Institut Català de Recerca per a la Governança del Mar (ICATMAR)

State of Fisheries in Catalonia 2020 (Part 1: Methods and Results)
Part 1: Methods and Results
(ICATMAR, 21-02)

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1. EXECUTIVE SUMMARY (RESUM EXECUTIU)

La present memòria presenta l'estat de les pesqueres a Catalunya l'any 2020. Tanmateix s'inclou les dades del seguiment biològic del darrer trimestre de 2019 que no va formar part de la memòria anterior (Institut Català de Recerca per a la Governança del Mar (ICATMAR). Estat de les Pesqueres a Catalunya. Part 1: Mètodes i Resultats (ICATMAR 19-01) 310 pp, Barcelona. Estat de les Pesqueres a Catalunya. Part 2: Annexos (ICATMAR 19-01) 557 pp, Barcelona). L'objectiu d'incloure les dades del seguiment biològic del darrer trimestre de l'any 2019 en aquest present informe de l'any 2020 es poder fer informes de l'estat de les pesqueres amb dades d'anys natural, es a dir, de gener a desembre.

SEGUIMENT BIOLÒGIC I PESQUER

Durant el període d'octubre de 2019 a desembre de 2020 s'ha continuat amb el mostreig pesquer. S'han seguit realitzant les sortides a mar i el mostreig biològic de les espècies escollides segons el pla descrit a la memòria 2019. Cal remarcar però, que degut a la pandèmia COVID19, durant els mesos de març, abril i maig, no es van poder dur a terme l'obtenció de dades amb la regularitat programada, el que ha afectat els resultats de finals d'hivern (març) i primavera (abril, maig).

S'ha seguit mostrejant als mateixos ports de la costa catalana, per bé que s'ha canviat la zonació, de manera que s'ha considerat Zona Nord els ports des de Roses/L'Escala a Arenys de Mar/Badalona; Zona Centre des de Barcelona a Tarragona/Cambrils; i Zona Sud/Delta, des de L'Ametlla de Mar a Sant Carles de la Ràpita. S'han obtingut dades de captures comercials i de mostrejos a bord de les barques pesqueres.

Les dades corresponents al mostreig biològic de totes les espècies s'han tractat a la present memòria, a nivell de relació talla/pes de les espècies objectiu, cicle reproductiu, estadis sexuals de mascles i femelles i índex gonadosomàtic (IGS). En el cas del lluç, s'ha obtingut també l'índex hepatosomàtic (IHS). En el cas de la demografia i biologia reproductiva de les espècies objectiu, els resultats es donen amb detall mensual.

Les espècies objectiu del seguiment biològic han estat: lluç (*Merluccius merluccius*), escamarlà (*Nephrops norvegicus*), gamba vermella (*Aristeus antennatus*), pop blanc (*Eledone cirrhosa*), galera (*Squilla mantis*), llagostí (*Penaeus kerathurus*) pop roquer (*Octopus vulgaris*), sardina (*Sardina pilchardus*), seitó (*Engraulis encrasicolus*), sonso blau (*Gymnammodites cicerelus)*, sonso ros (*G. semisquamatus*), llengueta (*Aphia minuta*).

Pel que fa a la pesqueria demersal, classificada a la memòria en 3 grans zones segons la fondària: plataforma, talús superior i talús inferior, els resultats es donen a nivell de Catalunya i zona (nord, centre, sud) amb detall estacional (tardor, hivern, primavera, estiu) i al nivell de cada port es dona un resultat global anual per a cadascuna de les espècies objectiu. A la zona Sud i els ports de l'Ametlla de Mar i Sant Carles de la Ràpita, donada la batimetria de la zona, la plataforma s'ha dividit en plataforma costanera (<40 m de fondària), plataforma mitjana (entre 41 i 75 m de fondària) i plataforma (>75 m de fondària). En el present informe es fa una comparativa dels resultats de tot el període de durada del projecte tant de les espècies objectiu com de les espècies comercials acompanyants i es valora el rebuig de la pesca, amb el que s'han obtingut dades d'abundància i biomassa de les espècies de la comunitat demersal i s'ha fet una valoració i classificació dels residus. Els resultats de les fraccions comercial i de rebuig es donen seguint el mateix patró.

A nivell de Catalunya, el percentatge de captura desembarcada respecte al rebuig a plataforma i talús superior es situa per sota del 70%,mentre que en els caladors de més fondària és superior al 62%. El percentatge de restes es situa entre el 3 i el 40% i ha estat més alt a la tardor del 2019 i hivern del 2020, cal destacar que a menor fondària (plataforma costanera i mitjana) les restes d'origen natural (plantes terrestres i marines) són més importants, mentre que les restes d'origen antròpic (plàstic, clinker, tovalloletes) abunden més a fondària. Les espècies acompanyants han estat diferents segons la fondària, a plataforma costanera les més rellevants han estat el moll de fang (*M. barbatus*), el pagell (*P. erythrinus*), l'orada (*S. aurata*) i el sorell blancal (*T. mediterraneus*. A plataforma mitjana han estat la gamba blanca (*P. longirostris*), la canana (*I. coindetii*) i la palaia (*C. linguatula)*. A plataforma profunda, el sorell (*T. trachurus*), el rap negre

(*L. budegassa*) i la canana (*I. coindetii*). Al talús superior la bròtola (*P. blennoides*), la maire (*M. poutassou*) i la gamba blanca (*P. longirostris*). Al talús inferior superior la bròtola (*P. blennoides*), la maire (*M. poutassou*) i el rap negre (*L. budegassa*).

Com a espècies objectiu de la pesquera demersal s'han considerat lluç, pop blanc, escamarlà, gamba vermella, galera i llagostí. De cadascuna d'elles s'ha elaborat una fitxa resum dels resultats biològics a nivell de Catalunya. Pel que fa al lluç, la tendència de la sèrie de captures és decreixent, les freqüències de talles indiquen que els exemplars petits, per sota del MCRS es capturen a plataforma tot l'any, on es donen les màximes abundàncies, la relació talla-pes presenta en general paràmetres de creixement (b) al voltant de 3,i pel que fa a la reproducció s'han trobat individus madurs tot l'any, per bé que el pic de posta es concentra entre novembre i gener i l'índex hepatosomàtic és força constant durant tot l'any. La sèrie temporal de captures d'escamarlà també presenta una tendència decreixent, es captura principalment al talús superior on també hi ha una part de la captura per sota del MCRS i màximes abundàncies els mesos de Juny i Juliol, la relació talla-pes presenta uns paràmetres de creixement (b) per sobre de 3 i del mateix ordre per a mascles i femelles, el cicle reproductiu mostra un pic de posta els mesos de primavera i estiu. La gamba vermella presenta una sèrie temporal de captures sense una tendència clara, bastant estable, les màximes abundàncies es donen al talús inferior, on es captura un porció important d'individus per sota la talla de primera maduresa, el paràmetre b de la relació talla-pes, és clarament inferior a 3 i diferent entre mascles i femelles i el pic de posta es centra en els mesos d'estiu. El pop blanc presenta una tendència decreixent en la sèrie de captures, que es concentren a la zona de plataforma, essent els individus petits presents de forma important els mesos d'estiu, paràmetre b de la relació talla-pes en general per sota de 3, amb un període reproductor de maduració avançada i posta a la primera meitat de l'any (hivern-primavera). La galera presenta una sèrie temporal estable en el temps, es captura només a plataforma, el paràmetre b de la relació talla-pes clarament per sota de 3 en ambdós sexes, el que indica creixement al·lomètric negatiu, amb un període posta centrat a la primavera. El llagostí no presenta una tendència clara en la sèrie temporal de captures, ha estat capturat per les barques d'arrossegament sobre tot a la plataforma costanera, presenta un creixement al·lomètric negatiu tant mascles com femelles, i cicle reproductiu amb un pic de posta entre primavera i estiu.

A nivell de zona (Nord, Centre, Sud), trobem que les espècies objectiu considerades en aquest estudi, tenen una presència més elevada a les captures de la zona centre, mentre que tant al nord com al sud, les espècies acompanyants de la pesquera, guanyen en importància (>64%). De la fracció de restes podem destacar que les restes antròpiques són més importants en pes a les zones nord i centre, prop de ciutats importants (Barcelona, Vilanova i la Geltrú, Tarragona), mentre que a la zona sud són més importants les restes d'origen natural.

Els resultats de la pesquera demersal obtinguts per a cada port segueixen en general les mateixes tendències que pel global de Catalunya.

Les dades de petits pelàgics (sardina i seitó) s'han obtingut en els ports de L'Escala, Palamós, Blanes, Arenys de Mar, Barcelona, Vilanova i la Geltrú i Tarragona. En tots ells, com estava previst, s'està desenvolupant el mostreig en base a la compra a llotja d'una mostra de la captura de les barques d'encerclament. Com en el cas dels demersals, s'han treballat els aspectes demogràfics, i s'ha fet també un estudi de les dades biològiques de les espècies (talla/pes, paràmetres reproductius). S'han fet alguns embarcaments puntuals per tal de definir la maniobra de pesca i poder interpretar els registres de VMS de la flota. Els resultats es donen seguint el mateix patró que per a la pesqueria demersal.

A nivell de Catalunya, pel que fa a la sardina, la sèrie històrica de desembarcaments mostra una tendència decreixent amb una certa estabilització els darrers anys, els individus més petits es capturen els mesos de tardor-hivern, mentre que les sardines més grans s'han capturat a l'estiu, el paràmetre b de la relació talla-pes dona valors al voltant de 3, el pic de posta es troba centrat en els mesos de desembre i gener. En el cas del seitó, la sèrie històrica de desembarcaments mostra fortes oscil·lacions, amb pics de captura els anys 2002, 2015 i 2018, mentre que entre el 2006 i el 2008 els valors de captura van registrar mínims històrics, l'estructura de talles indica que a la tardor-hivern es capturen individus per sota del MRCS i de la talla de primera maduresa, mentre que els mesos d'estiu es capturen sobre tot individus grans en reproducció, el paràmetre b de la relació talla-pes dona valors lleugerament superiors a 3, i pel que fa a la reproducció, el pic de posta es centra en els mesos entre juny i agost.

En l'anàlisi per zones, els resultats han estat similars, si bé es pot dir que a la zona nord, especialment al port de l'Escala, el percentatge d'individus petits tant de sardina com de seitó és més elevat, mentre que les sardines i seitons grans es concentren a la zona centre.

El pla de seguiment de la sonsera s'ha desenvolupat de la mateixa manera que els darrers 7 anys. És a dir, es realitza el seguiment científic d'aquest art de pesca, en base als acords del Comitè de Cogestió del Modalitat de la Sonsera (CCPGS). Pel que fa als resultats, a nivell global la pesquera de sonsera té una proporció d'espècies acompanyants per sota del 30% excepte a la tardor on el percentatge pot arribar al 45%, essent les més habituals el pagell (*P. erythrinus*), la llampuga (*C. hippurus*) i el sorell (*T. mediterraneus*). La sèrie històrica de desembarcaments es dona per a les dues espècies de sonso en conjunt, el sonso blau (*G. cicerelus*) i el sonso ros (*G. semisquamatus*), i presenta una evolució irregular, essent l'espècie dominant a les captures el sonso blau; la zona on es desenvolupa la pesquera de sonsos és exclusivament la zona nord. Els resultats de freqüències de talles mostren a tots els ports, que els individus més petits d'ambdues espècies de sonso es troben el mes de març, els valors del paràmetre b de la relació talla-pes oscil·len al voltant de 3 per al sonso blau, mentre que per al sonso ros els valors poden ser en alguns casos inferiors a 3, el període reproductor d'ambdues espècies es troba entre els mesos de desembre a març. De les altres espècies que es poden capturar amb sonsera, es mostren resultats de la més important en captures, el xanguet (*A.minuta*), la sèrie històrica de desembarcaments es manté relativament estable des de l'entrada en vigor del pla de gestió de la sonsera (2012), aquesta espècie es captura a la zona centre, en concret en sa gran majoria en el port de Barcelona, el rang de talles capturat és entre 2 i 4.5 cm TL i la temporada de pesca d'aquesta espècie es restringeix als mesos d'hivern, la relació talla-pes mostra un creixement al·lomètric positiu amb valors del paràmetre b clarament superiors a 3, no s'ha realitzat un estudi del cicle reproductiu del xanguet, donat que la temporada de pesca es restringeix a una època molt concreta de l'any.

L'estudi del pop roquer s'ha dut a terme enguany al port de Vilanova i la Geltrú, seguint el pla de mostreig previst a la memòria del projecte. S'han obtingut dades biològiques a partir de captures dels dos arts menors que tenen el pop roquer com a espècie objectiu: cadups i nanses. També s'ha iniciat el mostreig de pop roquer a Sant Carles de la Ràpita amb un patró de mostreig similar al de Vilanova i la Geltrú. Els resultats de la pesquera al port de Vilanova mostren que la sèrie històrica de captures té una tendència lleugerament decreixent, els individus més petits es capturen d'agost a desembre, mentre que els pops adults es capturen més a finals de primavera i durant l'estiu, per bé que els més grans s'han capturat durant l'hivern.

AVALUACIÓ PESQUERA

Per tal de poder tenir una bona caracterització de la flota pesquera a Catalunya, durant el 2019 i 2020 s'ha realitzat un estudi de métiers o d'estratègies pesqueres. Un métier és una unitat de pesca que comparteix una mateixa zona, tipus de pesca, espècie/s objectiu i/o temporalitats, és a dir, tenen una estratègia comuna. Després de la realització de diferents anàlisis prèvies i d'avaluar la metodologia i els resultats obtinguts, s'ha elaborat un protocol que serveix per a definir els métiers de les diferents flotes pesqueres de la costa catalana, així com conèixer la seva evolució temporal i espacial. L'anàlisi resulta en una millora del coneixement de la pesqueria per tal de poder gestionar millor els principals estocs i les espècies acompanyants i obtenir unitats de gestió per poder avaluar les poblacions.

Es presenten dos casos d'estudi, centrats en aquesta primera fase en el port de Vilanova i la Geltrú. El cas d'estudi I s'ha centrat en la definició dels métiers de l'art d'arrossegament en el període 2002-20 i la seva variació al llarg de la sèrie temporal i el cas d'estudi II en la flota artesanal i de palangre d'aquest mateix port i la definició dels métiers al llarg dels anys 2000-19.

En el cas d'estudi I s'han definit 4 métiers: OTB1, OTB2, OTB3 i OTB4, en funció de la fondària, de manera que OTB1 és el menys costaner i OTB4 el més profund. A OTB1, plataforma costanera, s'han descrit dos períodes temporals en funció de la composició específica i l'eslora de les barques: 2002-03 i 2007-20 definits per la diferent contribució dels molls (*Mullus* spp.) en aquest métier i pels vaixells grans (18-24m). A OTB2, plataforma profunda, s'han descrit també dos períodes: 2002-08 i 2009-20, definits per l'alternança en la importància específica del pop blanc (*E. cirrhosa*) i dels sorells (*Trachurus* spp.) i pels vaixells petits (6-12m) en el primer període i els mitjans (12-18m) en el segon. A OTB3, talús superior, 3 períodes: 2002-04, 2005-10 i 2013-20, definits per la importància de lluç (*M. merluccius*) i maire (*M. poutassou*) al començament de la sèrie temporal i a l'increment progressiu de la rellevància de l'escamarlà (*N. norvegicus*) en els altres períodes, els vaixells que marquen aquest métier són els grans al principi (18-24m) i els mitjans (12-18m) en els anys recents. Finalment, a OTB4, talús inferior, 2 períodes: 2002-07 i 2008-20, caracteritzats per la importància de la gamba rosada (*A. antennatus*) i pels vaixells més grans (24-40m) pe bé que els de 18-24m també són rellevants.

Pel que fa al nombre de vaixells i als desembarcaments hi ha una tendència decreixent en els 3 primers métiers (OTB1, 2 i 3), i una situació estable de nombre de vaixells i de creixement en desembarcaments en OTB4. Les dades de LPUE segueixen una tendència similar, per bé que són poc conclusives degut a que la incertesa, representada com un interval de confiança és gran. Pel que fa al rendiment econòmic dels métiers al llarg de la sèrie temporal, OTB1 presenta una tendència decreixent, mentre que OTB2 i OTB3 tenen tendències creixents. OTB4 és més estable al llarg de la sèrie, per bé que amb un interval d'incertesa més gran que el dels altres métiers.

En el cas d'estudi II s'han definit 7 métiers en funció de les espècies objectiu: "Hake", "Octopus", "Cuttlefish", "Bolinus", "Fish", Wedge clam" i "Mullus". El métier “Hake” ve definit per l’espècie lluç (*M. merluccius*) en més d’un 50%, s’han definit 2 períodes: 2000-07 i 2008-2019 caracteritzats per les diferències entre les espècies acompanyants. Aquest métier es refereix bàsicament a la pesquera de palangre de lluç. El métier “Cuttlefish” ve definit per la sípia (*S. officinalis*) en un 40% i s’han definit 3 períodes (2000-06, 2007-15 i 2016-19), segons les espècies acompanyants: pop roquer (*O. vulgaris*), llenguados (*Solea* spp.) i marbre (*L. mormyrus*). El métier “Octopus” correspon a la pesqueria de nanses i cadups, amb més d’un 80% de pop roquer (*O. vulgaris*) i sense períodes temporals definits. El métier “Wedge clam” no està sempre present al llarg de tota la sèrie temporal i té 2 períodes definits: 2000-08 amb més d’un 80% de bivalves desembarcats i 2009-13 amb un 47% de bivalves, posteriorment la seva importància en els desembarcaments ha continuat decreixent. El métier “Mullus” no apareix al començament de la sèrie, però ha anat guanyat rellevància al llarg de la mateixa i els molls (*Mullus* spp.) representen el 65% dels desembarcaments. El métier “Fish” està composat per una varietat d’osteïctis, és un métier no gaire selectiu amb 3 períodes definits: 2003-07, 2008-13 i 2014-18. El métier “Bolinus” correspon a l’activitat del rastell de cadenes i està dividit en 2 períodes: 2000-07 amb més del 50% de la composició de cargol de punxa (*B. brandaris*) i 2008-17 amb un increment de presència de sípia i pop roquer, a partir del 2017, aquest art de pesca està prohibit i ha desaparegut com a métier.

Pel que fa a les tendències en els desembarcaments i el nombre de vaixells, els métiers “Octopus”, “Bolinus” i “Hake” presenten tendències decreixents, mentre que “Cuttlefish”, “Fish” i “Mullus” creixen. La LPUE és bastant estable en el temps pels métiers “Octopus”, “Bolinus” (a partir del mig de la sèrie), “Fish” (des del mig de la sèrie), “Wedge clam” i “Mullus”, mentre que fluctua en els altres métiers.

Per a la propera anualitat s’espera fer una anàlisi considerada com a pre-avaluació d’estoc, que és un anàlisi de productivitat i susceptibilitat (PSA en anglès). La PSA ens permetrà conèixer les diferents històries de vida de les espècies, en aquest cas que componen un métier, i conèixer la seva vulnerabilitat depenent de la captura efectuada per cada métier.

D'altra banda, s'està assistint regularment a les reunions dels organismes oficials que s'encarreguen de l'avaluació dels estocs pesquers del Mediterrani (STECF i GFCM) i s'ha iniciat una exploració de diferents mètodes d'avaluació espacial per tal de poder avaluar en un futur altres mesures de gestió com zones de veda permanents.

PESCA MARÍTIMA RECREATIVA

El seguiment de la pesca marítima recreativa s'ha realitzat amb sistema d'enquestes a peu de platja i amb enquestes "online". Els resultats de l'anàlisi de les dades de les enquestes pel període 2020-2021 han estat publicades l'abril de 2022 amb el títol "Institut Català de Recerca per la Governança del Mar (ICATMAR). Report on the continuous monitoring of marine recreational fishing in Catalonia in 2020-2021". Barcelona. DOI: 10.2436/10.8080.05.9

SISTEMES DE LA INFORMACIÓ

Pel que fa als sistemes de la informació, s'ha dissenyat la base de dades (BBDD) pels mostrejos pesquers, tenint en compte la relació entre diferents fonts de dades, la necessitat de mantenir la qualitat de les dades, la disponibilitat immediata i l'accessibilitat des de diferents plataformes. S'han definit dues BBDD: BBDD SAP que conté dades d'embarcaments, disseccions, dades històriques de projectes i dades externes relacionades i geoSAP: informació georefenciada complementària al projecte (batimetria, filtres de profunditat, àrees gestionades, etc.). La BBDD ha estat creada amb PostgreSQL ja que compta amb un complement PostGIS per tal de facilitar el tractament de dades georeferenciades.

La BBDD està totalment operativa i conté les dades de tots els mostrejos realitzats des del novembre de 2018 fins al setembre de 2020, així com els seus tracks GPS. En concret, s'han realitzat 314 embarcaments, 542 pesques d'aquests embarcaments, s'han pres 1615 posicions manualment i unes 35200 automàticament amb el GPS, s'han mesurat uns 125000 individus i d'aquests se n'ha disseccionat uns 28000.

Com a dades no generades pel projecte, la BBDD conté l'històric de les embarcacions provinent de l'EU Fleet Register actualitzat al 2020, les notes de venda de les captures pesqueres realitzades a les llotges catalanes des de l'any 2000 al 2020, així com les posicions del sistema Vessel Monitoring System (VMS) de les embarcacions de la flota pesquera catalana d'arrossegament des de l'any 2002 al 2019. Per altra banda, s'han adaptat a aquest sistema i importat a la BBDD les dades històriques de la pesqueria de la sonsera a Catalunya del 2012-2020 (gairebé 10000 embarcaments), provinents dels estadills omplerts pels mateixos pescadors.

La Web d'introducció de dades s'ha desenvolupat, validat i està totalment operativa. La Web ha anat evolucionant en un procés de millora contínua des del seu llançament, focalitzat en millorar la usabilitat de la Web i el control de qualitat de les dades.

Com a primer producte del visualitzador s'ha definit i s'està desenvolupant un cercador de dades, que consisteix en una eina web per filtrar, visualitzar i extreure les dades crues dels mostrejos allotjats a la BBDD. L'eina està adreçada a qualsevol perfil que pugui tenir interès en les dades, anàlisis o resultats, en particular l'administració, científics, pescadors, confraries o món educatiu. En un futur, es pot aprofitar la mateixa estructura per tal de visualitzar gràficament aquestes dades.

EXPLOTACIÓ I ANÀLISI DE DADES ESPACIALS

Les dades geolocalitzades requereixen d'un tractament específic, i és per això que se'ls ha dedicat una especial atenció. Disposem de dades de caixes blaves o VMS (Vessel Monitoring System) obligatòries per a les embarcacions d'eslora superior a 15 m des del 2005 i per a les embarcacions d'eslora superior a 12 m des del 2012. Actualment disposem d'aquestes dades des de 2008 fins a 2017, les dades de 2018-2019 estan en fase de preavaluació i filtratge. També disposem d'un accés a dades AIS per bé que limitat. Es disposa igualment de dades GPS dels mostrejos realitzats.

Per tal de poder tenir un sistema de la informació geogràfica (SIG) s'ha introduït tota la informació a la BBDD. S'ha fet un filtratge de les dades VMS específic segons l'art de pesca, així per a l'arrossegament s'ha definit un perfil de velocitats amb dues modes 3.5 i 11 nusos corresponents a la pesca i la navegació respectivament. Per a la pesca d'encerclament el filtratge es troba en fase d'estudi.

En el cas de la monitorització del mostreig amb dades GPS, també hi ha un tractament diferenciat segons l'art de pesca. Per a l'arrossegament, la sonsera i la pesca de pop roquer es porta un dispositiu GPS a bord on es registren les posicions. En el cas de l'encerclament les dades s'obtenen demanant a llotja la posició de l'embarcació i accedint al registre AIS (Sistema d'Identificació Automàtica) per a aquella embarcació i dia. S'han realitzat mapes on es visualitzen tots els mostrejos realitzats enguany.

D'altra banda, s'han elaborat mapes de caracterització de l'activitat de la flota pesquera d'arrossegament amb les variables d'esforç pesquer (hores/km^2), captures globals (kg/km^2) per a tota la flota i per espècie objectiu i rendiment econòmic global (€/km^2). S'han analitzat de forma preliminar els anys 2008 i 2017. Es preveu que aquesta informació es pugui visualitzar per a tots els anys de forma més dinàmica a través dels sistemes de visualització del servei.

Durant el 2019 i 2020 s'ha estat treballant també en l'assessorament GIS a plans de cogestió, en concret amb la gestió del vedat de Roses, la gamba del Cap de Creus, la gamba de Palamós, sonsera, pop roquer i petits pelàgics del golf de Roses. Queda pendent de cara a projectes futurs d'estendre aquesta metodologia als altres plans de cogestió: sèpia i cranc blau.

PROBLEMES AMB L'EXECUCIÓ DEL SEGUIMENT BIOLÒGIC

S'ha de remarcar que durant els mesos de març, abril i maig del 2020 no s'han pogut realitzar les activitats de mostreig de camp i obtenció de mostres de peix degut al confinament obligat pel COVID19, per tant els resultats que es presenten a l'informe de hivern del 2020 es restringeixen als mesos de gener, febrer i primera setmana de març, i els resultats de primavera del 2020 es refereixen únicament al mes de juny del 2020.

REUNIONS DE L'EQUIP TÈCNIC ICATMAR AMB EL SECTOR PESQUER I L'ADMINISTRACIÓ

Durant el present període, de l'1 d'octubre de 2018 al 30 de setembre de 2020, s'ha realitzat un total de 181 reunions entre els membres de l'equip del projecte de l'ICM, el personal de la DGPAM i els diferents comitès de cogestió amb la participació també dels pescadors de les Confraries catalanes. En resum s'han fet:

- Un total de 28 reunions internes i de formació de l'equip tècnic del projecte.
- Un total de 89 reunions dels diferents comitès de cogestió: Comitè del pla de gestió de la sonsera, del pla de gestió del peix blau de l'Empordà nord, del cranc blau de les terres de l'Ebre, de la sèpia de les badies de Pals i de Roses, del pop roquer del litoral de Catalunya central i del pop roquer del delta de l'Ebre.
- 13 reunions amb el sector pesquer català.
- 31 reunions entre membres de l'equip ICM i el personal de la DGPAM de la Generalitat de Catalunya.
- Finalment 20 reunions de coordinació científica i tècnica de l'ICM per tractar del desenvolupament del projecte.

2. FISHERIES AND BIOLOGICAL MONITORING

The contents of this report on the state of fisheries in Catalonia 2020, within the framework of ICATMAR, corresponds to the program of sampling and analysis of data gathered from October 2019 to December 2020, which allowed to monitor the state of the fisheries in Catalonia. This work is a continuation of that started at the end of 2018 (ICATMAR 19-01), although considering the results obtained, some variables have been readjusted.

During this period, it should be noted that in March, April and May 2020, it was not possible to carry out field work activities and to obtain samples on a regular basis due to the confinement required by the COVID19 pandemic. Therefore, the winter 2020 samples correspond mainly to the months of January and February whereas and the spring 2020 samples basically refer to the month of June, which can produce a certain bias in the results that will have to be verified in the coming years. This sampling alteration also affects the historical catch series, where the amount of catch in 2020, in many cases, is lower than it would have been if fishermen had gone out fishing normally monthly.

The objectives of fisheries monitoring, however, remain the same:

a) To establish and consolidate the management measures that are currently being implemented in the different fisheries on the Catalan coast.

b) To share all the experience accumulated by scientists in the recent years and collaborate with the fishing sector to transfer the knowledge acquired to the different fishermen and their guilds on the Catalan coast.

c) To carry out management measures in agreement with the fisheries sector (endorsed by the competent administrations), with the aim that these measures lead to an improvement of the biological indicators of the populations of exploited organisms and the ecosystems they inhabit.

Based on the results obtained in the first year (2019), it has been considered appropriate to regroup the sampling along the Catalan coast, also separating 3 zones, but which group ports differ from those in 2019: NORTH, which includes ports from Roses to Badalona, area known as the Llevant coast (in 2019 it included from Roses to Blanes); CENTER, which includes the ports from Barcelona to Tarragona, on the west coast (in 2019 included from Arenys to Vilanova i la Geltrú); and SUD-DELTA, which includes the ports from l'Ametlla de Mar to Sant Carles de la Ràpita and which represents the area influenced by the river Ebro (in 2019 included from Tarragona to La Ràpita) (Figure 1).

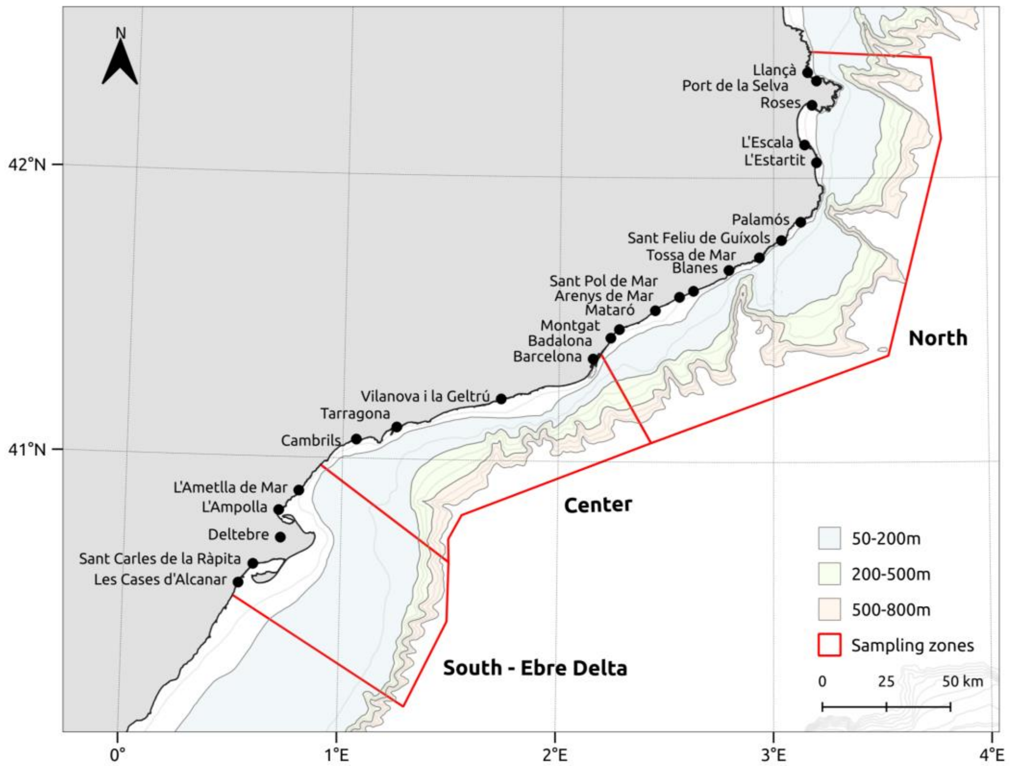


Figure 1. Detail of the sampling zones and fishing ports in Catalonia.

Then, the zoning is as follows:

• North area: Roses / Escala, Palamós, Blanes and Arenys de Mar.

• Central area: Barcelona, Vilanova i la Geltrú and Tarragona.

• South area (Delta de l'Ebre): Ametlla de Mar and Sant Carles de la Ràpita.

The target species of the biological sampling, depending on their importance in terms of catch and economic value are hake (*Merluccius merluccius*), Norway lobster (*Nephrops norvegicus*), blue and red shrimp (*Aristeus antennatus*), horned octopus (*Eledone cirrhosa*), spottail mantis shrimp (*Squilla mantis*), caramote prawn (*Penaeus kerathurus*), common octopus (*Octopus vulgaris*), European sardine (*Sardina pilchardus*), European anchovy (*Engraulis encrasicolus*) and the sand eels including Mediterranean sand eel (*Gymnammodytes cicerelus*), smooth sand eel (*G. semisquamatus*) and transparent goby (*Aphia minuta*) (due to its obligation to monitor within the framework of the “sonsera” Management Plan).

Sampling is divided into two major sections:

• Acquisition in the fish market of biological batches of European sardines and anchovies.

• Sampling on board where fishing and meteorological data were acquired. In addition, specific sampling was done depending on the type of fishery to be sampled:

Bottom trawling: size frequencies of the target and accompanying species were performed; subsequent biological analysis of target species (height, weight, sex, sexual status, gonadal weight) and the characterization of discards and debris were recorded.

Pots and traps: the common octopus was sampled *in situ*.

Sand eels: a sample of the catch was acquired and analysed in the laboratory (both target species and discards).

Sampling is intended to close an annual cycle with a monthly basis sampling throughout the year, as follows:

• Three samplings on bottom trawls (one in each area).

• Three small pelagic samples (sardine and anchovy) (one in each area). In l’Escala and Tarragona, the sampling of small pelagic fish was carried out monthly.

• Four common octopus' samplings in the port of Vilanova i la Geltrú, one sampling in Deltebre, and one in Sant Carles de la Ràpita.

• Two samples of sand eels (Mediterranean and smooth sand eels in the northern area and transparent goby in the northern and central area in season).

Samplings varied according on the target species to study:

Demersal species

On board sampling

- Three experimental hauls
  - ✓ Continental shelf (hake, horned octopus, caramote prawn and spottail mantis shrimp): 1 hour
  - ✓ Upper slope (Norway lobster, hake and horned octopus): 1 hour 30 minutes
  - ✓ Lower slope (blue and red shrimp): 1 hour 30 minutes
- Biological measures
  - ✓ Size frequencies of the target and accompanying species
  - ✓ Biological batch of the target species
- Three samples of discards, one from each fishery to allow the study of the community

Sampling in the laboratory (Institut de Ciències del Mar)

- Biological measures of the target species
  - ✓ Size frequency
  - ✓ Biological batch (size/length, total weight, sex, sexual status, gonad weight)
- Discards
  - ✓ Separation and identification of the discarded species

- ✓ Total number and weight of each species
- ✓ Size frequencies of each species
- ✓ Classification of debris including that with anthropogenic origin

Pelagic fish

Purchase of a batch of target species (European sardine and anchovy)

- Data on the batch origin (vessel, catch coordinates and total catch)

Sampling in the laboratory (Institut de Ciències del Mar)

- Biological measures of the target species
  - ✓ Size frequency
  - ✓ Biological batch

Common octopus

- Sampling, four times a month, in Vilanova i la Geltrú; two times with pots and two with traps. Sampling with pots, two times a month, alternatively in Deltebre and Sant Carles de la Ràpita.
- Biological measures of the target species
  - ✓ Size frequency
  - ✓ Biological batch

Sand eels

On board sampling

- Two monthly batches of 1 kg were obtained in the northern area
- When transparent goby is available, a same size batch is obtained from Blanes and Barcelona (one batch from each location).
-

Sampling in the laboratory (Institut de Ciències del Mar)

- Biological measures of the target species
  - ✓ Size frequency
  - ✓ Biological batch
  - ✓ Discards

- ✓ Individual length and weight

Debris definition and composition

The term debris includes two different types of items. On one side, the non-organic materials caught during fishing operations including all litter. On another side, organic materials such as dead shells, dead coral and plants (seaweed) are also considered debris. The following table describes all the categories of debris in which the items have been classified (Table 1).

