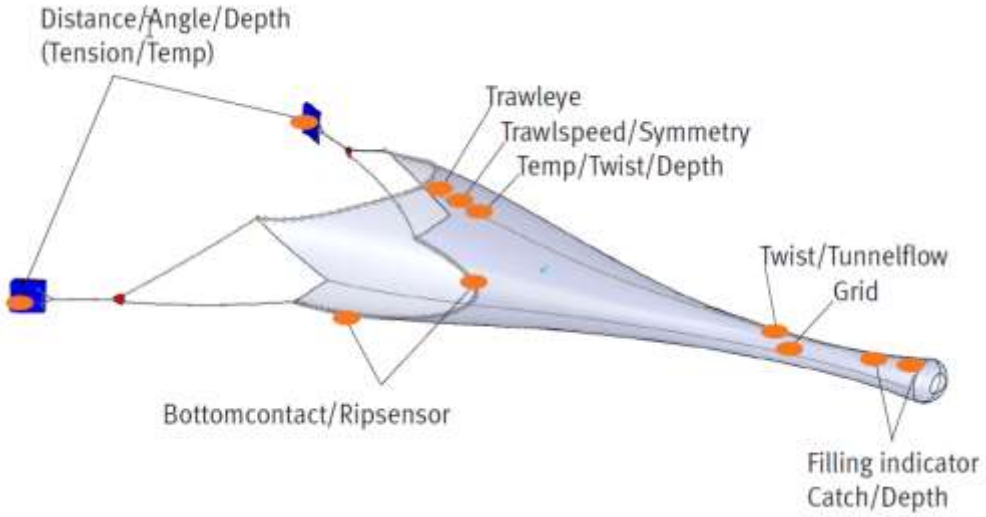
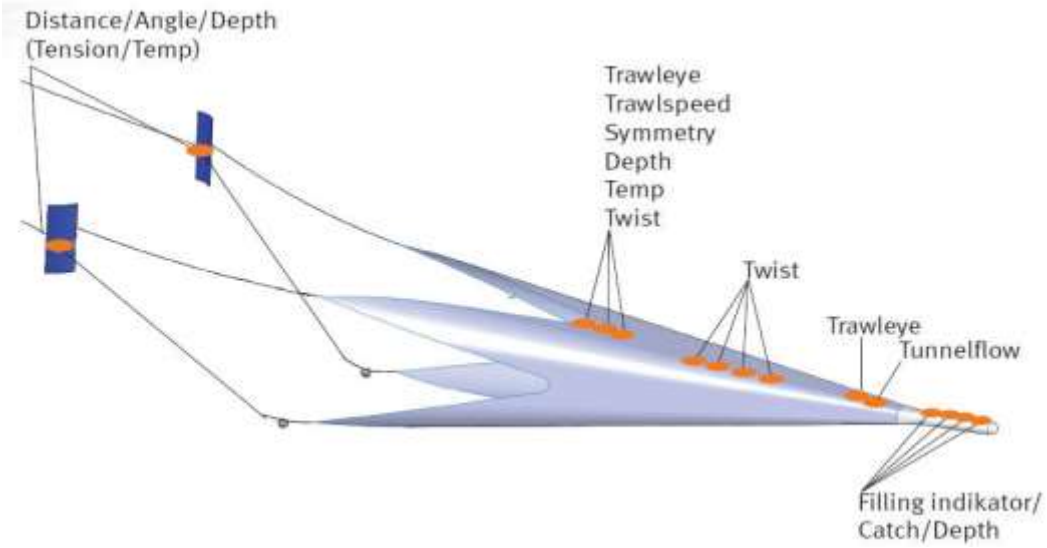
Bottom trawl



Pelagic trawl



Complete system for large trawler

Bridge system

- ScanScreen consisting of SRU and display:
- 3 x SRU (Receiver Units) + color monitors for bridge
- 1 x SRU + color monitor for winch station
- ScanTrack

Sensors

- 2 x Trawl Eye
- 2 x Door sensors SS4 Angle/Depth/Distance
- 2 x Height sensors for doors
- 1 x sensor for clump
- 1 x Height sensor for clump
- 2 x Trawl Speed/Symmetry sensors
- 2 x Tunnelflow sensors
- 2 x Trawl sensors SS4, Twist (Angle/Depth) sensors
- 4 x Trawl sensors SS4, Twist (Angle) sensors
- 6-8 x Catch/Filling sensors for bag

Chargers

- 2 x chargers for Trawl Eye
- QBC-X1 chargers

Hydrophones

- 4 x Hydrophones
- 2 x “Dummy hydrophones” for future steering of trawl/trawl doors

1 General

1.1 *Perspective – the need for innovation*

Since the mid-1980s there has been a major reduction of the fishing fleet worldwide. As a result of overcapacity in the fleet the construction of new, modern and resource-friendly vessels has occurred to a much lesser extent than is desirable. Instead, the need for new vessels in many places has been covered by 15-20 year old vessels purchased from other countries.

In each case and as a short-term policy it may be justified, but in a longer perspective it causes great damage. It has clearly affected the shipbuilding industry, which has lost a lot of expertise in the development and construction of modern fishing vessels. The equipment industry has been at a standstill. Compared with other industries, equipment vendors have not seen market conditions that justify the necessary investments in research and development that would result in products on par with what is possible.

Compared with 20-25 years ago we see that there are only a few manufacturers of advanced products for the fishing fleet. And worse than that, looking at these manufacturers' product catalogues we see that the focus is on smaller equipment for coastal vessels and recreational boats, which is understandable as the market for advanced equipment is too small to justify development of new technology.

Still, most disturbing is the lack of younger workers in the fishing fleet. We hear many people say that with better profitability in the fishery the fleet will attract young people. Imagine if it were that easy. We can't just throw overboard those who have struggled throughout their lives to keep it going despite the bad economy. Also, it's not so sure it's only money that is attractive for the generation of young fishermen. They have grown up with all sorts of data technology and seek quite different challenges in the workplace, at least if you want the best that can contribute to the development of the fishing industry and not just a conservation of the current state.

In the total picture it's easy to see that the future lies in modern, resource-friendly vessels, advanced equipment and qualified crew. To modernize the catch technique, you must have the most up-to-date technology and you have to have young people who understand and can use

modern technology, who see it as a challenge and can be a driving force for further development.

It is sad that authorities in most countries show so little interest in the fishing industry, and do not facilitate a sustainable livelihood. A bit of a boost is needed to recover the stagnation that has developed through many years.

The new Norwegian industry trawler Gollenes is equipped with Scanmar's advanced Catch system ScanBas.

1.2 *History - 30 years filled with great challenges*

Recently, three interesting fishery trade shows have been held in Scotland, Iceland and Denmark. Considering the difficulties the fishing industry has been through, the visitor turnout was surprisingly good, but the number of exhibitors decreased and there was little new to see.

Looking at the number of suppliers to the fishing fleet, the number of exhibitors has declined continuously over many years. The product range, which previously was mainly aimed at the larger vessels, is now focused on smaller coastal vessels, fishing boats and recreational boats. This transition has led to fewer international companies visiting the fairs.

Scanmar has recently launched a series of technological innovations and various sensors with extremely long working time and added value many say they could only have dreamed about. Moreover, Scanmar has been awarded several patents that will become important parts of new products, and therefore an important part of the lives of fishermen. It was therefore not surprising that several of those who visited us were wondering how we so often could come up with new technology and new products. These are questions we get often so we decided we might as well write an article.

New SS4 Net Sensor

Scanmar was established in 1980, at a time when there were major problems in the entire electronics industry, particularly in the fisheries. As in all other industries, it was the case that most vendors copied each other and there was a wide range of echo sounders and sonars from numerous suppliers but little innovation.

New SS4 Door Sensor

The founders of Scanmar were therefore keen to find a product range that distanced itself from other suppliers and since catching fish is the primary goal in fisheries it was natural to start there.

We studied many scientific research reports and, although the reports were of varying value, it was obvious that there was a great need to have better control of fishing gear to improve efficiency in fishery. To us it seemed strange that nobody had done anything about it earlier. It turned out that the reason for this was that no vendors, even the very

largest, had managed to develop a reliable wireless transmission technology. This is an absolute and indispensable prerequisite with respect to the great value of equipment and catch.

Even with all odds against us we chose to try. It was obvious from the start that there was a need to control the trawl's depth in relation to the location of pelagic fish, filling of the bag, and temperature of the water at the depth being fished. We developed robust technology for hydro-acoustic transmission of signals, and sensor electronics were completely encapsulated in a newly developed plastic material.

Scanmar's first Pinger

The products were a success and were soon in use in most of the world's fishing nations. When we were on board and studied many hauls with fishermen and scientists, we realized quickly that there was a need for much more information.

The first thing that became clear was that many experienced problems with the trawl doors. In a field report from a U.S. research institute in the early 1980's, we read that problems were encountered in 30% of the hauls. This was probably the crucial factor in the decision to develop Distance Sensors. The intention was to give the fishermen information about the distance between the trawl doors, if the doors had laid down (lost sensor contact) and not least to make it easier to rig after repairs or purchase of new equipment.

Door Distance sensor

Earlier you would receive information by making simple measurements on the warp, check the wear and tear on the trawl doors, etc. Despite this, there were not many who saw the need for distance measurements. But eventually "everyone" wanted them. We got a lot of feedback from the users saying that what they now experienced was entirely different than what they thought.

Grid sensor

The following year the Trawl Speed/Symmetry sensor was developed. With Distance Sensors on the trawl doors we quickly noticed how the changes in towing speed and underwater currents affected the door distance. And once different fish species' ability to swim in warm/cold water became thoroughly documented, it was obvious that it would be important to control the trawl speed and whether the trawl was skewed.

It took a while before this sensor became a success. But the Grid Sensor, a variant that was made to control the angle and water flow on shrimp grids, was an immediate

success. This was also the case with the Symmetry Sensor a little later, though now it is flow into the trawl opening and flow through the tunnel that counts.

The Trawl Eye was introduced at the end of the 1980's and was immediately indispensable to many.

Trawl Eye sensor

After a while other manufacturers came into the market. While we had built up extensive experience and had a good idea of the fishermen's future needs, the other manufacturers had none of these skills. Most went quickly out of business because they had to create simple solutions to get started as quickly as possible.

Scanmar's development in recent years has been extensive: new bridge solutions, angle measurements for doors, filling rate, twist and bucket effect, as well as several patents that will result in new products. You will find more information in this booklet and on our website, **www.scanmar.no**.

Henning Skjold-Larsen

1.3 *Patents*

Patents have two main functions in a modern society: the first and perhaps the most important is to give those who have invested much money in a product protection for a given period of time before any other manufacturers are able to copy and produce similar products without committing similar major investments.

The second purpose, which may not be as obvious, is because it takes a long time to develop products based on advanced, reliable technology. The development stretches over a long period, often 10-15 years, and many outsiders are involved in the development of some aspects. Since it must also be tried and tested under practical conditions others gain knowledge of the project's technology and are enabled to make improper use of the ideas.

When Scanmar was established in 1980, there were many who thought we should patent the first sensors and bridge systems. We considered it, but since it was not a developed market we wanted to welcome more manufacturers so more would participate in developing the market. This did not occur until many years later when some manufacturers copied the simple sensors.

The first thing we considered patenting was our hydro-acoustic telemetry link that forms the basis for a thoroughly reliable wireless system. The reason we did not do it was because the major market players within the fish finding industry in Japan, Europe and America said they had tried but not been able to succeed. Therefore they focused on the sonar, echo sounder, and cable-based systems. They would therefore be no threat to Scanmar.

We also considered patenting sensor technology in which the electronics are 100% protected because it is completely embedded in specially designed plastic. We chose this solution because protecting the electronics, rather than having them in a steel cylinder, creates robust sensors. This would therefore reduce the need for service and repair, thereby avoiding disruption to fishermen. When the large, established manufacturers were not interested, we expected that no others would focus on such advanced technology, but rather they would choose the easy and cheap solutions.

Many have therefore noted and asked us why in recent years we have changed policy and started to apply for patents for some of our new technological developments. The answer to that is simple and can be summarized in a few points.

- Scanmar is currently in possession of very advanced technology that is not only unique in terms of catch systems, but that is also very valuable in many other fields within the

Fisheries, Oil, Military, Deep Sea Research, and other industries. There is great interest in the technology Scanmar has developed in all these fields and we have found it appropriate to protect ourselves so that others are not able to easily use the technology we have spent millions to develop.

- In connection with the development of new products, Scanmar must have contact with research institutes and test tanks and undertake trials of active fisheries in many countries. Considering how long development takes we must protect ourselves against rogue actors.

- Most importantly though is that when a patent or a patent application is published we are able to know exactly what we are doing and what plans we have. This allows us to find the right partners to collaborate with and conduct testing of prototypes on research vessels and commercial fishing vessels without much risk that rogue competitors are trying to thwart our efforts. We have experienced it and ultimately it is the fishermen who suffer.

- To elaborate the last point further, we argue that the fishing industry (catching) as we know it is far behind other industries when it comes to technology and future potential. It is not the fishermen who are to blame for this, but there is a catastrophic need for renewal and efficiency of the fishing fleet (we're talking worldwide), not least in order to increase profits and recruit young people with knowledge of modern technology and a desire to increase the development of the industry. The fact that we, through patent protection, can inform our users of how we believe the development will be and what we are aiming at, gives fishermen some new thoughts and ideas. Furthermore, we get feedback that helps us in development, and perhaps the industry will again be attractive to the younger generation.

Scanmar has had some patents that we no longer maintain. The reason is simply that the development is fully completed and that all information should be made public. Currently, Scanmar has the following patents and patents applications for products and projects that are completed or under development (the proprietary solutions may have applications in most areas of underwater operations, but we confine ourselves to mentioning fisheries):

1. **Steerable trawl doors and clumps** (methods to change the roll and pitch angles) using hydro-acoustic transfer of control parameters so that the doors are 100% efficient no matter the conditions.
    - The patents include changes in the angles of attachment of the warp and the back straps and opening and closing hatches in the trawl doors so that it is easy to change the doors' angle of attack and roll and pitch angles.
    - Individual door manufacturers can make arrangements for use of patents so that they can use their own mechanical solutions.
    - The patents can be easily used for existing doors also if a mechanical solution can be obtained.

2. **Sensors that can be controlled remotely:**
    - There are many applications in fisheries: steerable trawl doors, selective fishing (several methods), etc.
    - Any other underwater activity

3. **Using temperature measurements to correct distance measurements via acoustic methods (e.g. echo sounder)**
    - Correction of echo sounder depth for varying temperature (speed of sound)
    - Accurate depth (important when fishing on slopes, in winter or summer, etc.)
    - Research (saves time)
    - Accurate Door Distance
    - Distance from the trawl to the vessel

4. **New technology for acoustic distance measurement:**
    - Measuring the distance from the trawl to the vessel
    - Positioning of the trawl in relation to vessels

5. **New technologies for sorting**
    - Sorting fish by using sorting grids, remote deployment technologies, acoustic sensors, cameras, and triggering mechanisms

6. **Trawl Geometry and catching efficiency solutions**
    - System to facilitate solution of problems of Trawl Geometry and catching efficiency that occur during trawling due to underwater currents, bottom conditions, etc.
    - The continuation of a system for automatic control of winches, propeller pitch and Door Angle.

As for the patents that only cover the Scanmar Catch Systems, these will be implemented as the products are finished. The others, which also include equipment manufacturers, will be completed along with various suppliers and users.

It goes without saying that in order to get the best solutions one must see the individual elements in context and adapt solutions to optimal performance for users.

1.4 *Closer contact with main users*

Scanmar has always had close contact with users, whether it has been researchers or commercial fishermen, in Norway or elsewhere around the world. It has been essential for several reasons.

As the first and only company that has been responsible for the development and expansion of Catch Monitoring, Scanmar has been completely dependent on getting feedback from the fishermen on the usefulness of the products we developed and produced.

However, since Scanmar products always represent something new on the market, it has not always been possible to ask the fishermen in advance what they need. It is not possible to comment on the usefulness of new technologies and new products before they have been tried in practice and experience is gained.

Scanmar has also faced the challenge that there are numerous species of fish to catch, vessels ranging in size from 10 to 150 meters, and large variations in fishing at different depths, shifting winds, currents and weather conditions. By participating in installation, training, and testing, and also by gathering feedback later, Scanmar not only learned a lot about what is needed to enhance fisheries, reduce fuel costs and save costs for repair and maintenance of equipment, we have also learned a lot of important needs that fishermen do not even know they have.

When we established Scanmar the first big question was whether we would achieve what none of the major echo sounder and sonar manufacturers had been able to do before us. Could we manage to develop a technology that would give us a reliable cable-free signal transmission? By thinking differently we thought we could do it, and we succeeded.

The next and most difficult question was whether we should try to create simple and affordable solutions to meet the simplest and most obvious needs such as bandwidth, depth, height, temperature and distance. Obviously this would minimize the risk and only involve a limited investment in development and production. The other option would be to take great risks and incur substantial costs by developing a technological platform that could form the basis for more advanced – and for the users even more important – sensors. We chose the latter.

Now, 30 years later, Scanmar equipment is found on thousands of boats. Fishermen are familiar with the robustness, reliability, and usefulness of the products we provide.

Scanmar has a proven technology, reliable production process, detailed knowledge of what the market needs by way of products, and specific

requirements for detailed information and the accuracy of individual measurements and registrations. None of this would have been possible without close contact with the fishermen who use the products.

The lessons and the knowledge we have accumulated over the years means not only that we have developed and manufactured products that meet users' requirements in terms of robustness, reliability, multi functionality, batteries with ultra-long life and extremely short charge times, etc. It also means that we have a good overview of the needs that are not covered, but still can be solved using technology that is already developed or that Scanmar can solve, in some cases together with tool manufacturers.

Another result of extensive development, testing and trials is that Scanmar today sits on a number of products that are of great importance to the fishermen and can be developed relatively easily. There are many products still to come.

It always takes time to spread knowledge and many people still do not recognize the observations Scanmar has made in recent years. These observations include using a trawl speed sensor (in the trawl opening and tunnel) and angle sensors (on the trawl and the bag) to reveal bucket effect, twisting, filling indicators, etc. We were actually surprised by how much these things mean for effective fishing, towing resistance and fuel consumption. And the fishermen who use it are no less surprised.

Proven products, knowledge of the fishermen's needs, and patented solutions in key technological areas place us and the fishermen in a completely new situation. Unlike before when it was necessary to guess what the fishermen's needs would be, we now have this knowledge and can join them to discuss specific solutions tailored to individual needs and then simply try them out in practice.

But we are aiming at something more. We have seen that there is often a major weakness in the performance of much of the fishing gear used today. This is due to the fact that much of the gear has been established on old traditions and was designed with little knowledge about the effect of water currents, towing speed and fish intake on the gear. We therefore want closer cooperation with individual companies so we can try new things, arrive at the correct solutions, offer affordable service plans and exchange programs, and do other things in the long term.

1.5 *Technology – more important than you think*

Since the breakthrough of information technology a few decades ago a big wave of information has flooded us and it is almost impossible to keep abreast of everything going on, which is clearly shown by the rise and fall of new companies.

In addition to the extraordinary emergence of new technology, good or bad, we see an accelerating rise of system-oriented solutions. Different products and technologies are connected together to provide users with greater value at a lower price than the products used independently of each other. No one could have avoided having noticed the incredible power struggle going on between the giants in the telecom, consumer products and communications market, exemplified by Apple and Microsoft, to get the greatest possible breadth of product offering.

When a product has been available for many years and there are many manufacturers competing, the experience is that products that are advanced also have the best user properties, longest life, etc. Cars are a good example of this: you can tell by used car prices. That is not the case when the new products are launched.

Most often it is not so difficult to make unauthorized copies of products, often called piracy. Examples include Rolex watches, Louis Vuitton handbags, etc. While the originals cost thousands of Euros, the markets in Asia, North Africa and other places are flooded with copies that only cost a fraction. Authorities in the EU and many other countries have begun to crack down on this and there are many buyers of copied products that have received fines of several thousand Euros. The reason for this is that no one is served by the manufacturers of pirated copies earning fortunes on the parasitism of those who have devoted a tremendous amount of product and market development of original products.

When it comes to products that are new in the market, it is often only after many years that we know enough to evaluate product quality and operating characteristics. We are not talking then about proprietary technology, and basically the market is served by having many manufacturers with different products, qualities, and capabilities to meet different purposes and uses. If we know what we need and are confident that a new product has the technology and features to meet that need, this is undoubtedly good for the society's development. Unfortunately it is often the case that new players do not know the customer's needs well enough and therefore promise more than they can deliver.

It is therefore natural that there is proliferation of new products based on new ideas. Some companies perform well, while many others have a short lifespan. It is a healthy move that many will try and just as healthy is that it is only the brightest that survive, develop technology and find new applications. It is too bad for those who have invested

in products that do not work. The supplier will disappear and consumers are left without a working product or access to service and support. Unfortunately, the consequence is usually that in addition to a wasted investment consumers suffer a loss of expected income. It may take many years to be able to acquire a replacement that works.
Scanmar has from the start in 1980 focused on developing products with the highest standards of quality, reliability and dependability. These are product requirements that allow users to be 100% sure the products meet their needs, even when it comes to accuracy requirements. That is a necessary requirement as products are increasingly being included as part of integrated solutions. Ten to fifteen years after Scanmar developed the first two generations of products, delivered two to three thousand systems, and trained users to take full advantage of the products to achieve a more efficient and cost-effective fishing, there were eight to ten manufacturers of simple sensors on the market. We were very pleased with that, because with the significant product development costs to meet the most extreme demands we could not meet the prices the owners of the smaller vessels were able to pay. Here they got a lot of options.

Now, some years later, it is sad to state that the vast majority of these manufacturers are out of the market and that this is due to products' lack of technology, quality and properties.

We have registered that many owners of smaller vessels not only have become aware of the benefits of Scanmar's most advanced sensors – Trawl Speed/Symmetry Sensor, Door Angle sensor, and Filling indicator – but they also say that the economy over time is significantly better than with cheap products. The reasons are that they fish more efficiently with less disruption to operations for repairs, service, etc. In addition, the sensors have much longer life.

David Gair (Aquarius) is among those who used the SuperCatch sensor very actively.

As in most other situations you get what you pay for. Most fishermen acknowledge that Scanmar's wide range of sensors and features, reliable transmission technology, robust sensors, battery and charging technology, etc. necessarily cost more than simple solutions. As so often occurs in society, experience has shown them that an investment in an advanced and reliable product over time provides a significantly better return. Scanmar's supreme position among the ocean trawlers around the world is just a result of this. Not to mention that there are thousands of smaller vessels that use Scanmar equipment. Most of these cabinets and sensors work just as well today as they did 20-30 years ago when they were acquired. Our hope and one of our objectives is that we should be able to offer affordable versions of our advanced systems adapted to their purpose.

