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JRC SCIENTIFIC AND POLICY REPORTS

Information Collection in Energy Efficiency for Fisheries (ICEEF2012)

Final Report

Edited by

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This report has been prepared under contract ICEEF Service Contract Nr. 256660
by CNR-ISMAR, Ancona (Italy)

Joint Research Centre

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28/02/2013

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Foreword

Introduction to ICEEF project

The Joint Research Centre (JRC) has developed a website on energy efficiency in fisheries, available at https://energyefficiency-fisheries.jrc.ec.europa.eu. The site is accessible directly through the Europe web-site of the Directorate General for Maritime Affairs and Fisheries (DG MARE). The pilot web-site includes reference documents and studies related to energy savings in fisheries, general information on research and funding opportunities and links to relevant EU projects, EU legislation and events, among others.

As the Commission is planning to update, further develop and maintain this web site, the Italian National Research Council (CNR) and the Institute for Marine Research (ISMAR, Ancona, Italy) were collecting information and material to update and develop further this web-site through monitoring of specialized websites as well as government agencies in EU27 for funding such initiatives (national level) and also into University departments and research centers in the EU and world-wide working in relevant topics. Furthermore, a terminology glossary in many EU languages was completed. The main aim of this project was to compile, through surveys on existing technical literature and data, including technical reports, state and EU reports, college and PhD theses, popular articles, conference and meeting proceedings, papers produced by non-governmental organizations and other forms of non-scientific literature.

ICEEF 2012

On the basis of the experiences of ICEEF 2010 and ICEEF 2011, further information has been collected during the renewal of the service contract No. 256660, ICEEF 2012, in relation to the state of the art of fisheries technology. The data collection focused in specific topics that can be essential to obtain important results in terms of energy efficiency, mainly related to technical issues, such as propulsion systems innovations. Nevertheless, there was a lack of activities in the funding of energy saving. Most of the material collected has been obtained by exhibitions and conferences. During these visits it has been possible also to further promote the website, considering that a rising up of website contacts has been noticed after such events.

Contents

ENGINE REPLACEMENT A PRIORITY IN THE NEW EMFF

EU Ministers reached a compromise on the future European fund to support fisheries and maritime affairs. This compromise can be a step forward for the reform of our Common Fisheries Policy. It leaves open the perspective of breaking with the past.

europa.eu/rapid/press-release_MEMO-12-806_en.htm#PR_metaPressRelease_bottom

THE WORLD'S FIRST FISHING VESSEL WITH LNG

To hybrid LNG propulsion systems for fishing vessels. In terms of energy and performances the use of LNG for marine propulsion is the world's first fishing vessel with LNG could be suitable even combined with marine diesel fuel.

www.lnggot.com/2011/the-worlds-first-fishing-vessel-with-lng/

FISHERIES COMMITTEE ADOPTS OVERARCHING COMMUNICATION CALLING FOR 'ABOVE MSY'

The fisheries committee in the European Parliament on 11 July adopted Nikolaos Salavrakos' report on the overarching communication. About MSY, a lot of researchers disagree with the use of this indicator for the assessment of the right fishing effort. Actually this is the news, I will read the report ASAP giving you some comment.

cfp-reformwatch.eu/2012/07/fisheries-committee-adopts-overarching-communication-calling-for-above-msy/

SHIPPINGEFFICIENCY INDICATOR

A form for a simulation of fuel saving, on the basis of some vessel parameters.

shippingefficiency.org/

CALL FOR PROPOSALS FOR ERC SYNERGY GRANT

Identifier: ERC-2013-SyG Publication Date: 10 October 2012 Budget: € 150 000 000 Deadline: 10 January 2013 at 17:00:00 (Brussels local time) OJ Reference: OJ C 305 of 10 October 2012 Specific Programme(s): IDEAS Theme(s): ERC

ec.europa.eu/research/participants/portal/page/ideas?callIdentifier=ERC-2013-SyG

COUNCIL TO MEET ON FISHERIES ISSUES

The European Commission's Fisheries Council is meeting in Brussels on 25 September for a public debate on the Commission's proposal on the European Maritime and Fisheries Fund 2014-2002.

www.fishnewseu.com/index.php?option=com_content&view=article&id=9007:council-to-meet-on-fisheries-issues&catid=46:world&Itemid=56

COUNCIL AGREES ON 'LESS AMBITIOUS' MEASURES FOR CFP REFORM, EMFF.

The European Council has agreed on a compromise which is less ambitious than what we have proposed. The original European Commission proposal stands to be reviewed in a next stage by the European Parliament," Commissioner Maria Damanaki commented.

fis.com/fis/worldnews/worldnews.asp?l=e&ndb=1&id=56369

€ 65 MILLION AVAILABLE FOR NEW INTELLIGENT ENERGY EUROPE PROJECTS

Funding projects that promote energy efficiency and renewable energy is at the heart of the IEE programme. The call closes on 8th May 2013 for all types of actions except the BUILD UP Skills initiative which has different deadlines. Find out more on the IEE website.

ec.europa.eu/energy/intelligent/getting-funds/call-for-proposals/how-to-apply/index_en.htm

SINAVAL-EUROFISHING 2013 TO HOST BIGGEST MARINE RENEWABLE ENERGY EVENT IN SOUTHERN EUROPE

The programme for SINAVAL-EUROFISHING Elite 2013 (16 to 18 April) is to include the first “Bilbao Marine Energy Week”, an event aimed at trade specialists and firms already working in the field of renewable Marine energy sources or seeking to diversify into this emerging sector.

http://www.sinaval.eu/portal/page/portal/SINAVAL/P_SINAVAL_PRENSA/P_SINAVAL_LISTADO_N PRENSA/2013/P_SINAVAL_P_EMS

Events

Description	Website	Location	Topic	Date
SEATEC		Carrara, Italy	Propulsion	10 – 12 February, 2012
ICES/FAO – WGFTFB	http://wwz.ifremer.fr/lorient_eng/ICES-FAO-WGFTFB-2012	Lorient, France	Fisheries	21 – 24 April, 2012
E-Fishing	http://www.e-fishing.eu/	Vigo, Spain	Fisheries	22 – 24 May, 2012
72th International Fishing Fair	http://www.fieradellapescancona.it/	Ancona, Italy	Fisheries	21 – 24 June, 2012
EFTC Meeting		Hirtshal, Denmak	Fisheries	28 – 29 March, 2012
SMM '12	http://smm-hamburg.de/en/press-service/press-information/	Hamburg, Germany	Propulsion	9 – 12 September, 2012
EFTP Meeting	http://www.eftp.eu/	Madrid, Spain	Fisheries	12 September, 2012
NAV 2012	http://www.atenanazionale.it/nav/index.php/NAV/NAV2012	Naples, Italy	Propulsion	17 – 19 October, 2012
Polar Fish	www.polar-fish.net/polar-fish/dk.aspx	Sisimiut, Greenland	Fisheries	5 – 7 October, 2012
Future of UK fishing	www.westminsterforumprojects.co.uk/forums/event.php?eid=466	London, UK	Fisheries	16 October, 2012
Offshore Mariculture 2012	www.offshoremariculture.com/	Izmir, Turkey	Aquaculture	17 - 19 October, 2012
International training course in trawl technology		Hirtshals, Denmark	Fishing technology	28 Oct. – 2 Nov., 2012
21st Century Challenges: unsustainable fishing	www.21stcenturychallenges.org/challenges/unsustainable-fishing/	London, UK	Fisheries	13 November, 2012
Foodtech 2012	www.foodtech.dk/FoodTech-12-1.aspx	Herning, Denmark	Fisheries	13 – 15 November, 2012

Description	Website	Location	Topic	Date
Foodtech 2012	www.foodtech.dk/FoodTech-12-1.aspx	Herning, Denmark	Fisheries	13 – 15 November, 2012
3rd Annual Carbon & Environmental Footprinting Conference		London, UK	Engines, fuel	22 November, 2012
Greenport south Asia	www.greenportasia.com	Mumbai, India		20 March, 2013
SMM 2013	smm-india.com/	Mumbai, India	Engineering	4 – 6 April, 2013
Motorship propulsion & emissions conference	www.propulsionconference.com/	Copenhagen, Denmark	propulsion systems	24 – 25 April, 2013
Ices/FAO WGFTFB	N/A	Bangkok, Thailand	Fisheries	6 – 10 May, 2013
Year's European maritime day	ec.europa.eu/maritimeaffairs/maritimeday/2012/programme_en.pdf	Gothenburg, Sweden		21 – 22 May, 2012
72th International Fishing Fair	www.fieradellapesca.it/	Ancona, Italy	Fisheries	21 - 24 June, 2012
SINAVAL 2013	http://www.sinaval.eu/	Bilbao, Spain	Engineering	16 – 18 April, 2013
NORSHIPPING 2013	www.nor-shipping.com	Oslo, Norway	Engineering	4 – 6 June, 2013
SEAWORK 2013	www.seawork.com	Southampton, United Kingdom	Engineering	25 – 27 June, 2013
Aquaculture Europe 2013	www.marevent.com/AE13Trondheim.html	Trondheim, Norway		9 – 12 August, 2013
Icelandic Fisheries 2013	tradeshow.free-press-release.com/exhibition.icelandic-fisheries-2013.78947/	Kopavogur, Iceland	Fisheries	September, 2013

Description	Website	Location	Topic	Date
Icelandic Fisheries 2013	tradeshow.free-press-release.com/exhibition.icelandic-fisheries-2013.78947/	Kopavogur, Iceland	Fisheries	September, 2013
Ocean systems engineering (icose13)	asem.cti3.com/asem13.htm	Jeju, Korea	Engineering	8-12 September, 2013
DANFISH international	www.danfish.com/	Aalborg, Denmark	Fisheries	October, 9 – 11, 2013
China Fisheries and Seafood Expo	http://www.chinaseafoodexpo.com/	Dalian, China	Fisheries	5 – 7 November, 2013
Expo Pesca & Acuiperu	www.thaiscorp.com	Lima, Peru	Fisheries	7 – 9 November, 2013

Scientific papers

1. **Transport of fish from Norway: energy analysis using industrial ecology as the framework**.
   Author: O. Andersen.
   dx.doi.org/10.1016/S0959-6526(01)00057-9

2. **Fuel Consumption and Greenhouse Gas Emissions from Global Tuna Fisheries: A preliminary assessment.**
   Author: Dr. Peter Tyedmers & Mr. Robert Parker.
   iss-foundation.org/wp-content/uploads/downloads/2012/03/ISSF-2012-03-Fuel-consumption.pdf

   Calculations for fishing gear designs – FAO fishing manuals. Revised, edited and enlarged. by P.J.G. Carrothers
   Author: Fridman, A.L. ;Carrothers, P.J.G. Lang.

3. **Fuel reduction in coastal squid jigging boats equipped with various combinations of conventional metal halide lamps and low-energy LED panels.**
   Author: Matsushita, Yoshiki; Azuno, Toru; Yamashita, Yukiko.
   dx.doi.org/10.1016/j.fishres.2012.02.004

4. **Comparison of CFL-based and LED-based solar lanterns.**
   Author: A.K. Mukerjee.
   dx.doi.org/10.1016/S0973-0826(08)60574-8

5. **Estimating the impacts of eliminating fisheries subsidies on the small island economy of the Azores.**
   Authors: Natacha Carvalhoa, Sameer Regeb, Mário Fortunac, Eduardo Isidroa, Gareth Edwards-Jonesd.
   dx.doi.org/10.1016/j.ecolecon.2011.05.013

6. **Integrated environmental assessment of fisheries management: Swedish Nephrops trawl fisheries evaluated using a life cycle approach.**
   Authors: Sara Hornborg, Per Nilsson, Daniel Valentinsson, Friederike Ziegler.
   dx.doi.org/10.1016/j.marpol.2012.02.017

7. **Fuelling the fisheries subsidy debate: Agreements, loopholes and implications.**
   Authors: Sarah Harpera, Daniele Bevacquab, Rachel Chudnowc, Sabrina Giorgid, Victoire Guillonneaud, Frédéric Le Manache, Tim Sutorf, Ussif Rashid Sumailag.
   dx.doi.org/10.1016/j.fishres.2011.10.007

8. **Fuel use and greenhouse gas emission implications of fisheries management: the case of the new England Atlantic herring fishery.**
   Authors: John Driscoll, Peter Tyedmers.
   dx.doi.org/10.1016/j.marpol.2009.08.005

9. **Emissions from fuel combustion in Swedish cod fishery.**
   Authors: Friederike Ziegler, Per-Anders Hansson.
   dx.doi.org/10.1016/S0959-6526(02)00050-1

Information collection from visits

Many visits have been carried out to the most relevant events related to energy efficiency in the fisheries sector in 2012. Table 1 contains the list of events attended. For each visit a major topic is proposed that states the main arguments of the event. The majority of information collected is from two international conferences, e-Fishing and NAV 12 (see § "Conference papers" and § "Meetings and working groups") and from the EFTC and EFTP working groups. A topic reference is included in order to identify the area of interest. Other information collected, coming from fairs and exhibitions are organized in terms of topics.

Table 1. List of visits carried out.

Visit	Location	Topic	Date
SEATEC	Carrara, Italy	Propulsion systems	10 – 12 February, 2012
Workshop "LNG FUELLED TUG" Rosetti Shipyard	Ravenna, Italy	Propulsion systems	23 March, 2012
EFTC Meeting	Hirtshal, Denmak	Vessel technology	28 – 29 March, 2012
Ices/FAO – WGFTFB	Lorient, France	Efficient fishing gears	21 – 24 April, 2012
6th World Fisheries Congress	Edinburgh, Scotland	Efficient fishing gear	7 – 11 May, 2012
E-Fishing	Vigo, Spain	Efficient fishing gear, propulsion systems	22 – 24 May, 2012
EFTC Meeting	Capo Granitola, Italy	Fisheries, Rules, regulations	6 – 7 June, 2012
XII Chamber of Commerce Forum	Brindisi, Italy	Fisheries	6 – 8 June, 2012
72th International Fishing Fair	Ancona, Italy	Fisheries	21 – 24 June, 2012
SMM '12	Hamburg, Germany	Propulsion systems,	9 – 12 September, 2012
EFTP Meeting	Madrid, Spain	Fisheries	12 September, 2012
EFTC Meeting	Rome, Italy	Fisheries	18 September, 2012
NAV 2012	Naples, Italy	Propulsion	17 – 19 October, 2012

Conference papers

E-Fishing – Fishing Vessel Energy Efficiency, Vigo, Spain, 22th – 24th, May, 2012

E-Fishing is an international forum for research into fishing vessel energy efficiency. The second edition of this International Symposium attracted entities and researchers interested in energy efficiency in fishing. Papers presented covered topics like hydrodynamics and new hull concepts, maneuvering and propulsion systems, electrical and hybrid diesel electric systems, fishing gear design and performance analysis, engines, fuels, additives and emissions, energy efficiency control and monitoring systems, ship projects, rules and regulations, auxiliary machinery, routing optimization, innovative refrigeration systems. The conference took place in Vigo (Spain) from 22nd to 24th of May 2012, coinciding with the celebration of NAVALIA, International Shipbuilding Exhibition. Below the list of papers presented. For the complete papers and presentations, visit the website: http://www.e-fishing.eu/papers.php

European Commission's website on Energy Efficiency in Fisheries.

Improving energy efficiency is decisive for competitiveness, security of supply and for meeting the commitments on climate change made under the Kyoto Protocol. At the end of 2006, the European Union pledged to cut its annual consumption of primary energy by 20% by 2020. On 22 June 2011, a new set of measures for increased Energy Efficiency was proposed by the European Commission to fill the gap and put back the EU on track. Fishing is one of the most energy-intensive food production methods in the world, depending almost entirely on fossil fuels. In 2008, the world's fishing fleets were responsible for about 1.2% of total global fuel consumption, corresponding to 0.67 liters of fuel per Kg of live fish and shellfish landed. In the same year, the EU fleet consumed 3.7 billion liters of fuel, representing 25% of the value of landings. Fuel consumption acts as an indicator of environmental impact with the EU fleet releasing 10,000,000 tons of CO_2, or else 1.81 Kg CO_2/Kg of fish landed. This represents 0.23% of global greenhouse gas emissions. Between 1995 and 2002 in the EU-25, fuel prices have increased by an average of 80%, while fisheries production declined by 17%. More recently, between 2002 and 2008, fuel prices increased by 152%, while average fish price increased by 67%, and profitability decreased by 33%. Landings in the same period decreased by 23% and in fact in 2005, imports of fish products surpassed EU-landings for the first time. The ratio landing value/fuel cost demonstrated a clear decreasing trend with the fuel efficiency of fish capture indicator being halved since 2002. Mostly because fishing capacity is greater than the available fish stocks, many fishing fleets in the EU have been facing economic problems. With added concerns about oil prices since 2005, energy efficiency is key to profitability and has become both a political and a scientific issue. It is now acknowledged that EU fishing fleets expend vast quantities of energy and that low overall efficiency is caused not by high oil costs but rather by structural deficiencies. The European

Commission has initiated a system to exchange ideas and best practices. The Energy Efficiency in Fisheries website is part of that initiative. Its primary target is fishery professionals and their associations. The website gives access to: research-funding opportunities; EU projects; initiatives by universities, research centers, companies and professional associations; consortia at regional and national levels; related EU legislation; reference information, studies and scientific literature; past and future events; most commonly used terminology on the subject and useful links. The site can be accessed at: energyefficiency-fisheries.jrc.ec.europa.eu/home

Paper

www.e-fishing.eu/paperslist/papers/1.European_Commission's_website_on_Energy_Efficiency_in_Fisheries_.pdf

Presentation

www.e-fishing.eu/paperslist/presentaciones/1.European_Commission's_website_on_Energy_Efficiency_in_Fisheries.pdf

An Energy Audit tool for increasing fishing efficiency (Topic: energy monitoring systems)

At least since we learned to admit that the oil reserves of the world are limited, improving energy efficiency has been regarded important. Recently the climate-abusing effects of exhaust gases from combustion processes have been increasingly focused. This is underlining the importance of improving the energy efficiency in all sectors presently depending on the use of internal combustion engines, among which we find modern fisheries. Actual fishing fleet is most cases not efficient because of outdated technology. Over the years the energy efficiency of the ship goes down due to obsolescence, while that of the state of the art rises. Maintaining an adequate level of energy efficiency requires a continuous monitoring of the energy profile of the vessel. In this way any causes of energy inefficiency can be identified, being able to act on them promptly and effectively. A proper system of energy consumption monitoring is therefore essential for maintaining high energy efficiency. Energy usage could be investigated using different approaches. Using an appropriate fuel consumption monitoring system it is possible to evaluate the energy performance of fishing vessel under different operating conditions. Once energy consumption has been related to each operating condition, fishermen can minimize fuel consumption. Energy efficiency investigation could be deeply carried out through an energy audit which allows to obtain an extensive energy profile of the fishing vessel monitored. With an energy audit it is possible to measure the energy consumption of each energy user, among which the propulsion system, the electric and the hydraulic users. For each energy user, suggestions to improve energy efficiency can be proposed to fishermen.

Paper

www.e-fishing.eu/paperslist/papers/2.An_Energy_Audit_tool_for_increasing_fishing_efficiency.pdf

Presentation

www.e-fishing.eu/paperslist/presentaciones/2.An_Energy_Audit_tool_for_increasing_fishing_efficiency.pdf

HydroPeche experimental and numerical developments for fishing devices optimization (Topic: efficient fishing gears)

Nitrogen oxides formation in internal combustion engines depends on the parameters of fuel injection, atomization, mixing, the values of the air-fuel ratio, the turbulence of the air flow, temperature, pressure, environment, etc., ie, is characterized by a set of design and operational factors. In order to quantify emissions of nitrogen oxides in the exhaust gases of medium-ship diesel engines the specialists of the department of ship power plants of the Baltic fishing fleet state academy have developed a computational model which includes a set of design and operational factors. The model is compact, easy to use, makes it possible to calculate specific emission of nitrogen oxides in the exhaust gas with the influence of design and operational factors with permissible error.

Presentation

www.e-fishing.eu/paperslist/presentaciones/5.HydroPeche_experimental_and_numerical_developments_for_fishing_devices_optimisation.pdf

Increased energy efficiency of the fishing fleet due to improved hydrodynamic performance (Topic: new vessel design and technology)

The main goal of the present article is to highlight the great potential that an improved hydrodynamic design could have on the energy efficiency of fishing vessels. A typical surface long liner was optimized employing Computational Fluid Dynamics; the results were validated by carrying out model testing on a towing tank.

Paper

www.e-fishing.eu/paperslist/papers/3.Increased_energy_efficiency_of_the_fishing_fleet_due_to_improved_hydrodynamic_performance.pdf

Presentation

www.e-fishing.eu/paperslist/presentaciones/3.Increased_energy_efficiency_of_the_fishing_fleet_due_to_improved_hydrodynamic_performance.pdf

Prawn Trawl Drag due to Material Properties- An investigation of the potential for drag reduction (Topic: efficient fishing gears)

Rising fuel costs, impending oil deficit and global concern for greenhouse gas emission necessitate improvements of energy efficiency in commercial fisheries. Innovative high strength netting materials provide the potential for a positive outcome in relation to the energy efficiency of prawn trawling. Usage of high strength netting in Australian prawn trawling applications has returned mixed results over the last 10 years. The presented work investigated the drag of prawn trawl models constructed from innovative and traditional materials. The major finding was that drag reductions achieved with innovative materials were not directly related to the associated reductions in twine area: knot area and orientation produce amplified effects on drag. It was also shown that netting stiffness affects trawl shape and hence the corresponding drag.

