European Commission

Study on engine power verification by Member States

Final report

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Maritime Affairs and Fisheries

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Directorate-General for Maritime Affairs and Fisheries
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ABSTRACT (EN)

Engine power of fishing vessels is one of the measures used to control fishing effort and to determine the fleet size of European fishing fleets, in order to ensure sustainable management of marine resources. For effective management of fishing effort, registered power values must be reliable. The engine power verification systems which EU Member States are required to establish were reviewed in 15 Member States. In addition, physical power verifications were conducted onboard 68 fishing vessels in 14 Member States. Most Member States have implemented an ineffective verification system, or no verification system at all. The measured engine power exceeded the certified engine power during 51% of the verifications, and for 16% of the inspected vessels there are secondary indications of non-compliance with engine power restrictions. Improvements of both the certification and verification system are necessary to increase the accuracy of registered engine power. In case engines which are capable of producing substantially more power than the power output stated at the fishing license of the vessel in which they are installed are operated to their full potential, this undermines the effectiveness of fishing effort regimes. Sealing certain engine settings or deploying continuous power measurement could prevent such infringements.

ABSTRACT (FR)

La puissance des moteurs des navires de pêche, est un des critères utilisés pour contrôler l'effort de pêche et la taille des flottes de pêches Européennes dans le but de pérenniser les ressources marines. Pour que la gestion de l'effort de pêche soit efficace il faut que la valeur de la puissance enregistrée soit fiable. Le système de vérification de puissance des moteurs que les Etats Membre doivent mettre en œuvre a été revu par les 15 Etats Membres. De plus les mesures de puissances ont été faites à bord de 68 navires de 14 Etats Membres. La plupart des Etats membres ont en place un système de vérification inefficace ou pas de système du tout. Les mesures de puissances des moteurs dépassent dans 51% des cas la puissance certifiée et pour 16% des navires inspectés il y a une deuxième indication de non-conformité de la limitation de puissance des moteurs. Une amélioration de la certification et du système de vérification est nécessaire pour accroitre la précision des puissances enregistrées. Si un moteur est capable de développer une puissance substantiellement supérieure à la puissance notifiée dans le permis de navigation du navire, cela montre l'inefficacité du régime de l'effort de pêche. Installer des scellés sur certains éléments ou la mise en place de système de mesure en continu de la puissance peuvent éviter de telles infractions.

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Glossary

BDC	Bottom Dead Centre (position of piston in liner)
Booster	PTI (see: PTI) system that can be used when the main engine is engaged.
Brake load	The load generated by the brake in an engine test bench configuration.
Brake power	The engine power measured after the engine at the crank shaft. On a test bench this load is generated artificially by a brake (water brake or other), and can be controlled to generate the desired operating conditions for the test.
BSFC	Brake Specific Fuel Consumption (g / kWh at reference ambient conditions)
Certificate	In the context of this study: Certificate of Classification (document issued by the competent Member State authority or a Classification Society that assures certain standard of seaworthiness of the vessel) or a separate Engine Certificate, issued by the same authority, certifying the characteristics of the engine. The Certificate includes a ‘power' value of the main propulsion engine(s).
Certified power	The engine power stated on the Certificate of Classification or separate Engine Certificate of applicable, issued by the Member State authority or an approved Classification Society.
Classification Society	Independent organisation certifying safety, quality and / or seaworthiness of structures, including ships. Examples of Classification Societies are Lloyd's Register, DNV-GL, RINA and Bureau Veritas.
COG	Course Over Ground
Commission	European Commission
Complaint	In the context of this study: a formal allegation, submitted to the Commission in writing by any stake holder such as a member of the public, fisherman or NGO. Any information obtained in another way, such as informal communication, does not qualify as complaint.
CFP	Common Fisheries Policy
CPP	Controllable Pitch Propeller; propeller with adjustable blade angle relative to shaft center line (pitch). 0% – 100% scale (max. angle). The propeller shaft in a CPP arrangement is hollow.
De-rating	Applying measures to decrease the maximum engine power compared to the maximum engine power corresponding with the engine's (original) rating.
EIAPP	Engine International Air Pollution Prevention certificate, corresponding to an individual engine, stating the compliance condition with IMP MARPOL Annex VI Reg 13 NOx requirements.

Engine room logbook	Document / book used engineering crew to documents performance parameters of the engine(s), adjacent systems and tank contents. Not every (small) fishing vessel has an engine room logbook.
EU	European Union
EU Pilot	EU Pilot is the Commission database which organises, following a complaint or in own initiative cases, the contacts between the Commission and Member States, contributing to an efficient solution by which Member States are requested to provide the necessary clarifications, information and remedies, within set deadlines, in order to ensure the correct application of European Union law. When no satisfactory solution is proposed, the Commission takes further action, including through infringement procedures.
FPP	Fixed Pitch Propeller; propeller with non-adjustable blades. Most propeller shafts in an FPP arrangement do not have an inside diameter.
Fuel rack	Mechanical system controlling the quantity of fuel injected per cycle.
Governor	Engine component typically found on engines with mechanically controlled fuel pump(s). This device receives a desired engine speed (RPM)signal (electronically, pneumatically, mechanically) and adjusts the fuel rack position to reach or maintain this speed. Several variables can be adjusted, such as minimum speed, maximum speed and speed droop.
GT	Gross Tonnage: standardized parameter to describe the volumetric dimensions of a vessel.
IACS	International Association of Classification Societies.
IAPP	International Air Pollution Prevention certificate, corresponding to a vessel.
License	Document specifying the specifics of the vessel's right to fish, issued by the competent Member State authority. This includes technical characteristics of the vessel, including engine power.
Licensed power	The engine (propulsion) power stated on the fishing license, issued by the Member State competent authority.
Load factor	Power output relative to maximum. Used is definition of ratings, presented in the software of electronically controlled engines as percentage.
MCP	Maximum Continuous Power, definition used in the Control Regulation.
MCR	Maximum Continuous Rated Power; highest output that can be demanded from the engine on a continuous basis according to the engine manufacturer.
Performance map	Set of data in tabular or graphic format that describes the capacity of the engine. Typically speed (RPM) vs. maximum torque, maximum power and BSFC (see BSFC).

Product Certificate	Certificate issued by recognized Classification Society at individual engine level, based on testing of that specific engine. Engines in a main or emergency function onboard ships with a rated power of 300 kW or more are required to have a Product Certificate.
Propulsion system	All connected components to propel the vessel, normally: engine and gearbox and propeller shaft and propeller.
Flag state	Country where the vessel is registered. This state is responsible for among others issuance of the Certificate of Class.
PTI	Power take-in: an arrangement featuring an electric motor, or shaft generator that can be used as electric motor, to power the shaft using power generated by auxiliary engines. If the PTI system and main engine can power the shaft simultaneously, this is referred to as *booster*.
Rated power	The maximum power (kW) the engine under consideration can develop, taking the applied rating into account. Specified by the engine manufacturer.
Rated speed	The maximum speed (RPM) the engine under consideration can reach, taking the applied rating into account. Specified by the engine manufacturer.
Rating	Performance Curve of an engine corresponding to specified engine settings and limitations to the use profile of the engine. High maximum speed and output values are in general associated with a low average permissible load factor.
Registered power	Maximum engine power of a vessel as registered in the Member State national fleet register, or the European Community Fishing Fleet Register.
SG	Shaft generator: component used to generate electrical power, driven by the main engine, often via PTO (see: PTO)
SOG	Speed Over Ground
Swept volume	The volume change in the cylinder when the piston moves from TDC to BDC and vice versa multiplied by the number of cylinders.
PTO	Power take-off. Extraction of power from the (propulsion) engine through application of an additional shaft at the gearbox. Usually driving a hydro pump or electrical generator referred to as shaft generator.
TDC	Top Dead Centre (position of piston in liner)
Test bench	Onshore facility to test the engine while running, sometimes in controlled ambient conditions. Also referred to as test bed, usually for larger engines.
Turbocharger	Engine component driven by exhaust gases. Its purpose is to increase the charge air pressure. This enables the combustion of larger quantities of fuel per cycle, resulting in a higher maximum power output of the engine.
Type Approval	Certificate issued by recognized Classification Society at engine type level, based on testing one engine as proxy for that engine type. Issued for certain engine types, up to a rated output of 300 kW only.

EXECUTIVE SUMMARY (EN)

Under European and national regulations, the maximum engine power that a fishing vessel is allowed to have at its disposal is one of the restrictive parameters to manage fishing effort. In addition, the total engine power of a fishing fleet is, in conjunction with gross tonnage, used to estimate the size of the fishing fleet. Member States of the European Union are subject to Art. 40 of the Council Regulation (EC) No 1224/2009[1] (hereafter "the Control Regulation") which requires certification of the maximum engine power of fishing vessels whose propulsion engine power exceeds 120 kW, except for vessels using exclusively static gear or dredge gear, auxiliary vessels or vessels exclusively used in aquaculture. Member states are required to verify the accuracy of certified engine power through the development and implementation of a sampling and verification plan.

The verification of engine power has been a key element of the reform of the control system undertaken in 2009, and it has been an important point of discussion during the negotiations of the Control Regulation and its implementing rules. In 2018, The Commission presented a (new) reform of the Control Regulation[2], which includes amendments that aim to further increase the accuracy of registered and certified engine power capacity. The Commission has received a number of complaints on the apparent discrepancies between vessels' engine power as registered in national fleet registers and their actual engine power. The main allegation is that the certified engine power is lower than the actual power of the vessel.

The objective of this study was to inform the Commission of the actions taken by Member States regarding engine power verifications made in the engine power control framework, and to assess the quality of such checks carried out in Member States. The study was conducted by a consortium of two companies based in the Netherlands. Part of the work was subcontracted to a German and to a French company. The specific objectives of the study are:

- Determining whether the control of engine power is a good indicator for controlling the fishing effort of the fleet;

- Conducting physical verifications on a sample of fishing vessels in order to provide the Commission with information that could be used to properly assess two complaints received by the commission regarding allegedly under-declared engine power of specific vessels, and to complement the controls already carried out by the Commission on:

    - the efficiency and reliability of the sampling plans developed by the Member States;

    - the effective and uniform approach to risk analysis and design of sampling plans;

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[1] Council Regulation (EC) No 1224/2009 of 20 November 2009 establishing a Community control system for ensuring compliance with the rules of the common fisheries policy, amending Regulations (EC) No 847/96, (EC) No 2371/2002, (EC) No 811/2004, (EC) No 768/2005, (EC) No 2115/2005, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007, (EC) No 676/2007, (EC) No 1098/2007, (EC) No 1300/2008, (EC) No 1342/2008 and repealing Regulations (EEC) No 2847/93, (EC) No 1627/94 and (EC) No 1966/2006. (OJ L 343, 22.12.2009, p. 1.)

[2] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Council Regulation (EC) No 1224/2009, and amending Council Regulations (EC) No 768/2005, (EC) No 1967/2006, (EC) No 1005/2008, and Regulation (EU) No 2016/1139 of the European Parliament and of the Council as regards fisheries control

- the effective implementation of the sampling plans in view of effective implementation of Article 62(6) of the implementing rules of the Control Regulation according to which the physical verifications shall prioritize trawlers operating in a fishery subject to a fishing effort regime, effective implementation of the Article 34 of Regulation (EC) No 850/1998 concerning the restrictions on fishing activities in the 12-mile zone around the United Kingdom and Ireland;

- Providing the Commission with risk criteria and best practices on sampling and power measurement that will help consolidate the existing rules on the system of control of engine power.

Physical verifications of engine power

Physical engine power verifications were conducted on board a sample of 68 vessels from 14 Member States, that were divided in the following categories:

- Atlantic pelagic trawlers;
- Bottom otter trawlers operating in the Mediterranean Sea, the Strait of Sicily and the Adriatic Sea;
- Beam trawlers operating in the North Sea;
- Deep sea long liners operating in the waters of the Azores and Madeira;
- Mid-water otter trawlers operating in the Baltic Sea;
- Mid-water otter trawlers operating near the Cantabrian coast.

Physical engine power verifications were conducted on the following basis:

- Selection of vessels took place on the basis of a risk assessment;
- Verifications were conducted in cooperation with, and under the authority of, competent Member State authorities[3];
- Verifications were conducted on an unannounced basis;
- The power was measured by means of a torque meter using strain gauges installed on a temporary basis at the propeller shaft in combination with a shaft speed meter;
- The following situations were evaluated:
    - Steaming at maximum engine speed (and propeller pitch if applicable);
    - Fishing at maximum engine speed (and propeller pitch if applicable);
      or
    - Pulling (bollard pull) at maximum engine speed (and propeller pitch if applicable).

[3] One Member State disputed its authority to facilitate the intended verifications on this study's basis. To ensure the necessary mandate, A Commission inspector accompanied the contracted engineers and the Member State inspector.

- In addition to the physical measurement, relevant documentation including the vessel's fishing license, class certificate and engine documentation were assessed to verify consistency of the registered engine power, and to determine the likelihood of non-compliance of the engine with the certified engine power capacity.

The results of the physical engine power verifications conducted within this study are summarized in figure 1. On board 51% of the verified vessels, the measured engine power exceeded the certified engine power capacity. Secondary evidence was collected which demonstrates that multiple operators of the vessels that did not exceed the registered maximum power output during the test, may have manipulated their engine during the test in order to temporarily decrease the maximum power output. For 35% of the inspected vessels, no indications of non-compliance were identified.

The distribution of compliance shows that among the investigated fleet segments, the non-compliance rate with certified engine power is the lowest among the mid-water otter trawlers operating in the Baltic Sea. The highest non-compliance rate was observed in the Mediterranean Sea, among bottom-otter trawlers operating in Gulf of Lion. Manipulation of the test by vessel operators was encountered mainly onboard North Sea beam trawlers.

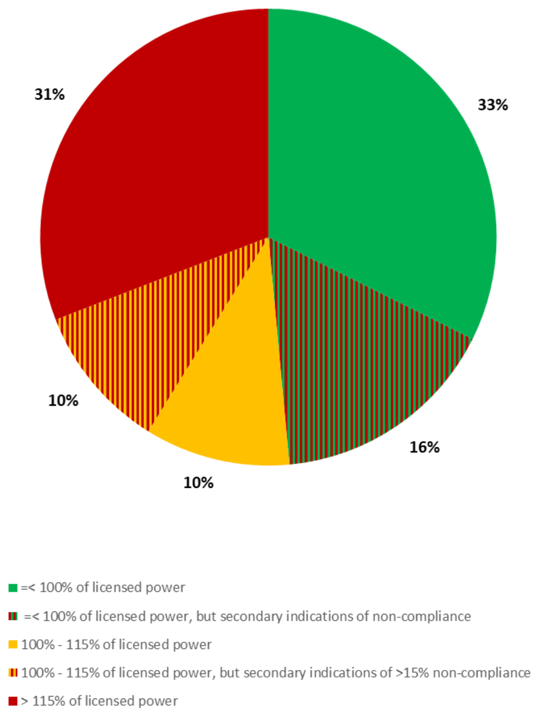

Figure 1. Overview of the physical verification results of all inspections conducted within this study.

Engine power as measure of effort

The assessment of whether or not engine power is a good indicator of fishing effort is to a large extent based on a review of existing literature and previously conducted research. The relation between engine power and fishing capacity is well established and validated: engine power is an indicator of the size of the gear that can be towed, the speed at which a certain gear can be towed, and the speed during the transit time between a port and the fishing grounds.

When fishing effort of a specific fishing typology is considered, previous studies have suggested that including additional factors could improve the effectiveness of fishing effort regimes. Examples of such factors are the number of hooks for long liners, or fishing gear characteristics of vessels operating towed gear.

In addition to regulating the fishing effort of specific types of vessels or within specific areas, engine power is a particularly useful measure to define the capacity of a fishing fleet. Engine power is related to the fishing capacity of all vessels subject to Art. 40 of the Control Regulation and, similar to the determination of gross tonnage, engine power can be determined uniformly across the wide variety of fishing vessel types within the European fishing fleets.

The formal and informal meetings with Member States' competent authorities within during this study demonstrated that not all inspectors and policy makers agree that engine power is a suitable measure of fishing effort. The following objections were raised against engine power:

- Engine power is a highly technical concept outside the field of competence of fisheries inspectors;
- Engine power verifications are costly;
- Controlling engine power places a significant burden on administrations' resources;
- The effect of engine power on fishing effort, given the other constraints applicable in the control framework such as TACs[4], is limited;
- The necessity to monitor engine power given the possibility to monitor other aspects (VMS[5], catch quantities) was questioned;

The contractor did not identify controllable parameters that could completely replace engine power as measure of fishing effort, or provide a suitable alternative way to determine the fleet capacity. On the other hand it cannot be ignored that the results of the physical verifications conducted by the contractor show that in general the checks currently carried out provide insufficient assurance that the certified engine power of fishing vessels reflects the actual situation. Since no suitable alternative for engine power as effort control measure could be identified, the contractor emphasizes that the quality of engine power control systems should be improved rather than that the measure as such should be replaced.

[4] Total Allowable Catch
[5] Vessel Monitoring System, providing real-time data such as vessel position and speed

Sampling and verification by Member States

For each Member State subject to this study, the sampling and verification system as required by Art. 41 of the Control Regulation and Art. 62 and 63 of the Commission Implementing Regulation[6] has been reviewed for the period from 2012 to 2017. Only 11 of the 15 Member States have implemented a sampling plan, of which five Member States conducted a verification series only once (in the period from 2012 to 2014). The remaining six Member States selected a sample for verification on a recurring basis (every 6 or 12 months). Recurring the sampling of vessels and verification process of engine power is not required by the regulation but generates a greater number of vessels to undergo a verification and it could be expected to have more of a preventive effect on the industry compared to a once-off verification round.

The aggregated number of vessels selected for verification by the 15 Member States under consideration within during this period was at least 989. For only 21 vessels, the data verifications described in Art. 41(1) resulted in the identification of potential non-compliance. 16 physical verifications were conducted on behalf of the competent authorities following these data verifications, and 39 on other grounds. These verifications found a total of 13 infringements. This is only 1,3 % of the vessels selected for a data verification, which is notably lower than the non-compliance rate found within this study.

Based on the information provided by Member States it cannot be determined with certainty why the number of non-compliant vessels is so low, but it seems that the following actions could have contributed to a higher success rate:

- More thorough analysis of VMS data, in particular comparison of average and maximum speed between peer vessels, and comparison of vessel speed against sea trial reference data;
- More thorough analysis of engine specifications and the maximum amount of power that can be obtained from the engine installed. A large discrepancy between certified and maximum obtainable power justifies further investigation.

Best practices and recommendations

The *certification* system should be improved to ensure that the certified engine power at the time of installation of the engine corresponds with the actual capacity of the engine. The *verification* system should be improved to ensure on-going compliance.

Unified definition of engine power

In the various rules and regulations that apply to fishing vessels, the definition of engine power is not entirely consistent. In particular the use of maximum *continuous* engine may suggest that intermittent use of engine power that exceeds the amount of engine power licensed to a fishing vessel is permitted, while intermittent use of excess power certainly increases the effective fishing effort.

[6] Commission Implementing Regulation (EU) No 404/2011 of 8 April 2011 laying down detailed rules for the implementation of Council Regulation (EC) No 1224/2009 establishing a Community control system for ensuring compliance with the rules of the Common Fisheries Policy.(OJ L 112, 30.4.2011, p. 1).

Excessive non-compliance

It was found that in most Member States, vessel owners are allowed to install engines in their fishing vessel that are much more powerful than their fishing license permits, as long as the engine is accompanied by a declaration that the power output is limited to the licensed value, for example provided by the engine manufacturer. Installation of such engines poses a risk of significant non-compliance when the applied de-rating is reversed without authorization.

Developing a guideline that indicates which engine type is appropriate to produce a specified amount of power, in combination with a prohibition of installation of excessively powerful engines, could help Member States to prevent the installation of excessively powerful engines.

There are several options to ensure ongoing compliance, which are particularly relevant to consider for de-rated engines. The following options were identified:

- Sealing (of critical components of mechanically controlled engines);
- Monitoring electronic engine data (of electronically controlled engines, that store the necessary data and can be accessed by inspectors);
- Pitch limitation (of vessels equipped with controllable pitch propellers, only feasible for selected gearboxes);
- Continuous propulsion power monitoring (in line with Commission proposal to reform the Control Regulation. Feasible on vessels with sufficient length of shaft available).

Depending on the implementation of a continuous propulsion power monitoring system, it might still be necessary to maintain a verification program in the spirit of Art. 41 of the current Control Regulation in the near or even distant future. As discussed before, sampling and verification as currently implemented by most Member States, if implemented at all, is not very effective. The existing regulatory framework provides sufficient options to improve the effectiveness of verification systems in Member States, in particular under Art 41(1)(g) of the Control Regulation.

Alternatively, replacing the risk assessment described in Art. 41 of the Control Regulation altogether by a random selection of vessels that are required to undergo a physical engine power verification, regardless of the vessel's risk profile could be considered. This would lower the administrative burden for Member State administrations yet increase the number of identified cases of non-compliance when compared to the current verification practice.

RÉSUMÉ (FR)

Selon les Règlements européens et nationaux l'un des critères limitatifs pris en compte pour gérer l'effort de pêche est la puissance maximale autorisée des moteurs des navires. De plus, la puissance totale des moteurs combinée avec les jauges brutes des navires est utilisée pour évaluer la taille d'une flotte de pêche. Les Etats membres de l'Union européenne sont soumis à l'Article 40 du Règlement européen (EC) n° 1224/2009 (ci-après dénommé Règlement de control) qui requiert la certification de la puissance maximale des moteurs de propulsion des navires de pêche pour toute puissance supérieure à 120 KW, excepté pour les navires utilisant des engins de pêche fixes et des dragues, les navires auxiliaires et les navires utilisés exclusivement en aquaculture. Les Etats membres ont la charge de vérifier la précision de la certification des puissances propulsives via la mise en place d'un plan de mesure par échantillonnage.

Un des éléments-clefs de la réforme du système de contrôle en entreprise en 2009 est la vérification des puissances propulsives. Cela a été un des points importants de discussion lors des négociations du règlement de contrôle et de ses règles d'application. En 2018, La Commission a présenté une (nouvelle) réforme du Règlement de contrôle, laquelle inclut un amendement dont l'objectif est d'accroître la précision des valeurs enregistrées et certifiées des puissances propulsives. La Commission a reçu de nombreuses plaintes concernant des incohérences entre la puissance de moteurs telle que notée dans les registres de flotte nationaux et la puissance effective des moteurs des navires. L'allégation principale est que la puissance certifiée des moteurs est inférieure à la puissance réelle développée par le navire.

L'objectif de cette étude est d'informer la Commission (DG MARE) sur les actions prises par les Etats membres en terme de vérifications faites dans le cadre du plan de contrôle des puissances des moteurs et d'évaluer la qualité de ces contrôles effectués dans les Etats membres. L'étude a été menée par un consortium de deux sociétés néerlandaises. Une partie des tâches a été sous-traitée à une société allemande et une société française. L'objectif spécifique de cette étude est de :

- déterminer si le contrôle de la puissance des moteurs est un bon indicateur pour l'évaluation de l'effort de pêche d'une flotte.

- Effectuér des mesures physiques sur un échantillon de navires de pêche afin de permettre à la Commission d'évaluer correctement deux plaintes reçues au sujet de la puissance sous-estimée des moteurs sur des navires donnés et de compléter les contrôles mis en œuvre par la Commission sur:
    - l'efficacité et la fiabilité du plan d'échantillonnage mise en place par les Etats membres.
    - l'approche efficace et homogène de l'analyse de risque et la conception des plans d'échantillonnage.
    - l'efficacité de la mise en place des plans d'échantillonnage dans le cadre de:
        - ✓ suspicions de fraudes de certains navires.
        - ✓ l'application effective de l'Article 62(6) des règles d'application du Règlement de contrôle dont la priorité sont les chalutiers opérant dans les zones soumises à un régime de gestion d'effort de pêche.
        - ✓ l'application effective de l'Article 34 du Règlement (EC)No 850/1998 qui concerne les restrictions des activités de pêche dans les 12 miles autour du Royaume-Uni et de l'Irlande.

- Rapporter à la Commission les risques et les bonnes pratiques sur l'échantillonnage et les mesures qui permettront de consolider les règles existantes du système de contrôle de mesure de puissance des moteurs.

Mesures physiques de la puissance des moteurs

Les mesures physiques ont été faites sur un échantillon de 68 navires de 14 Etats Membres.
Elles ont été effectuées sur les catégories de navires suivants :

- Chalutiers pélagiques en Atlantique;
- Chalutiers à panneaux opérant en Méditerranée, Canal de Sicile et Mer Adriatique;
- Chalut à perche en Mer du Nord;
- Long liners dans les eaux des Açores et de Madère;
- Chalutiers à panneaux en mer Baltique;
- Chalutiers à panneaux dans la zone Cantabrique.

Les mesures ont été faites de la manière suivante :

- la sélection des navires sur la base d'une analyse de risques;
- les mesures à bord ont été menées en coopération et sous l'autorité des Affaires Maritimes;
- les mesures à bord ont été faites de façon inopinée;
- La puissance a été calculée à partir:
  - du couple moteur mesuré au moyen d'une jauge de contrainte fixée de façon temporaire sur la ligne d'arbre.
  - de la vitesse de rotation de la ligne d'arbre avec un tachymètre.
- Les situations suivantes ont été prises en compte:
  - vapeur au régime moteur maximum (pas de l'hélice au maximum, si hélice à pas variable)
  - navire en pêche au régime moteur maximum (pas de l'hélice au maximum, si hélice à pas variable)
    Ou
  - essais de traction à régime maximum. (pas de l'hélice au maximum, si hélice à pas variable)
- De plus, les documents tels que le permis de navigation, le certificat de classe, la documentation sur le moteur et la ligne propulsive ont été vérifiés afin de s'assurer de la cohérence de la puissance agréée et de déterminer une éventuelle non-conformité du moteur avec la capacité de puissance certifiée du moteur.

Les résultats des mesures sont résumés au graphique 2. A bord de 51 % des navires vérifiés, les valeurs des puissances mesurées sont supérieures aux valeurs des puissances certifiées des moteurs. Nous avons eu la preuve que sur plusieurs navires, les moteurs ne délivraient pas la puissance limite agréée pendant le test. Les paramètres moteurs ont pu être changés temporairement par les opérateurs pour diminuer la puissance maximum délivrée. Pour 35% des navires vérifiés, aucune preuve de non-conformité.

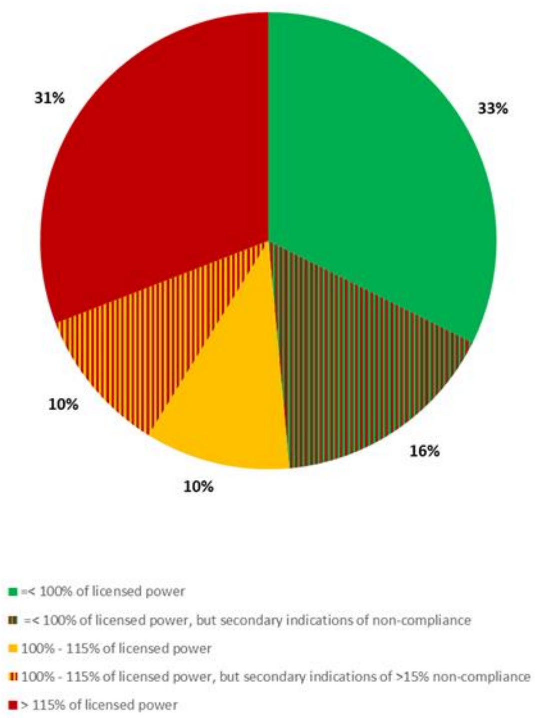

Figure 2. Vue d'ensemble des résultats de la vérification physique de toutes les inspections effectuées dans le cadre de cette étude.

La puissance des moteurs comme critères de mesure de l'effort.

La détermination si oui ou non la puissance moteur est un bon indicateur pour l'effort de pêche est basée sur une large consultation de la littérature existante et des recherches qui ont été menées par le passé. La relation entre la puissance des moteurs et la capacité de pêche est bien établie et validée : la puissance moteur est déterminante pour la taille des apparaux de pêche pouvant être tractés, la vitesse de traction de ces apparaux et la vitesse pendant le temps de transit d'un port vers la zone de pêche peuvent être complétées.

Pour certaines typologies de pêches spécifiques, une étude a suggéré qu'inclure d'autres facteurs à l'effort de pêche peut améliorer l'efficacité du régime de l'effort de pêche. Quelques exemples de ces facteurs : le nombre d'hameçons pour les longs liners, ou les caractéristiques des apparaux de pêche des navires tractants.

En plus de réguler l'effort de pêche pour un type de navire ou dans une zone déterminée, la puissance des moteurs est une mesure particulièrement utile pour définir la capacité d'une flotte. La capacité de pêche de tous les navires soumis à l'Art 40 du Règlement de contrôle dépend de la puissance des moteurs. De même que pour la détermination de la jauge brute, la détermination de la puissance des moteurs peut être appliquée de façon uniforme à de nombreux types de navires de pêche des flottes européennes.

Les réunions formelles et informelles avec les autorités compétentes des Etats membres dans le cadre de cette étude ont démontré que les inspecteurs et la politique des fabricants n'étaient pas d'accord sur le fait que la puissance des moteurs est une mesure fiable pour l'effort de pêche.
Les objections suivantes ont été avancées :

- La puissance des moteurs est un concept hautement technique en dehors du champ de compétences des inspecteurs des pêches;
- La vérification de la puissance des moteurs est coûteuse à mettre en place;
- Le contrôle de la puissance des moteurs demande une charge supplémentaire significative aux équipes administratives;
- L'efficacité du contrôle de la puissance moteur sur l'effort de pêche est limitée étant donné la présence de mesures déjà en place dans le cadre des quotas de pêche;
- La remise en question du fait de pouvoir contrôler certains paramètres (VMS, quantité pêchée) par le contrôle de la puissance des moteurs.

Le contractant n'a pas identifié d'autres paramètres pouvant être contrôlés et qui pourraient définitivement remplacer la puissance des moteurs comme mesure de l'effort de pêche, ou proposé une autre alternative fiable pour déterminer l'effort de pêche. D'autre part, d'après les résultats des mesures physiques effectuées par le contractant, nous ne pouvons pas avoir l'assurance que la puissance certifiée des moteurs des navires de pêche corresponde à la situation réelle. Le contractant insiste sur le fait que la qualité du système de contrôle de puissance des moteurs doit se perfectionner tant qu'une autre alternative fiable n'a pas été identifiée pour le contrôle de l'effort de pêche.

Echantillonnage et vérification par les Etats membres.

Pour tous les Etats Membres soumis à cette étude, le système d'échantillonnage et de vérification tel que requis pas l'Art 41 du Règlement de contrôle et l'Art 62 et 63 du Règlement déxécution de la Commission a été révisé pour la période de 2012 à 2017. Uniquement 11 des 15 Etats Membres ont mis en place un plan d'échantillonnage, dont uniquement 5 l'on fait une fois en fonction d'une analyse de risques (dans la période de 2012 à 2014). Ces 6 derniers ont sélectionné leur échantillon avec des vérifications récurrentes (tous les 6 ou 12 mois). La récurrence des vérifications et le contrôle des puissances des moteurs ne sont pas requis par le Règlement mais entraînent un nombre plus important de navires vérifiés et peuvent avoir un effet préventif plus important qu'un système de vérification unique.

Le nombre total des navires sélectionnés par les 15 Etats membres dans la période mentionnée est 989. Pour seulement 21 navires, le bureau d'analyse décrit dans l'Art 41(1) a identifé une potentielle non-conformité. 55 mesures physiques ont été effectuées au nom des autorités compétentes qui au total ont trouvé 13 infractions. Cela ne représente que 1,3 % des navires sélectionnés pour vérification.

Sur la base de ces informations fournies par les Etats membres, la cause du faible nombre de navires non conformes ne peut être déterminée avec certitude. Mais les actions suivantes pourraient contribuer à améliorer ce taux :

- Une analyse des données acquise via le VMS, en particulier la comparaison des vitesses moyennes des navires identiques et la comparaison avec les données des essais en mer.

- Une analyse des caractéristiques du moteur et de la puissance maximum qu'il peut délivrer.