For the analysis and plots of the debris, the categories analysed were the 10 with the highest weight which percentage of catch was higher than 2%.

Table 1. Type and description of the fishing debris.

Residue origin	Type of residues	Description
Anthropogenic debris	Cigarette stubs	Remains of cigarettes
	Clinker	Residue of coal-burning steamships
	Fishing gears	Any item used for fishing
	Glass	Hard, usually transparent material used for make bottles, windows, etc.
	Lumber	Any processed wood mainly from marine activities
	Metal	Metallic items, mainly cans.
	Plastic	All plastic derived items
	Ropes	Man-made strong cords to tie things together
	Rubber	Any item made of rubber such as tires, shoe soles, etc.
	Textiles	Items made out of fabric and shoes
	Unclassified debris	Debris not included in any other category
	Wet wipes	Single-use non-degradable cloth for hygienic purposes
Natural debris	Other marine algae	Any unclassified residue of marine algae
	Terrestrial animals	Carcasses or parts of them of terrestrial animals
	Shells	Hard body parts of marine mollusks
	Marine plants	Whole or partial marine plants
	Calcified remains	Any calcareous structure of biogenic origin

	Marine organic debris	Any marine animal too broken or degraded to be classified or correctly measured
	Terrestrial plants	Plants from terrestrial origin
	Codium bursa	
	Codium tomentosum	
	Coralline algae	
	Rhodophyta	

Geography of sampling

The results of the field sampling refer to the period from October 2019 to December 2020.

For bottom trawling, the results are presented at different levels: i) in Catalonia and in the northern, central and southern areas with seasonal detail, that is autumn (October, November, December), winter (January, February, March), spring (April, May, June) and summer (July, August, September), and ii) by port, with annual detail. The results of the demersal community affected by the fishery are presented, indicating the commercial, discarded and debris fractions. For each target species, the historical catch series and size frequencies are also shown. The size frequencies of the target species in Catalonia are presented on a monthly basis. The results of the frequencies are shown by depth layer (continental shelf 0-200 m, upper slope 200-500 m, and lower slope 500-800 m). In the southern area, in the ports of l'Ametlla de Mar and Sant Carles de la Ràpita, given the characteristics of their fishing grounds, trawlers concentrate their activity in the continental shelf area. Therefore, the area has been divided into 3 different strata (coastal shelf <40 m; medium shelf 41-75 m and shelf> 75 m); the slope strata have not been considered as fishing activity in these depths is of little importance.

The small pelagic purse seine fishery has been considered in an equivalent way to the bottom trawl fishery, as well as the artisanal sand eel and common octopus fisheries, with some particular specifications in each case.

The relationship between the fisheries and the sampling sites are listed in Figure 2.

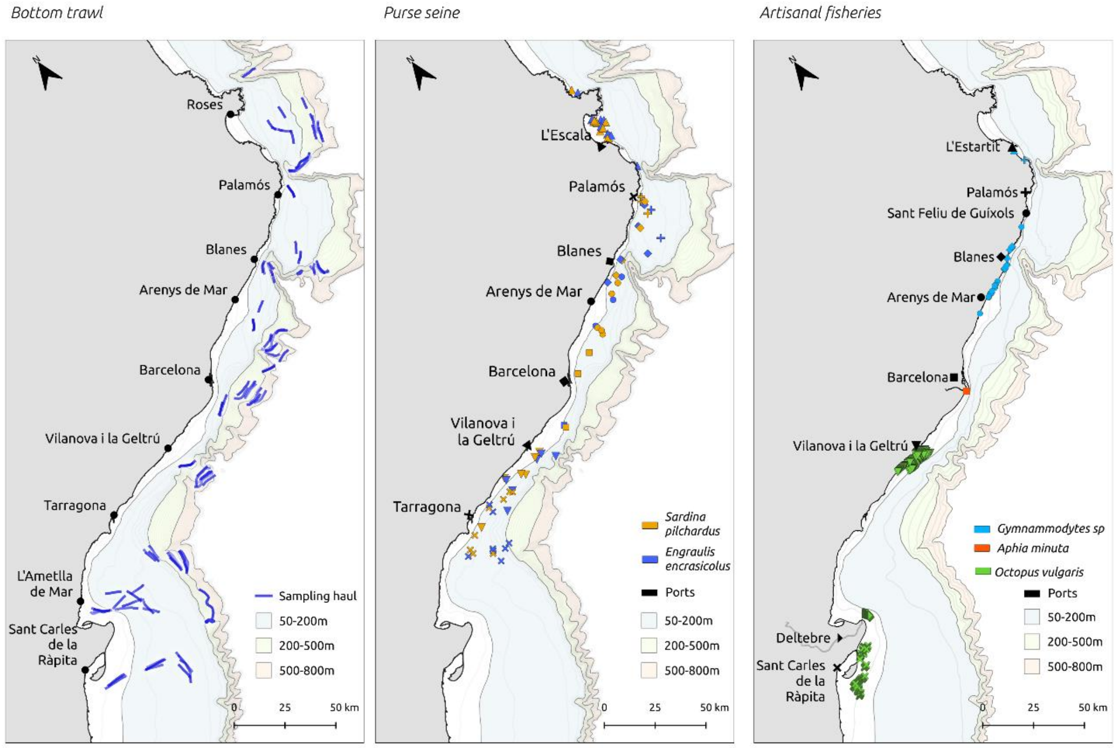


Figure 2. Field sampling carried out in the time period from October 2019 to December 2020. NORTH: from Roses to Arenys; CENTER: from Barcelona to Tarragona; SOUTH: from l'Ametlla to Sant Carles de la Ràpita.

2.1 BOTTOM TRAWLING

2.1.1 Bottom trawling in Catalonia

The characterization of bottom trawling for the 120 hauls conducted during October 2019 to December 2020 in Catalonia at seasonal level is shown per each fraction (landings, discards, and debris) in Figure 3.

Bottom trawl

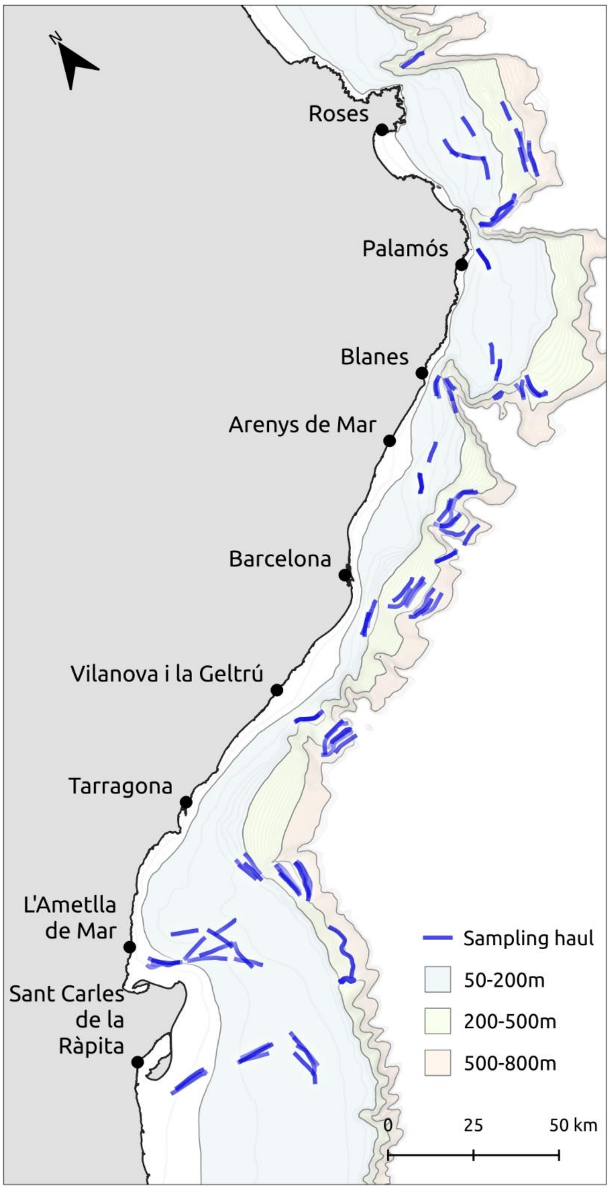


Figure 3. Map of bottom trawling hauls conducted in Catalonia from October 2019 to December 2020.

Landings included fish and shellfish with market size and value. Discards included unmarketable species with no commercial value or those commercial species that did not reach the minimum conservation reference size (MCRS). Debris included all human-origin items and natural debris such as shells, dead corals and seaweed. The percentatge of landed catch was between 26 and 85%. The landed catch was higher in deeper fishing grounds (upper slope and lower slope), where more than 62% of the catch was landed. In the shallow and middle continental shelf, the landed catch was always lower than 70%. The discarded catch was between 9 and 66% of the total catch, with the highest values found in the shallower fishing grounds, where it reached 66% during spring of 2020. The percentage of the debris fraction of the catch was between 3 and 40%, and it was specially higher during autumn 2019 and winter 2020 in the shallow and middle continental shelves (Figure 4).

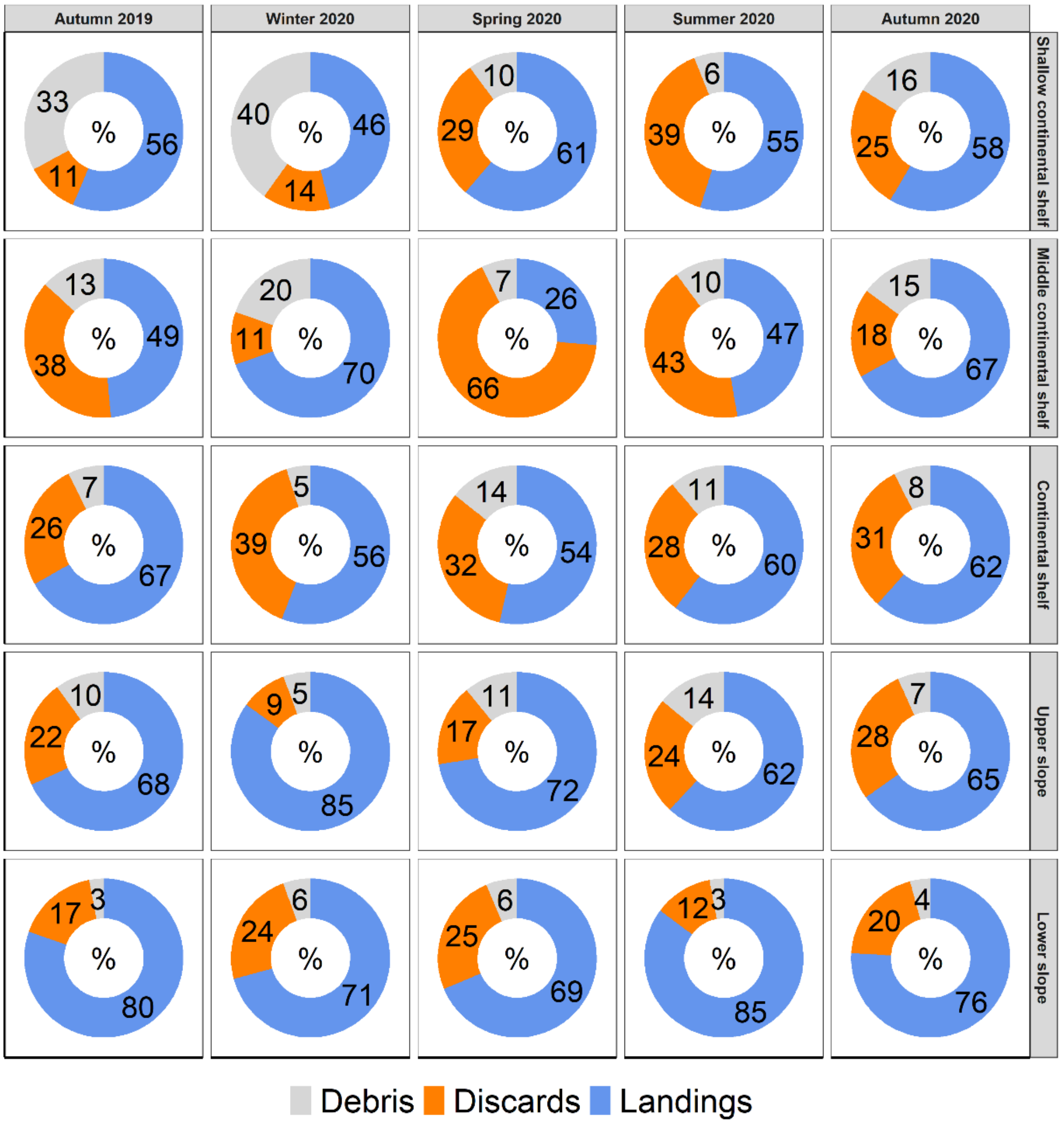


Figure 4. Catch composition for Catalonia. Percentage by weight of landings, discarded and debris fraction in each season and each fishing ground including all hauls in all ports sampled from October 2019 to December 2020.

Analyses of the samples collected on board by depth (continental shelf, upper slope and lower slope) are shown in terms of biomass percentage by species.For further information on the presence/absence of all species caught by port see Annex X.

The proportion of species with the most biomass within the landed catch (the 10 species most importants in weight and with a percentatge of catch higher than 2%) in the shallow continental shelf is shown in Figure 5. There, between 20 and 41 species were landed. Target species selected for its market value (*M.*

merluccius, *S. mantis*, *P. kerathurus*, and *E. cirrhosa*) represented between 5 and 43% of the landed catch. A higher proportion of target species were observed during autumn in both years, mainly *S. mantis* and *P. kerathurus*, where their abundances fluctuated seasonally. Other landed species with an important biomass were *M. barbatus*, *P. erythrinus*, *S. aurata*, *T. mediterraneus*, and *S. sphyraena*.

See Annex I for the common name and coding used for each species in the figures.

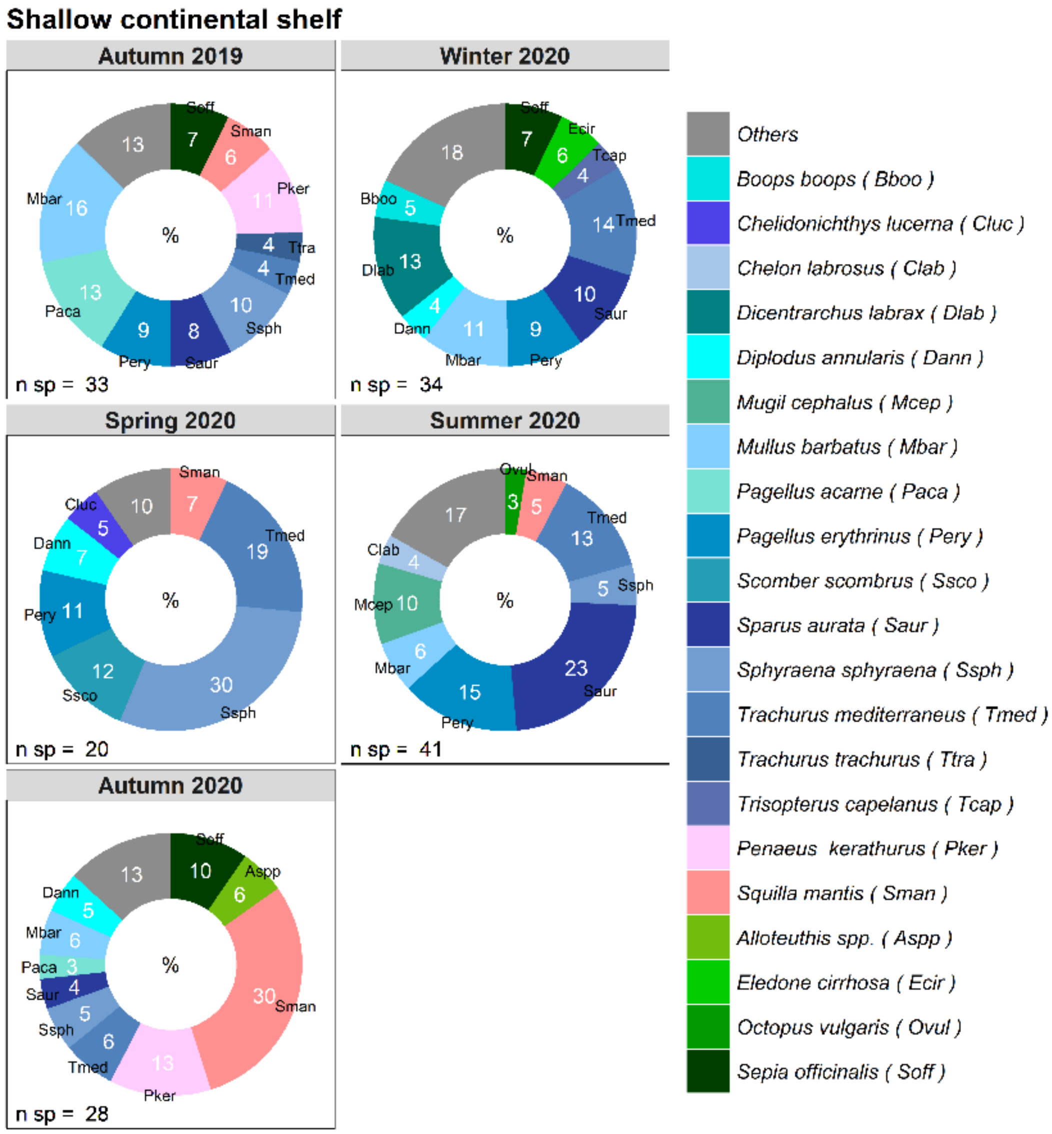


Figure 5. Species with most biomass within the landed catch in the shallow continental shelf for all hauls conducted in Catalonia for each season from October 2019 to December 2020.

The proportion of species with most biomass within the landed catch in the middle continental shelf is shown in Figure 6. There, between 29 and 48 species were landed. Target species selected for its market value (*M. merluccius*, *S. mantis* and *E. cirrhosa*) represented between 19 and 38% of landed catch. Other landed species with high biomass were *P. longirostris*, *I. coindetii*, *C. linguatula*, and *M. barbatus*. The crustacean *L. depurator* had the highest percentatge of landed catch in the summer 2020.

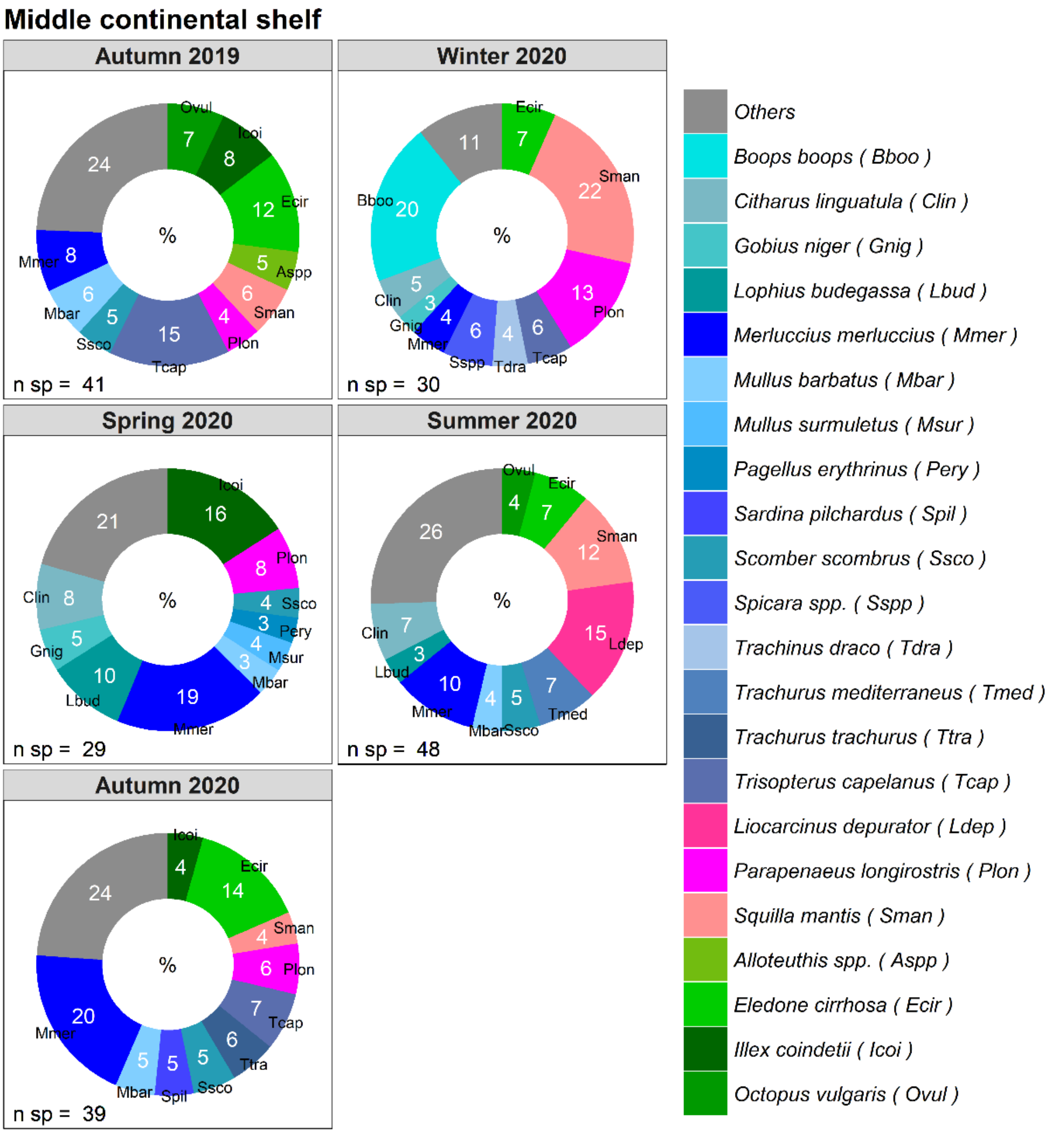


Figure 6. Species with most biomass of the landed catch fraction in the middle continental shelf for all hauls conducted in Catalonia for each season from October 2019 to December 2020.

The proportion of species with the greatest biomass within the landed catch fraction in the continental shelf (>70 m depth) is shown in Figure 7. There, between 52 and 68 species were landed. Target species selected for its market value (*M. merluccius* and *E. cirrhosa*) represented between 10 and 16% of landed catch. Other landed species with an important biomass were *T. trachurus*, *L. budegassa*, *I. coindetii* and *P. longirostris*.

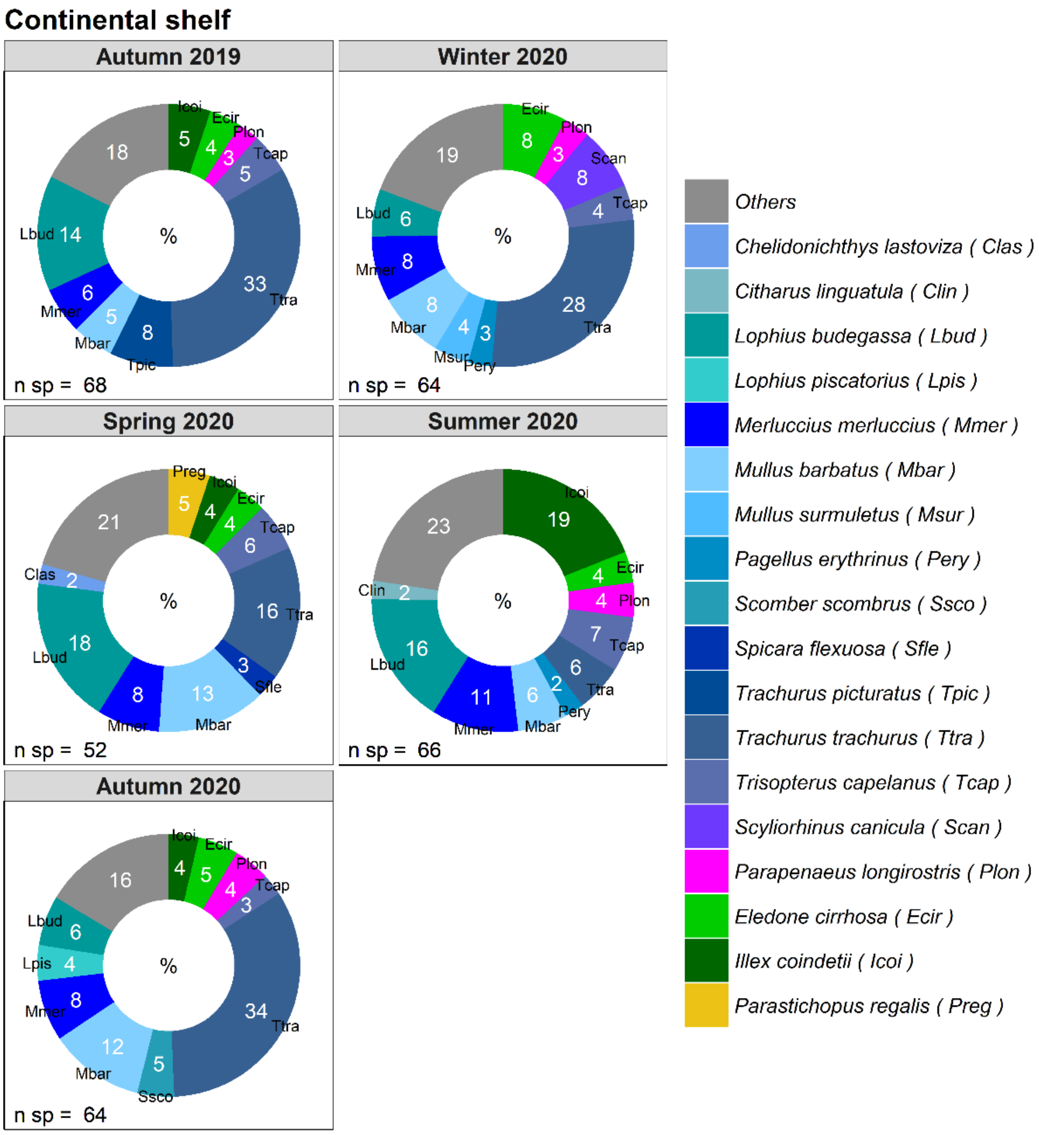


Figure 7. Species with most biomass within the landed catch fraction in the continental shelf for all hauls conducted in Catalonia for each season from October 2019 to December 2020.

The proportion of species with the most biomass within the landed catch fraction in the upper slope is shown in Figure 8. There, between 32 and 45 species were landed. Target species selected for its market value (*M. merluccius*, *N. norvegicus, A. antennatus*, and *E. cirrhosa*) represented between 19 and 39% of landed catch. Other landed species with an important biomass were *P. blennoides*, *M. poutassou*, and *P. longirostris*.

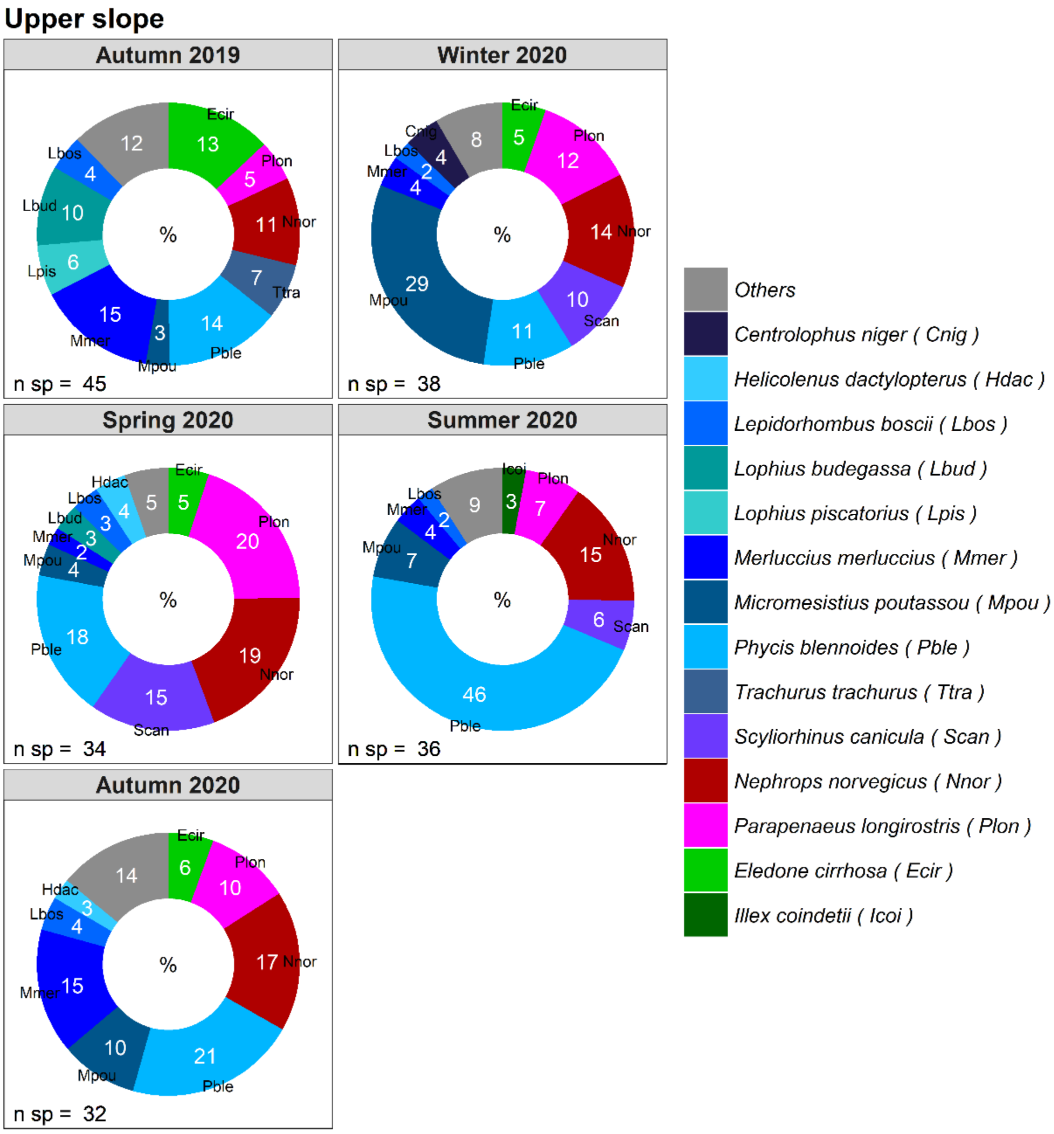


Figure 8. Species with the most biomass within the landed catch fraction in the upper slope for all hauls conducted in Catalonia for each season from October 2019 to December 2020.

The proportion of species with most biomass within the landed catch fraction in the lower slope is shown in Figure 9. There, between 25 and 32 species were landed. Target species selected for its market value (*M. merluccius*, *A. antennatus*, *N. norvegicus*, and *E. cirrhosa*) showed between 38 and 68% of landed catch, *A. antennatus* representing the most important fraction Other landed species with an important biomass were *P. blennoides*, *M. poutassou*, and *L. budegassa*.

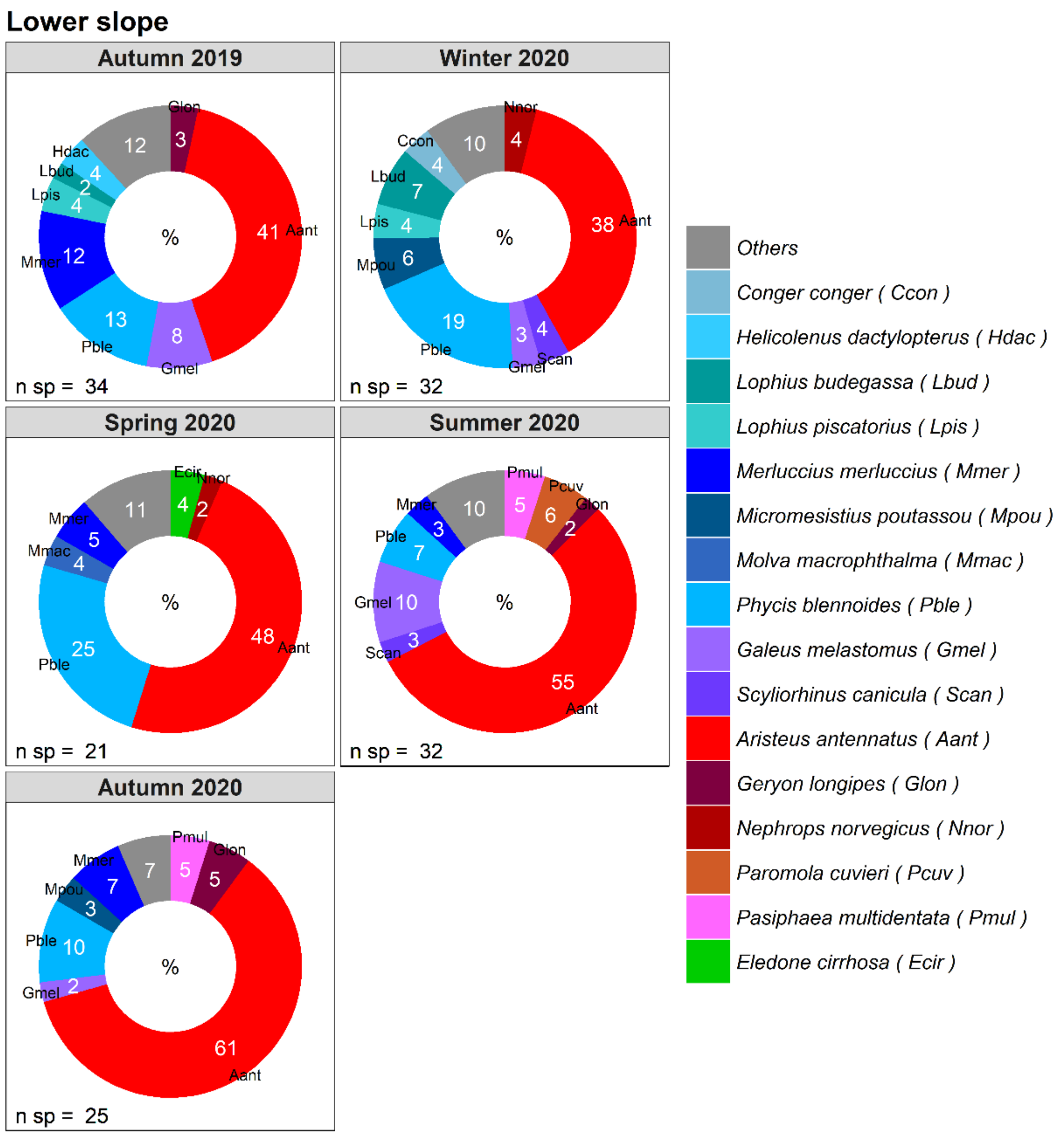


Figure 9. Species with most biomass within the landed catch in the lower slope for all hauls conducted in Catalonia for each season from October 2019 to December 2020.