Paper

www.e-fishing.eu/paperslist/papers/6.Prawn_Trawl_Drag_due_to_Material_Properties_An_investigation_of_the_potential_for_drag_reduction.pdf

Presentation

www.e-fishing.eu/paperslist/presentaciones/6.Prawn_Trawl_Drag_due_to_Material_Properties_An_investigation_of_the_potential_for_drag_reduction.pdf

Saving fuel to increase profitability and reduce environmental impact in a U.S. ground fish fishery (Topic: efficient fishing gears)

The profitability of commercial fishing businesses is at risk by rising and highly volatile prices for diesel fuel. Fishermen can respond to this threat by reducing their business costs including the amount of fuel that is consumed during a fishing trip or by increasing the value of their landings. A reduction in fuel consumption requires a lower rate of consumption or a reduction in the duration of fishing activity. We report on several efforts to reduce the rate of fuel consumption including the development and testing of a new large-mesh, fine-diameter trawl net, the use of semi-pelagic otter boards, and energy audits of fishing boats. The new trawl net and semi-pelagic otter boards reduced fuel consumption by 23% and 12% respectively without loss of commercial catch. Reduced paravane use and installation of a fuel flow meter were the most highly cost-effective options identified by the audit. They also realized very short payback periods. We also report on efforts to reduce fishing activity using acoustic codend catch sensors to signal a predetermined catch volume and reduce unnecessary fishing time. These sensors were tested on multiple fishing trips and we found that tow duration was reduced by as much as 50%.

Paper

www.e-fishing.eu/paperslist/papers/7.Saving_fuel_to_increase_profitability_and_reduce_environmental_impact_in_a_U.S._ground_fish_fishery.pdf

Presentation

www.e-fishing.eu/paperslist/presentaciones/7.Saving_fuel_to_increase_profitability_and_reduce_environmental_impact_in_a_U.S._ground_fish_fishery.pdf

Emission Reduction in the Norwegian Fishing Fleet: Towards LNG? (Topic: fuels)

The continued operation of fisheries is fundamental to Norway's economy bloom. However, there are some obstacles against fulfilling this. Firstly, operating in harsh waters makes the Norwegian fishing fleet quite energy intensive. This fact coupled with the recent increase in fuel prices and introduced taxes on emissions cast doubt on the economic profitability of the Norwegian fishing sector. Secondly, Norway is committed to a greener environment due to several regulations the fulfillment of which is high on the agenda. Key legislations driving emissions reduction in this sector are Marine Pollution (MARPOL) Annex VI regulations which introduce stringent limits on sulphur dioxide (SO2) and nitrogen oxides (NOx) emissions in the Emission Control Areas (ECAs) which come into force on 2015 and 2016, respectively. Besides, nowadays fish food consumers and other stakeholders are not only concerned with the quality of fish, but also with the environmental footprints associated with its production. Therefore, there are various economic and environmental drivers in favor of reducing adverse environmental impacts associated with fishing in Norway. Fishing vessel owners willing to continue operation in ECAs after 2015 and 2016 will need to modify their ships and/or the way they operate them. Among the technical options available there are those focusing on modifying engine systems, including switching to alternate fuels, such as Liquefied Natural Gas (LNG). LNG has proved technical feasibility in 26 LNG-fueled ships in operation, namely 15 ferries, 5 offshore support vessels, 3 coast guard vessels, 1 product tanker and 2 LNG tankers, of which 25 are in operation in Norway. This paper discusses the challenges and benefits related to the implementation of LNG-fuelled engines in the Norwegian fishing fleet as a step towards emission reduction.

Paper

www.e-fishing.eu/paperslist/papers/8.Emission_Reduction_in_the_Norwegian_Fishing_Fleet_Towards.pdf

Presentation

www.e-fishing.eu/paperslist/presentaciones/8.Emission_Reduction_in_the_Norwegian_Fishing_Fleet_Towards.pdf

Shymgen system: Optimizing the performance of shaft generator and drive train on fishing vessels (Topic: engines, auxiliary power)

This article outlines the impact of a variable speed generation system on a fishing vessel´s energy performance figures, analyzing electrical and hydrodynamic issues an presenting a practical case. A very interesting energy saving approach for vessels with different operating profiles is the use of a variable speed generation system, so the synchronous generator can be run at variable speeds over a wide range of engine rpm. This approach offers benefits by improving the energy efficiency of the propulsion train. It also improves the performance when running at partial load as well as propeller performance, increasing the open water efficiency by running on a higher pitch and advance ratio, and at the same time reducing cavitation, vibrations and noise.

Paper

www.e-fishing.eu/paperslist/papers/9.Shymgen_system.Optimizing_the_performance_of_shaft_generator_and_drive_train_on_fishing_vessels.pdf

Presentation

www.e-fishing.eu/paperslist/presentaciones/9.Shymgen_system.Optimizing_the_performance_of_shaft_generator_and_drive_train_on_fishing_vessels.pdf

Application of Hybrid-Electric Power Supply System in Fishing Vessels
(Topic: propulsion systems)

Costs reduction is a must in marine sector due to market evolution in these latest years. The price of catches drops daily meanwhile the fuel price raises parallel, so the profit of fishing activity is becoming less at the point of being untenable. This situation brings out the need of acting over both two parameters: cost reductions and catches increases. The project approach faces the substitution of propulsion system based on diesel engines by another one quieter, more environmental friendly and less petrol-price dependent. The solution defined with such a goal is a hybrid-electric propulsion system feed by three different energy sources: grid incoming electric energy stored onboard in Lithium cells, hydrogen stored onboard in high pressure bottles and auxiliary diesel engine driving an electric generator. Last two types of energy are transformed in electric power by a fuel cell and an electric generator respectively, while the first is consumed directly as it's stored.

Paper
www.e-fishing.eu/paperslist/papers/10.Application_of_Hybrid-Electric_Power_Supply_System_in_Fishing_Vessels.pdf

Presentation
www.e-fishing.eu/paperslist/presentaciones/10.Application_of_Hybrid-Electric_Power_Supply_System_in_Fishing_Vessels.pdf

Improvement of trawl efficiency using measurements at sea and numerical simulations
(Topic: efficient fishing gears)

This work has been carried out during the French national project EFFICHALUT. The objective of the project was to improve the energy efficiency of a bottom trawl of a fisherman. This was achieved through a better understanding of the behavior of the trawl. This better knowledge comes from sea trials during which the shape of the trawl was apprehended via measurement of warp tensions and bridles, and ii) numerical simulations. The measurement showed an imbalance between the upper and lower wings. The numerical simulation showed the same imbalance and further exaggerated deformation of the upper wings, again not expected. From this information the fisherman has proposed improvements to the design based mainly on the replacement of part of the netting of the top wing by ropes. The measurement by the fisherman of consumption of fuel during few months shows a decrease of 17% of the fuel consumption of the improved trawl relatively to the reference one. The plan of the trawl from this project has already been distributed to 15 boats. The saving for the entire 15 boats is estimated at 800K€ per year.

Paper
www.e-fishing.eu/paperslist/papers/12.Improvement_of_trawl_efficiency_using_measurements_at_sea_and_numerical_simulations.pdf

Presentation
www.e-fishing.eu/paperslist/presentaciones/12.Improvement_of_trawl_efficiency_using_measurements_at_sea_and_numerical_simulations.pdf

Energy efficiency through bycatch reduction - a radical approach (Topic: efficient fishing gears)

Global fisheries production is 144,000,000 tonnes annually; unfortunately 7,300,000 tonnes of unwanted fish (bycatch) is discarded. Prawn trawling is unselective, capturing up to 20 kg of bycatch for each kilogram of prawns. This bycatch can have a strong influence on the performance of the fishing gear and efficiency of the trawling system. A novel technological solution is a self-powered light source that illuminates the trawl path. This system has not only shown a decrease in bycatch of up to 30% (by weight) but an increase in prawn catch of up to 5.5%. This new device makes trawling more efficient, sustainable and acceptable to the market. This paper outlines the engineering development of the new system and presents results from preliminary scientific field trials.

Paper

www.e-fishing.eu/paperslist/papers/11.Energy_efficiency_through_bycatch_reduction_a_radical_approach.pdf

Presentation

www.e-fishing.eu/paperslist/presentaciones/11.Energy_efficiency_through_bycatch_reduction_a_radical_approach.pdf

A plan to develop and to build a sustainable, energy saving and economic viable Dutch flatfish vessel (Topic: fishing tactics and techniques, fishery management)

Innovation and cooperation between fishermen in the Netherlands is stimulated by the Ministry of Economy, Agriculture and Innovation. Within so-called "Knowledge Groups" (study groups) fishermen are working close together now in innovation projects and they cooperate with other stakeholders in the fish chain and with researchers from research institutes. Information about technique and economy is exchanged with each other while innovative ideas are born. One of the goals of fishermen is to develop an optimal sustainable fishing vessel with acceptable economic prospects. In the end the fishing industry likes to develop and built a new fishing fleet which can also give new impulses for labor in local industry. A recent product (in this case a feasibility study "Masterplan Sustainable Fisheries") of the Knowledge Groups includes a newly to be developed plan for renewal of the Dutch flatfish fleet. This study shows prosperous new opportunities to make the fleet more sustainable by building new to be developed 'green' fishing vessels and by introducing new fishing methods with less discards. Beside that less fuel consumption can save substantial volumes (and euros) of fuel and costs of maintenance of vessel and engines can be cut while revenues can be optimized.

Paper

www.e-fishing.eu/paperslist/papers/13.A_plan_to_develop_and_to_build_a_sustainable_energy_saving_and_economic_viable_Dutch_flatfish_vessel.pdf

Presentation

www.e-fishing.eu/paperslist/presentaciones/13.A_plan_to_develop_and_to_build_a_sustainable,_energy_saving_and_economic_viable_Dutch_flatfish_vessel.pdf

Energy saving aspects for fishing operations (Topic: fishing tactics and techniques)

In almost all fishing activities operational decisions, mainly made by the skipper, have major influences on the energy used by fishing vessels. The operational aspect to some degree also includes choice of fishing method and thereby fishing gear, as many vessels are using various gears during a season or on a year basis. Examples are medium-sized Norwegian purse seiners which both may use seines for various species and with different size (depth), dependent on the seasonal fishing conditions. And almost all of smaller Norwegian fishing vessels are combining different fishing gear, of which the most important are gillnets, longlines and vertical (jigging) lines, during a year and a season. Most correct choice of gear for various fishing (specie and availability) conditions have been found to have major impact on the energy expenditure during a season/year, to catch their quotas. For the direct fishing operations the use of engine power is dealt with in the energy aspect, not only for trawling to maintain towing speed, but also for other types of gears. The last operational aspect being considered is related to decisions both on fishing trip basis and for the single fishing activity as tow, set and haul. Particularly longline and gillnet operations are considered in view of practices related to current direction, haul start of first end/last end and division of fleet lengths of the total gear to be set. And the last overall view to be dealt with is that the overall fishing efficiency, as influenced both by vessel and gear qualities as well as the skipper and crew qualities, in many cases is the most important factor for the energy use, and particularly in a quota fishing regime. Fish efficient and save energy and money!

Paper

www.e-fishing.eu/paperslist/papers/14.Energy_saving_aspects_for_fishing_operations.pdf

Presentation

www.e-fishing.eu/paperslist/presentaciones/14.Energy_saving_aspects_for_fishing_operations.pdf

Energy audits of fishing vessels lessons learned and the way forward

(Topic: energy monitoring systems)

Commercial fishing activities are strongly fuel-dependent. The dramatic increase in the price of diesel fuel has impacted negatively on the economic incomes of fishing. Moreover, the overexploitation of north-Atlantic fisheries, over many decades, has caused international regulatory bodies to establish more restrictive catch quotas, on certain commercial fisheries. Both the fuel dependency and the restrictive catch limitation have brought the Basque commercial fishing industry to its ‘survival limit’. To examine the situation, an energy audit methodology for fishing vessels has been developed, with two objectives: a) to make shipowners aware of the way fuel is consumed in their activities; b) help shipowners to reduce their fuel bill. This contribution provides an overview of the methodology, together with the steps undertaken for energy audits. Three fishing vessels (a stern trawler, a live bait purse seiner, and a troller have been studied, for developing this methodology. The methodology uses a combination of commercial tools, such as

'GESTOIL' (an onboard fuel consumption management system) to collect and assess data. The energy audit has served to highlight the areas of major consumption and potential savings; it provides also a list of recommendations to shipowners, for changes in the operational patterns of a ship.

Paper

www.e-fishing.eu/paperslist/papers/16.Best_Available_Technology_makes_Drastic_Cuts_in_Fuel_Expenses_in_Trawl_Fisheries.pdf

Presentation

www.e-fishing.eu/paperslist/presentaciones/15.Energy_audits_of_fishing_vessels_lessons_learned_and_the_way_forward.pdf

Best Available Technology makes Drastic Cuts in Fuel Expenses in Trawl Fisheries

(Topic: efficient fishing gears)

The project aims at development of a new trawl system, designed to increase catch, eliminate bottom contact of the trawl doors and reduce energy consumption. The project is governed by the industry and is using best available technology, from a range of different well known sources. The vessel was able to improve the profitability of bottom trawling by around 40% by using Dyneema warps, flying pelagic doors, an innovative trawl design, with netting in T90 and made from Dyneema. The economic calculations proved that the payback time on the total investments was less than 12 months and the return on the investments were around 300%. At the same time the environmental impact will be reduced dramatically when the doors are lifted away from the bottom and the emissions per kilo of fish caught reduced.

Paper

www.e-fishing.eu/paperslist/papers/16.Best_Available_Technology_makes_Drastic_Cuts_in_Fuel_Expenses_in_Trawl_Fisheries.pdf

Presentation

www.e-fishing.eu/paperslist/presentaciones/16.Best_Available_Technology_makes_Drastic_Cuts_in_Fuel_Expenses_in_Trawl_Fisheries.pdf

On the opportunity of improving propulsion system efficiency for Italian fishing vessels (Topic: propulsion systems)

In this paper a review of some improvements is proposed for trawlers propulsion systems. Basically, fishing activity is characterized by two different operative conditions: sailing and trawling. The technical solutions herein proposed can be adopted in new or in existing vessels. The propulsion system efficiency is mainly influenced by propeller and main engine efficiency. Engine and propeller must be coordinated through the reduction gear in such a way that optimum conditions are reached both for sailing and trawling phases. Typically, a free fixed pitch propeller is used for propulsion system in Italian fishing vessels. For a given propeller thrust and operating condition, a two-speed reduction gear box can be adopted to perform each fishing phase without overloading the main engine and saving fuel. Bollard pull tests demonstrated that using a ducted propeller, thrust is increased up to 25%, if compared with a conventional propeller with same diameter and pitch. Main engine efficiency can be improved using a new hybrid diesel-electric propulsion system. In the propulsion system herein proposed, the overall power required by the vessel can be subdivided in multiple power units, each one obtained coupling a diesel engine with a permanent magnet brushless electric generator, while the propeller is coupled with an electric motor. Through an electronic management system, it is possible to maintain power units at different operating points and guarantee the minimum overall fuel consumption. Tests demonstrated a fuel saving up to 15%. One characteristic of this abovementioned improvements is that they could be applied contemporary in the same fishing vessel, adding each benefit in propulsion system efficiency.

Paper

www.e-fishing.eu/paperslist/papers/18.On_the_opportunity_of_improving_propulsion_system_efficiency_for_italian_fishing_vessels.pdf

Presentation

www.e-fishing.eu/paperslist/presentaciones/18.On_the_opportunity_of_improving_propulsion_system_efficiency_for_italian_fishing_vessels.pdf

A BEM method for the hydrodynamic analysis of fishing boats propulsive systems

(Topic: propulsion systems)

Ducted propellers are often used to increase the thrust when the maximum allowed diameter for the propeller is insufficient for normal subcavitating loading conditions. The hydrodynamic models based on potential flow theory are fast and reasonably accurate to simulate the flow around lifting bodies presenting sharp trailing edges. A versatile method is presented where the various components of the propulsive system: rotor, duct and eventually stator are simulated separately and interact with each other via induced velocities. The procedure converges within a few iterations and is faster and much more robust than attempting to solve the flow around the various elements of the propulsive system in a single run. There is little gain in optimizing the duct geometry, if the propeller's geometry, especially the pitch is not adapted.

Paper

www.e-fishing.eu/paperslist/papers/17.A_BEM_method_for_the_hydrodynamic_analysis_of_fishing_boats_propulsive_systems.pdf

Presentation

www.e-fishing.eu/paperslist/presentaciones/17.A_BEM_method_for_the_hydrodynamic_analysis_of_fishing_boats_propulsive_systems.pdf

Innovative energy saving fishing gears in the Dutch fleet

(Topic: efficient fishing gears)

Attempts to improve fishing gears are not new. It has always been part of the research agenda in Europe, in the 1970's aimed at improving catch and mechanical efficiency of fishing, in later decades aimed at reducing unwanted by-catches and sea bed impact. Dutch R&D resulted in new large mesh pelagic trawls in the 1980s and species selective beam trawls in the 1990s. Since 2008 the Dutch Fisheries Innovation Platform stimulates the development of innovative energy saving fishing gears in the Dutch fishing fleet. This approach has led to higher motivation in the industry and some new remarkable fishing gears being used to a growing extent. Examples are: SumWing, Pulse Trawl and Pulse Wing, HydroRig, and Outrigger. The energy saving potential and ability to address ecosystem concerns (by-catches and bottom impact) of these gears are discussed. Savings up to 50% in fuel costs and improvements up to 80% in net revenue can be achieved in beam trawling.

Paper
www.e-fishing.eu/paperslist/papers/19.Innovative_energy_saving_fishing_gears_in_the_Dutch_fleet.pdf

Presentation
www.e-fishing.eu/paperslist/presentaciones/19.Innovative_energy_saving_fishing_gears_in_the_Dutch_fleet.pdf

Analysis of existing refrigeration plants on board fishing vessels and improvement possibilities (Topic: auxiliary power, machinery)

The refrigeration plant has shown to be at least one of the largest electricity consumer onboard a fishing vessel, usually assuming 50% of the total power plant. It is therefore natural that efforts on improving energy efficiency have to take into account this installation and try to provide solutions for the reduction of consumption. In this paper a brief overview of the main types of refrigeration plants is made, identifying their characteristics and needs for each of the different types of fishing methods. Also, existing technologies whose implementation would result in energy savings are revised. These solutions have to consider various aspects of the cooling process, as the design and analysis of freezing systems and the holds themselves, control systems, different refrigerants and the influence of environmental regulation in this area, as well as the use of alternative energies such as the use of heat waste, either in absorption systems or Organic Rankine Cycles.

Paper
www.e-fishing.eu/paperslist/papers/20.Analysis_of_existing_refrigeration_plants_onboard_fishing_vessels_and_improvement_possibilities.pdf

Presentation
www.e-fishing.eu/paperslist/presentaciones/20.Analysis_of_existing_refrigeration_plants_onboard_fishing_vessels_and_improvement_possibilities.pdf

Calculation of fishing net shapes by gradient-based optimization
(Topic: efficient fishing gears)

Computer simulation is becoming an essential tool for the design and optimization of fishing nets since it provides a fast and low-cost method to test and evaluate new strategies to improve their energy efficiency. In this context, robustness and computational performance of the computer simulation methods are a key factor for designers. This work compares two families of simulation methods to evaluate the equilibrium shape of a fishing net in a uniform flow in order to find the most suitable in terms of robustness and computational efficiency: Newton-Raphson iteration and Optimization methods. Numerical tests with different nets reveal that the optimization method LBFGS is more robust and faster than Newton-Raphson, but it only supports force models deriving from a potential energy.

Paper

www.e-fishing.eu/paperslist/papers/21.Calculation_of_fishing_net_shapes_by_gradient_based_optimization.pdf

Presentation

www.e-fishing.eu/paperslist/presentaciones/21.Calculation_of_fishing_net_shapes_by_gradient-based_optimization.pdf

NAV '12th - 17th International Conference on Ships And Shipping Research, Naples, Italy, 17th – 19th, October, 2012

The aim of the conference was to launch a new series of initiatives, with a strong international connection, to highlight how the results of research and development can contribute to finding a solution to the crisis that the shipbuilding industry, and in particular the European Union, is facing. It is widely believed that only a greater emphasis on innovation will overcome the current critical moment. On the other hand new requirements relating to the protection of environmental values, and all the technology associated with them - such as pollution reduction, energy savings, improved methods for the design of hulls and propellers, new safety policies - impose new requirements on designers and builders of ships and onboard systems. In this context, the conference came out in support of:

- enhancing information relating the European research programs during the current crisis
- reinforcing the exchange of research results at international level
- offering dedicated support to those research and development activities of interest to the shipping industry
- facilitating the dissemination and exploitation of research and technology findings, offering a meeting point for both the scientific community and the world of shipbuilding, shipping and the wider maritime sector.

The Symposium on Composite Materials focused on the innovative sector responsible for producing the materials used in naval and marine applications. Composites are now widely used for military, commercial, and recreational vessels and their strong characteristics are widely recognized, in particular with regards to strength, rigidity, fatigue resistance, durability and general chemical resistance. However, the incorrect use of such materials as carbon, glass and other high-property fibers may lead to poor results in term of the final structure, and the main aim of the Symposium was to demonstrate – and discuss in the presence of experts - the proper composite technology, design and application requirements needed to obtain the best possible results for innovative and high performances application. More info about papers are available at http://www.nav2012.unina.it/Keynotes%20and%20accepted%20Papers.htm or contacting the organization committee (http://www.nav2012.unina.it/Contacts.htm).