Bonnes pratiques et recommandations

La *certification* doit être perfectionnée afin d'avoir la confirmation que la puissance certifiée des moteurs au moment de l'installation est conforme à la puissance réelle du moteur à bord. Le système de vérification devrait permettre la continuité de la conformité.

Définition commune de la puissance des moteurs

Dans différentes règles et législation qui s'appliquent aux navires de pêche, la définition de la puissance des moteurs n'est pas toujours cohérente. En particulier lorsque la puissance maximal continue est prise comme référence, cela implique que pendant certaines périodes la puissance peut être supérieure à la puissance indiquée sur le permis de navigation et donc que les limitations de l'effort de pêche sont inopérantes.

Non-conformité majeure

Il a été constaté que dans la plupart des Etats membres, les armateurs sont autorisés à installer à bord un moteur pouvant délivrer une puissance supérieure à celle mentionnée sur leur permis de navigation tant qu'il est accompagné d'une déclaration, délivrée par le fournisseur du moteur par exemple, mentionnant qu'il est taré à la puissance du permis de navigation. L'installation de tel moteur pose le problème d'un risque de non-conformité majeur lorsque ce tarage est modifié.

Etablir une ligne directrice qui indiquerait quel type de moteur est adapté pour délivrer telle puissance, ainsi que l'interdiction d'installer un moteur d'une puissance potentiellement excessive, pourraient aider les Etats membres dans la prévention de l'installation de moteur d'une puissance excessive.

Il y a plusieurs solutions pour s'assurer de la continuité de la conformité, qui sont particulièrement judicieuses dans le cas du dé-tarage des moteurs :

- le scellage (sur les composants mécaniques de contrôle du moteur)
- le contrôle des données électroniques du moteur (Sur les moteurs contrôlés électroniquement, les données sont enregistrées automatiquement et accessible par un inspecteur)
- la limitation du pas de l'hélice (sur les navires équipé d'une hélice à pas variable et équipé de certains réducteurs)
- un système continu de contrôle de la puissance de propulsion (en accord avec la proposition de la Commission sur la réforme du règlement de contrôle. Applicable sur les navires ayant une longueur de ligne d'arbre suffisante disponible)

En attendant la mise en place d'un système de contrôle en continu de la puissance propulsive, il pourra être toujours nécessaire de maintenir le programme de vérification dans l'esprit de l'Art.41 de l'actuel Règlement de contrôle, dans un futur proche et même lointain. Ainsi que vu précédemment, l'échantillonnage et les vérifications sont mis en œuvre dans la plupart des Etats membres et ne semblent pas efficaces. Le cadre des règles existantes comporte les solutions suffisantes pour améliorer l'efficacité des vérifications des Etats membres, en particulier l'Art 41(1) (g) du règlement de contrôle.

Une solution alternative serait de remplacer l'analyse de risques décrite dans l'Art.41 du Règlement de contrôle par une sélection aléatoire des navires qui seraient soumis à une mesure de la puissance des moteurs, quel que soit le profil de risque des navires. Cela permettrait de soulager la charge administrative des Etats membres et de quand même identifier un nombre plus important de non-conformité comparé aux pratiques actuelles.

1. Introduction

Engine power and gross tonnage are used to define fishing capacity of fishing fleets in the Common Fisheries Policy[7] (hereafter “CFP”) context. In accordance with Art. 22 (1) of the CFP, Member States are required to put in place measures to adjust the fishing capacity of their fleet to their fishing opportunities over time, taking into account trends and based on best scientific advice, with the objective of achieving a stable and enduring balance between them. The entry-exit regime laid down in Art. 23 of the CFP aims to prevent the fishing capacity of European fishing fleets from growing. In addition to fleet management purposes, engine power is one of the determinants of fishing effort in most fishing effort regimes, established to protect specific areas and fish stocks.

Taking the important role of engine power in European fishing policies into account, it is clear that registered engine power values should correspond with the actual engine power deployed by vessels. Full and adequate implementation of the regulatory certification, verification and registration obligations by Member States laid down in Council Regulation (EC) No 1224/2009[8] (hereafter "the Control Regulation") and the Commission Implementing Regulation[9] are essential for sustainable fisheries management and to realize a level playing field among competing fishermen.

The verification of engine power has been a key element of the reform of the control system undertaken in 2009, and it has been an important point of discussion during the negotiations of the Control Regulation and its implementing rules. In 2018, The Commission presented a (new) reform of the Control Regulation[10], which includes amendments that aim at a further increase of the accuracy of registered and certified engine power values. The implementation of the proposed measures, notably the installation of a mandatory continuous propeller shaft power monitoring system for a substantial portion of the EU fishing fleet, may be expected to affect all stakeholders and are therefore currently subject to an intensive public debate. The results of this study could contribute to the decision making process towards the establishment of a revised engine power control system of fishing vessels in the near future.

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[7] REGULATION (EU) No 1380/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC

[8] Council Regulation (EC) No 1224/2009 of 20 November 2009 establishing a Community control system for ensuring compliance with the rules of the common fisheries policy, amending Regulations (EC) No 847/96, (EC) No 2371/2002, (EC) No 811/2004, (EC) No 768/2005, (EC) No 2115/2005, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007, (EC) No 676/2007, (EC) No 1098/2007, (EC) No 1300/2008, (EC) No 1342/2008 and repealing Regulations (EEC) No 2847/93, (EC) No 1627/94 and (EC) No 1966/2006. (OJ L 343, 22.12.2009, p. 1.)

[9] Commission Implementing Regulation (EU) No 404/2011 of 8 April 2011 laying down detailed rules for the implementation of Council Regulation (EC) No 1224/2009 establishing a Community control system for ensuring compliance with the rules of the Common Fisheries Policy.(OJ L 112, 30.4.2011, p. 1).

[10] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Council Regulation (EC) No 1224/2009, and amending Council Regulations (EC) No 768/2005, (EC) No 1967/2006, (EC) No 1005/2008, and Regulation (EU) No 2016/1139 of the European Parliament and of the Council as regards fisheries control

The objective of this study was to inform the Commission on actions taken by 15 Member States regarding engine power verifications in the existing engine power control framework, and to assess the quality of such checks carried out in Member States. The study was conducted by a consortium of two companies based in the Netherlands. Part of the work was subcontracted to a German and to a French company. The specific objectives of the study are:

- Determining whether the control of engine power is a good indicator for controlling the fishing effort of the fleet;

- Conducting physical verifications on a sample of fishing vessels in order to provide the Commission with information that could be used to properly assess two complaints received by the commission regarding allegedly under-declared engine power of specific vessels, and to complement the controls already carried out by the Commission on:

    - the efficiency and reliability of the sampling plans developed by the Member States;

    - the effective and uniform approach to risk analysis and design of sampling plans;

    - the effective implementation of the sampling plans in view of effective implementation of Article 62(6) of the Commission Implementing Regulation according to which the physical verifications shall prioritize trawlers operating in a fishery subject to a fishing effort regime, effective implementation of the Article 34 of Regulation (EC) No 850/1998 concerning the restrictions on fishing activities in the 12-mile zone around the United Kingdom and Ireland;

- Providing the Commission with risk criteria and best practices on sampling and power measurement that will help consolidate the existing rules on the system of control of engine power.

The non-compliance rate found by the physical verifications does not necessarily provide a proxy for the suitability of engine power as indicator of fishing effort – this would only be the case if these verifications show that engine power cannot be controlled effectively. To determine whether engine power is a good indicator of fishing effort, existing literature has been reviewed, of which an overview can be found in section 3.

To determine the effectiveness of sampling and verification plans that aim at identification of fishing vessels which are potentially non-compliant with engine power restrictions, implemented by Member States, these plans and their output were reviewed and appraised. The relative number of non-compliance cases identified by the established sampling and verification procedures was used as the main measure of their effectiveness. The review focused on the period since 2011, when the current Commission Implementing Regulation entered into force.

The quality of the procedure of (initial) certification of engine power is an important determinant of the reliability and accuracy of certified and registered engine power of fishing vessels throughout its lifetime. The sampling and verification plan to be implemented should therefore not be appraise independently from the implemented system of certification of engine power. Both the certification system and the sampling and verification system implemented by Member States will be reviewed in section 4.

The contractor conducted physical power verifications in conjunction with Member States' competent authorities and in some cases Commission fisheries inspectors. These verifications were conducted on an unannounced basis onboard a sample of vessels selected by the contractor following a risk-assessment. The rate and magnitude of identified non-compliance with engine power restrictions within the sample provides an indication of the effectiveness of the verification and certification systems implemented by Member States. The physical engine power verification results are presented in section 5 and provide a general view of non-compliance of high risk vessels across a relatively large number of vessels, Member States and fishing typologies. Analysis of the obtained physical verification results and the sampling and verification systems implemented by Member States resulted in conclusions and recommendations for future policy, which will be presented in section 8.

Since the entry into force of the Control Regulation and the Commission Implementing Regulation, the Commission received multiple complaints[11] regarding alleged misreporting of engine power by fishing vessel owners. The contractor reviewed how these complaints were investigated by the Commission and the respective Member States. The objective of this review was to determine the likelihood that the vessels under consideration were indeed non-compliant with engine power regulations, based on the evidence gathered by the Commission and the respective Member State as well as the results of physical engine power verifications conducted within this study. These complaints will be discussed in section 6.

The remainder of this section will evaluate the regulatory and technical background of engine power as measure of fishing effort and fishing capacity.

1.2. Regulatory context of certification of engine power

1.2.1. Statutory certification of the classification of vessels

IMO conventions[12] oblige Governments of IMO Member Parties, including all EU coastal Member States, to assure a certain level of safety of their fleets. Vessels are issued a Certificate of Classification or equivalent certificate to demonstrate compliance with relevant rules and standards. The flag state duties that follow from this regulatory framework, also apply to most seagoing fishing vessels. A Flag State may choose to delegate selected duties to Classification Societies.

One of the certified items onboard a fishing vessel is the main propulsion engine. Engines in a main or emergency function onboard ships with a rated power of 300 kW or more are required to have a Product Certificate. Engines with a rated power less than 300 kW may be installed if a Type Approval has been issued. If a Type Approval is not available for an engine with a rated power lower than 300 kW, the engine may undergo tests to obtain a Product Certificate.

An engine type may be sold at a variety of 'ratings', which may involve slight engine layout differences such as turbocharger configuration and software. These variations exist to meet the needs of different applications. In general, high load ratings are associated with operation for relatively short periods at high load. The maximum continuous rated power (MCR) is the engine power that can be demanded (at the corresponding rated engine speed) continuously. This power value is also referred to as

[11] A complaint in the context of this study is the formal, written submission of an allegation to the Commission of an allegation by any stake holder, such as a member of the public, competing fisherman or NGO. Any information obtained in another way, such as informal communication, does not qualify as complaint.

[12] http://www.imo.org/en/About/Conventions/Pages/Home.aspx

maximum continuous power. An IACS[13] requirement regarding engine power is that an overload power of 110% of the rated power can be achieved without inflicting damage to the engine.

In Art. 5(1) of Regulation (EEC) No 2930/86 (replaced by regulation (EU) 2017/1130)[14], engine power is defined as *the total of the maximum continuous power which can be obtained at the flywheel of each engine*. This is in line with the definition of power according to ISO 3046-1[15] and chapter 5.2.3.1 of the NOx Technical Code.[16]

Art. 63 of the Commission Implementing Regulation states that:

'If the power of the propulsion engine is measured after the reduction gear, an appropriate correction shall be applied to the measurement in order to calculate the propulsion engine power at the engine output flange according to the definition in Article 5(1) of the European Regulation defining characteristics for fishing vessels. That correction shall take into account the power losses resulting from the gearbox on the basis of the official technical data provided by the gearbox manufacturer.'

Article 5(1) of the European Regulation defining characteristics for fishing vessels states that:

'The engine power shall be the total of the maximum continuous power which can be obtained at the flywheel of each engine and which can, by mechanical, electrical, hydraulic or other means, be applied to vessel propulsion. However, where a gearbox is incorporated into the engine, the power shall be measured at the gearbox output flange.

No deduction shall be made in respect of auxiliary machines driven by the engine.'

This provision is presumably included in the regulation for the verification of most outboard engines and some smaller diesel engines with gearboxes incorporated into the engine, for which power can, even at a test facility, not be measured at the flywheel. It could be argued that the situation of an engine with a separate gearbox installed on board a vessel is from a shaft power measurement perspective identical to that of an engine with an incorporated gearbox on a test bed: (in almost every case) the only place where shaft power can be measured is after the gearbox.

In addition to the above, the data that must be used for the correction for loss of power in the gearbox according to The Commission Implementation Regulation Art. 63(2) (official technical data provided by the gearbox manufacturer) is known as highly unreliable, often underestimating real losses. Moreover, this data is not always specified or available.

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[13] International Association of Classification Societies

[14] Regulation (EU) 2017/1130 of the European Parliament and of the Council of 14 June 2017 defining characteristics for fishing vessels

[15] ISO 3046-1 2002(E) Declarations of power, fuel and lubricating oil consumptions, and test methods — Additional requirements for engines for general use

[16] NOx Technical Code 2008 – Technical Code on control of emission of nitrogen oxides from marine diesel engines.

1.2.2. The Control Regulation

Art. 40 of the Control Regulation requires Member States to certify engine power and issue engine certificates for Community fishing vessels whose propulsion engine power exceeds 120 kilowatts (kW) except vessels using exclusively static gear or dredge gear, auxiliary vessels and vessels used exclusively in aquaculture. It is also required that a new propulsion engine, a replacement propulsion engine or a propulsion engine that has been technically modified shall be officially certified by the Member States' competent authorities as not being capable of developing more maximum continuous engine power than stated in the engine certificate. Such a certificate shall only be issued if the engine is not capable of developing more than the stated maximum continuous engine power, and there is no possibility to increase the performance of the propulsion engine above the certified power.

The part 'more than the stated maximum continuous engine power', could be interpreted in two ways: (1) the engine power should under no circumstance exceed the MCP power value, or (2) the engine should not be capable of producing more than the MCP *continuously.* The first interpretation would be more meaningful in a fishing effort context, since exceeding the certified maximum *continuous* power for substantial amounts of time would potentially increase the fishing effort accordingly. Art 39(2) 'Member States shall ensure that the certified engine power is not exceeded' confirms that the capacity to develop excess power on an intermittent basis should be prevented, in line with the first of the two interpretations above.

Art. 41 of the Control Regulation requires the Member States to establish a sampling plan that incorporates a risk assessment. The selected sample of vessels shall be subject to analysis of available information and data, as detailed in Art. 62 of the Control Implementing Regulation, to identify indications that the engine power of a fishing vessel is greater than the power stated on its fishing license. This is referred to as a *data verification* in the Control Regulation and throughout this report. In case indications of potential non-compliance are found, the Member State shall proceed to a physical verification of engine power.

1.2.3. Assignment of certification tasks

Art. 40(3) of the Control Regulation allows Member States to assign the certification of engine power task to Classification Societies or to other entities that have the necessary expertise to technically examine engines and their power. In all Member States, the governmental body responsible for implementation of the Control Regulation (fisheries authority) has assigned the certification duties to the (governmental) organization that is already responsible for the certification of engine power in the context of statutory certification of vessels. In a number of Member States, the certification of engine power task has subsequently been delegated to external Classification Societies. Table 2 in section 4.1 provides an overview at Member State level of which organization is responsible with the certification of engine power.

1.2.4. De-rating and other policy areas

If the rated power of the engine installed in a fishing vessel is greater than permitted according to the vessel's fishing license, it is an option to permanently change certain engine settings to restrict the maximum output. This is referred to as *de-rating.* De-rating is not prohibited under the Control Regulation (this would make it very difficult to find a matching engine for each licensed power value).

NOx Emissions

Under Regulation 13 of MARPOL ANNEX VI[17], seagoing vessels of 400 GT or more with an engine installed after the year 2000 are required to have an IAPP certificate. This means that installed engine must have an EIAPP certificate and Technical File. An EIAPP certificate proves that the engine is compliant with the applicable NOx emission regulations, and the Technical File specifies among others the characteristics of the (compliant) engine. Classification Societies and Flag State authorities responsible for statutory certification are authorized to issue an EIAPP certificate if it is demonstrated that the engine meets the applicable NOx emission limits Set in Art. 3 to 5 of Reg. 12 of MARPOL ANNEX VI, measured in accordance with the guidelines in the NOx Technical Code (NTC)[18].

In the NTC framework, emissions are calculated as the weighted average of the NOx emission (g / kWh) when the engine is running at 25%, 50% 75% and 100% of its maximum continuous load. This means that essentially, an EIAPP corresponds to a rating which must at least be specified in the Technical File, in accordance with Art. 2.4.1.3 of the NTC. The Technical File must also identify:

The full range of allowable adjustments or alternatives for the components of the engine.

This implies that prior to making the decision to de-rate the engine, it should be verified by the operator and certifying organization that, according to the information provided In the Technical File belonging to the engine, the engine EIAPP certificate is valid at the new rating of the engine. Some engine types have a wide range of EIAPP validity (engine speed and power) while others have not.

For vessels smaller than 400 GT or with less than 750 kW engine power and engaging exclusively in domestic voyages, an IAPP certificate is not required. According to Reg. 5.2 of MARPOL ANNEX VI, the flag state is responsible for the compliance of engines installed on board these vessels with all regulations in chapter 3 of MARPOL ANNEX VI. This includes Reg. 13, and thus the obligation to prevent the installation of engines that do not have an EIAPP certificate and Technical File, and to prevent de-rating to a rating that is not explicitly permitted according to the Technical File.

National rules

There are also national rules that restrict the maximum permitted de-rating. In the Netherlands, engines are not permitted to be de-rated to an output below 75% of the MCR[19]. In Spain this is 80%[20]. An overview of all national rules that restrict de-rating is not available, but organizations that certify engine power of fishing vessels should assure that engines are not de-rated to a rating outside their permissible range.

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[17] INTERNATIONAL MARITIME ORGANIZATION (2013) *MARPOL ANNEX VI AND NTC 2008 - WITH GUIDELINES FOR IMPLEMENTEATION*. London: International Maritime Organization, pp. 21 – 24.

[18] NOx Technical Code on control of emission of nitrogen oxides from marine diesel engines (integrap part of IMO MARPOL ANNEX VI)

[19] Vissersvaartuigenbesluit Art. 2.1 Reg 14.2

[20] Feedback on the draft final report of this study submitted to the Commission on behalf of Spain.

1.3. Technical context of certification of engine power

Most vessels are equipped with one or more rotating propellers to generate thrust, resulting in movement of the vessel. The parameters that can be controlled to generate the desired thrust are propeller speed (rpm) for fixed pitch propellers (FPP) and a combination of propeller speed and the pitch of the propeller blades in the case of controllable pitch propellers (CPP).

1.3.1. Fishing vessels equipped with fixed pitch propellers

Most fishing vessels that were subject to physical verification within this study are equipped with diesel engines and a fixed pitch propeller, in a single engine propulsion layout. Vessel speed and generated thrust are proportionate, and so are propeller speed and thrust for these installations. The relation between engine power, shaft speed and torque can be described as:

$$P_{engine} = T \times \frac{V \times 2\pi}{60}$$

Where

$P_{enigne} = engine\ power\ (kW)$
$T = Torque\ (kNm)$
$V = shaft\ speed\ (rpm)$

The simplified relation between engine power and (propeller) shaft speed can be described as:

$$P_{enigne} = C \times V^3$$

Where

$P_{enigne} = engine\ power\ (kW)$
$C = contstant$
$V = shaft\ speed\ (rpm)$

As long as all other parameters such as hull shape and water depth are constant.

The constant value C changes with vessel characteristic such as loading conditions and hull shape. Applying fishing gear can be considered a significant change of hull shape compared to the bare hull of a given fishing vessel, which affects the C value. More power is needed to generate the same shaft speed when additional resistance is added to the vessel. Interpolation and extrapolation of the propeller curve can be used to estimate the engine power at non-measured shaft and vessel speeds for vessels equipped with a fixed pitch propeller.

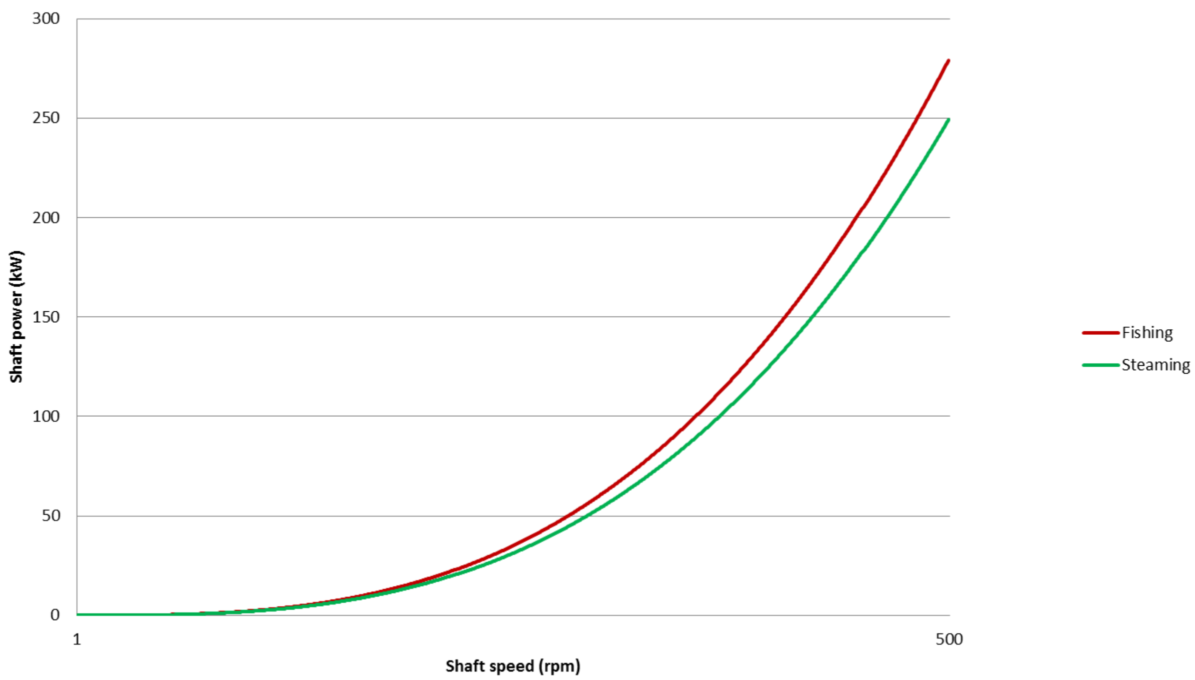

Figure 3. Example of propeller curve of fishing vessel with FPP.

1.3.2. Fishing vessels equipped with controllable pitch propellers

Fishing vessels with a controllable pitch propeller can adjust the engine speed and the propeller pitch independently from each other. The advantage of this system is a relatively high propeller efficiency across a relatively large output range. When the propeller pitch of a CPP vessel is fixed in a certain position, the propulsion system behaves as a FPP layout as shown in figure 3. When the pitch is adjusted, it will again have the properties of a FPP vessel, but with a different C value.

The relation between pitch and power at a constant engine speed (rpm) is almost linear. Figure 4 schematically shows the effect of engine speed changes for CPP vessel, when all other variables are kept equal. This figure shows that power verification of a CPP vessel should be conducted when the engine is running at its nominal speed and with maximum pitch. Figure 5 shows the effect of a changing C value for a CPP propulsion system, when the engine speed is kept equal. This graph illustrates that engine power verifications should preferably not only take place with maximum engine speed and propeller pitch, but also with significant resistance (pulling fishing gear or during a bollard pull test).

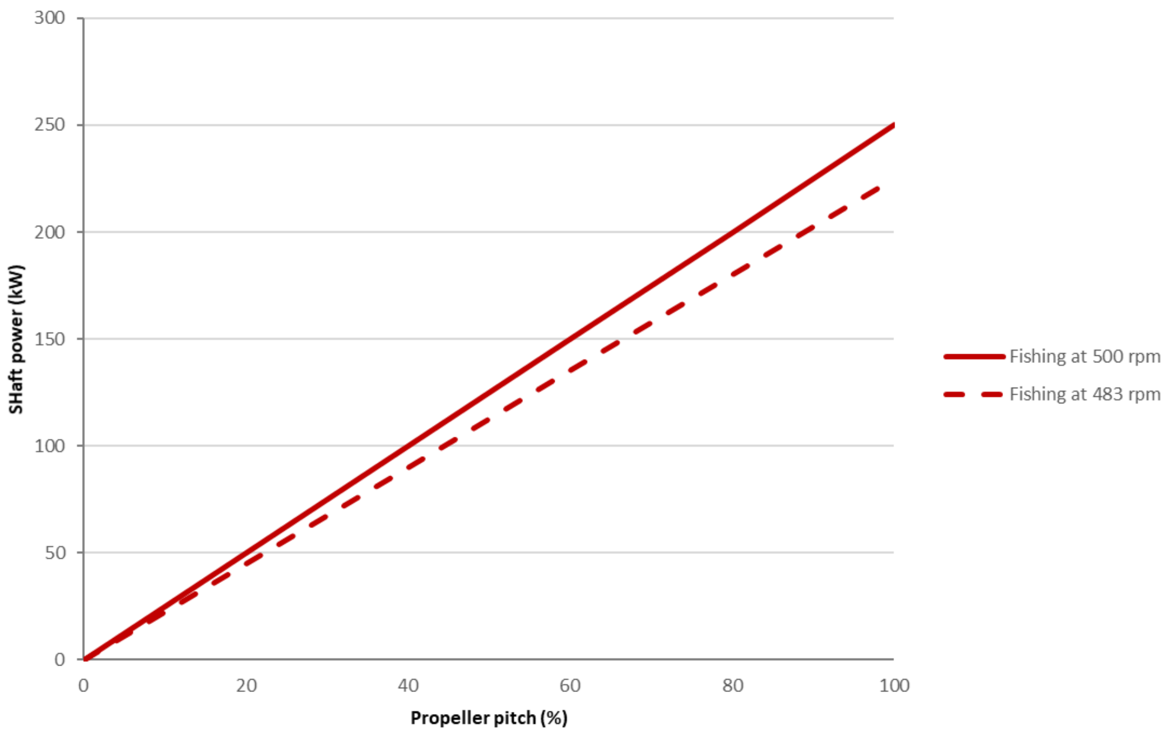

Figure 4. Relation between pitch and power in a CPP arrangement, effect of changing engine speed.

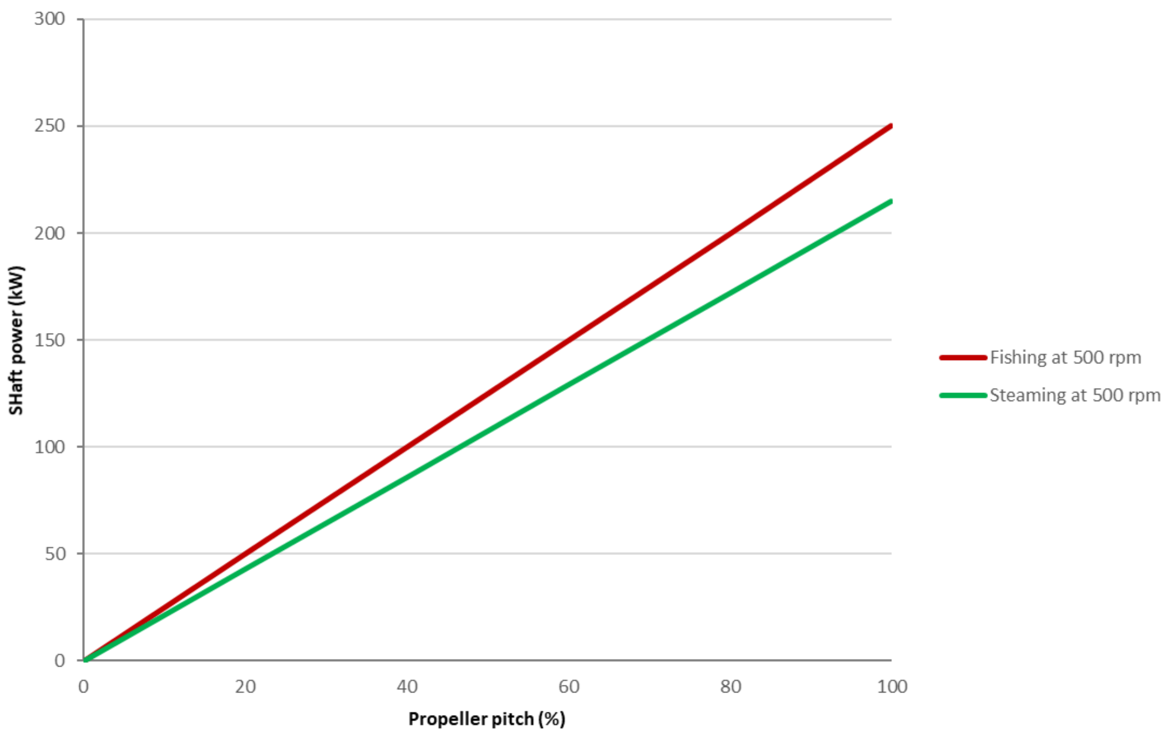

Figure 5. Relation between pitch and power in a CPP arrangement, effect of deploying fishing gear.

1.3.3. Engine power control

Engine types are usually sold at a variety of maximum power and speed combinations (ratings), to cater for the specific needs of various clients. Notable differences are the maximum crank shaft speed, the maximum power output and the average permissible load factor[21]. Patrol boats for example have engines with high a high peak power rating but a low average load factor; they are allowed to be very fast for a relatively short period of time.

It should be noted that on a test bench, any brake power value between zero and the maximum power at the respective shaft speed can be generated by adjusting the brake load. If a test bench is used to determine the maximum continuous brake power that will ultimately constitute the licensed power of a fishing vessel, it is critical that the engine is tested at its maximum speed and load combination, for which the maximum speed should equal the highest (power) point of the design propeller curve.

In case the certified maximum engine power is lower than the maximum potential power of the respective engine type, for example because different ratings are available or the engine has been de-rated, measures need to be taken to prevent the engine from being operated to its full potential in order to ensure compliance with the Control Regulation.

Figure 6 shows a typical performance curve of a marine engine. The propeller curve in grey shows the power demand of a propeller in a FPP configuration, whilst the power curve shows the maximum power that can be delivered at any given engine speed. This engine theoretically is the perfect match for a vessel fishing vessel having a license for 300 kW, which operates at a crank shaft speed of 2200 rpm. In case the fishing license allows less than 300 kW, the engine needs to be de-rated.

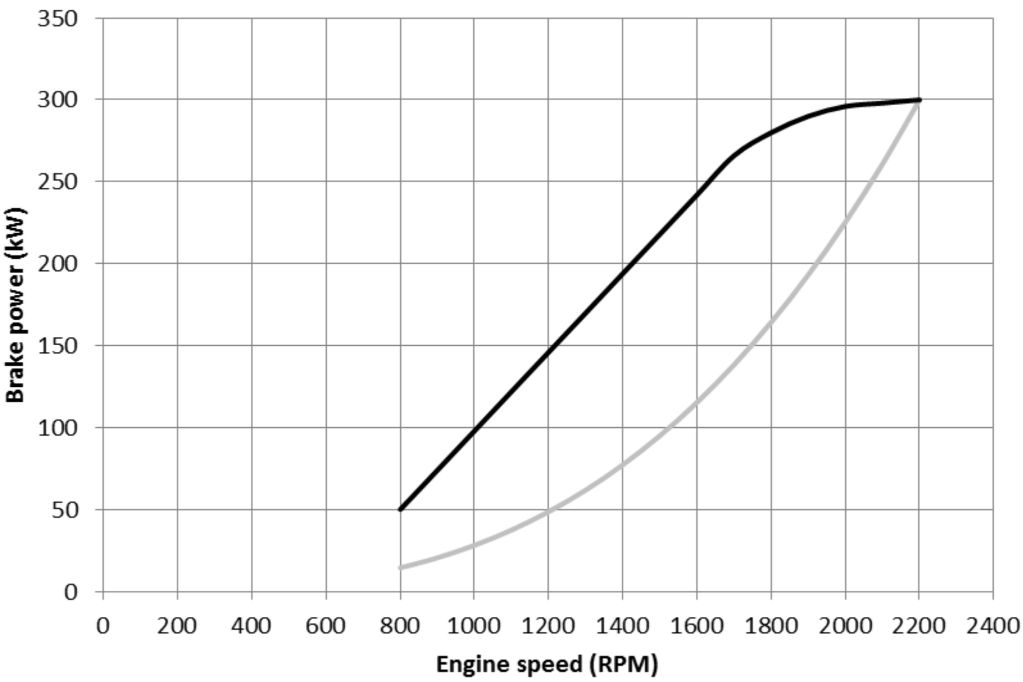

Figure 6. Performance curve of a marine engine.