We have noticed in the last couple of years that those who have simple systems and sensors from other manufacturers want to replace them, even if it initially will require a significant financial investment. This is a very interesting development because it means that after years of use they have learned that it's not the price you pay that is crucial, but the increased revenues and the product's robustness and reliability that matters.

From experience we know that where one leads others will quickly follow. Obviously, a market for more advanced products tailored to smaller vessels will develop and therefore strengthen the foundation to sell a volume that can provide reduced rates.

One could argue that this is on the side of technology - the theme of this article – which can be right. However, there is something more important: it helps to form the basis for new technological developments that could result in products that may come to mean even more for the fishermen's earnings. We have never hidden the fact that our goal has always been to offer the fishermen a full catch system. Today we have sensors that can provide all necessary and useful functions for active fishing gear. For the trawl those sensors include:

- Multi-functional Trawl Door Sensors.
  Some software is still lacking for the multifunctional sensors to work with all features enabled. See data sheets and other reviews for details and user benefits
- Multi-functional Trawl Sensors. See data sheet for details and user benefits
- Bottom Contact Sensor
- Rip Sensor (under the bellow)
- Tunnel Flow Sensor
- Symmetry Sensor
- Grid Sensor
- Catch Sensor

Scanmar has also been granted several patents for functions that are important in positioning and management of the trawl:

- Remote activation of sensors (on trawl/trawl doors)
- Steerable trawl doors
- Distance/positioning
- Correction of the speed of sound in water in relation to temperature variations
- Sorting (patent pending)

In connection with a complete and integrated catch system there are things of critical importance that most people do not think of in the first place: information that is reliable, complete, easy to understand and easy to act on. Scanmar offers the following:

- Highly advanced and reliable hydro-acoustic transmission link based on 30 years of experience and feedback from thousands of vessels and environmental conditions

- Advanced filtering systems in the receiver that removes noise, interference and other sources of error
- All information available in complex, but easy-to-use geometric images
- Ongoing development of critical data
- Simple assembly that gives the fisherman a clear message about how he should react

Part of the technology concept that most people have not thought of, but which is of crucial importance for a catch system to function, is the accuracy of the data included in the system. This also plays an important role for effective fishing. Scanmar does the following to get the most accurate possible information incorporated into the system:

- **Correction of speed of sound in water in relation to temperature variation**
  Speed of sound in water changes by approximately four meters per second per degree. This means that without temperature correction you can in most cases assume that the measured distances can vary by 6-7%. Scanmar has developed technology to compensate for this variation and thus ensure accurate and reliable measured data so that measured echo sounder depths and door distance measurements are correct.
  - Important for correction of sonar readings
  - Crucial for accurate and reliable door distance (rigging, bottom contact, etc.)
  - Contributes to accurate measurement of distance between vessel and trawl

- **Door Angles**
  Sensors are mounted accurately in the vertical and horizontal plane to prevent the measurements from being wrong when the angles change, even if they are calibrated when they are installed. Scanmar makes a series of measurements before the average value is calculated and sent to the vessel. This ensures reliable, accurate data. Simple, live measurements of door angles – the type generated by other products on the market – provide random data with large and unreliable results because the doors' stability varies from second to second (accurate mathematical calculations for the doors' stability).

It's been a long and extensive journey to get where we are today that has cost NOK 400 million. In return we have reached a technological level no one, including ourselves, could have imagined 30, 20 or even 10 years ago. But development continues. The next goal must be to develop more effective tools where technology, together with a lot of practical experience, provides a solid platform for an efficient and targeted development.

1.6 *Scanmar's screen presentations – unique solutions for full overview and further development when fishing*

A modern Catch System from Scanmar is something completely different and more dynamic than what a Catch Control System was ten years ago or what is otherwise offered in the market today.

Scanmar is introducing new additional features that not only make old Scanmar systems compatible with modern graphical display, but also allows them to display several of the newest and most advanced features. The new presentation gives, according to fishermen who have tried it, a whole new world.

In the early days of Catch Control it was the simple information such as catch, door distance, depth and temperature that increased efficiency, economic gains and substantial cost savings for fishermen worldwide.

Today, developments have taken a major step forward. In more than 30 years, thousands of fishermen have told Scanmar about their experiences and problems. This information, together with pioneering Scanmar technology, has laid the foundation for a completely new understanding of what it takes to fish effectively.

Now it's the dynamics that are the focus of the best, most innovative fishermen:

- How do the underwater currents affect door distance and door angle when it comes to efficiency and fuel economy?
- What does fish intake and filling of the bag mean for water flow, bucket effects and loss of catch?
- How can new technology show exactly where the fish are so fishermen can minimize towing time and fuel costs?

Most fishermen have begun to ask themselves these or similar questions. It's no wonder: more and more people use Scanmar Flow Sensors in one variant or another. Be it the Trawl Speed, Symmetry, or the Grid sensor, they have learned that the towing speed is important. This does not mean GPS speed, but the actual speed of the water passing through the trawl. Everyone who has used one or more of these sensors has seen the importance of proper water velocity in the trawl. It's not just trawl speed relative to fish swimming ability or even the right speed to get the fish back in the bag, but it also has a significant effect on the doors' angles and distance.

In the mid-1980s Scanmar developed a series of Flow sensors based on a completely new technology, but it took many years before most fishermen understood the importance of water speed and direction (symmetry) relative to effective fishing. Today, more than half of all fishermen who use Catch Control use a Flow Sensor. As they become more familiar with the Flow Sensor, more and more fishermen are declaring that that it is the main sensor, but they also typically recommend Door Angle, Trawl Eye, and Filling Indicator in the process.

This is really no surprise since these are all closely related. It is this mutual relationship – and the ability to understand the relationship – that makes some fishermen much more efficient than others. It is also the reason why even small vessels no longer buy the simple systems.

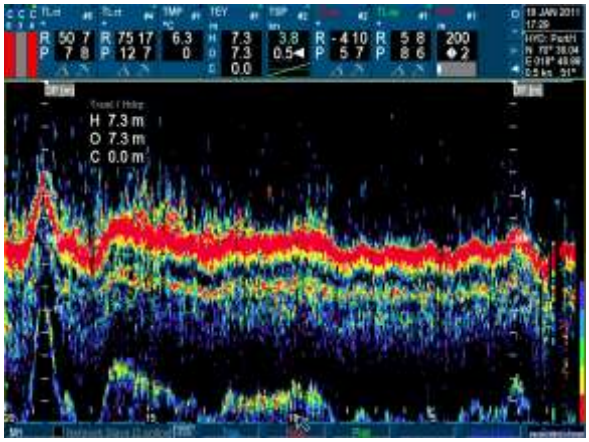
It is not uncommon for us to receive calls from fishermen who are angry at themselves because they intended to acquire new equipment for many years and, after finally installing a Scanmar system, they see what they have lost due to postponed investment.

The value of the new advanced sensors, and the dynamics and the relationship between them, can hardly be exaggerated. The point and the challenge, however, are also to present the details in such a way that they are easy to understand and that changes in towing speed, warp lengths and course comes easy and clearly, so that appropriate decisions can be taken immediately.

The main images show:

- Geometric image and development of the most important parameters in the last minute. This is the ideal image to make changes in towing speed, course, or warp lengths, or a combination
- Trawl Eye or Trawl image
- Log of fish intake and filling rate

Geometric screen



Trawl Eye screen image

Log of filling

Of course there are many other possibilities to choose from with simple selections on screen.

1.7 *Full control at a glance; solve problems before they occur*

During towing there are only two things you can do to affect the trawl geometry and fishing ability (apart from changing course):

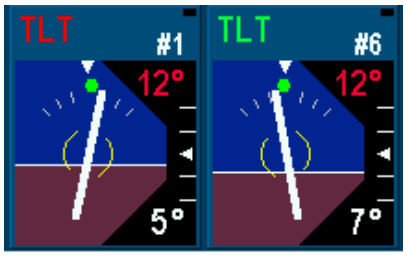
- Change the towing speed (water flow into the trawl)
- Change warp lengths

On the other hand there are many factors over which you have no control that influence trawl geometry:

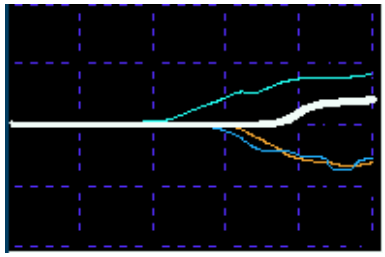
- Bottom conditions
- Depth variations
- Underwater currents
- Fish influx and filling

Although you cannot control these conditions you can immediately detect them through changes in door distance, towing speed or door angles. You must therefore focus on door angles and towing speed in order to obtain the correct door distance. If you have rigged the doors correctly, you can focus entirely on ensuring that the doors have the correct tilt angle. This you correct easily by adjusting the towing speed and in some cases by a small adjustment of the winches (Scanmar has patented steerable trawl doors). Scanmar has developed the program *ScanTrack* that processes and displays information so you instantly see if everything is on line or if you must take action to prevent problems from occurring.

Trawl Speed



Door Distance



Follow the thick line:
Above: Increase speed
Under: Reduce speed

1.8 *ScanTrack – New patent pending system for full catch control and simple rigging of trawl*

After more than 30 years of groundbreaking efforts on research and development, Scanmar can now offer Catch Systems based on the world's most advanced technology.

Scanmar's extensive range of sensors and advanced technology for processing of data has now enabled us to develop a new product that allows fishermen to anticipate problems that may arise and simply avoid them. In addition, the system shows how he can easily adjust rigging to get an optimal effect of the equipment.

Scanmars products are based on proprietary molding technology, unique battery- and charging technology and reliable cable-free transmission technology that work in all conditions. Scanmar has also developed technology to ensure accurate and reliable measurement data, for example temperature compensation for speed of sound in water so that depths and distances measured by echo sounders and Door Distance sensors are correct.

When it is necessary to make correct decisions quickly in critical situations and there are many factors that come into play, it is a requirement that all data is 100% reliable and that data update rate is optimal.

Finally, we possess the required technology and we have therefore chosen to develop a system that gives the fisherman a complete presentation where it is easy to understand what is happening: *ScanTrack*.

ScanTrack is an additional unit to the existing Scanmar bridge units that can be connected to most of Scanmar's previously produced systems, limited to how many sensors the bridge system can handle.

In all simplicity, the system records all data from all sensors connected to the system, including data from other sources than Scanmar. The fisherman enters the data he considers to be "correct" from the given situation, and deviations in the actual data will be displayed as deviations from a straight line.

Let's have a closer look at the benefits the system provides:

1. Fast decisions while fishing to avoid problems

- In a given catch situation, it is natural to focus on the three or even four types of information that have the greatest impact on the trawl efficiency in every situation.

- Trawl geometry is an example of something that concerns most people. Door distance is mainly a result of the doors' pitch angles and towing speed (flow in the trawl opening). When a desired value is selected (done with simple clicks on the screen in terms of sensor selection and setting), the image on the screen will be a thick straight line showing the door distance if real values are the same as the chosen. The other measurement values are hidden.

- If the door distance deviates from the selected value, the thick line points upwards or downwards, depending on whether it is the spread or if you have too little door distance (the deviation is also shown with the digit). At the same time, this or other factors that influence the door distance will show a similar deviation. By correcting these, particularly the greatest deviation, you will easily be able to correct the situation.

- If the door distance changes without any change in the selected parameters, you can check other parameters – those that may have not been displayed in ScanTrack, such as warp lengths – to examine other possible causes.

- In *ScanTrack* you put in a filter (simple clicks on the screen) that makes "natural" variations invisible. If you fish in an area where one would expect that the doors are very stable (small ScanFactor) you can for example add a filter of ± 2^0. However, if the seabed is very uneven, it may be natural to select ± 6 – 8^0.

- For door distance it may be appropriate to select ± 1 meter on a smooth seabed, while under more difficult conditions it may be natural to select ± 3 meters. Note: Temperature compensated distance measurements provide a much more accurate reading than usual distance measurements where inaccuracy can be up to ± 3%.

- In the same way as it is often desirable to focus on correct door distance, it may be important to focus on the height of the trawl, bottom contact, trawl speed, flow in the tunnel, etc. You choose when to observe the factors you believe have the greatest impact on the parameter you want to focus on.

- If you want to change the set parameters while fishing, this can easily be done with simple clicks on the screen. Examples of situations where you wish to change the setting may be that you are fishing at a different depth, that there is a change in the current conditions, filling of the bag, etc.

- Similarly, you can choose to replace the sensors (parameters) you want to keep an eye on by simple clicks on the screen.

- Since all data is there all the time, you can also click to see the history or retrieve the individual sensors.

2. Evaluate a finished haul with regards to if the rigging should be adjusted

- In all logging programs you can go back to study the development of the individual parameters and also discover whether there have been some short-term deviations. With the logging of many sensors, it is not easy to get a complete overview because of the amount of data.

- With *ScanTrack* the advantage is that you can easily study the interplay between the parameters that affect each other. To refer to the example above, there may be other factors than door angles and towing speed that has affected the door distance (and efficiency). These can include warp lengths (depths), side currents (trawl symmetry), filling, etc. It is often useful to make small adjustments that lead to the most efficient rigging throughout the haul.

3. Historical data as a basis for future trips

In *ScanTrack* you can store large amounts of data, making it easy to retrieve any data from earlier hauls in the same place, and see what experiences you have previously made.

We have shown and discussed *ScanTrack* with many people and without exception they are very positive about how the system will make everything much easier for them.

1.9 *Data logging – an important way to improve efficiency and financial results*

Ever since the start in 1980, Scanmar has been involved with Fishery Research Institutes (250 vessels are equipped with Scanmar systems) and the interaction between the institutes and Scanmar has proven to be of immense value to both parties. The different institutes have various tasks and aims with their research, but the common factor is that they all use Scanmar sensors to make underwater observations and log the data for further processing.

In the same period Scanmar has collected data from a vast number of commercial fishing vessels all over the world.

In addition to the basic purposes for using data from Scanmar sensors, Scanmar has analyzed the data with the purpose of finding relationships between various factors that may improve the quality of fishery research results and help commercial fishermen improve their economical results.

Based on our experience, sustainable and profitable fisheries have to be based on several different factors, such as realistic quotas, efficient fisheries and profitable fisheries (harvesting the various species when it is efficient, when prices are good, as bycatch, or with minimum fuel consumption and the least possible wear and tear on equipment and fishing gear).

It is worth noting that the last of these, as it relates to commercial fishing based on experience (logged data), is probably well known to experts, but it is only to a very small extent applied that experienced gained from logged data is utilized in commercial fisheries.

Another aspect benefit of logged data is traceability, not only in order to have better information about the resources and biomass, but also to obtain better information about the catching area and conditions in order to obtain better prices in the market place.

- We have seen that in areas with stable weather conditions the surface temperature gives a clear indication of the temperature at various levels in the sea and on the seabed, and consequently fish concentration.

- Fish availability is very often directly related to weather conditions and underwater currents, temperature, etc.

- The amount of fish caught is often a result of how the fish is caught; towing direction, fish orientation relative to towing direction, towing speed etc.

This information is all very general, but more information is available in the last ten pages under Catching Technique, as well as on **www.scanmar.no**.

The main purpose of a Scanmar system for commercial fishing is to optimize the efficiency of fishing operations and thereby reduce unwanted bycatch, fuel consumption and repair and maintenance costs.

However, right from the start we received and logged data from commercial and research vessels. We have then carefully analyzed the data in order to help fishermen increase efficiency by establishing relationships among data that may help improve trip and seasonal planning.

On a micro level, i.e. individual fishing vessels, logged data are of immense importance. We are constantly working on developing screen and log relationships which the fishermen may use, all dependent on their own operations and the area they are fishing.

In addition to observations made with Scanmar sensors, input from GPS (position, course and speed over ground) and other instruments on board the vessel may be incorporated as part of the display and logged on the Scanmar Bridge systems.

Here is a list of data (part of Scanmar system) we think are very relevant for both research programs and sustainable/efficient fisheries:

Temperature: Surface (hull mounted receiver), fishing gear and water temperature profile (logged during shooting). Patent pending for the latter. The profile of the water temperature is not only important for the fishing operation, but necessary for correct depth measurement for the echo sounder to compensate for different depth measurements in different seasons (speed of sound in water changes approximately 4 m/s per degree centigrade).

Underwater currents: Trawl speed/Direction related to towing direction (GPS)

Towing speed: Water flow in the trawl opening related to fish influx

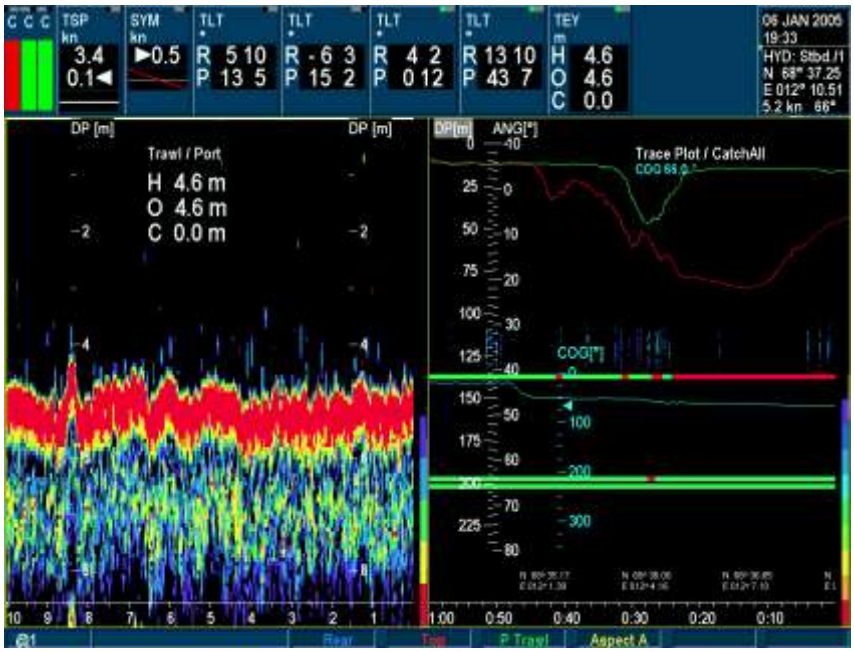
Twist and bucket effect: Huge negative effect on amount of catch (closed/open meshes reduce waterflow in trawl; causes fish to escape). May also be used for fish selection

Trawl geometry: Door Distance, Door Angle, Towing speed/Symmetry; the combination important for volume of water entering the trawl opening and have impact on twist and bucket effects, as well as fish behavior in the trawl

Trawl position: Pelagic (related to fish concentration/compensation for echo sounder measurements), and on/off bottom (fish escape). Also used to control how hard the gear goes on the bottom (important for catching certain species)

Continuous monitoring of filling rate: Full control of fish influx, and impact on Towing speed, Door Distance and Door Angles

The new generation of Bridge units, ScanMate 6, ScanBas and ScanScreen, provides a wide range of options where you can find exactly the combination of information that is most important to you for improving your results and saving expense to fuel, repair and maintenance.

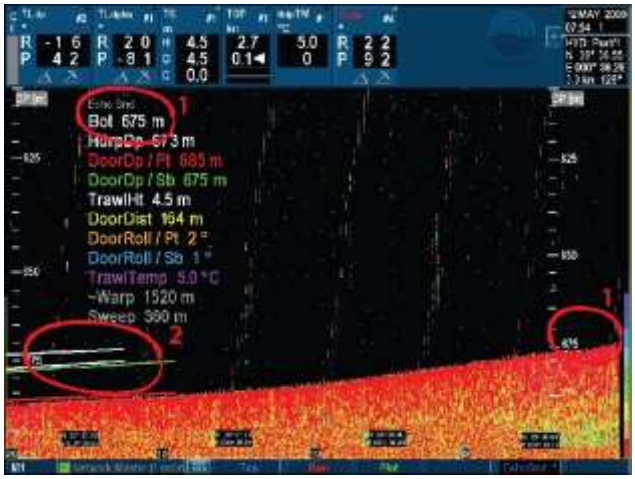


The log picture shows the activation of the Catch sensor (green/red line) and impact on the combination sensor Catch/Angle when fish pass the sensor on their way into the bag.

1.10 *Why is it so important to display accurate depth on an echo sounder?*

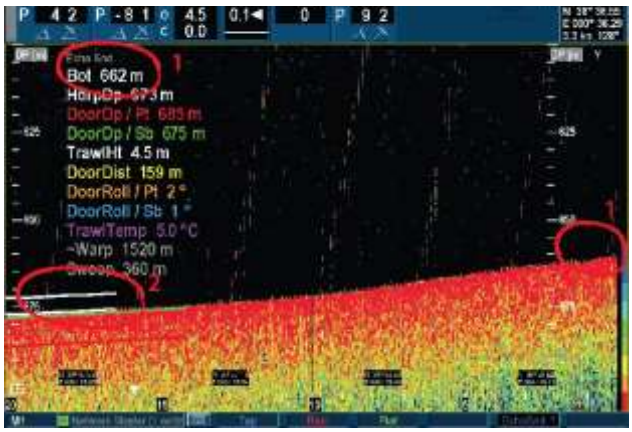
Since Scanmar produced its first graphic displays (CGM and RX-400) more than 20 years ago, fishermen have wondered why it is that the trawl sometimes appears to be above or below the seabed (in the trawl screen image) when the trawl actually is <u>on</u> the seabed.

We have tried to explain it, but many fishermen are accustomed to using and relying 100% on echo sounders so the reason is perhaps not so obvious. The fact is that while a depth gauge is almost 100% accurate, echo sounder readings vary with the temperature in the sea. Sound propagates with different speeds depending on water temperature causing differences of up to 6-7% (i.e. 30-35 meters at 500 meters depth). Just the difference of 10 degrees between summer and winter can cause variations of 12 or 13 meters. When fishing on hillsides and on the bottom with large depth variations, the varying measurements will have a significant effect on the proper positioning of the trawl as well as trawl and trawl door movement in the sea.



When making accurate echo sounder measurements it is not enough to measure the temperature at the surface and at the bottom, split the measurement in two, and then base the sounder on the result. Different temperature layers, with different distributions, make it important to know the temperature *profile* from the surface to the bottom. In fact, scientists often stop several times a day to record the temperature with a CTD probe with cable.

(1) Without echo sounder correction: shows depth 675 m.
(2) Trawl height



Scanmar has been granted a patent for a much simpler and convenient system. By logging data from the combined Depth/Temperature sensor during shooting of the equipment, an accurate temperature profile is generated and a modern echo sounder that has the proper input can adjust automatically or it can be adjusted to the best degree possible by hand.

(1) With echo sounder correction of temperature: depth 662 m

2 Products

2.1 *General*

Observations made through several decades show that the efficiency in modern trawl fishing is strongly affected by weather, wind and currents. In addition, the seabed conditions and temperature are of great significance as are different species' distinctive movement patterns.

Scanmar's business idea has always been to develop products that can help the fishermen be able to make adjustments to the equipment and fishing technique to be able to quickly adapt to changes in conditions.