The most important taxonomic group within the landing catch fraction was Actinopterygii for most of the fishing grounds except in the lower slope, where Crustaceans had the highest biomass and abunded the most (Table 2). Within the group Chondrichthyes, they were more present in the upper slope compared to all other fishing grounds. In contrast, Cephalopoda, were more important in both the middle continental shelf and continental shelf. Other Mollusca (Bivalvia and Gasteropoda) with commercial value were present in all fishing grounds except in the lower slope. Echinodermata were present only in the middle continental shelf and continental shelf.

See Annex II for the complete list of species' biomass in each fishing ground and Annex III for species' abundances.

Table 2. Biomass (kg/km^2) and abundance (ind/km^2) of taxonomic groups present in the landed catch in Catalonia. Mean and standard deviation in each fishing ground, including all hauls from October 2019 to December 2020.

	Shallow continental shelf		Middle continental shelf		Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
Actinopterygii	239.68	170.88	151.16	45.77	310.91	254.15	159.27	177.08	44.06	39.45
Chondrichthyes	1.10	2.04	0.10	0.27	10.08	33.41	17.50	40.86	10.51	19.66
Crustacea	41.83	30.77	54.79	51.23	19.27	23.13	69.85	55.94	85.17	46.76
Cephalopoda	29.52	15.09	59.47	33.45	58.36	48.26	21.96	27.65	3.40	4.98
Other Mollusca	2.38	1.95	2.23	1.37	0.73	2.03	0.08	0.25		
Echinodermata			0.35	0.94	6.41	15.94				
Abundance	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
Actinopterygii	2721.09	1863.25	3163.90	1083.22	5641.77	4977.46	1487.76	1130.97	269.68	241.22
Chondrichthyes	12.11	21.80	1.03	2.71	41.19	134.49	101.78	242.74	34.56	69.56
Crustacea	1545.24	1190.55	4945.36	4487.29	2510.63	3295.56	4782.57	4529.40	4866.47	2564.10
Cephalopoda	377.49	139.72	1039.12	663.70	1110.38	1227.65	158.63	219.22	15.52	23.65
Other Mollusca	257.53	205.04	129.27	71.55	37.26	136.29	3.93	12.94		
Echinodermata			2.71	7.18	51.32	128.29				

The proportion of species with most biomass within the discarded catch fraction in the shallow continental shelf is shown in Figure 10. In the shallow continental shelf, between 35 and 62 species were discarded. Most of the discarded catch was composed by pelagic fishes such as *S. aurita*, *E. encrasicolus*, *S. pilchardus*, *B. boops*, and *T. mediterraneus*. A small proportion of crustaceans were discarded, less than 8%. Benthic invertebrates such as *A. irregularis*, *O. canalifera*, and *A. serresiana* had a relative importance in some hauls, becoming an important fraction in both autumn 2019 and autumn 2020. Commercialized species like *M. merluccius*, *O. vulgaris*, *D. annularis*, and *S. mantis*, mainly discarded for not reaching the minimum conservation reference size, accounted for an important fraction of the discarded catch in some hauls during autumn and winter.

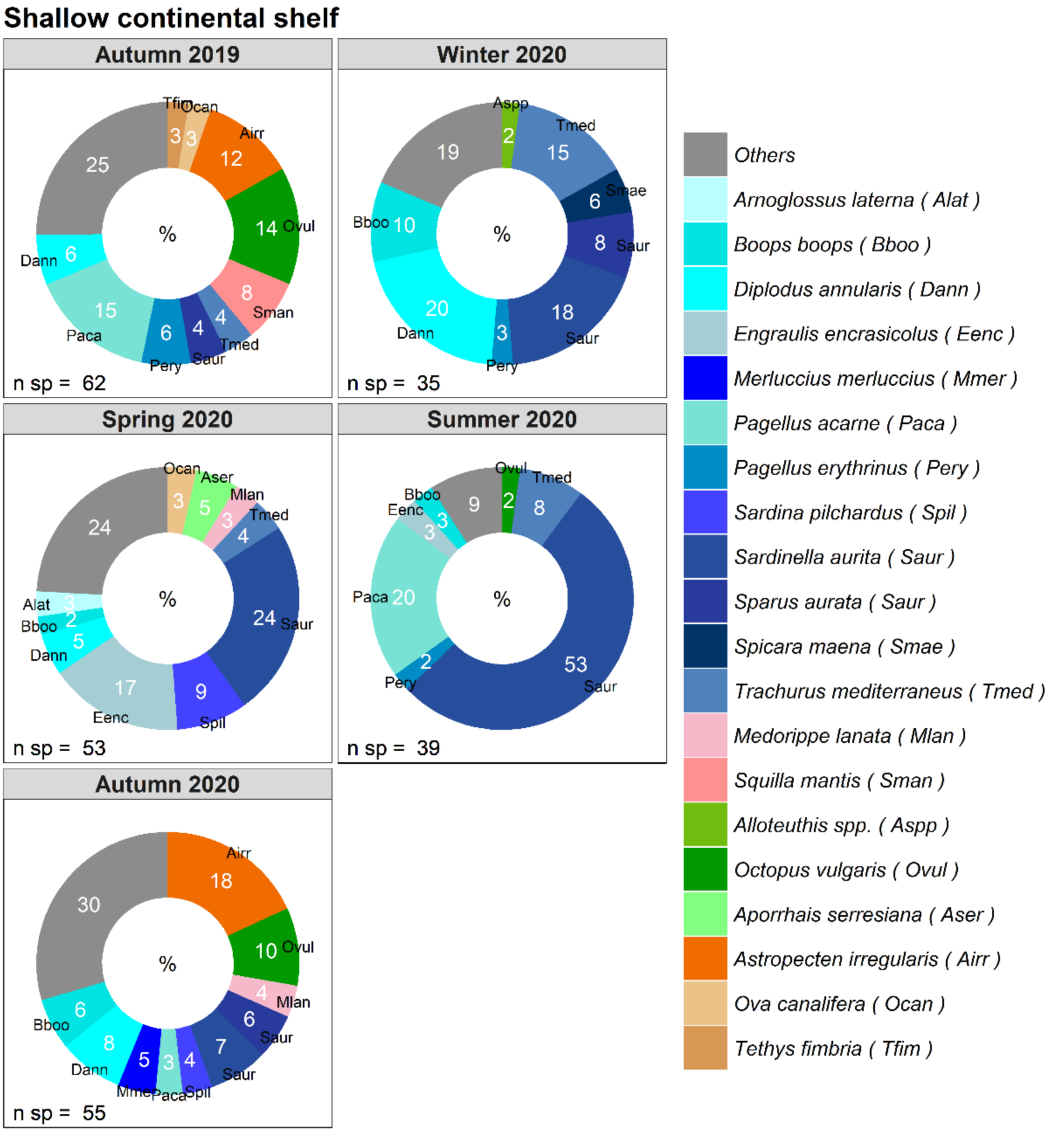


Figure 10. Species with most biomass of the discarded catch fraction in the shallow continental shelf for all hauls conducted in Catalonia for each season from October 2019 to December 2020.

The proportion of species with the most biomass within the discarded catch fraction in the middle continental shelf is shown in Figure 11. There, between 37 and 57 species were discarded. Most of the discarded catch was composed by pelagic fish such as *E. encrasicolus*, *S. pilchardus*, *S. aurita*, *B. boops*, and *T. mediterraneus*. Target species, including *M. merluccius*, were present in the discarded catch mainly during autumn 2020. Crustacean species, such as *S. mantis*, were important in the discarded catch in winter 2020. Benthic invertebrates, including *A. irregularis*, *H. tubulosa*, *P. mammillata*, *Spongosorites spp.*, and *Suberites spp.* accounted for a small fraction of the discarded catch.

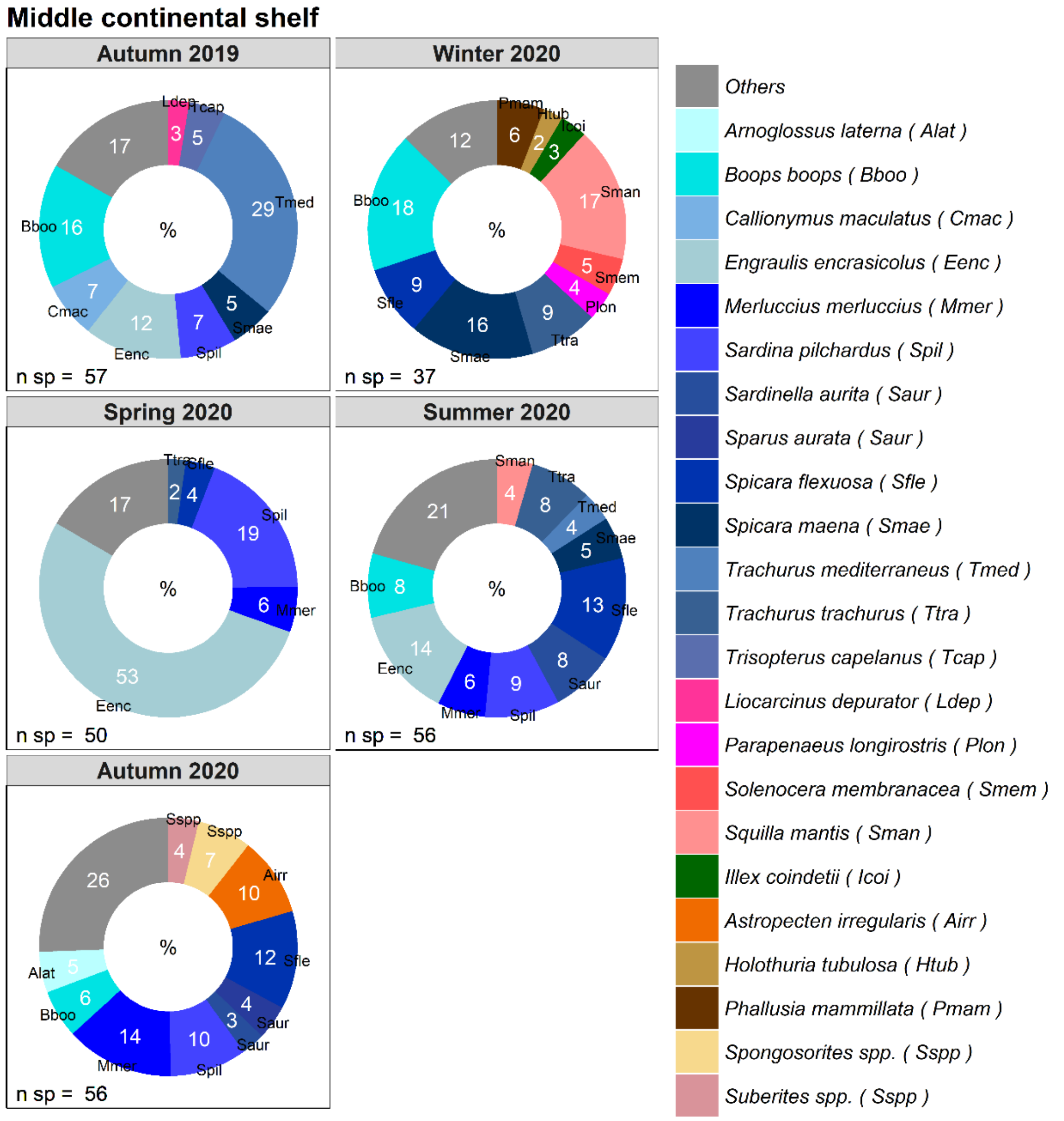


Figure 11. Species with the most important biomass within the discarded catch fraction in the middle continental shelf for all hauls conducted in Catalonia for each season from October 2019 to December 2020.

The proportion of species with the most biomass within the discarded catch fraction in the continental shelf is shown in Figure 12. There, between 113 and 173 species were discarded. Most of the discarded catch was composed by sharks (*S. canicula*). Other fish species present on the discarded catch were *B. boops*, *C. aper*, *S. flexuosa*, and *M. scolopax*, among others. Target species like *M. merluccius* and *L. budegassa* were discarded because they did not reach the minimum conservation reference size, being less than 8% of the fraction. Crustacean species represented a low proportion of the discarded catch. Benthic invertebrates, i.e. *L. phalangium*, *E. melo*, and *G. acutus*, accounted for a high proportion of the discarded catch during spring and winter 2020.

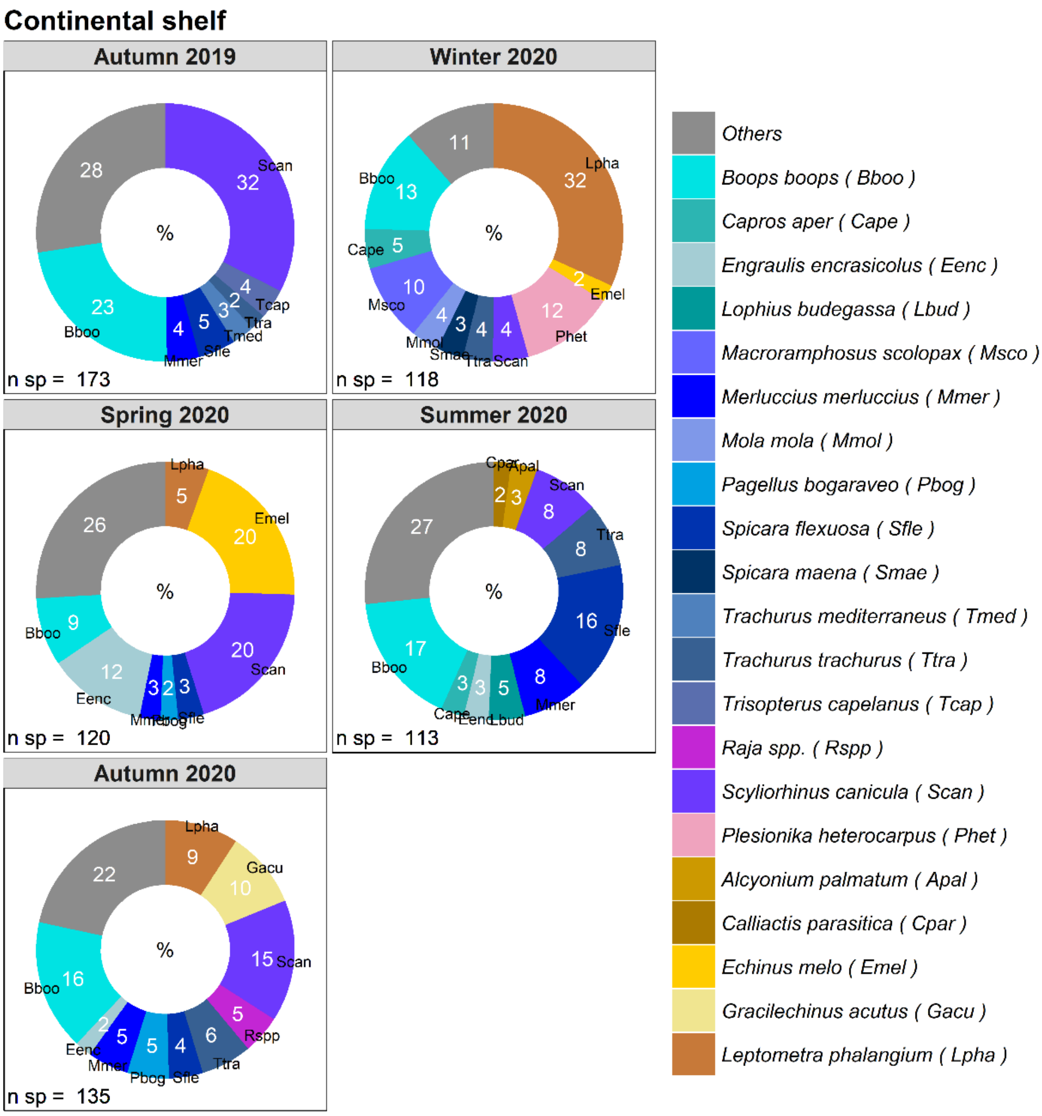


Figure 12. Species with most biomass within the discarded catch fraction in the continental shelf for all hauls conducted in Catalonia for each season from October 2019 to December 2020.

The proportion of species with most biomass within the discarded catch fraction in the upper slope is shown in Figure 13. There, between 71 and 129 species were discarded. Most of discarded catch was composed by sharks, mainly *S. canicula* although there was also a low proportion of *G. melastomus*. Other fish species present on the discarded catch were *C. coelorhincus*, *C. conger*, *G. argenteus*, *L. caudatus*, *P. blennoides*, and *T. trachurus*, but they all had a low presence in the catches (< 7%). Cephalopod species accounted for less than 9% of the discarded catch and benthic invertebrates added up less than 5%.

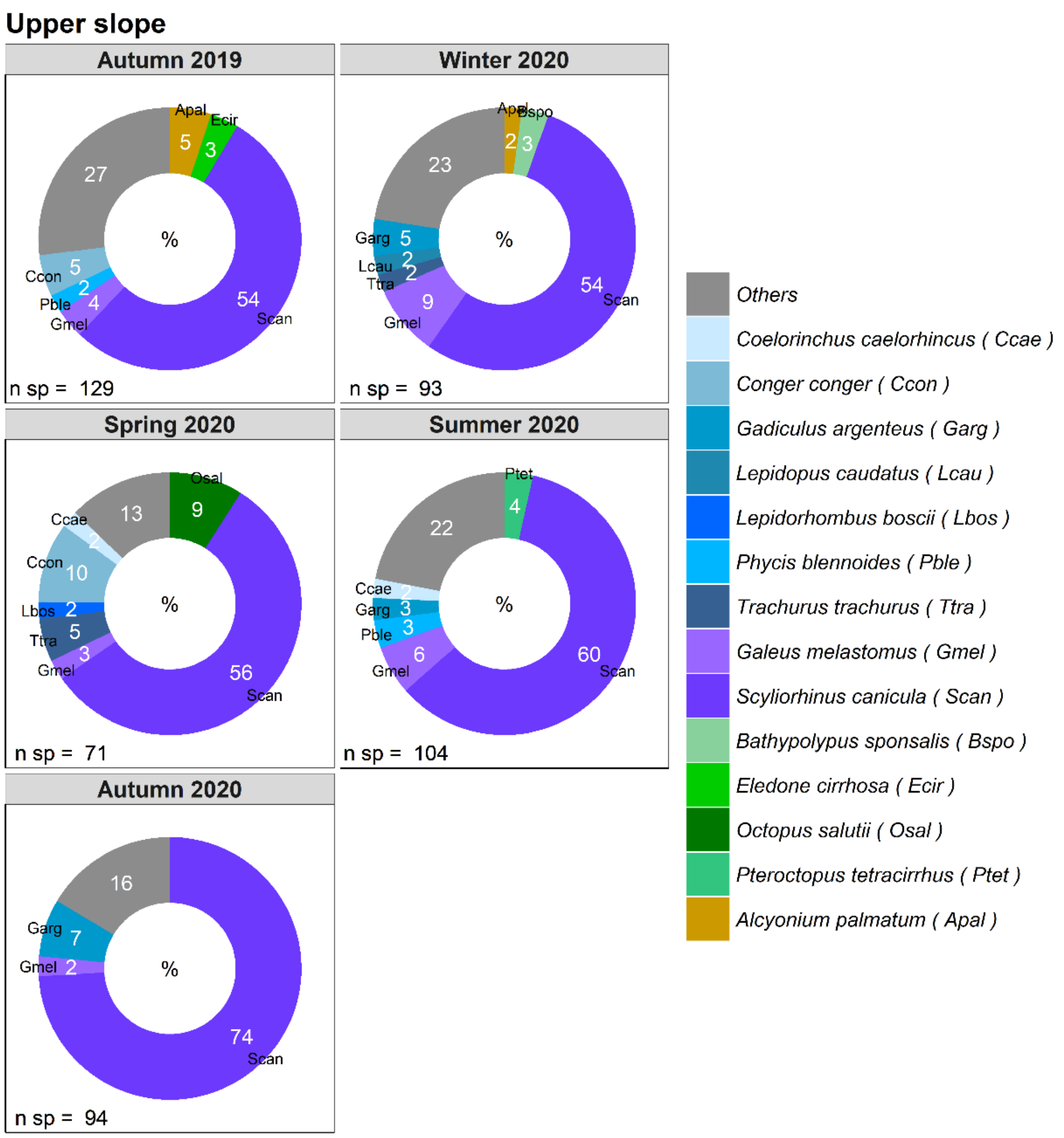


Figure 13. Species with most biomass within the discarded catch fraction in the upper slope for all hauls conducted in Catalonia for each season from October 2019 to December 2020.

The proportion of species with most biomass within the discarded catch fraction in the lower slope is shown in Figure 14. There, between 49 and 87 species were discarded. Most of the discarded catch was composed by sharks, mainly by the species *G. melastomus* and *S. canícula*, but, in a low proportion, by the species *E. spinax* and *C. monstrosa*. Other fish species present in the discarded catch were *C. caelorhincus*, *C. conger*, *H. dactylopterus*, *L. crocodilus*, *N. aequalis*, *T. scabrus* and *L. caudatus*. In autumn 2019, a high proportion of the species *M. mola* was observed in the discarded catch. However, this proportion corresponded to a single large and heavy individual, caught in one haul. Cephalopod species represented less than 13% of the discarded catch.

See Annex I for the common name and coding used for each species in figures.

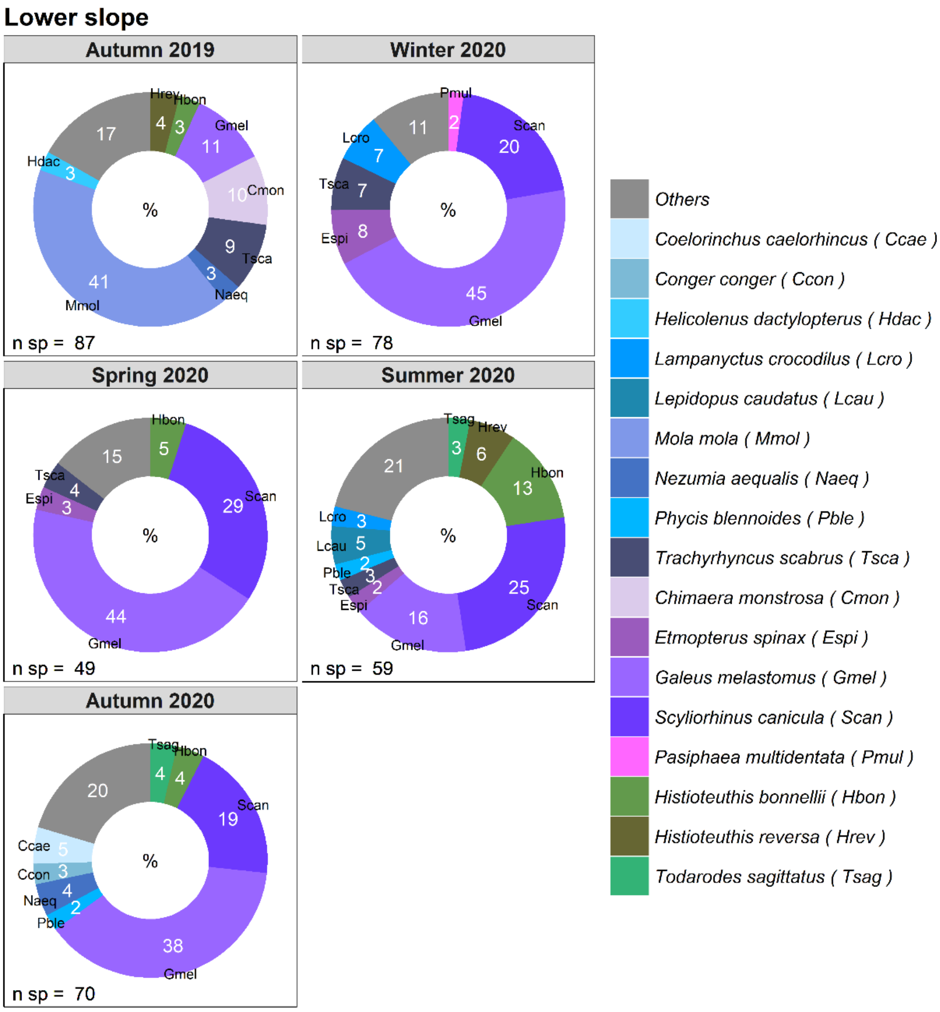


Figure 14. Species with most biomass within the discarded catch fraction in the lower slope for all hauls conducted in Catalonia for each season from October 2019 to December 2020.

The most important taxonomic group on the discarded catch in the shallow, middle, and continental shelves were Actinopterygii but in the upper and lower slopes, the most important group were Chondrichthyes (Table 3) within the group Crustacea, the higher biomass was found in the middle and continental shelves. Among the discarded molluscans, Cephalopoda were present in all fishing grounds whereas Bivalvia and Gasteropoda were mainly discarded in the shallow and middle continental shelves. Echinodermata had higher biomasses and abundances in the continental shelf but the high standard deviation indicated variability in the catches.

See Annex II for the complete list of species' biomass in each fishing ground and Annex III for species' abundances.

Table 3. Biomass (kg/km^2) and abundance (ind/km^2) of taxonomic groups present in the discarded catch in Catalonia. Mean and standard deviation in each fishing ground, including all hauls from October 2019 to December 2020.

	Shallow continental shelf		Middle continental shelf		Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
Actinopterygii	120.08	151.47	187.61	175.99	146.48	193.74	16.01	14.17	12.71	22.23
Chondrichthyes	0.34	0.47	0.41	0.34	45.11	87.10	51.39	60.19	26.55	52.96
Crustacea	6.47	5.20	13.92	17.03	19.41	88.47	2.94	2.46	1.77	2.11
Cephalopoda	5.74	5.83	5.00	7.55	3.81	4.06	5.30	8.16	3.96	6.14
Other Mollusca	5.26	5.82	3.98	4.98	3.09	7.40	0.30	0.57	0.03	0.10
Porifera	0.18	0.31	2.20	3.30	1.14	1.95	0.03	0.06	0.00	0.02
Cnidaria	2.43	2.42	5.06	6.02	7.53	9.04	1.96	5.72	0.13	0.31
Annelida	0.00	0.01	0.04	0.10	0.45	1.10	0.07	0.14	0.01	0.04
Sipuncula					0.01	0.03	0.01	0.04	0.00	0.00
Echinodermata	6.22	7.19	3.97	3.90	67.70	254.46	0.64	0.89	0.09	0.34
Tunicata	0.21	0.35	0.62	0.57	2.33	3.40	0.19	0.36	0.00	0.01
Bryozoa					0.00	0.01				

	Shallow continental shelf		Middle continental shelf		Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
Abundance	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
Actinopterygii	6181.13	6295.76	17430.28	18107.30	10412.54	33266.67	925.42	768.87	383.29	499.12
Chondrichthyes	106.05	129.87	203.25	165.97	453.09	616.22	551.31	570.15	150.61	252.13
Crustacea	879.61	629.30	2484.63	2571.15	7962.35	43239.96	658.29	453.35	329.68	639.03
Cephalopoda	49.05	41.44	190.09	253.30	268.83	233.08	146.30	233.05	36.34	52.33
Other Mollusca	486.80	504.04	386.17	430.86	285.57	421.17	26.71	43.63	6.29	13.14
Porifera	14.11	29.81	44.23	48.23	53.83	93.49	4.37	7.52	0.39	1.77
Cnidaria	417.58	437.59	1255.38	1498.93	1151.75	1331.31	293.07	745.13	36.74	106.63
Annelida	6.64	10.79	19.59	34.16	24.40	75.29	9.48	16.34	1.00	3.12
Sipuncula					4.94	21.07	4.38	10.03	0.30	1.73
Echinodermata	2125.88	2534.99	1691.64	1731.38	12872.61	51329.13	67.04	80.12	12.18	31.87
Tunicata	7.62	12.82	104.65	58.31	682.16	1773.08	19.14	34.41	0.67	2.53
Bryozoa					0.42	2.56				

The composition of the debris for the bottom trawling hauls in the shallow continental shelf is shown in Figure 15. The composition of debris was highly variable throughout the seasons sampled. Anthropogenic debris was scarce in this fishing ground, lower than 17%, and the most important anthropogenic litter was fishing gear, clinker, and plastic. Clinker was the material released from steamships as a residuum of coal-burning (Ramirez-Llodra et al., 2013). Natural debris accounted for most of the mass, mainly terrestrial plants, which accounted for the 97% of the total debris in autumn 2019. These large proportions of terrestrial plants mainly corresponded to tree trunks, especially abundant after torrential rains. Other natural debris was marine plants, marine organic debris, shells, the green alga *C. bursa*, and calcified remains. Calcified remains are defined as any calcareous structure of biogenic origin. Marine plants were especially abundant during winter 2020 and autumn 2020, when represented between 47 and 54% of the total debris.

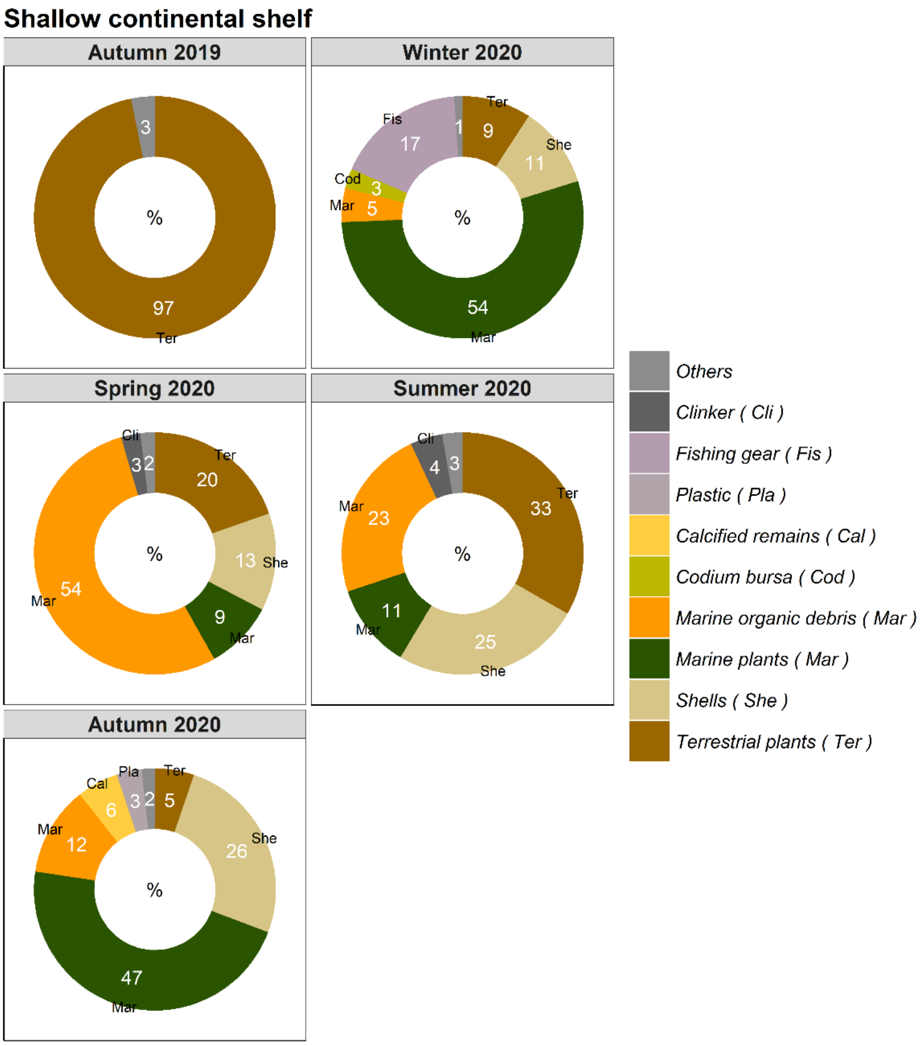


Figure 15. October 2019 to December 2020. Seasonal debris fraction in the shallow continental shelf. Biomass results are expressed in percentage.

The composition of the debris in the middle continental shelf is shown in Figure 16. The composition of debris in the catch was highly variable throughout the seasons sampled. Anthropogenic debris was scarce in this fishing ground, lower than 21%, being glass, lumber, and clinker the most important anthropogenic items caught. Natural debris accounted for most of the mass, mainly terrestrial plants, which accounted for 71% of the total debris during autumn 2019. Other natural debris was *C. bursa*, marine organic debris, marine plants, and shells.

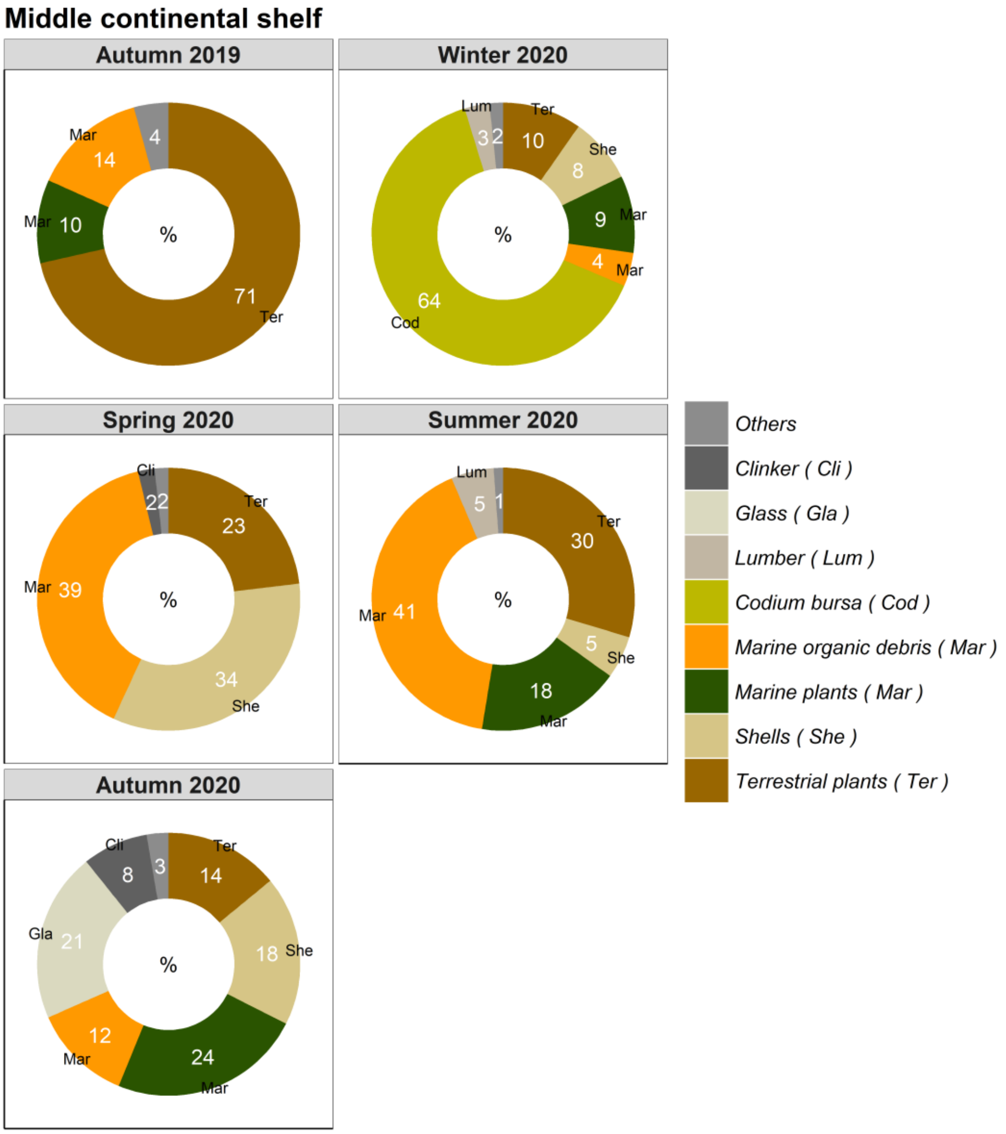


Figure 16. October 2019 to December 2020. Seasonal debris fraction in the middle continental shelf. Biomass results are expressed in percentage.