[21] Actual load expressed as percentage of nominal load (kW)

1.3.4. De-rating the engine

The engines currently on the market can broadly be divided into mechanically controlled diesel engines and electronically controlled engines. Both options come in a huge variety of arrangements and 'hybrid' systems of mechanical and electronic control aspects do also exist.

1.3.5. Mechanically controlled engines

This section describes a typical mechanically controlled engine equipped with a governor. It should be noted that not every existing system can be described in detail in this report. The governor shown in figure 7 receives a signal (physical, electronic, hydraulic or pneumatic) that corresponds with a desired engine speed. The minimum and maximum speed setting can be adjusted mechanically. The actual change of speed is in this example achieved by mechanically changing the position of the fuel pump plungers, which results in the injection of more or less fuel per engine cycle.

The easiest way to limit engine power of a mechanically controlled engine is to adjust the maximum engine speed (rpm) by adjusting the high-idle setting.

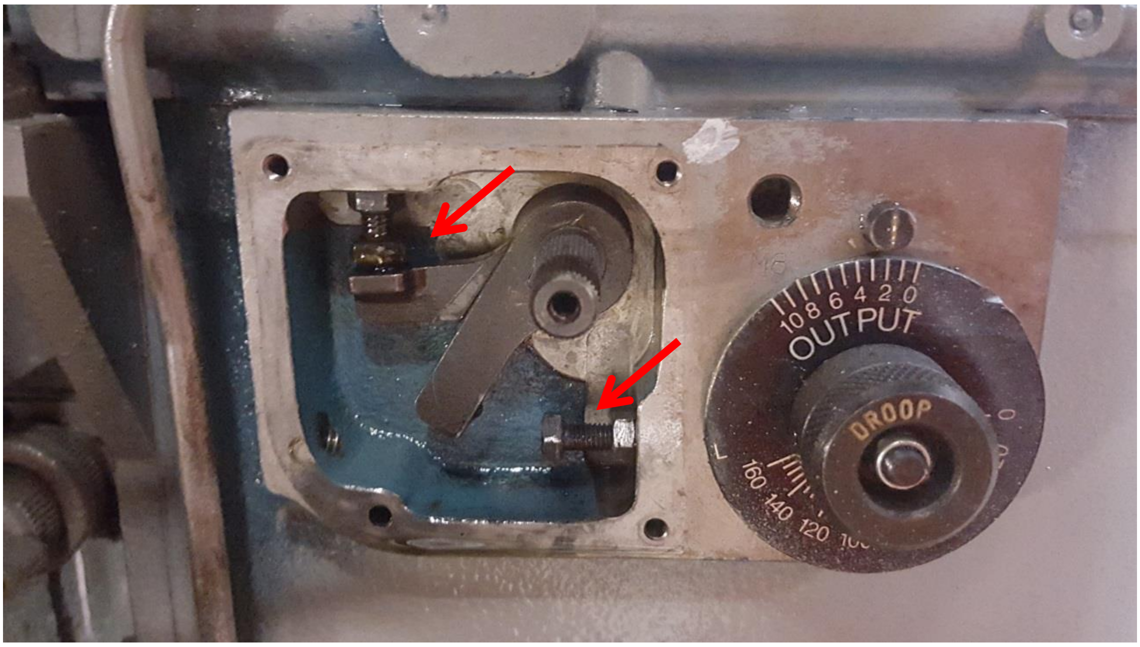

Figure 7. Typical setting of mechanical governor (Regulateurs Europa 1104 governor on Deutz TBD 645 L6F engine) Low and high idle set bolts indicated by arrows.

As long as the load profile of the vessel (fishing gear, propeller, hull shape) is constant, this method is effective; the maximum engine power is lowered along the propeller curve. Limiting the engine from figure 6 to 1800 rpm for example would result in a maximum brake power of approximately 170 kW (indicated as point A and B in figure 8). If however at 1800 rpm the load is increased, for example through application of heavier fishing gear, the engine will inject more fuel per cycle, resulting in greater torque and eventually greater engine power, up to the engine limit of 285 kW at 1800 rpm (indicated as point C in figure 8). The only way to prevent this is to also limit the fuel rack to the value corresponding with, in this example, 170 kW at 1800 rpm.

Not all engines are equipped with plug-and-play systems to limit the maximum fuel rack. It requires significant understanding of the engine to determine a safe yet effective method of fuel rack limitation. Figure 9 shows an example of fuel rack limitation on a relatively simple engine (Mitsubishi S6A300-3). The fuel rack moves in the direction of the yellow arrow to increase the injected quantity of fuel per cycle. The ring indicated with the red arrow limits the maximum fuel rack.

The examples in this section demonstrate that every type of engine, fuel pump, governor, etc. needs its unique approach when mechanical power limitations are considered, and knowledge of the engine is required to judge whether the engine is in compliance with applicable engine power restrictions or not.

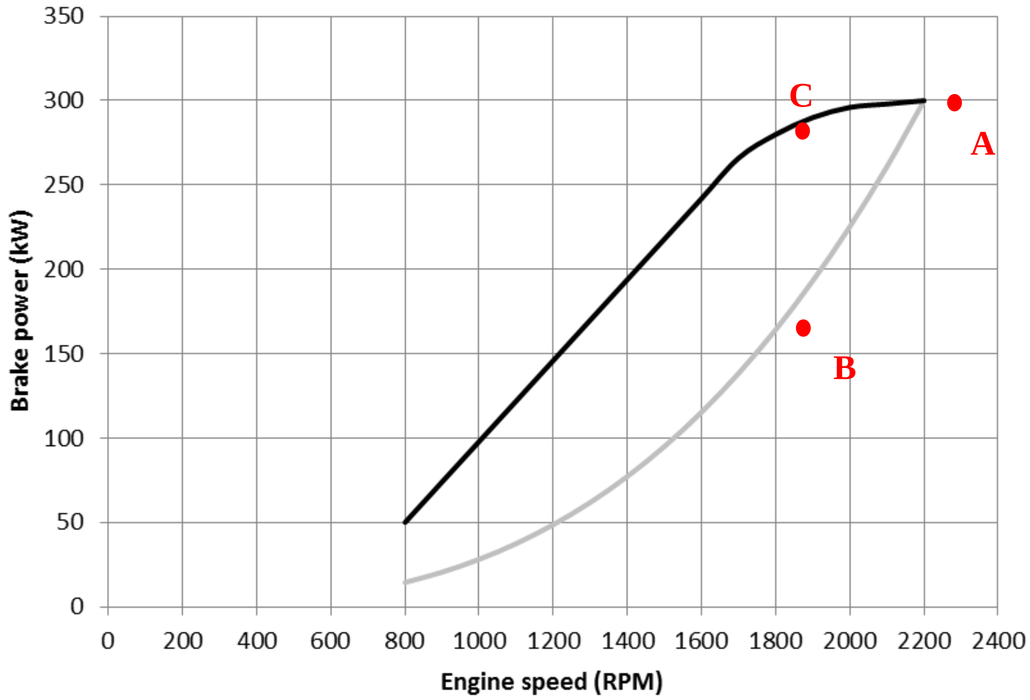

Figure 8. Performance curve of a marine engine.

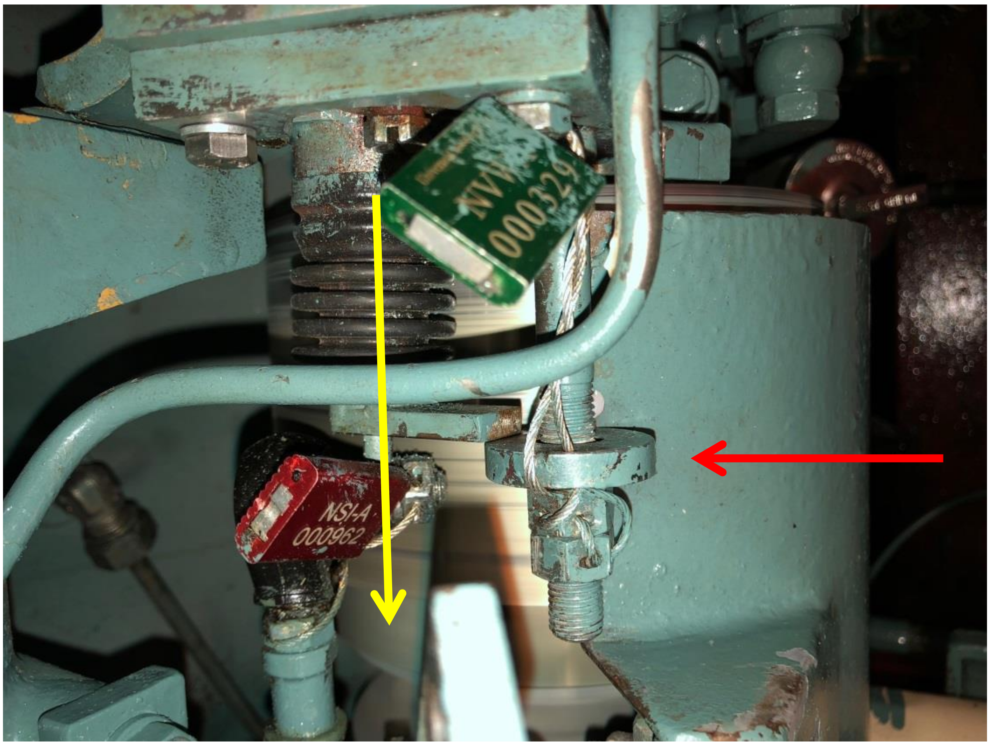

Figure 9. Example limit of fuel rack.

1.3.6. Electronic engine control

In general, electronically controlled engines use an industrial computer to decide on the fuel quantity and timing that electronically controlled fuel injectors should inject to generate the desired engine speed. The desired engine speed is provided to the computer via an electronic throttle signal, and the actual (current) engine speed is provided to the computer as feedback signal. The engine will receive the required fuel quantity to maintain or achieve its desired speed, as long as the engine stays within the boundaries of it performance curve.

Most electronically controlled engines do not have a set screw or other mechanical appliance to limit engine speed or fuel rack. The two options to limit engine power of electronically controlled engines are:

- Limiting the electronic signal fed to the engine computer;
- Changing the engine software to a different performance map.

The first option is effective, unless the throttle signal is successfully manipulated. Also increase load makes the power output exceed the licensed power in this case, since only the maximum engine speed is limited. The load can be increased by increasing the size of the fishing gear, for example.

The second option is more effective, since both speed and torque can be limited in the software. This requires involving the engine maker, since it usually not possible for users to change this kind of setting. Occasionally, the engine maker may need to provide the engine with a new rating and corresponding software (which for modern engines implies the requirement of re-testing the engine according to MARPOL Annex VI / EIAPP requirements). To ensure certified power is not exceeded, authorities should take measures to prevent unauthorized individuals from changing (remapping) the software again.

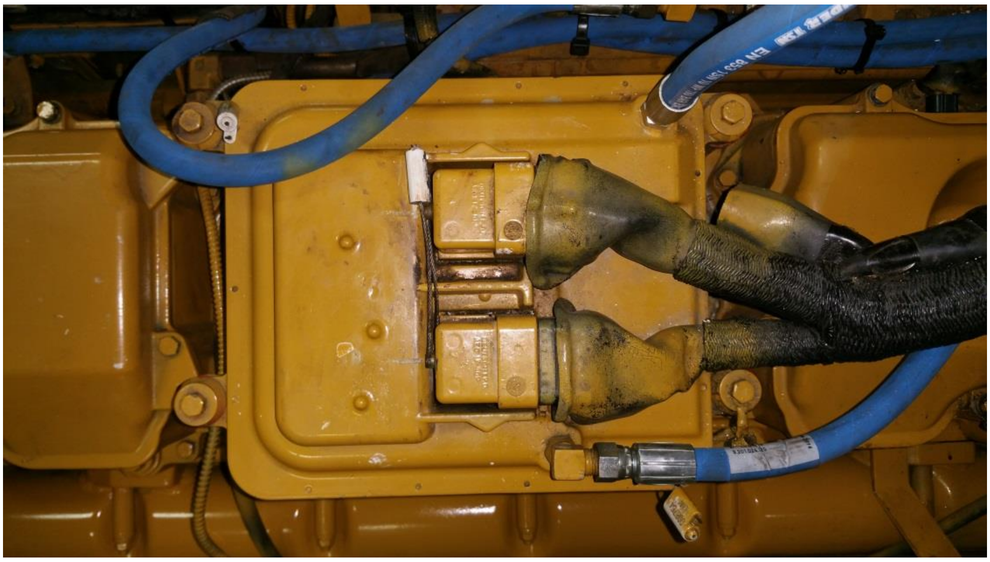

Figure 10. Caterpillar 3412E Electronic Control Module (ECM).

2. Methodology

The three pillars of this study are the evaluation of certification and verification systems of engine power implemented by Member States, physical verifications of engine power conducted by the project team and assessment of on-going complaints received by the Commission concerning alleged discrepancies between registered engine power and the real engine power of certain vessels. The following sources of information were used to perform the various tasks:

- Existing literature;
- Documentation provided by the Commission;
- Documentation provided by (the competent authorities of) Member States subject to this study (on request);
- Discussions during visits of the contractor to (the competent authorities of) Member States;
- Physical verifications of engine power onboard a sample of fishing vessels.

2.1. Sampling plan analysis

As discussed in the introduction, the verification of engine power of fishing vessels is a three-stage process. Member States are required to randomly select a sample of vessels following a risk assessment based on the risk factors listed in Art. 62 of the Control Implementing Regulation and additional factors introduced by the Member State competent authority. For each selected vessel, the Member State is required to carry out a data verification to identify vessels that potentially have registered less engine power than their real engine capacity. Vessels identified as potentially non-compliant must be controlled by means of a physical engine power verification.

Each Member State subject to this study was requested to submit its sampling plan, which should have been established and implemented in accordance with Art. 41 of the Control Regulation. The contractor visited each Member State at least once to discuss the properties of the respective sampling plan and the results of its implementation. To determine the effectiveness and degree of implementation of the sampling and verification schemes in Member States, the following was determined:

- Whether the sampling plan (design) incorporates all mandatory inclusion criteria according to Art. 62(1)(a) to (c) of the Commission Implementing Regulation;

- Whether the sampling plan (design) incorporates additional inclusion criteria according to Art. 62(2) of the Commission Implementing Regulation;

- Whether the sampling size was (designed to) determine the sample and sample size correctly based on the criteria above and the calculation in Art. 62(4) of the Commission Implementing Regulation;

- Whether verification procedure is (designed to) let the selected sample undergo a data verification incorporating all aspects listed in Art. 41 (1) (a) to (f) of the Control Regulation

- Whether the data verification is (designed to) incorporate additional factors in accordance with Art. 41 (1) (g) of the Control Regulation;

- Whether the data verifications have actually been conducted;
- The frequency of the sampling procedure and subsequent desk analysis;
- The number of data verifications carried out;
- The number of vessels identified as being potentially non-compliant relative to the number of data verifications conducted;
- The number of actual infringements identified relative to the number of data verifications conducted.

A high non-compliance rate found by Member States can be interpreted as evidence of a weak certification system. To enable analysis of the relation between certification system characteristics, verification system characteristics and observed (non-) compliance rates, the certification system in place was also discussed during the meetings with Member States' competent authorities.

2.2. Vessel inspections

A number of vessels was targeted for a physical engine power verification. These verifications were carried out under the authority of the respective Member State[22]. Given the complicating contractual requirements concerning these verifications such as the unannounced basis, the selection to be conducted by the contractor based on a risk assessment and the absence of legal authority of the contractor, close co-operation between the contractor and the Member States' competent authorities was essential. These practical aspects were also discussed during the various meetings between the contractor and the competent Member State authority prior to the physical engine power verifications.

2.2.1. Distribution of vessels to be inspected

The tender specifications set minimum requirements regarding the number of vessels to be selected, coverage of fishery typologies and geographical areas. The assignment of power verifications to the 15 Member States[23] subject to the study was done on the basis of equal treatment, by applying (1) a minimum number of verifications per Member State and (2) taking the fleet size in the respective fishery into account.

The minimum sample size per Member State per fishery type is calculated as follows:

Minimum sample size per MS (n_{min}) = $\frac{1}{2} \times \frac{Total\ sample\ size\ (nr.\ of\ vessels\ /\ fishery\ type)}{nr.\ of\ member\ states\ /\ fishery\ type}$

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[22] The German authorities disputed their legal powers to conduct the intended inspections. A fisheries inspector of the Commission attended the inspections in Germany to provide the required legal basis.

[23] Member States codes used in this document: BE–Belgium, DE–Germany, DK–Denmark, EL–Greece, ES–Spain, FI–Finland, FR–France, IE–Ireland, IT–Italy, LV–Latvia, NL–The Netherlands, PL–Poland, PT–Portugal, SE–Sweden, UK–United Kingdom.

The sample size per Member State was weighed to the size of its fleet that meets the descriptive criteria of the respective segment as per 01 February 2018 according to the Community Fishing Fleet Register [24]. These criteria are based on the descriptions listed in the tender specifications, provided by the Commission. The following criteria were applied:

<u>North sea, Shrimp and Plaice, beam trawlers</u>

Member state:	BE, DE, DK, FR, NL and UK.
Main gear:	TBB – Beam trawls
Length:	22 M < length < 24 M
Power:	=< 221 kW

<u>Baltic sea, pelagic trawlers</u>

Member states:	FI, LV, PL and SE.
Main gear:	OTM – Midwater otter trawls
Length:	> 18 M

<u>Atlantic, pelagic trawlers</u>

Member states:	FR, NL, UK and IE.
Length:	C10, C11, C12 (> 45 m)
Fishing type (main gear):	Towed gears (excluded: TBB)

<u>Deep sea long liners</u>

Member state:	PT
Gear includes:	LLS – Set longlines LLD – Drifting longlines
Fishing area:	Azores or Madeira (past 12 months, list provided by PT authorities)
Power:	=> 120 kW

<u>Mediterranean and Black seas, Bottom trawlers (ES, FR)</u>

Member states:	ES, FR.
Main gear:	OTB
Area:	Gulf of Lion (list provided by ES and FR authorities)
Power:	120 kW < power < 316 KW

<u>Mediterranean and Black seas, Bottom trawlers (IT, GR)</u>

Member states:	IT, GR.
Power:	120 kW < power < 316 KW

In case the method described above resulted in a sample size smaller than the minimum sample size was calculated using the formula above for a given Member State, the sample size of that Member State was set to the calculated minimum. The sample size was subsequently recalculated for the remaining Member States, after accounting for the assignment of minimum sample sizes by deduction

[24] http://ec.europa.eu/fisheries/fleet/index.cfm

of the fleet(s) from the *total fleet size* and deduction of the assigned sample(s) from the *total sample size*, of the Member State(s) that were assigned the minimum sample size.

2.2.2. Selection of fishing vessels to be inspected

The vessels' power to tonnage ratio was considered the most practical criterion to assess risk of engine power being in excess of the certified engine power, since a low kW/GT score indicates that a relatively large share of the installed power is used to propel the ship, and little power is left for fishing activities. A relatively low amount of power being available for fishing activities may be expected to be an incentive for operators to increase the vessel's engine power to a non-compliant level. The data required for this analysis are publicly available in the Community Fishing Fleet Register.

The vessels with the lowest kW/GT scores, that were actually landing during the agreed inspection time frame, were selected for inspection. For practical reasons, i.e. to avoid excessive concentration of inspections in a single location, inspections were divided between up to three ports per Member State, depending on the sample size assigned to the respective Member State.

The Commission and the project team agreed[25] the following changes to the vessels selection resulting from the procedure described, to allow for better assessment of complaints, as will be discussed in section 2.4:

(1) The initial allocation of 11 verifications to vessels in the Spanish fleet operating in the Mediterranean (Gulf of Lion) fleet was reduced to seven. The remaining four verifications were reallocated to the Spanish Cantabrian fleet to facilitate assessment of the complaint with reference 8091/15/MARE.

(2) The initial allocation of 11 verifications of vessels to the Italian fleet operating in the Mediterranean (Strait of Sicily) fleet was reduced to six. The remaining five verifications were reallocated to the Italian Adriatic fleet (operating from the port of Chioggia) to follow up on information received by the Commission regarding possible non-compliance with engine power restrictions concerning the local fleet of mid-water otter trawlers that also engage in pair trawling activities.

The final distribution of verifications among Member States is summarized in table 1.

[25] Spanish Cantabrian vessels: written confirmation (e-mail) April 11, 2018.
Italian vessels in Chioggia: written confirmation (e-mail) May 18, 2018.

Table 1. Number of power verifications per Member State.

	North sea, Shrimp and Plaice, beam trawlers	Baltic sea, pelagic trawlers	Atlantic, pelagic trawlers	Deep sea long liners	Mediterranean and Black seas, Bottom trawlers	Assessment of complaints	Total
BE	2						2
DE	3						3
DK	2						2
FR			2		4		6
NL	11		1				12
UK	2		4				6
FI		2					2
LV		3					3
PL		2					2
SE		3					3
IE			3				3
PT				10			10
ES					7	4	11
IT					6	5	11
GR					4		4
Total	20	10	10	10	30		**80**

2.2.3. Vessel inspection procedure

The inspections and physical verifications of selected vessels consisted of a document check, followed by a visual inspection of the propulsion machinery installation and a physical power verification.

Document inspection

The presence and consistency of the following documents was verified (only for those documents issued to the vessel and available for inspection onboard):

- Class certificates (assess power and max. speed);
- Sea trials certificates (look for power and max. speed);
- Bollard pulls test (look for power);
- MARPOL Reg. 13 nitrogen oxides (NOx) emissions certificates (look for power rating);
- Engine maker catalogues (check ratings against license output);
- Vessel monitoring systems (VMS);
- Fishing licenses;
- Safety certificates;
- Engine certificates, where applicable.

Visual inspection of vessel and propulsion system

The vessel, its fishing gear, its propulsion system and its relevant adjacent equipment, were inspected during the vessel inspections. The objective is to document:

- Vessel particulars;
- Engine and gearbox data;
- Sealing;
- IT tools related to engine power;
- Whether auxiliary engines are capable of contributing to propulsion power.

Physical power verification

A physical power verification was the main part of each vessel inspection. During this verification a full bridge strain gauge system and an optic shaft speed pick-up were applied to the propeller shaft, which measured the vessel's propulsion power during a sea trial. There are situations which make this type of verification technically impossible (e.g. insufficient accessible length of propeller shaft). This was the case onboard two of the vessels to be inspected within this study.

During the sea trial, the following situations were evaluated:

- Steaming: free sailing conditions in water of sufficient depth. Ideally a depth of at least three times the vessel's draught below the vessel should be maintained at all times. The vessel course should be as steady as possible, since steering affects the vessel's demand for power. Each measuring run should be of a duration that allows the power output to stabilize, and to allow for elimination of minor distortions and deviation through averaging. Under normal circumstances, a measuring run of 5 to 10 minutes at a data acquisition rate of one sample per second is sufficient. If the steaming verification took place in waters where there is current, the verification was performed twice, in opposite directions, to mitigate the potential tidal effect on vessel speed and demand for power.

- Fishing: The heaviest load situation a fishing vessel's propulsion engine will encounter under normal operational circumstances was simulated. For example for a beam trawler, this is towing the fishing gear just below the water surface. For otter trawlers, a fishing test was done. Otter trawlers were required to deploy the fishing gear to a normal operation position and run the engine at full throttle. If the fishing verification took place in waters where there is current, the verification was performed twice in opposite directions to mitigate the potential tidal effect.

  Otter trawler operators were given the choice to do a bollard pull test instead of a fishing test, to limit the verification's impact on the vessel's operation. This test is generally associated with higher risks of damage and injury than normal fishing. The decision whether it is safe of not to conduct such a test was under all circumstances made by the master, and subject to approval of the port authorities and Member State fishery inspectors responsible for the verification.

- The vessel group 'long liners fishing in the waters of the Azores and Madeira' do not operate their propulsion system when the gear is deployed (static gear). The sole benefit of high engine power for these vessels is the associated steaming speed, which allows for faster tracking of fish and quicker transiting between ports and fishing grounds. This justifies the verification of these vessels under steaming conditions only.

The aim of the physical power verification is to determine whether or not the engine is capable of delivering engine power that exceeds the licensed output without the need to tamper with sealing arrangements or to apply major conversions to the engine. This involves searching for hidden systems to de-rate the engine to cover-up any excess power output, within the legal and contractual constraints of the study. All findings and observations resulting from the documents inspection, visual machinery inspection an physical power verification are documented and evaluated. The relevant findings of every test conducted are documented in the individual vessel reports in Appendix I.

Measurement system and assumptions

The use of strain gauges to measure torque and convert this in conjunction with revolutionary shaft speed data into power is a generally accepted method of determining engine power. It is indirectly prescribed by Art. 63(1) of the Commission Implementing Regulation (measuring at the most accessible point between the gearbox and the propeller). It is also standing practice in several Member States to verify engine power by means of this method, and it is a recognized method to obtain shaft power according to ISO 15016:2015 (Ships and marine technology - Guidelines for the assessment of speed and power performance by analysis of speed trial data).

The system used to acquire power data is the Datum Compact Shaft Power Kit[26], especially designed for the purpose of verifying engine power in marine applications. The following specifications, assumptions and settings were used for the verifications:

Strain gauge type:	MM N2A-06-S1953-1KB/E2
Strain gauge accuracy:	± 2,5%
Sampling rate:	1 / second
Shaft speed resolution:	1 RPM
Micro strain resolution:	0,001 mV/V (minimum, verified on site by means of a Datum-Electronics Strain Gauge Simulator, certified / calibrated adhering to industry standard BS7882)
Shaft diameter (ext.):	± 0,5 mm
Shaft diameter (int.):	Only applies to hollow shafts, as per approved drawing of shaft. If unknown: assumed ± 0,5 mm.
Shear modulus:	As certified. If unknown: assumed 82100 N/mm2 for common shaft steel types. (Conversion of reported power results to ISO 15016:2015 standard: + 0,37%) For stainless steel, the assumed shear modulus is assumed 77459 N/mm2.

[26] The verifications referred to in the results sections as DK-01, LV-01, LV-02, LV-03, NL-07 and SE-01 were conducted by a sub-contractor using a system using a comparable layout of the manufacturer Binsfield USA.

2.3. Analysis of complaints

The project team were required to make an assessment of on-going complaints. This task initially referred to two specific complaints:

(1) (Reference 8087/15/MARE) The complainant argued that there are Irish vessels operating at much higher engine power than registered, and makes specific allegations against an Irish Atlantic Pelagic Trawler.

(2) (Reference 8091/15/MARE) The complainant argued that Spanish trawlers operating from Cantabrian ports have a much higher engine power in reality than their registered power and thus they exercise fishing capacities far greater than their entitlement.

The vessel subject to complaint (1) was identified by the contractor as vessel that fits into one of the fleet segments from which vessels would be undergoing physical engine power verifications within this study, and the vessels subject to the complaint ranked in the top-three within this fleet segment in terms of power to tonnage ratio. The vessel was therefore included in the sample of vessel to be physically verified irrespective of the objective to analyse the complaint.

In 2017 another complaint has been lodged concerning the engine power of Spanish bottom trawlers operating at the Cantabrian coast. This complaint was taken into consideration when analyzing complaint 8091/15/MARE. The main source of information available to the contractor regarding these two complaints regarding the Spanish Cantabrian fleet is the set of documentation and correspondence provided by the Commission and the Spanish authorities. Four physical power verifications were allocated to this fleet segment in order to further assess these complaints.

The Commission also received information regarding possible non-compliance concerning engine power deployed by pair trawlers operating from the Italian port of Chioggia. There was no additional information available to the project team that could be used to assess this complaint. Nevertheless, five physical power verifications were allocated to this fleet segment in order to assess this complaint. The analysis of all complaints will be presented in section 6.

3. Engine power as a measure of fishing effort

It was an objective of this study to determine whether the control of engine power is a good indicator for the control of fishing effort. Unless it would be found that engine power cannot be controlled effectively (which would mean it cannot be an adequate indictor for any purpose), this conclusion cannot be drawn from the on board inspection results. To meet the objective of this study to determine whether the control of engine power is a good indicator of fishing effort, existing literature has been reviewed and Member State inspectors and policy makers were invited during the meetings to share their opinion and to provide alternative control options that could replace engine power as a measure of fishing effort.

Fishing *effort* in the context of EU fisheries management is defined as the fleet capacity of a fleet multiplied by the amount of time spent at sea by that fleet. Fishing effort restrictions apply to specific fleet segments or areas, to protect vulnerable areas or species. Fishing effort restrictions are set independently from the Total Allowable Catches (TACs) which apply to certain fleets and species[27]. TACs establish the maximum quantity per fish stock that may be caught during a certain period, and hence are a measure of opportunity or output, while effort is a measure of input.

A variety of definitions of fishing *capacity* is used by different organizations and scientists, but in the context of EU fisheries management it is expressed as gross tonnage (GT) and engine power (kW) of a fishing vessel or fleet of vessels. A maximum amount of accumulated tonnage and power, known as capacity ceiling, is allocated to the fleet of each Member State. The mandatory entry-exit regime of fishing vessels is based on this definition, and is designed to prevent Member States´ fleets from growing over time[28].

A hybrid system of TACs and kilowatt day effort restrictions is applied to manage demersal fisheries in a plaice nursery area of the North Sea[29] and in the 12 mile zone around the United Kingdom and Ireland[30]. Kilowatt day effort restrictions also apply to demersal fisheries in the Mediterranean Western waters. The Commission adopted a proposal for a (new) multiannual management plan, including a kilowatt day effort regime, for the Mediterranean Western waters[31] on March18, 2018. The general effect of multiannual management plans for this area, the foreseen effect of this newly adopted plan and the effectiveness of effort restrictions have been studied by STECF[32]. It was found

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[27] https://ec.europa.eu/fisheries/cfp/fishing_rules/fishing_effort_en

[28] https://ec.europa.eu/fisheries/cfp/fishing_rules/fishing_fleet_en

[29] Council Regulation (EC) No 850/98 of 30 March 1998, for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms. Art. 29. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31998R0850&rid=1

[30] Council Regulation (EC) No 850/98 of 30 March 1998, for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms. Art. 34. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31998R0850&rid=1

[31] Procedure 2018/0050/COD Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing a multi-annual plan for the fisheries exploiting demersal stocks in the western Mediterranean Sea. https://eur-lex.europa.eu/procedure/EN/2018_50

[32] Scientific, Technical and Economic Committee for Fisheries (STECF) (2018), Fishing effort regime for demersal

that a combined TACs and effort regime in the North Sea has been effective in achieving its desired objectives, and positive side effects of this system such as increased selectivity were identified[33].

The STECF study also indicates that the effectiveness of any fisheries management plan is highly dependent on the accuracy of the underlying data set. In the context of management of Mediterranean trawlers, the definition of a fishing day, the weakness of logbook data and potential opportunities provided by VMS (and AIS) data are reported by STECF as factors of influence on the controllability of fishing effort[34]. The accuracy of registered engine power is not discussed in that report as potential threat to effective enforcement of fishing effort restrictions.

3.1. Advantages of engine power as measure of fishing effort

Both tonnage and power are measures that can be determined through well-established and documented procedures, independently from the fishing typology of the vessel, which makes them suitable measures of fleet size that enable comparison between different fishing fleets. Furthermore, the link between engine power and the ability to catch fish (fishing power) is obvious: engine power directly translates into thrust, which results in higher maximum steaming speeds and enables higher fishing speeds or the use of heavier gear. Higher steaming speeds enable vessels to transit quicker between fishing grounds and ports, while higher fishing speeds and deploying larger fishing gear enable the vessel to fish a larger volume of water, or a larger surface of sea bed. Marchal et al. (2002)[35] found engine power to be a good proxy for fishing effort, in particular of energy-intensive fisheries such as beam trawls and otter trawls. Eigaard et al. (2011)[36] analyzed several types of trawls and confirmed that engine power and harvesting potential are indeed related. In addition they note that this relation is likely to be non-linear, and inclusion of additional, fishing typology-specific factors in the definition of fishing effort would benefit the effort regime's effectiveness.