Scanmar's Catch systems have been developed over 30 years to give fishermen exact and reliable information that can contribute to more efficient fishing as well as economic profit as a result of reduction in damage and wear on equipment.

Scanmar's Catch systems are based on Scanmar's experience and proven technology, and are characterized by:

- Advanced acoustic transmission technology
- The most modern bridge systems based on unique signal processing technology
- Graphic presentation
- Complete range of robust and reliable sensors where the electronics are protected in especially developed plastic material.
- With the exception of ScanMate 2/4, all bridge systems can be upgraded to handle all sensors and will be upgraded with new sensors when needed.

Scanmar's Catch systems consist of:

Bridge systems

- Receiver units
- Display units

Sensors

- Trawl sensors (Multifunctional)
- Door sensors (Multifunctional)
- Flow sensors
- Trawl Eye
- Trawl sounder
- Bottom Contact sensors

Miscellaneous

- Hydrophones
- Chargers
- Mounting kit

2.2 *Bridge systems*

Scanmar's bridge systems consist of one or more receiver units and one or more display monitors. The receiver unit processes the signals received from the sensors, removes noise and false signals, and prepares the signals for simple and straightforward presentation.

ScanBas - a new dimension in logging and use of data

The registration and storage of all data during fishing will have great significance in the times ahead. The areas of usefulness are many. It will have great significance in being able to control all phases of a trawl haul, make the fishing more efficient through planning and also when it comes to information for the ship-owner and customer.

ScanBas registers data for a number of purposes, for example:

- Register everything that happens during a trawl haul, so that the new shift is quickly updated or to be able to rewind to see if anything happened while the screen was not being monitored

- Register all relevant data in a trawl haul to be able to compare it to a corresponding haul at the same grounds at an earlier time

- Register all data relating to fishing gear and its rigging in order to have reference data from different grounds or from when new equipment is adjusted

- Register weather and environmental data to get started with efficient fishing as quickly as possible when arriving at the fishing grounds

- Register all catch and customer data. The aim is to get the best possible information for the shipping company, but also for sale, considering traceability (catch area and quality)

In addition to the data that are registered automatically from Scanmar sensors and other connected instrumentation like GPS, winches, echo sounder and so on, additional data can be input automatically or manually by *ScanBas*. This allows one to operate several slave displays with a keyboard that can be placed in production, the cabin etc.

Database with information about the haul

The database holds all sets of data about the vessel, identification and so on depending on requirements so that it is easy to register specific data on every haul. A "barcode" like system that reduces the amount of transferred data and secures the shipping company against intruders getting access to the reports will ensure that the shipping company and customer get the data transferred at minimum costs.

Expanded User Areas

Increasingly, the focus is being put on selective fish species and sizes, damage to the bottom fauna, and energy consumption in proportion to the catch efficiency. The possibility exists that this will lead to further regulations and limits to the catch possibilities.

For fishermen this will mean increased demands for efficiency and, if possible, even greater focus on reduced costs.

Use historical data in planning

Under these conditions the best possible planning will give the best results. Planning is mainly about making use of experience and historical data to try to predict how things will develop. Changes to climatic conditions and the great ocean currents, with constant variations to biomass, do not make it easy to predict these developments.

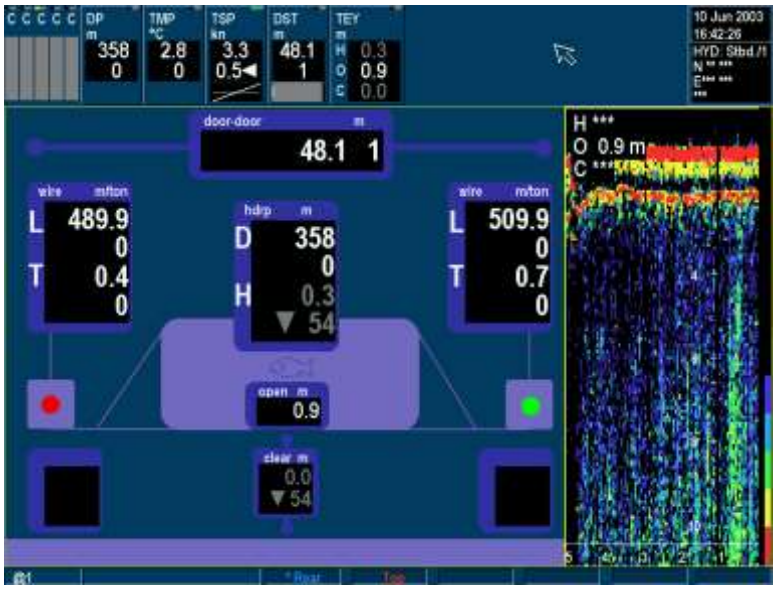
With the *ScanBas* system it will in time be possible to log all data that are relevant to the catch environment and compare them with historical plots. During later hauls at the same GPS position the historical plots may in the future be displayable on the screen along with the ongoing haul. This will make it easy to determine whether to carry on fishing or discontinue and try somewhere else.

Another important element will be to collect data at fishing grounds to be able to understand and predict the cause of fish movement over time as a consequence of changes to temperature, currents, or number of vessels at the grounds.

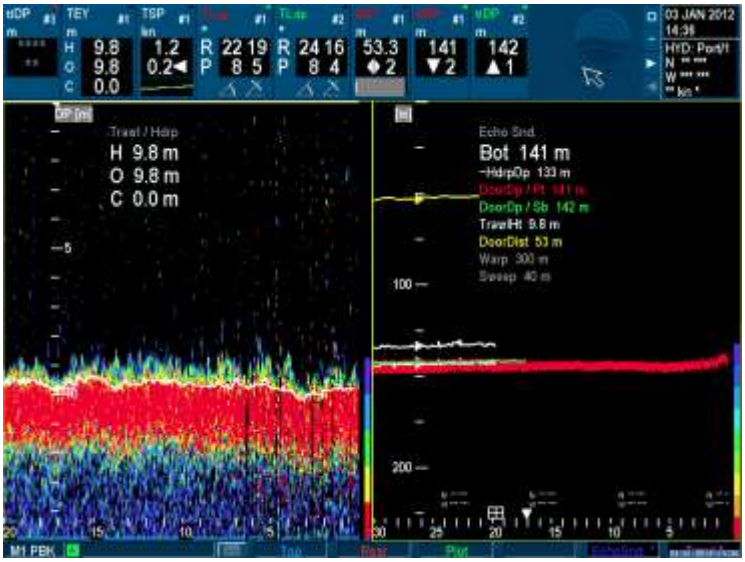
The *ScanBas* system has the far-reaching use of logging and registration of data as one of its main aims. When Scanmar sensors are used to register all conditions that influence the efficiency of fishing, many of the elements of importance to the fish quality and origin in relation to traceability are also being registered.

Geometry and log image, Filling indicator

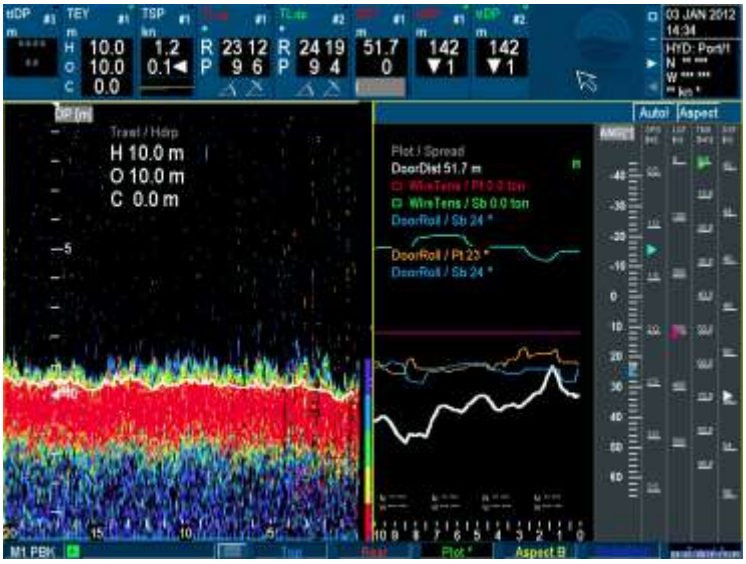
Geometry and Trawl Eye image



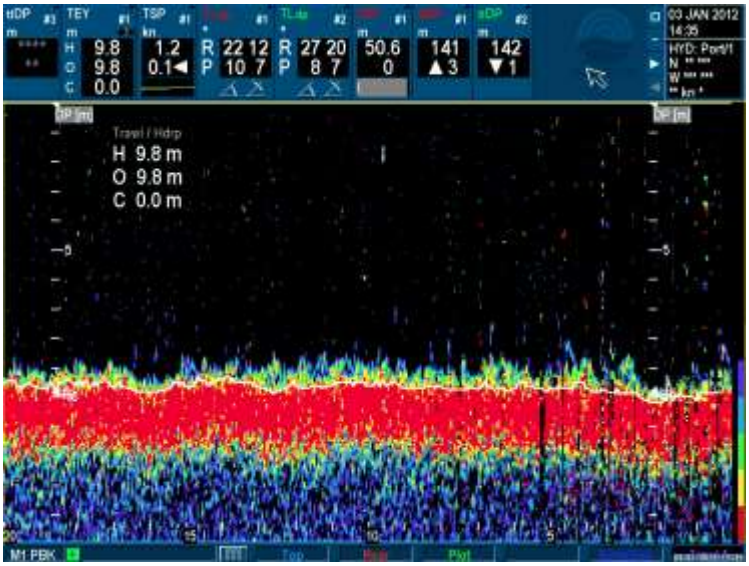
Geometry and Echo Sounder image



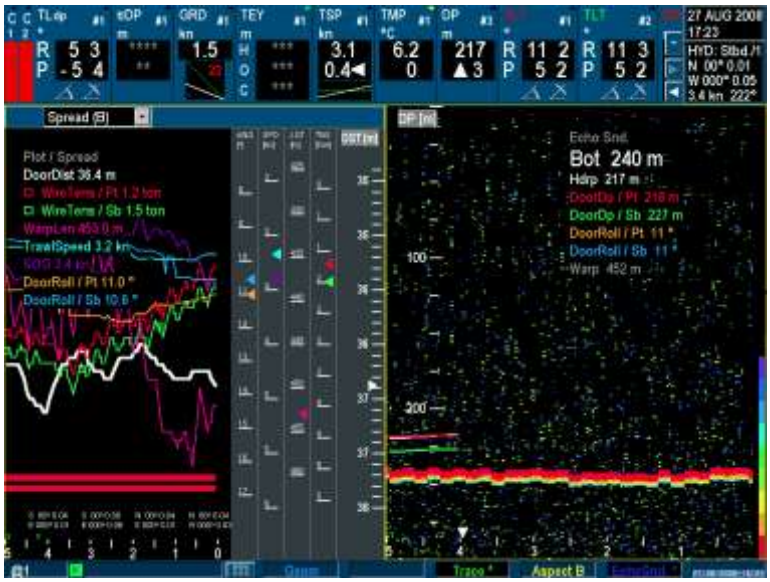
Trawl Eye and Echo Sounder image



Trawl Eye and log image



Trawl Eye image



Log and Echo Sounder image

Log image

ScanScreen

A modern Catch system with Trawl Eye, Flow sensors in the trawl opening and belly, Door sensors, and filling indicators in addition to the traditional sensors that laid the foundation for the development of a full capture system provides fishermen with so much important information that there is a need to use more screens in the system. This is of course even more important to those who fish with two or three trawls.

The usual procedure is to use two or three screens on the bridge console and one by the winch console, but screens can also be placed in the mess hall or other places where the trawl master or others can observe the action.

With the ScanBas system fishermen must switch between different images; with ScanScreen fishermen have a complete overview of what they want to focus on in every part of the haul.

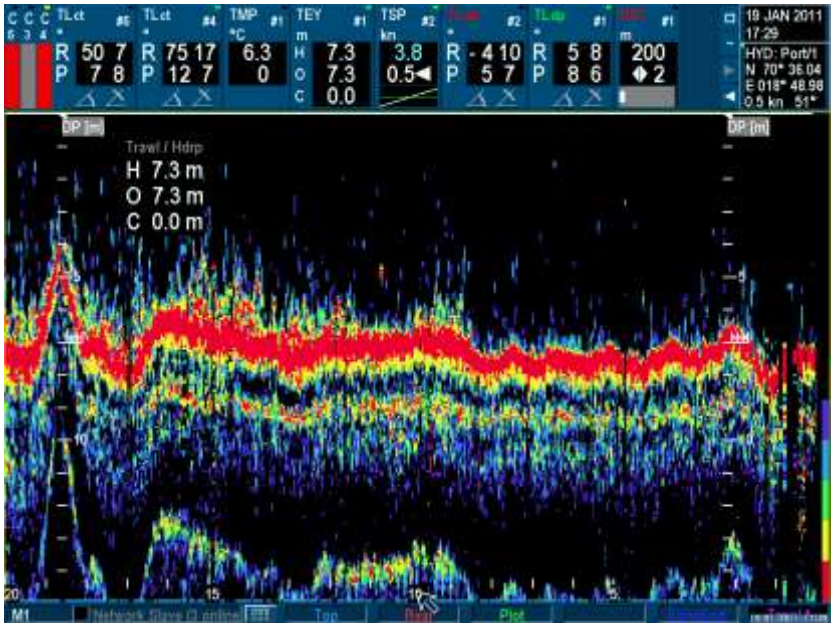
There are a number of vessels that have used the ScanScreen for many years and we only receive positive feedback. It is also a fact that many people who originally bought a ScanBas system later upgraded. One point that is worth emphasizing is that with a ScanScreen system fishermen are able to follow both the Trawl Eye's detection of fish influx and to view snapshots of the trawl geometry in addition to studying situations that are under development in various log images, such as:

- Door Distance
- Door Angles and stability
- Precise fish influx in the cod end and filling rate

An example of *ScanScreen* displayed on three screens during cod fishing

Screen image – Geometry

In the geometry image it is worth noting how easy it is to see that the doors are unstable (1), and that it is due to a side current from the starboard (2). At the same time, one can see that the two Catch sensors in use (3) are activated, and that the bag is twisted to starboard.



Screen image – Trawl Eye

The Trawl Eye image speaks for itself and you can clearly see where there are concentrations of fish.

Screen image – Log

The plot image shows the logging of two Filling Indicators (Angle sensors) that are combined with Catch sensors (stretch wire). The curves show the filling rate (repeated in each haul) and the variations show the fish influx. It is easy to see how these correspond with observations in the Trawl Eye image.

It is also worth noting how activation of the Catch sensors (4) is matching the filling rate, but especially how the fish influx takes place sometime before the Catch sensors are activated. This information is often used to turn and tow the same area a second time.

From the GPS position you can see exactly where the fish are entering. Also note how the strong record of fish in the Trawl Eye image also appears in the plot image.

ScanMate 6

ScanMate 6 is the modern equipment on most trawlers that do not use Trawl Eye or that do not see the need for expansion beyond six sensor functions in the near future. Unlike the traditional systems that *ScanMate 6* replaced – Rx-400, 600 and 4000 – the system now has graphical presentation of the trawl.

But *ScanMate 6* is much more than just a replacement for the old systems. First, *ScanMate 6* was designed around new receiver technology that provides significantly improved signal reception, especially at great depths and in difficult weather conditions. Boats with receiver issues due to propeller noise or other aspects associated with the vessel have seen major changes with the ScanMate 6 system. Automatic hydrophone selection, the process by which the receiver listens on both hydrophones simultaneously and automatically selects the signal to noise ratio that is better, was a vast improvement over previous versions.

In particular, the combination of advanced receiver technology and automatic hydrophone selection was a big step forward for seiners.

ScanMate 6 replaced the previous 4000 -, 600 - and RX-400-systems. First and foremost there is improvement in the receiver, both in terms of signal reception and treatment of the hydro-acoustic signals. Yet there is also improvement with regard to processing of data for presentation on the displays and logging of data for subsequent presentation of historical events.

Second, *ScanMate 6* is a system that can gradually be upgraded to a more advanced system, such as ScanBas or ScanScreen, when the need arises.
A complete *ScanMate 6* system consists of bridge equipment, two hydrophones, up to six sensor functions, and chargers. For those who require the use of more than six sensor functions, a ScanBas system without Trawl Eye receiver is an option.

Third, the displays are 19” flat panel color monitors. Since readability is very good, there are usually more opportunities for where the displays can be placed. The control unit is mounted separately so that the *ScanMate 6* can be operated from the Captain’s chair even if the cabinet is mounted a bit further away. The system can also be operated by wireless remote control.

Like the other systems, ScanMate 6 includes graphical presentation.

ScanMate 6 can connect to most echo sounders so it is possible to use the *ScanMate* screen as independent sonar or divide it by presenting Scanmar capture control on one side and sonar on the other. Also, several other graphic images can be displayed depending on what you want to focus on.

ScanMate 6 is compatible with all sensors except Trawl Eye.

2.3 *Sensors*

Sensors are, together with the receiver, the most important elements in a Catch system. Besides the vast amount of research and testing it took to find which observations are important in different contexts, as well as the measurements being precise and the update rate being adjustable based on need, there are a number of other requirements of sensors:

- Reliable – the electronics must be protected in order to avoid, to the greatest extent possible, disruption due to the sensors being in need of service or repair
- Pressure safe so they can be used at all desired depths
- Sending effect that gives enough range to reach the vessel
- Long working time between each charging
- Short charging time
- Easy to change sending frequency if there are noise problems or interference from other vessels

With the new sensor construction, new plastic technology, new battery technology, and new charging technology, Scanmar has met all these requirements in the new ScanSense SS4 sensor generation.

The SS4 sensors are designed for use in normal operation at depths down to 2250 meters. The reach from the vessel depends on the chosen sending effect; maximum 3000 meters.

SS4 sensors can easily be tested on board vessels by simply plugging the supplied cabel to a PC.

Other sensors have through many years documented that most of the requirements are fulfilled. Further development of these sensors is in progress.

2.4 *Trawl sensors (Pingers)*

Pinger is the term used for the sensors that are attached to the trawl and/or trawl bag and transmit simple information to the vessel. The method used for transmission and reception of signals is very simple and very reliable. Scanmar has delivered more than 30.000 Pingers through the years.

The new SS4 Pingers differ from earlier generations in "all" areas:

New sensor construction and newly developed plastic material
10 times larger battery capacity
Programmable sending effect – multiplies the working time
Fully charged in 2.5 hours
Multifunctional – the sensors have several functions built in
The functions can be used simultaneously or alternately
The sensors can be placed in different places as needed
Simple to switch frequency when interference occurs
Light diode shows when the sensor is transmitting
Simple self test

The sensors included in the SS4 Pinger series are:

- SuperCatch – Catch sensor
- SuperCatch – Filling sensor
- Twist sensor
- Depth sensor
- Temperature sensor
- Rip sensor

The sensors can be delivered with one function and be updated later, or have several functions at delivery.

2.5 *SuperCatch: Catch sensor, filling indicator – or both*

Scanmar SuperCatch meets all the requirements any fisherman could desire:

- Correct and precise information
- New robust and reliable design eliminating the need for service and repair
- Labor saving
- Negligible operating costs and long lifetime providing very profitable investment
- Extremely long operation time

Uses:

- **Catch Sensor**
  - Activation of the sensor with the stretch wire in the traditional way
  - Fast activation of stretch wire, important in large fish intake

- **Filling Indicator**
  - Indicates filling amount using both pitch and roll angle measurements on the bag
  - Pitch measurements show how the bag gradually fills up to the point where the sensor is mounted
  - Shows exactly where the fish intake is so that the vessel can be turned to fish again in the area where the fish were detected
  - Roll angle (twist) shows how the bag twists when it begins to fill and how it gradually rights itself when it is filled
  - The sensor can be programmed for normal or quick updating
  - Up /down notifications so that the trawl is not towed with the cod end upside down

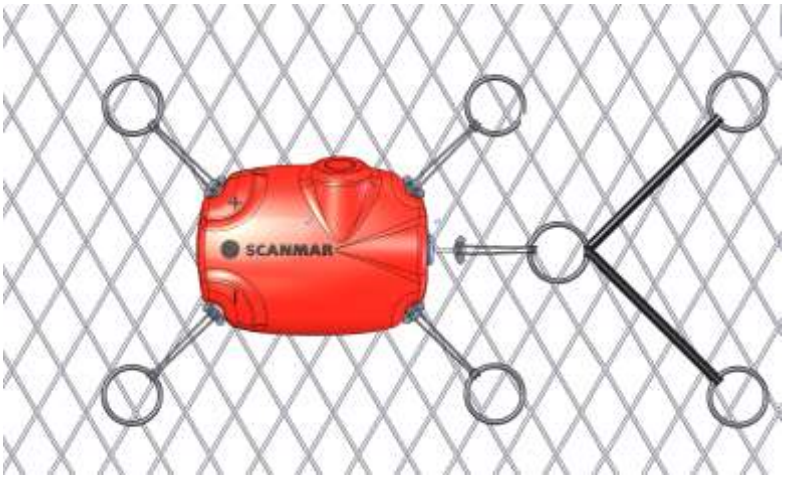
The log screen displays the activation of the Catch sensors (green/red line) and output of the Catch/Angle combination sensor when fish pass by the sensor on the way back to the cod end.

Sensor information:

- **Construction**
  - New design with double casting of the electronics provides 100% protection
  - Scanmar's newly developed Super Plastic eliminates damage to the sensor due to blows, tension, or dragging along the bottom with a twisted trawl

- **Batteries, operation time**
  - The new batteries have 10 times as much capacity as the old batteries
  - Transmission strength in sensors can be adjusted depending on the depth of the fish, something that in most cases will lead to a further increase in operation time
  - The sensor is always ready for use because a quick charge for a haul can be done in minutes
  - The improved battery capacity and increased time between charges means the battery can be used for many years before it must be replaced

- **Charging and programming**
  - Newly developed technology in the charger, the sensor, and the battery cartridge makes charging time a fraction of what is normal for this type of battery
  - Transmission power and frequency are easily programmed with the new charger
  - Choosing fast or normal refresh rate is also done easily via the charger
  - The charger has features that can check both battery and sensor condition.



Mounting of Catch sensor

2.6 *Twist sensor: good water flow is essential to getting the catch back to the cod end*

Twist and Bucket effect = sticker

As long as we have operated fishermen have asked us what the reason might be for why often the fish they see enter the trawl opening do not end up in the cod end. There can be several reasons. One can be that the towing speed is too low so that the fish stay in the opening and escapes in front of the trawl. But the suspicion has always been that it is usually because of other reasons.

As more and more fishermen started to use a Scanmar Trawl Eye in combination with the Trawl Speed sensor - both in the opening and in the belly we could eliminate some of the problems caused by too low towing speed.