The composition of the debris in the continental shelf is shown in Figure 17. Anthropogenic debris was between 21 and 49%, being wet wipes the most important item, accounting for the 5 to 32% of the total debris. Plastics represented between 2 and 14% of the catch. Despite plastics had a low percentage in mass, they were present in all seasons indicating the permanent presence of plastics in the continental shelf. Natural debris ranged among 48 and 80% of the total debris, with terrestrial plants being the most important items, ranging between 19 and 32%. Other natural debris caught was marine organic debris, marine plants, shells, calcified remains and the algae *C. bursa*.

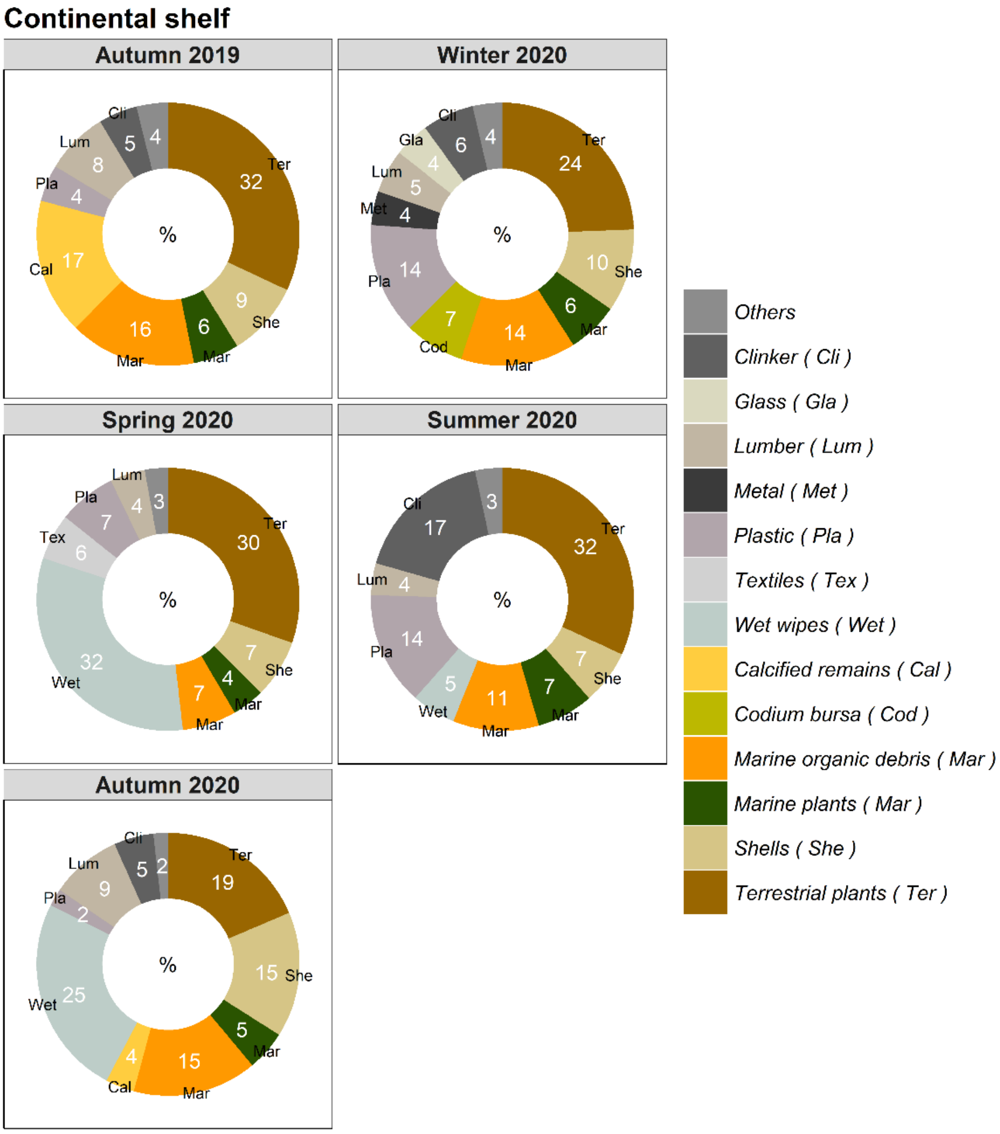


Figure 17. October 2019 to December 2020. Seasonal debris fraction in the continental shelf. Biomass results are expressed in percentage.

The composition of the debris in the upper slope is shown in Figure 18. Anthropogenic debris ranged between 16 and 59% of the total debris, being clinker the most important item caught, which accounted for 4 to 13% of the total debris. In the upper slope, plastics were between 5 and 10% of the catch. Other anthropogenic debris was lumber, glass, rubber, textiles, and wet wipes. Natural debris ranged between 38 and 81% of total debris, being terrestrial plants the most important category, which ranged between 19 and 40%. Other natural debris caught in the samplings was marine organic debris, marine plants, shells, and calcified remains.

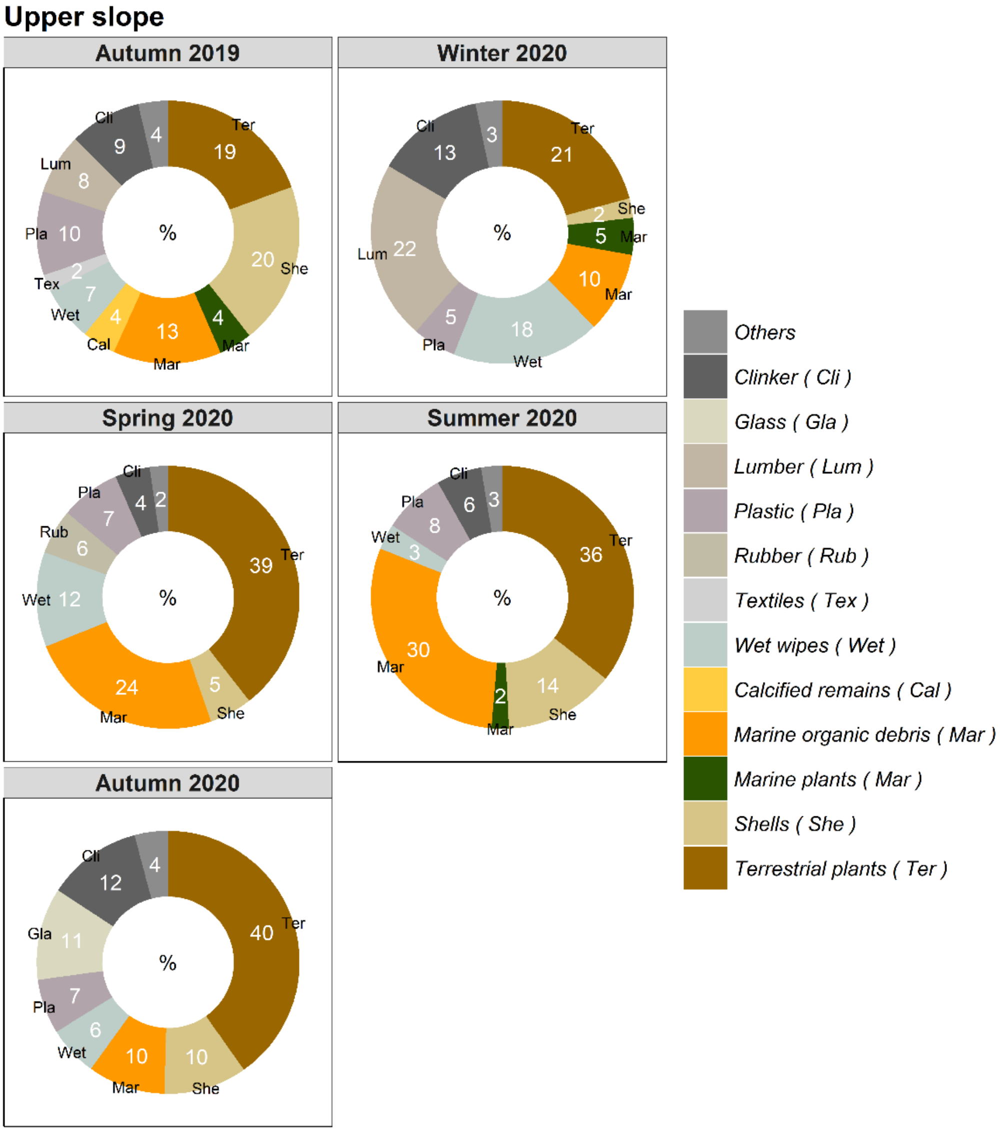


Figure 18. October 2019 to December 2020. Seasonal debris fraction in the upper slope. Biomass results are expressed in percentage.

The composition of debris in the lower slope is shown in Figure 19. Anthropogenic debris ranged between 41 and 67% of the debris fraction being wet wripes the most important item, which accounted for 14 to 36% of the total debris. Plastics ranged between 3 and 18%. Other anthropogenic debris was clinker, textil, lumber, glass, and fishing gears. The proportion of anthropogenic debris within the debris fraction of the catch was higher with depth. Natural debris ranged between 29 and 55% of the total debris, being terrestrial plants the most important item, which ranged between 20 to 33%. Other natural debris was marine organic debris, marine plants, shells, and calcified remains.

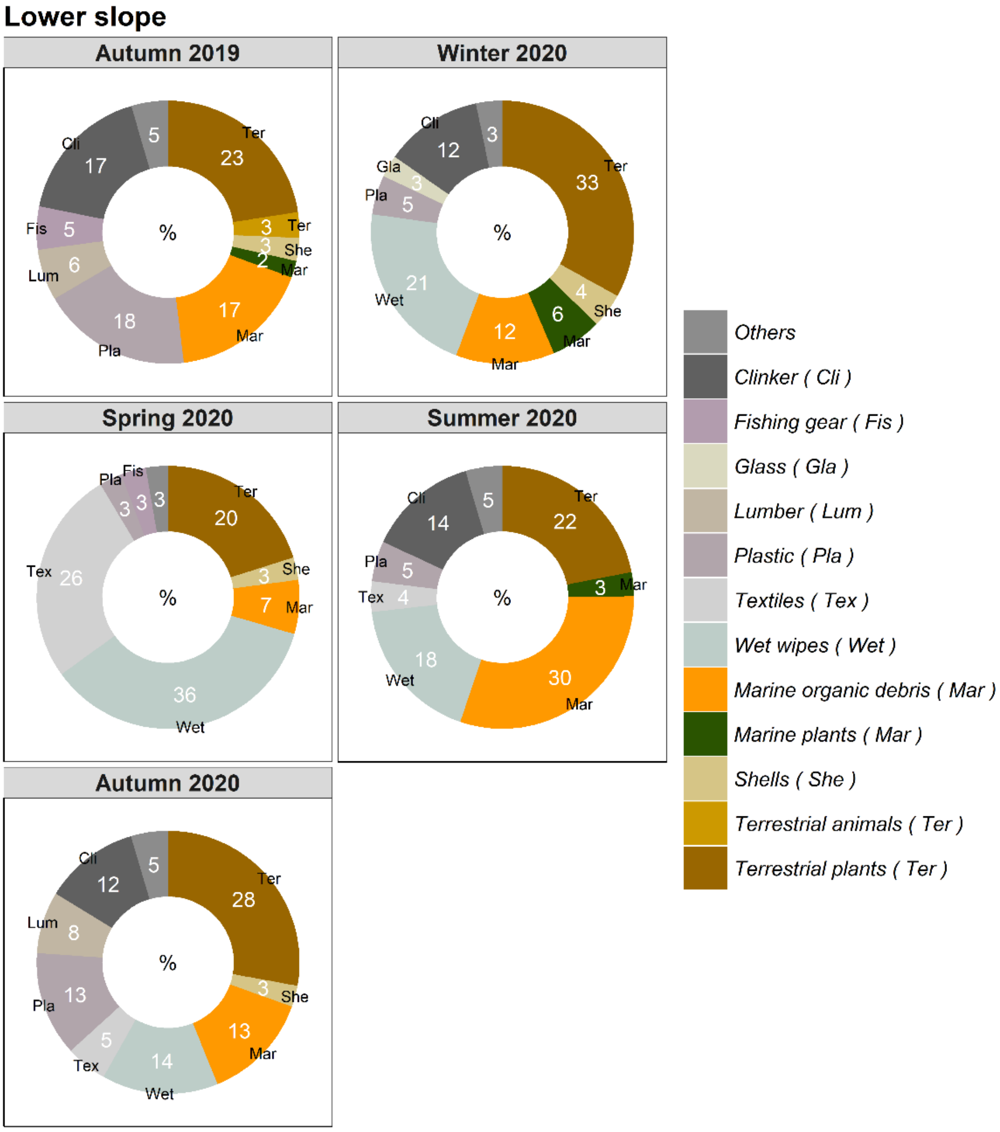


Figure 19. October 2019 to December 2020. Seasonal debris fraction in the lower slope. Biomass results are expressed in percentage.

See Annex I for the common name and coding used for each item in figures.

The biomass of the different type of debris present in the catch is shown in Table 4. Natural debris, including terrestrial plants and marine plants, had a higher biomass in shallower dephts (shallow and middle continental shelf), most likely because this type of debris is frequent near river mouths or near the coast after torrential rains. In contrast, anthropogenic debris such as plastic, clinker, and wet wipes, had a higher mass in deeper fishing grounds (continental shelf, upper, and lower slope), which may be explained by the ocean currents that transport the debris to deeper areas.

Table 4. Mass (Kg/Km^2) of the items present in the debris fraction of the catch in Catalonia. Mean and standard deviation in each fishing ground, including all hauls from October 2019 to December 2020.

	Shallow continental shelf		Middle continental shelf		Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
Terrestrial plants	76.50	179.19	18.93	13.44	17.81	23.85	10.70	15.08	2.54	4.38
Marine organic debris	9.71	8.53	12.82	12.92	7.49	6.39	7.04	18.03	1.49	1.91
Marine plants	24.46	45.17	7.84	7.78	3.47	6.51	0.83	1.12	0.30	0.65
Shells	10.66	10.03	6.63	6.94	5.71	6.65	4.39	10.31	0.28	0.70
Wet wipes	0.08	0.20	0.03	0.07	8.17	30.29	2.45	4.53	2.09	6.39
Clinker	1.01	1.27	1.40	2.72	4.41	13.83	2.63	2.60	1.01	2.29
Plastic	0.86	1.02	0.46	0.36	5.19	11.08	2.77	4.12	0.72	0.93
Codium bursa	1.12	2.05	5.07	12.86	1.02	3.20	0.19	0.83		
Lumber	0.06	0.15	1.01	1.93	3.63	6.72	1.40	4.29	0.21	0.59
Fishing gear	5.26	14.05	0.02	0.04	0.09	0.25	0.10	0.30	0.17	0.53
Calcified remains	0.66	1.75			2.84	15.08	0.47	2.14	0.04	0.14
Glass			2.75	7.27	0.35	2.10	0.61	2.40	0.11	0.36
Textiles	0.01	0.02			0.94	4.91	0.36	1.08	0.86	3.99
Metal					0.60	2.09	0.11	0.42	0.02	0.11
Ropes	0.16	0.35	0.12	0.14	0.22	0.86	0.07	0.15	0.04	0.08
Unclassified debris	0.04	0.12			0.23	0.76	0.08	0.15	0.04	0.18
Rubber					0.08	0.44	0.31	1.48	0.00	0.02
Other marine algae	0.03	0.05	0.09	0.21	0.02	0.09	0.03	0.09	0.01	0.04
Codium tomentosum	0.04	0.09	0.03	0.08			0.00	0.01		
Terrestrial animals					0.00	0.02			0.04	0.23
Rhodophyta			0.00	0.01	0.02	0.09				
Cigarette stubs							0.01	0.05		

2.1.1.1 Target species monitoring: Hake (*Merluccius merluccius*)

Annual catch history

The European hake, *M. merluccius*, is a demersal and benthopelagic gadoid widely distributed in the Mediterranean Sea, inhabiting the continental shelf and slope. The annual catch rates of hake during the period 2000-2020 in Catalonia indicated a progressive decline, more intense since 2010, reaching the minimum values in the last years (Figure 20).

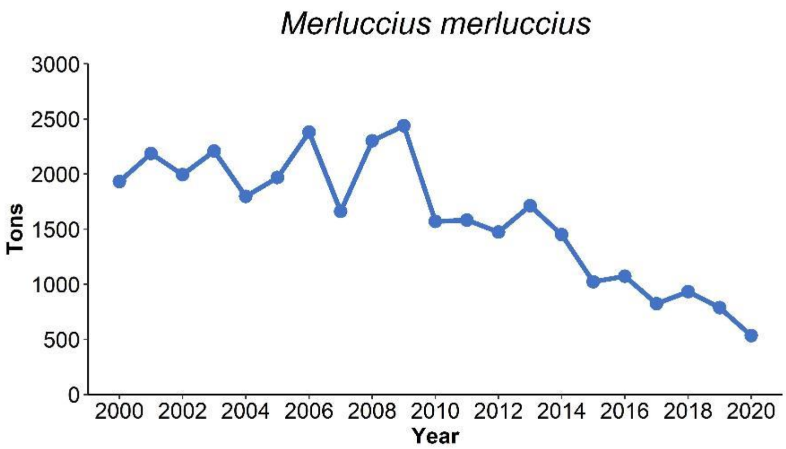


Figure 20. Merluccius merluccius. Time series of European hake annual catch (tons) in Catalonia for the period 2000-2020.

Population structure

To determine the hake size range captured in Catalonia, a monthly sampling was performed onboard commercial bottom trawl vessels from October 2019 to December 2020. To ensure that the whole size range population was monitored, the data also included the fraction of hake discarded by the bottom trawl fleet. The monthly length-frequency distribution of hake indicated that the species was more abundant in the continental shelf, despite being also present in the upper slope and, with lower abundances, in the lower slope. In terms of catch size, an important proportion of individuals, especially on the continental shelf, were captured below the minimum conservation reference size (MCRS).

Size range caught extended from 5 to 63 cm. In both upper and lower slopes, the catch was dominated by large-sized individuals (Figure 21). Small-sized individuals (<10 cm) were captured throughout the year. However, these recruits were more abundant from June to September, coinciding with the recruitment period. Hake otter trawl catch was dominated by juvenile individuals since adults (males > 24 cm and females > 36 cm) were poorly represented in the catch. It is important to notice the lack of sampling in April and May 2020, coinciding with forced quarantine due to the COVID-19 pandemic.

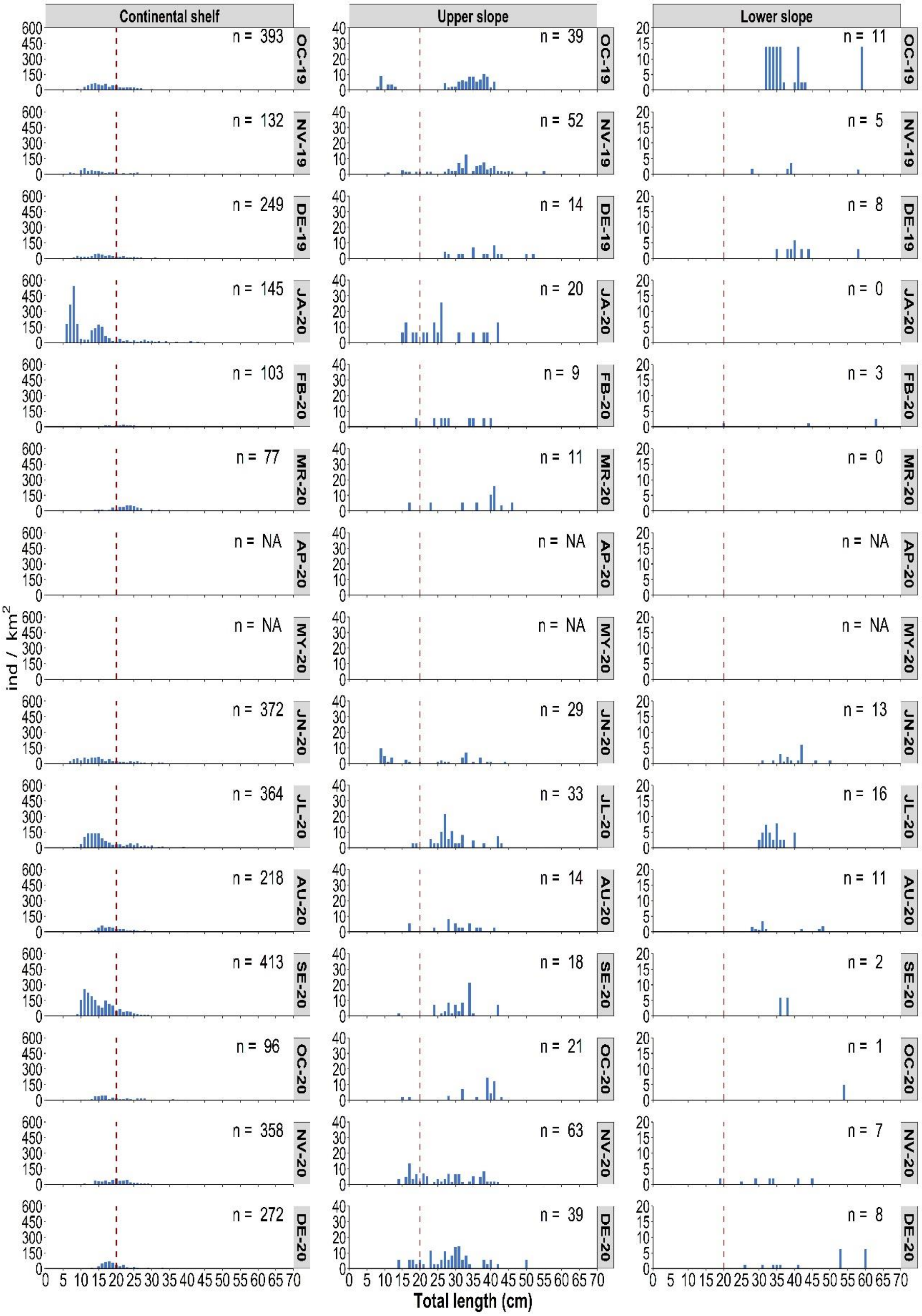


Figure 21. Monthly length-frequency distribution of hake (M. merluccius) at different depth stratum from October 2019 to December 2020 along the Catalan coast. The red dashed line indicates the hake minimum conservation reference size (MCRS) in the Mediterranean (20 cm).

Sexual morphology and sex ratio

Growth differences between sexes have been reported and linked to sexual size dimorphism (Morales-Nin et al., 1998). In detail, sizes below 40 cm are dominated by males whereas larger-sized individuals are clearly dominated by females (Recasens et al., 1998).

Length-weight relationship

The parameters of the length-weight relationship for the hake population were calculated using the relationship $W = a*TL^b$, where W is weight (g) and TL is total length (cm) (Table 5). According to length-weight relationship parameters for both sexes combined, hake displayed a positive allometric growth (b > 3) in both years (Figure 22). However, gadoid fish are known for their growth differences between sexes so that the growth curves were both combined and applied separately to males and females. Results revealed opposite directions of isometry by sex along the two years studied: males exhibited negative allometric growth (b < 3) whereas females had positive allometric growth (b > 3). This difference between hake males and females could be explained by the dominance of males in the smaller length classes and their absence from the larger ones.

Table 5. Hake length-weight relationship parameters in 2019 and 2020.

2019	a	b	R^2	n
Combined	0.0065	3.0309	0.9751	2464
Females	0.0066	3.0296	0.972	1202
Males	0.0086	2.9398	0.9553	1075
2020	a	b	R^2	n
Combined	0.0067	3.0234	0.9741	1654
Females	0.0064	3.0369	0.9853	729
Males	0.009	2.9262	0.9399	797

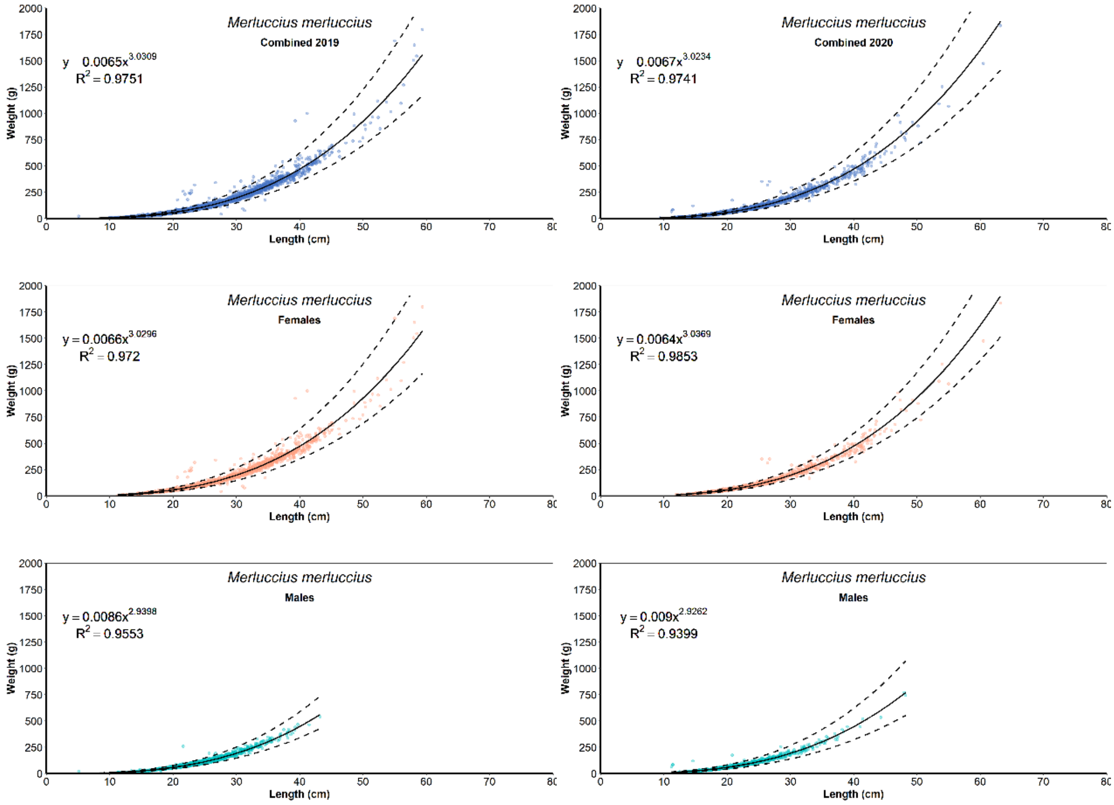


Figure 22. Length-weight relationship for hake population (M. merluccius) in 2019 and 2020. Parameters a and b were calculated for both sexes combined (blue), females (red) and males (green).

Reproductive cycle and gonadosomatic and hepatosomatic indexes

The reproductive cycle of hake was analyzed for 2019 (Figure 23) and 2020 (Figure 24), the two full years of monitoring. It was observed that males and females in advanced maturity and spawning (stages IV and V respectively) were present all year round, in a percentage that fluctuated between 15 and 50 %, depending on the month. However, the reproductive activity for females seemed to concentrate from November to January in both years, when the major percentage of spawners were detected. The proportion of individuals in a resting stage (stages II) was high for both years, especially in females. Results of the gonadosomatic index (GSI) indicated that the highest values were observed for females from November to January in both years, coinciding with the spawning peak, and the lowest values were recorded during the summer months. In 2019, males displayed maximum GSI values from April to August and the minimum was in January whereas in 2020 GSI remained constant at low numbers throughout the year. It was interesting to point out the high variability for both sexes, but especially in females.

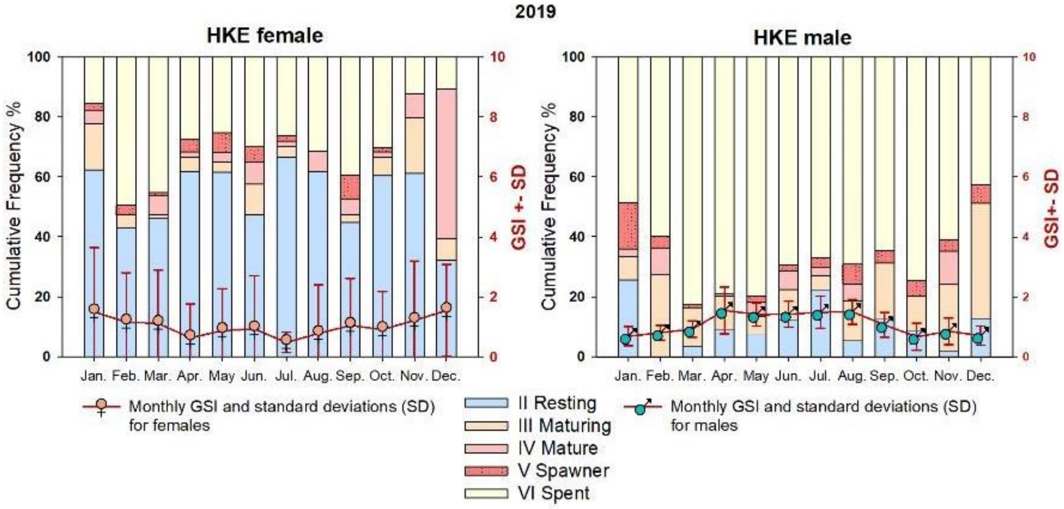


Figure 23. Hake (HKE) monthly gonadal cycle for females and males in 2019. Gonadosomatic index (GSI +/-SD) and percentage of different maturity stages.

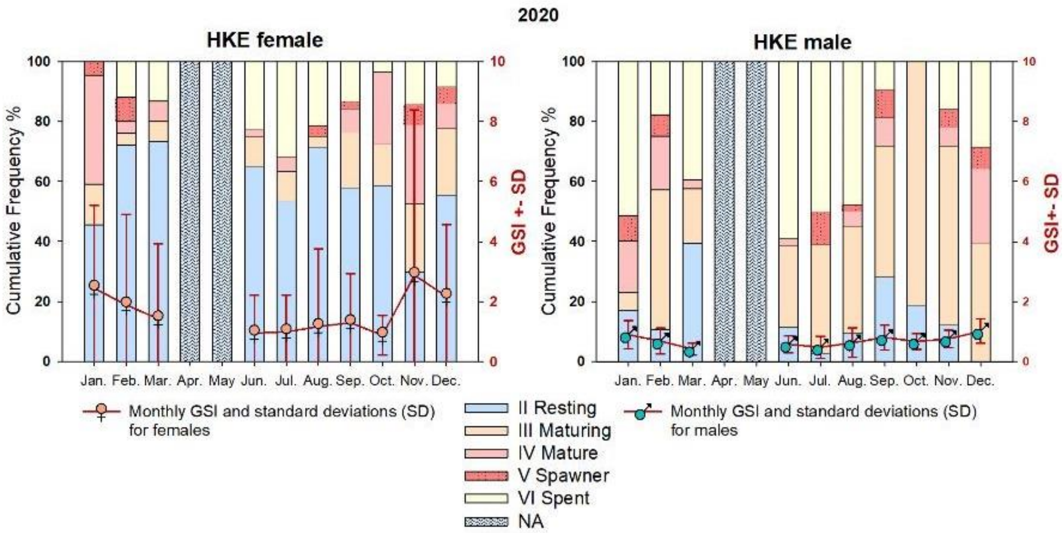


Figure 24. Hake (HKE) monthly gonadal cycle for females and males in 2020. Gonadosomatic index (GSI +/-SD) and percentage of different maturity stages.

Additionally, the relationship between the gonadosomatic index (GSI) and the liver somatic index (LSI) was reported for 2019 and 2020 (Figure 25, Figure 26). GSI varied according to gonadal maturity stages, especially in females, reaching maximum values when the spawning peak occurred. LSI remained much more constant throughout the year and seemed to be independent of maturity stages, excepting spawning males (stage V) that presented LSI values lower than the rest of the stages for both years.

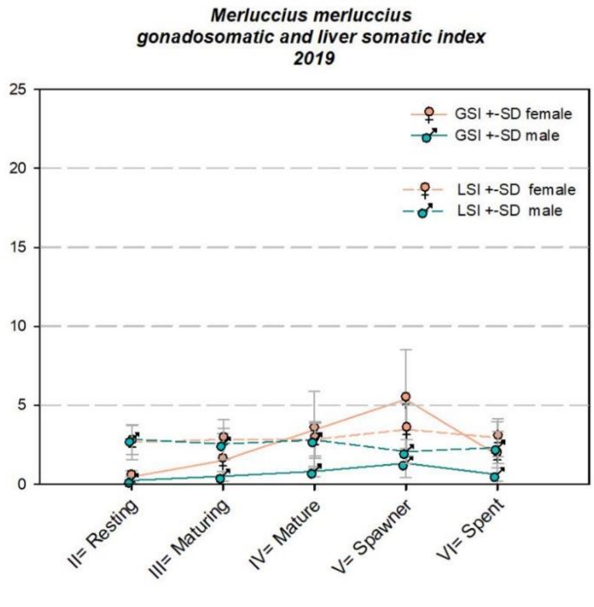


Figure 25. Gonadosomatic index (GSI) and liver somatic index (LSI) of hake (*M. merluccius*) for males and females separately according to gonadal maturity stages for 2019.

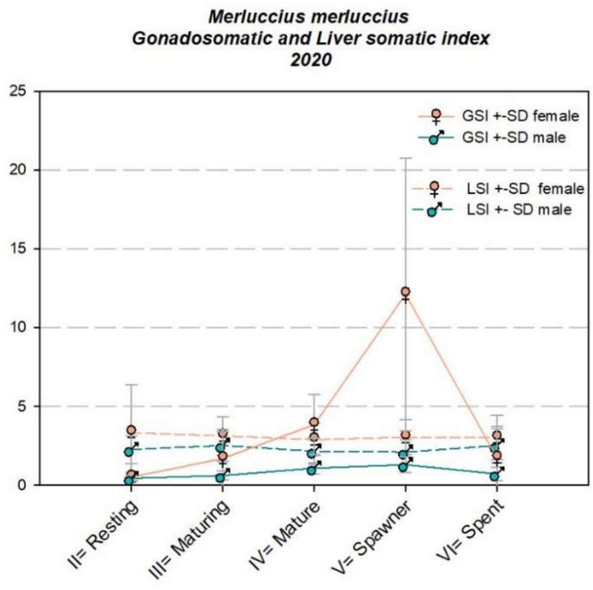


Figure 26. Gonadosomatic index (GSI) and liver somatic index (LSI) of hake (*M. merluccius*) for males and females separately according to gonadal maturity stages for 2020.