Energy management: a holistic operational strategy to enhance Ship energy efficiency of ships in service

(Topic: energy monitoring systems)

Reducing fuel consumption on board of ships is today a priority for the operators in view of the increasing prices of fuel and of the pressure by the international regulatory. Furthermore, at least in the case of CO2 emissions, there is a virtuous relationship behind environmental friendliness and economic benefit, as reducing marine fuel consumption by increasing the overall energetic efficiency of ships automatically means cutting down the emission of pollutants in the air. Finally, it must be reminded that Energy Efficiency for complex ships such as cruise vessels requires a holistic approach as all the main ship systems and processes related to the generation / transformation / consumption of energy must be in principle addressed and considered in an integrated manner if one aims to achieve an overall improvement. For such ships the main areas of intervention for Energy Efficiency actions are: propulsion efficiency, Waste Heat Recovery (WHR) efficiency and HVAC efficiency. The present paper addresses the first two items with more focus on the second as another paper was prepared by the Authors to illustrate possible operational actions to increase the propulsion efficiency of an existing ship in service. In any case, given the aforementioned complexity of large modern passenger ships, an optimized Energy Management policy strongly needs a dedicated Decision Support System. To avoid unnecessary proliferation of functions / systems, it is a natural choice that Energy Management onboard shall be performed by the Integrated Automation System. In order for the Automation System to evolve towards a support system for operational decisions and further towards a closed-loop control of the energy processes / plants on-board, it is necessary to implement in the system more knowledge on the plants / processes involved in the different tasks. The first step of this path is the ability to model and reproduce the whole cycle of energy consumption / production / recovery on board of a complex ship such as a latest generation cruise vessel.

Design and analysis of conventional and ducted propellers: a numerical approach

(Topic: propulsion systems)

In the paper a general design code, based on a fully numerical approach, is presented for the design of free running and ducted propellers. The presence of the hub and of the duct with the complex interaction that take places on the gap region, in fact, makes the design process of the latter propellers a difficult task if addressed with standard lifting line approaches. Built as a Lagrange multipliers minimization problem, the proposed design code represents an efficient way to overtake all the limitations of the original Lerbs' approach. In the paper the numerical design strategy is addressed, highlighting the capabilities to treat complex configurations. Afterwards the design of single and ducted propellers, panel and RANSE methods are applied in order to validate the design procedure: Open FOAM is employed, first, to assess the accuracy of the design approach and the results from the panel method and, secondly, to visualize the flow features on the most critical regions (at the propeller tip and at the duct trailing edge) for which reliable viscous computation are needed.

Cavitation tunnel tests on ducted propellers

(Topic: propulsion systems)

Propeller design requirements are nowadays more and more stringent, demanding not only to provide high efficiency and to avoid cavitation, but including also requirements in terms of low induced vibrations and radiated noise. Ducted propellers may provide the opportunity to reduce these negative effects or to increase the efficiency of heavily loaded propellers. This paper presents the development of a measuring device for the cavitation tunnel, in order to evaluate the forces on the duct. The measurement tool was designed and realized in house and it is at the same time the support of the duct to be placed in the cavitation tunnel and the device measuring the acting forces. By means of the developed measuring device, two ducted propellers with different characteristics (namely with accelerating and decelerating duct) have been tested at cavitation tunnel. The results of these two test series were compared with towing tank open water test data, showing a good agreement. Moreover, cavitation tests were also carried out, focusing the attention on the phenomena on the duct and on other interesting characteristics, such as thrust breakdown, providing useful data for future validations of numerical propeller design and analysis tool.

A computer program for prediction of resistance and power of the ship

(Topic: vessel design and technology)

Prediction of power and resistance of the ship is one of the most important components of ship design. Current practice of naval hydrodynamic design also wildly uses mathematical models. This is facilitated by developments in the field of computers and programming. These developments have facilitated the work with very long and sophisticated mathematical models. The purpose of this paper is to present the architecture of a computer code, written in Visual Basic, for prediction of resistance and power of the ship. In its current version the program uses the models of regression analysis Holptrop and Holtrop-Mennen. But the program is designed and planned to include other models of regression analysis in order to expand its field of application. The program gives a detailed report regarding the components and the coefficients of resistance, power and propulsion factors. Program also gives a graphical representation of total resistances and power depending on speed. The paper will be accompanied by a simple example of data entry and processing as well as relevant reports generated by the program.

Hybrid propulsion by gas engines for an ASD harbor tug

(Topic: engines, fuels)

Liquefied Natural Gas (LNG), compared to the traditional marine fossil fuels, has important key advantages as high efficiency, environmental friendliness and economic competitiveness. Unfortunately, up to now, the use of LNG as marine fuel is mainly hampered by the lack of appropriate infrastructures for ships bunkering. During the last ten years, LNG, as a bunker fuel, has been introduced in Norway, a true pioneer in marine gas propulsion. Presently it could be also available for ship bunkering in Italy and in several European countries, usually by a tank truck. In this paper the preliminary design of an ASD (Azimuth Stern Drive) tug, for towing and escorting operations (including firefighting and oil recovery duties) is illustrated. The vessel is characterized by a hybrid propulsion configuration, combining electric drive and gas engines. In fact, each of the two shaft lines is driven by a single LNG engine (Rolls Royce Bergen 2430 kW @ 1000 rpm) and an electric motor/generator (PTI/PTO) coupled through a dedicated gearbox. In Full Gas Mode, the maximum bollard pull and the maximum speed of the tug are respectively about 735 kN and 14 knots, while only the two electric motors, fed by the electrical power supplied by two Diesel generators, allow a cruise speed of at least 8.5 knots. It will be possible to adopt the MDO fuelled propulsion when the LNG system may be unavailable for any reason or whenever it will appear necessary to save LNG for the heavy duty phases of a service.

An Economic Analysis of the Costs Effectiveness Function for Measuring Ships' Technology Abatement Potential

(Topic: vessel management)

The European Commission and the International Maritime Organization (IMO) are looking into measures for reducing greenhouse gases and pollutants emissions of existing ships. Retrofitting vessels with green ship technologies is being considered. Apart from ethical and political considerations, there is a need to present and explain choices of ships, technologies and policy directives with rational economic analysis. This paper studies and analyses the cost centres on which such analysis should be based. Cost variables and parameters form the basis for building an economic assessment module that analyses private and social cost benefits of various technology measures. The study draws from the contribution of an economic analysis of the European FP-7 project Retrofit. The methodology narrows down cost variables to sensitive cost centres. The study finds that main retrofit costs will include capital costs, lead time costs, and running costs. Private or internal benefits are mainly limited to fuel savings. It emphasises the importance of distinguishing between investment and running cost of new technology in order to arrive at better investment decisions. Findings also highlight a non-stringent application, in the IMO proposed method, of the concept of opportunity costs in the marginal costs applicability criterion. The development and publishing of a guidebook on retrofit cost allocations with a clear definitions of the cost items and what the costs represent is recommended.

Monitoring systems: a strategic tool to enhance ship energy efficiency

(Topic: energy monitoring systems)

Public opinion shares a deep concern on the environmental impact of pollutants emitted by transport vectors in the air. Even if ships contribute to only 3.5% of the total CO2 emissions, all the marine stack-holders shall join in the objective of further reducing the emission levels from ships in the next few years. IMO is enforcing this objective via the introduction of new regulations on the energy efficiency of new-buildings and existing ships. The amendments to MARPOL Annex VI Regulations, add a new chapter 4 to Annex VI on Regulations on energy efficiency for ships to make mandatory the Ship Energy Efficiency Management Plan (SEEMP) for all ships. Other amendments to Annex VI add new definitions and the requirements for survey and certification, including the format for the International Energy Efficiency Certificate. The regulations apply to all ships of 400 gross tonnages and above and are expected to enter into force on 1 January 2013. On the other hand there is in this case a virtuous relationship between environmental care and economic convenience, especially as far as operational energy saving measures are concerned, as with the increasing costs of fuel every operational action which may increase the energy efficiency of the ship without any expensive re-fitting is expected to reduce the operational costs. It is recognized that monitoring of performance is the pivot around which the SEEMP is cycling as it provides a concrete basis upon which to set-up the planning and evaluate the results thus leading to the requirement for further improvement. Continuous on-line monitoring and immediate availability of all relevant data to the ship stack-holders is also the cornerstone of any progress towards increased ship autonomy. The ship Automation System is the natural candidate to act as the primary collector of all the data relevant to energy efficiency and as the manager of all the processes / plants which may affect the energy efficiency of the ship.

"99 XVINTAGE PROJECT" THE WÄRTSILÄ DUAL FUEL SOLUTION FOR A BREAKTHROUGH CONCEPT

(Topic: engines, fuels)

In 2016, less than four years from now, the IMO Tier III rules will enter into force, imposing a severe reduction in NOx emissions. The restrictions will apply to important designated areas, such as the Baltic Sea and the USA coastal waters. If conventional fuel is used, the means to comply with such regulations cannot be found on the endothermic prime mover. Post-treatment of the exhaust gases will probably be the most popular solution. An alternative answer is to simply change the fuel from diesel to LNG. More than 100 vessels in merchant, offshore and ferry applications are successfully operating on gas. To stretch the concept onto a demanding niche, Wärtsilä has developed a project, in cooperation with Fincantieri and Studio Pastrovich, for a 99 m megayacht called Xvintage, running on dual fuel technology. We will show technical features and the advantages of this solution. Fuel flexibility allows owners and operators to opt for the most suitable fuel (natural gas, marine diesel oil, heavy fuel oil) taking into account local environmental restrictions, fuel price variations and fuel bunkering possibilities.

Meetings and working groups

ICES/FAO WGFTFB – Lorient, France, 23th – 27th, April, 2012

The ICES-FAO Working Group on Fish Technology and Fish Behavior (WGFTFB) met in Lorient, France from 23–27 April 2012 to address four Terms of Reference. The main outcomes related to the ToRs are detailed below.

ToR A: Incorporation of Fishing Technology Issues/Expertise into Management Advice

As in the last previous 3–4 years, fuel prices were the dominant feature in all countries that affected fleet dynamics. Rising costs were manifested in multiple ways: shifts in gear, modifications to fishing practices, changes in vessel powering. Of particular note is the shift in the Netherlands away from traditional beam trawling to the use of the **pulse trawl** and the **SumWing**. It is now apparent that within the Netherlands, driven primarily by the cost of fuel, there is a huge demand to use the **pulse trawl** and the number of vessels applying to fish under the 5% derogation far exceeds the number of licenses available. Vessels not using the pulse trawl in the Netherlands are finding it increasingly difficult to get financial support from banks on economical (high fuel prices making beam trawling uneconomic) and ecological grounds (beam trawls are portrayed negatively).

As in previous years there is very little evidence of technology creep. Most changes are related to improving fuel efficiency measures. In the Netherlands and Belgium uptake of the **SumWing** has increased. The development of fuel efficient trawl designs, off-bottom doors in demersal trawling and the use of Dynex warp seen in 2010 and 2011 seems to have spread to many countries.

Uptake of selective gears continues to be limited and driven primarily by legislation. Interesting developments include the SELTRA used in Denmark and also tested in Ireland and also the Flip-flap trawl developed in the UK. Both of these devices are designed to reduce cod catches in demersal fisheries.

Discarding due to quota closures was especially noted in Ireland and Spain. Shifts in discarding rates were linked to population changes in Ireland and France.

A number of gear modifications have been tested and in some cases are being used to reduce the bottom impact of towed gears. As reported under Technical Creep there has also been considerable testing of trawl doors rigged to fish off-bottom, primarily driven by fuel prices. Both initiatives potentially have benefits in respect of reduced bottom impact.

Virtually no new fisheries were been reported in 2012. Experimentation of static gears as a means for targeting fish has continued although the indications are that these fisheries are still not economically viable in most cases.

ToR C: The Use of Artificial Light in Fisheries (Section 12)

The group reviewed the terms of reference and agreed that it would be necessary to address aims 1–3, before aims 4 and 5 could be completed. Therefore, priority should be given to tasks associated with aims 1–3 in the first year of the groups work.

It was agreed that in order to support the activities of the group in ad-dressing these ToRs the group would need to recruit further expertise in each of the following areas: physics and measurement of artificial light in water;

- engineering and design of artificial lights, including the development of energy efficient light sources;
- biology of vision, in particular recognition of the natural limits and variation;
- behavioural responses of fish to artificial light;
- technological application of artificial light in fisheries, including novel and innovative approaches.

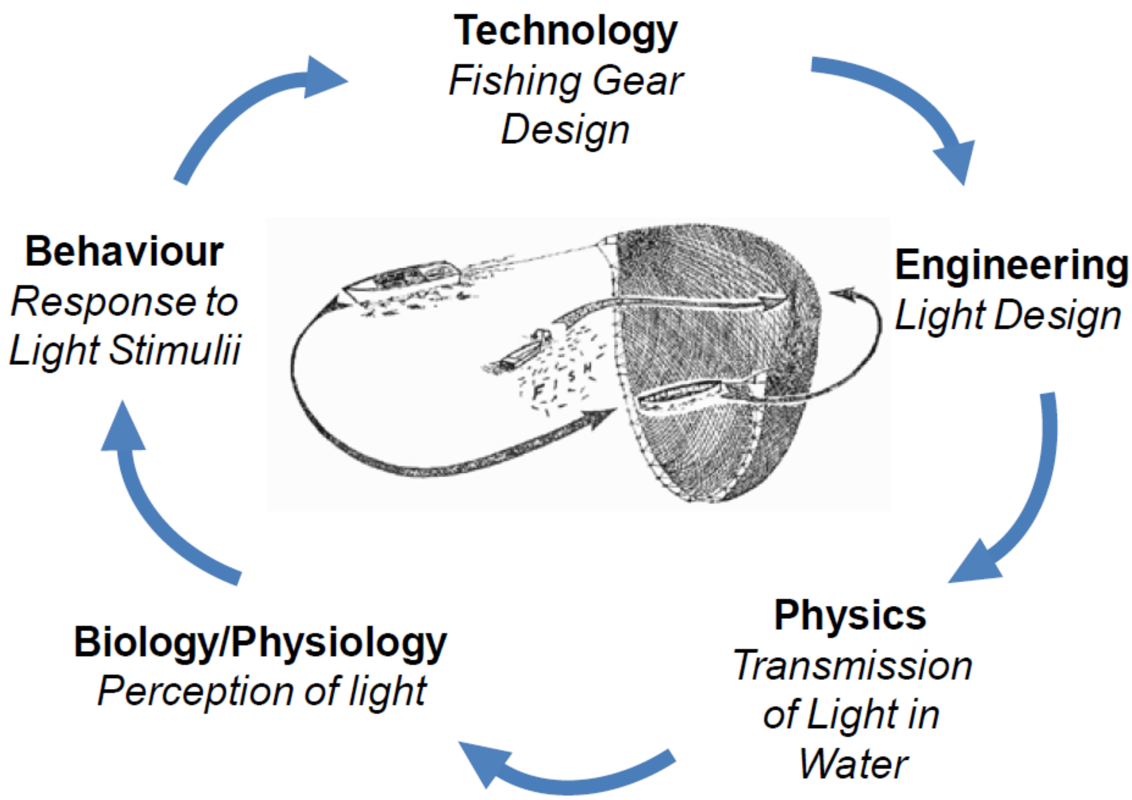

Figure 1. Artificial Light in Fishing – a multidisciplinary challenge (Illustration from Ben Yami, 1978).

The ICES/FAO WGFTFB Topic Group on the Use of Artificial Light in Fisheries makes the following recommendations to the ICES/FAO WGFTFB:

- The Topic Group on the Use of Artificial Light in Fisheries should con-tinue working by correspondence and meetings (at next WGFTFB meeting) under amended terms of reference (see below);
- It is proposed a theme session should be held at the next ICES/FAO WGFTFB meeting on "the use of artificial light as a stimulus on fish behaviour in fish capture"; and
- The Topic Group supports the proposal for the next WGFTFB meeting to be held in Asia. This venue will facilitate the development and work of this group, by opening lines of communication with experts in Asia currently working in the field of light fishing.

Amended Terms of Reference:

- A WGFTFB topic group of experts will be formed in 2012 to evaluate present and future applications of artificial light in fishing gear design and operations. The group will work through literature reviews, questionnaires, correspondence and face-to-face discussions.
- Specifically the group aims to:
    - Describe and summarize fish response to artificial light stimuli;
    - Describe and summarize use of artificial light in world fisheries;
    - Describe and tabulate different light sources to attract fish;
    - Describe challenges of current use of artificial lights in fisheries and identify/suggest potential solutions;
    - Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing by catch reduction devices and other sustainable fishing methods; and
    - Provide guidance on conducting experiments to investigate the use of artificial light as a stimulus in fish capture.

It is thought that artificial light, in the form of fire, has been used in fishing for thousands of years (Ben Yami, 1978). In the presence of artificial light, pelagic fish often school and move towards the light source and this technique is successfully employed in several fishing methods (Ben Yami 1978; Gabriel et al., 2005). Commercial applications of light in purse-seines, lift nets, and squid jigging are widely practiced, especially in Asian-Pacific countries. In jigging, hook and line, dipnet and purse-seine fisheries, artificial light sources are used to attract and aggregate squid and pelagic fish such as sprat, herring and mackerel (Ben Yami, 1988). In long-lining, light-sticks are widely used to encourage swordfish to ingest the baited hook (Hazin et al., 2005).

Indeed there are few fishing practices in which light is not sometimes used to attract or concentrate fish, and few fishing gears that are not sometimes used in combination with light to attract the fish (Gabriel et al., 2005).

Today, fire and gas lamps have been replaced by incandescent lamps, metal halide lamps or fluorescent lamps as the source of light these fisheries. While more convenient, safer and significantly more powerful, with respect to the light emitted, these lamps have generated new problems for the light fisheries in which they are used. First, competition between boats and métiers has led to an excessive level of light output from many established fisheries (Matsushita et al., 2012). As a result, the vessels incur increasing fuel costs and have an increasing environmental impact, in terms of light pollution and CO_2 emissions. Furthermore, this excessive level of competition, if unchecked, could easily generate a technological creep in catch per unit of effort and thus lead to overfishing. Commercial applications of artificial light for fishing have tended to be confined to surface or subsurface lights in fisheries that target pelagic and schooling species. Technological limitation partly explains the lack of application in demersal and deep water fisheries. Light systems operated at greater depths have mainly used battery packages for energy supply because cables were impractical. These batteries were heavy with a comparatively short life time and therefore not suitable. However, recent technological advances in battery and modern LED light technologies (Inada and Arimoto, 2007) have made available small, robust, powerful and energy-efficient light units that can be used in deeper waters for both static (e.g. pots and longlines) and towed fishing gears (e.g. trawls). Moreover, these new energy efficient light sources are continuing to develop and may be used to develop energy efficient and environmentally friendly fishing technologies for existing light fisheries.

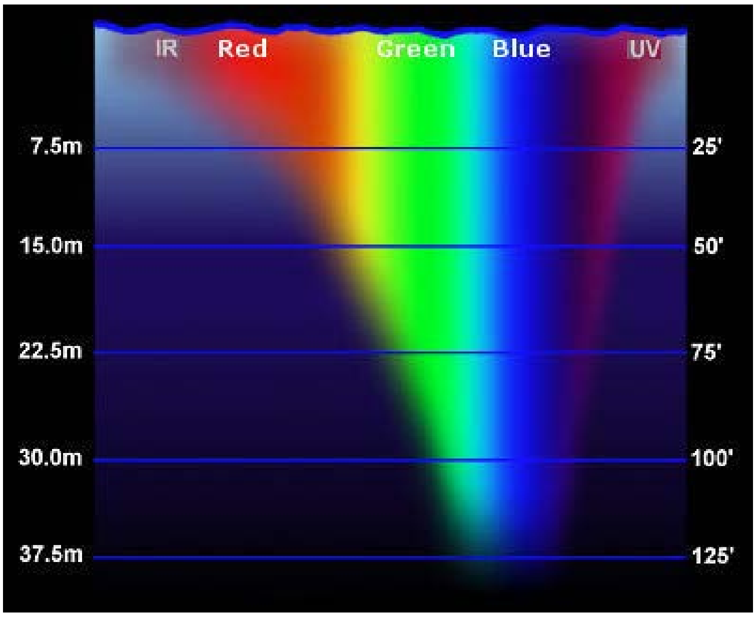

Figure 2. The spectral transmission of light in the open oceans: demonstrating the attenuation of different wavelengths of light, with greatest penetration in the middle wavelengths (450–570nm; blue and green) in comparison to longer (>620nm; red) and shorter (<450nm; violet and ultraviolet) wavelengths. (Reprinted from http://ultramaxincorp.com/?p2=/modules/ultramax/catalog.jsp&id=23 and cited by Arimoto et al., 2011).

Energy saving effect of LED fishing lamps for angling and jigging boats.