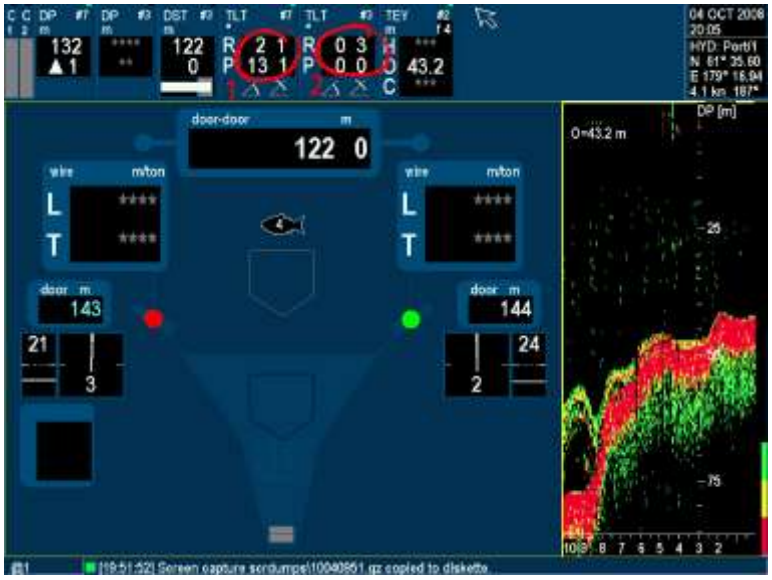
Stickers in medium large mesh gave us a hint what happens further ahead where the mesh is so big that the fish easily escapes through it?

We had our suspicions: Bucket effect and Twist!

Scanmar's *Trawl Speed, Symmetry* and *Grid sensors* have had angle meters implemented since 1985, and especially *Symmetry sensors* in the trawl opening and *Trawl Speed* sensor in the belly gave clear indications that the water flow and fish entrance affected the trawl's shape in different ways. We were also familiar with thorough tests made in 1985 by the German Institute of Marine Research which proved the presence of Bucket effect in a pelagic trawl.

We therefore decided to make some simple prototypes of angle meters for testing on trawl doors, trawl, bag, bottom gear, etc. and we registered among other things that the trawl's shape could change a lot with different directions of water currents, towing speed and fish entrance. In development of our new sensor generation SS4 *ScanSense*, multifunctional sensors, we therefore decided that Angle measurements would be implemented as a standard, not just as an additional function, but specifically in an individual sensor, which, granted, can be upgraded with other functions.

With the experience we have gained through six year with the use of the *Twist* sensor, we can determine that Bucket effects arise often with the result of water pressing through the open mesh and fish escaping.



The Screen image shows semi-pelagic fishing for Alaska Pollack in shallow water (150 meters). Trawl and gear are heavy and thus, together with short warps, the doors are tilted more than 20°. The change in trawl height is caused by wire being shot in order to achieve a larger vertical opening. The sensor boxes show: (1) mounted on the head line small twist, 2 ° to starboard, and 13° tilt, and (2) mounted in the middle of the trawl; good balance.

It was perhaps more surprising to register that "all" trawls and trawl bags have the ability to twist and create an unfortunate water current in the trawl, which again leads fish out through the open mesh. And the twist can be quite significant, 70° is not unusual. Now it turns out that the trawl straightens when the bag fills, but a lot of catch is lost before that happens.

The trawls we have done experiments with have also shown that the trawl usually has different heights on each side, which affects the water flow back into the trawl. And here the *Twist* sensor is of great benefit.

2.7 *Door sensors – new generation with many advantages*

We have heard trawl producers say that 80% of a trawl's efficiency comes from the trawl doors working perfectly. We do not know exactly, but what we do know is that the significance is large. Door Distance sensors have, as we see it, been the most important sensors for most fishermen though 25 years, and now many call the Door Angle sensor the most important sensor Scanmar has developed.

The sensors are based on SS4 ScanSense technology:

- New sensor construction and newly developed plastic material
- 5 times larger battery capacity
- Programmable sending effect – multiplies the working time
- Fully charged in 2.5 hours
- Can be charged while on the doors
- Multifunctional – the sensors have several functions built in
- The functions can be used simultaneously or alternately
- New mounting kit; easy to weld on
- Simple to switch frequency when interference occurs
- Light diode shows when the sensor is transmitting
- Simple self test

The sensors that are included in the new Door sensor series are mounted parallel to the door's horizontal and vertical axis. This makes the pockets simple to mount, while all sensors can be upgraded with an Angle function as well. The mounting is therefore important in order to receive correct angle measurements.

Functions included in the new SS4 Door sensor series are:

- Distance
- Angle
- Depth
- Tension
- Temperature

The sensors are delivered with one or more functions activated, and can, if desired, also be upgraded later by simply downloading a license.

2.8 *New Distance sensors – long working time, simple charging*

New technology, both when it comes to sensor construction as well as battery and charging technology, has made it possible to develop Distance sensors that can be programmed precisely to suit different conditions and to create solutions that eliminate laborious operations. Scanmar has developed three new variations of the Distance sensor based on the new SS4 technology so that each fisherman can have exactly what he wants.

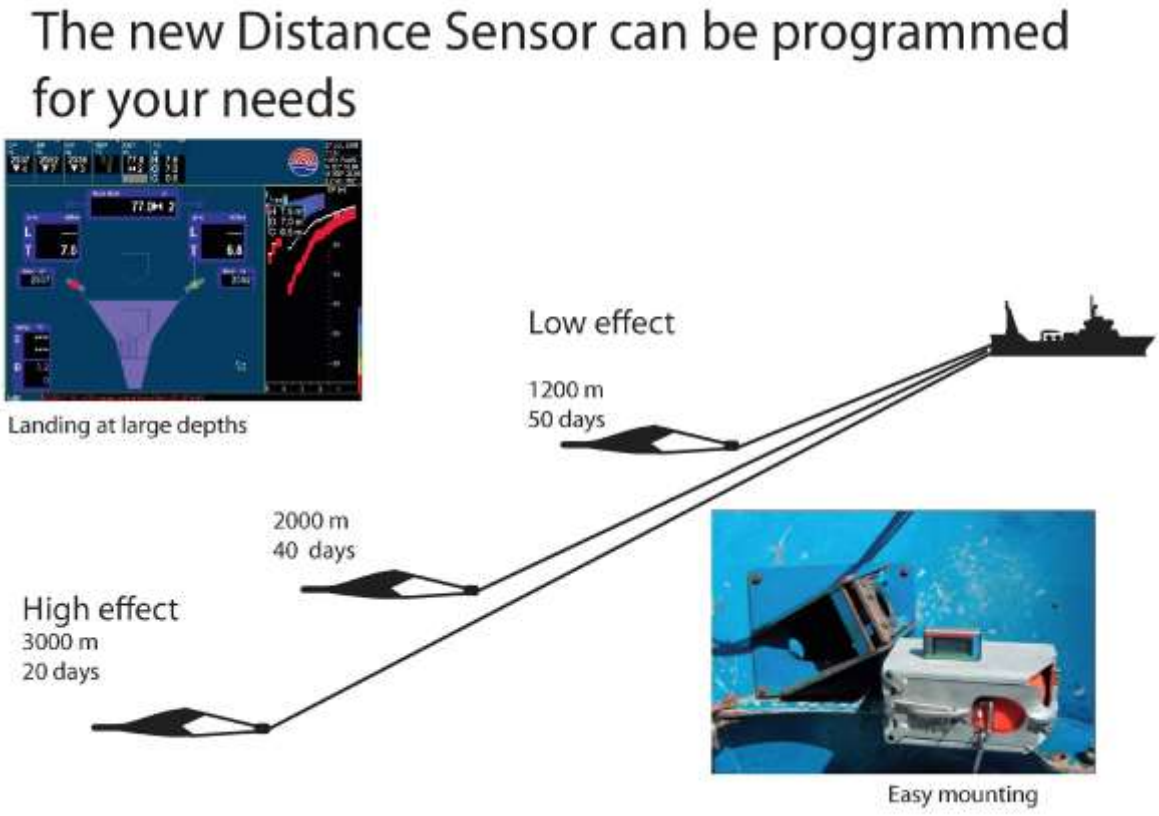
The most advanced of the new *Distance* sensors has <u>everything</u> you could wish for from a distance sensor:

- Several hundred working hours; varies with the setting
- Short charging time
- Charging while attached to the doors
- Programmable sending effect
- Programmable updating rate
- Multifunctional: Can also be combined with *Door Angle*, *Depth* and other functions, either when acquired or later with a simple download of a license.
- Programmed from the bridge
- Automatic programming of bridge unit and sensor

Distance sensors can later be upgraded so that they have full functionality on the same line as the most advanced sensors.

The Slave sensor (e.g. the mini-transponder) comes with all the same attributes and comes in different configurations. The most advanced is the full Slave sensor, which is upgradeable to include all the same functions as the Master Distance sensor. Including the full range of functions will allow fishermen to have a more complete picture of the trawl doors in particular, but the entire trawl setup as well.

In addition, the Slave sensor comes in a simpler variation that a direct replacement for previous mini-transponder sensors except that it requires a different door holder than the old sensors. The new “stripped down” Slave sensor has large battery capacity and is quickly charged, but cannot be programmed or upgraded.



The *Distance* sensors have probably been the sensors that have meant the most to many fishermen, even though some will probably consider *Trawl Eye, Trawl Speed/Symmetry* or *Catch* sensors as the most important, not to mention the new Door Angle sensors. If you ignore the bucket effect and twist of the trawl, the trawl doors' function is what means the most for efficient trawl fishing.

When Scanmar introduced the *Distance* sensor, the battery technology was a big problem and we chose two different updating rates, both acceptable in regards to charging frequency. What is interesting is that producers, who later have tested the market, have chosen the exact same updating, confirming that the choice we made 25 years ago was not bad.

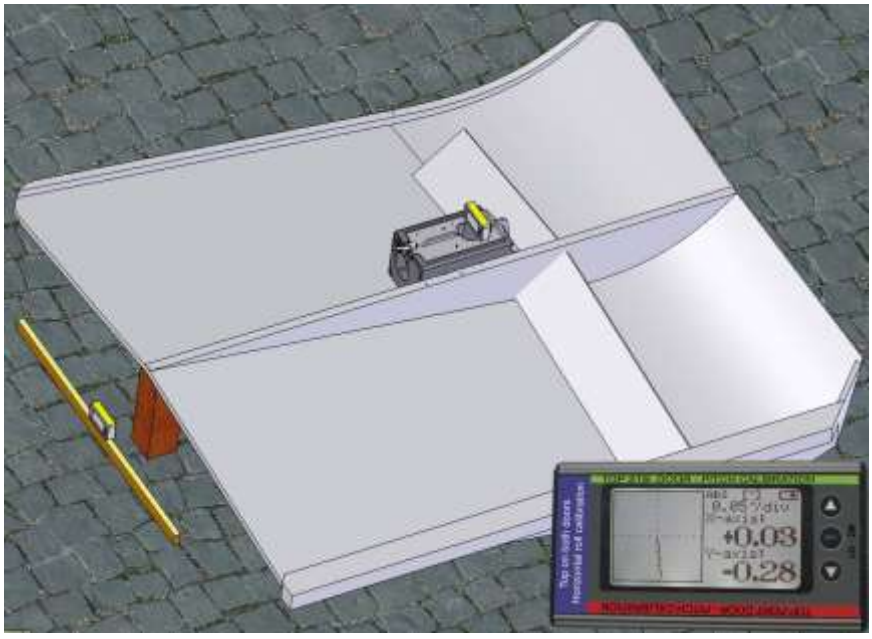
All the new *Distance* sensors from Scanmar are mounted on the doors in the same way as the *Angle* sensors; they are mounted in holders that are welded directly on to the doors, parallel with the door, and not like it is usually done by cutting a hole into the door, even though this is more costly to produce because of the sensors' construction, amongst others because it demands two acoustic senders, one on each side.

The advantages are first and foremost that the same sensors can be upgraded to also show the door angles; as it is 100% required that the sensors be mounted on the doors' vertical and horizontal direction. Besides, the sensor pockets will not stick out on the doors' backside and thereby reduce the spreading force because of the on the current.

2.9 *Door Angle: The Most Important Function?*

The question in the title can of course not be answered just like that, but the fact is that many fishermen claim it to be true. But one is, after all, a little extra excited when receiving something new, so let us look a bit closer at whether the Door Angle function really is the most important function.

Let us first dwell for a moment on the *Distance* sensors. When Scanmar chose to develop Distance sensors more than 25 years ago, it was mainly for the fishermen to know if the doors lie down. Research reports we studied showed that in certain areas errors could occur in 30% of the hauls. Simultaneously, the varying door distance would immediately reveal that something was wrong. But for many the greatest reward was perhaps in connection with the rigging of new gear, after reparations, during shooting etc. In other words, an array of other useful "applications" that were not thought of the first time around came "on their own" after some time.



Correct mounting position is vital to receiving accurate measurements. For more information on how to properly mount SS4 Door sensors, please go to our website www.scanmar.no

Door angles (bottom doors)

Here we are talking about three angles:

- Attack angle: Angle between trawl shoe and towing course
- Roll angle: The door's roll angle inwards (+) or outwards (-)
- Pitch angle: The shoe points upwards (+) or downwards (-)

Scanmar uses the doors' vertical axis (the line from the door's top to bottom) as an indication of the vertical position and roll angle. This is important for a correct and

comprehensive statement of all angles on all the doors and to understand the forces that affect the door.

The fishermen have “always” been most concerned with the Attack angle, and in “the old days”, in the lack of anything better, it was probably sensible. Today the situation is different.

Attack angle

There is a range of different doors on the market and fishermen make their choice based on their experiences, the door’s construction, etc. Regardless of why a fisherman chooses a certain door, there are a number of factors that make a door – any door – as efficient as possible.

There are big differences between the different doors when it comes to attack angle for largest possible spreading force; it can vary from a little under 30° to a little over 40°. The most interesting thing here is that most doors seem to have an area of about 6-8° around the optimal point where they have about the same spreading force in the entire area. This is interesting because one can fish at different depths (change the warp lengths) without it having significant effect on the spreading force. Thus, if the door is rigged correctly for the area being fished in the attack angle can be ignored.

Roll angle

The port door loses bottom contact, the trawl collapses. (1+2) A lot of pitch and roll makes the door unstable and loses bottom contact. (3) the trawl doors lay down and lose contact.

The roll angle is the factor that should receive the most attention. We all have an understanding of the trawl door’s crucial meaning for the trawl to fish efficiently, but do we share the same thought of what actually makes a door efficient?

Studies of trawl door efficiency have been conducted in which the spreading forces and towing resistance are measured in flume tanks. The measurements are taken while the doors are vertical and with different attack angles. Although this can be interesting information, it may perhaps also contribute to taking the focus away from what is important:

What is important is how much the door distance reduces when the door is not vertical; how much do you have to increase the towing speed in order to achieve the same door distance, and how much will the fuel consumption increase as a result of the increased towing speed?

We will look a bit closer at these questions:

If we disregard the forces that emerge from the door's friction against the seabed (relatively insignificant for modern doors), which increases somewhat when the door tilts a little outwards, and reduces when the door tilts inwards, we have the following conditions:

A small roll angle means little: up to 15° means a change of no more than 3-4%. If the angle increases more, up towards 30°, the force reduces by 13-14%, and if we get closer to 45° the change will be 30%. From these numbers it seems that it means little if the door's vertical position changes a bit, but over 15° it will have significant consequences for both door distance and fuel consumption.

Efficiency curves (door distance in relation to towing resistance) for trawl doors have been created, but since they are of little importance in comparison to the significance of the roll angle of the doors and the towing resistance from the trawl, we can disregard it.

We can then make the following, very simplified overview for how much it "costs" to increase the speed in order to obtain the same distance on the trawl doors:

The coefficients for the trawl doors' spreading force and towing resistance is measured in a flume tank when the doors are vertical, and since they are close to each other in value and the majority of the towing resistance (80%) comes from the trawl and gear, we can ignore them in a very simplified calculation.

The towing resistance increases at a rate five times the square force multiplied with the increase in towing speed. This means that if the towing speed doubles from 1 to 2 knots, the towing resistance quadruples. For trawl doors of 4 square meters this means that the towing resistance increases from 400 kg to 1600 kg.

If we imagine the same basis, but the trawl doors tilt approximately 30° inwards, the door area that is responsible for the square force (together with the towing resistance) is reduced by about 0.6 square meters. This means that the towing resistance has to be increased substantially in order to have the same square force, which again leads to a significant increase in towing resistance and fuel consumption.

If the towing speed usually is at 3.5 – 4 knots, the effects will be very significant.

One should focus on the meaning of roll angles between 15° and 30° and then note that the lost square force lies between 5 and 15% and make a rough estimate of how much the towing speed and fuel consumption increase. (NB! Remember to use the correct door size and towing speed in your calculations).

What also is important to many is to make sure to rig a bit differently depending on depth conditions/warp lengths.

Another thing; many do perhaps have trawl doors that are not quite accustomed to the trawl, in which case adjustment of angles, also the attack angles, can be of great significance.

NB! Be aware that when the towing speed increases the doors can straighten up, and a tall trawl will lose its height, so that the towing resistance does not increase as much as the calculations would imply.

Although what has been mentioned above are some of the greatest advantages of using the Door Angle function, there are many other benefits as well:

- In the shooting phase the Door angles instantly show if something is about to go wrong, allowing skippers to interrupt the shooting and wait for the angles to show that the door is in the right position again.

- They are almost indispensable in the landing phase; fishermen immediately see when the doors hit the seabed and can begin to tow before the doors lie down.

- Skippers immediately discover if a door loses contact with the seabed or is about to, so that necessary steps can be taken.

- Errors and damage that occur while fishing are instantly revealed by a change in the door angle.

- The door angles can be adjusted so that they react quickly in pelagic towing near the seabed or surface.

- It is simple to make changes in the towing speed, course, or warp lengths if the doors are in different depths.

We have also received feedback on several other advantages, perhaps especially when fishing semi-pelagic in a lot and varying current, but it would take too long to touch on all the elements here.

2.10 *Bottom Contact sensor; gives increased catch*

A bottom contact sensor that is mounted on a weight suspended by a rope skips along uneven ground. A Scanmar Bottom Contact sensor, on the other hand, has stable bottom contact. Yet we have learned little by little that this is not the most important thing. Yes, bottom gear having good contact with the ground is crucial to good catches of bottom fish. Obvious, you say? Yes, but what is good contact? Well, it can vary.

To give a rough description, we can say that it is appropriate to have hard contact on the bottom when it is hard, uneven ground with a lot of noise. Conversely, it is appropriate to go easy on the bottom when bottom conditions are such that the gear can dig into the surface. But not even this explanation is complete. Demersal species are different, some stay well above the bottom while others burrow down. Moreover, fuel is an item that should not be forgotten. The harder the bottom contact; the greater the towing resistance and fuel consumption.

What makes Scanmar's *Bottom Contact* sensor so useful is the precise angle measurement it provides. The sensor measures the angle in the same way as *Door Angle* sensor. It is therefore easy to detect how hard the gear goes in the bottom and when it has lost bottom contact. This makes it easy to fine tune the gear and adjust how hard the bottom contact is based on the species you fish.

The Bottom Contact sensor has a solid construction.

2.11 *Flow sensors; a new family of current meters*

Through use of Scanmar sensors on fishing and research vessels it has been determined that wind, currents, towing direction and towing speed have crucial meaning for the trawl's ability to catch.

It has been 25 years since Scanmar launched the combined *Trawl Speed/Symmetry* sensor. It was obvious at that time that the fishermen were not familiar enough with underwater currents and the effect these had on efficient fishing. Fishermen towed according to GPS-speed and trusted the winch producers' statements that the trawl was correctly towed as long as the warps were equal and pressure on the winch was the same.

The new family *Flow* sensors consist of combined *Trawl Speed/Symmetry* sensor, pure *Symmetry* sensor and *Tunnelflow* sensor, and a half-brother: the *Grid* sensor.

2.11.1 Trawl speed

All trawls have an optimal water flow. This varies with construction, mesh size, thickness of net material, knots, whether the material is new or old, etc. It is therefore important to tow at a speed that makes the trawl move through the ocean at the speed it was constructed for.

If the trawl moves too fast through the water a type of "bucket effect" is created in the trawl so that a pressure is formed in front of the trawl. If towing too slowly fish, especially larger fish because of their swimming strength and endurance, are given a chance to escape.

Underwater currents, whether they are with the towing direction, against, or from the side, will lead to the water flow into the trawl deviating from what is optimal unless the GPS-speed is changed and the trawl is pulled so that the water current is 90 degrees in relation to the trawl opening.

The *Trawl Speed/Symmetry* sensor gives Fishermen an opportunity to continuously adapt to changes in the water current so they always have the "correct" towing speed and symmetry.

Tunnelflow or Trawl Speed sensor in the belly

Because the trawl's circumference is smaller and the mesh is smaller further back in the trawl, a lot of the water has to get out through the side panels. This is when a "Bucket effect" occurs, which makes the mesh stretch. If this happens in an area with large mesh the fish escape or the trawl will be "coated".

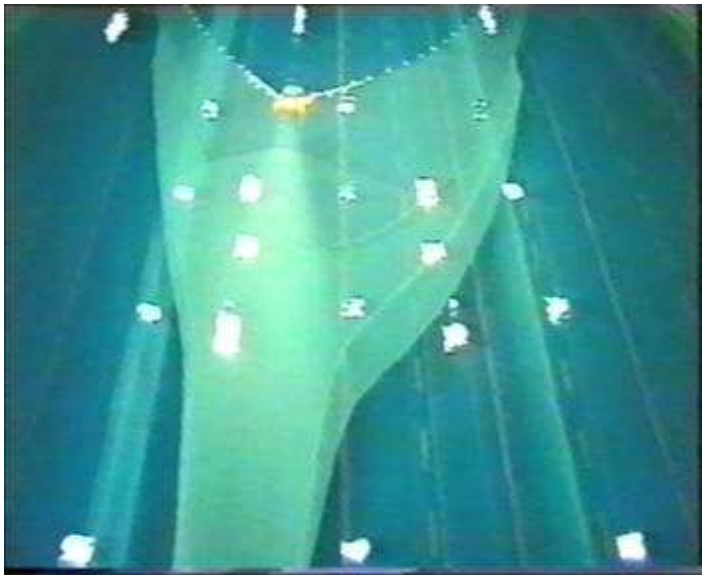
When the trawl bag fills the “bucket effect” will increase and move forwards in the trawl. Therefore we see that it often takes a very long time to fill the front part of the bag. Usually it will pay off to haul in and shoot again.

The *Tunnelflow* sensor shows the water flow and angle changes caused by bucket effects, while the *Trawl Speed* sensor shows the water flow and skewed position. Both show how the water flow is affected by the bucket effect and/or that the trawl is stretched out when the fish get to the back of the belly.

2.11.2 Symmetry

If the trawl does not move symmetrically trough the water current the direction of the water flow (the water flow given from the direction the vessel is moving in and side current) will come at a skewed angle at the opening. In this situation the whole trawl will be asymmetrical, the mesh on the opposite side of the current will stretch, the water flows through trough the mesh, and fish/shrimp escape.