Summary factsheet of the biological parameters and fishing activity in 2019-2020 of Hake in Catalonia

2.1.1.2 Target species monitoring: Norway lobster (*Nephrops norvegicus*)

Annual catch history

Norway lobster catches were obtained in the main ports of Catalonia, mainly in the upper slope.

The historical series of the Norway lobster in Catalonia indicated a progressive decrease in catches (Figure 27), more accute as of 2014 and reaching minimums of less than 200 t in 2020.

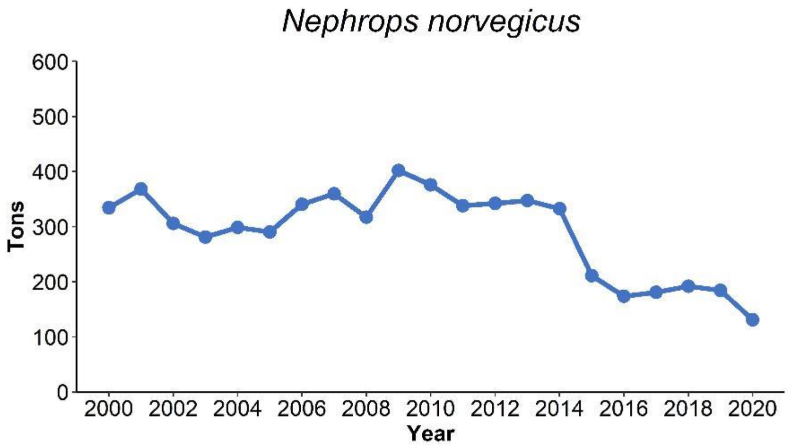


Figure 27. *Nephrops norvegicus*. Time series of Norway lobster annual catch (tons) in Catalonia for the period 2000-2020.

Population structure

The monthly length frequency distribution of Norway lobster in Catalonia in the period of the study (October 2019 to December 2020) indicated a greater abundance of individuals in the upper slope (Figure 28). In terms of catch size, a proportion of individuals, especially on the upper slope, were captured below the minimum conservation reference size (MCRS) of 20 mm (cephalotorax length).

In the upper slope, the greatest abundances were found in June and July, where they exceeded 450 individuals per km^2, with sizes ranging from 16 to 61.5 mm in cephalothorax length and with a greater presence of specimens at about 30 mm.

In the lower slope, the greatest abundances were found in December and January, where they exceeded 80 individuals per km^2, with sizes ranging from 18 to 59.8 mm in cephalothorax length and with greater presence of specimens at about 25 mm.

As with other species, it is important to notice the lack of sampling in April and May 2020, coinciding with forced quarantine due to the COVID-19 pandemic.

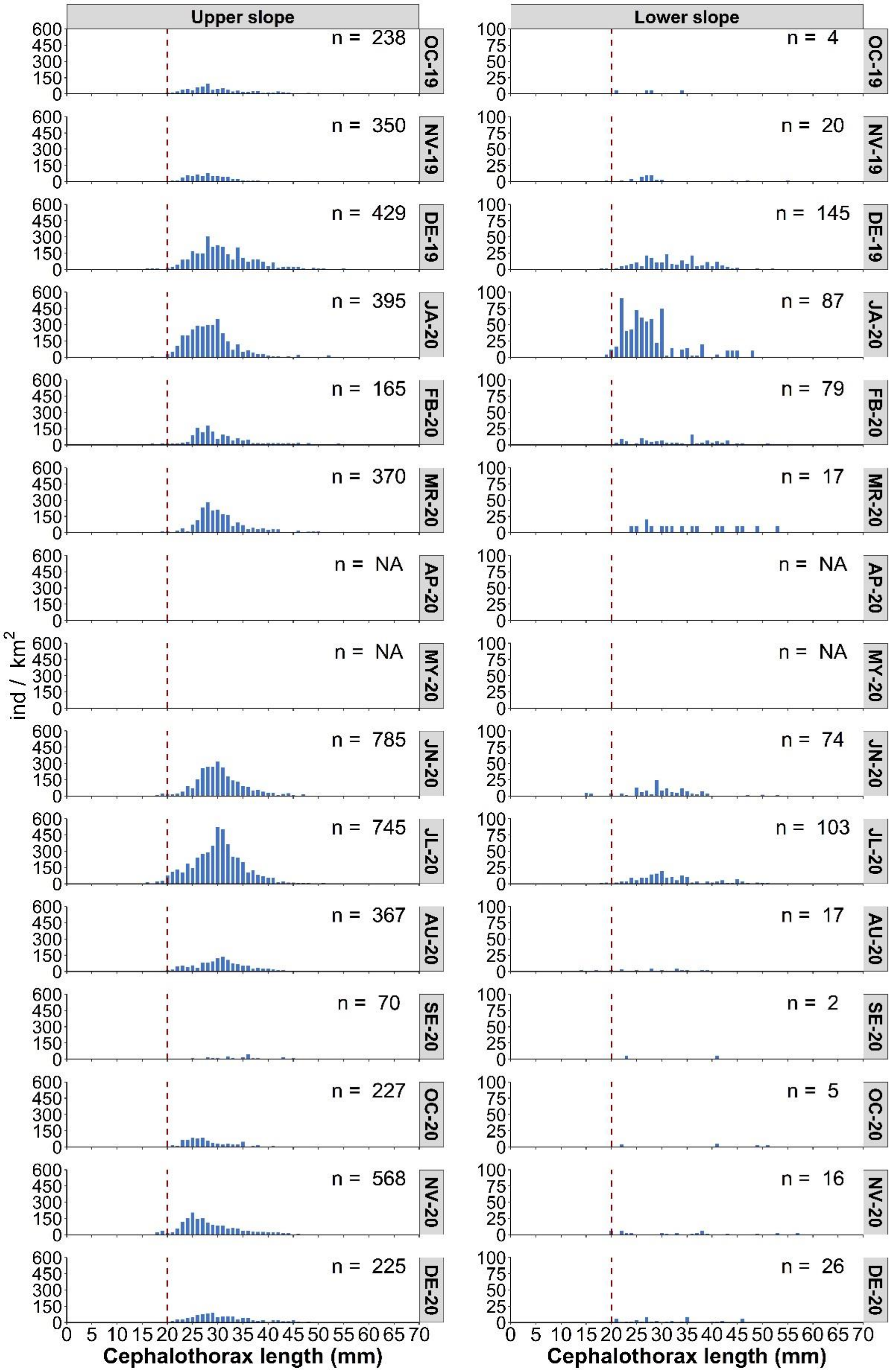


Figure 28. Monthly length-frequency distribution of norway lobster (*N. norvegicus*) for depth stratum from October 2019 to December 2020 along the Catalan coast. The red dashed line indicates the minimum conservation reference size (MCRS), defined at 20 mm.

Sexual morphology and sex ratio

Norway lobster, *Nephrops norvegicus* (Linnaeus, 1758), is a demersal crustacean widely distributed in the Mediterranean Sea. *Nephrops* populations are mainly located in deep waters on the continental slope from 300 to 600 m (Abello et al., 2002). Regarding its morphometric variables, differences have been seen between males and females, the males being the ones with the longest size and highest weight (Maynou and Sardà, 1997).

Length-weight relationship

The parameters of the length-weight relationship for the norway lobster population were calculated using the relationship $W = a*CL^b$, where W is weight (g) and CL is cephalothorax length (mm) (Table 6). The number of specimens used for the two genders combined was 2457 in 2019 and 2097 in 2020. This great number of individuals allowed good correlation coefficients in the relationships found. According to length-weight relationship parameters for both sexes combined, Norway lobster displayed a positive allometric growth (b > 3) in both years (Figure 29). As in many crustaceans, there are visual differences between males and females for the same species, so the relationships of both sexes were included separately. However, the relationships found in this study were very similar for both sexes. Males of greater size and weight than females were obtained but these lack of big females could also be explained by other factors (sexual behavior or reproduction periods). The updated values of these relationships help us to complete and adjust the fisheries management models.

Table 6. Norway lobster length-weight relationship parameters in 2019 and 2020.

2019	a	b	R^2	n
Combined	0.0005	3.1166	0.9476	2457
Females	0.0005	3.1130	0.9265	1039
Males	0.0004	3.1345	0.9492	1389
2020	a	b	R^2	n
Combined	0.0003	3.2144	0.9710	2097
Females	0.0003	3.2978	0.9558	775
Males	0.0003	3.2143	0.9725	1322

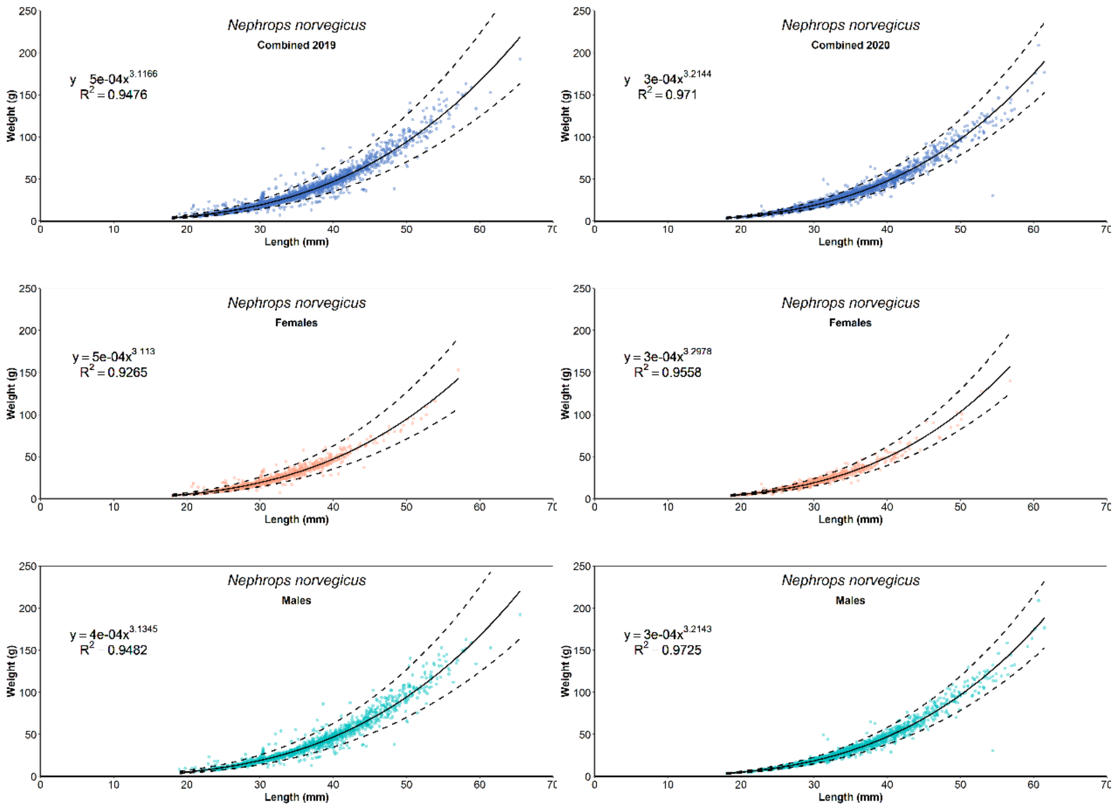


Figure 29. Length-weight relationship for norway lobster population (*N. norvegicus*) in 2019 and 2020. Parameters a and b were calculated for both sexes combined (blue), females (red) and males (green).

Reproductive cycle and gonadosomatic index

The reproductive cycle of the Norway lobster was analyzed in 2019 (Figure 30) and 2020 (Figure 31), which represented two full years of monitoring, except for the months of confinement. The reproduction period of the Norway lobster is less seasonal than the blue and red shrimp; even so, in spring and summer there was a greater concentration of individuals in advanced stages of maturation. This was also appreciated in the gonadosomatic index, which peaked in the summer months.

In 2019 (Figure 30), gonads began to mature in January, but it was not until the arrival of spring that advanced stages of maturation were observed. The spawn mainly occurred in summer but, until October, specimens were seen in advanced stages of maturation, coinciding with the highest values of the gonadosomatic index in July.

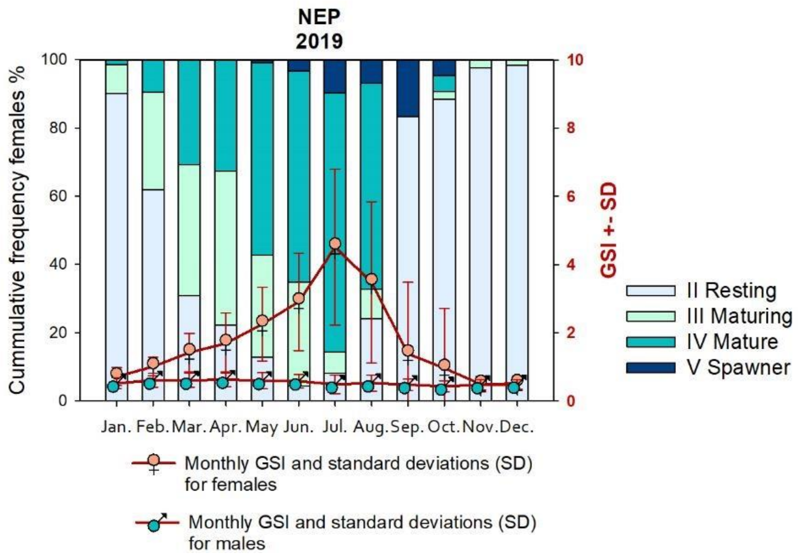


Figure 30. Norway lobster (NEP) monthly gonadal cycle for females in 2019. Gonadosomatic index (GSI*/-SD) and percentage of different maturity stages.

In 2020, the same pattern was observed (Figure 31), with gonads maturing in January although it was not until spring that advanced stages of maturation were seen. Unlike the previous year, the gonadosomatic index peaked in August and from September onwards, no individuals in advanced stages of maturation were found.

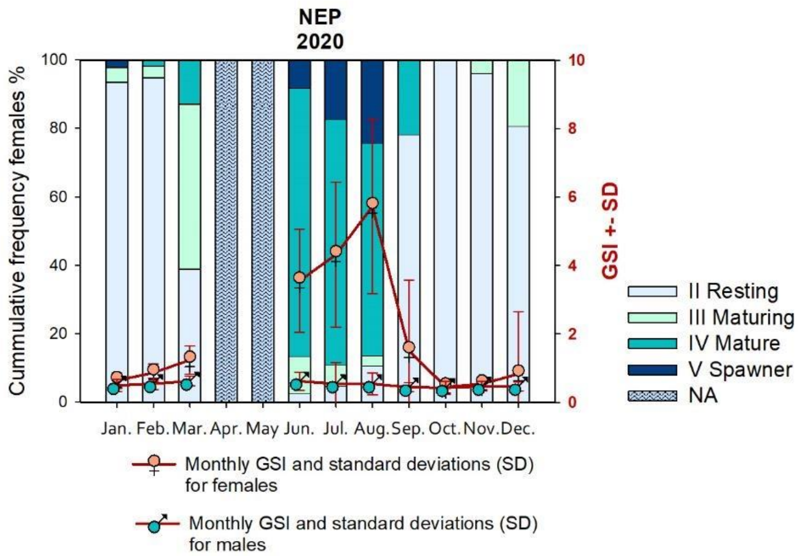


Figure 31. Norway lobster (NEP) monthly gonadal cycle for females in 2020. Gonadosomatic index (GSI*/-SD) and percentage of different maturity stages.

Summary factsheet of the biological parameters and fishing activity in 2019-2020 of Norway lobster in Catalonia

2.1.1.3 Target species monitoring: Blue and red shrimp (*Aristeus antennatus*)

Annual catches series

The blue and red shrimp, *Aristeus antennatus* (Risso, 1816), is a demersal species that inhabits both upper and lower slopes, at dephts from 200 meters to depths of more than 2000 m (Sardá and Cartes, 1993), although mostly on the lower slope. The anual catch rates of the blue and red shrimp during the period 2000-2020 in Catalonia indicated a stabilisation throughout time, especially from 2007 onwards (Figure 32). However, the catches were the lowest since 2007 (around 400 tons) in the last two years .

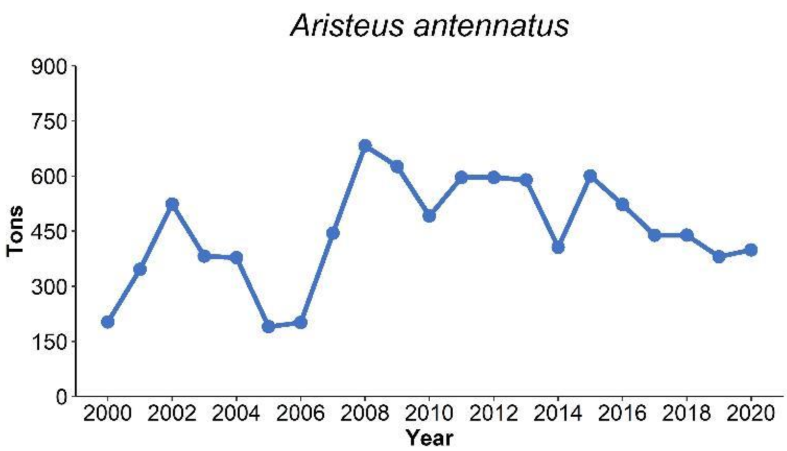


Figure 32. Time series of blue and red shrimp anual catch rates (tons) for the time period 2000-2020 in Catalonia.

Population structure

To determine the blue and red shrimp size range captured in Catalonia, a monthly sampling was performed onboard commercial bottom trawl vessels from October 2019 to December 2020. Size range included the discarded fraction of blue and red shrimp by the bottom trawl fleet; therefore, the whole size range population was monitored. The monthly length-frequency distribution of blue and red shrimp from October 2019 to December 2020 indicated that the species was more abundant in the lower slope. The species was also present on the upper slope but in lower abundance. The most abundant catches of blue and red shrimp were obtained in November on both slopes (Figure 33). On the upper slope, two clearly differentiated population structures were observed in November 2019. In terms of catch size, an important proportion of individuals in both slopes were capturated below the length at first maturity (28 mm, female's CL), despite that the blue and red shrimp does not have a regulated minimum conservation reference size (MCRS). The size for the cephalothorax length ranged from 13 to 72 mm. Adult individuals on the lower slope were captured more abundantly from June to August, coinciding with the breeding period. No sampling was carried out in April and May 2020 because of enforced quarantine due to the exceptional situation of the Covid-19 pandemic.

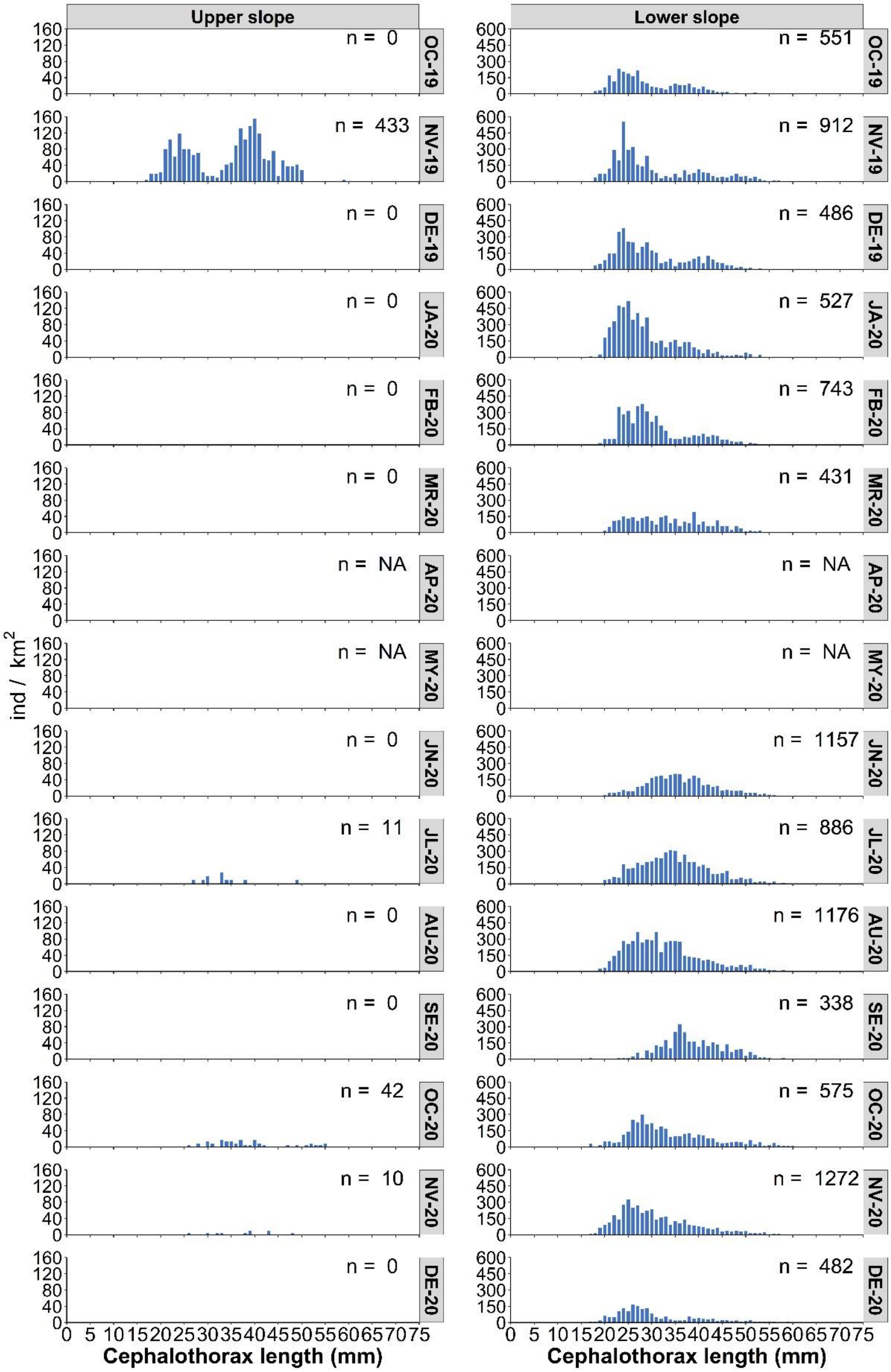


Figure 33. Monthly length-frequency distribution of blue and red shrimp (*A. antennatus*) for depth stratum from October 2019 to December 2020 along the Catalan coast.

Sexual morphology and sex ratio

The species presents a clear sexual dimorphism in both sizes and in external morphological characters (Sardà et al., 1995). The size ranges and mean sizes of females are higher than those of males and, proportionally, more females were caught than males.

Length-weight relationship

The parameters of the length-weight relationship for the blue and red shrimp population were calculated using the relationship: $W = a^* CL^b$, where W is weight (g), CL is the cephalothoracic length (mm), a and b are parameters estimated for the species, with b being the coefficient of allometry. The results obtained for the different length-weight relationships carried out on the different groups (combined sexes together, females and males) are shown in Table 7 and in Figure 34. The values of the allometry coefficient (b) were below 3 for the three groups.Therefore, the length-weight relationship in females and male specimens exhibited a negative allometry in throughout its development, with females being slightly bigger than males. This growth difference could be explained by the dominance of males in the smallest size classes and their absence in the larger ones, as observed. The number of individuals used to calculate this relationship was very high (around 3000 individuals each year), obtaining very high regression values for both sexes combined (> 0.9), so it will be very useful to better adjust the methods for stock assessment.

Table 7. Blue and red shrimp length-weight relationship parameters in 2019 and 2020.

2019	a	b	R^2	n
Combined	0.0041	2.3741	0.9596	2875
Females	0.0039	2.3882	0.9568	2598
Males	0.0509	1.5886	0.6398	277
2020	a	b	R^2	n
Combined	0.0029	2.4674	0.9756	2383
Females	0.0029	2.4672	0.9726	2185
Males	0.0069	2.1986	0.8332	197

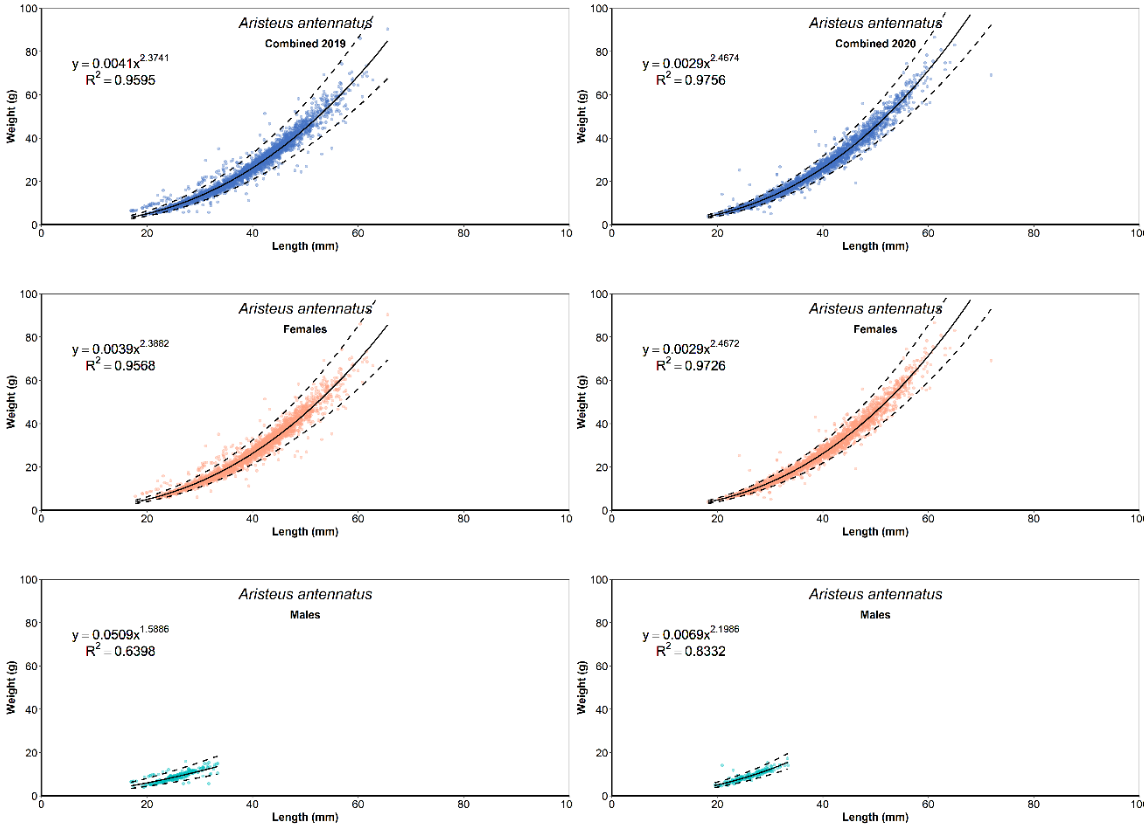


Figure 34. Length-weight relationship for blue and red shrimp population (*A. antennatus*) in 2019 and 2020. Parameters *a* and *b* were calculated for both sexes combined (blue), females (red) and males (green).

Reproductive cycle and gonadosomatic index

The reproductive cycle of blue and red shrimp was analyzed for 2019 and 2020, that is two full years of monitoring (Figure 35 and Figure 36). For females, the reproductive cycle was very seasonal because the highest percentage of mature and spawner (stage IV and stage V, respectively) shrimps was recorded in late spring and throughout the summer in both years. The beginning of gonads maturation was in May and maturation during until the last months of summer. The values of the gonadosomatic index (GSI) were correlated with the evolution of the gonads maturation, obtaining maximum values in July for both years. In this month of maximum GSI, for year 2020, there were 10 % fewer mature and spawner females and a higher percentage of maturiting females compared to 2019. Males presented a practically stable GSI throughout all the months in both years. In April and May 2020 there was no data collection because of confinement by the COVID-19 pandemic.

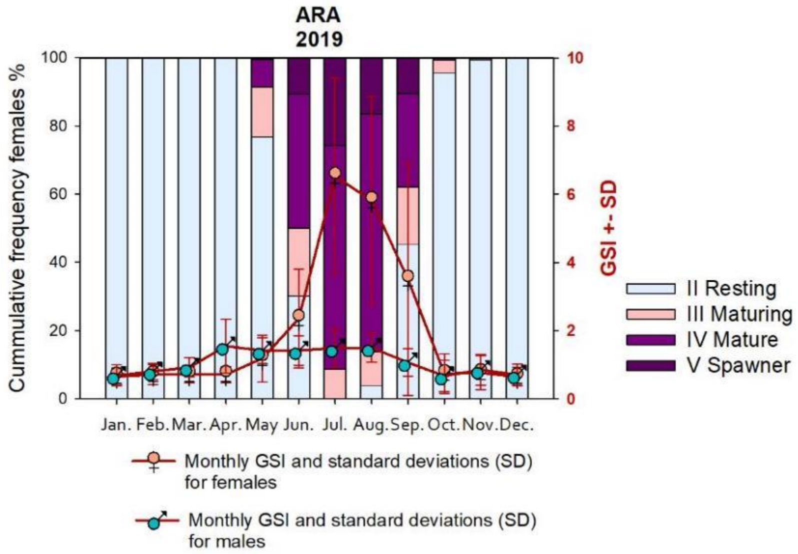


Figure 35. Blue and red shrimp (ARA) monthly gonadal cycle for males and females in 2019. Gonadosomatic index (GSI+/-SD) and percentage of different maturity stages.

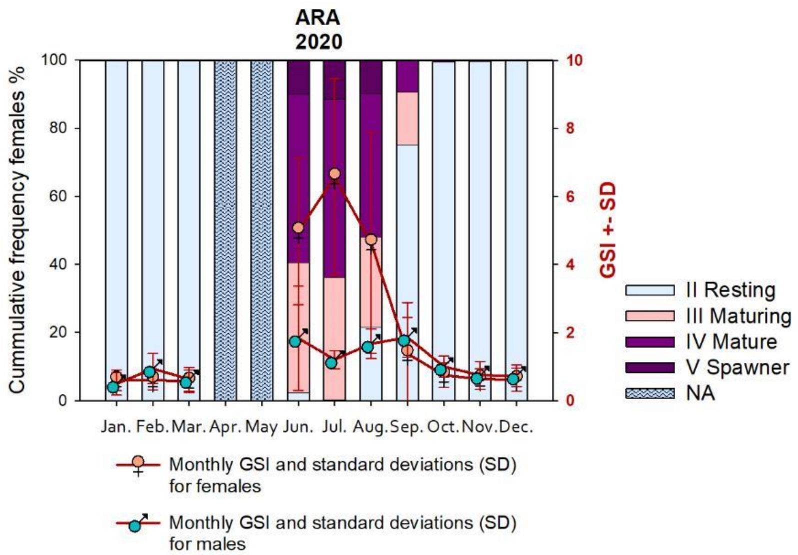


Figure 36. Blue and red shrimp (ARA) monthly gonadal cycle for males and females in 2020. Gonadosomatic index (GSI+/-SD) and percentage of different maturity stages.

Summary factsheet of the biological parameters and fishing activity in 2019-2020 of Blue and red shrimp in Catalonia

2.1.1.4 Target species monitoring: Horned octopus (*Eledone cirrhosa*)

Annual catch history

The horned octopus, *Eledone cirrhosa* (Lamarck, 1798), is a benthic, medium-sized octopus widely distributed over the north-eastern Atlantic and Mediterranean Sea. *Eledone cirrhosa* in north-western Iberian waters is a by-catch of trawling fishery. Annual catch rates of horned octopus during the period 2000-2020 in Catalonia indicated a general decline in time (Figure 37). In 2013, the maximum catches of the time series were recorded at around 1500 tons. From 2014 onwards, the trend declined for a prolonged period until the last years, 2019-20, when the lowest catches of the entire historical series were recorded (around 300 tons).

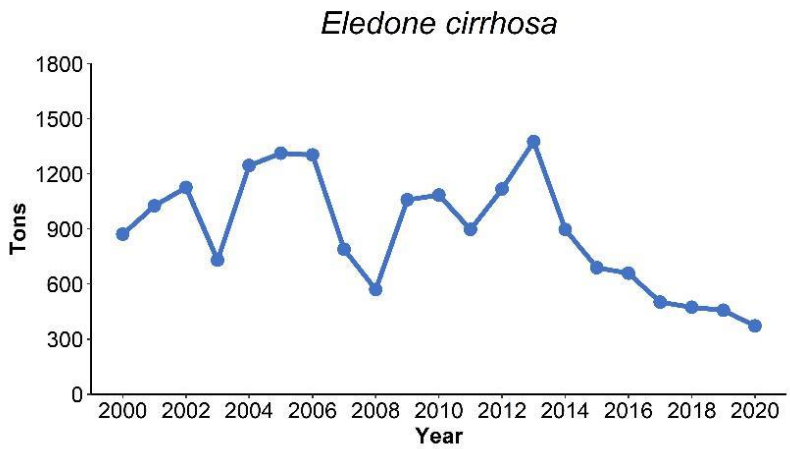


Figure 37. *Eledone cirrhosa.* Time series of horned octopus anual catch rates (tons) in Catalonia for the period 2000-2020.

Population structure

The monthly length-frequency distribution of horned octopus from October 2019 to December 2020 in Catalonia indicated that the species is more abundant on the continental shelf and less abundant on the upper slope (Figure 38). The size range of the individuals caught was between 2 and 15 cm in mantle length. The smallest sizes (< 6 cm) were mainly caught on the continental shelf and were most abundant between June and August, coinciding with the recruitment season. In July and August, the months with highest abundance of small sizes on the continental shelf coincided with the lowest abundance on the upper slope.