(Heui Chun An, Bong Seong Bae, Kyoung Hoon Lee, Seong Jae Jeong, Jae Hyun Bae and Seong Wook Park)

This presentation summarized research aimed to develop a highly efficient LED fishing lamp for the hairtail angling and squid jigging fishery to reduce fuel consumption and greenhouse gas emissions. Korean commercial fishing boats use a conventional metal halide lamp, which consumes fuel accounting for 65% of the total fuel consumption of the fishing boats. In this study, combination of LED lamp and metal halide lamp was used to investigate catch efficiency and fuel consumption. A 180W LED lamp unit with air cooled system was installed on a 9.77 ton angling boat. Catch efficiency and fuel consumption of vessels equipped with LED lamp and metal halide lamp were compared with those with metal halide lamps during fishing season of 2009 to 2011. Catch efficiency of vessels with the LED lamps was equal to or marginally higher than those with metal halide lamps. As for fuel consumption, LED lamps were shown to save 55% of energy use of metal halide lamp in hairtail angling and 26% in squid jigging.

Table 2. The power usage and relative catches of squid jigging boats using LED and/or metal halide lamps.

Vessel	Lamp	Power (kW)	Fishing day	Catch (kg)	Mean Catch (kg/day)
LED1	L 180W 140 +M 1.5kW 16-28	49 – 67 (Mean 58.2)	14	8,964	640.3
Metal1	M 1.5kW 54	81	9	3,594	399.3
Metal2	M54	81	8	8,352	1,044.0
Metal3	M54	81	10	4,826	482.6

It may be argued that the innovative use of light in fishing may lead to the reduction in energy usage by enabling the economic replacement of trawling with more fuel efficient alternative techniques. However, a number of the Asian delegates emphasized the conflict and acceleration of energy usage that can arise following the introduction of light fishing. The key driver for this problem is fishers simply attempting to outcompete each other with respect to light output, and therefore their ability to attract fish. If unchecked, such behaviour can also lead to overfishing. While some fishers in Asia have called for legislation to further limit power output from light fishing vessels, others have individually reduced their own power usage, and hence running costs, by avoiding other vessels.

Another solution is the introduction of low energy light sources, e.g., light emitting diodes (LEDs). LEDS have a number of advantages over conventional lamps. Their low energy usage means they have low operational costs; moreover they have a long operational life and contain no hazardous materials (e.g. mercury). They can also emit most wavelengths of light, over a narrowband wavelengths and in a highly directional beam (An and Matsushita, pers. comm.). Thus lamps can be produced which emit only the required wavelengths of light and in the required direction, thus minimizing wasted energy through the use of unnecessary wavelengths, as well as scattering and attenuation of the light. However there are also disadvantages to using LEDS: their narrow beam can be limiting in some applications and their luminous efficacy is generally less than metal halide (MH) discharge lamps (e.g. MH: 60–130 lm/W; LED: 30–100 lm/W; Matsushita, pers.comm.). Also, although LEDs are cost-effective in terms of running costs, they are expensive to buy (typically 5 times more expensive than metal halide lamps), however the prices are reducing (An, pers. comm.). Moreover wider beam LEDs are also being developed for applications which require a more diffused light beam.

ToR D: Innovation in Fishing Gear Technology:

It was acknowledged that the working scene is changing. Fishermen have PCs too, they use Internet more and more, are aware of threats to the fishing industry, have own ideas and creativity, and are not waiting for us.

- Good incentives are needed for successful innovation, such as: cost reductions (fuel price !!!), more days-at-sea (DAS) when using selective gears, or access to fishing grounds only if selective gears are used.
- Fishermen Study Groups (as in The Netherlands) can be used help the process of innovation. They create more motivation, and a sense of problem ownership by the fishers.
- Scientists should have a role in innovation. Developments by industry alone may lead to unwanted ecosystem effects. WGFTFB has an international view and wide experience, knowledge of gears, behavior, statistics, and suitable instrumentation (e.g. RCTV).
- Group interactions between fishers often occur, resulting in differing behavior. Experience shows that it is sometimes better to address a single individual and work with him, and then others will follow when they see results.
- Trust building and communication are important, but trust is easily lost.
- There is a tension between the objectives of creating more efficiency and ecosystem conservation. In order to survive businesses need efficiency and income exceeding costs, but on the other hand ecosystem constraints and conservation do not ask for more efficient gears and higher catches.

The topic group met on 25 and 26 April 2012 in Lorient, France. A total of seven presentations were given on various innovative developments on: Innovative Fishing Gears in The Netherlands;

An energy efficiency analysis for Italian fishing vessels through an Energy Audit tool; the Swedish Grid; Gear innovation to reduce cod capture in the Scottish Nephrops fishery; The prediction of the vertical forces applied on the seabed by a trawl gear; the effect of introducing pulse trawling in North Sea fisheries on a range of fish major target species; Innovative Low Impact and Fuel Efficient (LIFE) fishing practices; and a demonstration was given of the software DynamiT of Ifremer. The various aspects of innovation were thoroughly discussed. It was expressed that this Topic Group should not be continued next year, due to the fact that technological innovations in fishieries are proposed with a certain slowness and this makes it difficult to organize a devoted tor each year.

Innovative Fishing Gears in The Netherlands

(Bob van Marlen)

Attempts to improve fishing gears are not new. It has always been part of the research agenda in Europe, in the 1970's aimed at improving catch and mechanical efficiency of fishing, in later decades aimed at reducing unwanted bycatches and seabed impact. Dutch R&D resulted in new large mesh pelagic trawls in the 1980s and species selective beam trawls in the 1990s. Since 2008 the Dutch Fisheries Innovation Platform stimulates the development of innovative energy saving fishing gears in the Dutch fishing fleet. This approach has led to higher motivation in the industry and some new remarkable fishing gears being used to a growing extent. Examples from the Netherlands are: Pulse Trawl and Pulse Wing, SumWing, Outrigger, HydroRig, and Large Mesh Top panel in beam trawls, and Large Mesh front section in pelagic trawls. The energy saving potential and ability to address ecosystem concerns (bycatches and bottom impact) of these gears are discussed. Savings up to 50% in fuel costs and improvements up to 80% in net revenue can be achieved in beam trawling. The session is aimed at making an inventory of recent developments and identifying success factors for innovation.

Table 3. Drivers, actors and barriers mentioned.

Drivers	Actors	Barriers
Cost (fuel)	NGO's	Legislation
Salaries	Manufacturers	Low fish price
Market demands	Scientists	
Legislation	Fishers	
Social pressure	Fishermen's organizations	
Sense of ownership	Banks	
Communication strategies	Retailers	
	Consumers	
	Certification organizations	

Table 4. Updated summary of motives and level of uptake (OTM = Otter Trawl Mid-water; TBB = Twin Beam Bottom; LM =Large Mesh; LMTP = Large Mesh Top Panel).

Modification	Gear typea	Motive(s)	Level of use
Pulse Trawl and Pulse Wing	TBB	Bycatch ↓, fuel costs ↓	+++++
SumWing	TBB	Fuel costs ↓, impact ↓	++++
LM	OTM	Fuel costs ↓, catch ↑	+++
Outrigger	TBB	Fuel costs ↓	+
HydroRig	TBB	Bycatch ↓, fuel costs ↓	-
LMTP	TBB	Bycatch ↓	-

Figure 3. Pulse Wing.

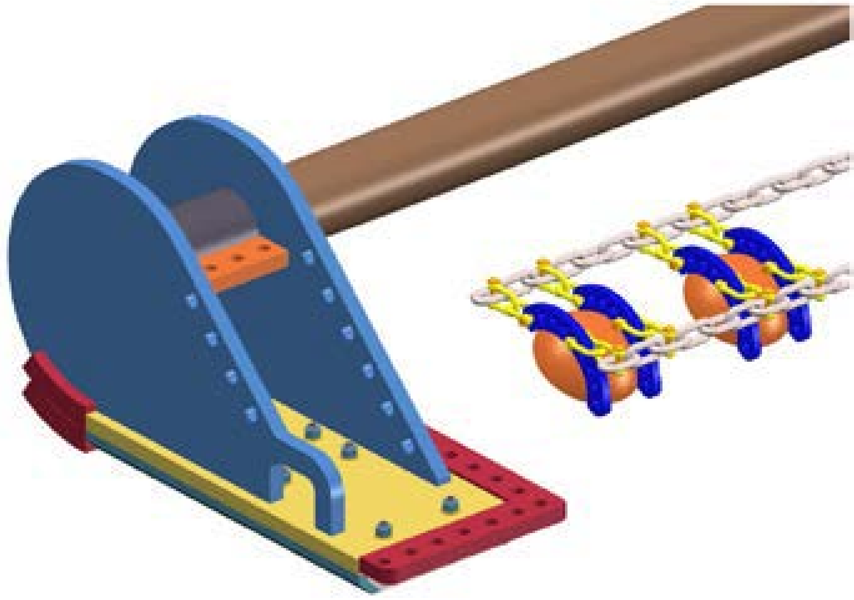

Figure 4. HydroRig.

Conclusions

- Success of introducing new selective, low impact and fuel efficient gears depends very much on strong (economic) incentives for fishers to use them. Sharp rises in fuel prices, threats of closing areas when selective gears are not used enforcement by law, and fish products losing markets if not caught in a sustainable manner are all strong incentives;
- Saving energy coincides well with reducing seabed impact and by catches, as gear components are designed with less bottom contact and releasing unwanted by catches avoids the need to drag these inside the net and bring these aboard.
- It helps when fishers identify themselves with potential solutions, instead of being told what is good for them, and involving them more directly in identifying research needs and setting up projects leads to higher motivation and acceptability. In addition there is a need for financial support of experiments.
- Scientists and fishers should preferably work closely together to create sustainable ecosystem friendly technologies and practices. Cooperation between fishers and scientists needs to be stimulated, with emphasis on open-minded attitudes on both sides.

Discussion

Static gears were not mentioned here, but a project was also done with three vessels using gillnets, pots and jiggers. There were many discussions in the Dutch fishing industry about fuel consumption and ambitious targets to reduce this by 2020 have been set.

ToR D is to learn about how innovation can be achieved and the role of science in it. In the EU there has been no real pressure to change anything for a long time. With increased incentives our role will change, e.g. as mentioned when a discard ban will be issued. Also many innovations we have suggested were not taken over by the industry, but the demand has increased recently. We should realize that we are not the only driving force, and that good platforms are needed to bring fishers together. Some expressed the view that scientists should change their role. In many projects scientific evaluation is needed. The example of the Dutch Fishermen Study Groups (called: ‘Knowledge Circles’) was deemed a good idea, and this attracted interest in other countries. The work under the phrase: “for fishermen and by fishermen”. The basis of many project is short with often a 3 year term, this may not be long enough.

It was commented that during the development of pulse trawling too little information was collected to conduct a real assessment of impacts and advantages and nevertheless many vessels have been given a license to use this method. Also interest for participation in SGELECTRA was expressed from Ireland.

The group felt that the scientific community should have a role in facilitating and evaluating innovation in the industry, but also can act as innovators itself. Then the industry needs to be given the chance to identify with a problem, and if so will ask the scientists for a solution.

An advantage this group has is that we can synthesize knowledge from all over the world, which fishers in most cases do not have. But on the other hand we should be open-minded and realize that we can also learn from what is going on in the industry. Fishers often change gears too quickly in experiments; it takes time for them to learn about the requirements for reaching scientific rigidity. It is often better to leave the choice to the fishers, and not to impose choices on them. A bigger mesh size is often the easiest solution, preferred by fishers, instead of more complex devices they have to install in their nets. Trust building and communication are important, e.g. involvement in stock assessment surveys by fishers might help to create mutual understanding, and examples of this in the Netherlands were given. Similar experience in Sweden was reported, with outcomes of surveys by fishers equaling the results found by the scientists. But the experience shows also that trust can be lost very quickly. This group is often associated with restrictions fishers experience from e.g. quota settings and other regulations. It is also wise to bring in fishers early in the innovation process.

Industry took over many developments started by scientists, e.g. large meshes in Norwegian and Dutch pelagic trawls. It is important to stress that we are working for the future of fishers. Often the reaction is: we don’t need what you suggest. It is recommended to make contact to the real innovators in the industry, there are differences in attitude in each group, and in any industry one deals with people who see a need for change and those who prefer not to take any risk and wait. New technology is often deemed as being misused by fishers, which hampered financial support, e.g. from the EU over many years.

GHG emission caps will become more stringent, it happens in the merchant marine right now, and will occasionally be asked of the fishing industry also.

The link to economy may not be only direct factor; costs associated with global warming may be much larger. The benefits might not go to the fishers addressing these topics. These diseconomies are not (yet) taken in the price of fish.

Our job has two aspects, a short term and longer term one. Projects are often short in duration. Results are often for a small group of fishers, scientists may be restricted in spreading out information.

Catch comparison of pulse trawl vessels and a tickler chain beam trawler
(Bob van Marlen)

Catch comparison trials were carried out on three vessels, MFV TX36 (fishing with HFK pulse wings), MFV TX68 (fishing with DELMECO pulse trawls), and MFV GO4 (fishing with conventional tickler chain beam trawls) fishing in the same area side-by-side in May 2011. The pulse wing is a trawl in which the 'SumWing' concept is integrated with pulse stimulation, and was used on board TX36. A total of 28 pulse modules spaced 41.5 cm apart are placed inside the wing and connected with parallel electrodes. The electrode array extends over ~6 m. The nets used on TX36 differ from the conventional model. The aft part was made of two identical parts next to each other. The DELMECO pulse trawl has 25 electrodes across its width spaced 42.5 cm apart, and was used on-board TX68. The nets used on TX68 were derived from the conventional beam trawl design. Conclusions of the work were:

- Lower fuel consumption (40–50%);
- Higher net earnings (150%);
- Fewer landings (60–80%);
- Fewer discards (30–40%);
- Spinal fracture in cod ca. 10%;
- No spinal fracture in whiting.

Table 5. Comparison of performance between the three vessels

Gear	Fuel (%)	Total catch (%/h – %/hect)	Landings (%/u – %/hect)	Discards (%/u – %/hect) fish + ben-thos	Nett Earn-ings/h (%)
CONV	100	100	100	100	100
PULS	43	37 – 48	62 – 81	33 – 43	156

Possible future work:

- Investigate ways to decrease effects on cod;
- Higher pulse frequencies (> 180 Hz);
- Affect cod behaviour in trawl;
- Measure field strength in situ on-board TX-19;
- Monitor future developments in pulse characteristics;
- Extend catch and bycatch data by further monitoring of pulse trawling, and more catch comparisons side-by-side;
- Further debate in SGELECTRA
- Further studies on ICES-questions when these are asked for;
- Compare direct mortality of benthic invertebrates of recent 12 m pulse trawls with conventional beam trawls;
- Current FP7 project BENTHIS (Trawling impact);
- Evaluate effect of introducing pulse trawls in North Sea fleets on major target species and non-target (benthic) species;
- Extend and improve models linking physical properties to biological effects.

Energy efficiency analysis for Italian fishing vessels through an Energy Audit tool
(Antonello Sala, Gabriele Buglioni, Emilio Notti)

At least since we learned to admit that crude oil reserves are limited, improving energy efficiency has been regarded important. Recently the climate effects of exhaust gases from combustion processes have been increasingly focused. This is underlining the importance of improving the energy efficiency in all sectors in which are currently depending on the use of combustion engines, among which we find modern fisheries. The actual fishing fleet, in most cases, is not efficient because of outdated technology. Nevertheless there is no question fuel consumption in fisheries can be reduced and should be a directive of fisheries regulators. There are new technologies and products available that can reduce fuel consumption and lower exhaust emissions. New fishing vessels have a great efficiency level, compared to the actual state-of-the-art. Over the years the energy efficiency of the ship goes down due to obsolescence, while that of the state-of-the-art rises. Maintaining an adequate level of energy efficiency requires a continuous monitoring of the vessel's energy profile through a methodological measurement approach. Any cause of energy inefficiency can be identified, and thus acted on promptly and effectively. An energy audit tool is therefore essential to maintaining high energy efficiency of the vessel. With an energy audit it is possible to evaluate the energy performance of fishing vessel under different operating conditions. Once energy consumption has been related to each operating condition and speed, fishers can modify fishing operations to minimize fuel consumption, through energy audit which allows obtaining an extensive energy profile of the fishing vessel monitored. The energy profile is defined through Energy Performance Indicators, so that comparisons between different vessels are possible. The system consists of flowmeters, torque and shaft r.p.m. meters, an ammeter, strain gauges, GPS, and a gear monitoring system, connected to a data logger. Gear drag and thrust are determined. Propeller characteristics are often not known by the fishers in Italy. Energy and fuel consumption indicators are used. The pelagic boats take more power than the bottom-trawlers. A number of follow up activities improving energy consumption were mentioned. If you can show benefits fishers are interested. The typical age of boats in Italy is old, 20–30 years, and therefore efficiency is problematic. A strategy is needed to come to proper solutions. Use of ducted propellers in bottom trawlers is advocated. A small reduction in steaming speed of 11 to 10 knots may save as much as 20%. Project ICEEF was brought to the attention of this group. A list of terminology in different languages is also on the project website, and private initiatives are linked to.

Discussion

Is there a sense of urgency? Yes, there is an economic urgency. Engine power control can be helped using this audit. Fuel meters are used more and more and fishers react to them. A Good Environment Status (GES)-like system is not used yet. The audit has no prediction element, but gives a picture of reality. Contacts with fishers came from regular gatherings at the laboratory that happen on Fridays. One has to improvise now and then; the system may be shut-off at times, when fishers do not feel comfortable. Landings and economic benefits could be added to the system. Revenues are not yet taken in, this would require a number of years of data collection as catches fluctuate. Sensors are auto-calibrated; in other cases the relation between measured value and reality is known. There is no need for frequent calibration. The torque meter gets special care. There is a good feedback from the skippers, who also suggest improvements, and ask for reports. Work with one fisherman when you introduce an innovation, others will follow, instead of trying to address a whole group, as they will behave differently in a group. Experience in France shows that it is difficult to compare vessels as calibrations may differ, hull shape, length, engine and gear may be very different. Increasing vessel power is often regarded as suspect. Economic certification on fuel economy is starting up in France. A total of 60–100 boats will be tested. The thrust on the propeller is of vital importance, and the drag of the fishing gear. Biologists only speak of vessel power, and seem to ignore gear characteristics. Trawls are often not well rigged. It is important to not only look at the net drawing, but take experiences of skippers onboard too in direct contact. It is also wise to involve net-makers in the process. Otherwise time is lost.

EFTP - Challenges for a sustainable European fishing fleet

The workshop took place from 6th to 7th June 2012 at the premises of the Institute for Coastal Marine Environment (IAMC), Italian National Research Council (CNR). A total of 28 participants from different countries and with different background disciplines and professional profiles, attended. The European Fisheries Technology Platform aims to identify the key challenges for the future of fisheries and fishing research, technology and innovation and to formulate, based on them, the sector's strategy and action plan that will strengthen its capacity to grow smart, sustainable and inclusive in the forthcoming years, thus, keeping a prominent role within the European Marine Economy. The EFTP, through its Board of Directors and Secretariat, is promoting a number of workshops aimed to discus and reach agreement on a series of issues that are or paramount relevance to the above mentioned process:

1. Fishing Vessel Technologies
2. Energy Efficiency
3. Discards

The aim of the Fishing Vessel Technologies workshop has been to make progress on the EFTP's RTDI strategy by compiling the inputs from a panel of stakeholders and experts from different European regions, developing diverse activities and representing different particular interests. Discussion has been lead to reach a consensus on the key challenges and on how efforts should be oriented in the forthcoming years with regards to those.

The workshop started with a set of welcome and introductory presentations, aiming to give attendants a broad overview of the current marine context scenario regarding strategic multi-stakeholder collaboration, public funding integration perspectives and forthcoming changes in policy and regulatory framework. In this context, Dr. Salvatore Mazzola presented an overview of the Italian fishing industry and on the general situation of the Mediterranean fisheries. He remarked a number of key areas where research and innovation yields positive outcomes for the industry to develop and grow sustainably, going from a biology and ecology perspectives to the equally relevant economics and governance issues. He also expressed the interest of IAMC-CNR to integrate and contribute to EFTP working groups and discussion fora.

Dr. Kathrine Angell-Hansen provided a wide overview of the JPI Oceans initiative. She explained its background, its aim and scope, its current status and forthcoming expectancies. She specially remarked JPI Oceans capacity to integrate outcomes from different stakeholders and initiatives related to European Marine and Maritime Research and Innovation. She remarked the crosscutting approach of JPI and emphasized the common areas of interest with EFTP. A video from Dr. Mogens Schou, advisor of the Danish Ministry of Fisheries, was played and shared with the audience. Dr. Schou focused his presentation mainly on the Reform of the Common Fisheries

Policy and on one of its main objectives: the discard ban and its consequences, making special emphasis on the transfer of responsibility to the fishermen. He presented this scenario as a great challenge but also as a great opportunity for the fishing industry to demonstrate its capacity to tackle the issue in collaboration with the research bodies. Finally, Dr. Adolfo Uriarte, made an overview on how funding instruments and relevant policies for the EFTP are evolving. Current prospects regarding some of the most relevant funding instruments for future of fisheries related research and innovation action were addressed. The process for the definition of Horizon2020 and the European Atlantic Ocean Strategy, was introduced as an opportunity for the EFTP to provide inputs that can influence the orientation of priorities towards European Fishing Industry's interests. Most specific and research and innovation related contents of the workshop were addressed in a total of four sessions focusing each of the following aspects:

1. Multipurpose fishing vessels.
2. Vessel security technology and on-board ergonomics.
3. Effective fish handling systems.
4. Fuel efficiency and footprint.

Conclusions achieved

The text below consists of an introduction and a summary of the round table discussion that was organised in four groups as above mentioned.