Some fishermen and inspectors advocated informally during the meetings held with the contractor that the link between engine power and fishing effort is very weak or even absent, but no clear argument was given *why* this would be the case. This contradicts the consensus among scientist that such a relation exists.

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fisheries in the western Mediterranean Sea (STECF-18-09), https://stecf.jrc.ec.europa.eu/documents/43805/2048604/STECF+18-09+-+Fish+effort+regime+dem+fish+West+MED.pdf

[33] Scientific, Technical and Economic Committee for Fisheries (STECF) (2018), Fishing effort regime for demersal fisheries in the western Mediterranean Sea (STECF-18-09), p.36, https://stecf.jrc.ec.europa.eu/documents/43805/2048604/STECF+18-09+-+Fish+effort+regime+dem+fish+West+MED.pdf

[34] Scientific, Technical and Economic Committee for Fisheries (STECF) (2018), Fishing effort regime for demersal fisheries in the western Mediterranean Sea (STECF-18-09), p. 39 and 40, https://stecf.jrc.ec.europa.eu/documents/43805/2048604/STECF+18-09+-+Fish+effort+regime+dem+fish+West+MED.pdf

[35] Marchal, P. (2002) 'A comparison of three indices of fishing power on some demersal fisheries of the North Sea', ICES Journal of Marine Science, 59(3), pp. 604–623.

[36] Eigaard, O.R., Rihan, D., Graham, N., Sala, A., Zachariassen, K. (2011), 'Improving fishing effort descriptors: Modelling engine power and gear-size relations of five European trawl fleets', Fisheries Research 110, pp. 39–46. https://doi.org/10.1016/j.fishres.2011.03.010

3.2. Disadvantages of engine power as a measure of fishing effort

Identical vessels with identical engines can have very different impacts on fish stocks and other aspects of the ecosystem in which they operate, mainly dependent on the type of gear used and the actual availability of the resource in the area[37]. In additional to purely technical and random effects, part of the differences may be explained by qualities and skills of individual fishermen. This relation is sometimes referred to as the 'skipper effect'. This type of factor is hard to quantify and hence cannot be incorporated in the regulatory definitions of (nominal) fishing effort such as kilowatt days.

The application of engine power as measure of effort is likely to function as a natural driver of innovation. If tonnage restrictions prevent fishermen to add new capacity to the fleet, and power restrictions prevent the addition of power to increase fishing capacity, the only remaining technical option to increase effective fishing effort is to seek technological improvements that lead to greater catches while deploying the same tonnage and power. Increased technical efficiency results in lower energy intensity of fisheries, and associated cost reductions for fishermen. The effect of increased catchability or 'fishing power' at constant nominal fishing effort is referred to as technological creep[38]. Technical creep has been studied and was found to be non-linear phenomenon explaining an average catchability increase of 3% to 6% per year for different types of fisheries[39]. The engine power data used in those studies came from interviews with fishermen and official databases.

The widespread misreporting of engine power found within this study indicates a potentially large discrepancy between registered and actual engine power of fishing fleets, which translates to poor reliability of calculated nominal fishing effort and of the estimated relation between nominal fishing effort and fish mortality. The fact that engines are occasionally replaced and vessels enter and exit fleets, implies that the average degree of misreporting is also not necessarily constant over time.

Several studies use a stochastic production frontier to estimate the individual effect of variables other than engine power on technical fishing efficiency (e.g. Pascoe, Andersen and de Wilde, 2001[40] and Andersen, 2014[41]). If the engine power of a group of vessels is presumed to be within certain limits, based on official databases, misreporting of engine power may affect the reliability of results found by

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[37] Scientific, Technical and Economic Committee for Fisheries (STECF) (2018), Fishing effort regime for demersal fisheries in the western Mediterranean Sea (STECF-18-09), p.42, https://stecf.jrc.ec.europa.eu/documents/43805/2048604/STECF+18-09+-+Fish+effort+regime+dem+fish+West+MED.pdf

[38] Marchal, P., Andersen, B., Caillart, B., Eigaard, O., Guyader, O., Hovgaard, H., Iriondo, A., Le Fur, F., Sacchi, J., and Santurtún, M. 2006. Impact of technological creep on fishing effort and fishing mortality, for a selection of European fleets. ICES J. Mar. Sci. 64: 192-209.

[39] Eigaard, O.R., Marchal, P., Gislason, H., Rijnsdorp, A.D., 2014. Technological Development and Fisheries Management. Reviews In Fisheries Science & Aquaculture. 22(2): 156-174.

[40] Pascoe, S., Andersen, J.L. and de Wilde, J. (2001) 'The impact of management regulation on the technical efficiency of vessels in the Dutch beam trawl fishery.', European Review of Agricultural Economics, 28(2), pp. 187-206.

[41] Andersen, J.L. (2014) 'Reasons for Technical Inefficiency of Danish Baltic Sea Trawlers', Danish Research Institute of Food Economics, Division for Fisheries Economics and Management. https://www.researchgate.net/publication/228548606_Reasons_for_technical_inefficiency_of_Danish_Baltic_Sea_trawlers

these stochastic production frontier analyses. It cannot be ruled out that misreporting of engine power has contributed to inflation of technological creep estimations.

In addition to the disadvantage that nominal fishing effort restrictions may need to be indexed regularly to offset factors affecting effective fishing effort other than engine power, such as technological creep, the fact that adequate control of engine power requires significant technical understanding of engines and propulsion systems from inspectors and policy makers is a disadvantage of engine power as measure of fishing effort. The meetings between the contractor and Member State authorities' representatives made it clear that most fisheries inspectors do not have the required technical expertise to effectively assess compliance with engine power restrictions, and given the required amount of training and experience to adequately do so it is unrealistic to assume that this will change. This undermines the effectiveness of engine power restriction as reliable fishing effort control method.

The significant number of infringements identified across the sample and the apparent lack of measures taken by competent authorities to prevent operators from deploying more engine power than licensed confirms that current control activities provide insufficient assurance that the maximum permissible engine power of fishing vessels is not exceeded and thus provides insufficient assurance that effort is adequately controlled.

3.3. Alternatives for engine power

Because of the complexity of engine power control and the apparent lack of expertise among organizations responsible for enforcement of engine power restrictions, it is important to consider potential substitutes for engine power that could serve as measure of fleet size and fishing effort. Several studies[42] suggested additional determinants to tailor effort regimes to the fishing typology under consideration and hence improve the effectiveness of those regimes. Inclusion of additional variables (e.g. trawl gear configuration, number of hooks on long lines, etc.) could improve the effectiveness of effort regimes. However for most suggested measures, it is proposed to apply them in conjunction with tonnage and engine power as determinants of fishing effort, not to substitute engine power. In addition, these measures are not suitable as determinants of fleet capacity.

During various meetings held in Member State subject to this study, participants were urged to suggest alternatives for engine power in the fleet size definition and fishing effort management context. No technical alternatives were proposed, but a small number of inspectors and policy makers suggested to base effort control solely on VMS data and / or TACs, and to discontinue the use of engine power as effort and fleet size measure.
Although VMS data provide a valuable source to determine and verify the time (days) component in a kilowatt days effort regime, it is rather useless to determine the power (kilowatt) component without the availability of a reliable engine power figure (or equivalent substitute). In the absence of engine power data, other parameters must be known and controlled to complete the fishing effort calculation, in conjunction with fishing speed (which follows from VMS data). Such parameters could for example be the exact gear type and configuration in combination with pull force at the trawl lines. It is unlikely

[42] Damalas, D., Maravelias, C. D. and Kavadas, S. (2014) 'Advances in Fishing Power: A Study Spanning 50 Years', Reviews in Fisheries Science & Aquaculture, 22(1), pp. 112–121. doi: 10.1080/10641262.2013.839620.

Pauly, D. and Palomares, M. L. D. (2010) 'An empirical equation to predict annual increases in fishing efficiency.', Fisheries (Bethesda), (2010-07), pp. 2010-07. Available at: www.fisheries.ubc.ca/publications/working/index.php.

that it is feasible to gather this type of data reliably on every vessel, and if so that it results in any simplification. Analysis of vessel speed data can however contribute to identification of potential engine power infringements in an early stage, for vessels with known vessel speed-versus-propulsion power characteristics, as was confirmed during the physical power verifications within this study.

3.4. TACs or effort

It should be noted that a choice between the application of TACs *or* fishing effort (based on kilowatt days or defined otherwise), or a combination of both (hybrid system) is a widely studied fisheries management subject outside the scope of this study. In a very general sense, effort restrictions are associated with overcapitalization and efficiency decreases whereas TACs are associated with decapitalization and fishing efficiency increases. Despite the apparent advantage of TACs over effort control, there are circumstances that make effort the preferred management method[43]. Notable disadvantages of a TAC system include the costs associated with stocks assessment and control of catches. Also the finding of Eigaard et al. (2014) that 'the main weaknesses of output control are imprecise estimates of stock size owing to e.g. mis-specification of biological parameters, poor coverage of surveys, and to over-quota catches due to discarding or misreporting' is valid argument against managing fishing effort by TAC setting alone.

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[43] Scientific, Technical and Economic Committee for Fisheries (STECF) (2018), Fishing effort regime for demersal fisheries in the western Mediterranean Sea (STECF-18-09), p. 45, https://stecf.jrc.ec.europa.eu/documents/43805/2048604/STECF+18-09+-+Fish+effort+regime+dem+fish+West+MED.pdf

4. Results (I) effectiveness of power verification by Member States

The systems implemented by Member States to certify engine power of fishing vessels and to verify the accuracy of certified power values are discussed in this section. According to the Control Regulation and the Commission Implementing Regulation, Member States are required to:

1. The Member State **certifies** the maximum continuous engine power and shall ensure that the certified engine power is not exceeded (Control Regulation Art. 39 and 40). To comply with this requirement, engine power output shall be verified during the certification trajectory.

2. The Member State **verifies** that the maximum continuous power output is not exceeded during the service life of the engine. Art. 62 of the Commission Implementing Regulation provides criteria to identify vessels at risk of non-compliance with engine power legislation. From those vessels that meet at least one of the criteria, a random sample is to be selected for an in-depth, desk-based, analysis. Art. 41 of the Control Regulation provides the required minimum set of aspects to be taken into account. Any indication of non-compliance identified during this desk-based analysis is required to be further investigated by a physical power verification onboard the respective vessel.

4.1. Certification of engine power by Member States

Each vessel is registered in a national fleet register, and also listed in the Community Fishing Fleet Register. These registers contain typical vessel characteristics such as tonnage, fishing gear, length and also engine power. The power capacity registered in both registers should be consistent, and is referred to as *registered* power. This value is normally based on the *certified* power. The certified power is the maximum or maximum continuous power of the engine in the configuration as installed onboard, provided by one of the classification societies or by a governmental survey organization (e.g. the MSO[44] In Ireland, FOD Mobiliteit in Belgium or ILenT[45] in the Netherlands). This power can equal the engine's *nominal* output (the maximum power the engine type under consideration can deliver on a continuous basis) or a *de-rated* output. De-rating is the change of electronic or mechanical settings to reduce the maximum output to a value lower than the engine's nominal output.

A fishing license is issued to each fishing vessel. This license contains characteristics of the fishing vessel, including its *licensed* power. The licensed power should normally be equal to the registered and certified power of the vessel, and is among others used to determine the fleet size of Member States, and to permit selected vessels to fish in restricted areas that are subject to a fishing effort regime[46]. The fishing license is issued by the national governmental organization responsible for the enforcement of fisheries legislation. It was found that in the Member States subject to this study, the licensed power is in practice 'copied' from the engine certificate without further verification.

The Control Regulation requires Member States to certify the engine power of fishing vessels. Certification of marine propulsion engines, outside the fishing industry, is aimed at providing assurance that an engine can be operated at its nominal load and for short periods above its maximum load without operational problems or consequential engine damage being caused. This means that, for de-rated engines installed in fishing vessels, additional checks and precautions must be taken to certify

[44] Marine Survey Office
[45] Inspectie Leefomgeving en Transport
[46] E.g. the North Sea Plaice box (max. 221 kW per vessel) or the Gulf of Lion (max. 364 kW per vessel).

that an engine cannot be operated at power levels above the certified power, in order to let an ordinary class certificate fulfill the purpose of power certification under the Control Regulation.

Table 2 provides an overview of the certification processes in the Member States subject to the study. Data such as 'type of seal applied' is essentially based on Member State documentation and statements of Member States' representatives made during the meetings held between the contractor and Member States' representatives, and could only be verified for the vessels inspected during this study. A dedicated *Engine Power Certificate* is issued to fishing vessels in Germany by [redacted][47] (previously also by [redacted][48]). A dedicated Engine Power Certificate is also issued in Italy. Engine Power Certificates issued by [redacted][49] were found on board vessels inspected in Italy. In Portugal, some vessels had a dedicated Engine Power Certificate, issued by *INSPECÇÃO DE NAVIOS E SEGURANÇA MARÍTIMA*, while other vessels carried a more general declaration stating the vessel characteristics, including engine power, issued by the IPTM[50].

It is the understanding of all other Member States within the scope of this study that either the 'general' engine certificate or the vessel's certificate of class provided by a classification society or governmental survey organization meets the requirement of the Control Regulation to certify engine power, as this document states a power figure. Some Member States do have a system in place to verify the certified engine output during the certification process and a system to prevent tampering with engine settings to fulfil the requirements of certification as intended by the Control Regulation. As indicated in table 2, it is could not be determined for all Member States that do not require an on board engine power measurement during the verification process whether engines are subject to physical power measurement on a test facility where the *maximum* output is actually tested prior to installation on board, in attendance of a surveyor.

No other system than the sealing of engine settings was found to be implemented to control engine power in the Member States subject to this study. Each Member State can be categorized in one of the following groups (as indicated in table 2):

- Member States that require sealing for electronically controlled and mechanically controlled engines, de-rated and not de-rated;
- Member States that require sealing for mechanically controlled, de-rated engines(but not: engines certified at rated power and electronically controlled engines);
- Member States that do not require sealing for any engine configuration (mechanically or electronically controlled, de-rated or not).

The latter group of Member States operates a system where the authorities accept a de-rated output level as the actual output of the engine without the application of measures to secure compliant engine settings such as seals, based on an attestation of the engine manufacturer, or without any proof of de-rating. This is ineffective to ensure compliance with the requirements of the Control Regulation. During a meeting between the contractor, a Commission inspector and Spanish fisheries inspectors[51], a declaration issued by an engine supplier and signed by an inspector was presented, which states that

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47 [redacted].
48 [redacted]
49 [redacted]
50 Instituto Portuário e dos Transportes Marítimos
51 Meeting with representatives of the Spanish Fisheries Authorities, Madrid, Spain, 27-03-2018

the engine [subject of that certificate] was adjusted [at the fuel pump] to its compliant output and was subsequently sealed. However on the engines of most of the inspected Spanish trawlers, no sealing was found to be applied. It is therefore uncertain in which group Spain should be placed.

The usefulness of sealing of electronically controlled engines could be disputed, because a physical barrier cannot guarantee that engine settings cannot be changed. Application of seals to e.g. connectors can however make tampering with engine settings of electronically controlled engines more difficult. The application of seals to a not de-rated engine (more about de-rating in section 4.1.1.) is theoretically unnecessary. It should however be certain that engines cannot be 'up-rated' to justify not applying seals to engines that are not de-rated. Whether or not the certification systems of Member States in the category *Member States that require sealing for electronically controlled and mechanically controlled engines, de-rated and not de-rated* provide sufficient assurance of compliance with the Control Regulation depends on the *quality* of their implementation, notably:

- Whether physical power verifications are part of the process;
- The quality of the applied seals;
- The quality of the sealing process;
- The documentation of applied seals and other details to facilitate control;
- The implementation of an alternative system to control electronically controlled engines;

The certification practice in Member States in the group *Member States that require sealing for electronically controlled and mechanically controlled engines, de-rated and not de-rated* should theoretically lead to a high compliance rate. In practice also the effectiveness of these systems is, similar to the previous group, affected by the *quality* of their implementation:

- The quality of the applied seals;
- The quality of the sealing process;
- The documentation of applied seals and other details to facilitate control;

The findings presented in this section and in table 2 indicate that 'sealing' is relatively widely used among Member States, and that the effectiveness of seals for this purpose depends very much on the type of seal applied, the engine (component) that is sealed, the documentation of the applied seal(s) and the mechanism in place to ensure that the correct engine settings (corresponding to compliant power output) are sealed. Because of the important role of sealing in certification context, sections 4.1.2 and 4.1.3 are dedicated to the various sealing methodologies implemented by Member States and their relative effectiveness.

4.1.1. De-rated engine output

It was explained in section 1.3 that engines are sold at a rating, which specifies among others the power and torque the engine can develop within its advertised (revolutionary) speed range at specified ambient conditions. In case the vessel is restricted to operate with less power than the rated output of the engine, it is possible to change mechanical or electronic engine settings to reduce the maximum engine power to a value that corresponds to the vessel's license. This practice is referred to as de-rating.

As discussed in section 3, engine power restrictions of 221 kW apply to manage fishing effort of demersal fisheries in a plaice nursery area of the North Sea and in the 12 mile zone around the United Kingdom and Ireland. The respective regulation states the requirement for vessels allowed to operate in these areas that 'de-rated engines did not exceed 300 kW before derating'. It was found that the concerned Member States do not regard engines with the capacity to produce more than 300kW without major conversions as de-rated if they were not acquired by the vessel owner at a rating above 300 kW.

This practice is disputable, as the relevant regulations do not define in detail the concept of de-rating. It may however be assumed that the purpose of including this provision in the regulation is to prevent very powerful vessels from operating in this area, in order to limit the maximum impact on the environment in case the applied de-rating is reversed unauthorized. The current situation is that most vessels inspected in within this study (see section 5 for verification results) that hold a license to operate in this area can be 'up-rated' to a power output above 300 kW without major conversions, which does not seem to align with the spirit of the regulation to prevent potentially very powerful vessels from operating in these areas. Changing electronic or mechanical settings in this context is not considered a major conversion by the contractor.

Table 2. Overview of certification systems in Member States

	Power certification merged with other (class) certificate (Y / N / U)	Certification duty delegated to Classification Society (Y / N / U)	Organization responsible for certification of vessels inspected (physical verification) during this study.	Physical power measurement conducted during certification process (at time of installation o/b vessel) of engines of vessels inspected (physical verification) during this study (OB / TB / U / N).	Re-measured after (major) maintenance	Seals applied by (SU / EM / EX / U)	seal type found during verifications (ME / LA / LE)	Unique numbering of seals (Y / N)	Additional restrictions concerning engine power control
Member States that require sealing for electronically controlled and mechanically controlled engines, de-rated and not de-rated									
BE	Y	N	[redacted]	TB	N	SU	LE	N	
DE	N	Y	[redacted]	OB	Y	EX	LA	Y	
NL	Y	N	[redacted]	TB or OB	Y	SU, EX	ME, LA	Y	*Maximum de-rating: 25% (of MCR)*
Member States that require sealing for mechanically controlled, de-rated engines(but not: engines certified at rated power and electronically controlled engines)									
UK	Y	N	[redacted]	U/K		EM	LE	N	
PL	Y	Y	[redacted]	OB		SU	-	N	
IE	Y	Y	[redacted]	U/K		EM	LE	N	
IT	N	Y	[redacted]	U/K		U/K	LE	N	*Government permits limited number of engine types per 'power class' to avoid mismatch of power vs. license for new engines.*
Member States that do not require sealing for any engine configuration (mechanically or electronically controlled, de-rated or not)									
DK	Y	N	[redacted]	U/K		N/A	-	N/A	*Seals occasionally applied by engine maker / service company but not for de-rating purposes. (ES) Maximum de-rating 20%*
FI	Y	N	[redacted]	U/K		N/A	-	N/A	
FR	Y	Y	[redacted]	U/K		N/A	-	N/A	
LV	Y	Y	[redacted]	U/K		EM	LE	N	
SE	N/A	N	[redacted]	U/K		N/A	-	N/A	
ES	Y	N	[redacted]	TB		EM	LE	N	
PT	Y/N	N	[redacted]	U/K		U/K	LE	N	

Codes:

EM	ENGINE MANUFACTURER OF SERVICE SUPPLIER
EX	EXTERNAL ORGANIZATION / COMPANY
LA	LAMINATED SEAL
LE	LEAD DISK AND STEEL WIRE SEAL
ME	METAL SEAL
N	NO
N/A	NOT APPLICABLE
OB	ON BOARD SHAFT POWER MEASUREMENT
SU	SURVEYOR
TB	TEST BED MEASUREMENT
U/K	UNKNOWN
Y	YES

Classification Societies:

[redacted]

MS organizations:

DG Shipping (BE)	Federale Overheidsdienst Mobiliteit en Vervoer, DG Shipping
ILenT (NL)	Inspectie Leefomgeving en Transport
IPTM	Instituto Portuário e dos Transported Marítimos
MCA (UK)	Marine and Coastguard Agency
Trafi (FI)	Finnish Transport Safety Agency

4.1.2. Physical properties of seals

Several types of seals were encountered during the study, with very different physical properties. The effectiveness of three common seals will be discussed to derive best (sealing) practices. Sealing is a widely used method to prevent unauthorized tampering with the physical appearance or position of an object. Well known examples are the sealing of freight container doors to ensure they have not been opened during transportation, the sealing of aircraft trolleys, but also the sealing of valves onboard ships in the closed position to prevent unauthorized discharge of polluted substances. Sealing can also be used in the engine power control context to ensure that a cover has not been removed, a set screw is locked in a certain position or to prevent dismounting of an entire component.

The most commonly used type of seal to secure engine power settings is a metal wire connected by a pressed lead disk. An example of this type of seal is shown in figure 11. This type of seal is widely available at low cost, and a simple identification mark can be pressed into the lead disk. If applied properly to a de-rated engine, the lead disk or steel wire needs to be broken to change an engine setting, in order to increase engine power. The biggest disadvantage of this system is the wide availability of seal wire, disks and presses. This type of seal does not have a unique number and can simply be replicated, making professional tampering with settings hard to detect.

Figure 11. Lead seal applied, but poorly documented and with questionable authenticity.

Two types of alternative seals were encountered. First, a uniquely numbered, laminated seal with steel wire. This seal was used until approximately 2015 in the Netherlands and is still being applied in Germany. Figure 12 shows an example of this type of seal. The biggest advantage compared to the lead seal is that this seal cannot easily be replicated. This seal is however still susceptible to tampering: it is possible to drill the seal wire out of the seal and reapply it with glue. This is barely detectible, and the reason why this type of seal is no longer allowed to be applied in the Netherlands.

Figure 12. Seal typically found onboard German vessels and previously on Dutch vessels.

The third seal type is only in use in The Netherlands and cannot be manipulated in the same ways the other seals can. An example of this seal is shown in figure 13. This seal is uniquely numbered and very hard to tamper with unnoticed. The wire has a strong tendency to fray, which makes re-application more complicated. In fact this seal meets all requirements of ISO 17712[52] except the breaking strength (this is relevant for containerized transport, for which the norm is designed, but not for the purpose of sealing engine settings).

Figure 13. Seal typically found onboard Dutch vessels.

[52] ISO 17712:2010 (EN) International Standard establishes uniform procedures for the classification, acceptance, and withdrawal of mechanical freight container seals.

4.1.3. Sealing decisions

Equally important to the application and administration of efficient, reliable and redundant seals, is the decision which components should be sealed. It appears that this is not formalized in any Member State except the Netherlands. The Netherlands operate system in which a number of independent organizations are accredited to seal engine settings according to instructions issued by the authorities (and to document the applied seals in a sealing plan, which is then submitted to the vessel owner and the government for approval). The instructions are generally well designed and typically require the application of many seals (in exceptional cases as many as 30 seals per engine).

In all other Member States where engine sealing was found, seals are being applied to the satisfaction of the responsible individual on board (Classification surveyor, government official, engineer from engine maintenance company or third party). This has resulted in a generally non-harmonized practice of sealing across Member States, which is sometime not effective and poorly documented and hence impossible to verify during controls.

The individual vessel inspection reports in Appendix I show the following problems found onboard inspected vessels:

- Broken sealing;
- Manipulated sealing;
- Sealing applied in a way that does not sufficiently assure on-going compliance;
- Use of seal types susceptible to tampering;
- Poorly documented sealing.

It should be noted that, as can be concluded from the physical power verifications that will be presented in section 5, the correct application of a theoretically sufficient number of seal has not in all cases resulted in compliance with engine power restrictions. For every vessel that has been subject to a physical power verification at the time of (initial) sealing, the current non-compliant status of the vessel could have been identified by the authorities early and easy if the vessel (fishing and steaming) speed had been documented during the physical verification (at the vessel's licensed output) and had been verified against actual VMS or AIS data on a scheduled basis at a later moment.

The widespread non-compliance among well-sealed engines found during this study, indicate that engine performance manipulation systems must have been active during the physical verifications. The apparent widespread presence of these systems show that sealing as control measure can only be effective if, in addition to proper sealing instructions and the use of reliable seals, the following is ensured:

- Sufficiently knowledgeable inspectors and / or contractors;
- Sufficiently honorable inspectors and / or contractors;
- Immediate in-depth assessment of compliance following (vessel speed) indications of non-compliance.

Furthermore, it could be argued that it is always possible to break into the control system of an electronically controlled engine, independent of the sealing quality. It is thus of paramount importance to also verify the electronic characteristics of the engine control system, and the historical electronic engine performance data if available when the sealing of electronically controlled engines is inspected.

4.1.4. Sealing verification

Since sealing ensures the lasting physical appearance of an object, the seal becomes useless as soon as it is broken or tampered with. This means that it is necessary to regularly verify the presence and appearance of seals, and legally require operators to notify the authorities about broken seals (which may be legitimate, for example resulting from wear or removed to enable maintenance). The presence and appearance of seals can only be verified if the original sealing is properly documented, at least including a list of all locations and numbers of applied seals, and preferably containing a picture of every seal. This sealing description should be kept on board or otherwise be shared among Member States, to facilitate international verification.

It was found that the necessity to re-seal is regarded differently among Member States. PRS[53] stated that verifying the position of set bolts against (pictures of) the original setting is sufficiently convincing to conclude that the engine power has not changed, whereas it is required to re-measure engine power (physically) before almost every occasion of re-sealing in Germany and the Netherlands. In most other Member States, engines are either not re-sealed at all when seals are found to be broken, or at the discretion of the surveyor of engine manufacturer. In those Member States, re-sealing is not normally conducted in conjunction with a physical re-verification of shaft power.

It should be noted that theoretically, it is not justified to reasonably assume compliance of de-rated engines that:

- are not sealed (or adequately restricted otherwise);
- have broken seals;
- have been re-sealed without an in-depth verification of on-going compliance, for example through a physical re-verification of shaft power.

[53] Polish Register of Shipping

4.2. Risk based verification of engine power by Member States

In addition to the certification of engine power, Member States are required to establish a sampling plan to verify the accuracy of declared engine power in accordance with Art. 41 of the Control Regulation and Art. 62 and 63 of the Commission Implementing Regulation. Table 3 summarizes the sampling and verification activities undertaken by Member States in the context of Art. 41 of the Control Regulation and Art. 62 and 63 of the Commission Implementing Regulation in the period from 2012 to 2017. The column *Sampling plan developed and implemented* shows that not all Member States subject to this study have implemented a sampling plan as described in Art. 62 (1) to (4) of the Commission Implementing Regulation.

4.2.1. Sampling plan implementation

Art. 62 (4) of the Commission Implementing Regulation defines the minimum number of vessels that must be subject to data verification (the sample size). It was stated during a meeting between the contractor and the Finnish fisheries authorities[54] that the documentary consistency of each vessel that enters the Finnish fleet is verified at the time of fleet entry. This includes the verification of power related information such as power figures stated on certificates. According to the authorities, the number of fleet entries exceeds the minimum sample size, which effectively waives the obligation to conduct risk-based verifications as required by the Control Regulation. Hence, a sampling- and verification plan in accordance with the regulations has not been implemented.

During a meeting in Gothenburg between the contractor and the Swedish fisheries authorities[55], a digital sampling system incorporating all requirements of Art. 62 of the Commission Implementing Regulation was presented. No sampling and verification system had been implemented to date. Inefficient communication between the various authorities (fisheries authority, transport authority), organizational issues and delayed political ratification allegedly contributed to the delay of the implementation.

Based on correspondence between the Italian fisheries authorities and the Commission, it seems that a sampling plan has been developed in 2012 or 2013, but an actual sampling plan could not be located by the Italian fisheries authorities. During a meeting between the contractor, Commission inspectors and representatives of the Italian fisheries authority and Coast Guard[56], this sampling plan was discussed, but apparently no sampling or engine power verification plan for fishing vessels has been implemented. No sampling plan has been received by the contractor since the before mentioned meeting.

Based on correspondence between the Commission and the Danish fisheries authorities reviewed by the contractor, it is evident that a sampling plan in accordance with Art. 62 of the Commission Implementing Regulation has been developed by the Danish fisheries authorities in 2012. This sampling plan determined that a total number of 39 vessels should be subject to a data verification. During a meeting between the contractor and representatives of the Danish fisheries agency in Copenhagen[57], it remained unclear whether these data verifications have actually been conducted. It was confirmed

[54] Meeting with representatives of ELY (Elinkeino- liikenne- ja impäristökeskus) in Helsinki, Finland, 17-05-2018.

[55] Meeting with representatives of Havs- och vattenmyndigheten in Gothenborg, Sweden, 09-05-2018.

[56] Meeting with representatives of Ministero delle politiche agricole alimentari e forestali Dipartimento delle politiche competitive, della qualità agroalimentare, ippiche e della pesca Direzione generale della pesca marittima e dell'acquacoltura in Rome, Italy, 22-03-2018.

[57] Meeting with representatives of the Danish Fisheries Agency, Copenhagen, Denmark, 23-04-2018.

with certainty that no physical verifications have been conducted since the sampling plan was established.

Since Finland, Sweden, Denmark and Italy did not implement a sampling plan in accordance with Article 62 of the Commission Implementing Regulation, the contractor could not assess its effectiveness.

4.2.2. Sampling frequency

Of the 15 Member States subject to this study, 11 have developed and implemented a sampling plan for the verification of engine power of fishing vessels. Five Member States conducted only a single sample and verification round in 2012, 2013 or 2014 whereas six Member States implemented the sampling procedure as a recurring process. Poland selects a sample every 6 months, whereas the sampling and (data) verification process is repeated annually in Germany, France, the Netherlands and Latvia. Representatives of the Spanish fisheries authorities expressed their intention to enter into an annual, recurring procedure[58]. At the time of the meeting with the contractor, an engine power verification round in accordance with the steps and procedures of Art. 62 of the Commission Implementing Regulation had only be conducted once, in 2014. A second round of verifications was conducted in 2017, but these verifications were not based on systematic sampling and a subsequent data verification round to identify potentially non-compliant vessels (reportedly each of the 12 vessels selected in 2017 has been subject to a data verification, but none of these vessels was identified as potentially non-compliant).

The regulations do not require Member States to implement the sampling and verification plan on a recurring basis. It may however be assumed that a recurring sampling and verification regime is more effective than an once-off approach. When the sampling and verification procedure is repeated, for example on an annual basis, the total number of vessels and the relative share of the fleet that has been subject to a verification will rise over time. If an effective verification regime is implemented, this should result in an increasing compliance rate over time. On the other hand, if a fraction of the fleet is subject to verification only once, this means that the relative share of controlled vessels will decrease over time, since some of the controlled vessels may be decommissioned or have its engine replaced.

In addition to the number of controlled vessels and the relative share of the fleet that has undergone an engine power verification, it may be expected that adequate engine power verifications will have a preventive effect. In other words, if it is known within the industry that power verifications are being conducted routinely, operators may be expected to be more inclined to ensure that their vessel and engine are compliant with engine power regulations.