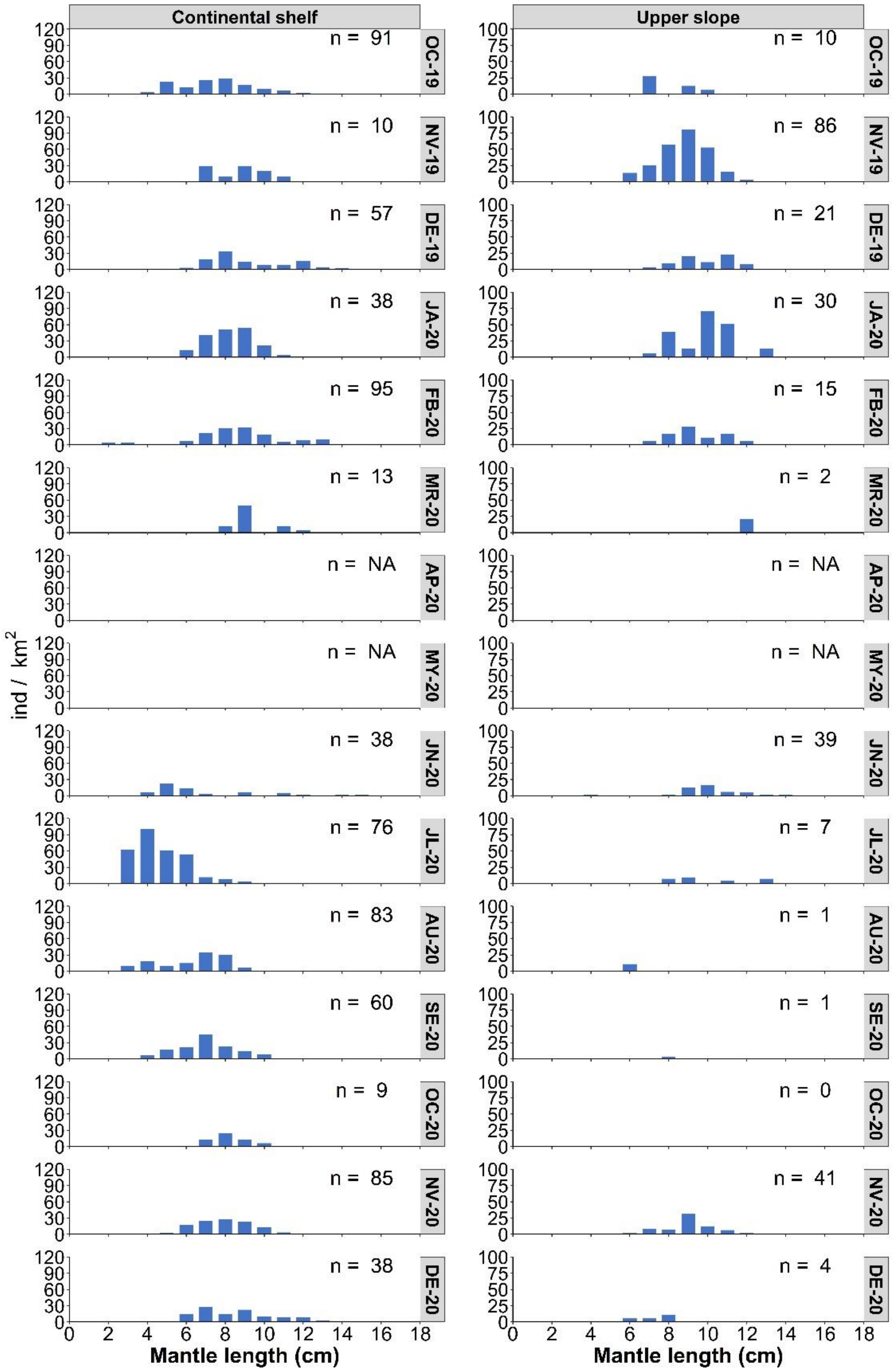


Figure 38. Monthly length-frequency Distribution of horned octopus (*E. cirrhosa*) for depth stratum from October 2019 to December 2020 along the Catalan coast.

Sexual morphology and sex ratio

There is hardly any sexual dimorphism in horned octopuses, and it is posible to distinguish, in large male individuals, the third right arm hectocotilized for reproduction. There is no other difference in color, apparent size or external shape between both sexes (Sánchez, 1976). Generally, there is a significant disproportion between sexes, there are more females than males, although it was found that it also depended on depth.

Length-weight relationship

The parameters of the length-weight relationship for the horned octopus population were calculated using the relationship: $W= a^* ML^b$, where W is weight (g), ML is the mantle length(cm), a and b are parameters that need to be estimated, with b being the coefficient of allometry. The results (Table 8, Figure 39) on the different length-weight relationships carried out for the different groups (combined sexes, females and males) showed that the values of the allometric coefficient (b) were lower than 3 for the combined sexes in both years, so the length-weight relationship specimens exhibited a negative allometry for growth. However, the results of length-weight relationship for each sex showed that males had a negative allometry in both years ($b < 3$) but females showed a positive allometry ($b > 3$) in 2020. Thus, there was a disproportionate growth between weight and length indicating that the rate of increase in weight was greater than that for length. The number of individuals used to calculate this relationship was about 800, with a very similar proportion of females and males. Regression values were high in both sexes combined, exceeding 0.8 both years.

Table 8. Horned octopus length-weight relationship parameters in 2019 and 2020.

2019	a	b	R^2	n
Combined	0.6702	2.6193	0.8863	853
Females	1.5406	2.2628	0.7720	440
Males	0.7886	2.5429	0.8341	375
2020	a	b	R^2	n
Combined	0.9151	2.5286	0.9019	633
Females	1.2977	3.3842	0.9022	312
Males	1.0588	2.4511	0.8386	296

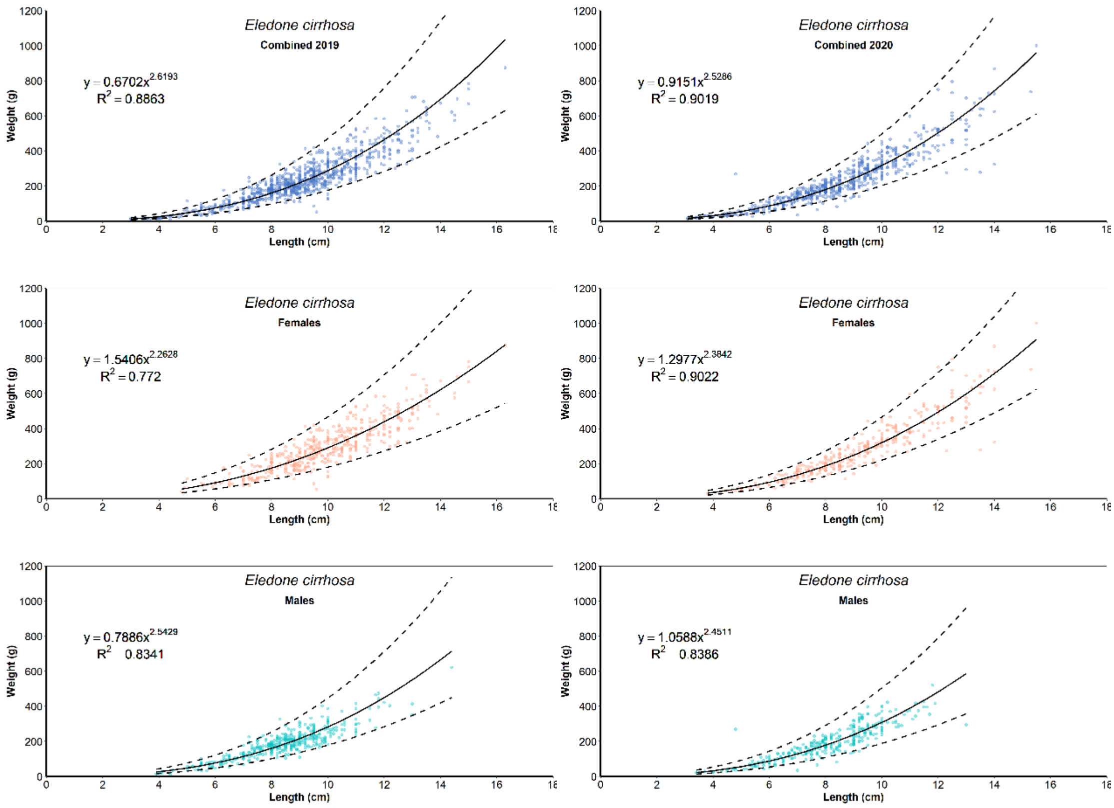


Figure 39. Length-weight relationship for horned octopus population (*E. cirrhosa*) in 2019 and 2020. Parameters a and b were calculated for both sexes combined (blue), females (red) and males (green).

Reproductive cycle

The reproductive cycle of horned octopus was analyzed for both 2019 and 2020, which represented two full years of monitoring (Figure 40 and Figure 41). Horned octopus showed a period of sexual maturity begining in January for males and a little later for females. This advance in the maturity of males may be related to the reproductive behavior of this species. Male's horned octopus deposit spermatophores in the female's ovary, where the sperm can be stored for weeks, until the female uses them to fertilize the oocytes. Mature animals of both sexes were found until July. The second half of the year, maturing but not fully mature individuals were observed in October. Comparing between the two years, without data in April and May 2020 because of the Covid-19 pandemic confinement, slight differences in the reproductive stages could be observed. In 2019, the maturation period in females began in March and, in 2020, females matured and spawned (stages IV and V, respectively) in February. For males, in October 2020 individuals in advanced maturation (30%) were observed; however, in 2019, no males were observed in this stage.

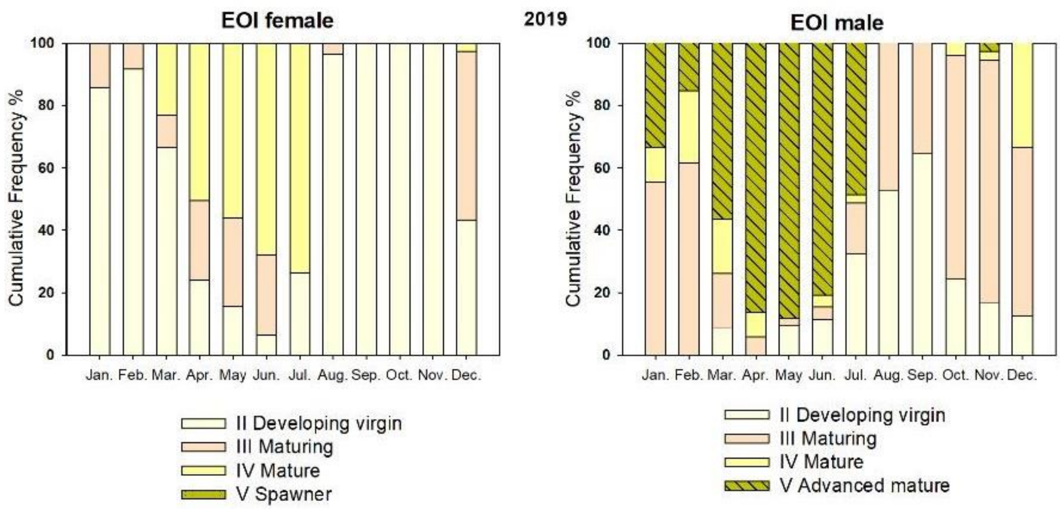


Figure 40. Horned octopus (EOI) monthly gonadal cycle for males and females in 2019. Percentage of different maturity stages.

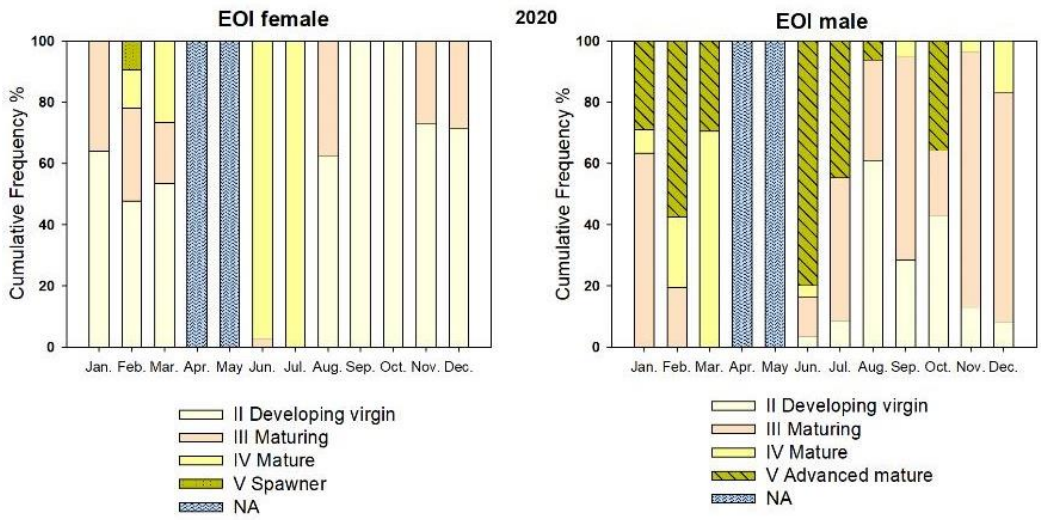


Figure 41. Horned octopus (EOI) monthly gonadal cycle for males and females in 2020. Percentage of different maturity stages.

Summary factsheet of the biological parameters and fishing activity in 2019-2020 of Horned octopus in Catalonia

2.1.1.5 Target species monitoring: Spottail mantis shrimp (*Squilla mantis*)

Annual catch history

The spottail mantis shrimp is mainly captured at the southern edge of Catalonia, from the ports of l'Ametlla de Mar to Sant Carles de la Ràpita. Since 2005, catches seemed to remain stable in the absence of a more detailed analysis of these catches by unit effort (Figure 42).

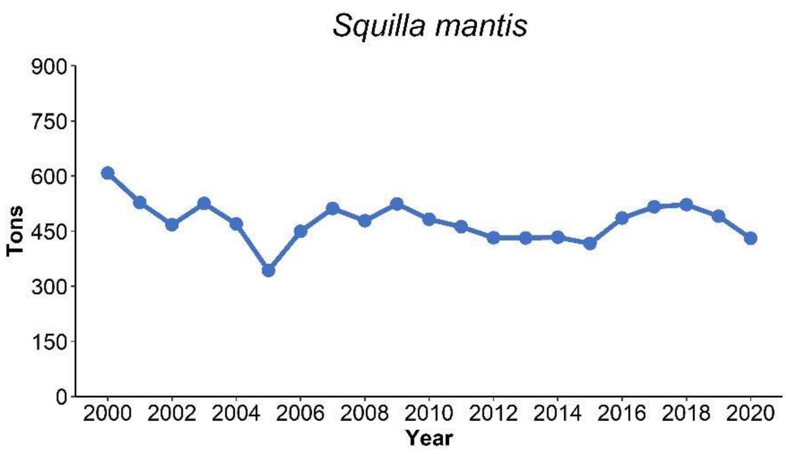


Figure 42. Time series of spottail mantis shrimp annual catch rates (tons) for the time period 2000-2020 in Catalonia.

Population structure

The stabilization of the spottail mantis shrimp catches can be explained by the biology of this species. This species presents a high renewal rate and the females in breeding seasons incubate their eggs in galleries. The highest abundances were recorded in the coastal and median shelf, coinciding with the range of distribution of the species (Figure 43).

In the absence of a more detailed analysis, there were no notable differences in lengths by depth strata. The sizes ranged between 8.5 and 37.5 mm, with the highest abundances around 25 mm. The largest sizes seemed to be found in the winter months wereas the smallest ones were caught in the summer. Information from longer periods of time is still needed to reach conclusions on the evolution of the sizes of this species. In this shrimp, the minimum conservation reference size (MCRS) has not been established yet.

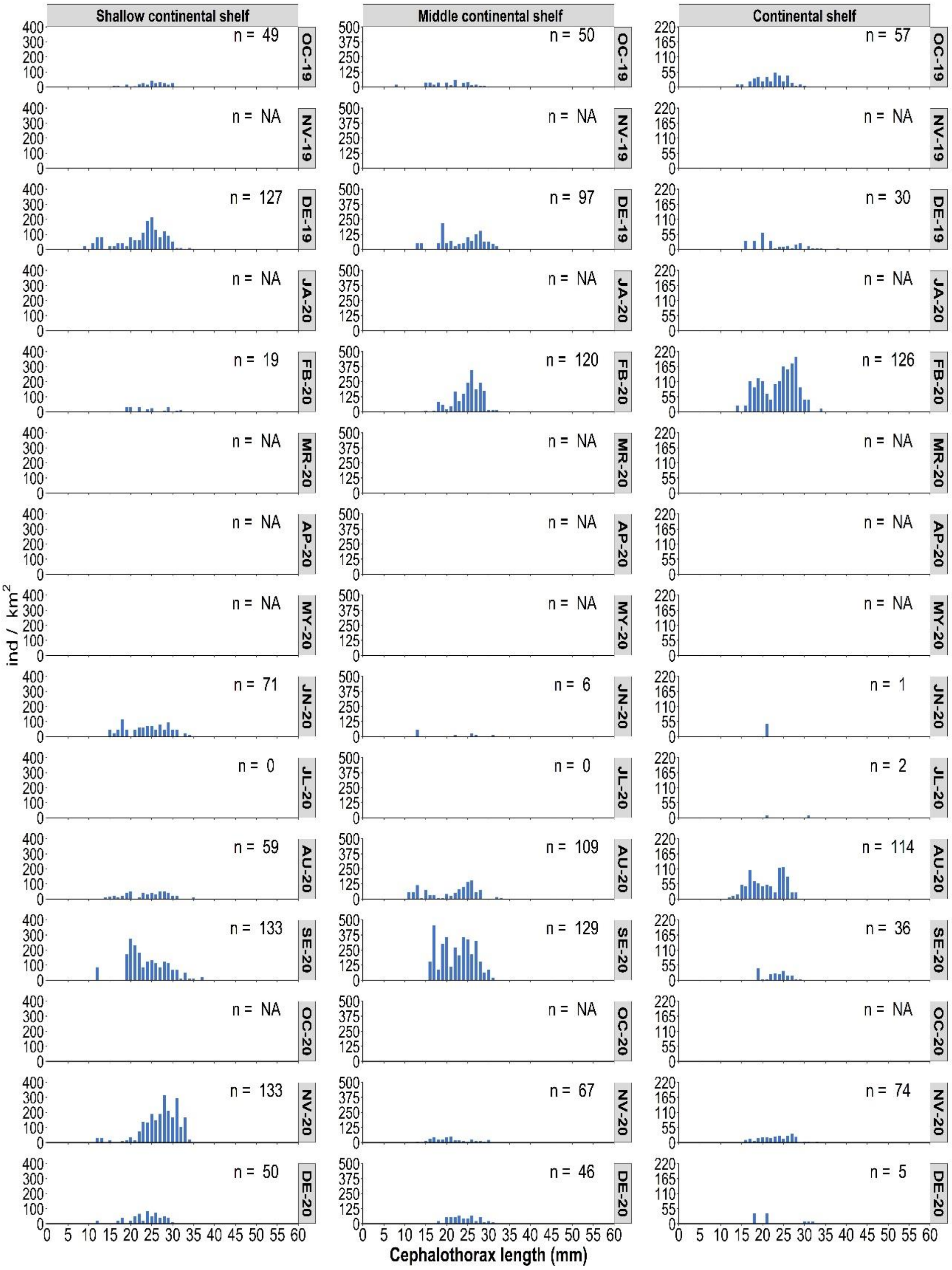


Figure 43. Monthly length-frequency distribution of spottail mantis shrimp (*S. mantis*) for depth stratum from October 2019 to December 2020 along the Catalan coast.

Sexual morphology and sex ratio

The spottail mantis shrimp is a burrowing species associated with littoral soft bottoms, where sediment is silty sand to sandy mud (Atkinson et al., 1997). Size-wise, females and males are similar (Abelló and Martín, 1993). However, the sex ratio in the species' catches can be affected by their reproductive behavior, since females take care of the eggs in galleries (Maynou et al., 2004).

Length-weight relationship

The parameters of the length-weight relationship for the spottail mantis shrimps were calculated using the relationship $W = a*CL^b$, where W is weight (g) and CL is cephalothorax length (mm). The number of specimens used for the two genders combined was 921 in 2019 and 696 in 2020, allowing good correlation coefficients in the relationships obtained. According to length-weight relationship parameters for both sexes combined, spottail mantis shrimps displayed a negative allometric growth ($b < 3$) in both years (Table 9 and Figure 44). As in many crustaceans, there were differences between males and females of the same species, so the relationships of both sexes were included separately. In this case, the relationships were very similar, and more detailed analyses must be done to appreciate differences between the sexes. The updated values of these relationships will help us complete and adjust the fisheries management models.

Table 9. Spottail mantis shrimp length-weight relationship parameters in 2019 and 2020.

2019	a	b	R^2	n
Combined	0.0167	2.2962	0.6428	921
Females	0.0122	2.3890	0.7094	493
Males	0.0260	2.1665	0.5684	428
2020	a	b	R^2	n
Combined	0.0023	2.8907	0.9211	696
Females	0.0025	2.8739	0.9075	370
Males	0.0022	2.9077	0.9339	326

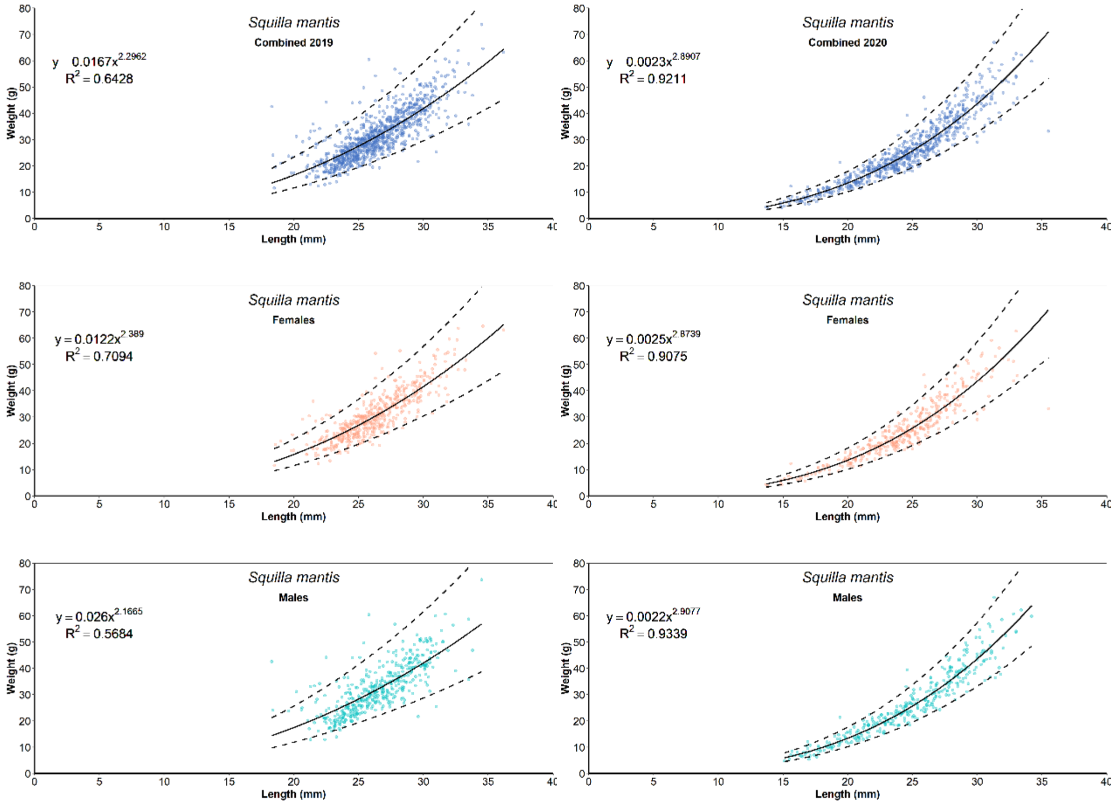


Figure 44. Length-weight relationship for spottail mantis shrimp population (*S. mantis*) in 2019 and 2020. Parameters *a* and *b* were calculated for both sexes combined (blue), females (red) and males (green).

Reproductive cycle

The reproductive cycle of the spottail mantis shrimp population was analyzed for 2019 (Figure 45) and 2020 (Figure 46), the two full years of monitoring, except for the months of confinement. The reproduction cycle of this shrimp is seasonal, with a maturation peak in spring despite individuals with advanced stages of maturation could be found from January to June.

In 2019 (Figure 45), the gonads began to mature in February, but it was not until spring when the proportion of advanced stages of maturity dominated. In 2020 (Figure 46) we could not get much information due to the Covid-19 pandemic confinement, which directly affected sampling on the months of advanced stages of maturation in the species.

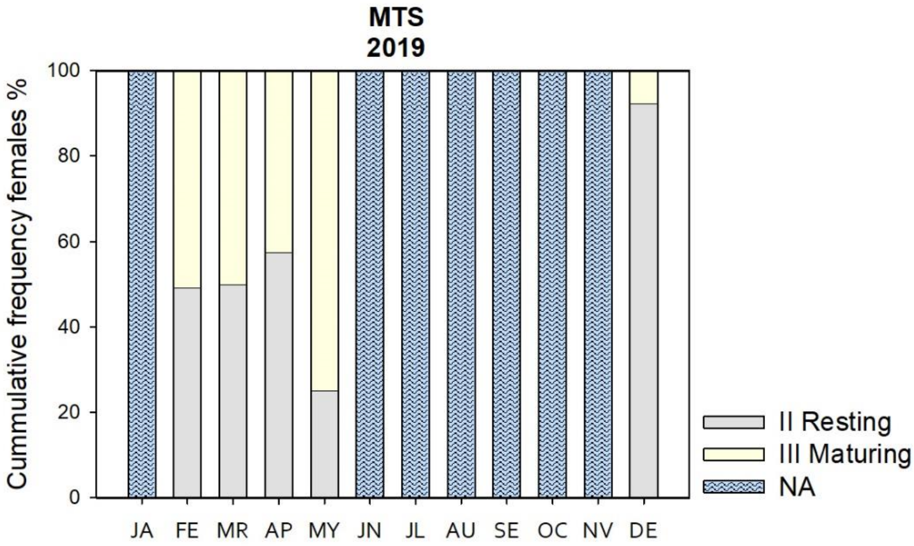


Figure 45. Spottail mantis shrimp (MTS) monthly gonadal cycle for females in 2019. Percentage of different maturity stages.

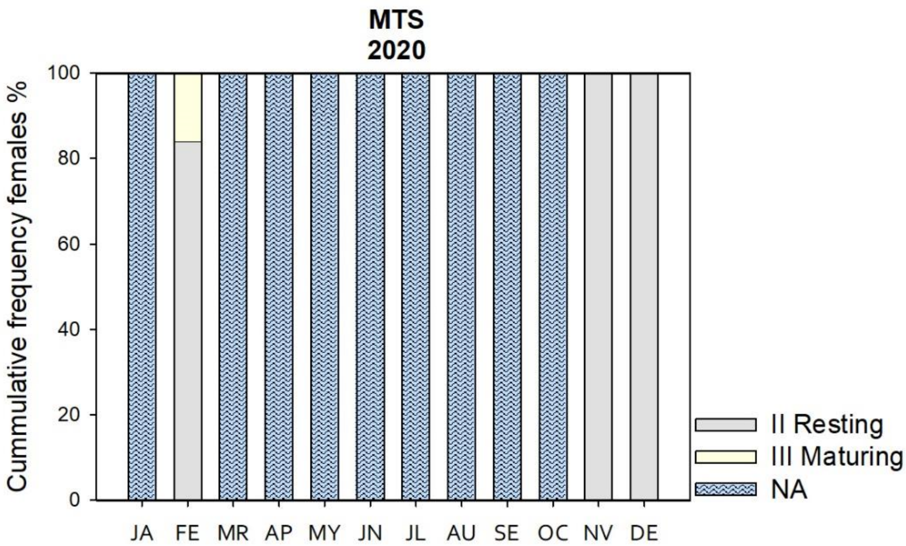


Figure 46. Spottail mantis shrimp (MTS) monthly gonadal cycle for females in 2020. Percentage of different maturity stages.

Summary factsheet of the biological parameters and fishing activity in 2019-2020 of Spottail mantis shrimp in Catalonia

2.1.1.6 Target species monitoring: Caramote prawn (*Penaeus kerathurus*)

Annual catch history

Caramote prawn catches were very low in Catalonia and were mainly fished in the ports of the southern Catalan coast (l'Ametlla de Mar and Sant Carles de la Ràpita). Total catches in Catalonia did not reach 100 t (Figure 47), and, similar to the spottail mantis shrimp, they seemed to remain stable since 2010, with a considerable decrease in 2020, most likely influenced by the Covid-19 pandemic situation.

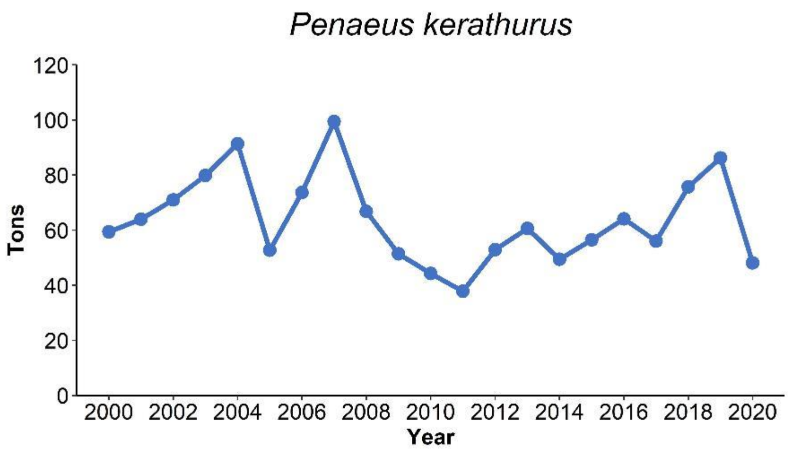


Figure 47. Time series of caramote prawn annual catch rates (tons) for the time period 2000-2020 in Catalonia

Population structure

The results on the caramote prawn catches analyses are not conclusive because of the scarcity of the catches. It is noticiable that an important part of the population is caught by trammel nets, that are not been considered in this study. It is expected that, in the coming years, the number of individuals measured will be higher allowing a more detailed study of the biology and demography of this species. Like the spottail mantis shrimp, the caramote prawn was sampled shortly after the start of the fishing monitoring throughout Catalonia. The data showed that the highest abundances were recorded in the shallow continental shelf (<40 m depth), coinciding with the range of distribution of the species (Figure 48). The especies is not caught in the continental shelf > 75 m depth. Differences in lengths by depth strata were not observed with the collected data. The sizes ranged between 26 and 50 mm, with the highest abundances being around 30 mm. The largest sizes seemed to concentrate in December, but more data is needed to validate this estatement. In the caramote prawn, the minimum conservation reference size (MCRS) is no established yet.

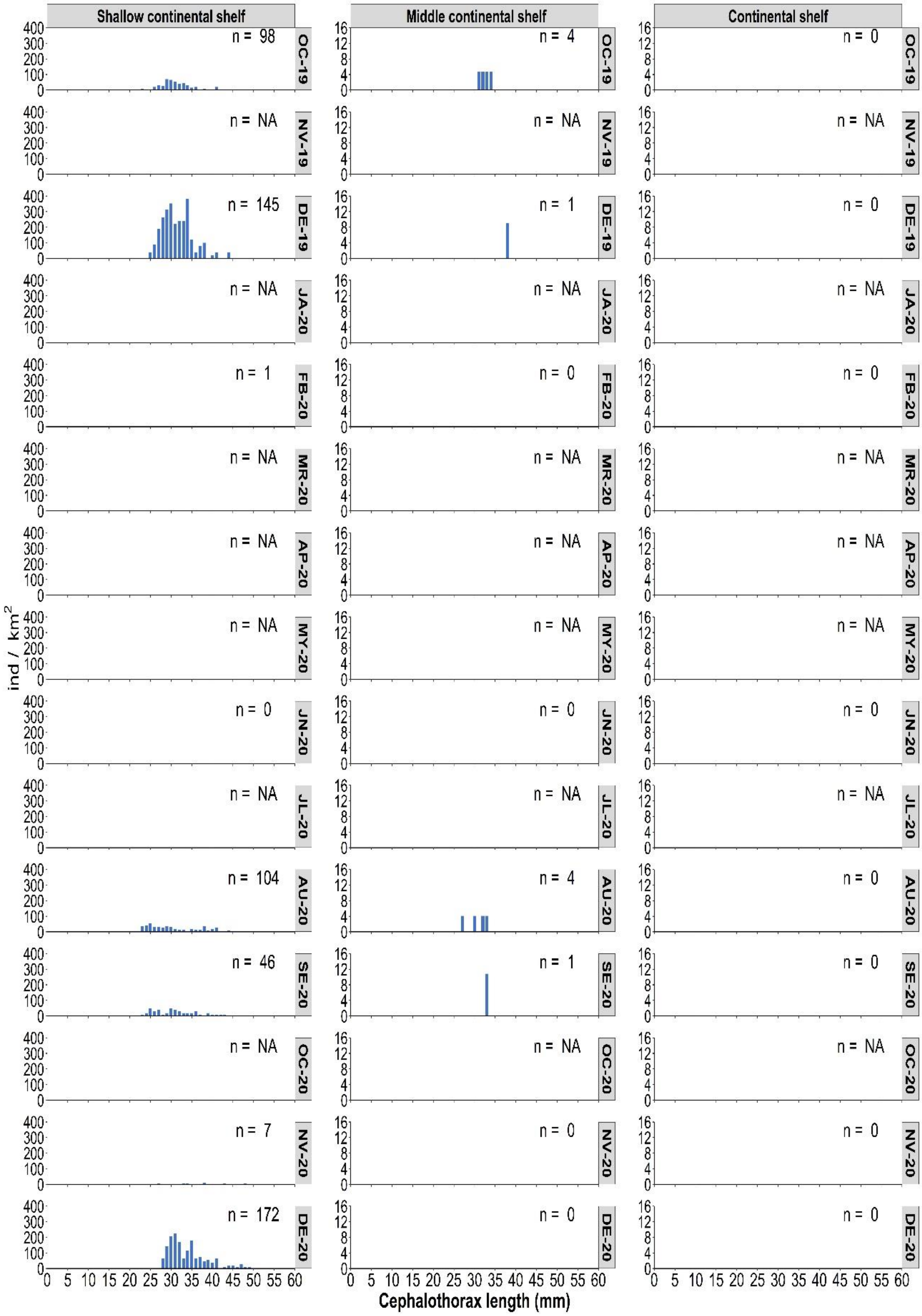


Figure 48. Monthly length-frequency distribution of caramote prawn (*P. kerathurus)* for depth stratum from October 2019 to December 2020 along the Catalan coast.

Sexual morphology and sex ratio

The caramote prawn is a penaeid shrimp, common at shallow depths, on sandy bottoms and at river mouths (Zariquiey, 1968). As in other species of crustaceans, this prawn presents a clear sexual dimorphism, present both in its total length and in the size at first maturity (Rodríguez, 1985). Regarding its distribution by depth strata, it is seen that at certain times of the year, the mature individuals move to deeper waters, while the juveniles remain in shallow areas (Silva et al., 2003).

Length-weight relationship

The parameters of the length-weight relationship for the caramote prawn population were calculated using the relationship $W = a*CL^b$, where W is weight (g) and CL is cephalothorax length (mm). The number of specimens used for the two genders combined was 213 in 2019 and 149 in 2020, allowing good coefficients, although there was a lack of data for small sizes and at certain months of the year. According to length-weight relationship parameters for both sexes combined, caramote prawn displayed a negative allometric growth (b < 3) in both years (Table 10 and Figure 49). As in many crustaceans, there are differences between males and females of the same species, so the relationships of both sexes were included separately. In this case, it seems that there were differences between the sexes, with females reaching larger sizes. The updated values of these relationships help complete and adjust fisheries management models.

Table 10. Caramote prawn length-weight relationship parameters in 2019 and 2020.