Multipurpose fishing vessel technologies

Dr. Vegar Johansen, from SINTEF, introduced his presentation with an overview on the current status of the European fishing fleet. Factors such as the limited fishing opportunities, the overcapacity and large activity outside EU waters were remarked. From a technical perspective, one of the most relevant technical matters of the European fishing fleet is the diversity of technical standards. It should be deeply considered in implementing future innovations; establishing strong standards contributes to guarantee the existence of a market offering attractive opportunities for innovation uptake. Multipurpose fishing vessels provide an opportunity to increase profitability for the sector and even to diversify the activity towards other complementary ones. One of the issues that in nowadays context gains more and more prominence has to do with the opportunity currently available technologies offer to have detailed real time information on the fishing activity. This technical context will probably open new possibilities for more flexibility in regulating the activity, making it possible that vessels use multiple gears (i.e. to cope with seasonal variations of some target catches) and even that they open time slots to accomplish different complementary activities such as marine observation, marine litter collection and sea cleaning, spills' contingency cooperation, tourism, maintenance and transport activities related to aquaculture, support to development of marine energy platforms, etc. Thus, in this context, flexible technology becomes the challenge. Multipurpose vessels should be capable to serve many of the above mentioned purposes. There are also some specific challenges regarding the incorporation of some of these activities, for example, the involvement of fishing fleet in data collection for stock assessment and in other marine observation activities would benefit from the improvement of systems to automate the data capture and facilitate transmission. Involving fishing crews in other activities different from fishing and fish handling, will require relevant efforts in training and skilling the crews for multipurpose work. Security requirements must also be considered in this scenario. EU and national regulations should also encompass this process to make it feasible. On-going experiences of multipurpose activities should be identified and benchmarked. In Norway for example it is being successfully accomplished a collaboration between fishing fleet and oil companies to involve them in transport and support to maintenance activities. Dr. Bernardo Patti, from CNR_IAMC remarked the relevance that the broad adoption of VMS should have in the application of the ecosystem approach making feasible the purpose to integrate data from commercial fisheries in stock assessment. Enhanced VMS is considered a key technology at the present. This technology is evolving to interactive VMS and current work show how feasible it is to integrate the VMS information in complex geo-referenced decision support systems. The speaker referred two on-going projects: SSD-PESCA “Decision support system for sustainable management of fisheries in the southern regions in Italy” and the Italian flagship programme RITMARE.

Interactive VMS integrates logbook with touch screen, GPS antenna and software tools for different purposes and geo-referenced data analysis. The project has integrated technologies to become a fisheries observation platform serving to different stakeholders and purposes (environmental and at the same time helping fishermen to operate more efficiently). CPUE estimates, for example, can be obtained and in fact the platform designed is already providing forecast maps that help collaborating skippers in their decision processes.

System includes different means to catch relevant data, a system for transmission and a land platform to process the information gathered. The pilot system has been installed in a number of bottom trawlers operating in the southern Adriatic Sea basin.

Future improvements should base on a new generation of sensors and radar technologies capable to measure and detect different environmental parameters and events (with relevance in fishing under safe conditions, i.e. surface currents, waves… and in efficiency) with high resolution, and new systems for device switching and data real time data transmission.

Discussion among participants in the workshop remarked a number of challenges that were before the end of the workshop prioritised though the voting process carried out.

Outstanding challenges:

- Implementing the ecosystem approach by using the vessel to capture data.
- Integrating the sustainability concept and multipurpose activities for the global ship design.
- Catering the ship for complementary activities like tourism, energy transport and support to maintenance activities, surveillance and support to contingency plans, litter gathering, etc.
- Develop technologies (gears and management systems for multi-gear vessels) to make feasible and efficient a multispecies catching to cope with seasonal variations.

With few exceptions **there is a clear consensus that future efforts in this field should mostly concentrate in demonstration of available technologies under commercial conditions operation, and in further steps towards innovation and technology transfer.**

Most of the challenges identified would also require a support from policy action to facilitate not just the demonstration activities but mainly a feasible uptake of technologies by the industry. Such support would require in some cases, for example to cater tourism on board, adaptations in the European, national and regional regulatory frameworks, that facilitate at the same time the assumption of risks by assurance companies… Support in other cases could comprise incentives for the fleet to facilitate investment, training incentives for crews to perform alternative activities, etc.

With regard to the scope for action implementation, most of the issues can be considered of EU and even international relevance, however regionalisation of actions would also be recommended to select possible multipurpose alternatives in coherence with the area context.

The maximum framework considered to achieve these challenges is 2020, however, and given the current available knowledge and technologies, relevant results could be available within a midterm, by 2016.

The fishing industry has clear a niche of opportunity in implementing the concept of business hybridization. Growing smart under this new business model, would definitely benefit from integrating knowledge and technology in adapting the production means, from multipurpose vessel to multipurpose business, to operate under optimal conditions and take the most from this adaptation process.

Vessel security technology and ergonomic work on board

Dr. Emilio Campana, from CMR-INSEAN, focused his presentation on vessel safety aspects and energy efficiency. Although energy aspects will be summarised at 3.4 section in this report, it was developed the idea that future vessel technologies will mainly focus on improvements of design tools and experiments for safety purposes and on greening the vessel to reduce fuel consumption for efficiency and sustainability purposes .

Navigation and manoeuvring conditions are frequently dangerous at the open sea; violent water-vessel interaction can damage the vessel structure and equipment, seriously alter the vessel dynamic stability and put the crew under extremely risky situations. The more precisely interactions can be measured and consequences predicted, the more efficient vessel designs and decision support systems will be.

Research tools to make progress in this area comprise numeric modelling, model testing and full scale trials. One of the key challenges for the future research in this area is to integrate more information about the fluid-structure interactions and its consequences, to make the models more complex and to combine the results obtained with data from model and full scale tests. This will make it possible to improve models' prediction capacity to the possibility to introduce real operation conditions in design and predict ship behaviour and optimal manoeuvring. And further, allow a complete physical understanding on what happens to the boat in different situations. CFD-EFD integration: may help filling the gaps and improve the knowledge significantly in this area.

Key technologies to concentrate future efforts should mainly consider hydrodynamics (for simulation of stochastic environmental phenomena, to develop models capable to predict instability and capsizing risk during real operation under bad weather conditions); electro-elasticity (to optimize the elasticity of the hull design) and electromagnetism (improving x-band radar systems to provide spatio-temporal information on wave fields and surface currents). The integration of research improvements in these areas, together with high computational capacity possibilities, and an approach based on design possibilities plus model testing and full scale trials, would allow significant improvements in design efficiency for safety purposes. New materials and surface treatment technologies should also be considered in addressing new and more safety vessel designs.

Dr. Xabier Aboitiz, from Azti Tecnalia focused his presentation on challenges regarding safety of on board activities, not only dependant on vessel behaviour in different navigation and manoeuvring conditions, but also dealing with the special conditions of labour on board. As far as fishing vessels are not just transport units but catching, handling, processing and storage units the relevant regulatory framework comprises not just maritime safety regulations, but also labour safety conventions and Directives. One of the key aspects to gain efficacy in developing new safety and ergonomic devices, or in introducing safety and ergonomics in on-board technologies (gears, deck equipment…) is to have a reliable base of information on accidents that allows the identification and assessment of risks. There are available risk assessment methods, but they have been developed for land conditions, considering standard tasks and labour journeys. Working at the sea is significantly different from land standards and thus, specific risk-assessment tools should be defined.

Again, having more, long term and good quality information and adequate tools to analyse it, is essential to support the decision making process on board. Software tools should be developed for this purpose, and again specific characteristics of the fleet and of the work on-board should be considered: easy to understand and use tools, quickly processing information and providing outputs for the skipper, automatic feed of data through sensors', sensors' networks and other devices, are just some of the requirements for future development to achieve such challenge.

Outstanding challenges:

- Improving vessel stability by means of new designs based on complex modelling, model testing and full scale trials.
- Continuous monitoring of different parameters affecting ship safety, improvements in radar technologies.
- Freak wave detection and improvement of information on severe weather conditions and its interaction with the vessel's structure and devices.
- Improving the design for noise and vibration reduction and thermal control inside the vessel.
- Development of new protocols for risk assessment adapted to on board real operation conditions.
- Monitoring dangerous aspects of on-board operations, such as gear handling.

Some of the above mentioned challenges still require significant research and development efforts to related core technologies. Namely improvements in numerical simulation and modelling, EFD-CFD integration, X-band radar and design optimisation would benefit from oriented research efforts aiming to address more complex and affordable solutions.

Available technologies should also be applied for demonstration purposes in existing vessels (i.e.: decision support systems, monitoring systems, etc.) given this should provide relevant data to speed up related research activities and better adaptation to market and real operation requirements. On-board risk assessment and development of ergonomic workstations would also require the acquisition of some new knowledge through good quality and long term data. Risk assessment can benefit from tools developed for on land operations however specific development and major efforts in technology transfer for implementation should be made, to yield preventive measures and decisions. Dangerous operations, and particularly gear handling, should probably require specific research and development and innovation to provide tools that detect precisely the risks and support real time decision taking. All the challenges are of international relevance, although the approach to the problem should consider specificities of the fleets and operation areas. One of the key drivers constraining the improvements in this field is the lack of economics in and incentives for investment in new vessels. Thus, short and mid-term possibilities would benefit from development and innovation efforts that can provide partial step-by-step improvements, nonetheless necessary to make progress towards better and safer working conditions on board. Research-based improvements in vessel safety and on-board security would be expected available technologies in the long term (10-15 years). However significant improvements in monitoring safety and ergonomic parameters, in developing decision support systems and in introducing improvements for a more comfortable life at the sea, should be feasible within a shorter term.

Fuel efficiency. Fisheries' carbon footprint reduction.

Contributions to this topic were provided with regard to four main aspects: efficient vessel design and equipment, gear technologies, analysis of energy use through energy audits and decision support systems. Dr. Antonello Sala, from ISMAR-CNR, remarked the current relevance of fuel costs for the catching sector, representing, in average, 55% of the total running costs. Improving profitability ratio is depends strongly on the possibility to reduce energy consumption as far as increasing the amount of catch is not a presumable scenario and fishermen's possibilities to influence the prices is kept low. Energy audits can help establishing the baseline to implement measures for fuel consumption reduction, as far as they consist in systematically approach the evaluation of energy consumption in fisheries. Many factors influence the energy consumption in a vessel and the variety of fleets and technical standards makes this analysis a complex process.

One of the key aspects to consider is the selection of instruments that should be used to measure energy consumptions in a vessel. Current work has been performed at ISMAR to determine what the main energy consumers are in a fishing vessel, which are the best instruments for measuring, and how far consumption patterns differ among different kinds of vessels. This has provided some evidence on the adequacy of the instrumentation used (acoustic fuel meters, torque meters, oil flow and pressure meters, Ammeter claws, strain gauges, GPS and gear monitoring systems) and on the measurements taken. One of the challenges was to integrate these elements in a common system to systematically record consumptions and facilitate the post-processing of information. Results also recommend to use a series of indicators for comparison such as power delivered, fuel consumption, total towing force and vessel speed. The research carried out suggests that some inefficiency come from obsolescence of designs and devices. Some improvements can be achieved from retrofitting, however, in the future, energy efficiency will have to be better considered in fishing vessel's design. It can even be expected that Energy Efficiency Design Index is also applied to fishing vessels.

The work also evidenced that audits are crucial to determine an energy efficiency strategy and to identify the areas for improvement. In general, it can be said that relevant savings can be obtained from using navigation with controllable pitch propeller, from optimizing the routes (if weather and environmental information is also considered) and from strategically reducing speed. Development of fishing gear technologies can also play a key role in energy efficiency. Gear design and improvements in otterboard can also yield significant improvements. Again, it is crucial to use different measuring technologies (distance, tension, pitch and roll sensors…) and the analysis strategy should consist in comparing traditional designs with new ones operating under full scale commercial conditions. Computational simulation could also benefit from exhaustive data from experimental field trials, making a good alternative for future estimates if models can be optimized, thanks to current efforts in field trials.

Dr. Zigor Uriondo from AZTI, emphasised the idea that currently available vessels were built when fuel prices were significantly lower than today, and that far, energy efficiency was not given enough relevance. Energy consumption reductions can be expected from technical improvements but also from operational changes. Technical improvements are restricted by the low expectancies on a short term fleet renewal. Consumptions profiles are different for different kinds of ships and it is not evident the optimal-feasible solution in each case. Derived from this variety of fleet it is also that new sources for energy could be considered but it has to be considered the different needs; propulsion, generation vs. consumption. Then improvements should be addressed differently, one issue is new generation systems and propulsion and another is reducing consumptions. Specialised and independent energy audits can recommend feasible improvements. Optimal results could only be expected by stressing the need to improve new vessel designs to integrate in it a proper approach to energy efficiency. Improvements in generation and propulsion will come from alternative prime-movers, heat recovery systems, alternative energies and fuels. Small changes in equipment and on-board devices including efficient fishing gears are the key areas for improving the carbon print through lowering fuel consumption of the current fleet. Dr. Karl Johan Reite, from SINTEF, points out that the amount of information to be considered in taking decisions to optimise the efficiency of the activity, and in particular the energy efficiency of the fishing ship, is great and complex. A more systematic approach to the decision making process is required. He divides the types of decisions into operational and design decisions. He further establishes three operational decision levels: strategic, tactical and immediate. The operational decisions will affect the vessel's energy efficiency within the constraints given by the design decisions. Decision support systems can be developed to help both, design and the three levels of operational decision. In its most simple form a decision support system may provide the operator with better information. The second step would be to make the operator able to perform 'what if' analysis, and the third step to give the operator direct advice with respect to what to do. For the second and third step, simulation of the process to optimize would be needed, making simulation of the fishing process a necessary goal. It would be of great benefit to all if there is a strong commitment to exchange experiences and information and to open access to experimental data, to enforce and fasten technological development and its impact.

Outstanding challenges:

- Standardise fishing vessel energy efficiency measurements and measuring devices for energy monitoring and decision support systems.
- Develop energy monitoring and decision support systems
- Develop tools to aid the design of more energy efficient vessels.
- Development of alternative energy propulsion and generation systems.

Research within future fishing vessels design, should specially focus on energy efficiency with respect to design, building materials, equipment, etc. The lack of knowledge about vessel behaviour during operational conditions is also an important issue that should be addressed.

Development can be achieved to register data of different nature that influences the energy performance of the vessel and integrate this data in a decision support system. Computing techniques should be considered in this to let the system learn from past and predict future scenarios. Energy efficiency and reducing fisheries' carbon footprint is a global problem, so solutions should come from a Pan-European scope of actions. Apart from the facilitating and speeding effect that incentives derived from policy action could have, it is a key driver to work with fishermen in training them to understand and manage the energetic aspects of the work on-board. Decision support systems which are easy to use can be of much to their users for reducing energy consumption.

EFTP: Key challenges to promote the energy efficiency in fisheries from a research and innovation perspective

The workshop took place on the 12th September 2012 at the premises of Secretaría General de Pesca, in Madrid. Participants from different countries and with different background disciplines and professional profiles attended.

The European Fisheries Technology Platform aims to identify the key challenges for the future of fisheries and fishing research and technology and, based on them, to formulate the sector's strategy and action plan that will strengthen its capacity to grow smart, sustainable and inclusive in the forthcoming years, thus keeping a prominent role within the European Marine Economy. The EFTP, through its Board of Directors and Secretariat, is promoting a number of workshops aimed to discus and agree on a series of issues that are of paramount relevance in the above mentioned process:

- Fishing Vessel Technologies
- Discards.
- Energy Efficiency.

The aim of the Energy Efficiency workshop has been to make progress on the above mentioned process by putting together the inputs yielded by a panel of stakeholders and experts from different European regions, developing different activities and representing different particular interests. Discussion addressed the key challenges and how efforts should be oriented in the forthcoming years with regard to them.

The workshop started with a set of welcome and introductory presentations, aiming to give attendants a broad overview of the current marine context scenario. Mrs. Aurora de Blas, Deputy Director of General Secretary of Fisheries from the Ministry of Agriculture, Food and Environment of Spain, and Mr. Javier Garat, president of the European Fisheries Technology Platform, presented this workshop highlighting the importance of energy efficiency in the fisheries sector.

Then Mr. Miguel Pena – Castellot, from DG MARE at European Commission, analyzed the importance of rising fuel costs in fisheries, the reaction by the sector and the reaction by European Commission.

Finally, before the working session, Mr. Torgeir Edvardsen from SINTEF exposed how the EFTP and other Technology Platforms gain increasing influence on research and innovation issues in Brussels, also mentioning the importance of the strong commitment from the sector.

At this point the prioritization of research and innovation issues commenced. To facilitate this process, a discussion document was drafted in order to introduce the scope of the problem and propose major challenges and core technologies to promote. The following questions were proposed for the debate:

- Core technologies, required for application to solve the identified challenge.
- Background: what has already been done:
  - Are there any available technologies suitable to help solving the problem? If not, what is the reason? If yes, why those technologies have not reached the market yet?
- Necessary activities: type of activities, expressed in % from research, demonstration, innovation and market development.
- Scope: the most suitable scope for addressing the challenge: National, EU Regions, EU Level or international.
- Key drivers: aspects which would facilitate and promote the process: technology, market and/or regulation.
- Priority: order the challenges according to the urgency / importance to be solved. Priority was assigned from 1 to 5, corresponding 5 to the higher priority.
- Horizon: expectancy for the challenge to be solved. Short (5 years), Medium (10 years) or Long (20 years) term.

Conclusions achieved and situation

An important element for the sustainability of the fisheries sector is the need to reduce energy consumption and to do so throughout the entire value chain in the fisheries, “from the ship to the shop”. The increased focus on energy consumption is also a core aspect to improve fishing industries’ corporate strategy to cut down expenditures in its processes and an environmental challenge to fulfill international obligations like the Gothenburg protocol and the Kyoto-agreement to cut down greenhouse gas emissions. The greenhouse effect causes changes in oceanographic conditions of seas and oceans and, therefore, in fishing resources. Fishing is one of the most energy-intensive food production methods in the world, depending almost entirely on fossil fuels. In 2008, the world’s fishing fleets were responsible for about 1.2% of total global fuel consumption, corresponding to 0.67 liters of fuel per kg of live fish and shellfish landed. In the same year, the EU fleet consumed 3.7 billion liters of fuel, representing 25% of the value of landings. Fuel consumption acts as an indicator of environmental impact with the EU fleet releasing 10,000,000 tons of CO_2, or else 1.81 Kg CO_2/kg of fish landed. This represents 0.23% of global greenhouse gas emissions. Between 1995 and 2002 in the EU-25, fuel prices have increased by an average of 80%, while fisheries production declined by 17%. More recently, between 2002 and 2008, fuel prices increased by 152%, while average fish price increased by 67%, and profitability decreased by 33%. Landings in the same period decreased by 23% and in fact in 2005, imports of fish products surpassed EU-landings for the first time. The ratio landing value/fuel cost demonstrated a clear decreasing trend with the fuel efficiency of fish capture indicator being halved since 2002. Mostly because fishing capacity is greater than the available fish stocks, many fishing fleets in the EU have been facing economic problems. With added concerns about oil prices since 2005, energy efficiency is the key to profitability and has become both a political and a scientific issue. It is now acknowledged that EU fishing fleets expend vast quantities of energy and that low overall efficiency is caused not by high oil costs but rather by structural deficiencies.

Main topics and challenges to focus RTD & innovation efforts in energy efficiency

Topic 1: Data acquisition and control systems. Energy Audits

The aim of this topic is to develop a portable and reusable tool to obtain full information on the generation and use of energy on board. This requires the implementation of a data collection system, subject to quality control and stored on a Geo-referenced-chronologic way for further analysis.

– *Challenge 1: Tools for energy data acquisition*

It includes software and hardware (sensors, data loggers, etc.). Difficult to measure energy flows: one unique input (gasoil) but many different outputs. Sensors on board are a critical point, in particular the inexpensive and reliable method of measuring fuel consumption. The data acquisition system should not interfere with normal use of the vessel, but it's good to include navigation data. Data Acquisition Systems (DAS) and accurate sensors are relatively expensive, so present costs are assumable for large ships but prohibitive for smaller ones.

– *Challenge 2: Energy management and control systems*

The integration of data collection with some settings criteria allows implementing energy management systems that help decision making. The simplest option is to measure fuel consumption and show with the relation speed-consumption specific for a vessel. A more complex system should optimize aspects as the electricity consumption (for example deciding when to connect the cooling).

– *Challenge 3: Energy audits.*

An energy audit, which requires extensive expertise and a good data acquisition, may propose solutions for each vessel. It is a necessary step to reduce energy consumption of existing vessels. Transparent energy audits should be promoted, defining the existing “base line” in terms of energy efficiency and advising about how to improve. Efficiency improvements could result in improved catching ability of ships, and this is not acceptable. Proper means should be identified and provided in order to certify this catching ability is not modified (speed/position data loggers, etc.) In any case, legal aspects should be adapted to technological development, and should not be a barrier.

Topic 2: Propeller train optimization

– *Challenge 1: Propeller selection and new designs*

There are many qualified companies and technology centers in Europe dedicated to propeller design, but fishing boats are often equipped with propellers not matching correctly their needs, despite this is a critical aspect in fuel consumption control. Interventions frequently focus on engines, but some experts consider this is probably not the best factor to influence on. However, it appears to be no awareness about the importance of a correct propeller selection, and could be really useful a sort of "propeller selection guide" summarizing the main aspects and criteria.