4.2.3. Sample size

In general, the Member States that implemented a sampling plan have closely and correctly followed the procedure to determine the minimum sample size described in Art. 62(4) of the Commission Implementing Regulation. This section of the rules leaves little room for interpretation, except for the number of vessels to be included that have a relatively low (registered) engine power to (registered) tonnage ratio. A comparison between the power to tonnage ratio of an individual vessel and the average of a group of vessels is more meaningful when the average is compared to a fleet of similar vessels. Therefore the regulations allow the fleet to be divided in segments along length categories, target species, etc. for this analysis.

[58] Meeting with representatives of the Spanish Fisheries Authorities, Madrid, Spain, 27-03-2018

- A breakdown into a larger number of subcategories may be expected to produce a lower number of vessels to be required to be subject to a data verification (based on their power to tonnage ratio).

- The nature of the power to tonnage ratio assessment leaves potentially non-compliant vessels unidentified if a large portion of the respective fleet segment is in fact non-compliant, as this will affect the average power to tonnage ratio of the fleet segment – particularly in case of well defined, relatively small fleet segments.

Belgium deviated from the sample size determination procedure described in Art. 62 of the Commission Implementing Regulation. Instead of taking the square root of the size of each of the three individual risk groups identified in this article (vessels operating in an effort regime, vessels subject to power limitation and vessels with low power to tonnage ratios), almost the entire Belgian fleet (77 of 82 vessels in 2012) met the criteria specified in Art. 62 (1)(a) and (b) of the Commission Implementing Regulation. This group of vessels was divided into al large fleet segment and a small segment (cut-off value: 98 GT and 221 kW). From both groups, the square root was taken to determine the sample size (total: 12 vessels). From the text of the sampling plan it follows that it was assumed that this was the correct interpretation of Art. 62 of the Control Implementing Regulation. This deviation from the required sampling procedure resulted in selection of 15% of the fleet, which is a very large fraction, especially compared to Member States with large fishing fleets. The impact on the effectiveness of the sampling and verification procedure of this deviation may therefore be assumed to be negligible.

4.2.4. Data verifications

According to the information provided by Member States, the total number of vessels that should have been selected for a data verification (Commission Implementing Regulation Art. 62 (5)) in the period from 2012 till 2017 is at least 989. The number of physical (power) verifications (Control Regulation Art. 41, Commission Implementing Regulation Art. 63) conducted in this period that directly followed from indications of non-compliance obtained during a data verification is 16, all carried out in Spain. In addition to engine power verifications that were conducted following a data verification, The Netherlands, Spain and Latvia have conducted a total of 39 physical power verifications following a random or undefined selection process, or for another purpose such as the assessment of a complaint. Scheduled verifications (e.g. data verifications carried out at the fleet-entry of a vessel, or physical power measurements carried out within the certification process of a vessel) are not accounted for in the power verification numbers presented in table 3.

Art. 41 (1)(a) to (f) provides six sources of information that should be consulted to identify ‘indications that the engine power of a fishing vessel is greater than the engine power stated on its fishing license’, and the option to include (g) ‘any other document providing relevant information on vessel power or any related technical characteristics’. Almost every Member State that implemented a sampling plan or indicated during one of the various meetings with the contractor and / or in the text of its sampling plan that at least the sources of information (a) to (f) were taken into account.

Although it is not possible to determine the exact performance of the data verifications without knowing the real non-compliance rate of the sample of vessels selected for a data verification by Member States, it may be assumed that a substantial number of non-compliant vessels have not been identified as potentially non-compliant by the Member States’ data verifications, based on the substantial non-compliance among vessels inspected by the contractor. This may have been caused by the application of inefficient indicators of non-compliance required to be taken into account by art 41 of the Control Regulation, or inadequate data verifications conducted by Member States, or a combination of both.

It should be noted that the survey authority responsible for issuance of documents (c) *Engine International Air Pollution Prevention Certificate* and (d) *Class certificate* will normally ensure that the power values are identical on both documents. The power value stated on the *Class certificate* or equivalent document is usually transferred to (e) *the sea trial certificate* and (f) *the community fishing fleet register*. It is therefore not very likely that verifying he consistency of engine power on these four documents will generate many indications of non-compliance.

The indicated sources of information (a) *Vessel monitoring system records* and (b) *the fishing logbook* are potentially valuable in the process of finding indications of non-compliance. It could for example be argued that if vessels with similar characteristics (length, tonnage, registered power, gear type and dimensions) operate consistently at different speeds, or land different quantities of catch (with a comparable catch composition), this justifies further investigation. For most Member States, the contractor could not effectively determine to what extent the sources *VMS* and *fishing logbook* had been sufficiently exploited to identify indications of non-compliance by Member State authorities. The outputs of the sampling procedures presented during the meetings lacked in most cases the necessary detail to determine with certainty the thoroughness of the conducted data verifications.

It should be noted that Belgium indicated in its sampling plan[59] that It considers VMS and the fishing logbook to be irrelevant for the verification of engine power. On the other hand, additional documents under (g), in particular engine manufacturer information have been used by the Belgian authorities, which led to the identification of two medium to high risk vessels. The sampling report provided by Spain shows that the average and maximum speed of selected vessels, obtained from the VMS records, have been compared to sea trial data. Comparison of VMS and fishing logbook data between vessels is less effective when non-compliance within the fleet segment is widespread, as this results in a biased fleet segment average. The Spanish approach, i.e. the comparison between VMS data and sea trial vessel speed data (provided that the engine power was determined in a reliable way at the time of the sea trial) may have contributed to the relatively high verification effectiveness.

- Vessel speed analysis is an effective method to identify potential non-compliance, in particular when reference data of vessel speed and engine power under documented circumstances (sea trial data) are available.

In the French sampling procedure, more documents are evaluated than the minimum required by in Art. 41(1) of the Control Regulation. The data verifications conducted in France identified at least three vessels that should have undergone a physical engine power verification. In the Netherlands, the swept volume of the engine is considered as risk factor under (g) of Art. 41(1) of the Control Regulation, and notifications from the industry (to the authorities) are also taken into account. In the United Kingdom (Scotland), all selected vessels that were selected for a data verification, were visited to verify the physical engine characteristics. This is also the case in Poland.

The low number of indications of non-compliance identified by the data verifications conducted in Germany and the Netherlands could be explained by the fact that all vessels that meet one of the criteria listed in Art. 62 of the Commission Implementing Regulation have been subject to a physical engine power measurement at least once, which is also the case for all de-rated vessels in Poland. The

[59] BELGIE – Nationaal controleprogramma ingesteld voor de controle van het geïnstalleerde motorvermogen aan boord van vissersvaartuigen, p 3.

number of vessels identified as potentially non-compliant by conducting data verifications in Spain (16) and Belgium (2) could reflect the real situation, although this cannot be determined with certainty.

France, Latvia, Ireland and Greece have adopted a sampling plan in accordance with the regulations, but the desk analyses yielded a very low number of potentially non-compliant vessels, or no vessels at all. This could be explained by a high compliance rate of the fleet, inadequate sampling methodology or suboptimal data verification procedures. Given the results of the verifications conducted by the contractor, indicating substantial non-compliance throughout the EU, it is worthwhile to re-assess the currently implemented data verification practices and to consider:

- To improve the use of vessel speed data. Especially comparison with peer vessels and reference (sea trial) data could contribute to the identification of potential non-compliance.

- To extend the use of engine specific data such as advertised power ranges and other characteristics that could indicate unrealistically low registered power values.

4.2.5. Physical power verifications

In the context of Art. 41(2) of the Control regulation, *verification of engine power* (not Art. 40, *certification* of engine power), only Spain, the Netherlands and Latvia have conducted physical verifications. Of all Member States that identified potential non-compliance by conducting data verifications, only Spain (in 2014) fully delivered on its obligation to proceed to physical verifications. Belgium formalized agreements with a third party to conduct power verifications if necessary, but these verifications have not been conducted. During the meeting between the contractor, a Commission inspector and representatives of the French authorities[60],it was stated that the French fisheries authorities are currently in the process of developing tender specifications for a physical power verification contract to follow up the indications of potential non-compliance.

In the period since 2012, at least the Danish, UK (Scotland) and Portuguese authorities acquired portable power verification systems with the intention to let their fishery inspectors conduct physical verifications. All Member States conducted trials to practice and test the use of these systems, which have not yielded success in Denmark and Portugal to date. Portuguese fisheries inspectors expressed the intention to acquire training from the engine power measurement equipment manufacturer in a renewed attempt to implement the physical power verification system. The UK (Scotland) authorities[61] have successfully conducted 10 trial verifications to date, but did not use the system for actual control purposes yet.

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[60] Meeting with representatives of Direction des Pêches Maritimes et de l'Aquaculture, Paris, France, 14-06-2018.
[61] Marine Scotland

Table 3. Output of Member State sampling and verification plans.

	Sampling plan developed and implemented	Interval between data verification rounds (months). No interval (once-ff) indicated as OO	Vessel group determination in order to determine sample size as required by (EC 404/2011 Art 62(1))	Number of vessels selected for data verification (2012 - 2017)	Number of data verifications (2012 - 2017)	All criteria (EC 1224/2009 ART 41(1)) used for analysis of vessels (data verifications)	Further criteria in addition to (EC 1224/2009 ART 41(1)) minimum requirements used for analysis.	All vessels subject to data verification visited by MS inspector – not required by (EC 1224/2009 ART	Number of vessels identified as potentially non-compliant (by data verification)	Nr. of physical verifications (2012 – 2017) following data verification indications of non-compliance.	Nr. of physical verifications 2012 – 2017 not following data verification indications of non-compl. (power measurements for certification not included)	Number of **infringements** confirmed by a physical verification	Infringement % of vessels selected for data verification
BE**	Y	OO	N	12	13	N	Y	N	2	0	0	**0**	0%
DE	Y	12	Y	216	216	Y	N	N	0	0	0	**0**	0%
DK	U/K	OO	Y	39	U/K	U/K	U/K	U/K	0	0	0	**0**	0%
FR**	Y	12	Y	232	232	Y	Y	N	3	0	0	**0**	0%
NL**	Y	12	Y	102*	102*	Y	Y	N	0	0	26	**4**	3,9%*
UK**[SC]	Y	OO	Y	30	30	Y	N	Y	0	0	0	**0**	0%
FI **	N	-	-	-	-	-	-	-	-	-	-	-	-
LV	Y	12	Y	1	1	Y	N	N	0	0	1	**0**	0%
PL**	Y	6	Y	U/K	U/K	Y	N	Y	0	0	0	**0**	0%
SE **	N	-	-	-	-	-	-	-	-	-	-	-	-
IE	Y	OO	Y	16	16	Y	N	N	0	0	0	**0**	0%
PT	Y	OO	Y	44	0	U/K	U/K	U/K	0	0	0	**0**	0%
ES **	Y	12	Y	97	97	Y	N	N	16	16	12	**9**	9,3%
IT	N	-	-	-	-	-	-	-	-	-	-	-	-
GR	Y	OO	Y	200*	200*	Y	N	N	0	0	0	**0**	0%
Total				989*	907*				21	16	39	13	1,3%*

Clarification of values marked with *:

NL	stated *approximately* 15 to 20 per year – average of 17 per year assumed for infringement % calculation.
GR	stated *approximately* 200.
Total	Accumulated sample number of data verifications based on confirmed data only.

Codes:

Y	YES
N	NO
U/K	UNKNOWN
OO	ONCE

Clarification of Member States marked with **, continues on following page:

** BE The group determination of vessels, which is part of the sample (data verification) size determination process, is not exactly as required by the Commission Implementing Regulation (Art. 62(4)) but was done on the basis of 'large fleet segment' vs. 'small fleet segment'. The impact on the sample size is limited. Although two vessels were marked 'medium to high risk', these vessels were not further investigated. Of the items to be verified as described in Art. 41(1) of the Control Regulation, (a) and (b) are considered irrelevant by the Member State, (c) is not available for each vessel and (d) is not issued. Under (g) the engine makers' catalogues are consulted.

** FR Data verifications were conducted in 2016 and 2017. In addition to the items to be verified as described in Art. 41(1) of the Control Regulation, the French authorities verify the following documents under point (g): L'acte de francisation, Le permis de navigation (PN), Le permis de mise en exploitation (PME) ou la licence Communautaire and Les authorisations de pêche.

** NL The Netherlands states in its sampling plan (version 2016) that because 100% of the fleet at risk has undergone a physical verification, the requirement to sample vessels and verify engine power in line with Art. 41 of the Control Regulation is surpassed and no further verifications need to be done on the basis of the Control Regulation. It states that nevertheless, a sample at the size corresponding to the sampling procedure described in Art 62(4) of the Control Implementing Regulation is verified at the inspection points listed in Art. 41(1) of the Control Regulation, supplemented under (g) of that article by the criteria 'engine type and swept volume of the engine' and 'notifications from the sector' on an annually recurring basis. Furthermore, it states that a number of inspected vessels undergoes a physical engine power verification on an annually recurring basis.
** UK Data for Scotland only.
** FI Finland conducts a documentary check of vessel and engine characteristics at the time of fleet-entry. The reasoning applied is that since the number of vessels checked at fleet entry exceeds the number that would need to be verified according to Art. 62(4) of the Commission Implementing Regulation, it is not necessary to conduct further verifications as required by Art. 41 of the Control Regulation.
** PL In Poland, all vessels selected for a data verification are also visited by an inspector for in inspection.
** SE Sweden has demonstrated the state of development of its system to meet the verification requirements that follow from Art.41 of the Control Regulation, but this system has not yet been implemented.
** ES In Spain, verifications were conducted in 2012 and 2017. The engine power verification process conducted in 2012 (16 physical verifications) followed the steps as required by the Control Regulation and Commission Implementing Regulation and resulted in the identification of 8 non-compliance cases. The verifications conducted in 2017 (12 physical verifications) did not follow these steps, and resulted in the identification of one non-compliance case.

5. Results (II) Physical power verifications in 15 Member States

Physical engine power verifications were carried out on board 68 vessels in 14 Member States. No verifications could be completed in Greece. The verification results and each deviation from the original target of 80 verifications in 15 Member States will be discussed in the relevant subsection hereafter.

An overview of the physical power verification results is presented in figure 14. The following arbitrary categories are distinguished:

- The measured propeller shaft power equals the vessel's licensed power or is lower;
- The measured propeller shaft power exceeds the vessel's licensed power, but by 15% or less;
- The measured propeller shaft power exceeds the vessel's licensed power by more than 15%.

During some verifications, the master refused to operate the engine at its maximum speed or the propeller at its full pitch (in case of a controllable pitch propeller), or both. In some of the other cases, the engine was almost certainly being manipulated during the test, in order to be less powerful than during normal fishing operations. If manipulation of the test was suspected, this was further investigated through analysis of the vessel speed profile and the engine characteristics. Identified (further) non-compliance based on secondary evidence is indicated as shaded in figure 14. The defined (shaded) categories are:

- The measured propeller shaft power equals the vessel's licensed power or is lower, but there is secondary evidence of non-compliance;
- The measured propeller shaft power exceeds the vessel's licensed power by 15% or less, but there is secondary evidence of non-compliance exceeding 15%.

Both the non-compliance rate (relative number of cases of non-compliance) and the non-compliance magnitude (relative amount of excess power) were found to be substantial. Table 4 provides a summary of the results of each physical verification that was planned to be conducted. This table includes the 12 targeted vessels that were not verified. The vessel identification codes in this table correspond to an individual vessel report for each vessel in Annex I. These reports provide more detailed information and evidence, if applicable, at vessel level. Sections 5.2 to 5.7 provide an overview of (non-) compliance at fleet segment level.

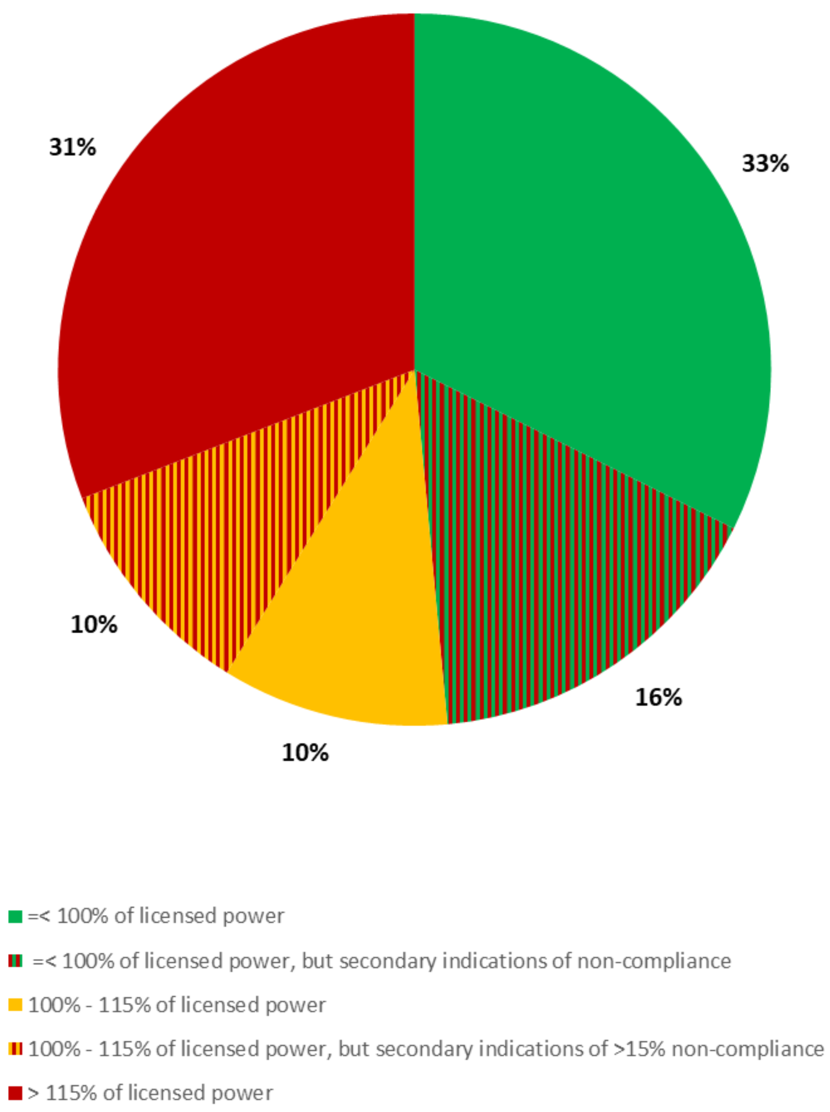

Figure 14. Overview of the results of the physical engine power verifications conducted within this study.

Table 4. Summary of all physical verification results.

Vessel identification		Fleet segment	Vessel inspected	MS inspector present	COM inspector present	Inspection announced	Licensed engine power	Measured engine power	Full throttle during test	Test conditions	Secondary indications of non-compliance	Score (figure 14)
		APT ADOT BMOT COT MBOT NSBT PLL *				B (boarding) S (short notice) A (announced) U (unknown) **	(kW)	(kW)		S (steaming) F (fishing) P (pulling)	N (no) S (speed vs AIS) E (engine specifications) G (gearbox id plate) H (digital engine history) P (physical signs of tampering) ***	
BE	01	NSBT	Y	Y	N	B	[redacted]	211	Y	S, F	S	
BE	02	NSBT	Y	Y	N	B	[redacted]	208	Y	S, F	S, E, H, P	
DE	01	NSBT	Y	Y	Y	B	[redacted]	245	Y	S	E, H, P	
DE	02	NSBT	Y	Y	Y	B	[redacted]	258	Y	S, P	N	
DE	03	NSBT	Y	Y	Y	B	[redacted]	237	Y	S, P	E, P	
DK	01	NSBT	Y	Y	N	S	[redacted]	219	Y	S, F	N	
DK	02	NSBT	N	N	N	-	[redacted]	-	-	-	-	-
ES	01	MBOT	Y	Y	N	B	[redacted]	333	Y	S, P	N	
ES	02	MBOT	Y	Y	N	B	[redacted]	755	N	S, F	N	
ES	03	MBOT	Y	Y	N	B	[redacted]	333	N	S, F	N	
ES	04	MBOT	Y	Y	N	B	[redacted]	282	Y	S, F	P	
ES	05	MBOT	Y	Y	N	B	[redacted]	666	N	S, F	E, H, G	
ES	06	MBOT	Y	Y	N	B	[redacted]	330	Y	S, F	N	
ES	07	MBOT	Y	Y	N	B	[redacted]	1138	N	S, F	E, H, G	
ES	08	COT	Y	Y	N	B	[redacted]	508	Y	S, P	G, H	
ES	09	COT	Y	Y	N	B	[redacted]	724	Y	S, P	N	
ES	10	COT	Y	Y	N	B	[redacted]	635	Y	S, P	N	
ES	11	COT	Y	Y	N	B	[redacted]	368	Y	S, P	N	
FI	01	BMOT	Y	Y	N	B	[redacted]	556	N	S	N	
FI	02	BMOT	Y	Y	N	B	[redacted]	573	N	S	N	
FR	01	MBOT	Y	Y	N	U	[redacted]	538	Y	S	P	
FR	02	MBOT	Y	Y	N	U	[redacted]	357	Y	S, F	N	
FR	03	MBOT	Y	Y	N	U	[redacted]	708	N	S, F	N	
FR	04	MBOT	N	Y	N	-	[redacted]	-	-	-	-	-
FR	05	APT	Y	Y	N	S	[redacted]	3177	Y	S	N	
FR	06	APT	N	Y	N	-	[redacted]	-	-	-	-	-
UK	01	APT	Y	Y	N	B	[redacted]	4335	Y	S	N	
UK	02	APT	Y	Y	N	B	[redacted]	6207	Y	S	P	
UK	03	APT	Y	Y	N	B	[redacted]	5155	Y	S	P	
UK	04	APT	Y	Y	N	B	[redacted]	4225	Y	S	N	
UK	05	NSBT	N	N	N	-	[redacted]	-	-	-	-	-
UK	06	NSBT	N	N	N	-	[redacted]	-	-	-	-	-
GR	01	MBOT	N	N	N	-	[redacted]	-	-	-	-	-
GR	02	MBOT	N	N	N	-	[redacted]	-	-	-	-	-
GR	03	MBOT	N	N	N	-	[redacted]	-	-	-	-	-
GR	04	MBOT	N	N	N	-	[redacted]	-	-	-	-	-
IE	01	APT	Y	Y	N	U	[redacted]	2465	N	S	G, P	
IE	02	APT	Y	Y	N	U	[redacted]	2570	N	S	E	
IE	03	APT	Y	Y	N	B	[redacted]	3014	N	S	E, P	
IT	01	MBOT	Y	Y	Y	B	[redacted]	290	Y	S, F	N	

Table continues on following page

Table 4 (Summary of all physical verification results), continued.

Vessel identification		Fleet segment	Vessel inspected	MS inspector present	COM inspector present	Inspection unannounced	Licensed engine power	Measured engine power	Full throttle during test	Test conditions	Secondary indications of non-compliance	Score
		APT ADOT BMOT COT MBOT NSBT PLL *				B (boarding) S (short notice) A (announced) U (unknown) **	(kW)	(kW)		S (steaming) F (fishing) P (pulling)	N (no) S (speed vs AIS) E (engine specifications) G (gearbox id plate) H (digital engine history) P (physical signs of tampering) ***	
IT	02	MBOT	Y	Y	Y	B	[redacted]	205	Y	S	N	
IT	03	MBOT	Y	Y	N	B	[redacted]	733	Y	S, F	N	
IT	04	MBOT	Y	Y	N	B	[redacted]	241	Y	S, F	N	
IT	05	MBOT	Y	Y	N	B	[redacted]	228	Y	S, P	N	
IT	06	MBOT	Y	Y	N	B	[redacted]	286	Y	S, F	N	
IT	07	ADOT	Y	Y	N	B	[redacted]	233	Y	S, F	P	
IT	08	ADOT	Y	Y	N	B	[redacted]	545	Y	S, F	G	
IT	09	ADOT	Y	Y	N	B	[redacted]	570	Y	S, F	G	
IT	10	ADOT	Y	Y	N	B	[redacted]	624	Y	S, F	G	
IT	11	ADOT	Y	Y	N	B	[redacted]	544	Y	S, F	G	
LV	01	BMOT	Y	Y	N	U	[redacted]	87	Y	S, P	N	
LV	02	BMOT	Y	Y	N	U	[redacted]	304	Y	S, P	N	
LV	03	BMOT	Y	Y	N	U	[redacted]	114	Y	S, P	N	
NL	01	NSBT	Y	Y	N	S	[redacted]	216	Y	S, F	S	
NL	02	NSBT	Y	Y	N	S	[redacted]	217	Y	S, P	N	
NL	03	NSBT	Y	Y	N	S	[redacted]	220	Y	S, F	S	
NL	04	NSBT	Y	Y	N	S	[redacted]	232	Y	S, F	S	
NL	05	NSBT	Y	Y	N	S	[redacted]	216	Y	S, F	S	
NL	06	NSBT	Y	Y	N	S	[redacted]	202	Y	S, F	S	
NL	07	NSBT	Y	Y	N	S	[redacted]	202	Y	S, F	N	
NL	08	NSBT	Y	Y	N	S	[redacted]	235	N	S, F	S	
NL	09	NSBT	Y	Y	N	S	[redacted]	219	Y	S, F	S	
NL	10	NSBT	Y	Y	N	A	[redacted]	234	Y	S, F	S	
NL	11	NSBT	Y	Y	N	A	[redacted]	231	Y	S	N	
NL	12	APT	N	Y	N	-	[redacted]	-	-	-	-	-
PL	01	BMOT	Y	Y	N	B	[redacted]	240	Y	S, F	N	
PL	02	BMOT	Y	Y	N	B	[redacted]	419	Y	S, F	N	
PT	01	PLL	Y	Y	N	B	[redacted]	232	Y	S	N	
PT	02	PLL	Y	Y	N	B	[redacted]	371	Y	S	E	
PT	03	PLL	Y	Y	N	B	[redacted]	445	Y	S	N	
PT	04	PLL	Y	Y	N	B	[redacted]	165	Y	S	P	
PT	05	PLL	Y	Y	N	B	[redacted]	328	Y	S	P, H	
PT	06	PLL	Y	Y	N	B	[redacted]	328	Y	S	N	
PT	07	PLL	Y	Y	N	B	[redacted]	391	Y	S	N	
PT	08	PLL	Y	Y	N	B	[redacted]	202	Y	S	N	
PT	09	PLL	Y	Y	N	B	[redacted]	273	Y	S	N	
PT	10	PLL	Y	Y	N	B	[redacted]	430	Y	S	N	
SE	01	BMOT	Y	Y	N	B	[redacted]	424	Y	S, P	N	
SE	02	BMOT	N	N	N	-	[redacted]	-	-	-	-	-
SE	03	BMOT	N	N	N	-	[redacted]	-	-	-	-	-

Table continues on following page

*
APT: Atlantic Pelagic Trawler
ADOT: Adriatic Sea (pair) Trawler
BMOT: Baltic Sea Mid Water Otter Trawler
COT: Cantabrian Otter Trawler
MBOT: Mediterranean Bottom Otter Trawler
NSBT: North Sea Beam Trawler
PLL: Portuguese Long Liner
**
Short notice: Announcement of physical verification prior to verification in accordance with agreements. All vessels engaging in > 24 hour fishing trips to be inspected on arrival may be notified during their last fishing trip before the inspection. APT to be inspected on departed may be notified < 24 h before departure.
***
Gearbox id plate: Some gearbox type and identification plates state the maximum input speed / torque / power values.
Although this cannot be regarded as evidence of non-compliance, a large discrepancy between the gearbox power intake and the maximum power produced by the engine is unusual.

Physical signs of tampering includes (but is not limited to) broken seals.

5.1. Practical insights gained during physical verifications.

It was a challenging task to complete the vessel inspections, including the physical power verifications in accordance with the methodology and within the available time. The contractor had been contracted by the Commission, whereas the inspections were planned to be conducted under the authority of the respective Member State. This created a situation in which the contactor has no authority to instruct inspectors or to require cooperation from vessel operators, but was still be expected to ensure that the methodology, which had been approved by the commission, was respected. One of the objectives of the meetings held between the contractor and Member State authorities prior to starting the physical power verification works was to outline exactly the procedure to be followed, and to identify potential problems in an early stage. Despite these meetings, some issues related to the inspections emerged. This could perhaps be partly be explained by the fact that physical engine power verifications are never or seldomly conducted in most Member States, which follows from the results presented in section 4.

5.1.1. Authority conduct a physical power verification

Representatives of the authorities in Germany, Ireland and the United Kingdom (Scotland) questioned the authority of their fishery inspectors to conduct physical engine power verifications according to this study's methodology from the beginning. A Commission inspector attended the verifications in Germany to resolve this issue. In the United Kingdom (Scotland), the legal authority of inspectors to conduct inspections in accordance with the methodology remained unclear, but inspections were conducted in practice without problems. The Irish authorities[62] confirmed prior to the first test that Irish fishery inspector do have the necessary power to conduct these verifications.

In addition to the disputed authority describe above, it occurred on site that the Member State inspector(s) did nor bear or exercise the authority to require cooperation from vessel operators. This resulted in the evasion of control by one vessel in France, and contributed to the failure to inspect any vessel in Greece.

During certain physical power verifications, Member State inspectors commented that it contradicts standing practice to conduct such time consuming inspections on an unannounced basis, and that the maximum duration of an inspection (4 hours) should not be exceeded. It is however not always possible to complete a physical engine power verification within four hours.

5.1.2. Following the agreed methodology

The methodology of the vessel inspections and physical engine power verifications has been developed by the contractor with great care and has been approved by the Commission. The methodology aimed to ensure that the Commission would be provided with complete, comprehensive and reliable information regarding the compliance with engine power restrictions of the inspected vessels.

Objections were raised by the operators against the operation of their engine at full power. It is however not possible to determine with certainty that the certified engine power cannot be exceeded without running the engine at full load. In accordance with international maritime legislation, a vessel must be able to operate at full load. At the same time, the master remains responsible for safe navigation. This implies that he retains the right to refuse operation at full or any other load if he deems that unsafe. Many inspectors did apparently not interpret the operators' refusal to operate at full load

[62] SFPA (Sea-Fisheries Protection Authority)

as insufficient cooperation with the study, given their reluctance to require the vessel operator to operate their engine at its maximum power.

5.2. Atlantic Pelagic trawlers

It was an objective of the study to physically verify the engine power of Atlantic Pelagic Trawlers registered in France (2), Ireland (3), The Netherlands (1) and the United Kingdom (Scotland) (4). These vessels engage in long and irregular fishing trips, and do not always land in their flag state. This makes verifications complicated to schedule, in particular for Member State authorities. The contractor's attempts to schedule a verification of the selected Dutch vessel and the second of the two selected French vessels did not succeed. Consequently, these verifications have not taken place. The summarized verification results corresponding to this fleet segment are summarized in figure 16.

A general consideration for this type of vessel (Atlantic pelagic trawler) is that most of them are equipped with powerful shaft generators that can be used to obtain power from the shaft, but also to add propulsion power generated by auxiliary engines to the propeller shaft. It cannot be verified with certainty during this type of inspection whether the electric motor can only be used when the main engine is clutched out (power take-in arrangement), or that this power can be added while the engine also drives the propeller shaft (booster arrangement). The latter would effectively result in increased propulsion power.

The observation that this type of propulsion is not common on other (smaller) types of fishing vessels, and that this type of arrangement is very difficult to control effectively, could be an argument to prioritize Atlantic pelagic trawlers in case the continuous monitoring based power control proposal will be adopted.

5.2.1. United Kingdom (Scotland)

The inspections in the United Kingdom (Scotland) were conducted from the port of Peterhead in conjunction with Marine Scotland fishery inspectors. In line with the approved sampling methodology, vessels with low kW to GT ratios were inspected. The selected Scottish trawlers have more registered power and a greater tonnage than high-risk Atlantic pelagic trawlers in the Atlantic pelagic trawler fleets of other Member States subject to this study, but the kW to GT *ratio* of the various fleets is comparable.

The vessel inspections showed that, in accordance with the findings presented in section 4.2, only the engine settings of permanently de-rated[63] engines are sealed in the UK. One of the selected vessels was registered as permanently de-rated, but the single seal applied was found to be broken. No further indications of the use of excess power were found.

5.2.2. Ireland

The inspections in Ireland were conducted from the port of Killybegs in conjunction with SFPA[64] fishery inspectors and MSO[65] surveyors. Although the measurement results did not provide non-compliant power values during the test, secondary indications of non-compliance were found. The applied fuel

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[63] Permanently de-rated is the term used on the 'Certificate of British Registry' as issued by the MCA (Marine and Coastguard Agency) to refer to derating of engine power that is made permanent, e.g. through the application of sealing of engine settings.