The *Symmetry* sensor has twice the working time as the combined sensor and can be used alternately by changing the battery.



Asymmetry leads to open mesh and direct loss of catch

2.12 *Grid sensor*

Sorting grids were first used in the shrimp fleet (Pandalus Borealis) in the late 1980's. The purpose was to fish shrimp in areas where there were a lot of small fish, without getting this as bycatch. Since then the use of grids has become increasingly widespread and are now being tested in various fisheries.

Scanmar developed early on a highly sophisticated sensor, *Trawl Speed/Symmetry* sensor, which very precisely measured water velocity into and across the trawl opening. To obtain absolute accurate measurements the sensor that was developed had an inclinometer (angle measurer) which was used to correct the measurement if the sensor was not lying horizontally.

It was therefore easy to create a variation of the sensor, the *Grid* sensor, which measures the water flow through the sorting grid and the grid's angle. Shrimp grids (Pandalus Borealis) are most efficient around 45^0.

- Water flow through the sorting grid is the most important observation
  - It is not rare for the grid to be blocked by the skate, seals, sharks, rocks, etc.
  - In some seasons there are large numbers of jellyfish that clog the mesh in the bag, so that water doesn't flow through. When this is the case it's time to end the haul.

- With shrimp (and fish that with no swim bladder) the bag sinks as it fills. It is common to start the haul with an angle above 50^0 and end it when the angle approaches $37\text{-}38^0$.

- Changes in the angle give a good indication of the catch at any time, and the log curve also shows where the influx was the greatest.

Trawl Eye and Grid sensor used on a shrimp trawler. The shrimp influx is visible on the left side of the screen which displays the Trawl Eye's detection. It can also be seen as blue markings in the log image of the Grid sensor to the right. The grid angle has fallen (ascending curve) from about 55^0 to 44^0. Impact in the angle is corresponding to the influx of shrimp.

2.13 *Trawl Eye – an advanced "echo sounder" placed on the trawl*

The Trawl Eye is Scanmar's most advanced sensor. More than a thousand Trawl Eyes have been sold since their introduction in 1990 and we are still alone in the market with such an advanced sensor. The Trawl Eye is suitable for use in bottom trawling as well as pelagic trawling in most fisheries around the world. Many of the species are in fact impossible to see on an echo sounder or sonar, and trawling without a Trawl Eye is like fishing blindfolded.

Because the *Trawl Eye*, when placed on the headline, is close to where the fish are, it has much better detecting ability than anything correspondingly mounted on the vessel. A skipper with experience will therefore easily determine whether it is fish or bait, and if he is fishing for the "right species"and not wasting time and resources unnecessarily.

More and more of those who do pelagic trawling have begun to use an extra *Trawl Eye* in the belly, often together with a *Flow* sensor or an *Angle* sensor, in order to ensure that what they see in the trawl opening ends up in the back of the bag.

Two different types of Trawl Eye

With the many areas of application and different fisheries, Scanmar was quick to see the need for two variations of the *Trawl Eye*. The broad beam *Trawl Eye* was first introduced to the market intended for trawls with low opening and is today largely used for catching white fish. In fishing for shrimp or species that keep close to the seabed, the narrow beam *Trawl Eye* usually offers the best detection abilities.

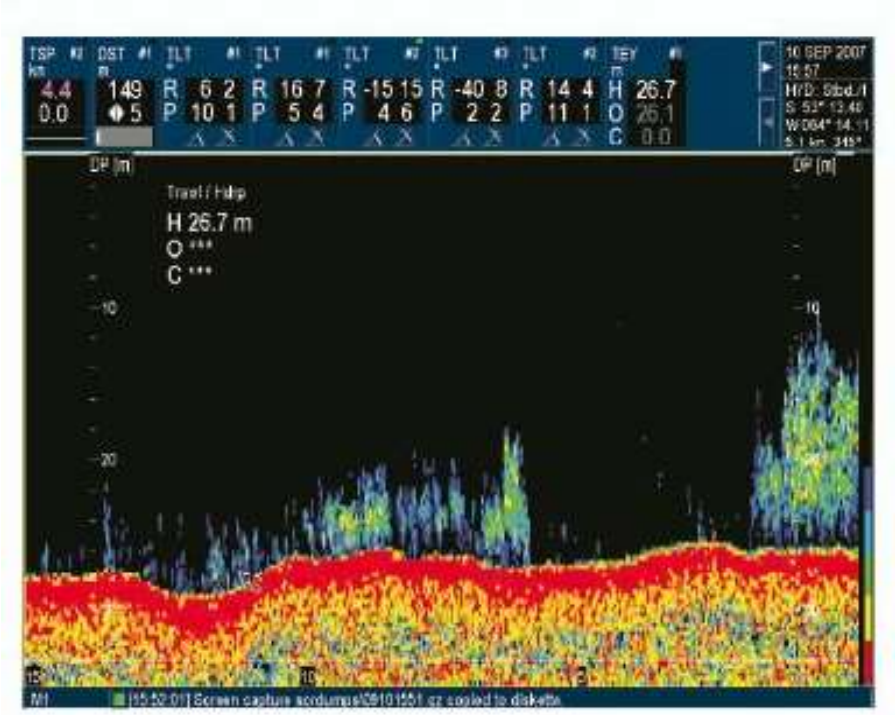
Narrow beam *Trawl Eye* is usually used in pelagic trawling as well.

Bottom trawling

The *Trawl Eye* gives precise information of the trawl opening and contact with or clearing from the seabed. For bottom trawling you can therefore keep the trawl down on the seabed and avoid that it lifts in areas where essentially all the fish enters, i.e. in the center of the trawl.

Amongst the twin rig trawlers there are currently many that use a *Trawl Eye* on each trawl to compare the trawl openings, seabed contact and not to mention the catch entrance. When they have more entrance in one trawl they move sideways so that they achieve maximal entrance in both trawls.

To achieve the best possible results it is important that the *Trawl Eye* is mounted securely tight and directly over the bottom gear. Many trawls have to a greater or lesser extent an overhanging ceiling. With a *Trawl Eye* on the headline one will in this case <u>not</u> be able to determine whether the trawl presses on or lifts from the seabed. In these cases it would therefore be correct to move the *Trawl Eye* back onto the top of the trawl so that it will be as close as possible to being right above the bottom gear. By sowing in a suitable bag into the net line with a safety rope up to the headline, the *Trawl Eye* will be placed precisely and securely every time.



Clear detection of "Hoki" close to the seabed.

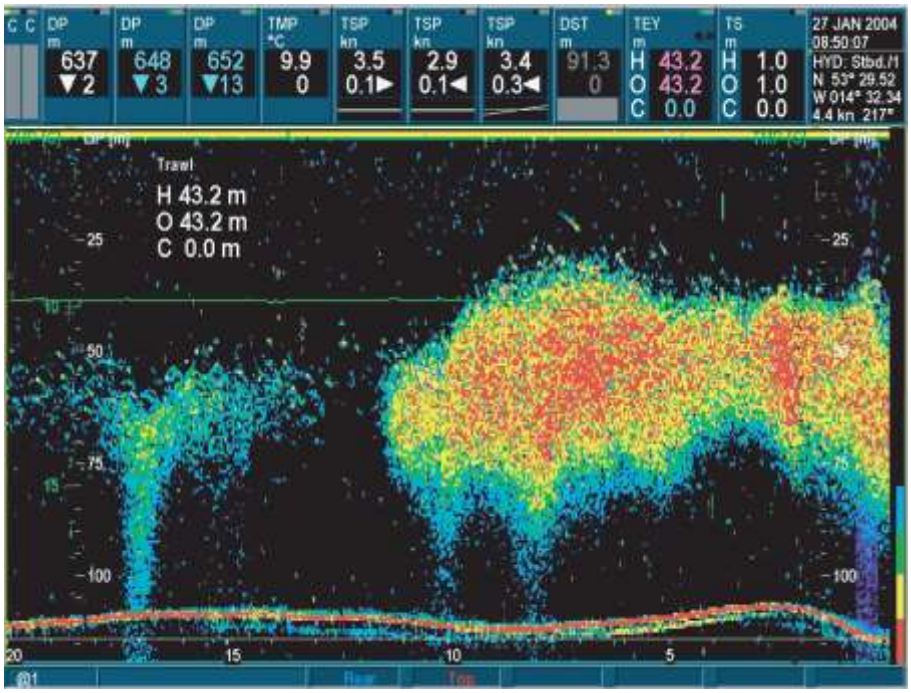
Pelagic fishing

In pelagic trawling, a narrow beam *Trawl Eye* is the most commonly used both in the trawl opening and in the belly. The application areas are more varied in comparison to bottom trawling. Many use the *Trawl Eye* as a headline sensor instead of trawl sonar or for when the trawl sonar is not working because of broken cables or other faults. This allows the fishing to continue. Some skip the trawl sonar in certain types of trawling and only use *Trawl Eye*.

Pelagic fishing when it is important to be as close to the seabed as possible while avoiding landing on the seabed and snagging, the *Trawl Eye's* resolution is vital and trawl sonar does not give sufficient accuracy.

In Iceland we see that skippers use the *Trawl Eye* on the ground rope when fishing closely to the seabed. They use low range, which provides further increased precision. Additionally the *Trawl Eye* is programmed with upward view to see the fish that enters.

The skipper, Gisli Runolfsson, on the trawl Bjarni Olafsson, explains it this way:
- When fishing close to the seabed I always use *Trawl Eye* on the ground rope in order to get as close as possible. I program the *Trawl Eye* to seeing 15 meters up and 15 meters down. On the cable sonar the ground rope is so wide it gives too strong an echo to provide precise information of the distance from the ground rope to the seabed. At the same time the upward view is important in order to see when the herring comes over the ground rope and begins to enter the trawl.

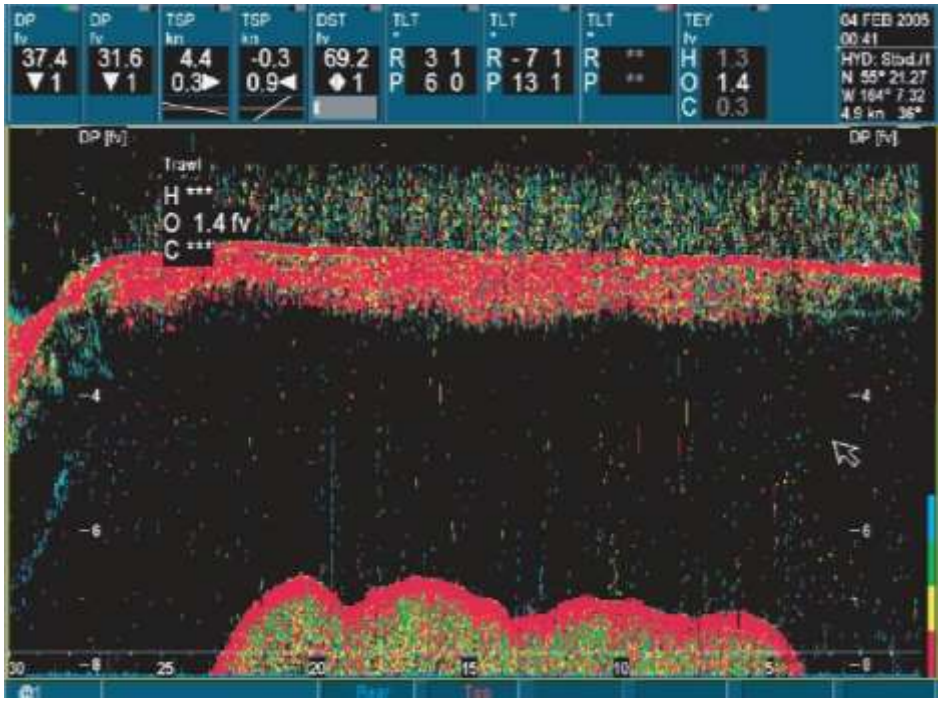


Trawl Eye in the belly

Trawl Eye in the belly is also an important area of use in pelagic trawling. Placed in a net bag stitched into the center of the net ceiling in the required area of the belly, it shows height, entrance, and where appropriate, distance to the seabed. You can also see if any of the fish escape outside or under, or, by programming the *Trawl Eye* to look upwards, over the trawl caused by the fish escaping through the mesh further ahead.

If you do not have the expected opening in the belly, this may be due to poor water flow or simply that the trawl is tangled further ahead (even though everything looks ok on the trawl sonar). As the cod end fills the opening (and water flow) will reduce. In many cases it will be sensible to haul before the bag is completely full and shoot again instead of continuing to tow for a long period of time for the bag to fill completely.

The entrance into the belly also shows if your trawl is correctly positioned vertically in relation to the fish. In many cases the entrance on the trawl sonar turns out to be bait that does not end up in the back of the trawl. Many also use this sensor to register the size of the fish. Large and small fish can use different time from the opening until appearing in the tunnel.



2.14 *Trawl Sounder*

The *Trawl Sounder* is a simplified *Trawl Eye* showing the height of the trawl opening, if the trawl is on the seabed and the distance between the trawl and seabed. It is therefore ideal together with the *SS4 Door* sensors to view simplified trawl geometry, but it's also ideal with a *Trawl Speed/Symmetry* sensor to get full control of the trawl geometry. The *Trawl Sounder* also provides a simplified "sonar" that shows whether it is fish influx and amount of fish.

Mounted in the belly it shows if the height of the trawl is stable or whether there is a bucket effect that allows fish to escape. It also shows the amount of fish that pass and along with a *Trawl Eye* in the trawl opening one can easily see if the fish in the trawl opening ends up in the bag.

The image shows a simple setup with a *Trawl Sounder*, *Door Distance* sensors, *Trawl Speed/Symmetry* and a *Grid* sensor on a shrimp trawler.

The *Trawl Sounder* shows how perfect the landing was, that the towing situation was stable, and the influx of shrimp on the right side of the image.

2.15 *Hydrophones*

Scanmar has developed hydrophones based on recordings and experience with more than a thousand vessels. For vessels with a keel that fish in difficult conditions, we recommend using two hydrophones, one on each side of the keel. The hydrophones can be mounted in the keel or in trunks that Scanmar has specially produced.

In recent years it has become more common for two sets of hydrophones to be installed on new builds. This reflects the change in signal reception as a result of the load and/or fishing conditions, as well as a new feature to reduce the vessel's fright response in fish.

We are pleased to announce that the standard trawl hydrophone consists of three variants:

- **Standard hydrophone**

- **Standard hydrophone with temperature sensor**. Under certain conditions the temperature at the surface provides a good indication of the temperatures further down in the sea. By logging over time, this can give good estimates of the possible existence of fish.

- **Standard hydrophone with noise sensor that measures noise level and frequency generated by the vessel in the low frequency range that fish not only perceive but are scared of.** Change of towing speed/pitch will usually lead to large changes in frequency and noise level (different types of fish have special limited frequency ranges where the influence/intimidation is greatest), so that the fright response is reduced significantly.

- **"Noise Hydrophone"** with properties as described above.

A license for upgrade of the bridge unit is required to use the fright response function.

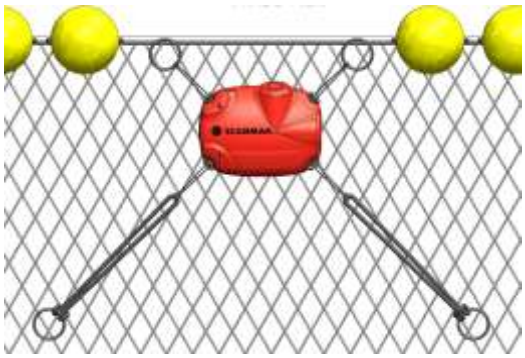
2.16 *ScanSafe – a new mounting kit for faster attachment of sensors*

Our greatest challenge has always been how to find better and less demanding solutions for the fishermen. Simplification of the way of attaching the sensors on the trawl and bag is one of them. The aim has been that it should be easy to attach and detach, that the attachment method must be absolutely reliable, and that sensors should be placed in the exact same place every time so that the data is comparable and reliable when looked at in a bigger context over time.

In the course of the last couple of years we have finally arrived at a design-protected method that satisfies our requirements and we have received very good feedback from those who have started to use the new attachment kit.

The main point is that the attachment material is mounted precisely where you want the sensor to be placed, and that the attachment hook, which is especially developed for Scanmar sensors, new as well as old, slips into the attachment ear. The whole operation takes no more than a few seconds and all the attachment material stays on the trawl.

Trawl and cod end mounting



Headline mounting

Catch mounting

2.17 *Additional equipment*

Mounting kits for trawl sensors

Mounting material such as rubber straps, wire and carabin hooks can be ordered as kits or supplies.

Mounting kits for Door sensors

There are two types of mounting kits for Door sensors; one for the traditional HC4 Distance sensors, and one for the new SS4 Door sensors. The holders have a solid construction of material in stainless steel treated to prevent corrosion.

Door instrument (inclinometer)

The instrument is a useful tool for mounting the Door sensor holders, and is delivered to all vessels with the first holder. It is being used to mount the holders parallel with the doors vertical axis.

Chargers

Charger QBC-X1 is for charging all Scanmar's sensor batteries, except the Trawl Eye battery. The charger is also a programming and test unit with a number of useful functions.

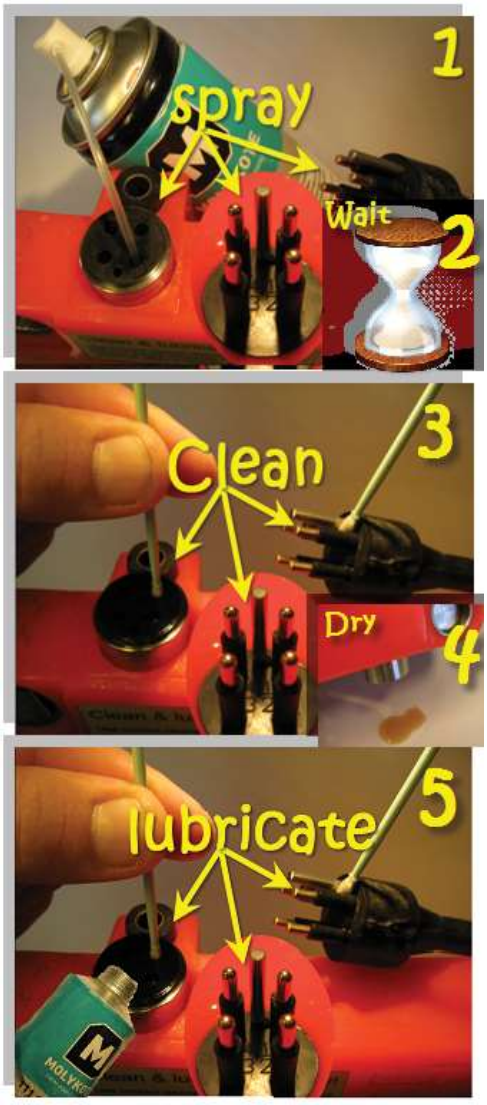
Charger TBC-05 is for charging the Trawl Eye battery.

Trawl Eye – weekly cleaning & lubricating procedure

If the connectors on the Trawl Eye battery and charger are not kept clean and lubricated there will be leakages and build-up of contaminants on the connectors. This will create an electrical circuit when the Trawl Eye is submerged in seawater and a corrosion process will start. Low pressure on the O-ring sealing will also cause leakage and corrosion, eventually leading to defective connectors. We therefore strongly recommend that you use our new maintenance kit for weekly maintenance to ensure the durability of your Trawl Eye and reduce repair costs.

The kit consists of a contact cleaner, grease compound and foam tips for keeping connectors clean and lubricated. It also includes new support rings for the Trawl Eye battery to enforce the O-ring's sealing. The increased pressure from the support ring makes the lubrication even more important.

Cleaner, grease compound and foam tips are available as supplies after the first kit.



1. Use Molycote S-1002 electrical contact cleaner with tube installed and spray the cleaner on the connectors (Trawl Eye battery and charger). Fill the holes completely in the battery connector.

2. Allow to soak for 1-2 minutes.

3. Manually scrub the contacts with the foam tip and remove contaminants and dirty silicone. **Do not use Q-tips (cotton swab)!** Using Q-tips may result in small cotton fibers inside the connectors, which will lead to leakage and corrosion.

4. Shake/drip out remaining fluid and allow to drying. Use compressed air if available. Inspect the connectors. If not clean, repeat step 1 to 4.

5. Lubricate with Molycote 111 Compound. Use a clean foam tip to apply a thin layer into the holes and on the pins (battery, Trawl Eye and charger).

3 Catching Technique

3.1 *Catch systems - increased efficiency with modern trawl instrumentation*

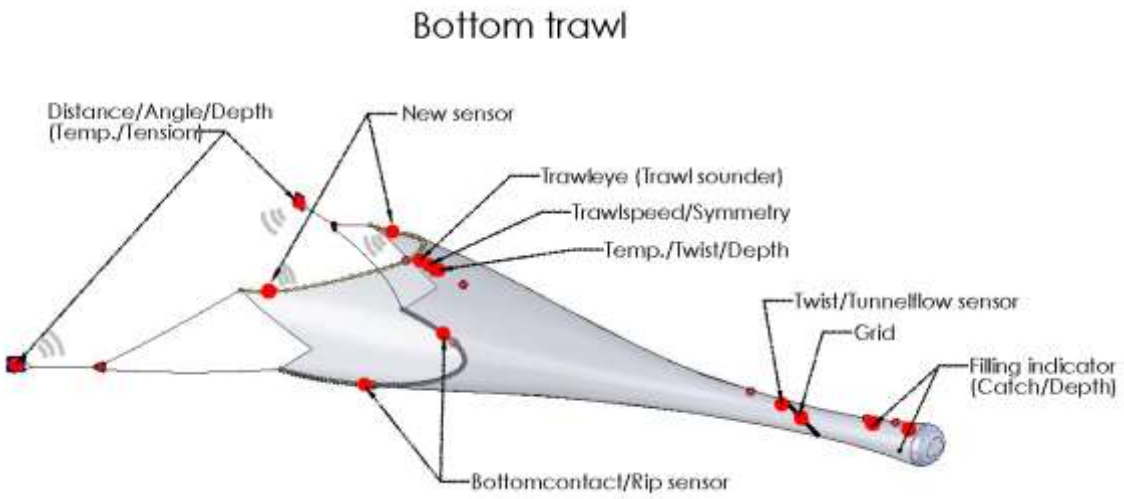
We have no ambitions nor the knowledge to take on the task of teaching fishermen how to fish, that goes without saying, but through 30 years it has been appreciated that we convey knowledge that we pick up, some here, and some there. With more than 4500 Scanmar systems delivered, we have observed a lot and we have tried new things, so we have gained a knowledge base that may be of use to some.

If what we describe here does not fit with your experiences (35.000 species are fished around the world), then it may be that you still pick up on an idea or thought you can ponder.