– *Challenge 2: Engines selection and configuration*

The correct choice of the engine is critical for fuel consumption. In particular, engines have poor performance when working under low load. A configuration to consider is the use of two different engines when two different regimes are frequently used.

– *Challenge 3: Transfer case (gear box)*

In addition to possible improvements in design and maintenance, proper selection and modification when necessary are important. In some vessels, the choice of two gear ratios could be a good option. Despite gear boxes are not much extended (at least within Spanish fleet), recent studies suggest significant savings derived from using two gears instead of just one.

– *Challenge 4: Integrated design.*

Optimized design of the entire drive train is recommended, starting from hull data and the vessel final usage. In particular, hybrid diesel-electric propulsion should be considered.

Topic 3: Alternative fuels and complementary energies

In this topic the principal aims are to analyse and assess, through feasibility and techno-economic studies, the potential use of other fuels, and/or alternative energy for fishing vessels. Main fuels to consider are: LNG, CNG, LPG, hydrogen, biofuels, and syngas. Main alternative energies to consider, usually as auxiliary energy, are: wind turbines, sails and solar PV. It is necessary to study the economic and energetic feasibility in order to obtain complete information and offering energy-efficient solutions to the energy consumption of the fishing vessels.

- Challenge 1: Alternative fuels, as:
  - Natural gas, liquid or compressed
  - biofuel
  - hydrogen
  - LPG
  - Syngas

- Challenge 2: Renewable energies, as:
  - Solar
  - Wind turbines
  - Sails
  - Waves

Energy harvesting from waves is a technology in a too early stage to be useful for fishing purposes.

Topic 4: Modifications in the vessels, and new design approaches

The main objective in this topic is to study the vessels shape, and to recommend possible changes, in order to obtain a boat design that minimizes energy consumption, without forgetting stability, safety and functionality for each application.

- *Challenge 1: Shapes and sizes configuration*

Design technologies must optimize energy consumption. Computer simulation methods and testing of models can be improved, but especially should be more widely used in fishing boats.

Merchant sector has implemented an energy efficiency index system for boats to fulfil; this is not the case in fisheries sector.

- *Challenge 2: Use of low friction painting. Maintenance*

Maintenance of the ship painting in contact with water can help reducing friction and therefore reducing fuel consumption.

- *Challenge 3: Hydrodynamic modifications: bulbs*

The design of bulbs may be an option on ships already constructed, but changing hull configuration could be the most expensive action, and current regulation is a barrier. In any case, correct data acquisition would be crucial in order to suggest and assess hull modifications.

Topic 5: Energy for uses other than propulsion

In this topic is included:

- the generation of electricity (auxiliary engines or dynamos),
- consumer equipment (electricity, cool and heat);
- the residual energy recovery engines (such as heat or for electricity generation)

– *Challenge 1: Auxiliary engines*

Improvements in electricity consumption management would allow using engines of lower power, at higher load. This greatly reduces consumption. Generating electricity with a part of the propulsion engine reduces consumption as well.

– *Challenge 2: Heat recovery*

The residual heat from the propulsion engines contains more than 60% of the energy of the fuel. This energy is in the exhaust gases, and in the water used for cooling the engines. Some of this energy can be recovered for:

- Heating, if necessary.
- Cooling the refrigeration room. Absorption machines are not suitable for the movement of the vessel, but adsorption systems had an interesting potential.
- ORC machines can generate electricity from surplus heat. Even with hot water used to cool the engine, it is possible recover more than 6% into electricity. Desalination of sea water to obtain potable water through evaporation. This would get a big energy savings by eliminating the demand for the traditional purification system through reverse osmosis.

– *Challenge 3: Electricity on board consumers*

The use of electric consumers (such as kitchens, heating and/or cooling systems, desalination systems, lights, deck machinery (hydraulic, electric), pumps, etc.) must be minimized and correctly regulated.

It is recommended to explore possible advantages derived from converting hydraulic actuators, or other systems, into electric ones (example: an electric rudder system works just when the movement is needed, whilst hydraulic systems include a pump working 24 hours a day). As an example of aspects to improve we find the inadequate use of cookers, permanently switched on for coffee.

Topic 6: Energy efficiency during fishing operation

It is also possible to reduce an important amount of energy at the moment of the fishing operation. There are two main ways of doing this: through applying the innovative and appropriate fishing gears or through the execution of an optimized fishing operation.

- *Challenge 1: Fishing Gears*

Different gears which allow saving energy are already developed, although it is possible to implement new technologies and optimizations of the old ones. They are divided into active gears (trawls and nets), mobile gears (trawl doors) or passive gears. It is also possible to use fishing gears simulations and monitoring of fishing gears, guided by sensors on hook lines. These technologies already exist but not on the market yet, because there is no request for them. In addition they should be improved and more specific ones should be developed. Research is the most necessary activity to be done in this challenge, besides innovation, demonstrations and market developments are also important. Its scope is focused on a European Union level and it is an important issue that the key driver should be the regulation of this new technologies. Experts assure that this is a really high priority challenge which should be improved in less than five years. They also mention that instrumentation is fundamental, and that it is an error that some of these technologies are considered as an increasing-catch machine, as the eco-sonda, normal sonda and sonar.

- *Challenge 2: Fishing operation*

Fishing operation refers to saving energy through adapting the way of fishing. There are some core technologies already developed on fishing operation, based on discrimination tools, as acoustical and visual ones. These technologies are not yet in the market, but acoustic tools are more developed than visual tools at a research level. Research is the most necessary activity to be done in this challenge (on a 40%), besides innovation, demonstrations and market developments are also important (20% each). It is supposed to be developed at an EU level, using regulation and technology as its key drivers. This challenge is less primordial than fishing gears, and should be achieved in a medium horizon (approximately 10 years) as experts considered.

Topic 7: Efficient steering and navigation

The main objective of this topic is to achieve lower fuel consumption by introducing variations on the way of storing, way of processing and of transporting fishes. Besides, routes optimization represents an interesting option. It is necessary to study the economic cost of implementing the different proposed models to assess their actual implementation capacity.

– *Challenge 1: Optimization of routes*

Talking about optimization of routes, there are some oceanographic and meteorological algorithm developments, which some of them are in the market but not really developed or adjusted to specific needs. Necessary activities to be done on this challenge are research on a 80% and innovation on a 20%, but on an international scope and with technology and market as key drivers. This challenge should have a medium priority and should be developed on. a short or medium horizon, between 5 and 10 years.

– *Challenge 2: Fishing effort control by area instead of time.*

This was a proposed challenge for this topic which should be developed specifically on the Mediterranean region. Core technologies involved are remote data acquisition and management, some of which are on the market and maybe have some problems to be available because of its regulation. Research on a 50% and demonstration on another 50% are the necessary activities for this challenge which should have the regulation as a key driver. It is. necessary to develop it in a high priority and in a short horizon (less than 5 years).

Topic 8: Other aspects related with energy efficiency in fishing activity

– *Challenge 1: Fishing vessel energy consumption at port facilities.*

It is frequent keep running a high power auxiliary engine to supply small consumption in a port. This represents great fuel consumption, plus an inadequate environmental impact. Alternative systems should be considered. Implementing renewable electricity supply onboard is difficult; nevertheless, implementing it at ports could be relatively easy.

– *Challenge 2: Gas emissions reduction (CO2, NOx…).*

Considering all the elements involved in the fisheries activity, reduction in energy use is linked to a decrease in the emission of harmful gases to the environment. Therefore reducing energy consumption would contribute to environmental improvement.

– *Challenge 3: Social and economic effects of increases in fuel costs.*

Fluctuations in the energy price imported by the European Union causes instability in fisheries management and therefore presents a risk for the stability of employment and the economy involved. Reducing energy consumption will reduce it significance in operating costs, thereby reducing the social and economic risks.

– *Challenge 4: Market approach*

In the fisheries sector, further than improving research and development, it is really necessary facilitate the actual incorporation of the technology to the market. This is quite complicated due to the sector is composed by small companies or individual fishermen.

- *Challenge 5: Regulatory aspects (gas, propeller, engine...)*

Regulatory aspects discourage the change to new fuels, at least in the Spanish and Italian context. In Norway, however, natural gas is already allowed as ship fuel. It is necessary that competent authorities get involved in the research and development carried out. This would facilitate developing adapted regulation at an early stage, facilitating the implementation of this technology.

Propulsion systems

TWIN DISC Srl

Diesel-electric propulsion is not a new invention. In 1903/4 electric power transmission was the only method to overcome basic technical problems such as propeller rotation inversion. Today, modern power electronics have made it possible to fully utilize the "power station" concept and to make power generation onboard even more efficient. Even if it is not possible nowadays to provide a full electric propulsion system due to technical difficulties mainly related to energy storage, some innovative solutions are appearing on the market.

“Blue Drive” system

The “Blue Drive” system, proposed by TWINDISC srl (Figure 5) is intended to small vessels with power from 80 to 150 HP. The system consists of an electric device moved by an electric engine with power up to 6 kW, mounted after the reduction gear and directly with the propeller. This allows the electric actuator for a double functioning: when maximum power is requested for sailing, the electric actuator is moved by the thermal engine and can recharge battery pack. At minor power demand, i.e. during maneuvering or sailing at slow speed, the electric actuator provide for the power needed for propulsion, while the thermal engine could be switched off.

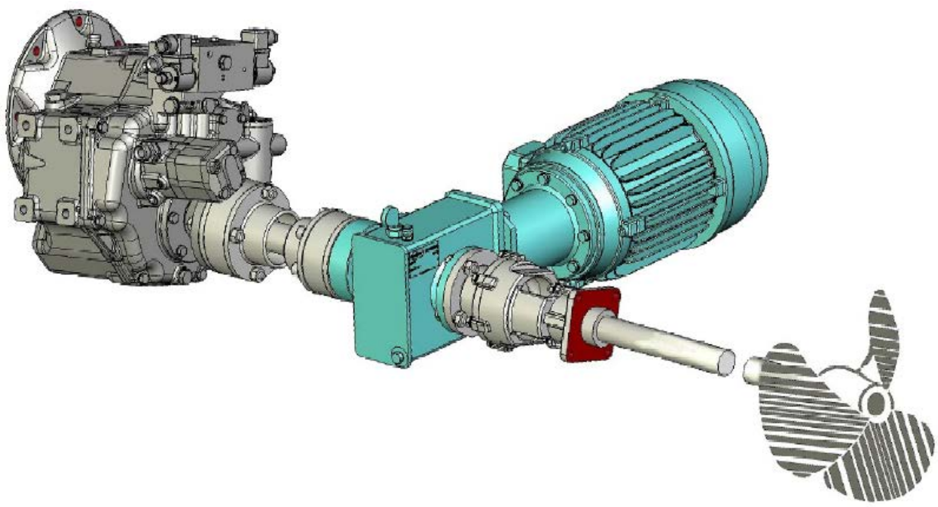

Figure 5. “Blue Drive” system layout. The “Blue Drive system” device is positioned along the propulsion system chain after the reduction gear, thus it is connected directly with the propeller shaft.

This system is installed onboard a small fishing vessel (Figure 6) since 2010 in Ischia Harbour (Naples, Italy). The wooden vessel is 8 mt long and is equipped with BETA MARINE main engine with 90 HP @2600 rpm (Figure 7).

Figure 6. F/V "Simba". This small fishing vessel is equipped with the "Blue Drive" system since 2010.

Figure 7. "Blue Drive" system installed onboard a small fishing vessel.

The owner highlighted two major advantages: the first is a fuel saving quantified in 50€ per day of activity (considering 150 days/year the total money saving is 7500 €/year). The second benefit is the opportunity to sail and fish wherever, also where thermal engine propelled vessels cannot sail.

“3Nergy” system

The “3Nergy” system provided by TWINDISC considers planning and semi-displacement hull, powered with thermal engine with 250 – 370 HP. As shown in Figure 8 the system consists of 3 power input (main engine, an auxiliary engine and the electric engine) and one output. Depending on the requests, the power generation can be shared among these inputs. When the maximum power is requested, the main engine is fully utilized, while the 3Nergy reduction gear can recharge the batteries. At partial loads, when the main engine efficiency decreases, the electric system can assist or fully provide the power for propulsion.

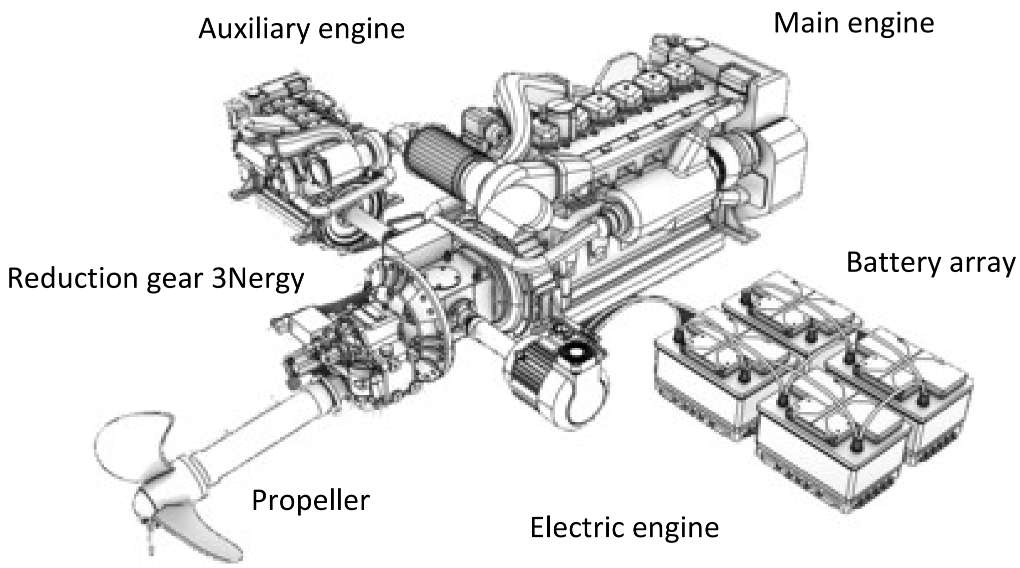

Figure 8. “3Nergy” system layout.

This system is still in a “development” step mainly due to the autonomy of battery array. Nevertheless this layout represents an innovation as actual already existing hybrid systems are configured only like “series” type, where a thermal engine is used to move an electric generator, thus having the main engine always running.

REINTJES GmbH: Two-speed reduction gear.

Fishing activity is characterized by two basically different fishing conditions, corresponding to sailing and trawling phases. Engine and propeller must be coordinated through the reduction gear in such a way that optimal conditions are reached for both sailing and trawling phases. In many propulsion systems, propeller is designed to absorb the maximum power delivered by the main engine during sailing, obtaining the vessel reach the maximum speed. With a fixed pitch propeller, efficiency decrease during trawling as the advance coefficient is less for trawling condition and the diameter over pitch curve of that propeller decrease rapidly with the advance coefficient. Furthermore the main engine could be overloaded during trawling due to the high gear drag resistance. If the propeller is designed for trawling, the propeller efficiency is better at towing speed, but will not be able to absorb all the power delivered by the main engine and the maximum speed will be not achieved. Using a 2-speed reduction gear it is possible for the main engine to provide the requested power to the propeller under the thermally overloaded limit. Changing reduction ratio from sailing to trawling phase the propeller, running at different rotational speeds for the same engine speed, can provide the requested thrust at an acceptable efficiency level.

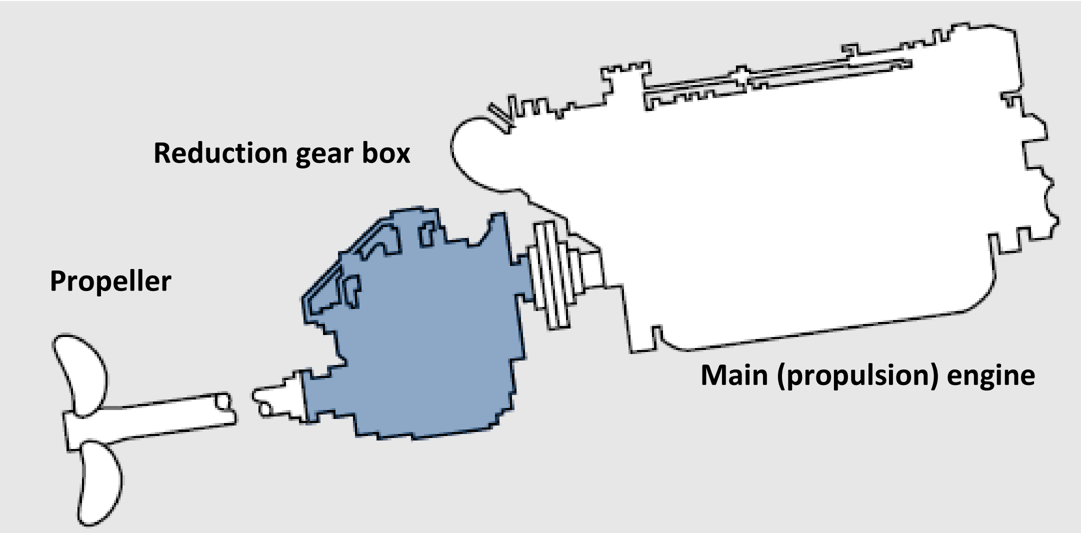

Figure 9. Propulsion system layout. The reduction gear is devoted to the conversion of the power generated by the propulsion engine. Engine revolution speed, typically between 1000 to 2000 rpm is lowered to a range of 150 – 300 rpm, depending on the reduction gear ratio. At the same time the torque delivered to the propeller increases of the same ratio.

Figure 10. Two-speed reduction gear layout.

In order to analyze benefits coming from the use of a two-speed reduction gear in trawl fisheries, a comparison between two “twin” trawlers has been carried out in 1995 in Spain. As in Table 5, Trawler A was equipped with a 1–speed reduction gear with a 6 reduction ratio R, while the vessel B mounted a 2-speed reduction gear with a 5.18 reduction ratio R for sailing and 6.3 for trawling.

During sailing, trawler A reached a speed of 13.5 kn, while trawler B a speed of 14 kn. A fuel saving of about 15% was achieved by vessel B compared to vessel A during sailing. During trawling, vessel B obtained a total towing force (TTF) of 7 t, trawling at a speed of 5 kn, while for vessel B a TTF of 6 t and a speed of 2.5 kn was measured. Considering that the thermal load limit of the engines installed onboard, that is the exhaust gas temperature over which the engine is overloaded, is about 410°C, the engine of the vessel A resulted as overloaded, as the exhaust gas temperature was around 435°C, both for sailing and trawling, while the gas temperature of vessel B was about 385° C during sailing and 400°C during trawling. Better performances from the propulsion system apparatus must be intended as more efficiency and fuel saving. Reintjes reported a fuel saving of up to 15% during each hour in sailing conditions.

Table 6. Main parameters of two "twin" trawlers, A and B, during comparative tests.

		Trawler A	trawler B
Length over all	[m]	23.6	23.6
Engine Type		Caterpillar 3412 DITA	Caterpillar 3412 DITA
Power installed	[kW]	493	493
Max. engine speed	[rpm]	1800	1800
Max. gas temperature	[° C]	410	410
Propeller diameter	[mm]	1800	1800
Pitch over diameter ratio		0.81	0.81
Reduction gear Type		Conventional reduction gear	Two-speed reduction gear
Red. ratio during sailing		6.1	5.18
Red. ratio during trawling		6.1	6.3
Sailing			
Max. speed during sailing	[kn]	13.5	14
Max. engine speed during sailing	rpm	1800	1850
Gas temperature	[° C]	435	385
Trawling			
Max. speed during trawling	[kn]	2.5	5
Total towing force	[t]	6	7
Gas temperature	[° C]	435	400

Helseth: controllable pitch propeller

Helseth AS is a specialized propeller manufacturer, operating in modern facilities close to Molde in north-western Norway. The core design and manufacturing programme comprises adjustable pitch and controllable pitch propellers with diameters of up to 4400 mm, and up to 4500 kW engine power. The fixed pitch propeller (FPP) is normally casted as one single block (Figure 11). This is the cheapest propeller type and, if correctly designed and if run only on the operational point, it has the best effi ciency of the three designs. Also, lack of moving parts makes it a reliable design, requiring little maintenance.

Figure 11. Fixed pitch propeller.

The FPP is mainly used on:

- small vessels with restricted budget;
- small vessels with reversing gear;
- high speed vessels with very high propeller load;
- larger vessels with one dominating operational mode, i.e. ocean going cargo vessels.

The controllable pitch propeller (CPP) has rotatable blades which are controlled by either a rod running through the propeller shaft, or through a servo system built into the propeller hub (Figure 12).

Fishing activity is characterized by two basically different fishing conditions, corresponding to sailing and trawling phases. This difference reflect also a different propeller operating conditions among such phases. A CPP can optimize the blades configuration in order to obtain great performance both during sailing and trawling. Comparison between FPP and CPP with same geometry demonstrated a fuel saving of up to 10%. Other advantages consist on the opportunity to run the engine at a specific speed, allowing for an improved engine room layout, as it is possible to couple with a fix running speed engine devices such as electric generators or pumps, avoiding the use of auxiliary engines. The propeller thrust will be managed by the pitch instead of the engine speed

Figure 12. Controllable pitch propeller. The hub contains the hydraulic pitch control gear. One of the major advantages in using a CPP is the opportunity of substitute one propeller blade when it is damaged, instead of repairing it or changing the propeller.