[64] Sea-Fisheries Protection Authority

[65] Marine Survey Organization

rack sealing of the main engine onboard the vessel IE-02 does not correspond to its de-rated output. Evidence of tampering with engine settings prior to the physical verification was found onboard vessel IE-03. Furthermore, the master of vessel IE-03 refused to operate above 72% pitch. The potential true maximum power values of these vessels are presented in figure 16, and detailed verification reports are enclosed in Appendix I. An explanation for the fact that only indirect evidence has been found, could be that the owners of the vessels were informed about the verifications by the local authorities earlier than as agreed with the contractor.

5.2.3. France

The inspection in France was conducted from the port of Saint Malo in conjunction with GMPC[66] fishery inspectors and Affaires Maritimes inspectors. Whereas most other inspections were made during a dedicated verification sea trial, this was not possible from Saint Malo (larger vessels can only enter and leave the port for a short period of time before and after high tide). The inspectors and project engineers were collected at sea by an Affaires Maritimes vessel. No non-compliant power values were measured, and no secondary indications of non-compliance were found.

Figure 15. Distribution of physical verification results conducted in the fleet segment Atlantic pelagic trawlers, ordered from high to low measured relative power.

Remark: the master of fishing vessel IE-03 refused to operate above 72% propeller pith during the verification.

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[66] Gens de mer, Pêches et Contrôles Délégation à la Mer et au Littoral de l'Ille-et-Vilaine

5.3. Baltic Sea mid-water otter trawlers

It was an objective of the study to physically verify the engine power of mid-water otter trawlers registered in Finland (2), Latvia (3), Poland (2) and Sweden (3). The first inspection in Sweden was conducted in good order. The subcontractor failed to verify the engine power of the second vessel due to a series of technical and practical problems during multiple attempts. The delays encountered also left insufficient time to complete the third verification. The verifications within this fleet segment in the other Member States have all been completed.

5.3.1. Finland

Inspections in Finland took place from the ports of Reposaari and Uusikaupunki in conjunction with ELY[67] fishery inspectors. The verification of vessel FI-01 was delayed because the vessel had just suffered an engine failure. Fishing or pulling was not possible due to the shallow port and ice conditions. The master refused to operate the engine at its maximum load while steaming (maximum speed and pitch). The verification of vessel FI-02 was delayed because the vessel had to tow another, immobilized, vessel to port. Fishing was not possible due to the ice conditions. The information available to assess compliance with engine power restrictions is therefore limited for both vessels, but no indications of the use of excess power were found during these verifications.

5.3.2. Latvia

The inspections in Latvia were conducted from the ports of Skulte and Salacgriva in conjunction with fishery inspectors of the department of fishery control of the State Environmental Service[68]. None of the vessels reached non-compliant power levels during the verifications, but the engineer on board pressed the control lever of the vessel LV-02 manually to a position that resulted in excess power output, which is non-compliant with Art 40(2) of the Control Regulation, which states that an engine may not be capable of developing more than the [in the certificate] stated engine power.

5.3.3. Poland

Inspections in Poland took place from the port of Kolobrzeg in cooperation with OIRM[69] inspectors. The vessel PL-01 is registered as permanently de-rated, but it is unclear how exactly it has been de-rated. Furthermore, the engine details do not correspond with the emission documentation onboard, which make it for the contractor impossible to verify whether the installed engine is compliant with applicable NOx regulations, and to verify the consistency of engine power stated in different documents. Non-compliant engine power values were not measured. Based on the engine power measurement report on board, it may be concluded that the engine power of PL-01 has been measured at least once. PRS[70] determined the maximum permissible engine speed on the basis of that measurement, and documented it on the vessel's class certificate.

[67] Elinkeino- liikenne- ja impäristökeskus
[68] Zvejas kontroles departamenta , Valsts vides dienesta
[69] Okręgowy Inspektorat Rybołówstwa Morskiego
[70] Polish Register of Shipping

5.3.4. Sweden

The inspection in Sweden took place from the port of Västervik in cooperation with fishery inspectors of the Sea- and Water Authorities[71]. No indications of non-compliance were found.

5.3.5. Baltic Sea, general

In general, the power verifications conducted onboard mid water otter trawlers in the Baltic Sea give the impression of a relatively high compliance rate. However, of the visited Baltic Member States, only Poland operates a system of scheduled physical power measurements and documentation of de-rating to ensure compliance with the Control Regulation. Power verifications are conducted and sealing is applied to de-rated engines only when new engines are installed. These measures are implemented by PRS.

Power certification and verification in Latvia, Finland and Sweden is an entirely administrative process. The observation that the compliance rate is high, despite the absence of adequate control, suggests that the operators' incentive to increase engine power is relatively low. This could be related to the absence of engine power based effort regimes in the Baltic Sea. Another explanation could be that the installed engines do not require substantial de-rating to produce the licensed output.

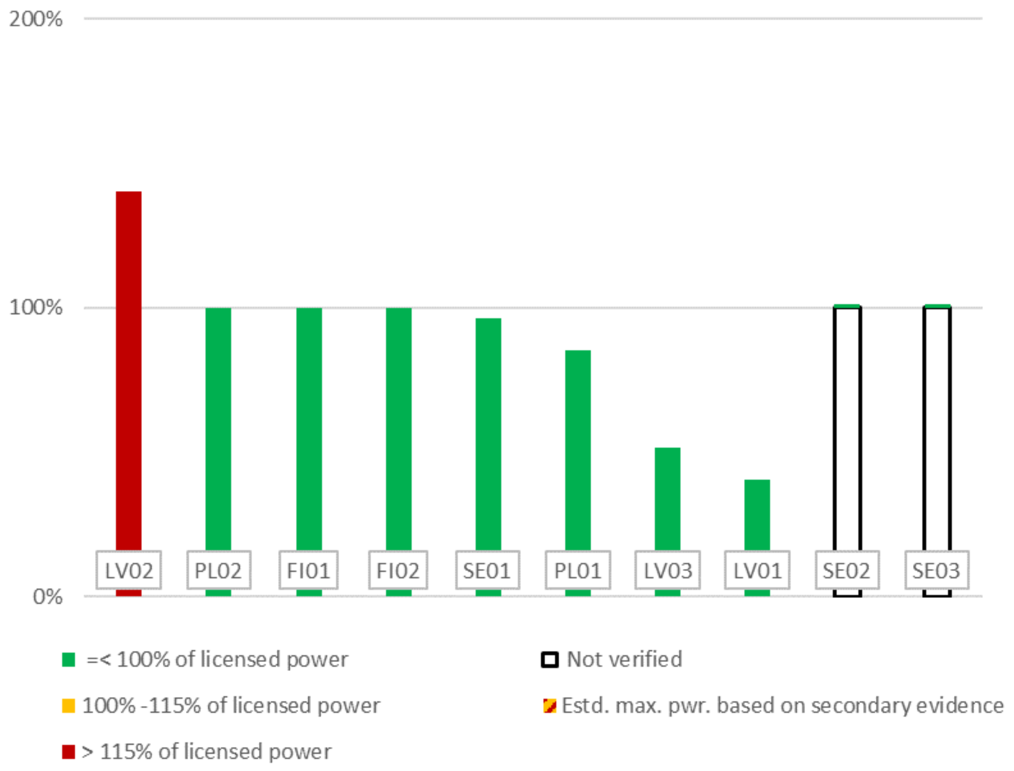

Figure 16. Distribution of physical verification results conducted in the fleet segment Baltic mid-water otter trawlers, ordered from high to low measured relative power.

[71] Havs- och vattenmyndigheten

5.4. Deep Sea long liners

In according with the project specifications, 10 fishing vessels that use long line gear in the waters of the Azores and Madeira were inspected: three from Funchal and Caniçal (Madeira), two from Ponta Delgada (Azores) and five from the ports of Sesimbra and Peniche (mainland). The inspections were conducted unannounced, in cooperation with fishery inspectors of DGRM[72], Local fishery inspectors[73], coast guard officers and local maritime police.

It was anticipated that the non-compliance rate in this fleet segment would be low, because the vessels use static gears. The only incentive imaginable to install relatively large engines is to increase the vessels' maximum speed, in order to reduce the transit time between the ports and the fishing grounds. This can however result in a substantial increase of fishing capacity, since it typically takes up to several days for this type of vessel to reach the fishing grounds. Non-compliance was found in five cases, ranging from a marginal discrepancy between actual and registered power to a vessel operating more than twice its licensed power.

In general, the power values registered on the navigational certificate, the fishing license and in the fleet register are consistent, but do not necessarily reflect the real situation. None of the supposedly de-rated engines was secured (sealed) at its de-rated setting, and the engine parameters corresponding to the de-rated setting (e.g. engine speed, fuel rack setting) were not documented for verification purposes. The engine of vessel PT-02 was found properly sealed (by the engine manufacturer), but not at its de-rated output. No engine documentation was onboard this vessel to verify, but it is likely that the engine was supplied by the engine dealer or manufacturer at a higher power rating than the vessel's licensed power.

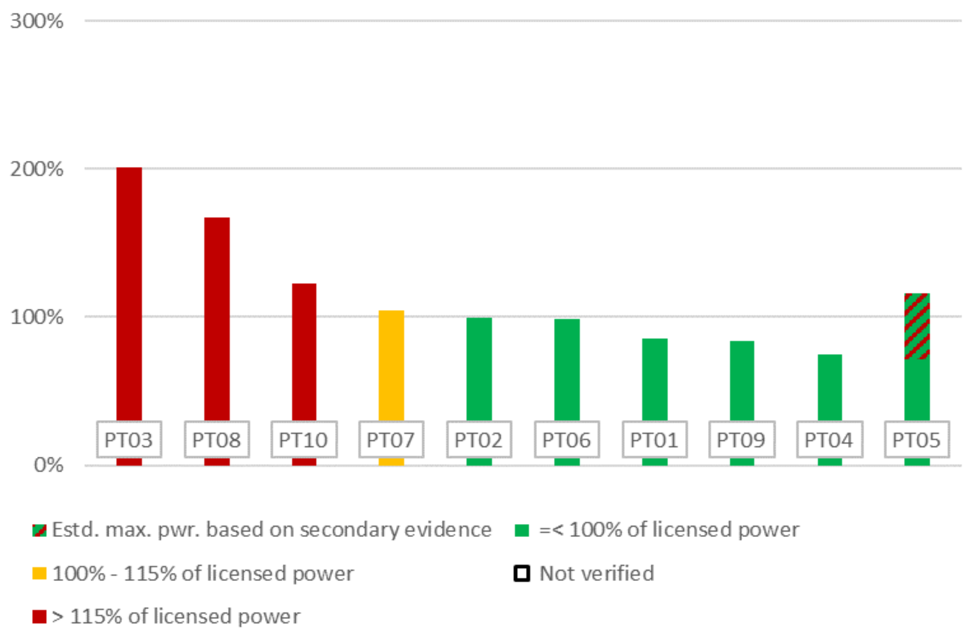

Figure 17. Distribution of physical verification results conducted in the fleet segment Portuguese long liners operating in the water of Madeira and the Azores, ordered from high to low measured relative power.

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[72] Direção-Geral de Recursos Naturais, Segurança e Serviços Marítimos

[73] direção regional de pescas

5.5. Mediterranean Sea bottom otter trawlers (Gulf of Lion)

An original objective of the study was to physically verify the engine power of 15 bottom otter trawlers that operate in the Gulf of Lion; 11 from Spain and 4 from France. Due to a request from the Commission, in order to adequately assess allegations made against part or the Spanish trawler fleet operating near the Cantabrian coast, it was decided to replace four Spanish Mediterranean bottom otter trawlers by four Cantabrian trawlers. The results of the Cantabrian verifications will be presented in section 6. The remaining 11 vessels in the Gulf of Lion sample were all visited unannounced upon arrival in port after a fishing day, to immediately undergo an engine power verification. In Spain the verifications were organized in conjunction with Spanish fishery inspectors[74] and Guardia Civil officers, whereas the verifications in France were conducted with French fisheries inspectors[75] and Affaires Maritimes officers.

One ship owner of the targeted French trawlers refused to cooperate with the control. Extensive communication between the project engineers on site, the Commission single point of contact and the DPMA[76] did not result into conveyance of the necessary orders to the Affaires Maritimes officers on site to exercise their powers and force co-operation. This resulted in reduction of the sample size by one, to a total of 10 verifications in the Gulf of Lion region. It is recommended to verify the engine power of this vessel in the future.

Figure 18 shows a summary the verification results. The obvious conclusion is that under-declaration of engine power is widespread within this sample, and that in many cases the registered power is exceeded substantially (by up to more than 200%). From analysis of the documentation available onboard the vessels in both Member States it remained in most cases unclear on what basis the engine has been certified at its registered (clearly de-rated) power value. It was noted that fishing vessels FR-03 carried a letter from engine dealer [redacted] stating that the engine had been electronically de-rated to a compliant output level. This did clearly not correspond with the real situation during the verification. Whether or not the engines have actually been de-rated at some point in time (e.g. during the test bed trial), no measures are in place to prevent unauthorized alteration of engine settings.

In most cases the engine identification plate at the engine shows the registered (de-rated) power output, which does not reflect the real engine capacity. Those engine identification plates are – in some cases obviously – forged.

The authorities in both Member States provided the project engineers with registered details of the vessels to be inspected, including engine particulars. It was noted that the engine brand and type found onboard fishing vessel ES-04 did not match the details of the engine that was supposed to be installed according to this registration information.

[74] Subdirección General de Competitividad y Asuntos Sociales, Secretaría General de Pesca
[75] Service Mer Eau Environnement/Pôle Pêche Maritime Activités Nautiques
[76] Direction des Pêches Maritimes et de l'Aquaculture

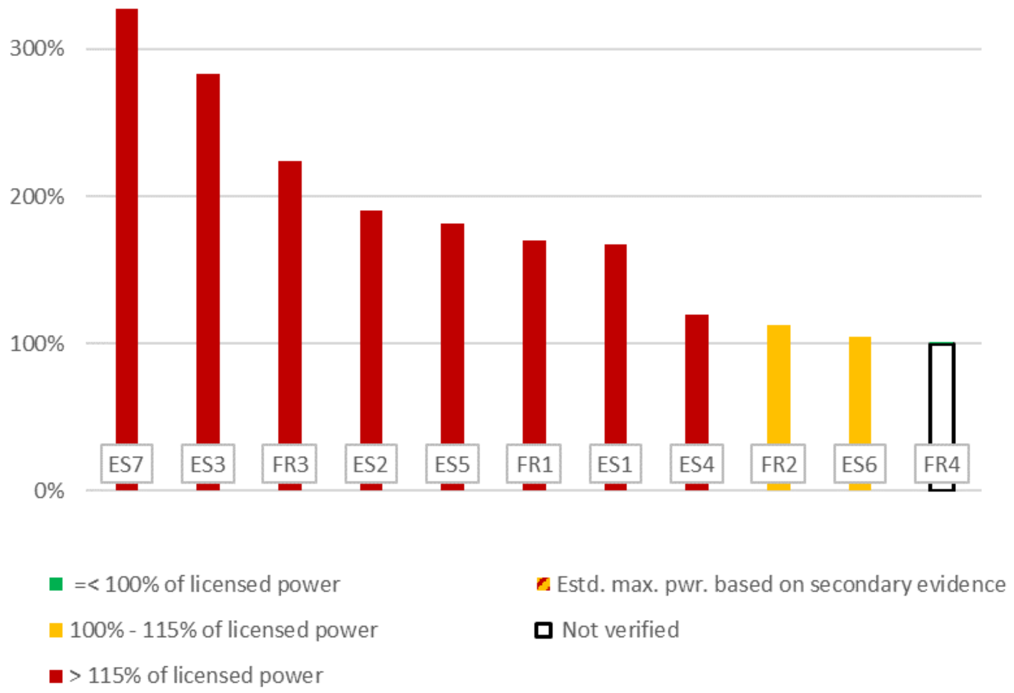

Figure 18. Distribution of physical verification results conducted in the fleet segment bottom otter trawlers operating in the Gulf of Lion , ordered from high to low measured relative power.

Remarks:

The masters of ES-2 and ES-3 refused to fish at full engine speed during the verification. Electronic evidence was found onboard vessels ES-5, ES-7 and FR-3 that the engine was not operating at its maximum output during the verification. Evidence of tampering with engine settings was found at the engine of vessel ES-4.

5.6. Mediterranean, Aegean Sea bottom otter trawlers (Strait of Sicily, Aegean Sea)

An original target of the study was to verify the engine power of 15 bottom otter trawlers that operate in the Strait of Sicily and the Aegean Sea; 11 from Italy and 4 from Greece. As discussed in section 2.3, the Commission requested to replace 5 of the 11 targeted vessels operating in the Strait of Sicily by five pair trawlers operating from the port of Chioggia in Northern Italy, in order to assess the validity of information received by the Commission containing allegations against this specific fleet segment. The results of those five verifications will be presented in section 6.3.

5.6.1. Italy

The inspections on Sicily were conducted in cooperation with Italian fishery inspectors[77], the Italian coast guard and two times in attendance of a fishery inspector representing the Commission. In all cases, the verification visits were conducted in an unannounced manner, as agreed. In forthcoming cases, vessels were detained prior to departure to facilitate the verification. In other cases the crew of laid up vessels was ordered to come to the port and take part in the verification.

Figure 19 shows mixed results of both compliance and non-compliance of Italian vessels. The Italian inspectors conducted their own (routine) engine power inspection simultaneously to the contractor's physical power verifications. The Italian verification is based on a check list that essentially verifies whether the engine appearance matches the registered engine details. The verified elements include the number of cylinders, the identification plate and the presence of seals (if applicable).

During the verification trial of fishing vessel IT-02, an engine failure occurred. The reason for this failure was overheating of a non-original piece of tube between the turbocharger (compressor side) and the inlet air receiver. This failure occurred during the fishing trial and obviously resulted in immediate termination of the verification. At the time of the failure, the engine delivered 12% more engine power than the maximum output licensed to the vessel. It is unlikely that this engine operates at this output level during normal fishing operations because the engine can in its current condition apparently not withstand the associated temperatures.

The inspected Italian vessels carry a certificate issued by [redacted] stating the *total power of the propelling machinery at a specified revolutionary engine speed without overload with the ship at the full load draft*. This certified power value is also used to determine the power stated at the fishing license of the vessel. It was found that the certified engine power value does not always correspond with the actual capacity of the engine. The most notable difference was found in the case of fishing vessel IT-03, where the real power output was more than twice the certified maximum power. From analysis of the information found onboard and the documentation submitted by the authorities it is remains unclear how the certified power value has been established. In case of de-rated engines, it is not documented how unauthorized changes of settings are prevented and how it can be verified that the engine continues to operate at its de-rated settings.

[77] Direzione generale della pesca marittima e dell'acquacoltura.

5.6.2. Greece

No verification has been conducted in Greece. A member of the project team visited the Greek authorities[78] twice to introduce the project, gather information on the engine power verification practices in Greece, outline the study objectives and agree on the roles and responsibilities of all organizations involved in the physical verifications to be conducted. It was agreed, and confirmed in writing, that the inspections would take place under the mandate of Greek fishery inspectors and that the inspection team would be supported by the Hellenic Coast Guard.

Based on information provided by the Greek authorities, it was decided to base the inspection team near the port of Keratsini. It was outlined by the authorities that large numbers of high-risk vessels that meet the selection criteria were expected to land frequently. This would provide a perfect opportunity to select the highest risk vessel present in port for inspection on an ad-hoc basis.

It was agreed to start the verifications on December 13th 2018. A fishing vessel was selected and approached in port, but the operator denied the contractor's engineers access to the vessel. Contrary to the statements that were confirmed in writing, made during the prior meetings, the authorities now disputed their mandate to force vessel owners to co-operate with the physical engine power verifications. Furthermore, several new demands were presented to the contractor's engineers by the Greek inspectors, including the request for a detailed handbook containing every step of the verification and a signed letter from the contractor's attorney stating that the contractor assumes all liabilities of potential events that could take place during the physical power verification trial. Because some of the demands were considered illegitimate by the project management, some were considered to contradict prior agreements and others could not be met on short notice, the first verification was canceled.

The authorities informed the contractor's engineers that a large number of landings was expected in the port of Keratsini on the evening of December 14th 2018. When the project engineers arrived in port they noted that the vessel indicated as the highest risk target within the fleet was present. The contractor's engineers requested the authorities to start the verification of this vessel immediately. For unknown reasons it took the authorities too long to get ready for this verification. The vessel left the port and evaded control. The only other vessel in the port of Keratsini that night (which met the required characteristics) was particularly low-risk. The actual situation was not in line with the expectation expressed by the Member State inspectors that many high-risk vessels would land in that port that night.

The Greek authorities informed the project engineers that no inspectors would be available to conduct new attempts on Saturday and Sunday. After extensive communication between the project team, the Greek authorities and the single point of contact representing the Commission for this project, it became clear that sending an inspector representing the Commission on extremely short notice (before Monday, December 17th) was not feasible. However it was agreed that on Monday December 17th a new attempt would be made to verify the engine power of a high-risk fishing vessel. The authorities were provided with a list of high risk-vessels that met the selection criteria, and it was agreed that the authorities would monitor the position, course and landings of those vessels. To increase the chance of success it was also agreed that in addition to Keratsini, nearby ports could be visited for this inspection as well. On Monday afternoon, the project engineers were informed by the contact point representing the Greek authorities that, contrary to agreements, the authorities had

[78] Ministry of Rural Development and Food, DG for Fisheries, Directorate Control of Fishing Activities and Products.

contacted vessel owners about the unannounced inspections to be conducted. The engineers were also told that 'Monday was too soon after the weekend to conduct a verification'.

After the cumulative breach of agreements and the lack of cooperation from the Greek authorities to facilitate unannounced engine power verifications on board high risk fishing vessels according to the approved verification methodology, the project management and the single point of contact representing the Commission jointly decided to make no further verification attempts in Greece within the scope of this study.

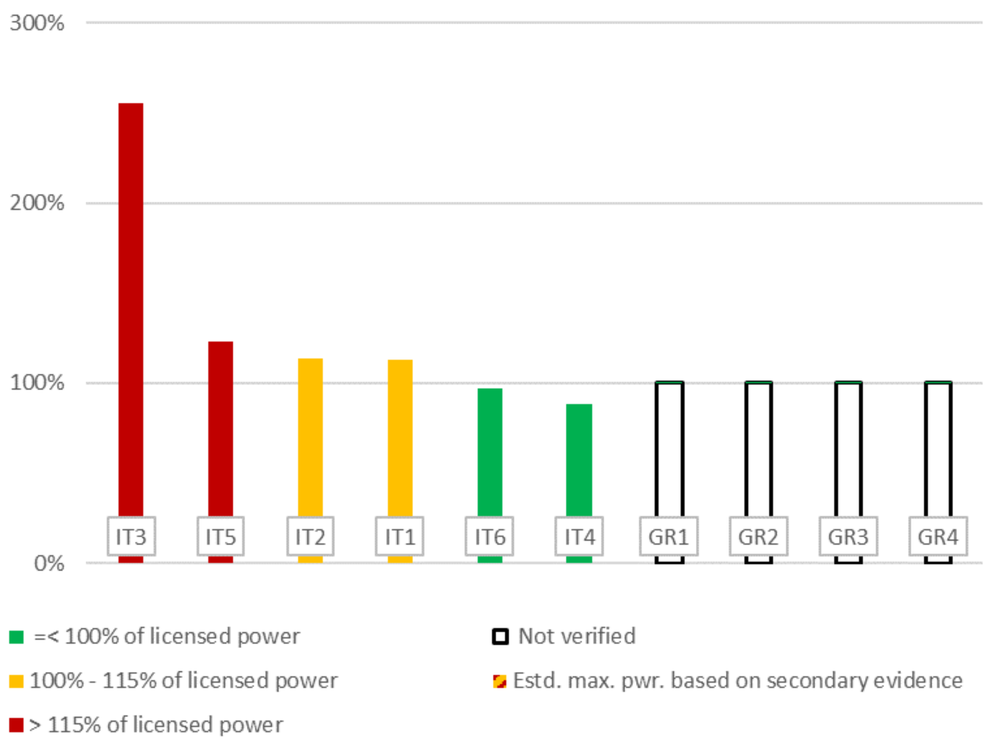

Figure 19. Distribution of physical verification results conducted in the fleet segment Bottom otter trawlers operating in the Strait of Sicily and Aegean Sea , ordered from high to low measured relative power.

Note:

The engine of IT-02 failed during the verification.

5.7. North Sea beam trawlers (plaice box)

A target of the study was to physically verify the engine power of 20 beam trawlers operating in the North Sea plaice box or the 12 mile zone around the United Kingdom and Ireland. In the Netherlands, 11 trawlers were inspected together with fishery inspectors from the *NVWA*[79]. In Belgium, two beam trawlers were inspected in cooperation with surveyors from the *FOD Mobiliteit en Vervoer* and fishery inspectors from the *Dienst Visserij*[80]*.* In Germany, three beam trawlers were inspected in conjunction with fishery inspectors from *Fischereiaufsicht*[81] and fishery inspectors from the Commission. In Denmark, one trawler was inspected in conjunction with fishery inspectors from the *Danish Fisheries Agency*.

Two UK (England) flagged beam trawlers were scheduled to be verified. The verifications could not take place during the week agreed with the contractor due to sick leave of (too many) fishery inspectors. Alternative inspection dates were not presented by the Member State, and the contractor had only limited options to schedule these verifications during the remaining period available for inspections.

The contractor was present in a Danish port where together with the Danish fishery inspectors the landing of target vessel DK-02 was awaited for an unannounced inspection. The timing was based on an estimation of the duration of the fishing trip, based on historical voyage data of the vessel. This fishing trip was unusually long (more than twice the average duration), and from the vessel track it could not be derived when the vessel intended to land. Also the authorities could not get in contact with the vessel or its owner. After consultation with the Commission, it was agreed to cancel this verification and remove this vessel from the target list.

The remaining 17 North Sea beam trawlers of the originally targeted 20 vessels were inspected. The contractor used vessel characteristics from the Community Fishing Fleet Register [82] by the contractor to conduct the risk assessment on which the vessel selection was based. The main gear of all targeted vessels in the fleet segment North Sea beam trawls was registered to be TBB (beam trawls). However in three cases, the inspected vessel was apparently operating its registered secondary gear (OTB – bottom otter trawls).

Figure 20 shows that for seven vessels, the physically measured shaft power exceeded the registered engine power: in six cases by less than 15% and in one case by 17%. The shaded bars in this overview indicate the estimated real maximum power, based on secondary evidence. In most cases, secondary evidence is a speed comparison between the vessel speed when operating at its licensed power (during the verification) and the vessel speed during normal fishing and steaming operations, based on AIS or VMS data. Also electronically stored historical engine performance data (if available) and original test bed data were used to estimate the real maximum engine power.

The findings presented in figure 20 justify the conclusion that during most verifications, the engine performance was manipulated. Compared to the other investigated fleet segments, the non-compliance of North Sea beam trawlers with engine power restrictions appears to be much better concealed. Sophisticated, hard-to-detect, manipulation systems must be active onboard many vessels to enable the crew to switch between ‘compliant’ and ‘real’ engine power settings. A possible explanation for the observed difference in tampering professionalism between fleet segments is that

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[79] Nederlandse voedsel en waren autoriteit
[80] Part of DEPARTEMENT LANDBOUW EN VISSERIJ, Flemish government
[81] Fisheries Control agency of Landesamt für Landwirtschaft, Umwelt und ländliche Räume Schleswig-Holstein
[82] http://ec.europa.eu/fisheries/fleet/index.cfm

the flag states of North Sea beam trawlers, in particular the Netherlands and Germany, have implemented a much more stringent and matured certification and control (of engine power) system than other Member States.

It was noted that, although there is a wide variety of installed engine brands and types in the fleet of North Sea beam trawlers that meet the criteria (TBB gears, up to 221 kW, in the North Sea area), the vessels identified as high risk have mostly Mitsubishi (type S6A300-3 and S6RF300) and Caterpillar (3412E series) engines installed. These engines have the potential to produce substantially more engine power than registered. This is particularly relevant in the context of effort regimes in the Plaice Box and the 12 mile zone around the UK and Ireland[83], where the original rating of engines (de-rated to 221 kW) is not allowed to exceed 300 kW. Within this study, the engines found onboard vessels subject to these effort regimes are without exception capable of delivering more than 300 kW without major conversions. In addition, many engines installed onboard the inspected North Sea beam trawlers are electronically controlled, which allows for electronic tampering. This is in sometimes nearly impossible to detect – especially in case the inspector does not have all necessary IT tools at hand.

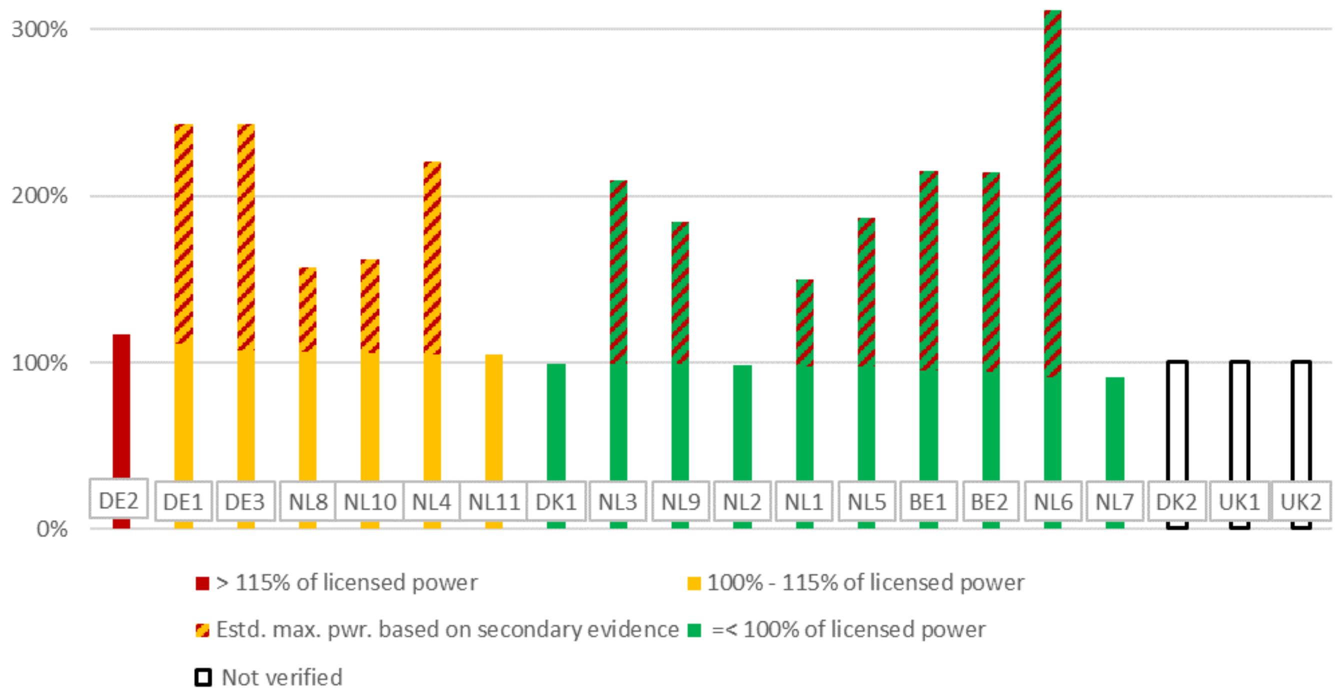

Figure 20. Distribution of physical verification results conducted in the fleet segment North Sea beam trawlers operating in the Plaice Box and the 12 mile zone around the UK and Ireland, ordered from high to low measured relative power.

[83] OJ L 125, 27.4.98, p. 1- 36. Council Regulation (EC) No 850/98 of 30 March 1998, for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31998R0850&rid=1

5.7.1. The Netherlands

The Netherlands has accredited multiple commercial measuring and sealing agencies, and operates a highly standardized and formalized system of power verification and sealing of engine settings[84]. Section 4.3 discussed the technical prerequisites for effective application of seals as control measure, including the use of uniquely numbered and robust seals, complete and up-to-date administration of applied seals and the accreditation of knowledgeable and honorable compliance engineers.