In this article we will in a simple way describe a few of the problems that can arise while fishing and different things you can possibly do in order to improve the situation as best you can. For simplicity we will keep to single bottom trawls and pelagic trawls, but where it is relevant it also applies to twin rigs, pair trawls, semi pelagic trawls, shrimp trawls and Danish seiner.

Everything we refer to here is what fishermen have done in different situations and which we believe has been of great help to them.

3.2 *Bottom trawl – description of sensors' functions and value*



The illustration shows a large bottom trawl equipped with relevant sensors for fishing in difficult conditions. It goes without saying that on smaller trawls, and when fishing in local, known conditions, one can do with fewer sensors. But there are those who use more sensors than illustrated here. This concern mainly Filling sensors (Angle) or Catch sensors on the trawl bag for registration of precise GPS position where there is fish entrance. Then you can turn and re-sweep where the fish entrance is good instead of continuing the towing haphazardly on the same course. There are also those who want one or two extra Angle sensors on the headline and trawl if the currents affect the trawl geometry (twist).

Many of the sensors shown can either be individual sensors or multifunctional sensors. The illustration depicts the following sensors with an explanation of how they work:

1. On the trawl doors

Door Distance

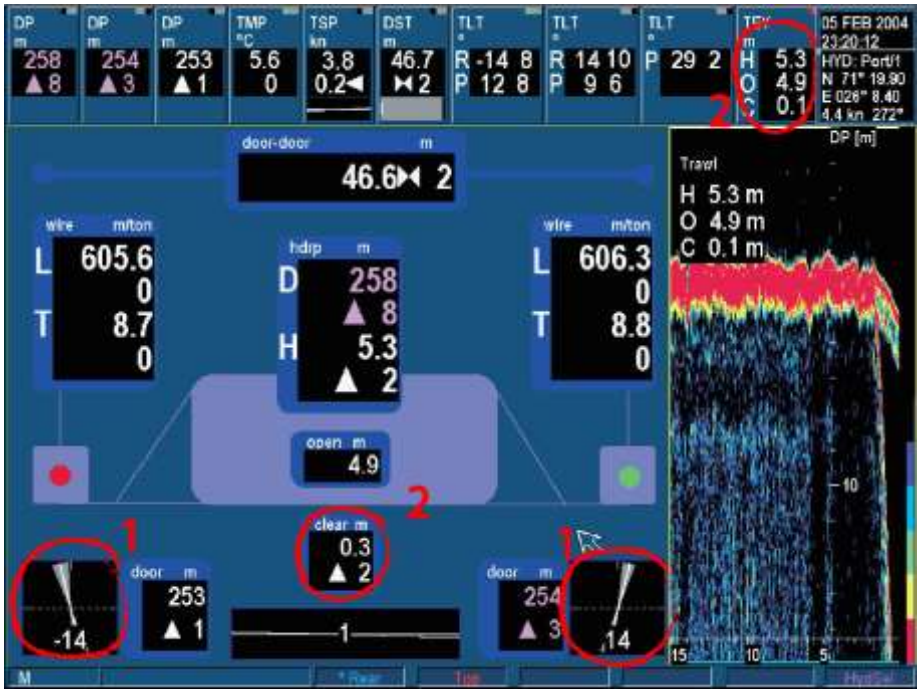
The Door Distance function shows the distance between the doors and, if applicable, at what speed the distance changes. The sensors also show if the door sensors are not in contact with each other because the doors have lain down or are out of position.

The sensors are very useful in the shooting phase because one can early discover problems that may arise.

In the towing phase the sensors give a decent picture of whether the doors have the distance they are supposed to have or if the door/trawl snatches so that the distance changes quickly. They also show how the distance is reduced when the bag fills up or changes as a result of a change in towing speed because of underwater currents or changed vessel speed. Warp length changes also affect the door distance.

Any change in door distance has an effect on the sweeping angles, the trawl's seabed contact and fishing ability.

Information about the door distance can also be important in order to avoid problems when hauling in difficult conditions.



The trawl doors (1) have lost contact with the bottom and the trawl (2) is lifting.

Door Angle

The Door Angle function shows the trawl door's roll and pitch angles as well as the door's roll and pitch stability (*ScanFactor*).

In the same way as the Door Distance function, the Door Angle sensor gives important information in the shooting phase.

Moreover, the Door Angle sensor is very useful in the landing phase: the angles change immediately when the trawl door hits the bottom and it is possible to start the towing before the doors lie down. A lot of time can be lost before the doors rise and towing lying doors and a collapsed trawl can easily lead to damages.

The Door Angle function will show if damages have occurred on one of the doors, if there are problems with the fixing of the warp lines, or if the back straps are incorrectly adjusted. Both the angle measurement and *ScanFactor* will immediately show if something is wrong.

Considering as the bottom trawl gains square force both from water currents and seabed contact, the roll and pitch angles are important for the doors' spreading. The

pitch angle is normally set according to the nature of the seabed; the roll angle is of importance for the door's pressure on the seafloor (the pressure increases when the doors tilt outwards and reduces when the doors tilt inwards). The square power from the water current is largest when the doors are vertical. Accurate Door Angles are therefore the most important factor for the doors to operate optimally. Most efficient Door Angle depends on and varies with seabed conditions and current conditions/towing speed.

When the doors have low stability (high *ScanFactor*), it can be a sign that the doors are about to lose contact with the seabed or lie down.

Adjustments of the warp lengths and changing the towing speed will have an impact on the door angles as well as the doors' stability. Filling of the cod end has the same effect: the larger the resistance in the trawl, the greater the powers that go through the sweep lines and doors will be the result is increased lifting forces through the warp lines. The greater the relationship between the lengths of the warps and the depth (small angle), the smaller this effect will be.

Depth

The Depth function has gradually become common also on the bottom doors; that they can be combined with other Door functions with long lifetime make it even more attractive.

The Depth function on the doors is especially good to have in the landing phase. The doors can be placed on the seabed at the right moment, just before the trawl lands, and the towing can start without problems.

In the towing phase the Depth function, especially in combination with Door Angle, gives immediate information if the doors leave the seabed during the haul. The combination is especially important in the rigging in order for the trawl to fish effectively with minimal towing resistance and without losing contact with the seabed.

Tension

Tension sensors mounted on the trawl doors are used in two different ways, either by measuring the tension in the warp lines or in the sweep lines. Primarily researchers use them, but they can also be advantageously used in commercial fishing.

Tension in the warp lines is used for regulation of the winches because the measurements are more accurate than the measurements that can be done on blocks and winch drums.

Measurement of the tension in the sweep lines is a suitable way to measure the trawl's symmetry: equal tension in the sweep lines means the trawl is in "balance" around the water currents that travel through the trawl.

Temperature

Temperature measurements on the trawl doors are important when fishing in areas with varying temperature. The reason is that the fish often are positioned in areas where the current brings bait, or because fish (shrimp) of different sizes stay in different temperature layers. If the temperature is different for each door it might be smart to change the course and tow in the temperature layer one believes to give the best catch.

The Temperature sensor is necessary regardless, both because it is interesting to log together with fish occurrences for later use, but also because the speed of sound in water greatly varies with the temperature. Temperature correction of echo sounder data has begun to spread (it will become very common as soon as people become more aware) and it can also be necessary with correction of the Door Angle measurements for an accurate door square.

2. On the trawl wings

Distance sensor

Researchers and certain larger fishery companies are the main users of distance sensors on the trawl wings. They are used to measure correct horizontal trawl opening, but usually together with Distance sensors on the doors. Then you achieve the right distance as well as being able to experiment to achieve most efficient sweep angles. Correct angle varies with species, season, time of day (lighting), depth, temperature, etc.

3. On the headline

Trawl Eye

The Trawl Eye is a sensor that is indispensible for larger trawls and twin rigs. On the Trawl Eye you can see height of the trawl, if the bottom gear is touching the seabed, distance to the seabed and entrance of fish and shrimp. The Trawl Eye has a good resolution and shows fish close to the seabed, fish that go undetected by the echo sounder on the vessel.

On a twin rig information is registered from the entrance of the two separate trawls, such as information to change the course, so that optimal entrance is achieved in both trawls.

Most fishermen go back and study the Trawl Eye picture to see where the fish entrance was good. With the newest software version the Trawl Eye picture can be rewound and therefore give a better picture resolution than what has been the case before.
The Trawl Eye comes with two batteries so that the sensor always is ready for use because the one battery can be charged while the other is used for fishing.

Trawl sounder

The Trawl sounder is a simpler version of the Trawl Eye, but with rougher and less detailed registration of the fish entrance.

Trawl Speed/Symmetry sensor

Those who understand and can use this sensor cannot do without it. It gives the trawl speed through the water (simply, water speed into the trawl opening), which is different from GPS speed where there are underwater currents and where the underwater current that enters the trawl is skewed.

The trawl speed consists mainly of two components: the vessel's GPS speed (speed over the seabed) and any underwater currents, the component that works with or against the trawl's towing direction.

Correct trawl speed (relative to the trawl's construction) is important because it is crucial for the trawl's efficiency and fuel consumption that it is towed with the correct speed (through the water – not over the seabed). If the towing speed is too low, there is a lot of fish that do not enter the trawl, if it's too high bucket effects will arise, which allow fish to disappear through the panels instead of ending up in the cod end.

Correct towing speed is important for the fuel consumption. In accordance to all laws of physics, the resistance will increase with the square of the speed increase. This means that if the water current speed increases because of a counter current (on the seabed), the towing resistance will increase more than you tend to believe, and thus there will be a significant increase in fuel consumption.

The Trawl Speed sensor is the sensor it has taken the longest time to help the majority of fishermen understand the value of. Some understood and benefitted from it early on, but most were used to the GPS speed being the same regardless of currents. Perhaps they did not consider that there could be other currents at the seabed (not to mention along slopes).

The symmetry part of the sensor gives information if the water currents are skewed when they enter the trawl opening. If this is the case, the trawl mesh will close on the one side and the bag will bellow out and the mesh will be stretched on the other so that fish and shrimp disappear.

Many took what some winch producers said literally: equal warp length and the same pressure on the drums. Now we (and they) know better. It is important to adjust the warp length so the water current enters the trawl opening symmetrically.

Symmetry sensor

The Symmetry sensor is the exact same as the Trawl Speed/Symmetry sensor described above, except only measurement of the skewed water current is activated, thus achieving longer battery lifetime.

The fishermen can make the choice between the two solutions. The programming lies in the battery and by changing the battery you can choose the most appropriate solution at any time.

Angle sensor

An Angle sensor mounted on the headline/top of the trawl immediately shows if the trawl is incorrectly rigged/unstable by showing changes in the pitch, because the line/top of the trawl is moving vertically. This is a larger problem than most recognize and it weakens fishing ability because the problems travel backwards in the trawl.

A skewed trawl caused by construction or rigging can be seen horizontally. This often leads to a twist in the trawl, which bothers many pair trawlers.

Depth sensor

A Depth sensor is primarily useful in the landing phase; with a Depth sensor on the trawl and trawl doors it is easy to place the trawl on the seabed and avoid loss of time before the trawl starts to fish.

Together with a Temperature sensor the Depth sensor gives a perfect temperature profile from surface to seabed. This is used to correct the echo sounder picture by automatically providing the correct speed of sound in water, regardless of what setting the echo sounder has. This is a big problem and is the reason that the use of sea map data is not as common as it could be (the depth that is registered with the echo sounder will always vary with the temperature of the ocean).

Temperature sensor

Temperature sensors have been used to determine the possibility of fish being positioned at a certain temperature, based on personal experiences with the species being fished. Different species can thrive in different temperature layers.

The most common use is to find currents where the fish stays and grazes on bait that travels with the current.

The temperature sensor is also used to some extent when it comes to the size of fish/shrimp being caught because fish/shrimp size can be temperature dependent.

4. Bottom gear/belly

Bottom contact sensor

The Bottom contact sensor is an Angle sensor that primarily shows whether or not the bottom gear is on the seabed.

Even more important is to see how hard the gear hits the bottom. This primarily concerns hard/soft seabed, so that one has good contact but avoids that the gear digs

down. The species being fished and the current conditions are also elements that are very critical for how the gear should be rigged to achieve desired contact.

Rip sensor

As opposed to before, where Tension sensors were used as Rip sensors, we now see that an Angle sensor is a better alternative (Tension sensors can be used). Not only does is show immediately if the belly splits or problems arise with the bottom gear, but often changes in the angle can catch the problem so early that the damage can be reduced significantly; in some cases be avoided all together.

5. The trawl

Twist sensor

Twist sensor is often the term used when an Angle sensor is used on the trawl net. It primarily shows twists in the trawl, which causes loss of catch and can indicate that there are other problems with the trawl, for example snatched mesh, etc.

The Twist sensor also shows longitudinal angle changes. Bucket effects caused by fish piling in the tunnel are often the source. A bucket effect in the trawl is also created when the bag is turned 180° so that the water flow is reduced.

The sensor will also immediately show if there are damages on the trawl and if foreign elements have entered the trawl. We have registered submarines, but trash and lost fishing equipment is more common; in the northern Pacific/Okhotsk Ocean lost crab and shrimp pots are common examples. It's important to be alerted early so that large damages can be avoided.

Tunnelflow sensor

The sensor shows the water current in the trawl and changes in longitudinal angle. This is an alternative to the Twist sensor, but shows changes in the water current instead of twists in the trawl.

The Tunnelflow sensor can also show, in the same way as the Twist sensor, if the trawl or bag is twisted, with reduced water flow as a result.

Grid sensor

The Grid sensor has been in use for more than 20 years and has primarily been used on shrimp grids to keep an efficient grid angle and give information about blockage of the grid.

Sorting grids are relevant for other species and are being tested on different types of grids with different grid angles.

6. Cod end

Catch sensor

The Catch sensor was one of the first sensors to hit the marked. The sensor is based on a tension meter and is activated when the trawl bag is filled up to the point where the sensor is mounted.

The sensor is most suitable for traditional diamond mesh that open across the length of the trawl.

Because of the bucket effect that is created in front of the fish in the trawl bag, the measurements can be a bit uncertain seeing as the trawl bag expands before it is completely filled up. Besides, the water flow becomes very low and because the fish is drifting/swimming, the sensors can often be activated and deactivated a few times before they are stably activated.

In addition to the sensor showing when the trawl bag is filled to where the sensor is mounted, it also gives a clear indication that something is wrong if it is not activated. Some use the sensor specifically to see where they have good entrance and often turn for a new haul where the entrance is good.

It is common to use several sensors, both to see the entrance and to follow the filling to improve hauling and production.

Filling sensor

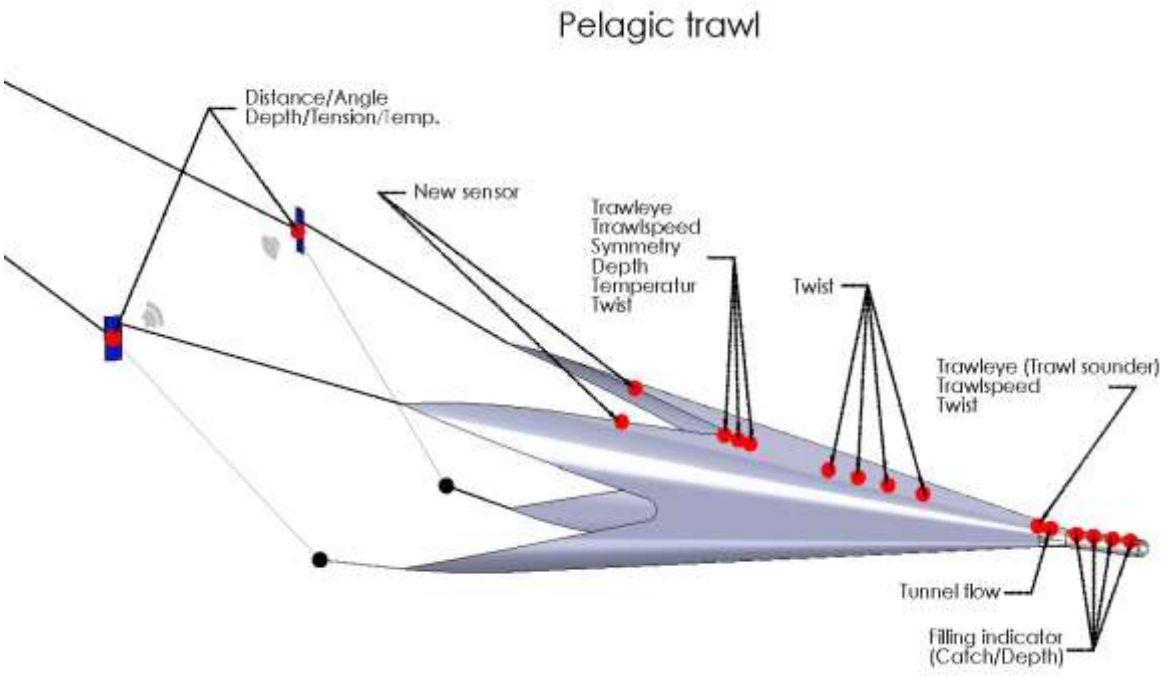
The Filling sensor is the new Catch sensor and is based on responses from the angle along the cod end as a consequence of the bag filling up. When you have gained some experience you will find that it is more accurate than a traditional Catch sensor.

The Filling sensor is suitable for all types of trawl bags, and compared to the Catch sensor it is more suitable for bags with good water flow, constructed with T-90 or square mesh.

While on a traditional Catch sensor you can estimate deposition of the entrance when the bag is filled to where the sensor is attached, a Filling sensor will immediately show angle changes continuously and is especially sensitive to registering entrance/filling.

The Filling sensor shows Twist of the trawl bag and notifies when something is about to go wrong. Twist of the trawl bag often occurs in the shooting phase, especially when fishing with a grid.

3.3 *Pelagic trawl – description of sensor functions and value*



The illustration shows a large pelagic trawl equipped with relevant sensors. It is obviously fully possible to manage with fewer sensors, but the illustration has been created to more easily explain how certain problems can be solved.

There are also those who use more sensors than shown here; which primarily concerns Angle sensors on the headline to view the horizontal position when turning, or if there are difficult currents, or several Twist sensors on the trawl to see if Twists or Bucket effects are created.

The sensors depicted can either be individual sensors or multifunctional sensors. The illustration shows the following sensors with an explanation of how they work.

1. On the trawl doors

Door Distance

The sensors show the distance between the doors, and at what speed the square changes. The sensors also show if the door sensors are not in contact with each other due to the doors being out of position in relation to the other.

The sensors are very useful in the shooting phase because one can discover problems that arise early on.

In the towing phase the sensors give a decent picture of whether the doors have the desired distance or have changed due to changes in the towing speed because of underwater currents or changed force. Changed warp lengths can also affect the door distance.

When hauling in difficult conditions information about the door distance can be important in order to avoid problems.

The Door Distance sensor is perhaps the sensor that has been of greatest importance to the majority of fishermen.

Door Angle

The Door Angle function shows the trawl's roll and pitch angles as well as the door's lateral and longitudinal stability.

In the same way as the Door Distance function, the Door Angle function gives important information in the shooting phase. You will be fully aware of whether the angles are as they should be or if something is about to go wrong after only a short period of using the sensor.

The Door Angle function together with Door Distance and Depth is a combination many see as indispensible in pelagic fishing. Increasingly more see the advantage of including temperature compensation in order to obtain 100% accurate depth position for fishing shoals and trawl and precise distance between the doors. Distance measurements on the new SS4 Door sensor are automatically compensated for temperature, making the most accurate measurements on the market today.

The Door Angle sensor will show if the doors are not as they should be as a result of problems with the securing of the warp lines, back stoppers being incorrectly adjusted or the vertical sweep angles being unequal (which is quite common).

The sensors indicate whether or not the doors have the correct roll angle throughout the haul. This is particularly important when changing course to "catch" a shoal, because the change leads to the doors being on different depths and it may take some time before they are on equal depth again, which is necessary when catching the shoal to avoid twist and bucket effects in the trawl.

The roll angle, i.e. how much the doors tilt inwards or outwards, is important regarding the trawl`s response to a speed increase of the vessel and adjustments of warp lengths. This of course concerns where it is necessary to make rapid changes; one should perhaps be especially alert when fishing close to the surface or seabed.

Adjustments of the warp lengths and changes in the towing speed will have an effect on the door angles, as does the filling of the cod end. The greater the resistance in the trawl, the greater the powers that travel from the trawl through the sweep lines will be.

We have, on several occasions, registered that the trawl doors have different pitch angles: a 10-degree difference is not uncommon. We do not know what this means for the efficiency of the trawl, but we do see that it results in increased tension in the sweep lines so it probably means that the trawl is vertically skewed.

Depth

The Depth function on the trawl doors has become indispensible to many in pelagic fishing, especially since Scanmar combined it with the Door Angle sensors, eliminating the problem of the short battery lifetime between each charging. This has now been further improved.

Shooting is done very precisely and efficiently by shooting the doors a certain number of fathoms below the shoal so the trawl sinks quickly, then the doors are lifted to the desired depth so that the trawl is immediately positioned where the fish are. Temperature compensation can often be useful in this situation.

When trawling at the surface or close to the seabed, the Depth function gives a security that the trawl is exactly where you want it to be.

In the same way that the Symmetry sensor revealed how inefficiently a trawl fishes when it is not horizontally symmetrical, negative effects have been registered when the trawl is not horizontal. This means that it is deeper on one side, causing Twist in the trawl and often bucket effects both being factors that allow fish to disappear through stretched mesh. With control over the Door depths this can be avoided. Still, at least with a lot of current it may be an advantage to have Depth sensors on both sides of the headline.

Tension

Tension sensors mounted on the trawl doors are used in two different ways: either by measuring tension in the warp or in the sweep lines. Primarily researchers use them, but they can also be advantageously used in commercial fishing.

Tension in the warp lines is used to regulate the winches because the measurements are more precise than the measurements done in blocks and winch drums.

The measuring of the tension in the sweep lines, both over and under sweep, on both sides can be smart, especially when it comes to the rigging. A lot indicates that uneven tension in the over and under sweep lines leads to a vertically skewed trawl.

2. On the headline

Trawl Eye

Although it is natural for many, because of experience and practicality, to use trawl sonars in pelagic fishing, there are many who use Scanmar Trawl Eye instead. This is due to different factors. For some, ice destroys the cable, for others it’s illegal to use cables because of birds. Some alternate between Trawl Sonar and Trawl Eye depending on what they are fishing and then there are those who state that they get more relevant data from the Trawl Eye.

To many the Trawl Eye is important because they want more details about the fish entrance and to compare what they register on the Trawl Eye mounted in the tunnel and what ends up in the cod end.

The amount registered in the Trawl Eye is also relevant to bucket effects that occur further back in the trawl when the fish moves back. A large entrance indicated often that the speed should be reduced in order to avoid bucket effects that make the trawl stretch and the fish escapes, a very common phenomenon.