The CPP is mainly used on vessels with varying load or running on varying speed, i.e.:

- Short Sea Shipping vessels;
- Ferries;
- fishing vessels;
- offshore vessels;
- high speed vessels with normal propeller load;
- patrol vessels;
- rescue vessels;
- research vessels.

The adjustable pitch propeller (APP) operates as an FPP, but the pitch may be adjusted manually with an adjustment screw located on the propeller hub. The APP is more expensive than the FPP, but cheaper than the CPP as there is no servo system.

The APP has brought the following advantages from the CPP:

- Forgiving for design errors;
- The pitch may be adjusted to correspond to the power when engine is worn down;
- Each blade may be changed independently if damaged;
- Future-proof with regard to changes of use of the vessel, extension of the vessel etc.

The APP may be used on any vessel where flexibility of pitch setting would be favorable.

Figure 13. Adjustable pitch propeller. The pitch of the blades cannot be modified automatically or with any gears, but only manually, thus imposing the stop of the vessel.

Fuels

Introduction to LNG for fisheries

Marine Diesel Oil (MDO) is a vital but costly input to fishing production, accounting for a large proportion of the running costs of a fishing vessel. Urgent actions are needed to investigate different propulsion options for the fishing fleet, regarding for instance the use of alternative fuels, such as LNG (Liquefied Natural Gas). Another very important advantage is the reduction in air pollution, in fact, the combustion of LNG as fuel allows reductions of about 23% of CO_2 emissions. Furthermore utilizing the lean burn technology, enormous reductions of NO_x (-92%) can be achieved. With the common depuration processes, that follow gas extraction, the SO_x emissions are eliminated (-100%). Finally there are very low emissions of particulate and a no visible exhaust gas. MARPOL Annexes define the emission controlled areas as shown in (Figure 14). Ships operating in designated Emission Control Areas (ECAs) are required to comply with more stringent fuel sulfur and engine NO_x limits.

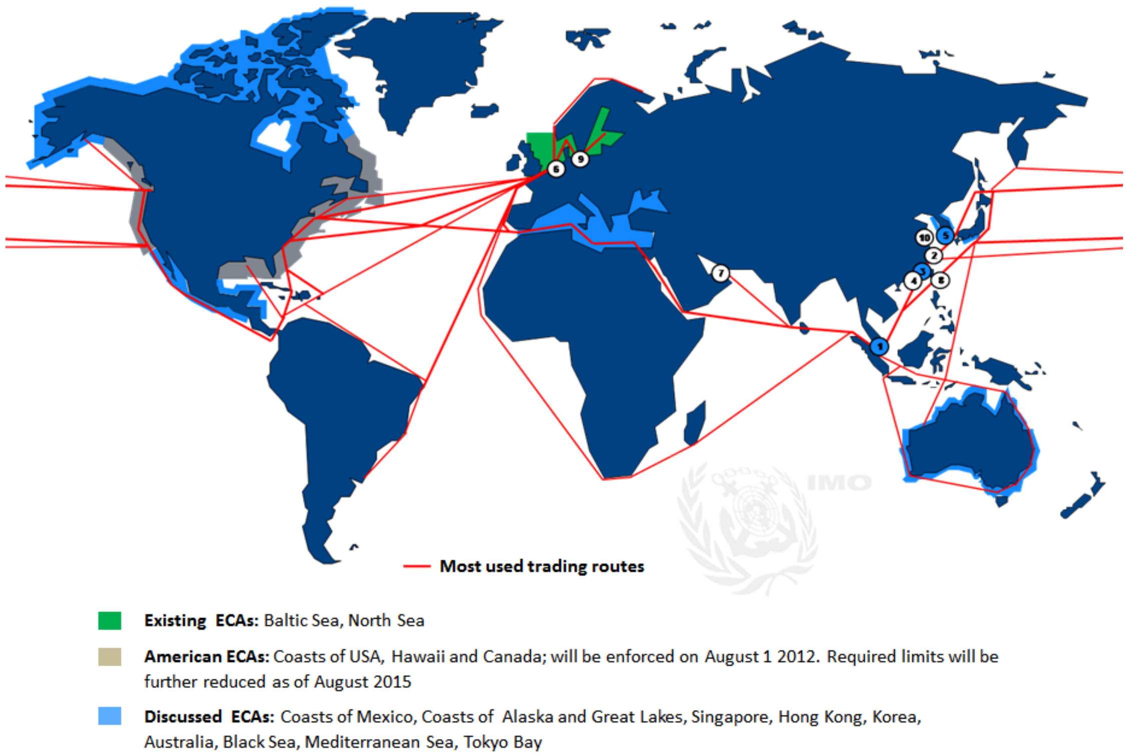

Figure 14. Areas of application of ECAs.

International regulations regarding pollution from ships are contained in the IMO "International Convention on the Prevention of Pollution from Ships", known as MARPOL 73/78. On 27 September 1997, the MARPOL Convention has been amended by the "1997 Protocol" which includes Annex VI titled "Regulations for the Prevention of Air Pollution from Ships". In particular, Annex VI regulates the matter of emission of such substances as sulphur oxides (SOx), nitrogen oxides (NOx) and particulate matters. Annex VI entered into force on 19th May 2005 and in October 2008 IMO adopted a set of amendments to Annex VI of the MARPOL Convention. The set of amendments to Annex VI of the MARPOL Convention introduces new standards regarding emission from ships of such substances as sulphur oxides (SOx) and particulate matters and nitrogen oxides (NOx) (Figure 15). The most stringent changes regard SOx emission. Reduction of SOx and particulate matter emission are going to be achieved by limiting the maximum sulphur content of the fuel oils used onboard. Two sets of emission and fuel quality requirements are defined by Annex VI: (1) global requirements, and (2) more stringent requirements applicable to ships in Sulphur Emission Control Areas (SECA). On the global level, sulphur cap will be reduced initially to 3.50% (from the current 4.50%), effective from 1st January 2012; then progressively to 0.50 %, effective from 1st January 2020 (or in 2025 at the latest), subject to a feasibility review to be completed no later than 2018. Annex VI introduces much more stringent requirements for ships operated in SECA. As from 1st July 2010, the maximum sulphur limit has been reduced to 1.00%, (from 1.50%), while from 1st January 2015, sulphur content in ships' fuel must be below 0.1 %.

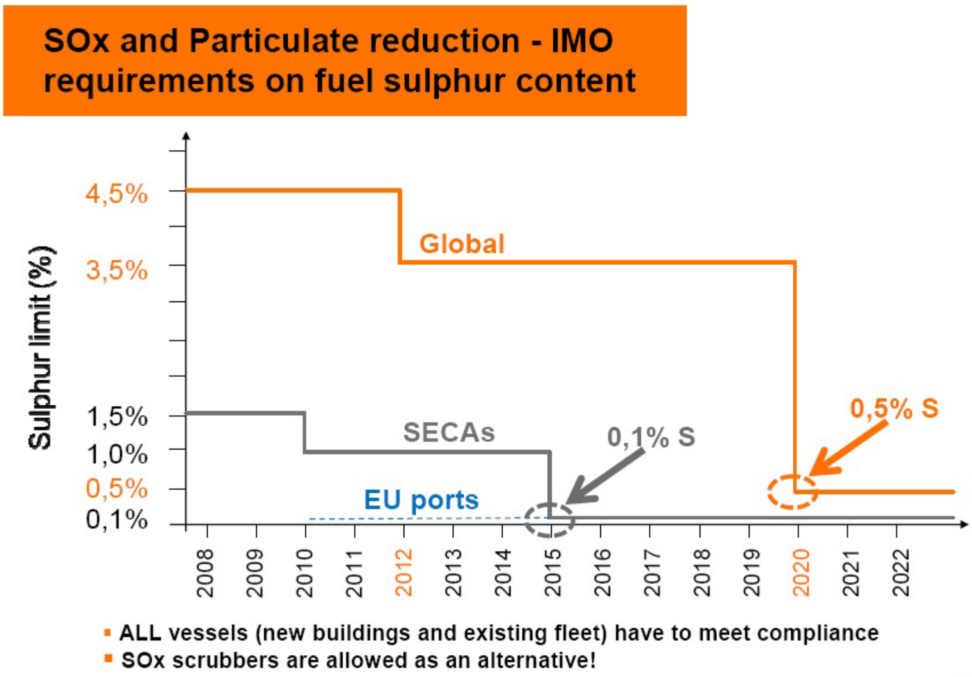

Figure 15. IMO requirements from the point of view of Sox emissions.

Unfortunately, critical aspects, regarding the LNG as marine fuel in fishery activities, are represented by the very expensive initial cost of a dual fuel engine (about three times as expensive as traditional Diesel engine), the fuel storage on board and the lack of proper infrastructures for an efficient LNG distribution. Future rises in diesel oil price may render the LNG-option economically viable, but a more detailed economic analysis is needed for a conclusion.

Monitoring systems

FuelMACS

The fuelMACS is a fuel and engine performance monitoring system which allows for performance indicators evaluation, energy management fuel consumption monitoring. The system can track one or many vessels in order to compare energy performances and fuel consumption. Besides the fuel consumption monitoring, the system allows for a global vessel monitoring or a disaggregated overview of engine, hull and other parameters.

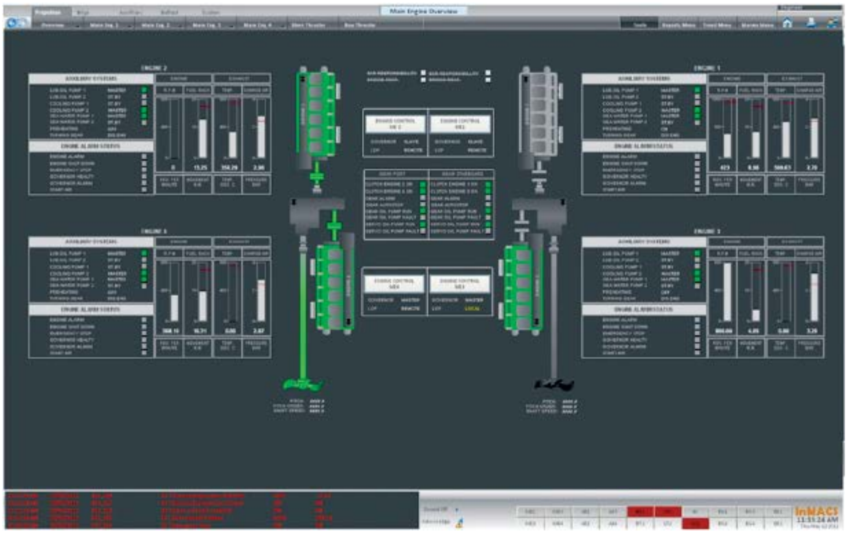

Figure 16. Engine performance monitoring tool.

Figure 17. Fuel consumption and energy efficiency indicators.

The major innovation is related to the system design according to the latest Marpol convention. The system allows the owners to evaluate the EEDI (Energy Efficiency design index) and the Energy Efficiency Operational Indicator (EEOI) in order to plan a SEEMP (Ship energy efficiency management plan). More details at www.dataprocess.no.

Engines

Today diesels provide the overwhelming majority of propulsion and electrical generating power for the world's fishing fleets. With such complete dependence on diesels, it is little wonder that the record high diesel fuel prices of 2008 caused a near panic in the commercial fishing industry (see Alaska Sea Grant Marine Advisory Program asg-52 2010).

On the basis of official data sheets provided by major engine manufacturers (A, B, C, D)[1], Figure 18 shows that the maximum fuel consumption (FC) is directly proportional with the maximum brake power (BP) which represents the maximum power deliverable to the propeller. It is obvious that the higher the power requested, the higher the fuel consumption.

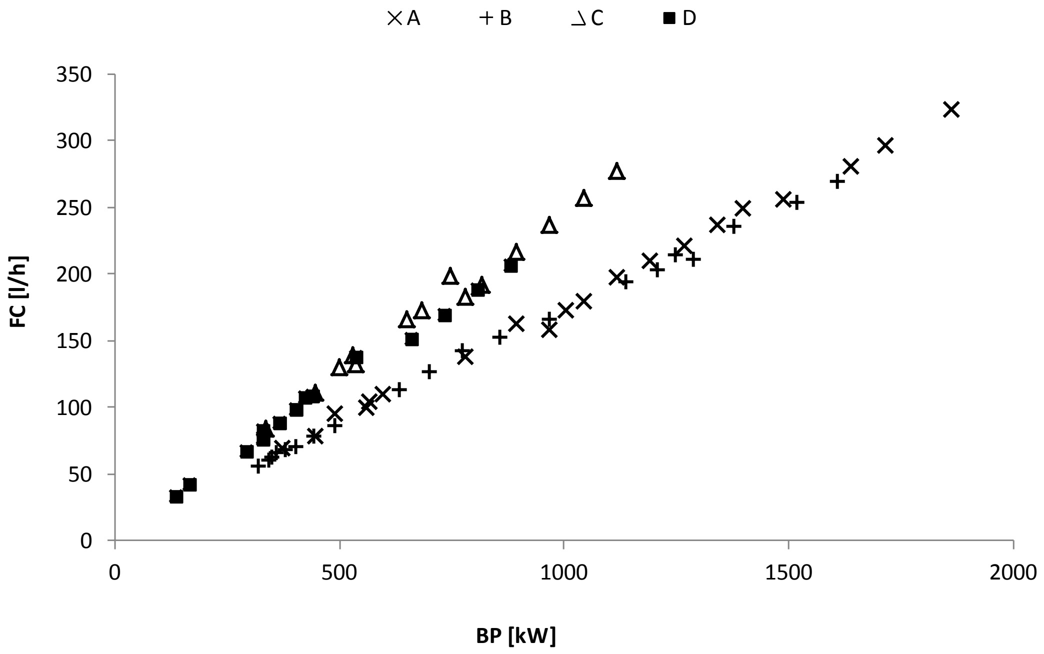

Figure 18. relationship between brake power and fuel consumption for the major marine diesel engines installed onboard fishing vessels (BP= brake power in kW; FC= fuel consumption in l/h; A, B, C, D represents four major engine manufacturers, identified with generic symbols).

As shown in Figure 18, the relation between power installed onboard and fuel consumption at the maximum power suggests that the power to be installed should be minimum as possible,

[1] The authors feel they do not explicit the name of the engine manufacturers.

considering that powerful engines running at partial loads has lower efficiency. It is crucial to reduce as much as possible the amount of power needed and to choose the engine that is able to deliver the power request at an high efficiency condition. Despite this obvious conclusion, many owners prefer to install more power in order to make possible to increase propulsive performances, without considering the lowering of engine efficiency at partial loads.

For each of the engine manufacturers considered, Table 7 shows the range of brake power (BP) available for heavy duty engines, together with the maximum fuel consumption declared (FC) and the specific fuel consumption (SFC). On the basis of the minimum specific fuel consumption, higher specific fuel consumption are reported as percentage. The specific fuel consumption represents the efficiency of the engine, as the higher the SFC, the higher the fuel consumption required by the engine in order to generate the same power.

Table 7. Fuel consumption values for the range of power considered. For each engine manufacturer the range of power of marine diesel engines mostly used onboard fishing vessels is compared with the fuel consumption (FC) at the maximum power and the specific fuel consumption (SFC). Referred to the minimum specific fuel consumption, the higher specific fuel consumption of other engines is reported as percentage (A, B, C, D represents four major engine manufacturers, identified with generic symbols).

Engine Manufacturer	PB	FC	SFC	%
	[kW]	[l/h]	[g/kWh]	
A	373 - 1864	69 - 323	152	2%
B	320 - 1610	56 - 269	149	0%
C	339 - 1118	84 - 277	214	44%
D	136 - 883	33 - 206	207	39%

From Table 7 it could be observed that the range of specific fuel consumption is 152 to 207 g/kWh. The opinion of engine manufacturers interviewed is that, after a huge development which allowed for a reduction in specific fuel consumption in a range of 15 – 25%, actual efforts in the development of new engines are focused on issues like emissions reduction engine durability and reliability. In their opinion further sensible improvements in terms of fuel consumption (more than 3 – 5% at each new engine concept) is not comprised in the short term. This approach could represent an opportunity for the development of new engine generations, such as LNG fuelled engines and for the introduction of new fuels like diesel from algae and biodiesel.

Conclusions

ICEEF 2010 and ICEEF 2011 information collection has been carried out taking into account a list of relevant topic, as listed below:

- Engines, fuels (incl. biofuels), emissions, reduced environmental impacts;
- Vessel design and technology including propulsion systems, new hull systems, fishing boat design, auxiliary power;
- Vessel operation (maintenance of hulls and engines);
- Use of alternative or renewable energy sources (wind, hydrogen fuel cells etc.);
- Efficient fishing gears (e.g. reduced gear drag), selectivity;
- Fishing tactics and techniques (e.g. from active to passive techniques, routing optimization etc.);
- Fuel management systems, energy monitoring and control systems, energy audits, other energy uses onboard (e.g. auxiliary engines);
- Innovative refrigeration systems;
- Rules and regulations (to the extent that EU or national rules impact significantly on energy consumption by restricting/stimulating energetically suboptimal vessels);
- Other innovations and techniques.

Information collected during ICEEF 2012 has shown that innovation and development is relevant just in few of the above mentioned topics. Development in propulsion systems and in new engines, as well as new fuels, are still promising while topics like the use of alternative or renewable energy sources seem to be not affordable in the short and medium term. Most of the information collected was related to engines, propulsion system optimization and fuel management systems. Other topics like new efficient fishing gears are considered mainly at a “research” level, mainly due to due to suspicion and tradition. Related to other topics, no innovation was introduced, since previous ICEEF 2010 and 2011.

As commented during ICES/FAO WGFTFB in Lorient, due to the fact that technological innovations in fishing are proposed with a certain slowness, this makes it difficult to organize a devoted tor each year. It is opinion of most of the experts that mainly subsidies are the major cause of a slow development of an innovative and efficient fisheries.

One of the goals that can be achieved through the data collected among ICEEF 2010, 2011 and 2012 is to provide, for each relevant topic and area of possible improvement, a comparison between the state of the art of actual fishing technology and the state of the art of available innovations, thus highlighting the benefits obtainable.

ANNEX - Effects of engine replacement on the fuel consumption reduction in fisheries.

RATIONALE: THE PROPULSION SYSTEM ONBOARD FISHING VESSELS

Typical propulsion system on board fishing vessels (Figure 19) consists of a high speed marine diesel engine (1) that, through a reduction gear (4), drives the intermediate shaft (5). Generally a fixed pitch propeller (7) produces the required thrust for the different fishing phases, running at different speed. The power take-off forward is used for other energy users, such as hydraulic or electric users. Unless using a controllable pitch propeller, the requested propeller rpm is obtainable only controlling the engine revolution speed. Since the different power requirements occur in the whole fishing trip and the design of a fixed pitch propeller could be optimized only for one operating condition, at least one of the two different fishing phases, imposes a not efficient operating point to the engine.

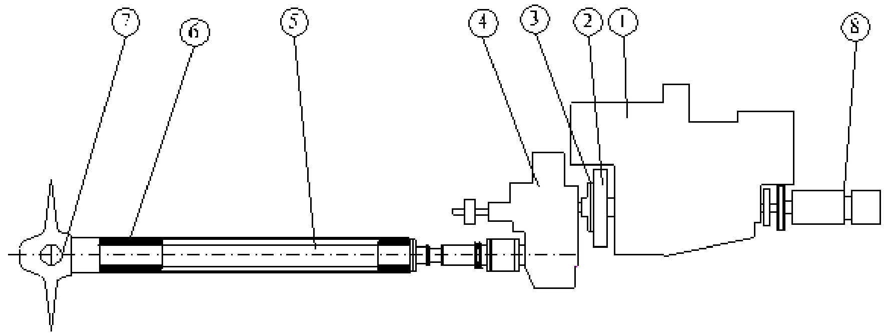

Figure 19. Standard propulsion system of a fishing vessel: 1) diesel engine, 2) flywheel, 3) coupling flange, 4) reduction gear, 5) intermediate shaft, 6) stern tube, 7) fixed pitch propeller; 8) Power take-off forward.

Main engine

The power installed onboard fishing vessel depends on the total amount of power needed to carry out fishing activities, mainly referred to sailing and trawling. Depending on the power required to reach the design speed it is necessary to install a total amount of power on the basis of the overall propulsion system efficiency.

For fishing vessels of small and medium size, the choice now lies with high speed turbocharged four-stroke diesel engines, for a power range extending from a few tens to a thousand kW. The major advantages of this engines are the economy and operational reliability, with an overall efficiency of about 45% - 50% (ration between mechanical power delivered over the thermal power provided by the fuel consumed). Slow speed diesel engines could be characterized by higher efficiency but in many cases the minimum power size is over the right size for fishing vessels (more than 1300 kW)

Reduction gear box

The reduction gear box is the device responsible for putting the propeller in the conditions of using the power delivered by the propulsion motor. It simply changes the values of torque and rotational speed, without absorbing any significant amount of power (typical efficiency: 95% - 98%).

Propeller

The propeller is the devoted device which produces the requested thrust, depending on the speed or drag to be obtained. The propulsion system of a fishing vessel typically consists of a diesel engine driving a fixed blade propeller which exhibits its best efficiency only at its designed point. Therefore, the efficiency of a fixed blade propeller (with fixed pitch), designed for steaming optimal performance, will drop when trawling. The *vice versa* is as well true.