The certification system of power measurement and sealing of engine settings in The Netherlands is considered to meet the technical standards for effective engine power limitation through sealing, but the non-compliance rate is significant. This can partly be explained by the fact that physical seals are less effective to prevent tampering with electronically controlled engines than with mechanically controlled engines. It was also noted that of the multiple accredited sealing agencies, [redacted] seems to be responsible for the sealing of all non-compliant Dutch vessels within the sample. It was noted from the sealing and measurement reports inspected onboard that no attention has been paid by this agency to the electronically stored historical engine performance data, which could have revealed non-compliance in an early stage.

In addition, it was found suspicious that [redacted] engineers have apparently re-sealed critical engine settings (maximum rpm, maximum fuel rack) of multiple inspected vessels shortly after the engine settings had been sealed by a Member State surveyor.

5.7.2. Belgium

The engine settings of both inspected beam trawlers in Belgium had been sealed by an [redacted] surveyor, by means of lead seals applied to the fuel rack (Mitsubishi) and ECM connector (Caterpillar). The number and position of seals had not been documented by the authorities after application, which would have been useful for future reference and control purposes. Broken seals were found and inconsistencies in historical engine data were identified onboard the vessel BE-02.

The project team was informed that between the verification of vessel BE-01, equipped with a Mitsubishi engine, and the date of submission of this report, the engine has been replaced by a Caterpillar C18 engine. It was also mentioned by the surveyor that the engine would be subject to annual electronic verification of its performance history. Although it is unclear what justifies the choice for a C18 (since a Caterpillar C12 type engine can also deliver the licensed 221 kW), scheduled data verification of electronically controlled engines is a sensible verification approach.

5.7.3. Germany

The engine power of the three beam trawlers visited for inspection in Germany were certified by [redacted][85], following a physical power measurement and application of seals [redacted] approved service supplier [redacted]. The subsequently delivered power certificate contains information such as pictures of the applied and the fishing and steaming engine speed for control purposes. The seals in use are better than lead seals (uniquely numbered laminated seals) but susceptible to tampering.

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[84] Uitvoeringsregeling Zeevisserij Art. 87 and related documents / instructions
[85] [redacted]

Electronically controlled Caterpillar 3412E engines were found onboard two of the inspected vessels. The type and serial number of the engine and the serial number of the ECM are documented on the power certificate. This is insufficient to verify the most important engine characteristic for this type of engine; namely the software type and version installed. For at least one engine the extracted historical engine performance data revealed clear evidence of IT manipulation. The external appearance of the engine had been modified substantially (unauthorized addition of wiring, probably a tampering system). The unauthorized wiring is visible on pictures on the power certificate provided by [redacted].

The findings in Germany reconfirm the observation that sealing of components of electronically controlled engines is relatively ineffective, particularly when the (external) communication adapter is not sealed and engine IT systems cannot be read out and analyzed simultaneously with the power verification.

5.7.4. Denmark

The originally targeted number of beam trawlers to be verified in Denmark was two. The conducted physical verification did not reveal non-compliance. The subcontractor's engineer did not have the necessary Scania IT tools at his disposal to investigate the electronic control system. No seals were found on this engine. As discussed in section 5.7, the inspection of the vessel DK-02 was cancelled.

5.7.5. North Sean beam trawlers, general

The large number of vessels in this fleet segment apparently equipped with sophisticated power manipulation systems justifies in-depth investigation of these vessels and their engines to reveal these systems. Important aspects before contracting such an investigation to consider are mandate, responsibility and liability. It could become a time consuming procedure to identify these systems, and it may be necessary to (partly) disassemble engines because systems could be built-in. The verifications have shown that measuring and documenting the vessel's speed (fishing and steaming) at its licensed power during a trial can be used very effectively to identify non-compliance thereafter.

6. Results (III) Assessment of on-going complaints

Businesses, governments and members of the public have the right to file a complaint with the Commission regarding a wide variety of subjects. In case a complaint is within the jurisdiction of the Commission and there are sufficient grounds to do so, the Commission may open a Pilot Case[86] to investigate the allegations. The normal procedure is to inform the respective Member State about the complaint received and request more information. If deemed necessary, the Member State may be requested to investigate the allegations, and to appropriately follow up on the results.

One of the tasks of the project team was to evaluate two Pilot Cases concerning allegations related to engine power of fishing vessels, both opened in 2015. All documentation submitted to the contractor was evaluated to identify strengths and potential weaknesses of the investigations carried out by the respective Member States. It was agreed to conduct four physical engine power verifications on board vessels that belong to the fleet segment subject to the first Pilot Case, and an engine power verification on board the single vessel subject to the second Pilot Case as well.

At a later stage of the study, it became clear that the Commission received information regarding allegedly misreported engine power of Italian pair trawlers operating from the port of Chioggia. Since no documentation or correspondence was shared with the contractor regarding this case, it was not possible to carry out a full scale evaluation. It was agreed to include five pair trawlers that operate from this port into the physical power verification sample.

6.1. Complaint 8091/15/MARE – Spanish Trawlers at the Cantabrian coast

The Commission received multiple complaints concerning Spanish trawlers that allegedly use much more engine power than permitted according to their fishing license. Specific vessels and a specific port were named in these complaints. The legitimacy of this complaint was evaluated as follows:

(1) The available documentation and correspondence concerning the complaints has been reviewed;

(2) Four physical verifications were conducted onboard vessels that are part of the fleet subject to this complaint.

6.1.1. Evaluation of correspondence and steps taken

The complaint (8091/15/MARE) was investigated by the Spanish authorities through data verifications and physical power verifications onboard 12 vessels, contracted to the company [redacted]. The Commission deemed this follow-up satisfactory and no infringements were detected (except one, but the owner of the non-compliant vessel was already in the process of acquiring additional engine power capacity). The associated EU Pilot case was subsequently closed. Analysis and comparison of the verification reports shows that the bulk of the content of each report is a generic explanation of the measurement principle and process, and that only sections 1, 10, 11 and 12 are vessel-specific and thus relevant for further analysis by the contractor. Every report provides an (average) power figure

[86] EU Pilot is the Commission database which organises, following a complaint or in own initiative cases, the contacts between the Commission and Member States, contributing to an efficient solution by which Member States are requested to provide the necessary clarifications, information and remedies, within set deadlines, in order to ensure the correct application of European Union law. When no satisfactory solution is proposed, the Commission takes further action, including through infringement procedures.

as result. Without the following contextual information, the reported power figures have little meaning:

- Activity of the vessel during the test (steaming, fishing);
- Engine speed (rpm) and / or shaft speed (rpm);
- Throttle position;
- Propeller shaft shear modulus (assumption).

Most fishing vessels do not reach their maximum engine power output while steaming. The propeller curve could have been estimated if both engine speed and engine power would have been reported. This would have made the result comparable to power values obtained during a later verification. Above all, omission of the basic context prevents any third party from determining the reason for the power figures being unrealistically low for the engine types installed. The reports contain numerous indications that the rated power of most engines is much higher than measured and registered. These hints were not highlighted in the reports, and no attempt has been made to explain the surprising outcomes. Below listed are some examples of extraordinary results found in the [redacted] reports. In many cases there is a substantial mismatch between the registered engine power and the maximum intake power of the gearbox. This is not an infringement in itself, but highly unusual. At least two engines were originally supplied at a much higher power rating than the engine power stated at the vessel's (current) fishing license. Unless these engines have been permanently de-rated, the engine cannot be compliant with applicable engine power restrictions.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

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[redacted]

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[redacted]

6.1.2. Physical verifications performed by the project team

The physical verifications carried out within the scope of this study onboard four Spanish trawlers operating from Cantabrian ports followed the same procedures as applied throughout the study. The main characteristics of these verifications are that they take place on an unannounced basis, under the authority of the Member State and that a strain gauge system is applied to the shaft to measure power under various operating conditions. To select the target vessels, the project team and the Spanish fishery authorities compared a list of vessels operating in the area that corresponded with the vessel characteristics provided by the complainant. In line with the methodology of this study, the qualifying vessels were ranked based on their power to tonnage ratio. The lowest ranked vessels (that were operative during the verification period, and landed in ports that could reasonably be reached by the team during the available time frame between the vessels' PNO message and the vessel's actual landing) were selected for verification.

The results of these verifications are summarized in figure 22. The measured maximum average power exceeded the licensed power in all cases, by 53% to 198%. These results confirm the allegations made by the complainant.

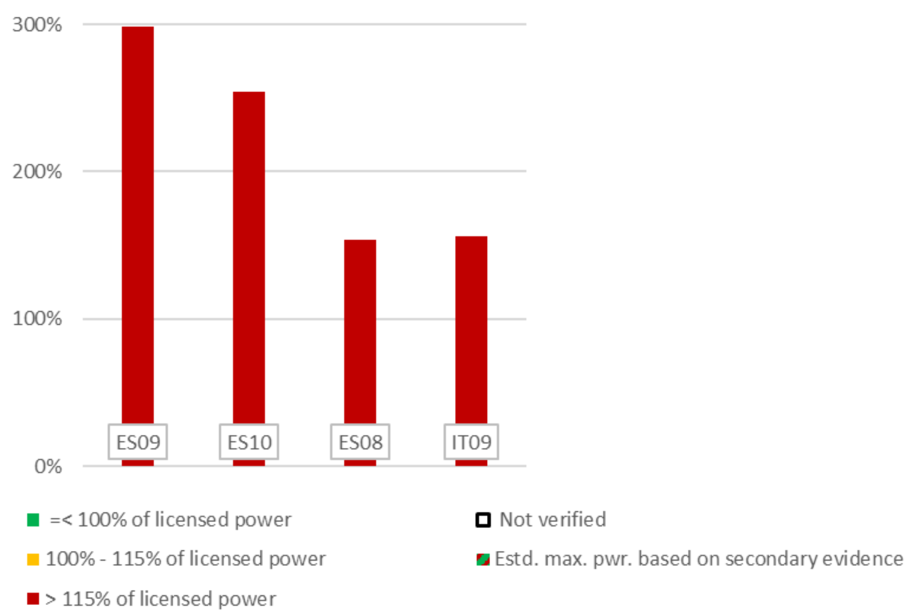

Figure 22. Distribution of physical verification results conducted in the fleet segment Trawlers operating from Cantabrian ports, ordered from high to low measured relative power.

It is unlikely that the remarkable difference between the verifications performed by the project team can be explained by the selection procedure. Most vessels verified by the Spanish authorities and [redacted] in 2017 appeared in this study's selection as well, many of them also qualifying as high risk. Based on the evaluation of the measurement reports provided by the Spanish authorities and the measurement results obtained within the this study, it is very unlikely that 11 of the 12 vessels verified earlier were actually compliant.

Based on the available information it is not possible to determine who is responsible for the unrealistic measurement results that led to the dismissal of the complaint. It is technically possible that the reported power values were actually measured, for example due to one or more of the following (hypothetical) causes:

- The owners were informed in advance and may have applied de-rating techniques;
- The verification was carried out while the vessel was steaming, but not under fishing or pulling conditions;
- The engine was not operated at its maximum speed during the verification;
- The propeller was not at its maximum pitch position during the verification;
- Incorrect steel property assumptions were made.

The contract probably specifies whether [redacted] was contracted on a measure-only basis, or was supposed to deliver a comprehensive assessment of compliance. This case clearly demonstrates the need for a technical framework for physical power verifications performed or contracted by Member States, which at least defines:

- The (minimum) operating conditions of the vessel that must be evaluated (fishing / pulling / steaming) during such a verification;
- The data / parameters that must (at least) be collected during such a verifications;
- The parameters that must (at least) be reported following such a verification;
- Which organization / contract party is responsible for (which part of) the compliance assessment.

6.2. Complaint 8087/15/MARE – Irish Atlantic Pelagic Trawlers

Pilot case 8087/15/MARE, which concerns the alleged discrepancy between the registered and actual power of the Irish flagged Atlantic pelagic trawler [redacted] was evaluated. All documentation made available by the Commission to the project team regarding this complaint has been reviewed. This vessel was constructed in 1998 with a Caterpillar 3608 main engine with a rated output of [redacted] KW. In 2004 it was de-rated to the authorities' satisfaction to [redacted] kW. In response to the complaint submitted to the Commission in 2015, the Irish authorities compared the vessel's speed in 2016 to its speed in 2015 based on AIS data, which did not show indications of non-compliance. Furthermore, the fuel rack setting and sealing were checked by an MSO officer in conjunction with and engine manufacturer's engineer. Seals were found in tact and settings were found unchanged.

The numerous cases of misreported engine power found throughout this study provide clear indications that at least part of the engine supply and maintenance industry is or was facilitating misreporting of engine power. It must be acknowledged that the verification of engine settings of this specific engine type is a specialist task that cannot be expected to be performed by any Member State officer without engineering assistance. At the same time, it has been demonstrated that the application of lead seals do not adequately prevent tampering with engine settings. Taking the above into account, verifications of settings and seals, de facto conducted by engine supply or maintenance engineers, cannot rule out completely that the engine is non-compliant.

Comparing vessel speed data from 2015 to data from 2016 is in this case irrelevant. A useful comparison would have been a comparison between speed data from 2016 to the vessel's speed prior to de-rating (in 2004), to verify that the power decrease has indeed resulted in a substantial drop of maximum steaming speed. It is unclear to the contractor whether a physical shaft power verification was conducted when the de-rating was first accepted by the MSO (in 2004). This would at least have provided a reasonable assurance:

- That the reported engine settings indeed correspond to an output of [redacted] KW;
- Of the vessel speed when steaming at [redacted] kW propulsion power (if reported, not taking the possible effect of propeller characteristics change into account).

Without doubt, the follow up actions of the 2015 complaint should have included a physical verification of engine power, which they did not. Based on the available information, it is not possible to determine whether the applied sealing is (in principle) adequate to prevent the use of excess power.

The project team and the Commission agreed to target the vessel [redacted] during the physical verifications in Ireland, similar to the investigated Spanish and Italian cases. The vessel owner was informed by the authorities further in advance than agreed that an engine power verification would take place on February 4th, 2019 at 16:00. The Member State inspector bearing the necessary mandate and having the required expertise was not present in the port of Killybegs at the agreed date and time. It was observed by the project engineers that the target vessel left port for a very short (few hour) trip that evening. Given the loss of unexpected character of the verification resulting from the failure to inspect the vessel the first time, and expected 'preparation' of the engine for the test, it was decided to cancel this physical verification.

6.3. Italian Pair Trawlers operating from the port of Chioggia

Initially, the analysis of the fleet segment *Italian Pair Trawlers* was outside the scope of this study. The Commission requested to replace part of the sample of 11 vessels that were initially intended to be verified in the Strait of Sicily fleet segment by pair trawlers operating from the port of Chioggia. This request was based on information indicating possible non-compliance in this fleet segment. In conjunction with the Italian authorities it was agreed to modify the sample accordingly and include five pair trawlers that operate in the Chioggia area. No in-depth information regarding the nature of this request was made available to the contractor. Inherently, no analysis of correspondence or previously collected evidence has been done.

The physical verifications onboard these trawlers were performed according to the same procedure as applied during the verifications from Sicilian ports and throughout the study. The main characteristics of these verifications are that they took place on an unannounced basis, under the authority of the Member State and that a strain gauge system was applied to the shaft to measure power under various operating conditions. In line with the other power verifications of this study, the qualifying vessels were ranked based on their power to tonnage ratio. The lowest ranked vessels available were selected for verification.

Figure 23 summarizes the results of the verifications conducted by the project team. Non-compliance was found in all cases. An assessment of the engine arrangement and other characteristics of the vessels and its operation suggest that the reported non-compliance is a significant underestimation of the actual situation. More details of the vessel-specific findings can be found in the individual verification reports enclosed in Appendix I.

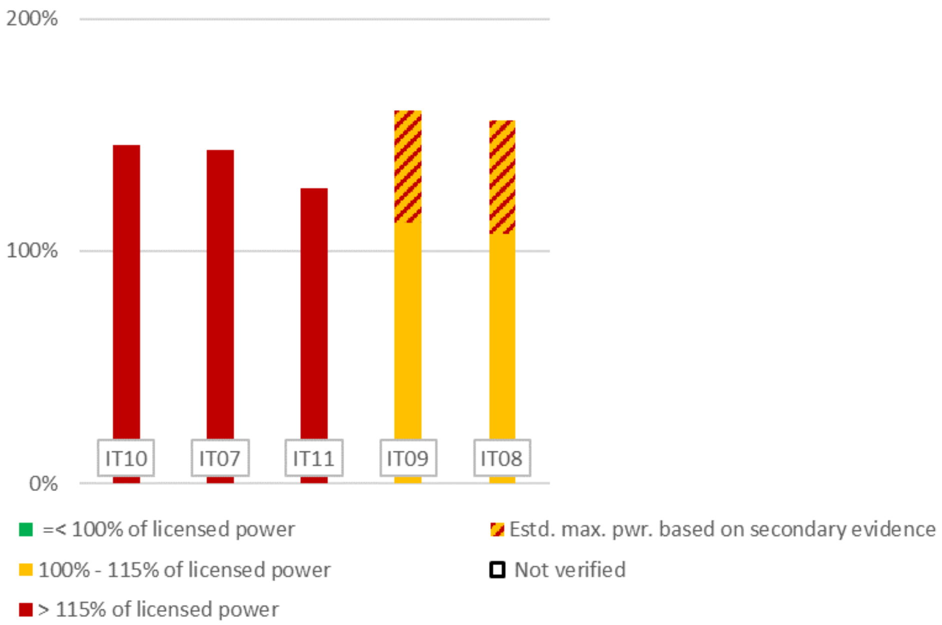

Figure 23. Distribution of physical verification results conducted in the fleet segment ´pair trawlers operating from the ports of Chioggia´, ordered from high to low measured relative power.

7. Evaluation of technical systems to ensure on-going compliance

The only method currently implemented by a number of Member States to ensure compliance with the certification requirement of the Control Regulation that certified engine power is not exceeded is the sealing of engine components. Provided that a sealing-based system is properly implemented, controlled and maintained, it can be particularly useful to ensure on-going compliance of mechanically controlled engines in a conventional directly-driven propulsion arrangement. A system based on the sealing of components is arguably less effective to ensure compliance of vessels with diesel-electric propulsion systems and electronically controlled engines.

It may be expected that the number of fishing vessels equipped with electronically controlled engines will continue to rise, and that more diesel-electric vessels will enter the fishing fleet. Because sealing is less effective for these propulsion systems, the possible alternatives for sealing will be outlined and assessed in this section. Understanding the relative (dis)advantage of each option should contribute to the establishment of an effective engine power control or system for the future. The options that will be assessed are continuous power monitoring, limiting propeller pitch and using electronic engine performance data.

7.1. Continuous power monitoring

It is technically feasible to continuously measure and securely store shaft power data onboard ships. A large number of larger seagoing vessels such as passenger ships are equipped with these systems for performance optimization purposes. Continuous monitoring of shaft power, using a permanently installed measuring device, is incorporated as requirement for specific types of fishing vessels in the draft reform of the Control Regulation. No Member State has adopted this system to date[87]. There are systems using various principles for this purpose, e.g. strain measurement, optical measurement and the application of a torque flange. Two manufacturers[88] have been approached to discuss the technical considerations and to roughly estimate the costs associated with non-invasive (optical and strain) systems. A comparison is provided in table 5. As the price and specifications vary with vessels configuration, the following assumptions underly this comparison:

- Fixed pitch propeller (solid shaft);
- 200 mm external diameter;
- 250 rpm at full load;
- 800 kW at full load;
- Service engineer required for 2 days;
- Service engineer expenses €1000 per vessel;
- Exchange rate (EUR / GBP) is 1,15.

This comparison is based on the commercial version of the instruments, which are not suitable for control purposes without modifications. It should be noted that according to the manufacturer, the strain gauge based system can be modified on request to a shorter version; up to minimum of 95 mm length. It is also possible produce modules suitable for shafts with smaller diameters.

[87] A trial with continuous monitoring of engine power has been conducted in NL. This system was however based on the measurement of charge air pressure and shaft speed, instead of shaft torque and shaft speed. A the time of submission of this report, this system is used on a limited scale in addition to the mandatory sealing of engine settings.

[88] [redacted]

Table 5. Elementary cost-benefit analysis of two continuous power monitoring systems.

	Strain gauge based system	Optical system
Estimated costs (one off)	€ 10.643 *	€ 14.951 *
Maintenance costs (annually, average)	Maintenance free, data needs to be collected.	Maintenance free, data needs to be collected.
Accuracy	0,1 %	< 0,25% F.S.D. on torque
Minimum external shaft diameter	150 mm	100 mm
Dimensions	L: 195 mm D: 306 mm + stator and receiver	L: 344 mm D: 490 ± 30 mm + stator and receiver

General considerations

- Installation is technically not possible onboard every vessel (see: minimum shaft diameter and dimensions);
- System requires power supply, but some types of fishing vessels are from time to time laid up 'dead ship' for extended periods of time. This poses a design / redundancy challenge;
- Data needs to be shared real-time, or as in Art. 35(3) of the Proposed Amended Control Regulation, extracted and analyzed on a regular basis;
- Systems must be sufficiently tested for redundancy and possibilities to tamper with the measuring system and / or recorded data;
- Transmitted data must be sufficiently encrypted.

* These prices are non-binding indications and do not include mounting of receiver stator, brackets, power supply to position etc. (to be arranged by client / shipyard). Prices increase with larger shaft diameters.

7.2. Pitch limitation (Controllable Pitch Propeller only)

As discussed in section 1, shaft power is at a constant shaft speed (rpm) nearly proportionate to propeller pitch in a CPP arrangement. This implies that securely limiting the propeller pitch is a reliable method to limit engine power, provided that the pitch is limited at the maximum engine speed and under loaded conditions (i.e. while fishing). Figure 24 graphically shows this method: the blue line indicates that limiting the maximum pitch at approximately 88% would provide a reliable assurance that the engine will not exceed its hypothetically licensed power of 221 kW, provided that the engine speed cannot be increased above 500 RPM. This implies that the vessel will not be able to reach it’s licensed power while steaming.

It should be noted that if there is any doubt whether the engine is operating at its true maximum speed, the engine speed setting should be blocked and sealed as well to adequately use pitch limitation as engine power control method. The actual pitch control can be either a mechanical or a hydraulic system, and the CPP control layout varies greatly from gearbox to gearbox (type). This means that a gearbox type-specific limitation and sealing instruction needs to be developed to adequately ensure ongoing compliance with power restrictions.

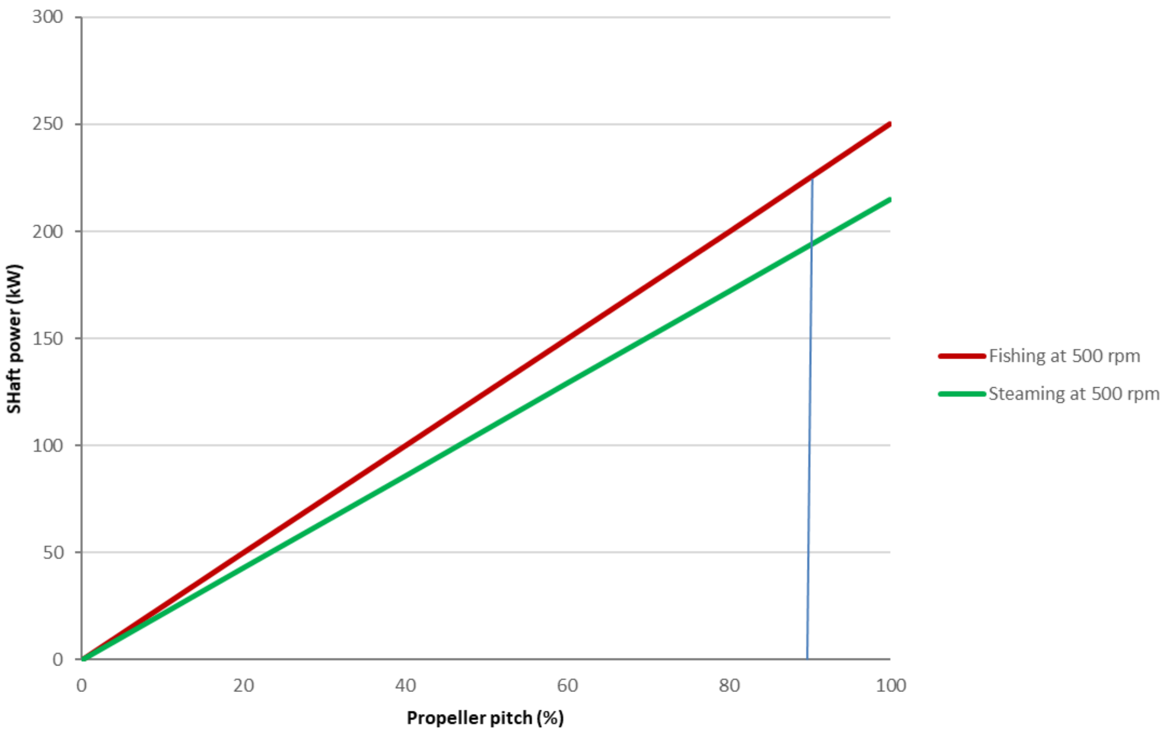

Figure 24. Controllable pitch propeller curve, steaming vs. fishing conditions.

7.3. Use of electronic engine data

A large share of recently installed engines is electronically controlled. Electronic engine control allows for more precise fuel injection timing and injected quantity setting, which for example enables the engine to produce less hazardous emission gasses at a given level of power output. Electronic engine control requires a lot of sensing data to feed the IT system. Many electronically controlled engines do not only use performance data for engine control purposes, but also record, process and store them internally. This type of data is sometimes referred to as historical engine performance data.

This dataset typically contains the following information, which could potentially be used for engine power control purposes:

- Engine revolutionary speed (rpm) vs. time. If it is known that the engine produces the certified amount of power at a certain engine speed (while steaming), and the engine control system reveals that the engine has been operating at a higher engine speed, this implies non-compliance;

- The engine load factor vs. time. The load factor is normally a percentage of the nominal load, which is thus proportionate to engine power. If the load factor histogram shows that the engine has been operating at a load factor that corresponds with a non-compliant power level, this is an indication of non-compliance.

Electronic engine data can only be used for verification purposes if the following prerequisites are met:

- Sufficiently useful engine performance data must be stored internally in the engine control IT system, and this data set needs to be downloadable on board (without disassembly of the controlling computer). This may imply that not all electronically controlled engines are eligible for this type of control;

- The authorities or contracted controlling agencies must be able to connect to the IT system and extract all relevant data without the need for an engine manufacturer, dealer of maintenance company to facilitate this. In practice this means that the inspector must have all necessary IT tools at his disposal (software, license, connectors) to extract this type of data;

- The IT system must provide the inspector with sufficient certainty that the control module has not been exchanged during the engine's service life, the engine settings have not been modified or manipulated and the data is interpreted correctly;

- This verification methodology requires recurring analysis of performance data to ensure on-going compliance;

- At least once the engine performance data (digitally stored in IT system) should be validated against a physical shaft power verification to ensure compliance and correct interpretation of the historical engine performance data.

7.4. Diesel-electric propulsion

Diesel-electric propulsion is a system in which the propulsion power of the propeller shaft(s) is generated by one or more electric motors. The electric power is generated by one or more diesel generators, and the arrangement may include a battery system. The main advantage of a diesel-electric system compared to conventional diesel-direct propulsion is that the flexible use of engines and power storage allows the system to operate at a higher efficiency, resulting in a reduction of operational costs and environmental impact. The disadvantage is that the traditional verification and control of maximum power is not very effective. It is for surveyors and inspectors nearly impossible to determine the true maximum output of the electric motors and to effectively restrict the software controlling these motors.

The only reliable system to verify compliance of fishing vessels equipped with diesel-electric propulsion with engine power legislation is a system that involves continuous engine power monitoring. Currently, the number of fishing vessels equipped with diesel-electric propulsion is small, but more vessels may be expected to be added to the fleet in the future.

8. Conclusions

Engine power as indicator of fishing effort

The fishing fleet size of Member States of the European Union is defined in terms of tonnage and engine power. In addition, units fishing effort defined as *kW * fishing days* are allocated to certain fleets or vessels through fishing effort regimes in order to manage fisheries sustainably. Correct declaration and registration of tonnage and engine power is therefore essential from an environmental perspective and to ensure a level playing field between competing fishermen.

In the context of the management of fishing capacity of fleets, engine power is a logical parameter that cannot easily be replaced. If the fisheries management choice is made to maintain or establish effort regimes and / or hybrid effort and TAC systems, engine power should arguably remain part of the effort calculation. Engine power contributes to fishing power, despite the fact that its relative contribution to effective fishing effort may not be equal across different fishing typologies. Inclusion of more variables in the fishing effort calculation could improve the effectiveness of fishing effort regimes.

Although the strength of the relation between engine power and fishing effort may sometimes be disputed, the widespread misreporting of engine power found within this study could be interpreted as evidence of the existence of such a relation.

Compliance

The physical engine power verifications conducted onboard 68 fishing vessels across 14 Member States showed that misreporting of engine power is a widespread phenomenon within the sample.

Effectiveness of certification by Member States

The fact that non-compliance was found in almost every Member State and in every investigated fleet segment (Mediterranean bottom otter trawlers, North Sea beam trawlers, Baltic mid-water otter trawlers, Atlantic pelagic trawlers and deep sea long liners) indicates that the current systems of certification as implemented by Member States do in general not effectively meet their objective to 'ensure that the certified engine power is not exceeded' (Control Regulation, Art. 39 (2)).

In every Member State within the scope of this study, the governmental department that is responsible for implementation and enforcement of the Control Regulation ('fisheries authority') has delegated its engine power certification tasks following from the Control Regulation (Art. 39) to another body. In some Member States this is another governmental organization, while in other Member States certification duties are delegated to one or more Classification Societies.

It was found that classification societies [redacted] (in Italy) and [redacted] (in France and Italy) seem to systematically supply engine (power) certificates of which the stated engine power does not necessarily correspond with the maximum power that can in practise be obtained from the engine. This is particularly worrying because classification societies are generally regarded as competent and honourable bodies within the marine industry, responsible for a wide range of certification duties. Based on the information collected within this study, it is not possible to determine with certainty why the power values certified by classification societies do in many cases not reflect the actual situation. It could be that classification rely heavily on attestations from engine suppliers, that may in some cases not describe the true situation. If a classification society surveyor has in fact attended a test bed trial or onboard shaft power verification of a de-rated engine, and bases the vessel's certified engine power thereon, no measures seem to have been taken to prevent post-verification alteration of settings. If such measures were taken after all, they have not been properly documented and made available to Member States' fishery inspectors for inspection purposes.

Also the governmental survey organizations in those Member States that have not delegated certification duties to a classification society rely heavily on declarations from the engine maker and in applicable cases on de-rating measured applied by engine suppliers. Exceptions are Germany, Poland and the Netherlands, where power verification measurements are a standard procedure within the certification process for (almost) every fishing vessel.

<u>Effectiveness of verification by Member States</u>

The Control Regulation (Art. 41) and the Commission Implementing Regulation (Art. 62 and 63) require Member States to implement a system to verify the accuracy of registered engine power. This system is a three-stage process:

(1) The entire fleet is subject to a risk assessment. A sample of each vessel that meets at least one of the criteria listed in Art. 62 of the Commission Implementing Regulation must be subject to a data verification.

(2) Art. 41 of the Control Regulation provides the minimum set of aspects that must be incorporated in the data verification of each vessel identified in step one. The purpose of this analysis is to identify vessels that potentially operate with higher engine power than certified;

(3) The vessels identified in step two as potentially non-compliant must be subject to a physical power verification.

Examination of the verification systems implemented by the Member States within the scope of this study showed that some Member States have fully implemented the system, while other Member States have not (yet) implemented a system at all. Some Member States have implemented this system on a once-off basis, while others have implemented it on the basis of recurring verification rounds. Only one Member State (Spain) proceeded to physical verifications in the period under investigation following the data verifications during the investigated time frame from 2012 till 2017. Only Spain and The Netherlands have identified misreported engine power during this period (13 cases).