The Trawl Eye comes with two batteries so that the sensor is always ready for use, because the one battery charges while the other is used for fishing.

Trawl Sounder

A Trawl Sounder is a simpler version of the Trawl Eye, but has a coarser and less detailed registration of the fish entrance.

Trawl Speed/Symmetry sensor

Those who understand and can use this sensor cannot be without it. It shows the trawl speed through the water (simply, water speed into the trawl opening), which is different from the GPS speed when there are underwater currents and skewed water currents that enter the trawl from the side.

The Trawl Speed consists of primarily two components: the vessel's GPS speed (speed over the seabed) and any underwater currents that work with or against the trawl's towing direction.

Correct trawl speed is important because it is crucial for the trawl's efficiency and fuel consumption that the trawl is towed at the right speed (through the water, not over the seabed). If the towing speed is too low there are species that are impossible to catch, if it is too high bucket effects will be created which allow fish to escape through the panels instead of ending up in the cod end.

Correct towing speed is important for fuel consumption. In accordance to all laws of physics, the resistance will increase with the square of the speed increase. This means that if the water current speed increases because of a counter current (under water), the towing resistance will increase more than you tend to believe, and thus there will be a significant increase in fuel consumption.

The Trawl Speed sensor is the sensor it has taken the longest time to help the majority of fishermen understand the value of. Some understood and benefitted from it early on, but most were used to the GPS speed being the same regardless of currents. They did perhaps not consider that there could be other currents under water.

The symmetry part of the sensor provides information if the water currents that hit the trawl opening are at a skewed angle. If they are the mesh will close on one side and the trawl bag bellows out and the mesh will stretch on the other, allowing fish to escape.

Symmetry sensor

The Symmetry sensor is the exact same sensor as the Trawl Speed/Symmetry sensor described above except that only the skew measurement of the water current is activated, thus achieving longer battery lifetime.

The fishermen can make the choice between the two options themselves. The programming lies in the batteries and by changing batteries you can choose the solution most suitable at any time.

Angle sensor

An Angle sensor mounted on the headline/top of the trawl immediately shows if the trawl is incorrectly rigged or unstable by showing changes in the pitch angle, because the line/top of the trawl moves vertically. This is a bigger problem than most realize, and it reduces the fishing ability because the problems move down the trawl.

It can be vertically skewed as well. From what we have seen while fishing, by viewing the depth of the trawl doors, which are often unequal, different tensions in the over and under sweep lines on both sides, different pitch angles on the doors, seabed contact in semi pelagic trawling and especially statements from pair trawls, indicate that vertical skews are not an insignificant problem. This often leads to twists in the trawl. Especially the pair trawlers seem to be bothered by this, but in pelagic fishing there is also reason to believe that it leads to great losses of fish that are already in the trawl.

Depth sensor

Depth sensors are necessary on a pelagic trawl in order to be certain that the trawl is at the exact depth it is supposed to be.

The shooting is significantly simplified when the depth of the headline is compared to the Depth sensors on the doors.

Temperature sensor

In certain pelagic and semi pelagic fisheries, the Temperature sensor is crucial in order to be able to place the trawl in the temperature layer the fish is positioned in.

A Temperature sensor (together with a Depth sensor) is also necessary to be able to register the temperature profile in the ocean and correct the echo sounder picture so that it shows the correct deep for the shoal.

3. The Trawl

Twist sensor

Twist sensor is often the term used when an Angle sensor is used on the trawl net. It primarily shows twists in the trawl, something that causes loss of catch, and can also indicate that there are other problems with the trawl, for example hooked mesh.

Twist sensors also show longitudinal angle changes. They are often caused by bucket effects, which are created by fish piling up in the tunnel or in front of it. One or two Angle sensors placed in this area will show changes in the angles so the speed can be reduced if needed, and will lead to the fish ending up in the cod end instead of escaping through wide open mesh.

The bucket effect in the trawl is also created as the trawl bag fills. We have registered that when the bag is approximately two – thirds full it will not be filled any more, or will fill very slowly due to the bucket effect affecting the entire trawl.

The sensor will also immediately show if there are any damages to the trawl and if there are foreign objects in the trawl. We have registered submarines, but it is more common with normal trash and lost fishing equipment; in the northern Pacific/Okhotsk Ocean lost crab and shrimp pots are typical examples, both for bottom trawlers and semi pelagic. It is important to be notified early to prevent damages.

Trawl Eye sensor

More and more fishermen have started to use Trawl Eye on the belly and for some it is completely indispensable.

With the Trawl Eye mounted on the belly you can easily see if it is fish or krill that enter the cod end, and thus whether or not to continue fishing.

The Trawl Eye is also useful in order to estimate the size of the fish getting caught; the time it takes from the fish entering the trawl until it is in the belly gives an indication to the size of the fish. A large fish usually uses a lot more time than a small fish.

The Trawl Eye also shows how the height of the belly increases when there is fish entrance and how it reduces when the bag is “full”; bucket effects in the bag travel to the belly.

Tunnel flow sensor

The sensor shows the water flow in the tunnel and changes in longitudinal angle. This means that as a shoal moves backwards in the trawl the sensor will show both how the water flow is reduced and the bucket effect created by the shoal.

This provides a clear indication of how many fish are passing and therefore an early notification of when the bag might overfill because of the amount of fish.

Changes in the water current show if the trawl is stretched out (straightened) when the fish enter the trawl; a lot of fish are lost because the stern of the trawl is turned when the fish pass through.

Grid sensor

The Grid sensor has been used for more than 20 years and has mainly been used on shrimp grids to keep an efficient grid angle and give information on blockage of the grid.

Sorting grids are relevant for other species and are being tested on different types of grids with different grid angles.

4. Trawl bag

Catch sensor

The Catch sensor was one of the first sensors to hit the market. The sensor is based on a tension meter, and the sensor is activated when the trawl bag is filled to the point where the sensor is mounted.

The sensor is most suitable for traditional diamond mesh that opens across of the trawl longitudinally.

Because of the bucket effect that occurs in front of the fish in the trawl bag, the measurement can be somewhat uncertain because the trawl bag expands before it is completely filled. Moreover, the water flow becomes very low and because the fish drifts/swims the sensor can often be activated and deactivated a few times before being stably activated.

In addition to the sensor showing when the trawl bag is filled to where the sensor is mounted it also gives a clear indication that something is wrong if it is not activated.

It is normal to use several sensors, both to see the entrance and to keep an eye with the filling to improve future hauling and production and avoid overfilling.

Filling sensor

The Filling sensor is the new Catch sensor and is based on changes in the angle along the vessel as a consequence of the filling of the bag. After some experience one will find it more precise than a traditional Catch sensor.

The Filling sensor is suitable for all types of trawl bags, and compared to the Catch sensor it is more suitable for bags with good water flow, constructed with T-90 or square mesh.

While on a traditional Catch sensor you could estimate the entrance when the bag is filled to the point where the sensor was mounted the Filling sensor will immediately

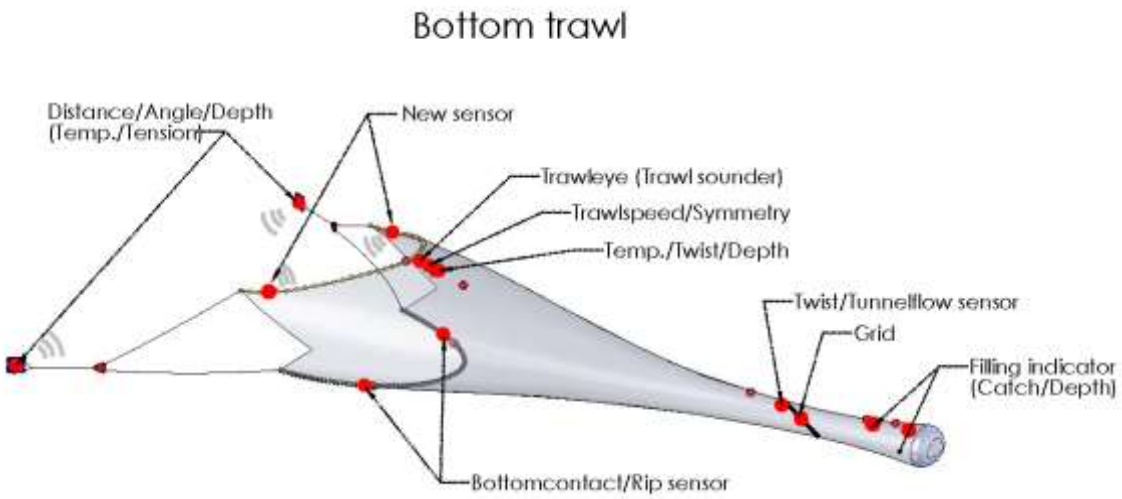
show continuous fluctuations in the angle and is especially sensitive in registration of entrance/filling.

By using several Filling sensors on the trawl bag it has been registered that trawl bags have a tendency to twist when the fishing starts and that the twist is reduced as the trawl bag fills up. In the observed cases this has been a very good indication of the trawl's filling degree and rate.

The Filling sensor also shows twist in the trawl bag and alerts when a problem may arise. It is also perfect for controlling the filling rate and avoiding overfilling.

3.4 *Bottom trawling – Some tips for maximal benefit from your Scanmar system*

How modern instrumentation can help you increase catch, minimize fuel consumption and reduce repair and maintenance costs.



It is nearly 30 years since Scanmar developed the first Catch control systems: Trawl Eye/Trawl Sounder, Distance sensor, and simple Depth, Catch and Temperature sensors. We have received feedback from fishermen all over the world and there is no doubt that most of them are very satisfied with the results they have achieved thanks to Scanmar systems.

Many have told us how difficult it was (in the beginning) to believe what the sensors showed, but their understanding grew as they gained more experience and so did their benefit from using the new sensors. Changes were made to the rig, towing speed, and virtually across the board when it turned out it would increase efficiency and improve the economy.

What we appreciate the most, however, is when we hear of how some who have learnt to benefit from the systems under difficult conditions in areas where they previously were not able to fish.

Scanmar's latest new, the ScanBas and ScanMate series of bridge systems, new Trawl sensors, Multifunctional Door sensors, Flow sensors, etc, do not relieve the fishermen of their challenges, but in return they definitely have a great impact on the fishermen's economy.

Many have told us this, but all have also emphasized the sensors' lifetime between each charging and that you can practically "forget" about charging.

Most fishermen have their experiences and their way of doing things, but we still receive inquiries of how such and such problems can be solved, and we have therefore decided to create a general overview based on what fishermen have told us.

Before shooting

1. Before the fishing starts it is generally important to control that the trawl doors, trawl and gear are in order, and that warp and the sweep lines are attached to the doors in such a way that the doors work perfectly in relation to the fishing depth, warp lengths and the towing speed. One should especially check this if there were inconsistencies in the previous haul.

2. The trawl doors should be rigged so they stand nearly vertical when you have the desired square, or perhaps tilt inward a bit. Then the forces from the water are maximally utilized. When fishing on a soft seabed, or pelagic/semi pelagic close to the seabed, we recommend letting the doors tilt inwards so that they respond quickly should it be necessary to lift the trawl. Normal pitch angle is 5-10°, but increases on difficult seabed.

   - When the warp lengths increase, the doors tilt inwards, and when reduced they straighten up and tilt outwards.

   - When the towing speed (water speed in the trawl opening) increases, the doors will straighten up/tilt outwards, and the opposite if the towing speed is reduced.

   - If you are going to fish in an area where you go from shallow to deep water, or vice versa, you should rig the doors so that you have an optimal angle for the main part of the haul, while there can be some over/under square in the beginning or at the end.

   - If the doors are lightly touching the seabed and the square is increased, the doors can easily lose contact with the seabed if the doors are greatly tilted inwards.

   - **NB!** It has been common to mark the trawl wires every 50 meters, and when the wire length needed to be changed one would use these markings. With Scanmar Door Angle sensors (and correct rigging) we see that the need for adjustments normally concerns only a few meters.

3. Ensure that the sensors are correctly mounted on the trawl and are charged.

   - The Trawl Eye should be mounted on the top of the trawl precisely over the bottom gear. Then you see whether or not the gear has contact with the seabed.

   - The battery in the Trawl Eye should be changed between each haul.

   - The new SS-4 sensor generation with *ScanPower* Smart batteries has such a long battery lifetime that there is no need for frequent charging,

at least no more than once a week, but in most cases much rarer. If in doubt, put on the charging clamps and check. A few minutes in the charger will be enough to complete a haul anyways.

- With older generation sensors you have to be more careful and charge like you are used to.

4. That you have control over the door distance and door angles in the shooting phase means that there are fewer problems than before, while simultaneously, due to information from the trawl sensors, there has occurred an array of problems which one was not aware of before: mesh is caught, mess with the bottom gear, twist of trawl/bag, etc.

    - Pay attention during launching that what you can observe looks OK. Is there something you are unsure of? Stop. It saves time in the long run.

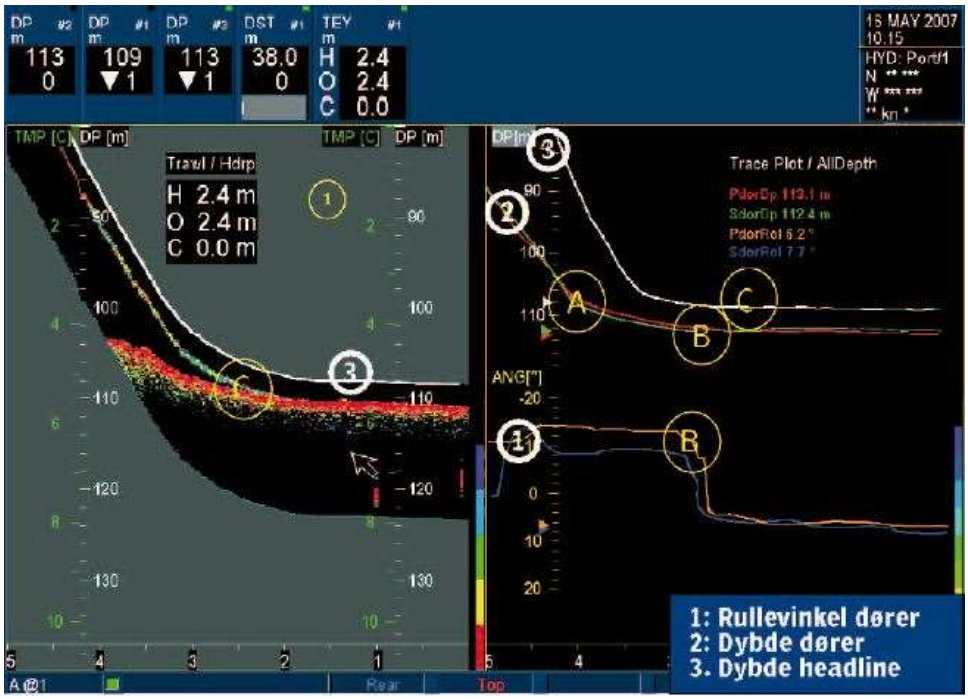
Shooting phase

5. Scanmar's Door Angle, Depth and Distance sensors give full control in the shooting phase; you can see the depth of each door, the distance between them and that they have the right angle so problems do not arise. Should there be indications that problems may arise it is easy to correct with the winches.

    - Much more often that you might think (or discover) problems arise in the shooting phase; it can for example be simple things like mesh getting caught on the bottom gear. **NB!** When there is something abnormal on the screen the smartest thing to do is to interrupt the shooting and haul to see what is wrong. It is usually foolish to hope the problem will fix itself; normally a small problem will only grow to become a big one.

    - Angle sensors have generally proven very useful during the shooting phase by showing immediately when something begins to go wrong. By monitoring the Door Angle sensors one can immediately see if the door angles change so that problems may arise. Therefore the shooting can be interrupted so that the doors can regain their normal shooting angle. On the trawl and cod end the Angle sensors show if mesh is caught, the trawl is twisted, etc.

    - With bottom trawling it has proven to be smart to stop the shooting when the doors are a couple of meters above the bottom, wait for the trawl to sink to the same depth, and place the trawl and doors on the seabed about the same time. Then you avoid the doors lying down, being dragged along the seabed and damaged. On the contrary, the doors will land elegantly, straighten up and the fishing starts immediately.



The landing phase as it is displayed on the screen.

The landing phase is executed as follows: First the winch brakes are applied when the doors are approximately 10 meters above the seabed (A).
The door's sinking decelerates, while the trawl continues descending at the same speed.
When the doors have landed on the seabed (B), the boat speed increases somewhat, the doors straighten up to the vertical, the spread increases, and shortly after that the trawl lands on the seabed (C).
The entire operation takes around two minutes from when the winches are braked until the trawl is in the correct position to start the haul – with no problems of the doors falling over or other problems.

Towing phase

6. During the towing phase there are only three ways to affect the trawl: change towing speed, change the warp lengths, or change the course. That the alternatives are few does not mean that it is simple; changing one of these factors will impact one or both of the others, while affecting the trawl in several different ways.

7. While fishing you might end up in deeper water. Then you must shoot more wire (depending on length/depth compared to the warps) so the doors do not lose contact with the bottom. This will lead to increased door spread and changed door angles. This can lead to the following problems:

   - Overspread of the doors: the bottom gear loses contact with bottom.

   - Not enough door spread (too large roll for the door angles), the bottom gear is not stretched out; the height of the trawl will be unstable and most likely reduced, depending on the rigging.

- The door angles will change and the doors can be unstable and possibly lie down or lose contact with the bottom, which immediately leads to the bottom gear losing contact.

- If you go from deeper to shallower water you will have to consider shortening the wires (reduce door distance) and increasing the towing speed to find the most optimal solution.

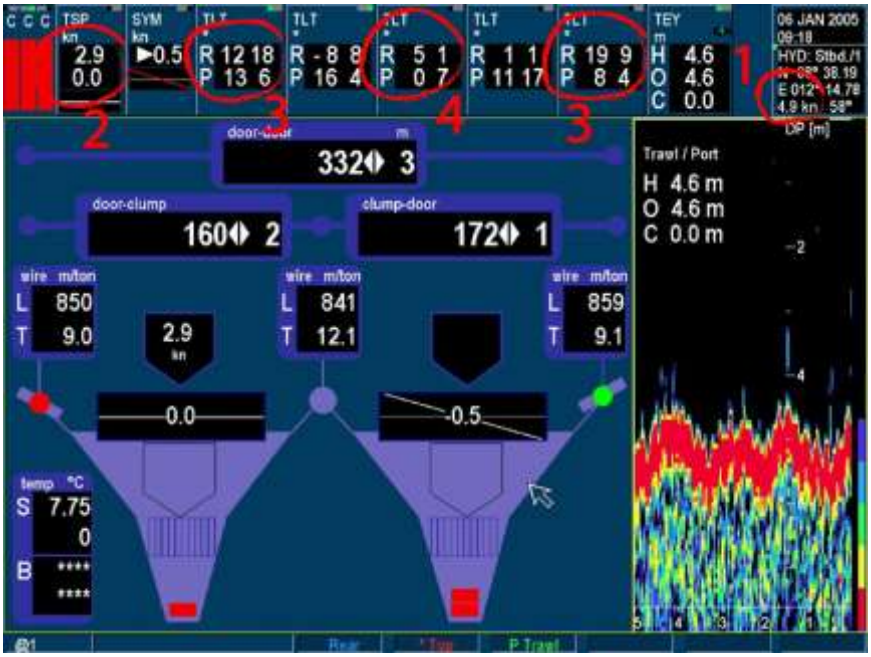
- An incorrect door spread also leads to the trawl and bottom gear not acting like they should and this leads to the bottom gear easily getting caught or the trawl ripping.

When the spread is different from what is optimal, there is no easy and/or perfect solution. You must always try to find the best balance; change towing speed (water current into the trawl) and warp lengths until you have the solution you believe is best at any time.

NB! Always attempt to have the spread as correct as possible.

Trawling on edge: (1) the trawl doors on separate ridges depths 675 and 660 meters (2) in between the trawl 690 meters.

8. In modern fishing one will always come into areas with underwater currents, maybe not only one, but two simultaneously. This is difficult to solve, but again you must search for the best compromise, even if it is far from perfect. We can look a little at the effect of an underwater current.



The fishing is occurring in very strong current (1): GPS 4.9 kn., (2) Trawl speed S 2.9 knots. This makes the doors unstable (3), but the twin rig and gear press hard in the seabed (4), allows the bottom contact to be kept.

- If the underwater current comes from behind it means that the speed of the trawl through the water is lower than the speed the trawl is made for, and lower than the GPS speed. Thus the GPS speed must be increased with the difference between the trawl speed (from the Trawl speed sensor) and desired speed, otherwise fish with great swimming strength will disappear before in reaching the trawl opening.

  Current from behind will also reduce the pressure on the trawl doors and make them unstable. The result is also a reduction in the square. The solution is to increase the towing speed so that it is correct, but it may also be necessary to shoot more wire to hold the square up. How full the bag is will affect how much the door spread changes when the trawl speed changes.

  NB! In situations like this with strong current from behind it may be profitable to just trawl with the current. Then the fixing of the warp and back strap should be changed so the doors are forced to stand vertically or perhaps so that the doors tilt outwards at the beginning of the haul.

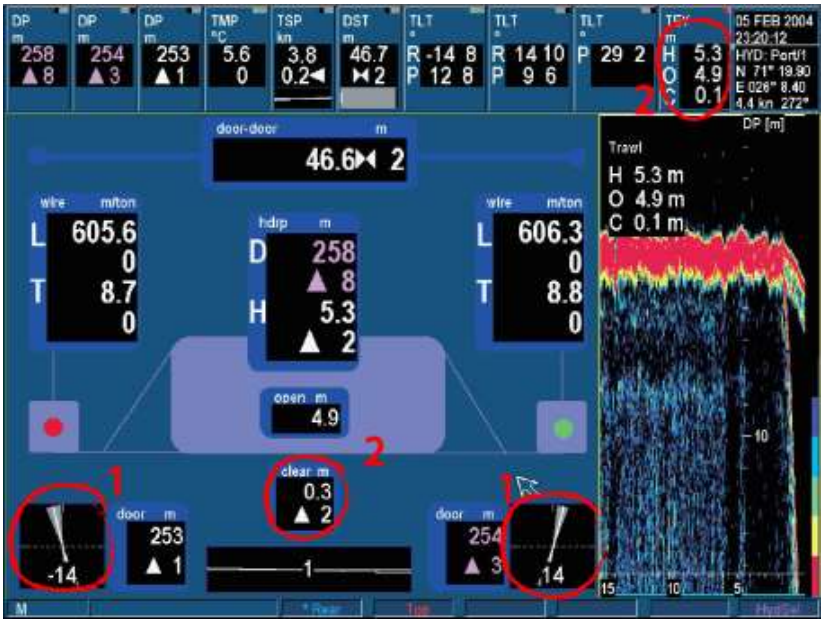
- If the underwater currents are against the towing direction, the GPS speed has to be reduced (the trawl moves quicker through the water), otherwise there will be a bucket effect in the trawl opening and in the trawl. The bucket effect in the trawl opening makes it easy for fish to escape, while inside the trawl it will lead to wide open mesh and fish will escape through the panels.