2019	a	b	R^2	n
Combined	0.0044	2.4202	0.9131	213
Females	0.0033	2.4967	0.9428	92
Males	0.0036	2.4778	0.7532	121
2020	a	b	R^2	n
Combined	0.0052	2.3713	0.9633	149
Females	0.0032	2.4999	0.9621	88
Males	0.0028	2.5652	0.9072	61

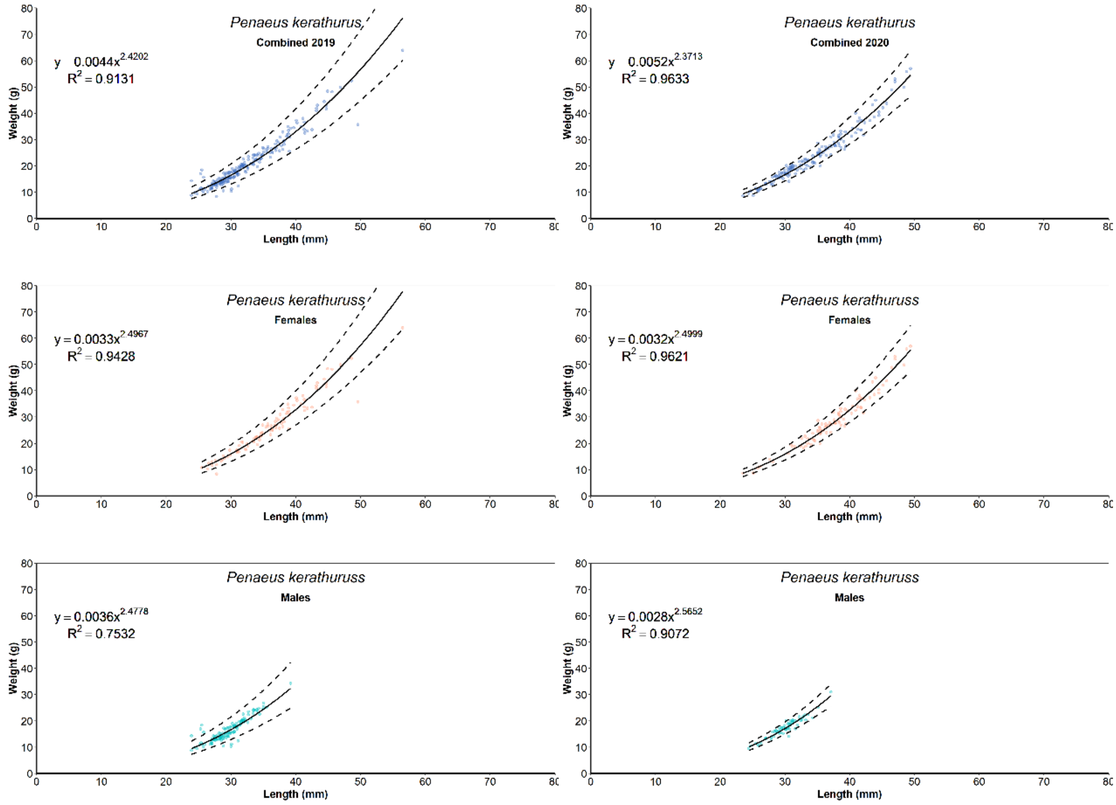


Figure 49. Length-weight relationship for caramote prawn population (*P. kerathurus*) in 2019 and 2020. Parameters *a* and *b* were calculated for both sexes combined (blue), females (red) and males (green).

Reproductive cycle and gonadosomatic index

The reproductive cycle of the caramote prawn population was analyzed for 2019 (Figure 50) and 2020 (Figure 51), representing two full years of monitoring, except the months of confinement. The reproduction cycle of this prawn is seasonal, with a peak of maturation in spring and summer (not clearly visible in our sampling due to the no availability of data), despite advanced stages of maturation could be observed from spring to autumn.

The monthly gonadal maturation of females has been calculated. In 2019 (Figure 50), the gonads were in an advanced state of maturation in summer, coinciding with a peak in the gonadosomatic index, but they had been in these states since spring. In 2020 (Figure 51), the same situation as the previous year was found.

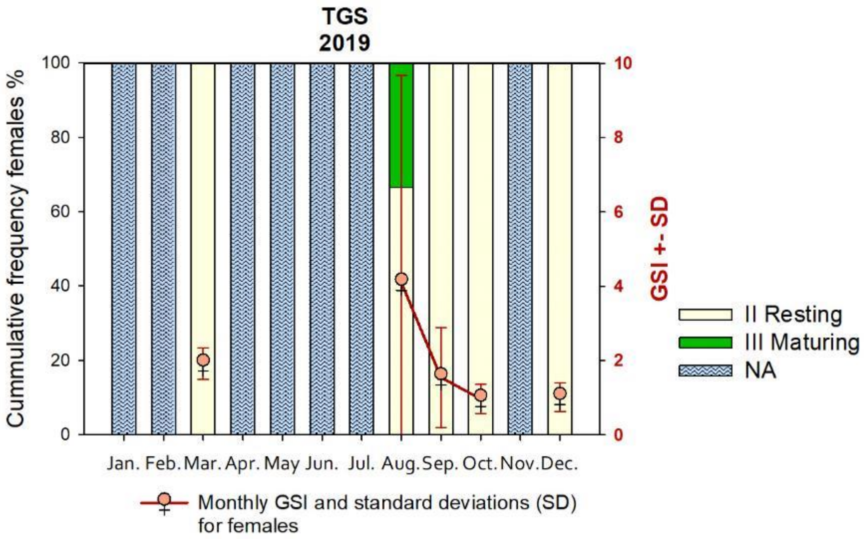


Figure 50. Caramote prawn (TGS) monthly gonadal maturation cycle for females in 2019. Gonadosomatic index (GSI+/-SD) and percentage of different maturity stages.

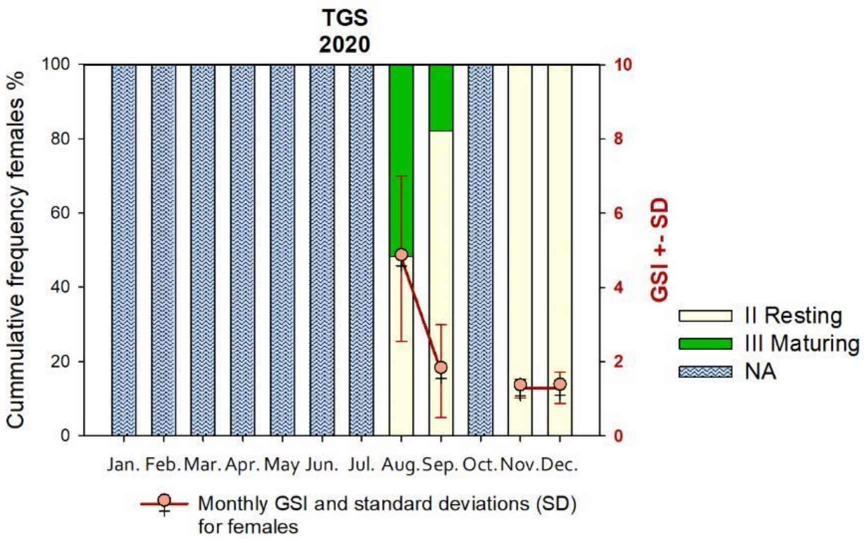


Figure 51. Caramote prawn (TGS) monthly gonadal maturation cycle for females in 2020. Gonadosomatic index (GSI+/-SD) and percentage of different maturity stages.

Summary factsheet of the biological parameters and fishing activity in 2019-2020 of Caramote prawn in Catalonia

2.1.2 Bottom trawling by zone

This section shows the bottom trawl sampling results according to each zone: North (ports of Roses, Palamós, Blanes, and Arenys de Mar), Center (ports of Barcelona, Vilanova i la Geltrú, and Tarragona), and South (ports of l'Ametlla de Mar and Sant Carles de la Ràpita).

2.1.2.1 North Zone

Figure 52 shows the bottom trawl commercial fishing activities and bottom trawls conducted in the North zone between October 2019 and December 2020.

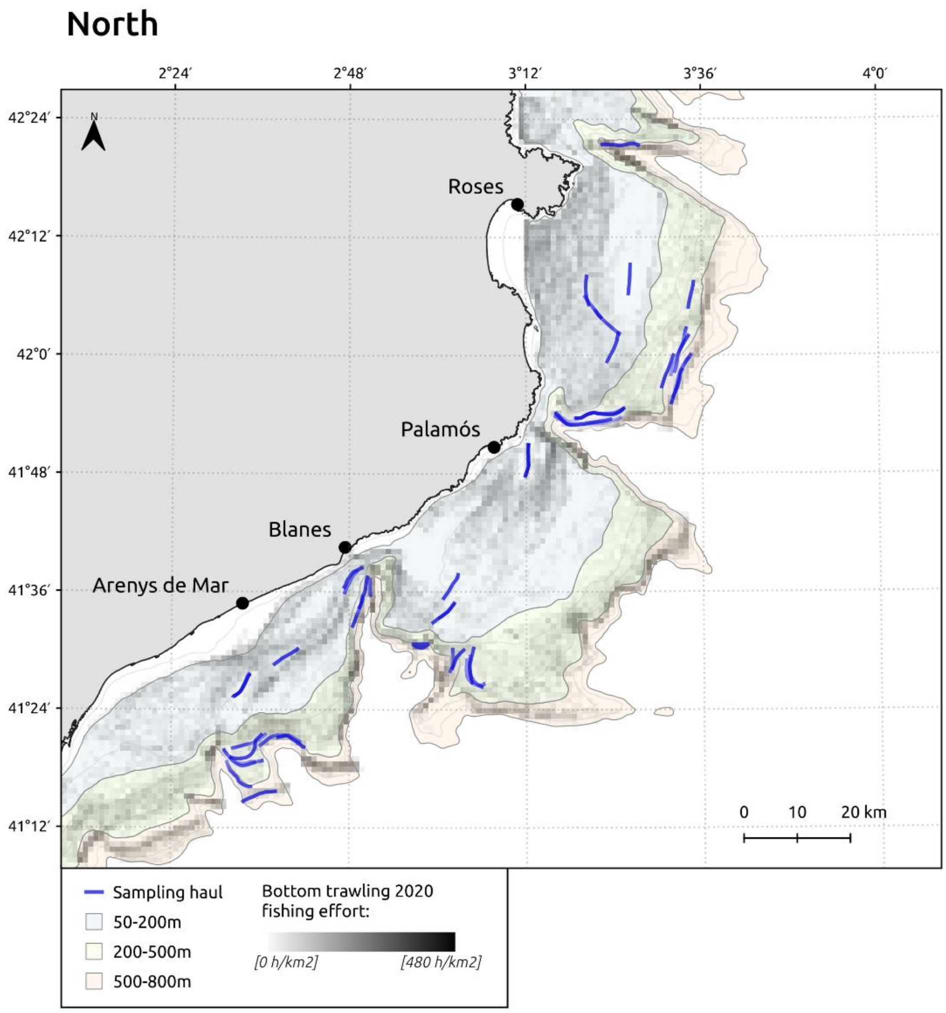


Figure 52. Map of the bottom trawling hauls conducted in the north zone from October 2019 to December 2020.

The catch composition in the north zone per each season and fishing ground is shown in Figure 53. The percentage of the landed catch was between 52 and 87%. In most of the seasons sampled, the landed catch was higher in deeper fishing grounds (upper and lower slope). The discarded catch ranged between 10 and 42%, and the highest discarded ratio was observed in the continental shelf in autumn 2020. The percentatge of the debris fraction was between 1 and 12%, which was lower in the lower slope.

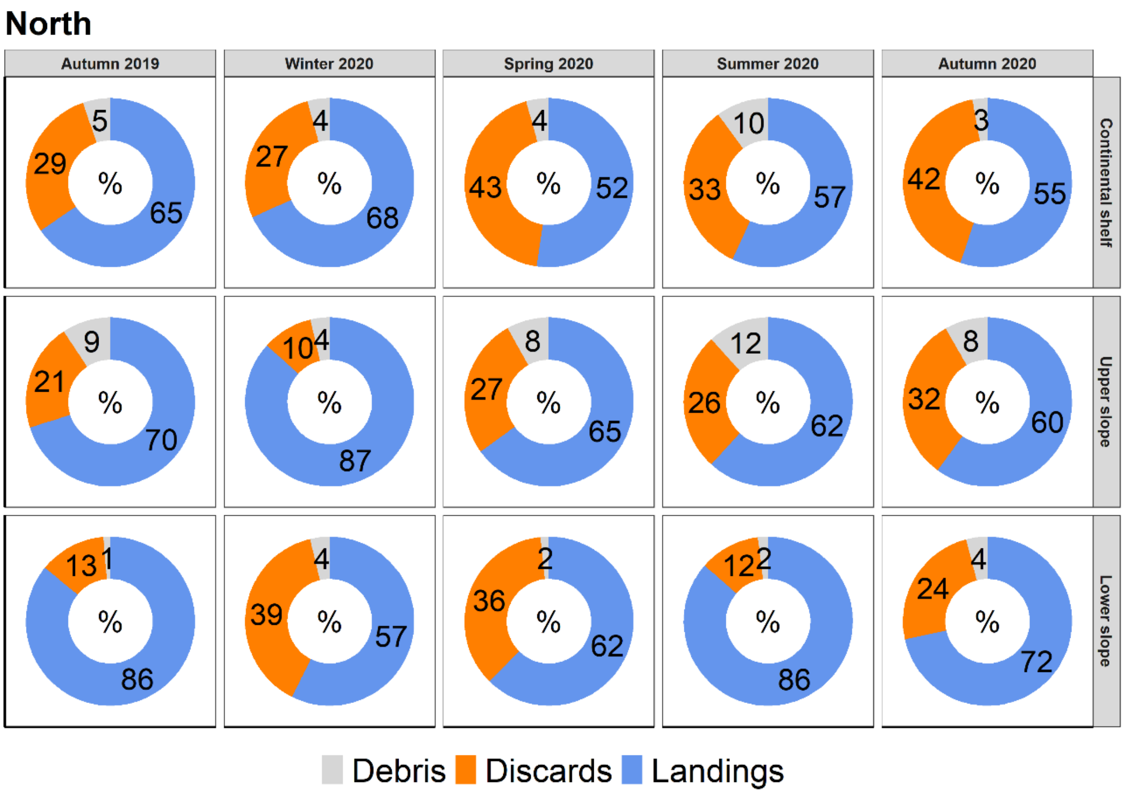


Figure 53. Catch composition in the north zone. Percentage by weight of landings, discarded and debris fraction in each season and each fishing ground including all hauls in all ports sampled from October 2019 to December 2020.

The composition and proportion of landed species in the continental shelf of the north zone is shown in Figure 54. There, between 38 and 46 species were landed. Target species selected for its market value (*M. merluccius* and *E. cirrhosa*) represented between 10 and 16% of landed catch. Other landed species with an important biomass were *L. budegassa*, *I. coindetii, T. trachurus* and *M. barbatus*.

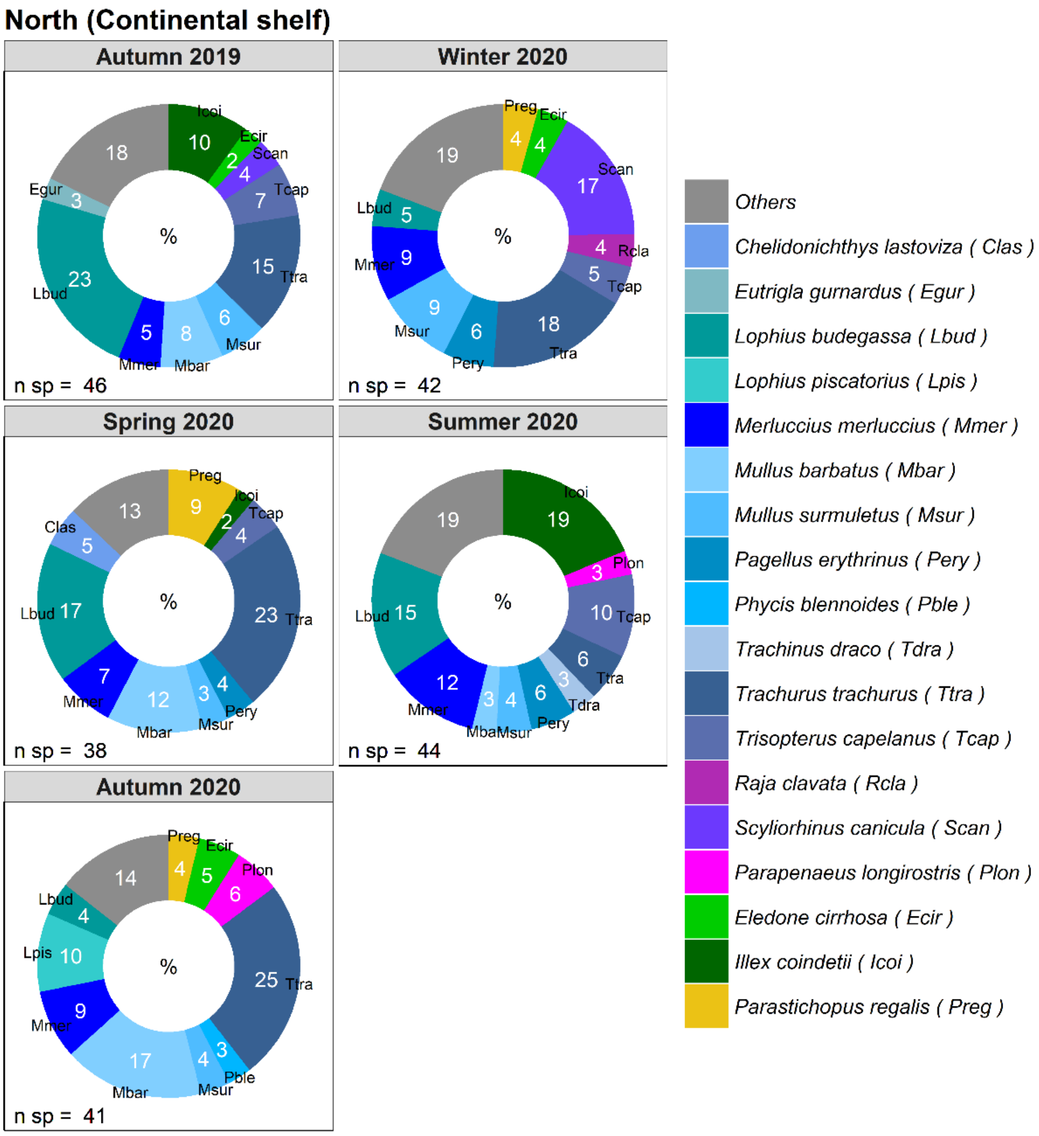


Figure 54. Species with most biomass within the landed catch in the continental shelf for all hauls conducted in north zone for each season from October 2019 to December 2020.

The composition and proportion of landed species in the upper slope of the north zone is shown in Figure 55. In the north upper slope, between 22 and 38 species were landed. Target species selected for its market value (*N. norvegicus*, *M. merluccius*, and *E. cirrhosa*) represent between 16 and 36% of the landed catch. Other landed species with an important biomass were *P. blennoides*, *M. poutassou*, and *L. budegassa*. One of the most important landed species in the upper slope was the crustacean *P. longirostris*, with a landed proportion between 3 and 17%. This species was caught throughout all seasons, but with a higher proportion in spring 2020.

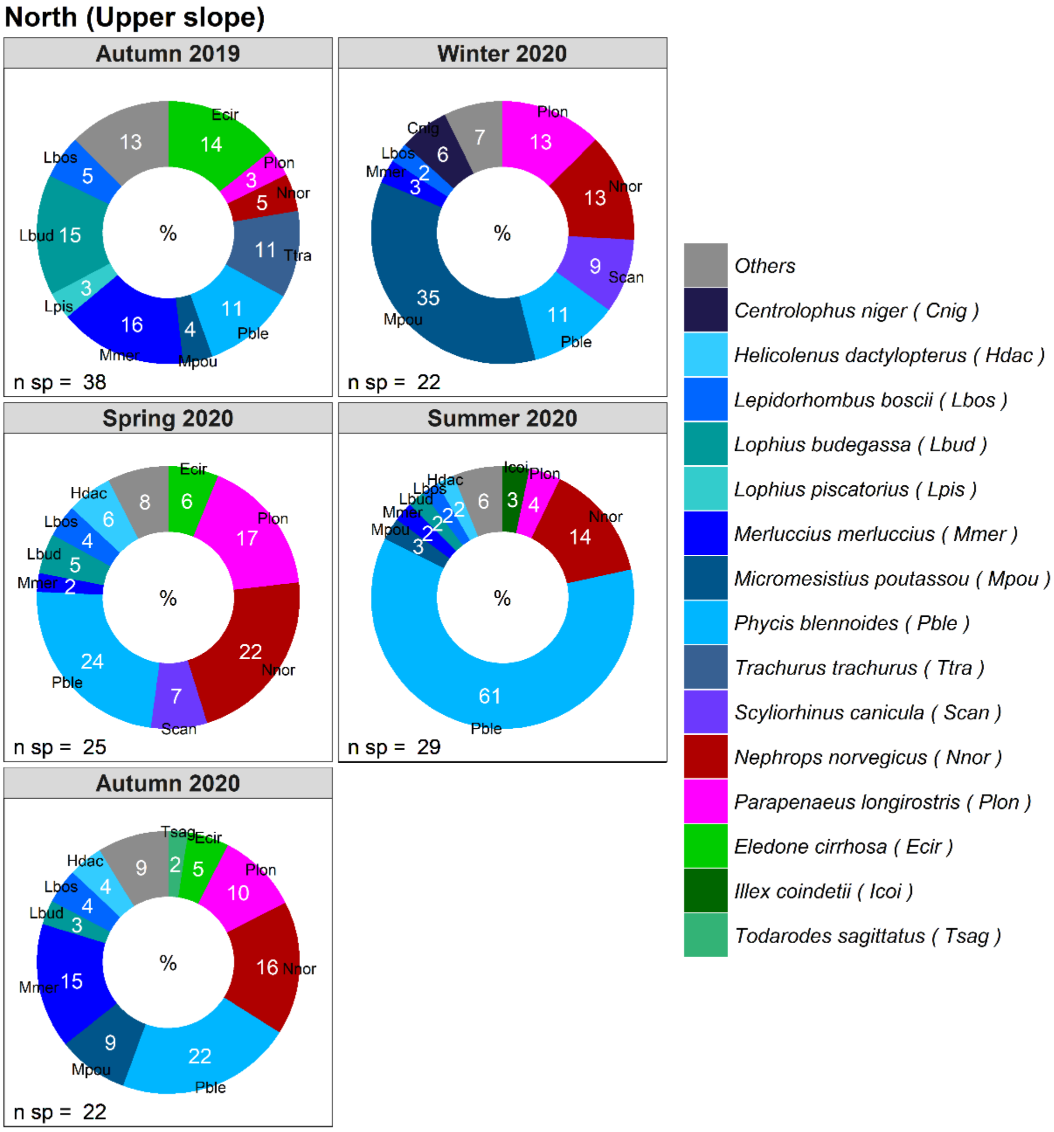


Figure 55. Species with most biomass within the of landed catch in the upper slope for all hauls conducted in north zone for each season from October 2019 to December 2020.

The composition and proportion of landed species in the lower slope of the north zone is shown in Figure 56. There, between 12 and 25 species were landed. Target species selected for its market value (*A. antennatus*, *N. norvegicus*, *M. merluccius* and *E. cirrhosa*) represent more than 40% of the landed catch in all seasons, being the blue and red shrimp (*A. antennatus*) the most abundant of them. Other landed species with an important biomass were *P. blennoides*, *M. poutassou*, and *L. budegassa*.

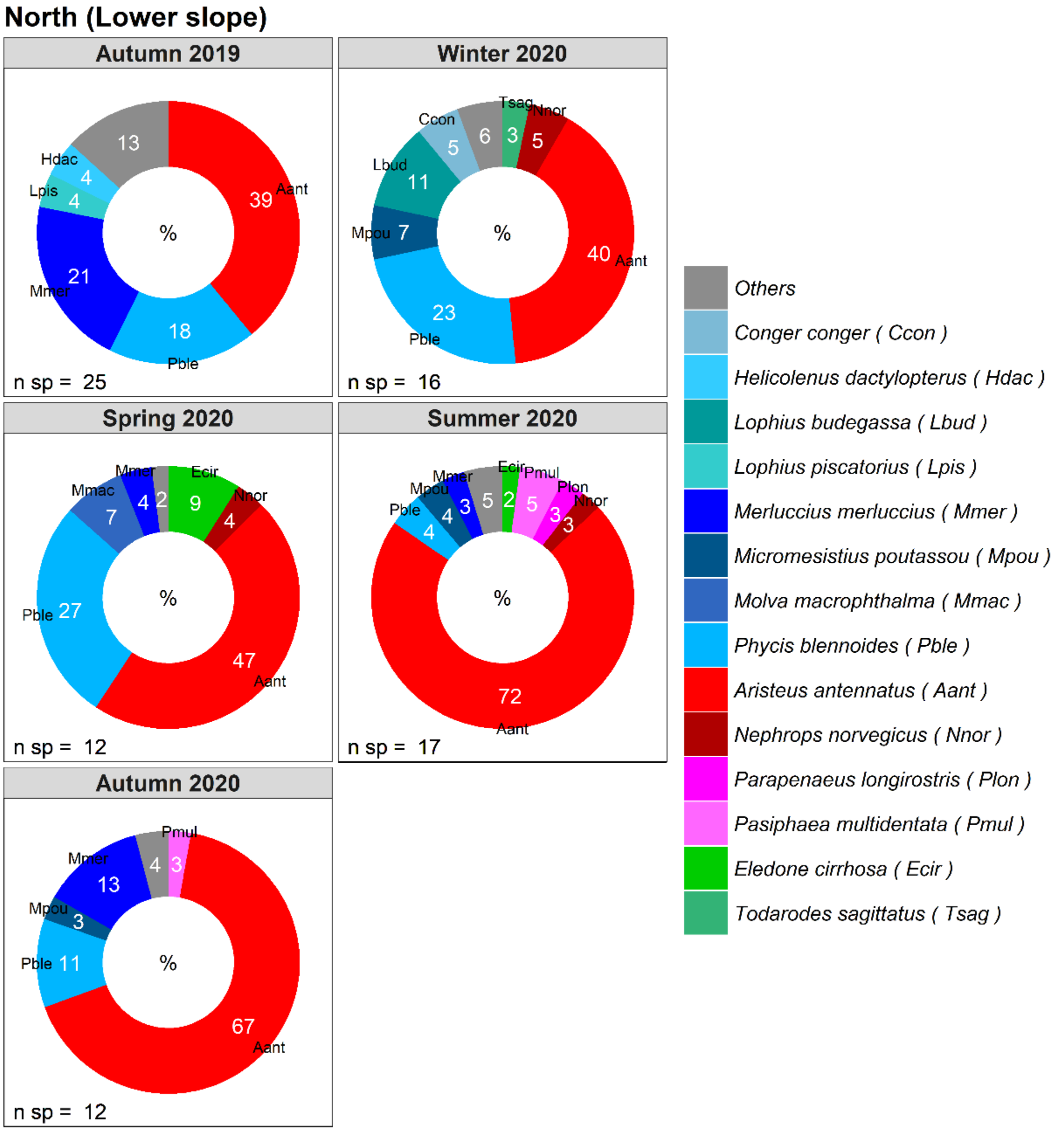


Figure 56. Species with most biomass within the landed catch in the lower slope for all hauls conducted in north zone for each season from October 2019 to December 2020.

In the north zone, the taxonomic group with more biomass within the landing catch was actinopterygii in all fishing grounds sampled, except in the lower slope, where crustaceans were the most important group (Table 11). Chondrichthyes group were more important in the continental shelf. Similarly, cephalopoda, they were more abundant and had higher biomass also in the continental shelf. Other Mollusca (Bivalvia and Gasteropoda) with commercial value were present in all fishing grounds except in the lower slope. Echinodermata were present in the continental shelf only.

Table 11. Biomass (kg/km^2) and abundance (ind/km^2) of taxonomic groups present in the landed catch in the north zone. Mean and standard deviation in each fishing ground, including all hauls from October 2019 to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	287.70	148.51	217.39	219.29	51.24	49.27
Chondrichthyes	21.05	47.55	10.87	30.03	0.45	1.74
Crustacea	12.10	16.88	73.48	65.83	73.90	39.45
Cephalopoda	44.92	37.75	23.74	33.12	4.58	6.41
Other Mollusca	0.10	0.28	0.12	0.32		
Echinodermata	13.38	21.68				
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	4650.58	2943.98	1808.62	1213.08	323.53	310.75
Chondrichthyes	90.24	188.29	74.54	214.71	1.66	6.44
Crustacea	1558.66	2560.69	4982.60	5603.75	4531.78	2524.96
Cephalopoda	869.16	1020.82	201.65	277.56	23.94	31.39
Other Mollusca	3.28	9.28	6.34	16.91		
Echinodermata	108.13	174.26				

The proportion of species with most biomass within the discarded catch in continental shelf of the north zone is shown in Figure 57. There, between 68 and 114 species were discarded. The most important fish on the discarded catch were *B. boops*, *S. canicula*, and *T. trachurus*. Target species such as *M. merluccius* and *L. budegassa*, discarded because they did not reach the minimum conservation reference size, accounted for less than 13%. Benthic invertebrates like *L. phalangium*, *E. melo* and *G. acutus* showed a high proportion of the discarded catch in some seasons.

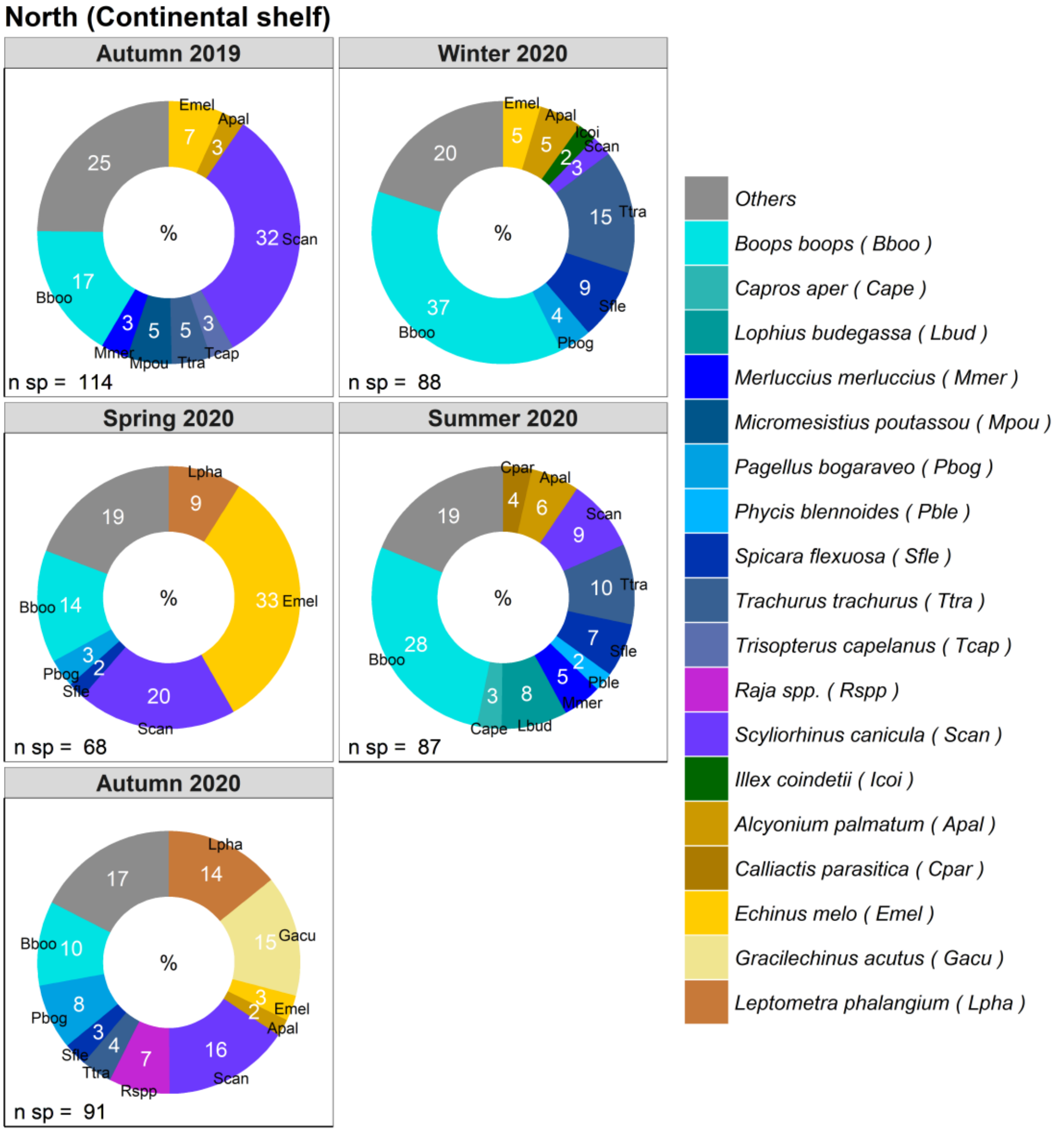


Figure 57. Species with most biomass within the discarded catch in the continental shelf for all hauls conducted in north zone for each season from October 2019 to December 2020.

The proportion of species with most biomass within the discarded catch in the upper slope of the north zone is shown in Figure 58. There, between 49 and 87 species were discarded. Most of discarded catch was composed by sharks, mainly *S. canicula*. Other fish species present in the discarded catch were *C. caelorhincus*, *C. conger*, *L. caudatus*, and *T. trachurus*, despite having a low proportion. Cephalopod species represented less than 10% of discarded catch and benthic invertebrates, such as *A. palmatum*, accounted for less than 8% of the discarded catch.