It should be considered that all fishing vessels subject to the power certification and verification requirements in Art. 40 and 41 in Germany and the Netherlands undergo onboard power measurements as part of the certification process when the vessel is commissioned and after engine maintenance has been conducted that requires the removal of seals. Fishing vessels with de-rated engines are subject to a physical engine power measurement as part of the certification process when a new engine is installed In Poland.

Because many more cases of misreported engine power were revealed within this study than by the aggregated verification efforts of 15 Member States during 6 years combined, it can only be concluded that the data verifications carried out by Member States did in general not effectively identify vessels that should have been subject to a physical engine power verifications. The fact that the verification system laid down in the Commission Implementing Regulation has not been fully implemented in every Member States has presumably contributed to the low success rate.

Complaints

In the context of this study, two (closed) pilot cases regarding alleged under-declaration of engine power were investigated. In one case the allegations were made against an entire fleet segment in Spain, while in the other case an allegation was made against a single vessel in Ireland. Power verifications were conducted during this study to investigate compliance of the respective Spanish fleet segment. These verifications found several cases of non-compliance of substantial magnitude. The physical power verification on board the Irish vessel was cancelled for reasons discussed in section 6.2, but based on the evaluation of the correspondence between the Irish authorities and the Commission, the project team is not convinced that the investigations conducted by the Member State provided sufficient basis to dismiss the allegations against that vessel.

For the faith of the public in Member State authorities and the Commission, it is very important that substantiated complaints are evaluated with the greatest care, and that appropriate follow-up steps are taken. It is primarily the responsibility of the Member State to follow-up these engine power-related complaints, and to provide the Commission with evidence that the complaint has been investigated and appropriate actions have been taken. In both evaluated cases discussed above, it can only be concluded that the investigation efforts of the Member States were insufficient and / or inadequate attempts to assess the allegations.

Notable identified shortcomings of the submitted evidence regarding the power verifications conducted in Spain are the absence of sea trial context, measuring accuracy and assumptions made, which resulted in highly unlikely measurement results being reported. The Irish authorities failed to conduct a physical shaft power verification on board the vessel subject to the complaint, which would at least have provided assurance that the registered engine settings correspond with the certified engine output and would have provided a basis for future vessel speed evaluation.

8.1. General recommendations

8.1.1. Initial compliance and certification

Recommendation (1): Certification

After the Control Regulation entered into force, the Commission opened 16 pilot cases to ensure full and adequate implementation of Art. 40 and 41. All Member States concerned except Sweden replied that an existing certificate fulfilled the certification requirements of engine power laid down in the Control Regulation (Art. 40). Sweden stated that it was developing a power certification system that was expected to be implemented in 2013. The subsequent closure of all 16 pilot cases could be regarded as consensus between the Member States and the Commission that the existing certificates referred to by the Member States indeed meet the Control Regulation requirements. The layout and specifications of these certificates (referred to as certificate of class, seaworthiness certificate, etc.) are not fully harmonized among Member States, and do not necessarily explicitly state *maximum continuous* engine power – in most Member States just engine power.

Since the measured maximum engine power during the physical verifications of this study did in many cases exceed the maximum engine power licensed to the concerning vessel, it is recommended to adapt the certificates that are currently used to make them comply with the Control Regulation (Art. 39 and 40), or to introduce an additional certificate. This certificate should unambiguously state the *maximum* power that can be obtained as intended by the Control Regulation. In addition the adjective *continuous* does not really add value in the Control Regulation context, since it is not possible to verify whether maximum engine power is truly continuous during a physical verification, and the intermittent use of excessive power also affects a vessel´s fishing capacity.

In addition, the ‘engine power certificate’ should specify whether the declared maximum power output is the maximum output of the *engine type* under consideration, or that any form of de-rating has been applied to ensure compliance. In case the engine has been de-rated, all measures taken to prevent unauthorized reversal of de-rating should be listed on the ‘engine power certificate’ to facilitate adequate control (whether the engine is still in its compliant, de-rated, condition) at a later point in time. The documented details should include, if applicable and possible, verifiable engine settings, verifiable software details, and verifiable sealing details.

Recommendation (2): Improve the (legislative) definition of de-rating

De-rating in the context of engine power is the reduction of maximum engine power without major conversions (e.g. the change of engine settings). The existing rules do however not specify that the ‘original’ rating in the context of de-rating is the maximum power output of the engine *type*. In other words, if an intrinsically powerful engine is supplied by the engine dealer or manufacturer at a low power rating that corresponds to the power stated at the vessel´s fishing license, it may juridically not be de-rated (but could potentially deliver much more power when settings are changed). This is particularly relevant in the context of effort regimes in the Plaice Box and the 12 mile zone around the UK and Ireland[89], where the original rating of engines (de-rated to 221 kW) is not allowed to exceed 300 kW. Within this study, the engines found onboard vessels subject to these effort regimes were without exception capable of delivering more than 300 kW without major conversions.

As will be discussed in section 8.1.2, engines that are not de-rated do arguably not need technical measures to ensure on-going compliance (since these engines cannot produce more power than permitted according to the vessel’s fishing license). This of course only applies when ‘not de-rated’ means that the engine operates at its true maximum capacity, instead of being a powerful engine advertised at an already de-rated output (which could potentially be reversed).

Recommendation (3): Increase reliability of declared power values

It was found that the incorrect certification and registration of engine power by Member States’ competent authorities is to a large extent based on other certificates and declarations submitted by fishing vessel operators, actors within the engine industry (engine dealers and maintenance organizations), classification societies and third parties, that do not accurately or truthfully describe the engines, including their maximum continuous power, as installed onboard.

To increase the reliability of declared power values, it is recommended to draw the Member State authorities’ attention to their responsibility to reasonably assure that a certified engine will not be operated at a greater power than certified, which directly follows from the Control Regulation (Art. 39). In practise this implies that either a Member State inspector, or a qualified representative of a third party bearing delegated authority to issue such a certificate, must for every engine to be newly installed attend the test bed trial and ensure that the brake load is increased above the certified power of the engine and that the engine responds correctly (i.e. that the licensed power is not exceeded). The operational parameters, in particular physically and electronically verifiable values, must be documented in detail when the engine is running at its certified maximum power and corresponding

[89] OJ L 125, 27.4.98, p. 1- 36. Council Regulation (EC) No 850/98 of 30 March 1998, for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31998R0850&rid=1

speed. In case physical or electronic barriers that need to be sealed are applied in order to de-rate the engine, these barriers should be applied and sealed immediately after the test.

If no test bed trial as described above can be conducted, a shaft power verification should be conducted after installation of the new engine onboard. The operational parameters, in particular physically and electronically verifiable values, must be documented in detail when the engine is running at its certified power and speed. In case physical or electronic barriers are applied to de-rate the engine which require sealing, these barriers should be applied and sealed immediately after the sea trial.

Recommendation (4): Eliminate the risk of excessive non-compliance for new engines

It was found that in several cases, the discrepancy between the registered power and measured power was very large. From the rationale behind the use of engine power as one of the parameters to define fishing effort, it follows that the ecological and economic impact of the use of excess power is to a certain extent proportionate to the magnitude of excess power. It is recommended to develop legislation that prevents the installation of very powerful engines, relative to the vessel's licensed power.

The Italian authorities stated that operators are not allowed to install an engine type, if the engine manufacturer's product range includes a less powerful engine model that also equals or exceeds the vessel's licensed power. This system could not be examined in detail during this study, but the described principle could potentially reduce the risk of large-impact infringements.

It is strongly recommended to embed the least powerful engine selection principle in legislation and to establish a working group to map the product ranges of engine models and configurations found onboard fishing vessels according to their maximum continuous output. This working group should involve or consult engine manufacturers and independent experts. The resulting document may serve as validated reference for Member States in their individual engine admission decision. The use of a single reference is expected to boost harmonization of admission criteria of (new) engines among Member States. This reference document should be updated on a regular basis to include updated power ratings and the introduction of new engine models. This will not only contribute to increased compliance with the Control Regulation, but also with NOx emission requirements and national regulations that restrict the maximum permissible de-rating.

8.1.2. Ensuring on-going compliance and verification

The non-compliance rate found during this study's physical power verifications highlights the undeniable need to adapt the existing legislation and the procedures that are currently applied by Member States, to ensure compliance of individual vessels with certified engine power throughout the service life of the vessel. To achieve this, the Commission proposed to install continuous power measurement and logging systems at the propeller shafts of a large number of vessels equipped with active gear.

For certain vessels, this is technically possible and, provided that the system is sufficiently redundant, could indeed ensure a higher level of compliance than any other technical measure. The following considerations must be taken into account:

- Depending on the technical specifications of the system to be installed, introducing the system on the scale as proposed would require a significant investment (given the estimated cost of EUR 11.000 to EUR 15.000 per vessel);

- Systematic data extraction and analysis is required to actually increase compliance. More and specifically trained inspectors will be required to achieve this;

- Systems need to be able to sustain the harsh environment they will be installed in. In particular smaller vessels, with power interruption during layup periods, could be challenging.

- It is not technically possible to install a power measurement system on every vessel. Especially small vessels will be challenging, since there is a minimum shaft diameter, and a certain minimum length of shaft needs to be available for installation in addition to a minimum space surrounding the shaft.

Vessels with diesel-electric propulsion systems, and vessels with diesel-direct propulsion *with* electronically controlled engines but *without* the option of reliable data monitoring can currently not effectively be controlled with regards to their compliance with engine power legislation. These vessels should thus be prioritized when implementing continuous monitoring systems.

Since a continuous shaft power measurement device cannot be installed on every engine, it is necessary to consider alternative measures to ensure on-going compliance of vessels that cannot be equipped with a continuous monitoring system. The following methods were identified in practise:

- Limiting propeller pitch
- Evaluation of electronic engine data
- Sealing critical engine settings

Which power verification option can actually be applied is propulsion system-specific. Figure 25 shows the available options to ensure on-going compliance. In most cases, this provides the policy maker with a choice between either continuous monitoring or one or more of the alternatives. This choice is based on the assumption that at least one continuous monitoring will be found fit for purpose and approved by the authorities in the future. Technical considerations regarding continuous monitoring were discussed in section 4.4.1 and more detailed recommendations regarding the alternative control measures will be discussed hereafter.

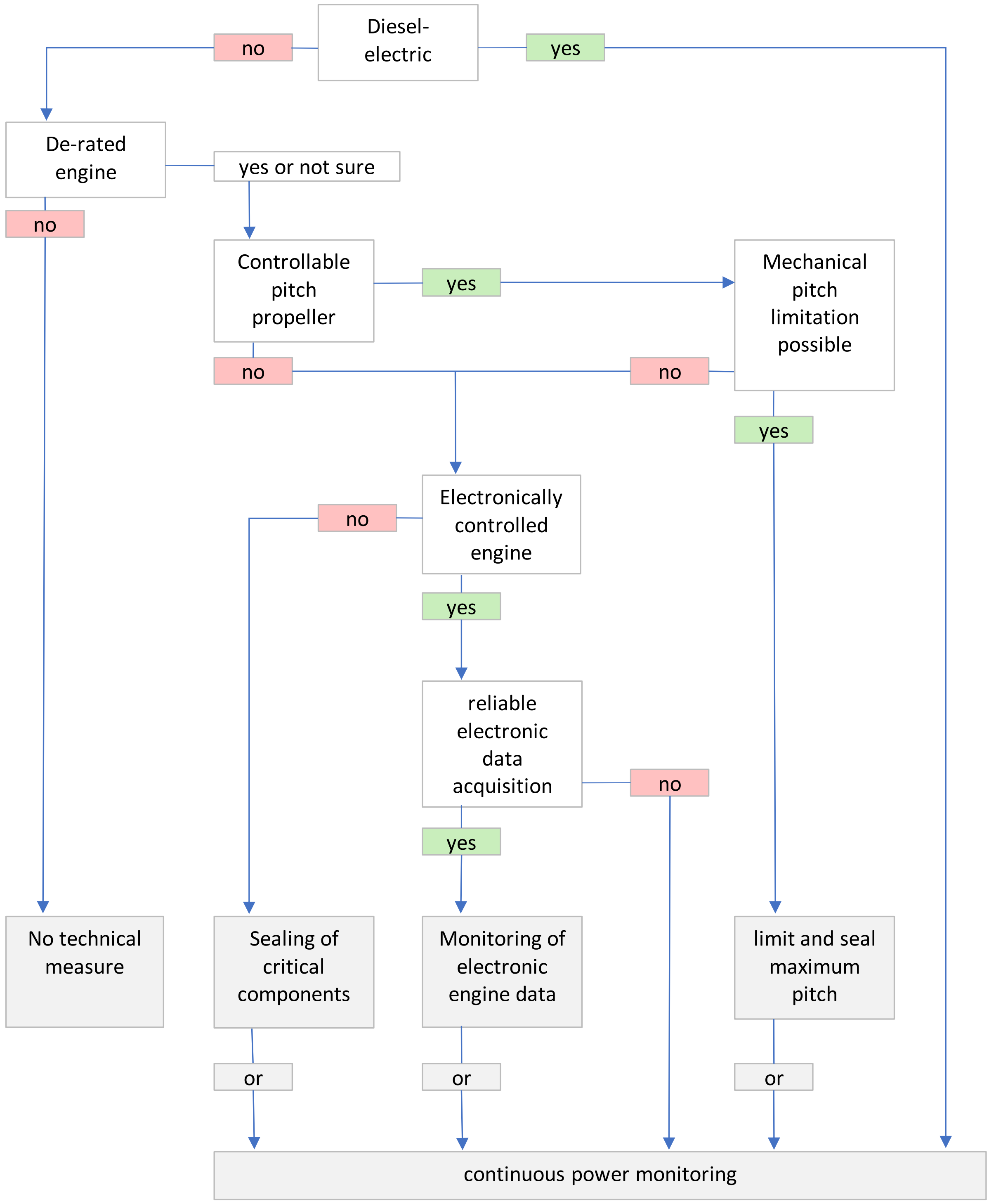

Figure 25. Available options to ensure on-going compliance with engine power restrictions.

Recommendation (5): Considerations when applying pitch limitation

Only propulsion systems featuring a controllable pitch propeller are suitable for the application of pitch limitation as propulsion power control measure. The principal characteristics of controllable pitch have been discussed in section 1 of this report. The maximum permissible pitch should be determined through a physical power measurement at the propeller shaft, while the engine runs at nominal speed and the vessel is fishing or simulating fishing activity. When applying this method, is must be assured that the maximum engine speed (rpm) cannot be increased once the propeller pitch is securely limited.

In practise this means that the maximum engine speed setting should preferably be sealed (even if the engine is operated at its supposed maximum speed) and a gearbox type-specific pitch limitation system must be developed. No pitch-limited vessels were encountered during this study, but it is known that several vessels in The Netherlands have pitch-based power limitation. It is strongly recommended to involve the CPP gearbox manufacturer to determine on a type-by-type basis whether and how the pitch can be limited, and to harmonize the permittable methods per gearbox type across Member States.

Recommendation (6): Considerations when applying the use of electronic engine data

The number of electronically controlled engines found onboard fishing vessels is rising steadily. For those vessels not equipped with continuous propeller shaft power monitoring, or with propeller pitch limitation measures, electronic engine data could be used to control compliance with engine power restrictions. This option is important to consider, because sealing of components of electronically controlled engines to prevent alteration of engine settings is far less reliable and more complicated than the sealing of components of mechanically controlled engines, which will be discussed hereafter. The 'data' meant in this context are for example the historic operating conditions *revolutionary speed* (rpm) and *load factor* (% of rated power) vs. time (example format: 31% of total running hours between 55% and 60% load factor). Not all electronically controlled engine types store these data.

At several occasions within this study it was found that the electronic engine control characteristics did not correspond with the declared characteristics and / or there were strong indications that the operator could change the engine control settings, or switch between different control computers. This shows that either fishermen have substantial in-depth understanding of electronic engine control systems, and the IT tools to manipulate them at their disposal, or there is collusion between parties within the engine industry and the fishing industry, or both.

In case the use of electronic engine data is considered for the control of engine power, the following should be considered:

- Not every electronically controlled engine stores sufficient parameters (vs. total operational time). It must at least be possible derive from the extracted data for how long during its entire service life the engine has been operated at a certain shaft speed. It must also be possible to derive at which power or load (factor) it has been operating. The engine manufacturer, or an engine dealer, should demonstrate for each engine type to the authorities that sufficient performance data can be extracted to facilitate efficient and reliable power control.

- It must for each engine subject to electronic engine data analysis as control measure be possible to verify whether another computer has governed the engine. For example through verification of running hours of the control computer against the running hours of engine. In case an engine control computer needs to be changed for maintenance reasons, this should be communicated to the competent authorities without delay.

- Performance data should be extracted, stored and evaluated on regular basis, for example once per year. Given the suspected collusion between the fishing sector and the engine industry, it is strongly recommended to exclude the engine supply and maintenance sector from these verification tasks. For this reason, it is recommended to only grant permission to apply engine performance data based control to those engine *types* of which the manufacturer or distributor formally agrees to full cooperation. This includes:

  - Providing a certain minimum number of IT and specialist tools to the competent authorities and independent accredited inspection companies;

  - Provide the authorities' and third party engineers with sufficient training and practise opportunity to efficiently and reliably collect and evaluate the required data.

- It is recommended to develop a verification work instruction for every electronically controlled engine type that may be subject to an electronic engine performance data control scheme. This document should contain technical procedures, the exact data series to be collected and the recommended way to analyse them. It is strongly recommended to harmonize this type of verification procedure among Member States.

- The correctness of initial electronic settings should be verified during a sea trial featuring a physical power verification at least once. During this sea trial, the vessels speed should be documented. This enables the competent authorities to identify a possible unauthorized change of setting in an early stage, through comparison of the vessels speed at correct engine settings with later VMS or AIS data.

Recommendation (7): Considerations when applying the sealing of engine control components

The method of 'sealing' is widely used to prevent physical alterations to a certain components, such as twisting a screw or opening a cover. As discussed in section 4.3, the current practise of sealing components related to engine (power) control varies greatly between Member States. The vessel inspections conducted within the context of this study show that sealing of mechanically controlled, de-rated engines *can* be effective, provided that both the sealing process and the subsequent verifications are of sufficiently high quality. In the current situation, this is not the case in most Member States.

In most Member States, sealing of engine settings is the domain of engine suppliers. Based on the observations made during this study, it is obvious that onboard several vessels mechanical or electronic systems are in place to manipulate the output of mechanically controlled engines. In these cases, the engine is temporarily de-rated by a hidden technical system during the physical verification. Based on for example the obtained speed before and after the verification, compared to the vessel speed during the verification, it is certain that this de-rating is indeed reversible. Given the scale of this illegal manipulation and the technical complexity of engine control, it is unlikely that these systems are developed without assistance from the engine supply or maintenance sectors. It is therefore, similar to electronically controlled engines, recommended to assign sealing tasks of mechanically controlled engines to competent authorities or independent, accredited parties.

Before discussing the engine-related technical considerations, the following generic considerations should be addressed:

- The most practical seal type to seal engine components is a so called wire seal. ISO 17712 provides standards for sealing of transport containers. The security wire seals that meet ISO 17712 requirements are not suitable for sealing of engine components, because the high security wire seal has a too thick (3,25 mm) wire. All other requirements could however be adopted in the fishing vessel engine context, notably:

    - Redundancy requirements;
    - Unique numbering / marking;
    - Tampering indication.

  At this moment only The Netherlands demand the use of seals that meet these criteria. Also in Germany uniquely numbered seals are applied, although it is known that the type in use is not 100% tamper resistant.

  In all other member states, only the traditional lead seal was encountered (a wire, closed by a pressed lead disk). This type of seal is very susceptible to fraud, because it can easily be duplicated (no unique numbering). It is recommended to require at least the use of uniquely numbered seals that are sufficiently tamper resistant, when they are supposed to prevent unauthorized actions.

- It was observed during this study that onboard most vessels where seals were applied, the inspectors did not have information available with the number (if applicable) and location of seals, and their external marking or appearance. This makes efficient control of seals impossible. It is recommended, for every engine power related seal, to document:

    - The position of the seal;
    - The external marking of the seal;
    - (recommended) a picture of the seal as applied.

  The sealing of the entire propulsion system should be bundled and subsequently stored both on board and at the competent authorities' office. Ideally, this information should be shared among Member States to encourage and facilitate the control of foreign flagged vessels.

In addition to the variety of seal types used by Member States and the lack of registration of applied seals, there is no consensus among Member States about which engine components should be sealed, and how re-sealing and verification should take place. The elementary principles of (mechanical) engine control were discussed in section 1.3, showing that both fuel rack and engine speed must be controlled to effectively limit power. In reality, there is are numerous speed control and fuel pump and control devices, in many configurations. It is therefore inevitable that sealing instructions are designed on an engine type-specific basis.

The following (sealing) systems were encountered in the visited Member States:

- Sealing by the authority's inspector, to the inspector's satisfaction;
- Sealing by the engine supplier, to the supplier's satisfaction;
- Sealing by a third party to the third party's satisfaction;
- Sealing by a third party in accordance with the authorities' instructions;
- No sealing at all.

In the current situation, it occurs that one Member State requires the application of ten or more seals, while another Member State's competent authority is satisfied with only one or two seals on the same engine type, or no seal at all. Depending on the role of sealing in the future legislation (also depending on the uptake of continuous monitoring systems), it is recommended to develop for each engine type a 'recommended sealing guide' to assist authorities with the implementation of a more reliable and harmonized sealing methodology and to avoid double work for Member States. The development of these sealing guides could be integrated with the recommendation to map the maximum engine power and speed of the product ranges of engine brands that are found or to be found onboard fishing vessels, in order to increase reliability of declared power (recommendation nr. 4).

Although sealing may be preferred over continuous engine power monitoring in certain cases, for example because it is more cost efficient than continuous monitoring and still relatively reliable, the method as such is more susceptible to fraud than continuous monitoring. It is therefore recommended to physically verify the engine power of every de-rated engine at least once during a sea trial, to obtain an indication of the vessel's steaming and fishing speed. If a vessel's operational speed is systematically higher, the authorities should proceed to a check of the applied seals. If all seals are in good shape, the authorities should proceed to a physical re-verification. If the vessels appears to be de-rated during this verification, which follows from the vessel speed, the authorities should proceed to installation of a continuous monitoring devise or start a semi-continuous monitoring trial (during which removable equipment is placed on board to continuously measure shaft power for example for the duration of several weeks or months).

Finally it is important to consider that it is inevitable that seals will be broken during the service life of the engine, for example in order to conduct maintenance. If a relatively large number of the applied seals is broken, or one of the most critical seals, the only option to ensure ongoing compliance is to re-measure the engine power and subsequently re-seal the engine components.

8.1.3. Improving the power verification methodology

The current Control Regulation and Commission Implementation Regulation require Member State authorities to conduct a number of two-step verifications. As presented in section 4.5, this requirement has in most Member States not been implemented very effectively. How the verification regimes could be improved, depends on the adoption of (new) control and verification measures.

<u>Scenario 1. Installation of continuous monitoring devices on all fishing vessels</u>

If all fishing vessels, or a very large share of the fishing fleet, will be equipped with continuous power monitoring systems, the focus of control should naturally be on the extracted power data, possibly in conjunction with the evaluation of vessel speed data. There is no need for complex risk analyses or one-off power verifications targeting vessels equipped with continuous power measurement devices.

Scenario 2. The control mix contains continuous monitoring, sealing of engines and gearboxes (CPP) and the evaluation of electronic engine performance data.

In this scenario, all vessels are equipped with one of the systems that are suitable to control engine power. The focus of control should naturally be on extraction of power data and engine performance data, in conjunction with analysis of vessel speed. Vessels equipped with sealed engines and gearboxes should be visited for unannounced checks of the presence of seals. If the suggested procedures have been followed, all vessels with de-rated engines will have been physically verified at least once. Re-measurement of engine power is still necessary in case the seals of a mechanically controlled engine in a vessel that is not equipped with a continuous shaft power monitoring device are found broken, or non-compliance is suspected. For vessels equipped with a continuous monitoring system or with an electronically controlled engine subject to an electronic engine data control scheme, a (new) physical verification is only of any value to eliminate doubt and investigate suspected fraud, for example resulting from the vessel speed evaluation.

Scenario 3. Continuous monitoring devices will not be installed, or on a small number of vessels, or at a slow pace and no reliable alternative such as high quality sealing is implemented.

In this scenario, the reliability of certified and registered power values will not improve and it should be anticipated that non-compliance remains widespread. To still generate an incentive to improve compliance under these circumstances, it is recommended to drastically increase the number of physical power verifications. Provided that these verifications take place unannounced by honourable and competent organizations, and infringements are sanctioned accordingly, the increased chance of exposure may generate an incentive for fishermen to make their vessel compliant with applicable engine power restrictions, which may lead to a higher compliance rate.

In scenario 3, it will remain necessary to conduct unannounced (physical) power verifications. In scenarios 1 and 2, the need for such verifications would eventually (almost) disappear, since the actual power of every vessel has been verified and measures will be taken to ensure on-going compliance. Also in scenarios 1 and 2, it is likely that there will be a lengthy transit period before all vessels are compliant, during which the actual capacity of the engine is unknown and engine power verifications should be conducted.

Recommendation (8): Increased number of physical verifications of engine power

In case verifications of engine power as currently described in the Control Regulation (Art. 41) and the Commission Implementing Regulation (Art. 62 and 63) remain part of the control system, it is recommended to replace the currently prescribed minimum number of data verifications by a minimum number of physical verifications (proportionate to fleet size). The selection of vessels could be based on a simple risk-assessment, indications of non-compliance, a random selection or a combination. An increased number of physical verifications conducted by Member States is likely to result in more cases of identified non-compliance (which could provide an incentive for operators to declare their engine power correctly), which will provide the authorities with a better understanding of the magnitude of the problem across the various fishing fleets.

It is also recommended to require the verification of engine power of fishing vessels from other Member States. The minimum number of foreign fishing vessels to be verified annually should be proportionate to the number of foreign vessels landing in the member state and the maximum number should be proportionate to the number of domestic power verifications. It is expected that this system of cross-checks contributes to harmonization of power limiting measures across Member States and to ensure that vessels that usually land in a Member State other than their homeport do not escape control.

Recommendation (9): Improved specifications of physical verification of engine power

As discussed in section 6.1, the Spanish competent authorities contracted an organization to conduct 12 physical shaft power verifications. The submitted reports contain highly unlikely power values and insufficient details to reproduce the verifications or assess their credibility. Also the power verification reports found onboard German and Dutch vessels contained in many cases insufficient information to reproduce and assess the verification. It is recommended to establish guiding principles for Member States and their contractors to ensure a certain minimum quality level and scope of physical power verifications. These guiding principles should require documentation of at least:

- Engine particulars:
    - Engine type;
    - Engine serial number;
    - Engine rated power / speed;
    - Engine software details (if applicable);
    - Engine performance history (if available).

- Gearbox particulars:
    - Gearbox type
    - Gearbox serial number;
    - Gearbox reduction ratio.

- Operating conditions of the vessel:
    - Steaming / pulling / fishing;
    - Speed / course / water depth.

- Operating conditions of the engine (if available):
    - Engine speed (rpm);
    - Throttle position;
    - Pitch position;
    - Boost pressure;
    - Exhaust gas temperature;
    - Fuel rack setting;
    - Load factor.

- Measurement system and assumptions:
    - Shaft external diameter;
    - Shaft internal diameter;
    - Shaft material shear modulus.

The recorded vessel speed (ideally: fishing and steaming, compensated for tidal effects at licensed maximum engine power) should be compared regularly to vessel speed data received via the VMS system. A substantial and consistent increase of vessel speed compared to the test data should lead to further investigation. An option to consider for these vessels is the application of a long term measurement removable power verification kit (e.g. 30 day continuous monitoring by means of a removable system).

Recommendation (10) Increase the empowerment of inspectors

In the view of several Member State authorities and their inspectors, the current legal basis to conduct unannounced physical power verifications, particularly when the vessels to be inspected are selected by a third party, is insufficient. Although the Commission disputed that this is the case, it contributed to delay of the verification works within this study and affected the verification effectiveness in general. Based on the feedback received during the meetings with Member States authorities and the experience during the vessel inspections, it could contribute to the efficiency of future verifications to include the following provisions in the Control Regulations:

- Inspectors have the right to select any fishing vessel of their choice for an unannounced physical power verification;
- Inspectors should not select the same vessel for verification twice within 24 months unless there are indications of non-compliance;
- Vessel operators should be obliged to facilitate a physical verification of engine power;
- Facilitation of inspection includes that the vessel is accessible for the installation of equipment and ready to undergo the necessary trials for up to eight consecutive hours from the moment the inspection is announced;
- During the verification the vessel must be operable and if required, the gear must be deployed;
- It is required to run the engine to its maximum power for the duration of time that is to the satisfaction of the inspector.

The last provision is of particular importance because in multiple cases, vessel operators refused to increase the engine speed or propeller pitch above a certain threshold for alleged safety reasons. It is however unacceptable if a marine engine cannot be operated to its full potential, and probably non-compliant with statutory requirements.

Recommendation (11): Increase the level of expertise among inspectors

Adequate control of engine power requires significant technical understanding of engines and propulsion systems from inspectors and policy makers. It is widely acknowledged that the current level of expertise of most fisheries inspectors is insufficient to conduct effective engine power verifications. This is a threat to the delivery of the objectives of engine power control within the CFP.

It is recommended to involve the organization responsible for engine power certification, as required by the Control Regulation, in the engine power control activities. The fact that engine power is a competency of surveyors, and not so much of fisheries inspector, range of competencies was for most Member States one of the reasons to delegate the engine power certification requirement in the first place. Alternatively or in addition to involving the certifying authority, it could be considered to outsource (part of) the engine power verification duties to expert organizations.

In addition, it is recommended to develop training for fisheries inspectors to develop (at least) a basic understanding of the subject.

Recommendation (12): Improve the definition of verified engine power

The Commission Implementing Regulation (Art. 63) states that:

'If the power of the propulsion engine is measured after the reduction gear, an appropriate correction shall be applied to the measurement in order to calculate the propulsion engine power at the engine output flange according to the definition in Article 5(1) of Regulation (EEC) No 2930/86. That correction shall take into account the power losses resulting from the gearbox on the basis of the official technical data provided by the gearbox manufacturer.'

As discussed in section 1.2.1 this is not necessarily in line with what the regulation referred to states, and the official technical (energy losses) data provided by the gearbox manufacturer are not always available and very inaccurate. It is recommended to replace the text above by a slightly adapted text from Regulation (EU) 2017/1130 (Art. 5(1)):

'The engine power shall be the total of the maximum continuous power which can be obtained at the flywheel of each engine and which can, by mechanical, electrical, hydraulic or other means, be applied to vessel propulsion. However, where a gearbox is incorporated into the propulsion system and power is measured on board, the power shall be measured at the most accessible point of the shaft between the gearbox and the propeller.'

Or, to fully address diesel-electric propulsion and potential alternative future hybrid systems, engine power could be replaced by propulsion power throughout the regulatory framework. In addition the adjective 'continuous' does not really add value in this context, since it is not possible to verify whether maximum engine power is truly continuous during a physical verification and intermittent use of excessive power is also affecting the marine environment. This would change the definition above to:

'The propulsion power shall be the maximum power that can be applied to propel the vessel. The propulsion power shall be measured at the engine output shaft on a test bed or at the most accessible point of the propeller shaft on board a vessel. No correction should be made for incorporation of a gearbox in the propulsion system'

8.2. Specific follow-up of this study

8.2.1. Untested vessel

As discussed in section 5.4, the vessel FR-04 refused to cooperate with the inspections, which eventually rendered the vessel untested. It is recommended to conduct an inspection or power verification onboard this vessel, given the non-compliance of similar vessels.

8.2.2. Further investigation

For 38% of the vessels that were tested as compliant, secondary indications of non-compliance were found. This evidence typically consisted of clear indications with mechanical or electronic engine settings or an AIS speed analysis which revealed a much higher speeds during normal operations compared to the vessel speed during the test.

As mentioned in section 5.7 (North Sea beam trawlers), these vessels are apparently equipped with sophisticated power manipulation systems. To reveal these systems, an in-depth investigation of these vessels and their engines would be required. Important aspects before contracting such an investigation to consider are mandate, responsibility and liability. It could become a time consuming procedure to identify these systems, and it may be necessary to (partly) disassemble engines because systems could be built-in.

Annex Removed

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