- An underwater current that is not 100% with or against the speed direction will, together with the vessel's movement, lead to the current meeting the trawl at an angle from one of the sides. Unless one corrects this by having different warp lengths, the trawl will not be symmetrical around the water current. This will also lead to the mesh being closed on one side and wide open on the other and the current and fish going out through the side panel.

  Scanmar's Trawl Speed/Symmetry sensor also shows side currents (Symmetry = water current hits the trawl opening at 90°). A skewed trawl is ineffective and this is obvious to more and more. Fishermen correcting for the side currents is done with the help of the winches, and modern auto trawl systems can do this automatically because of information provided by Scanmar's Symmetry measurements.

- Another effect of side currents is that when the one door has more area towards the current than the other, the door angles will change unevenly and lead to the doors standing in different vertical positions. It is common, when fishing in the same area and knowing the current conditions, to rig the doors differently.

- If fishing in an area where two different currents occur at the same time, for example tides from two fjords or the outlet of two rivers, it can often pay off, if possible, to fish with/against the current direction for the one current and adjust for the other.



The trawl doors (1) have lost contact with the bottom and the trawl (2) is lifting.

9. If during a haul one ends up in areas where the seabed conditions change, both the square and the door angles change. This is due to the square forces that spread the trawl doors, which comes from both the water

currents and from friction against the bottom. It is difficult to comment specifically, but it can be mentioned that one can try to change the towing speed and/or the warp lengths to correct this, but if the change in seabed conditions is big is likely to be most profitable to haul and change the rigging of the doors to achieve different angles before the fishing continues. Another option is to rig the doors so that they easily hit the bottom and thereby get a larger proportional square force from the water masses.

10. As the cod end fills, the weight of the fish and increased water resistance will lead to increased tension in the sweep lines, which leads to reduced square. Increased towing speed can compensate for this, but unless the towing speed is much lower than what the trawl is constructed for, the situation will worsen. Shooting more wire can be another solution but it can also cause problems, especially for the door angles and the door stability. A different problem is that the increased stretch that occurs in the sweep lines will propagate further onto the doors and warp and may cause the doors to lose contact with the bottom, and the same with the bottom gear.

Twist and Bucket effect = stickers

The water currents that enter the trawl will always create a bucket effect somewhere in the trawl`s. Where this occurs is dependent on the speed of the water current in relation to the trawls construction, mesh size, etc. If the towing speed is low this will have little effect because the bucket effect occurs in the trawl bag. One must however be aware that twists in the trawl, changes in course, and fish entrance can also be of significance to the bucket effect.

A twisted trawl will not only lead to fish disappearing under the trawl where it is twisted, but also lead to unwanted bucket effects that means lost catch.

12. Scanmar's new generation of Pingers, SS4 *ScanSense*, consists of Catch, Depth, Temperature and Rip sensors, all with built-in Angle meters that show Pitch (bucket effect, fish entrance and filling) and Twist of trawl and bag. The sensors have been widely used for some years now, but show

that there are other advantages that can be part of increasing the catch. Some examples:

- When a sensor is mounted on the trawl just behind the headline, it shows the angle of the trawl, both in the perpendicular and longitudinal directions. Besides, it shows whether or not the trawl is stable.

- We have seen examples where the angle on the top of the trawl has been as much as 20°, while the height simultaneously showed large movement up and down. This can explain why sometimes one cannot detect the bottom gear or why one has jumping values. But more importantly it is evidence that something is wrong.

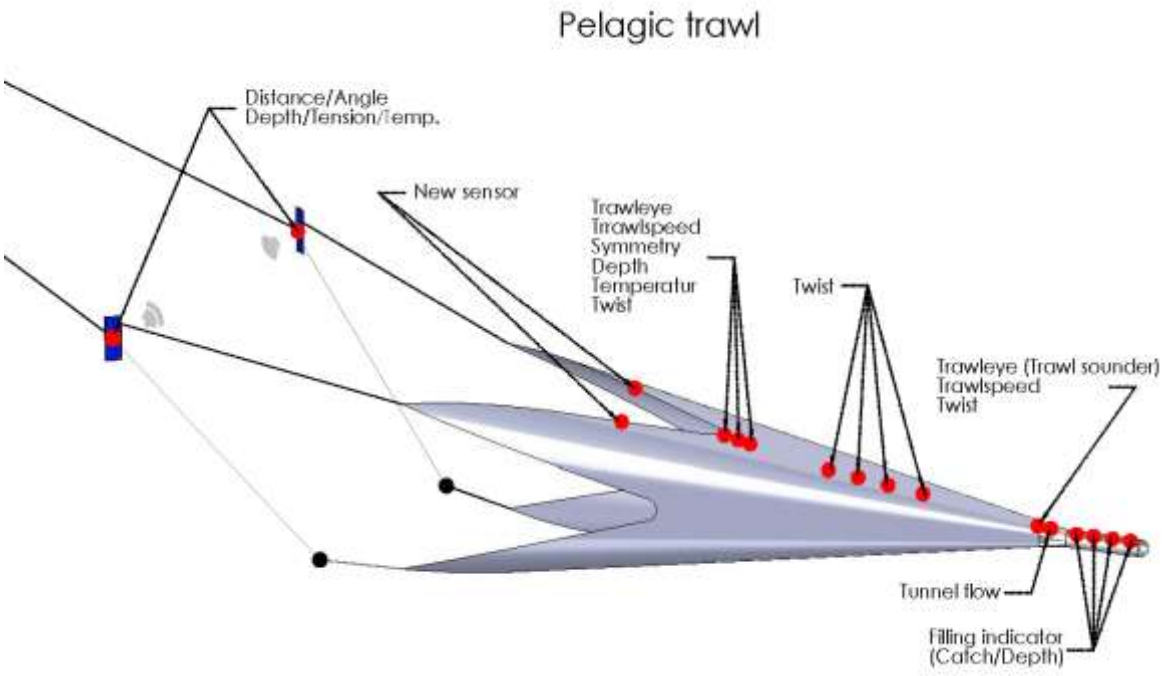
- We have seen similar effect on the Roll (Twist) angle. On pelagic and Semi-pelagic trawls it may be a result of the doors being on different depths, while on a bottom trawl it can indicate damage, improperly working doors, or tension damage on the bottom gear.

- By attaching several Angle (Twist) sensors on the trawl net, we have discovered that the trawl is often twisted, so often in fact, and so much, that we think it may be a big problem in pelagic fishing. Fish escape through the deformed mesh and a lot of the fish that escape are hurt or dead. We have also observed how the pitch angle changes when fish move to the back of the trawl; not only does it show fish entrance, but it also shows that the bucket effect occurs when the fish pile up, and again leads to fish escaping.

- What has been said about the trawl can be said even more strongly about the cod end. A twisted bag is actually a very common situation and the use of grids in fishing can often enhance the problem. Catch/Angle sensors provide, in addition to normal quantity information, a clear indication of the filling rate because the angles change with great precision. When using T-90 mesh it is absolutely necessary to use an Angle sensor. The same applies when a lot of rope is used to reinforce the sack; then it is difficult to make the tension sensors work 100 %.

- To use combined Depth/Angle sensors on the cod end can often be very useful, especially when hauling; it is easy to avoid the sack hitting the seabed where there is a danger of ripping. But also when fishing for species with little buoyancy it can be useful to see if the bag can hit the bottom.

3.5 *Pelagic trawling – a lot to gain with simple means*



There is always an array of things you can do to increase the efficiency and reduce the fuel consumption. In pelagic/semi pelagic fishing the expression "every little bit counts" seems to apply.

Fuel consumption is a very significant cost in pelagic trawling. It is possible to obtain meaningful savings and therefore many should perhaps think a bit differently than they do today where we look at fuel consumption per hour or per day instead of looking at it in relation to tons of fish caught.

When it comes to pelagic trawling we have, based on conversations with innumerable fishermen, formed an impression of what the largest challenges are: positioning of the trawl, correct towing direction, correct towing speed, flow through the belly and level of filling/filling rate.

One of the things we appreciate the most in Scanmar is when we receive feedback from fishermen who actively try new changes and adjustments, especially when the results are good and they are willing to share their experiences with others.

We will not attempt to hide that these experiences are of great value to us when it comes to the development of new sensors and presentation of the bridge units, for example from pelagic trawling:

- Trawl construction
- Positioning of the trawl and trawl doors at the right depth
- Towing direction
- Water current measurements

- Fish entrance
- Twist and Bucket effect in trawl and cod end
- Filling rate, avoid overfilling and ripping

We will look closer at each of these points and especially point out what others have done with the help of information from new Scanmar sensors.

Trawl, bag and trawl doors

When fishing for different species, for example herring, capelin and blue whiting, and in different grounds, the fish will be positioned at different depths, but also in different ways, so that different technique is required to catch the fish efficiently.

If one can come to a solution where there is essentially only need for one trawl, one bag, and one set of doors, one has come far. Experiences we have knowledge of indicate that large gains can be achieved by using a smaller trawl, wider belly, longer intermediate section and a bigger bag than what has been common to use. Then you achieve reduced towing resistance, reduced bucket effect and that the fish that you see at the trawl opening end up in the cod end.

One set of trawl doors can also be sufficient for the trawl to work optimally at different depths if a good "general solution" is found; then adjustments can be made with the help of different weights, wire length, sweep line length and setback.

Positioning of the trawl and trawl door at right depth

Door Distance, Angle and Depth sensors are of great help in the shooting phase and when it comes to quickly positioning the trawl at the right depth.

For the sake of clarity we would like to note that the speed of sound in water varies with the temperature of the water, and in greater depths there can be different temperature layers that can make it difficult to know the accurate depth of the shoal that is picked up on the sonar or echo sounder. In this case the temperature profile on the Scanmar system will be helpful.

Wind, currents and other conditions can make it difficult to make the doors stay at the same depth. To achieve this (and it is more important than most think) it may be required to change towing direction.

Strong current that affects the trawl doors (1) leads them to tilt separate ways and move at different depths.

Towing direction, towing speed and fish entrance

A very common occurrence and a very serious problem in pelagic and semi-pelagic fishing is that good fish entrance in the opening often is not reflected in corresponding amount of catch in the bag.

It goes without saying that Trawl Speed and Symmetry sensors are of great use in order to achieve correct towing speed and direction, but the fact is that many have discovered that using Trawl Eye and Trawl Speed sensors in the belly can be just as useful. An explanation can be that the shoal's size, positioning, and how it moves means a lot for how the water flow in the trawl will be. This is quite different from what you would expect.

Twist and Bucket effect

Good water flow through the tunnel and intermediate section is essential for the fish to get to the cod end. That incorrect towing speed can be a cause of poor water flow is something most people have learnt, but it might also be due to a number of other reasons. Some of them are mentioned above and we will name a couple more.

A large fish entrance creates greater Bucket effects than a small one and it occurs further in the front of the trawl where the mesh is bigger and the fish disappear. It has therefore proven to be reasonable to reduce the towing speed when the fish entrance is good.

Another observation we have made the last couple of years it that both trawl and bag have a tendency to twist. This contributes also to the formation of bucket effects in the trawl and that the towing speed should be reduced.

Trawl Eye and Trawl Speed sensors/Tunnelflow sensor or Twist sensor in the belly provide complete information of what is going on in the trawl and if what you are doing is correct.

Level of filling and filling rate

In pelagic/semi-pelagic fishing the filling of the bag is of great importance in the sense that if a normal cod end is filled two-thirds a bucket effect will be created further ahead in the trawl and the result of continued towing is continued consumption of fuel without increasing the amount of catch.

In pelagic fishing it is also so that large amounts of fish can be caught in a short period of time. The level of filling and filling rate in these cases are extremely important, either to avoid overfilling and ripping of the bag or to get ready to haul.

Scanmar's new *SuperCatch* sensor, whether it is with a traditional Tension sensor, Angle sensor or a combination, can be programmed with immediate updates (normal updating time is more than a minute because of signal processing).

3.6 *Bottom trawling – simple steps to improve the efficiency – tips for smaller trawlers*

A while back there was not much information or tools to use during fishing. When Scanmar "invented" the Catch Control System and introduced the first Catch, Depth, Temperature, Height and Distance sensor it was revolutionizing and fishermen were very satisfied with the new systems.

We know more now and can ask ourselves the question: Was it not as smart as we thought? Do not misunderstand, most fishermen have had great use of the systems, but the danger is being so content with what you have that you forget to be critical and ask question whether you are using it to its full potential etc.

There is still a lot to gain for absolutely everyone who fish with a bottom trawl, whether they have Scanmar's most advanced Catch Control, or nothing at all. The key lies within learning more about what you do and using it in practice.

Scanmar's new advanced systems have been written about many other places, but here we will look at the basics, where there is a lot to gain for a new user and maybe a bit to learn for those who have done this for a while as well. Thirty years experience and cooperation with fishermen have at least taught us a lot, which has made us view things with new eyes.

Towing phase

The towing phase is the most time-consuming operation in a haul, and besides larger losses and damages it is this that is crucial for efficient and profitable fishing.

When fishing with a bottom trawl, looking for fish becomes an insignificant part of the trawl haul. Firstly, the echo sounder is not good enough to see demersal fish and shrimp. Secondly, the fishing occurs over vast areas. Therefore reports from others and earlier experiences are the most important basis for your decisions.

Usage of previously logged data, both normal weather data and data from prior hauls in the same area give a valuable basis. Temperature and underwater currents together with catch data from prior hauls can be a good basis to determine whether or not to cancel a haul.

Often, maybe especially when fishing along a slope, it can be hard to know if the trawl is positioned as desired. Not only are the circumstances difficult, but the inaccuracy in the Echo Sounder is so great that it is impossible to know exactly where you are.

Since Scanmar appeared on the market many have used the Catch sensor to determine whether to turn and fish the same area again or to continue on the same course. Many have increased their catch and reduced fuel cost by doing this. The new Filling sensors give even better information.

Most people believe that largest possible height and vertical opening on the net is optimal for fishing. Scanmar has therefore delivered thousands of Trawl Eyes/Trawl sounders and sets of Distance sensors, and one keeps the focus on the trawl height and distance between the doors. This would be great if it was not for the wind and waves, poor seabed conditions, and underwater currents.

Many, especially manufacturers with little experience, have been in a tank and seen demonstrations of trawl models. There one does not encounter these problems; there is a "carpet floor", no wind or waves and the current is constant from ahead. There is a lot to learn from a flume tank as long as one understands that it is a demonstration under ideal conditions.

Trawl height/Vertical opening/Geometric form:

The trawl height is more or less given by the manufacturer when the door distance and sweep lengths are given, assuming a certain towing pace (the trawl's speed through the ocean) and that the door distance is correct and stable.

There are a lot of things that affect the trawl height, which we believe the fishermen should pay attention to in order to fish more efficiently.

Towing speed:

In practice, as the towing speed increases the net fills, or bucket effects are created in the trawl, the towing resistance will increase and the trawl height will fall. This will not have the same effect on a cod trawl with its construction and 4-6 meter height as it would on a shrimp trawl with its construction and 10-20 meter height, but it will still be affected.

Although the price of oil is high, higher towing speeds are economically viable when the catch is good, especially if fish and shrimp are not positioned high in the ocean so you lose catch with a low trawl.

Normally the vertical opening and the trawl opening's geometry will change, simultaneously as the bottom gear is less effective.

Distance between the Trawl doors:

The door distance is crucial for the trawl`s vertical opening and height. It is assumed to be as desired and stable, but is it?

- When the door distance is measured acoustically it is essential that the instruments are accurate and reliable. We have seen examples where this is not always the case; a 2-3 percent variation is not uncommon.

- The water temperature affects the speed of sound in water. A door distance of 100 meters will show a difference of around three meters if the temperature

varies with ten degrees, summer/winter, or in different grounds. Automatic temperature compensation in the new SS4 Door Sensors will minimize this variation.

- With wind and waves coming against the boat, the speed will constantly change, even if the average speed remains the same. With normal warp length this will affect the doors` movement and stability (this does not apply to boats with Syncro winches). This manifests in the trawl.

- The problems are similar when fishing on poor seabed or along a slope.

- The four previous points apply when the trawl is directly behind the vessel and the warps are equal in length, but not always. Imagine that the trawl still is straight behind the vessel, but the warps are different length. Regardless of how "right" the door distance is the trawl will not achieve the proper vertical opening, height or form needed for efficient fishing.

- Even worse, when there are side currents the trawl will not be straight behind the boat but out to one side. Having the right door distance will not help in this case unless the warp lengths are adjusted in accordance to the side current.

Drawing a conclusion here would be, first and foremost, that regarding the trawl opening's height, vertical opening and geometry, and if one only has a Distance sensor and Trawl Eye/Trawl sounder to refer to, one must constantly consider the effects of waves, wind, and currents.

Secondly one must understand what effect the water current's direction into the trawl opening has, not only to optimize the opening and geometry in relation to the water current, which is the only thing of importance, but also in relation to what occurs further back in the trawl.

Symmetry

If there are no underwater currents the trawl will follow straight behind of the boat and a line between the trawl doors will be at a 90 degrees angle to the towing direction. If the rigging and everything else is as it should be, the direction of the water current into the trawl will be the exact same as the towing direction and the trawl will be symmetrical in relation to this. If there is current from one side at the seafloor, the strength and direction of this will make the trawl asymmetrical. This causes the net to close on one side and the mesh to open on the other and fish and shrimp will follow the current out through the mesh.

By adjusting the warp lengths so that the doors no longer are perpendicular to the towing direction, but to the water current, the trawl will be symmetrical around the water current, although the warps have different length and the trawl no longer is straight behind the vessel.

Trawl speed

The trawl speed is the trawl's speed through the water (often referred to as the water speed into the trawl). Net material, mesh size and the trawl's construction determine the trawl's optimal towing speed. In this context it is important to be aware that the trawl's speed is the sum of the boat's speed (GPS) and underwater currents going with or against the vessel.

If the underwater current travels with the boat the trawl speed will be lower than the boat's speed and fish will escape in the front of the trawl if it is too slow; the speed must be increased.

If the underwater current is towards the vessel, the trawl speed will be higher than that of the vessel and a strong bucket effect may be created in the trawl. The mesh will be stretched and fish will escape. The speed must be reduced.

Bucket effect and Twist

Bucket effect and Twist occur in all trawls. How large this problem is will differ from trawl to trawl, and haul to haul, so it is difficult to have a general perception of the size. "Stickers" are a clear indication of the problem, but it is perhaps important to remember that more fish can get away in the front where the mesh is bigger.

Conclusion

Based on our experiences we are certain that those who are concerned with efficiency and have had Scanmar Distance and Height sensors a couple of years will achieve improvements by using a Trawl Speed/Symmetry sensor.

In addition, an Angle-based Filling sensor will be very useful in order to be able to see where the fish are positioned, as well as the possibility of moving it to different places on the trawl to reveal Twist and Bucket effects so that the fishermen can adjust the towing speed or make small changes to the net in order to increase the water flow through critical areas.

3.7 *Trawl Speed/Symmetry and Door Angle sensor – alpha and Omega*

More and more open their eyes to how unbelievably important this combination is for efficient fishing. With the help of these sensors you can have full control over the trawl geometry while simultaneously assuring optimal towing speed.

Fishing along a slope, seabed conditions, underwater currents etc. have a great impact on the trawl doors so that they are often significantly less efficient than they should be. Underwater currents, whether they come from ahead, behind or from the side, create big problems for the trawl's ability to catch, either because bucket effects form in the trawl opening and in the trawl or because the trawl is not symmetrical in relation to the water current, which again leads to fish escaping through the side panels in the front of the trawl where the mesh is bigger.

That trawl geometry is not only the trawl's horizontal and vertical openings, but also the trawl's symmetry around the water current, which has an even larger significance, is a more and more widespread perception. We see an array of even quite small vessels, both single and twin rigs that use the Symmetry sensor, often together with the Distance sensor, as their most important information source for efficient fishing.

This is not very surprising really because it immediately affects the amount of catch if the trawl is skewed when towed through the water current.

Seeing so many use combined Trawl Speed/Symmetry sensors they have realized the importance of correct towing speed. Then the question arises: what do the trawl door angles mean for symmetry and towing speed and fuel consumption?

Most people understand that when the door is not vertical it is not as efficient as it should be, but how important is that? And what angles do the doors have? On the basis of what one learns by using the Trawl Speed and Symmetry sensors one really begins to understand the importance of Door angles, and especially the roll angle, for efficient fishing.

Many have therefore bought or tried the Door Angle sensor, and the truth is that most, even though they are aware of the sensor's importance, experience that the significance is much greater than expected. Many believe that the Door Angle function is the most important function Scanmar has developed.

What perhaps baffles most people, us included, is how sensitive the doors are under towing. The accuracy of the sensor readings is therefore crucial for a good result. The measuring head on the Trawl Speed/Symmetry sensor is made from special components and the sensors are put through extensive calibrating tests in a special flume tank before they enter the market.

Likewise the accuracy is extremely important for the Door Angle sensors; Scanmar has constructed them so that they can be mounted directly on the door blade, parallel with the shoe, and calibrating is done in a hand turn with an instrument that is included.

(1) Reduced Trawl Speed leads to (2) the doors laying down inwards and (3) reduced door distance.

The interaction between the Towing speed (water current into the trawl), the trawl doors' roll angle and the warp length makes it possible to adjust the gear much more accurately than one would think. Especially when a side current comes into the picture, it could otherwise present problems. Uneven seabed, in slope and poor weather also make it difficult.

We see that more and more are aware of the combination of Trawl Speed/Symmetry sensor and Door Angle sensor, and we receive feedback that is very encouraging to us.

The fishing is occurring in very strong current (1): GPS 4.9 knots, (2) trawl speed 2.9 knots. This makes the doors unstable (3), but the twin rig and gear pressed hard against the seabed (4) allows the bottom contact to be kept.

Product launches in 2012/2013

Scanmar has over the last 8-10 years invested substantially in development of new sensors which are introduced to the market.

The new sensor generation has extremely long operation time, short charging time and is molded in a very solid plastic material which makes it extra robust and protects it from mechanical or electrical damages.

Also in terms of functionality, accuracy and presentation, which makes it much easier to anticipate problems, there will be much new to come the nearest year.

Product news:

- **Combined Height/Depth/Temperature sensors for Purse Seiner**
  - Depth and Height
  - Depth and Temperature

- **Depth sensor for Purse Seiner**

- **Combined Height/Depth sensor for trawl doors**
  - Height
  - Height/Depth

- **Hydrophone**
  - Measures low frequent noise from the vessel that scares fish. The noise frequency and strength is combined with scientific data about common fish types' sensitivity to noise, and the fright effect at different distances to the vessel will be displayed in the bridge unit.

You find more information about our new products on our website: **www.scanmar.no**