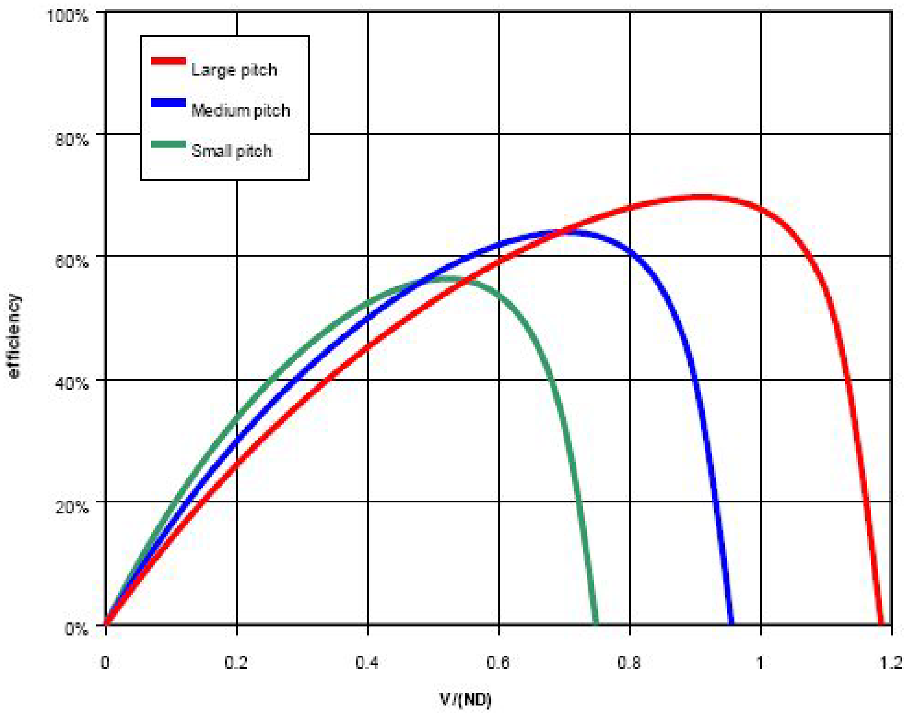

Figure 20. Typical propeller efficiency diagram. Depending on the propeller pitch, efficiency vary in a wide range of values. The efficiency is represented against the speed, expressed in fractions of the vessel design speed.

In Figure 20 the red line is referred to a propeller suitable for high speeds, (for sailing) while the green line is better for low speeds and high thrust requests (for trawling). It is possible to note that the maximum of each curve corresponds to a different speed. This means that it is not possible for a fixed pitch propeller to maintain high performances in so different conditions such as trawling and sailing. Typical efficiency wide in a range of 50% - 60% but for small variation from the optimal speed, efficiency decreases sensibly.

Propulsion system efficiency chain

The propulsion system efficiency chain is below illustrated:

$$\eta_T = \eta_{eng} \times \eta_{red} \times \eta_{hull} \times \eta_{prop}$$

Where $\eta_{eng}$is the engine efficiency, $\eta_{red}$is the reduction gear efficiency, η_{hull} is the hull efficiency and η_{prop} the propeller efficiency. In most cases it is possible to consider almost 1 hull and reduction gear efficiency, so that the previous equation becomes:

$$\eta_T = \eta_{eng} \times \eta_{prop}$$

As we can see, overall efficiency is mainly influenced by engine and propeller efficiency. Typical efficiency range for fishing vessel is around 50% – 60%. This means that only 50% - 60% of the power input provided by fuel is suitable as mechanical power for the propulsion when propulsion system is working in optimal condition. Out of this condition the efficiency can decrease by 50%, mainly due to propeller performance characteristics. So that, in order to maintain high propulsion system performances, thus obtaining great fuel savings, any improvement must be coordinated and taking into account other propulsion system devices.

CONTRIBUTION OF NEWER ENGINES FOR FUEL SAVING IN FISHERIES

Comparing the actual state of the art of marine diesel engines with those installed 20 years ago (the average life of a good and well maintained engine) many improvements were achieved to reduce specific fuel consumption (the amount of fuel needed to produce the same power) and GHG and NOx emissions, mainly due to the introduction of turbocharged with intercooler engines and electronic management. Comparing some datasheet, it is possible to estimate a reduction in specific fuel consumption of about 10%, of new engines. It is important to note that the fuel consumption mentioned is referred to brake Power, which means the theoretical power delivered by the main engine during tests.

Nevertheless, engines manufacturers interviewed declared that changing an old engine with a new one is not an action rising to fuel saving. Other needs can make mandatory the engine replacement, such as rising in management costs wasteful lube oil expenditure, losses in cylinders pressure, any time the refitting cost is too much compared with the replacement.

Advantages in fuel savings could be achieved when the engine replacement is done from the point of view of the overall propulsion system. It is important to select an engine with torque and rotational speed which allow the propeller to guarantee maximum performance.

During last decades, speaking on engine replacements, power installed onboard has increased due to the fact that fishermen were sure about the more power installed onboard the bigger the net they can drag and the higher speed during sailing. It is a double error. First of all it is not true because the total amount of power usable depends on the power usage capability of the propeller, for the trawling phase, while the maximum speed obtainable during sailing depends on hull characteristics, especially for displacement hulls (Messina and Notti, 2007). Furthermore the bigger the engine, the higher the fuel consumption.

The aim of the engine replacement should be the reduction of power installed, selecting an engine suitable for the existing reduction gear and propeller or including the propeller and the reduction gear into the refitting.

Diesel electric propulsion system

The diesel electric propulsion system could be suitable, especially for big trawlers. In this configuration the thermal engine provide the required power working at optimal conditions while the electronic part of the propulsion system share the power delivered by the thermal engine, depending on the needs. Recent developments in such a propulsion system foresee a storage of part of the power produced in many array battery. This amount of power is available when the vessel is approaching the harbor or during “light” working phases. This solution comes from light duty ships and to provide a solution for pollution reduction. As an example, a Rolls Royce solution is illustrated below.

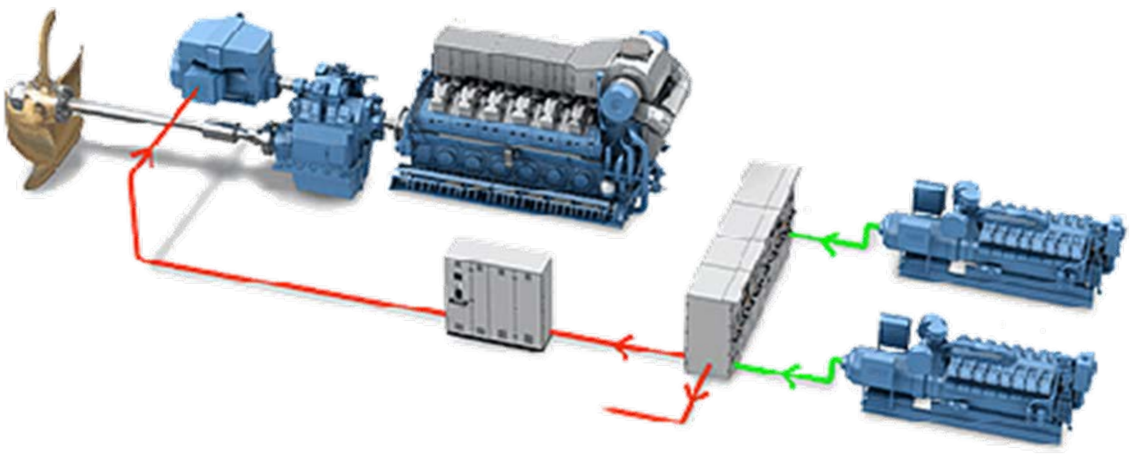

Figure 21. Rolls Royce Propulsion system layout.

Compared to the traditional propulsion system, with a main engine coupled with the propeller through a reduction gear, also a shaft power generator is coupled to the main engine through the reduction gear, while few auxiliary power engines are installed for electric power generation. An electronic control system manage the total amount of power requested and the best configuration for the minimization of the fuel consumption. The **HSG** (hybrid shaft generator) system is actually an advanced power electric system for conditioning the power coming from a shaft generator so that the switchboard see a constant voltage and frequency, and the correct phase angle to match other generator sets running in parallel. This opens the way for much more flexible uses of engine and propeller speed variations to maximize both propeller and engine efficiencies by running them at their design points. Doing so also helps to reduce exhaust CO2 and NOx emissions.

The HSG drive supplies fixed frequency to the switchboard even when engine rpm varies. It also allows SG to operate in parallel with auxiliary gensets. The shaft generator can function either as a generator or as a motor. The HSG allows the propulsion system to be optimized, reducing fuel consumption and emissions in all modes. The aim of this new system is to expand the range of efficiency of the main engine and the propeller. Several configurations are available, depending on the power request. So that The HSG concept is suitable for offshore, merchant and fishing vessels. (more info at http://www.rolls-royce.com/marine/ship_design_systems/prop_sys/hsg/)

Another hybrid diesel electric solution were analyzed in a pilot project (Notti et al, 2011), through a technical feasibility of a new propulsion system architecture, studied in 2008 through a research funded by the European Community (EC Regulation 2792/99, Article 17 - Innovative measures. n.27/IM/06 Project). In the propulsion system herein proposed, the overall power required by the vessel is subdivided in multiple power units, each one obtained by coupling a diesel engine with a permanent magnet brushless electric generator, while the propeller is coupled with an electric motor. Through an electronic management system, it is possible to maintain one or more power units at different operating points to guarantee the minimum overall fuel consumption. In this study two power units have been considered. Many load tests have been done on a marine diesel engine, to evaluate its fuel consumption, torque and power delivered against the revolution speed. An algorithm to control the power units have been obtained from experimental data. The carried tests demonstrated the so conceived propulsion system as really reliable. A fuel saving of up to 15% was achieved with a power units equipped with a 257 kW @ 3800 rpm diesel engine. The proposed propulsion system could be useful both in new vessel and for a re-dumping of existing vessels. Further advantages are related to the possibility to avoid propeller shaft and reduction gear, then reducing weights, noise and pollution.

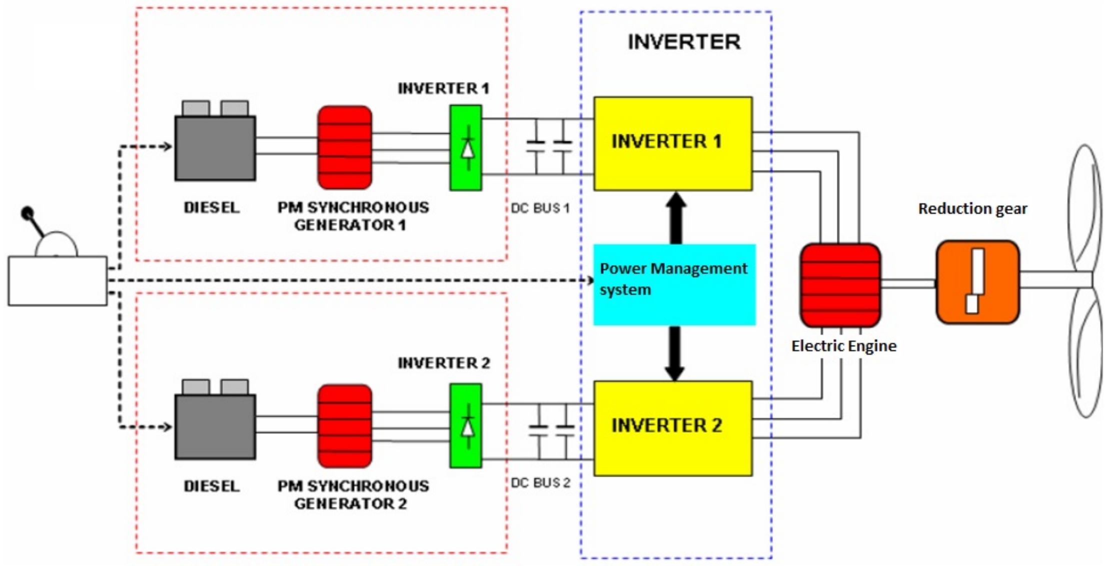

Figure 22. Hybrid diesel electric propulsion system layout. Power units (1, 2) are obtained by coupling a diesel engine and a permanent magnet synchronous electric generator. Each power unit is managed by one inverter which is connected to the electronic part of the system through a bus DC. The DC bus provides the continuous power flow from power units to the electronic part. In the electronic part, one inverter per power unit drains the electric power to the electric engine. The electric engine, through a reduction gear if needed or directly coupled, moves the propeller on the basis of the input by the power management system.

SOME DEVICES TO OBTAIN POWER SAVING ONBOARD FISHING VESSELS

It is necessary start to think on how to reduce the power demand instead of how to reduce the fuel consumption of the power installed. Some devices can decrease the amount of power needed, maintaining vessel performances.

Bulbous bow

A bulbous bow, whether incorporated into the vessel when constructed or as a retrofit, will reduce fuel consumption 12% to 15%. The reduced fuel consumption will provide greater range or a slightly higher speed for the same power applied. The greatest amount of benefit will be at the high end of the semi-displacement speed range, reducing as your speed decreases (

Table 8). At low speed (around 6 knots and lower) the bulb will even cause an increase in drag because of its greater wetted surface area. At a low speed the added power consumption is negligible and generally little time is spent in this speed range.

Figure 23. Bulbous bow of a fishing vessel.

Table 8. Effective (PE) and delivered (PD) powers for both basic (1) and bulbous bow form (2) at speeds (V)

V [knots]	P_E [HP]			P_D [HP]		
	1	2	%	1	2	%
5	10	12	+ 20.00	23	19	- 21.00
6	18	21	+ 16.70	37	32	- 15.62
7	30	33	+ 10.00	59	53	- 11.32
8	50	46	- 8.70	93	85	- 9.41
9	77	67	- 14.92	137	125	- 9.60
10	112	97	- 15.46	197	170	- 15.88
11	179	169	- 5.91	299	260	- 15.00
12	343	321	- 6.85	543	492	- 10.36
13	674	582	- 15.80	1109	967	- 14.68
14	1203	1112	- 8.18	2153	1931	- 11.50

In addition, you will find increased sea keeping ability due to dampening of the pitching motion. When charging into head seas there is the chance of slamming the bulb on the troughs, but this is limited to a very narrow range of wave train and heading. A slight change in direction and/or speed will cure this ill-effect.

Ducted propellers

A “ducted” propeller is fitted around with a ring-shaped hydrodynamic profile. For a trawler, the use of a ducted propeller is power-saving (Messina and Notti, 2007). Due to its smaller diameter, if compared with a conventional propeller, it could be installed also on already existing trawlers. Comparative tests demonstrated the advantages of a ducted propeller which lie mainly in the possibility to realize, for the same power, greater thrusts than those generated by conventional propellers. For the same reason, the same thrust required can be achieved with less engine power and thus less fuel consumption.

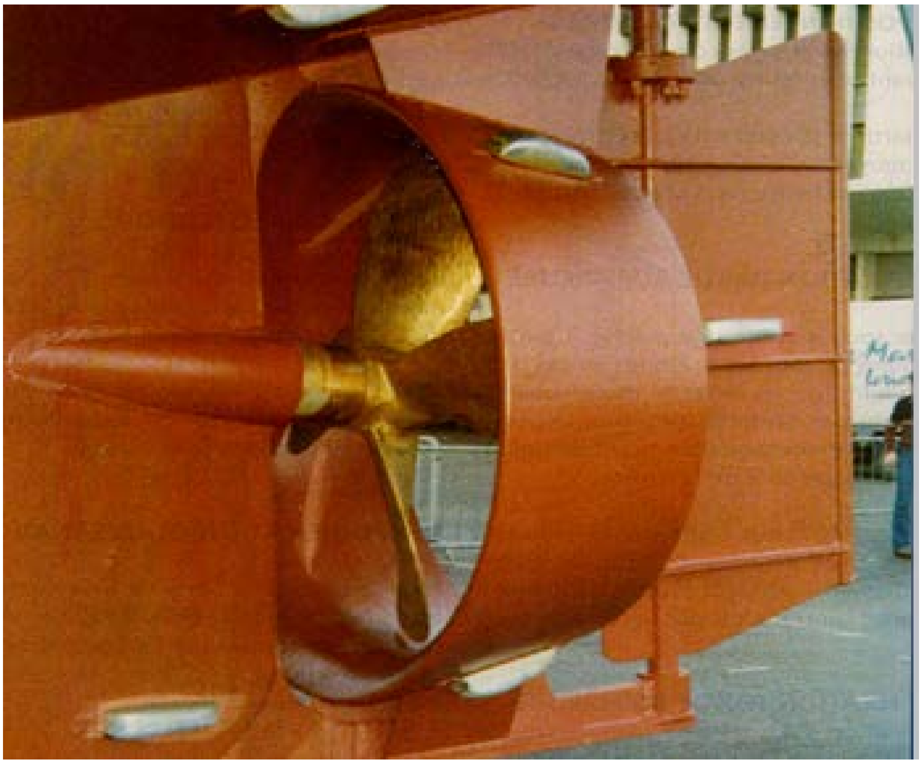

Figure 24. Ducted propeller.

Table 9. Comparison of the power delivered (PD) between a B 4-70 open propeller and a B 4-70 ducted in nozzle 19a NACA profile propeller; both propellers with a 2 m diameter (D) and 0.8 pitch over diameter ratio (P/D).

T (kg)	PD (kW)		Ratio
	B 4-70 (D = 2.0 m)	B 4-70/19a (D = 2.0 m)	
4000	204	172	84%
5000	276	227	82%
6000	355	285	80%
7000	440	346	79%
8000	530	411	78%
9000	625	480	77%
10000	726	551	76%

As illustrated in Table 9, for the same thrust (T) ducted propeller requires less power (PD). Looking at the ratio between open propeller and ducted propeller power delivered (PD) the reduction in power demand is almost 20% in all the range of thrust considered (Notti and Sala, 2012).

Grim wheel

A Grim wheel is placed in the propeller slipstream and can freely running, working as a water-turbine, powered by the propeller wake. Its diameter is about 20% larger than the propeller.

Figure 25. Greem wheel applied to a controllable pitch propeller. The Greem wheel is a free running propeller which operates as a stator, increasing propeller counter pressure thus the propeller efficiency.

The power saving is about 5 to 12%. A Grim wheel could be applied either to new or to already existing propellers proper room is available. Higher fuel savings could be obtained when a Grim wheel is used in association with heavily loaded propeller.

Slowly running propellers

Such propellers give an improved propulsive efficiency by increasing the amount of water through the propeller disc. The same thrust could be produced with less engine power by reducing rpm and increasing propeller diameter. The diagram of Figure 26 shows, for a B 3.50 series propeller, how much power is requested at different propeller diameters, for a thrust of 6000 kg. Increasing propeller diameter from 1.45 to 1.85 m (just 40 cm more) the power saving for the same thrust is about 20% (from 550 to 450 kW).

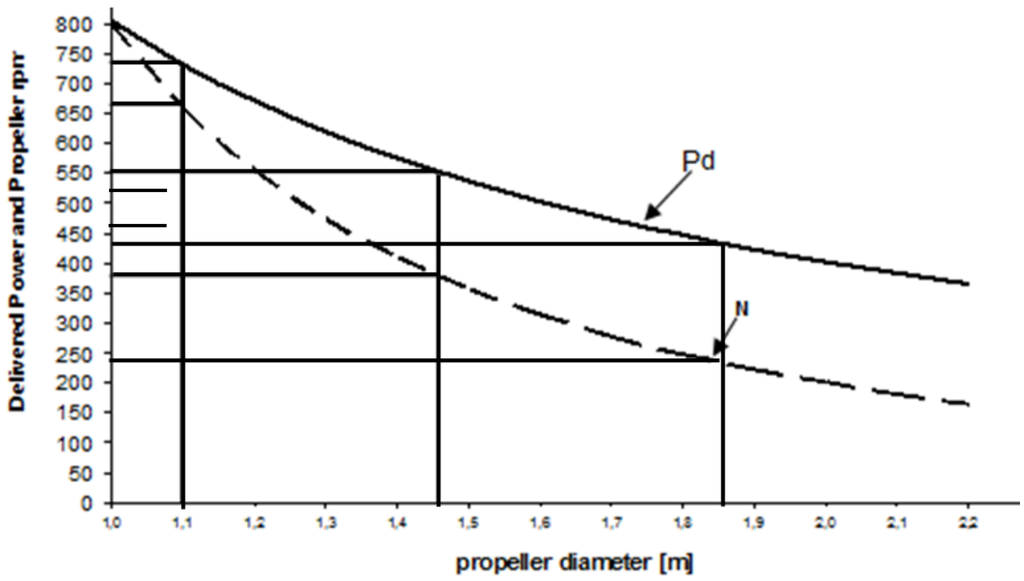

Figure 26. Relation between powers (PD), revolutions (N) and propeller diameters (D) to give the same thrust for a B 3.50 series propeller with P/D = 0.8.

CONCLUSION

New engines are more fuel efficient than older engines mainly thanks to improvements in fuel combustions, turbocharging and electronic management for fuel ignition into cylinders. Nevertheless, a fuel saving strategy based only on an engine replacement is just theoretical as the propulsion system could not take advantage of such a saving. Thinking about changing the main engine, the best strategy is to reduce to find a way to reduce fuel consumption. But it is necessary first of all to reduce devices and users power demand. Many of them are already existing and "historically steady".

Furthermore, for European Fisheries, according to art. 25 par. 3 of the EC Reg. 1198/2006, "the new engine can be funded as long as a 20% of reduction in power installed".

Important savings could be obtainable finding the way to improve the capability of the propulsion system to use the power delivered by the main engine rather than installing a huge amount of power, not use in most cases.

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