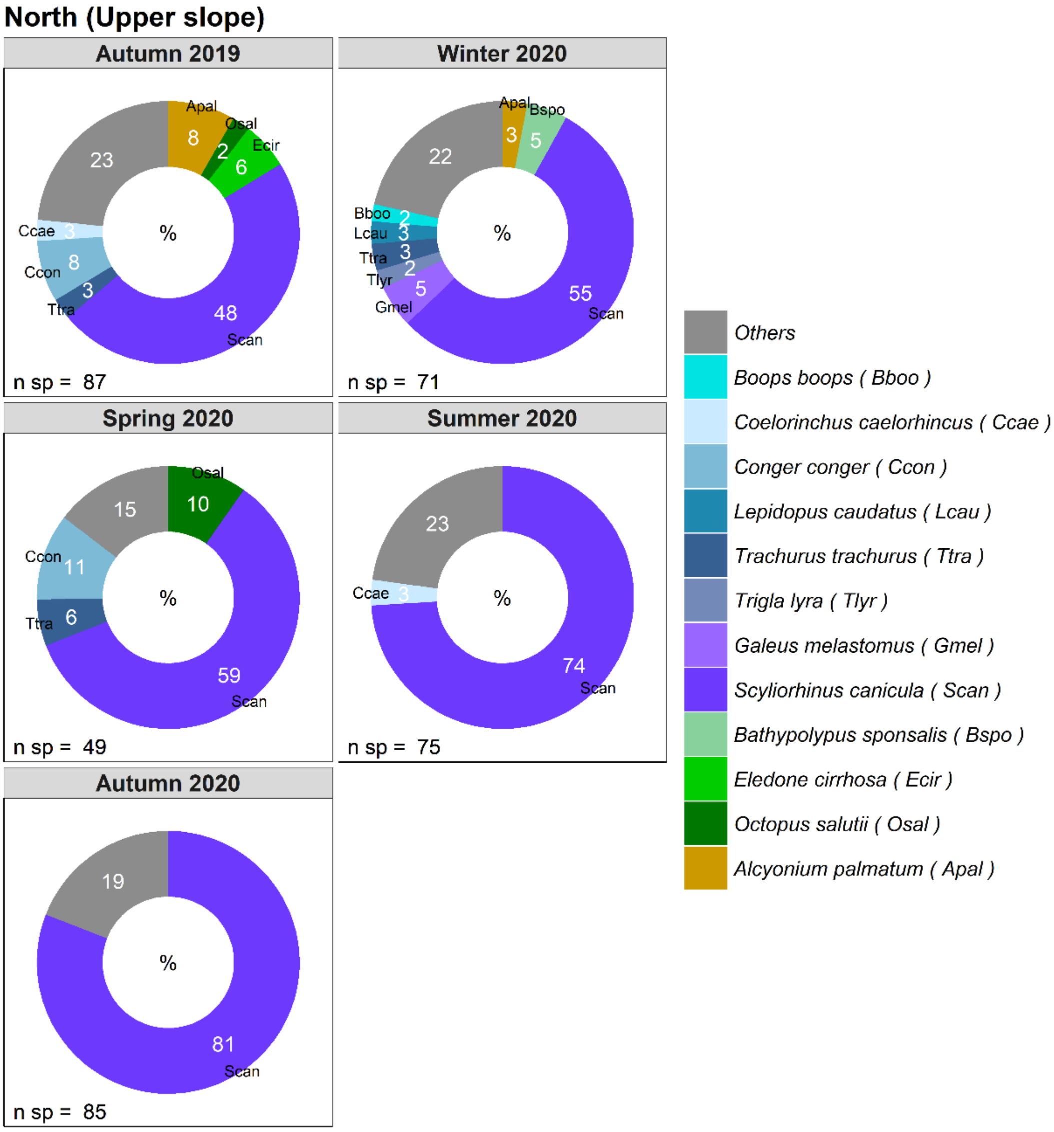


Figure 58. Species with most biomass within the discarded catch in the upper slope for all hauls conducted in north zone for each season from October 2019 to December 2020.

The proportion of species with most biomass within the discarded catch in the lower slope of the north zone is shown in Figure 59. There, between 24 and 53 species were discarded. Most of the discarded catch was composed by sharks, mainly *G. melastomus* and *S. canicula*. Other fish species present in the discarded catch were *C. coelorhincus*, *C. conger*, *L. caudatus*, and *T. scabrus*. Cephalopod species accounted for less than 21% of the discarded catch with the most important species being *H. reversa* and *T. sagittatus*. During summer 2020, the crustacean *P. cuvieri* accounted for 7% of the discarded fraction. Benthic invertebrates represented less than 2% of the discarded catch.

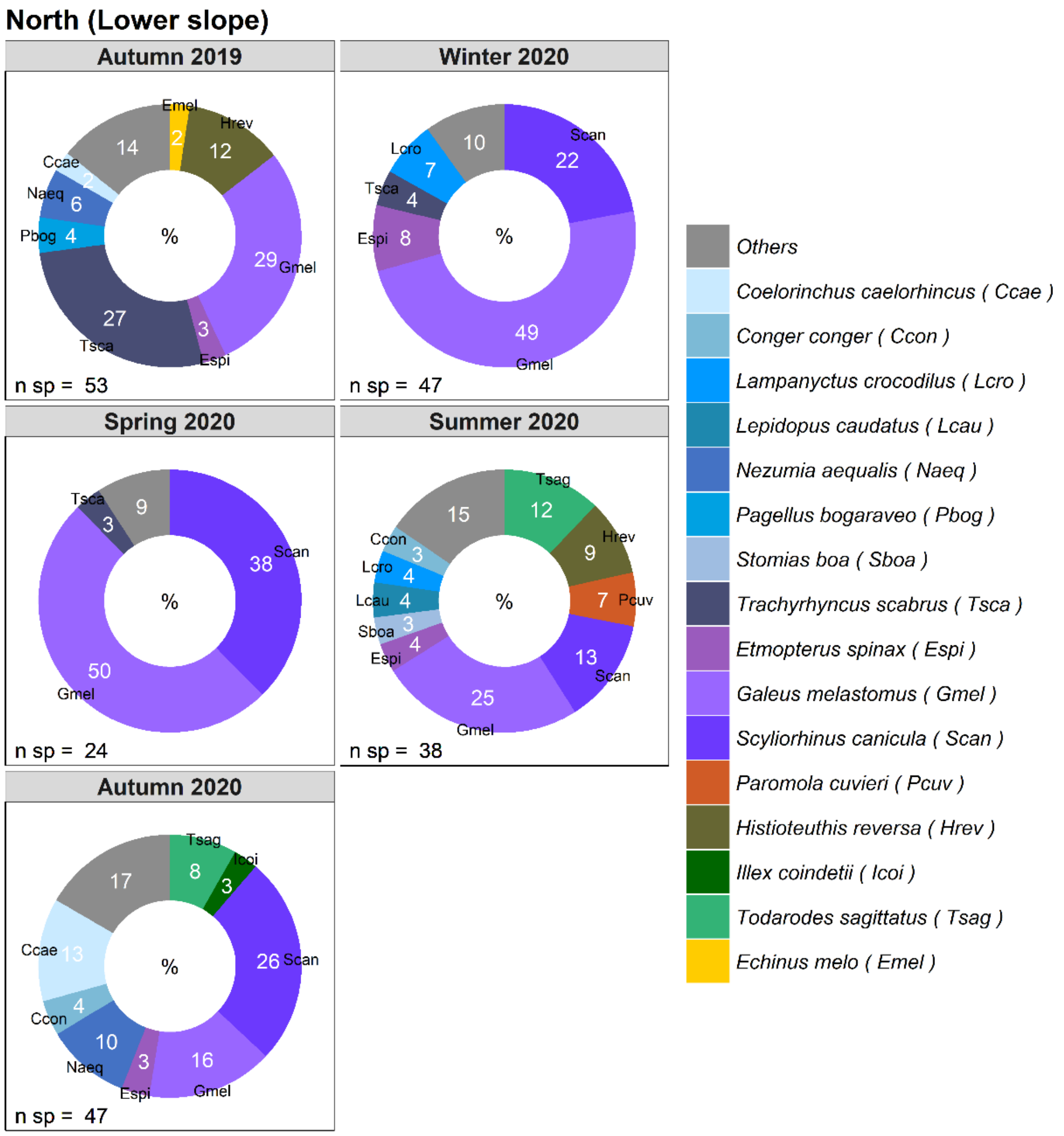


Figure 59. Species with most biomass within the discarded catch in the lower slope for all hauls conducted in north zone for each season from October 2019 to December 2020.

In the north zone, the most important taxonomic group within the discarded catch in the continental shelf were actinopterygii wereas, in the upper and lower slopes, were chondrichthyes (Table 12). The highest biomass of the discarded crustacea was found in the continental shelf and the upper slope. Discarded cephalopoda were present in all fishing grounds. Within the group other mollusca, such as discarded bivalvia and gasteropoda, the highest biomass and abundance were found in the continental shelf. Cnidaria were present in all fishing grounds but had a higher biomass in the continental shelf. Echinodermata had higher biomasses and abundances in the continental shelf but the high standard deviation reveals a variability in the presence of echinodermata throughout the samplings.

See Annex IV for the complete list of species' biomass in each fishing ground and Annex V for species' abundances.

Table 12. Biomass (kg/km^2) and abundance (ind/km^2) of taxonomic groups present in the discarded catch in the north zone. Mean and standard deviation in each fishing ground, including all hauls from October 2019 to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	105.67	63.80	17.90	15.66	10.93	14.89
Chondrichthyes	42.84	61.84	65.41	68.28	40.64	72.28
Crustacea	3.37	3.77	3.20	2.37	1.68	1.70
Cephalopoda	3.89	3.85	6.69	7.93	3.20	3.33
Other Mollusca	0.72	0.89	0.45	0.72	0.06	0.14
Porifera	1.90	2.71	0.04	0.07	0.01	0.03
Cnidaria	10.37	10.79	3.38	7.46	0.19	0.43
Annelida	0.22	0.50	0.11	0.18	0.01	0.03
Sipuncula			0.00	0.01	0.00	0.00
Echinodermata	52.46	117.41	1.01	1.07	0.13	0.48
Tunicata	1.84	1.92	0.28	0.45		
Bryozoa	0.01	0.02				
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	3950.78	2706.19	912.43	683.38	427.93	609.56
Chondrichthyes	359.55	617.08	497.02	365.22	192.67	335.32
Crustacea	642.27	685.36	609.18	443.16	265.24	359.39
Cephalopoda	218.20	225.66	120.53	94.66	34.66	30.57
Other Mollusca	76.89	87.40	34.89	52.12	7.08	15.55
Porifera	79.05	114.55	6.02	9.06	0.82	2.49
Cnidaria	1227.82	1233.23	488.54	966.43	54.23	151.71
Annelida	7.78	18.72	16.10	18.85	1.40	3.61
Sipuncula			2.26	6.00	0.64	2.47
Echinodermata	25063.88	75865.85	80.04	101.80	1.91	6.65
Tunicata	131.15	140.47	22.01	43.83		
Bryozoa	0.94	3.76				

The composition of debris in the continental shelf of the north zone is shown in Figure 60. Anthropogenic debris varied between 3 and 46%. The most important anthropogenic debris were clinker, plastic, lumber, metal and glass. The higher proportion of anthropogenic debris was observed in winter 2020. Natural debris varied between 51 and 93% of the total debris, being terrestrial plants the most abundant, which represented between 14 and 57%. Other natural debris were marine organic debris, marine plants, shells, calcified remains, and the algae *C. bursa*.

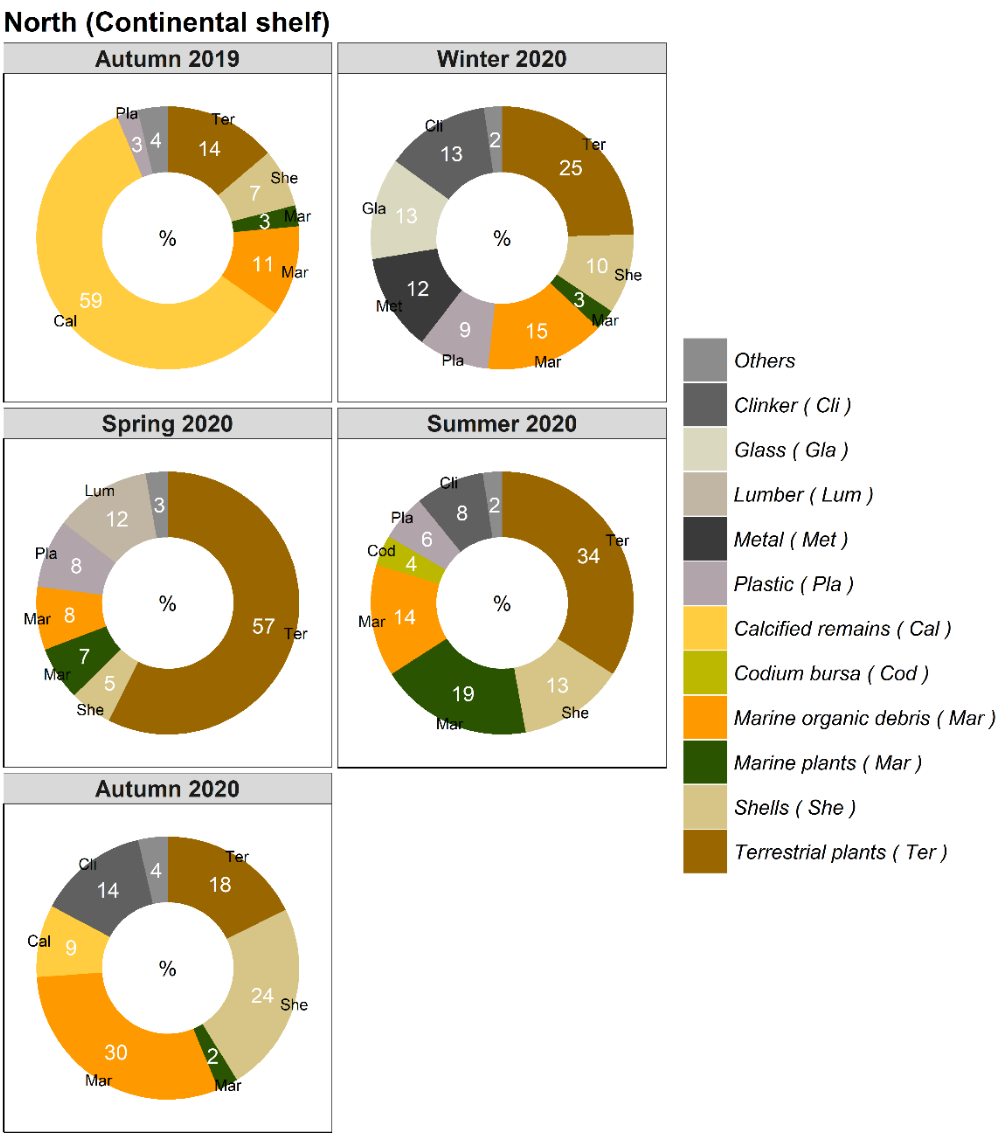


Figure 60. Items with most mass within the debris fraction of the catch in the continental shelf, including all hauls in the north zone for each season from October 2019 to December 2020.

The composition of debris in the upper slope of the north zone is shown in Figure 61. Anthropogenic debris ranged between 16 and 57%. The most important anthropogenic debris was clinker, plastic, lumber, metal, rubber, and glass. The highest proportion of anthropogenic debris was observed in winter 2020. Natural debris was between 41 and 80% of the total debris, being terrestrial plants the category with most biomass, ranging between 19 and 47%. Other natural debris were marine organic debris, marine plants, shells, and calcified remains.

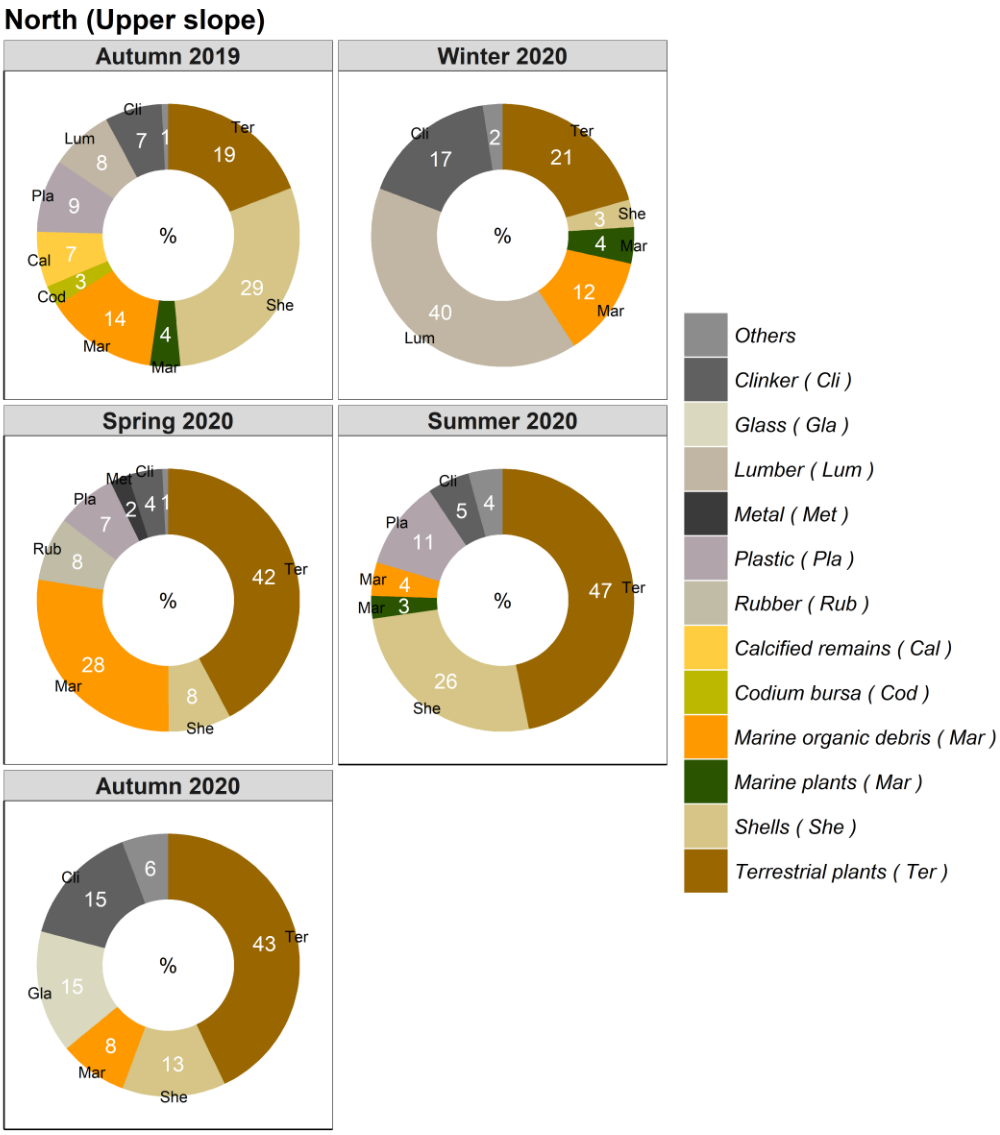


Figure 61. Items with most mass within the debris fraction of the catch in the upper slope including all hauls in the north zone for each season from October 2019 to December 2020.

The composition of debris in the north zone in the lower slope is shown in Figure 62. Anthropogenic debris ranged between 28 and 49%. The most important anthropogenic debris was clinker, plastic, fishing gear, lumber, ropes, and glass. The higher proportion of anthropogenic debris was observed in winter 2020. Natural debris was from 47 to 69% of the total debris, being terrestrial plants the most important category, ranging between 11 and 62%. Other natural debris included marine organic debris, marine plants, shells, terrestrial animals, and calcified remains.

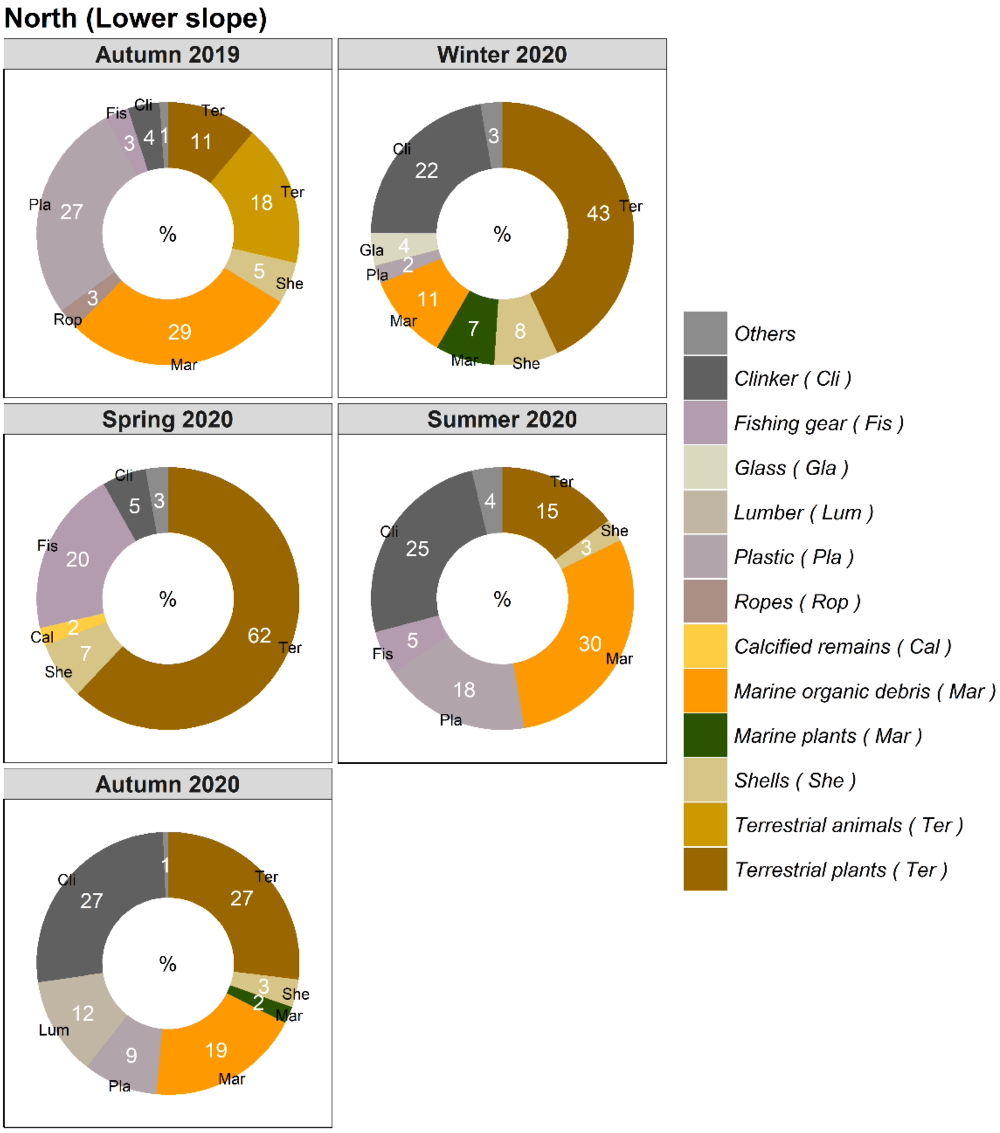


Figure 62. Items with most mass within the debris fraction of the catch in the lower slope including all hauls in the north zone for each season from October 2019 to December 2020.

The biomass of the different types of debris present in the catch in the north zone is shown in Table 13. Natural debris, including terrestrial plants and marine plants, had a higher biomass in the continental shelf and the upper slope; these type of debris are frequent near river mouths or the coast after torrential rains. Antrhopogenic debris such as plastic, clinker, and wet wipes had higher masses in the continental shelf and the upper slope.

Table 13. Mass (Kg/Km^2) of the items present in the debris fraction of the catch in the north zone. Mean and standard deviation in each fishing ground, including all hauls from October 2019 to December 2020.

	Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd
Terrestrial plants	10.10	8.55	13.10	19.40	2.33	5.46
Shells	4.18	5.04	7.41	13.28	0.39	0.95
Marine organic debris	5.37	4.70	4.48	5.84	0.84	0.94
Calcified remains	6.03	22.21	0.71	2.85	0.02	0.07
Clinker	2.53	4.30	2.93	3.07	1.20	2.73
Plastic	1.90	2.54	2.84	5.16	0.41	0.48
Marine plants	3.02	8.32	0.91	1.30	0.27	0.86
Lumber	0.51	1.99	2.04	5.55	0.16	0.50
Glass	0.77	3.09	0.95	3.15	0.13	0.49
Codium bursa	0.60	1.57	0.34	1.09		
Metal	0.75	2.94	0.19	0.56		
Rubber	0.17	0.64	0.52	1.97		
Fishing gear	0.11	0.29	0.08	0.21	0.22	0.67
Wet wipes	0.07	0.18	0.25	0.40	0.00	0.00
Ropes	0.07	0.16	0.06	0.10	0.05	0.11
Textiles	0.08	0.22	0.05	0.16	0.00	0.01
Unclassified debris	0.09	0.22	0.02	0.06	0.01	0.03
Other marine algae	0.02	0.05	0.05	0.12	0.02	0.06
Terrestrial animals					0.08	0.33
Rhodophyta	0.04	0.13				
Cigarette stubs			0.02	0.07		

2.1.2.2 Center zone

Figure 63 shows the bottom trawl commercial fishing activities and bottom trawls conducted in the Center zone between October 2019 and December 2020.

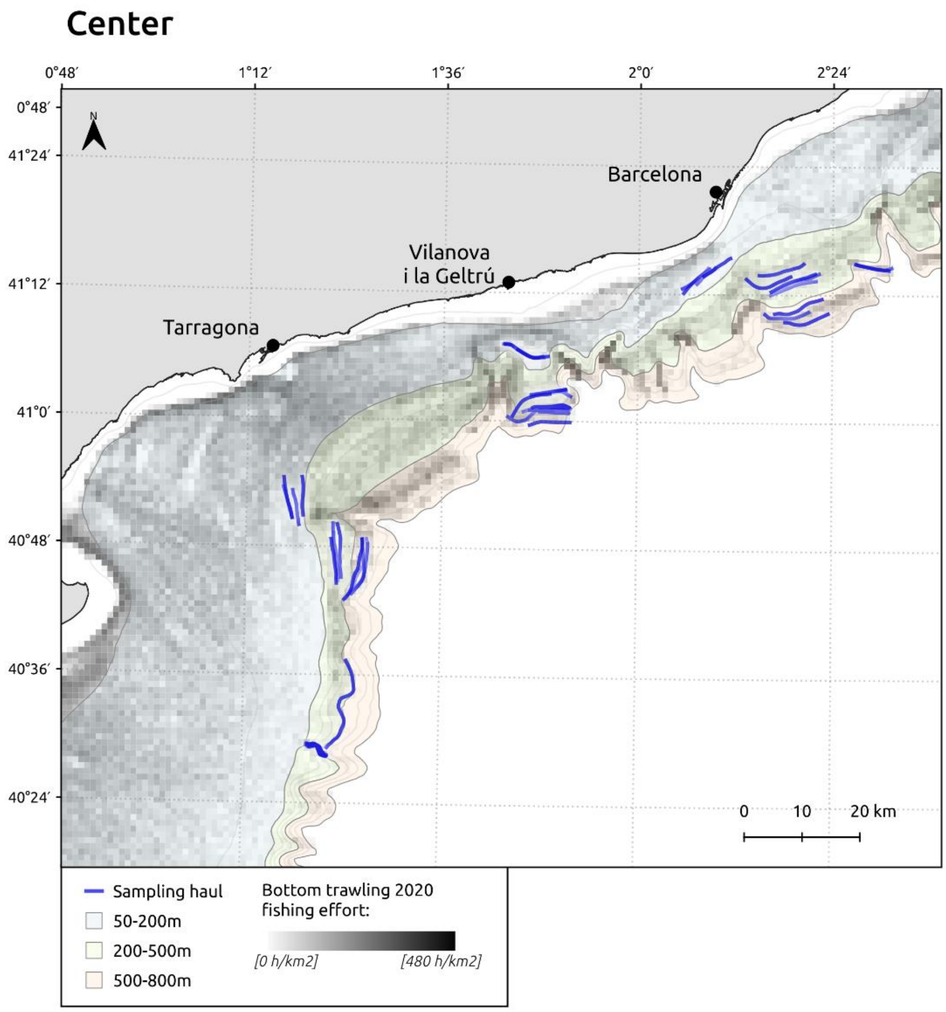


Figure 63. Map of bottom trawling hauls conducted in the center zone from October 2019 to December 2020.

Catch composition in the center zone per each season and fishing ground is shown in Figure 64. The percentage of the landed catch was between 23 and 84%. In most of the seasons, sampled landed catch was higher in deeper fishing grounds (upper and lower slope). The discarded catch ranged between 6 and 72% and the highest discarded ratio was observed in winter 2020 in the contiental shelf. This high discard ratio is caused by the high density of crinoids caught in some hauls. The percentatge of debris fraction ranged between 4 and 26%, being lower in the lower slope.

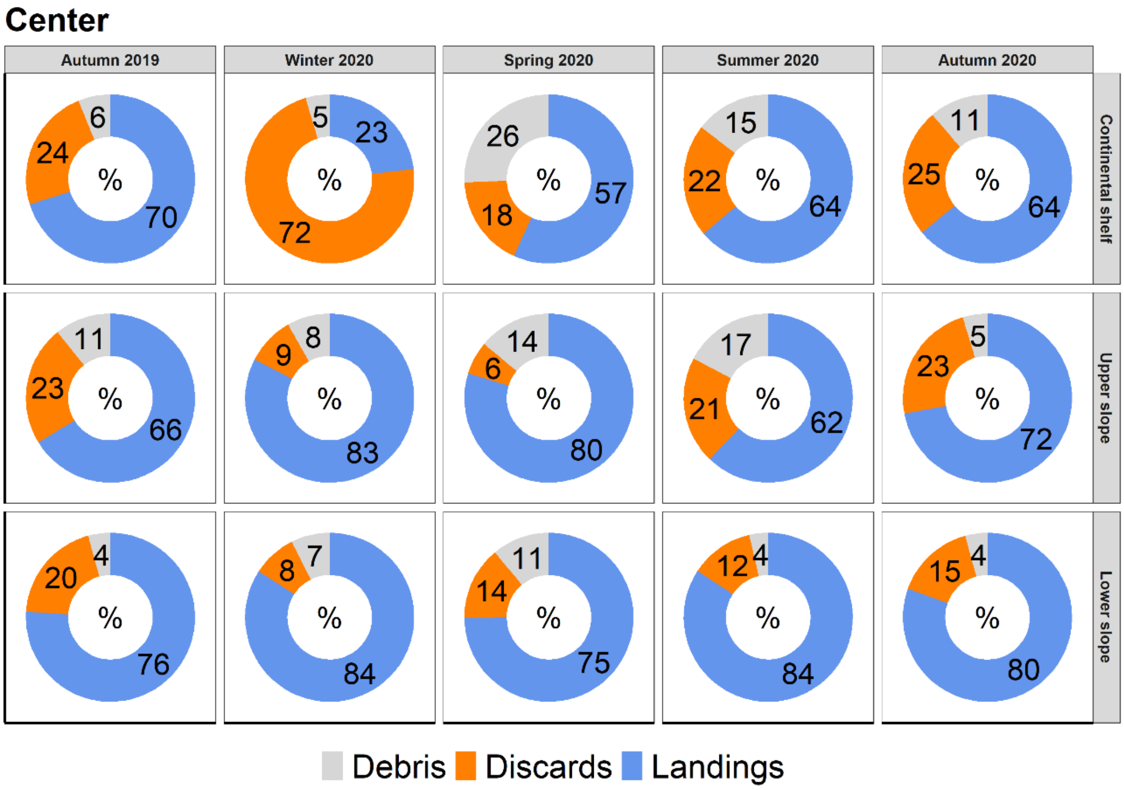


Figure 64. Catch composition in the center zone. Percentage by weight of landings, descarded, and debris fraction in each season and each fishing ground including all hauls in all ports sampled from October 2019 to December 2020.

The composition and proportion of the landed species in the continental shelf of the center zone is shown in Figure 65. There, between 31 and 47 species were landed. Target species selected for its market value (*M. merluccius* and *E. cirrhosa*) represented between 6 and 16% of the landed catch. Other landed species with important biomasses were *T. trachurus*, *L. budegassa*, *I. coindetii,* and *M. barbatus*.

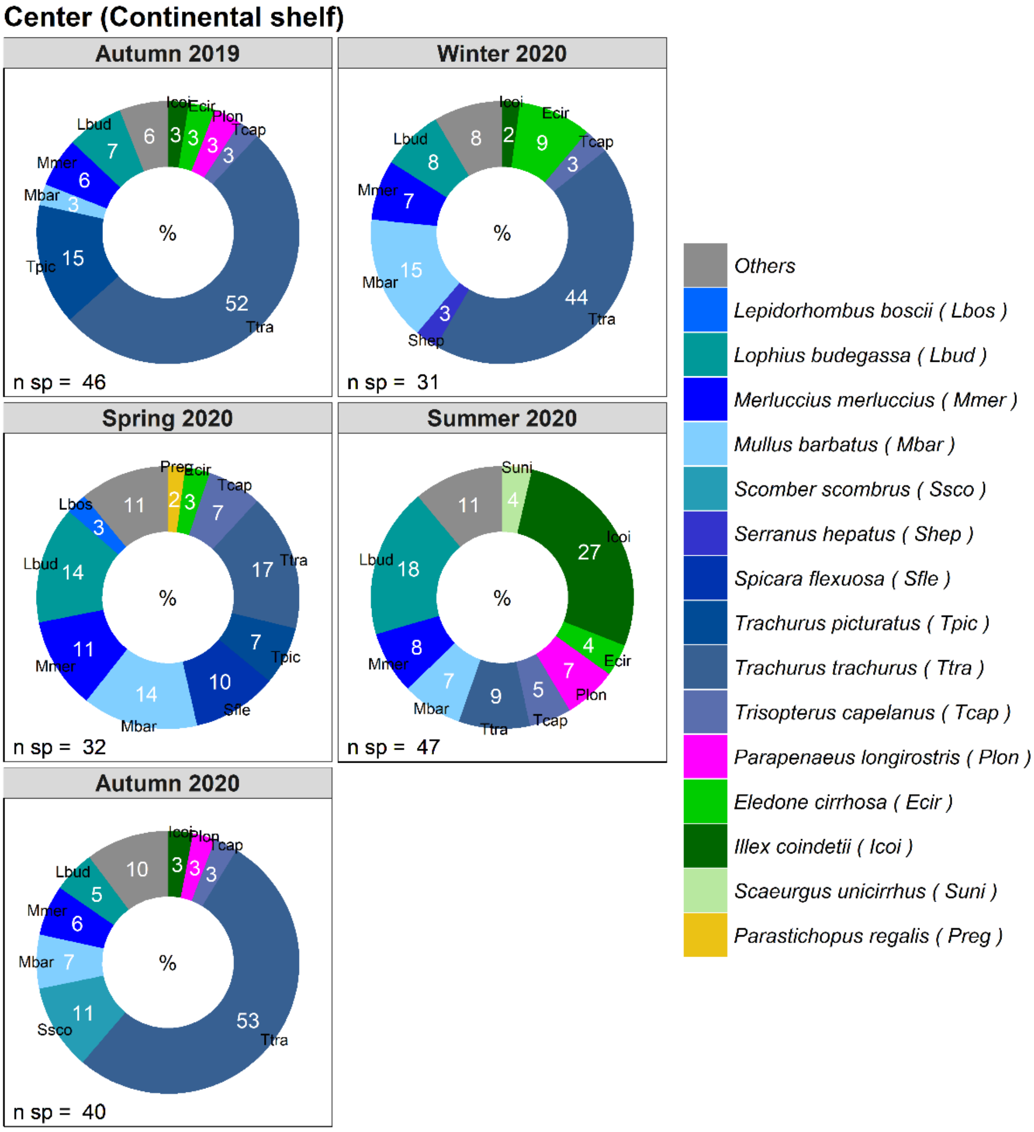


Figure 65. Species with most biomass within the landed catch in the continental shelf for all hauls conducted in center zone for each season from October 2019 to December 2020.

The composition and proportion of landed species in the upper slope of the center zone is shown in Figure 66. There, between 23 and 32 species were landed. Target species selected for its market value (*N. norvegicus*, *M. merluccius* and *E. cirrhosa*) ranged between 18 and 46% of the landed catch. Other landed species with important biomasses were *P. blennoides*, *M. poutassou*, *S. canicula*, and the crustacean *P. longirostris*. This last species accounted for more than 26% of landed catch in spring 2020.

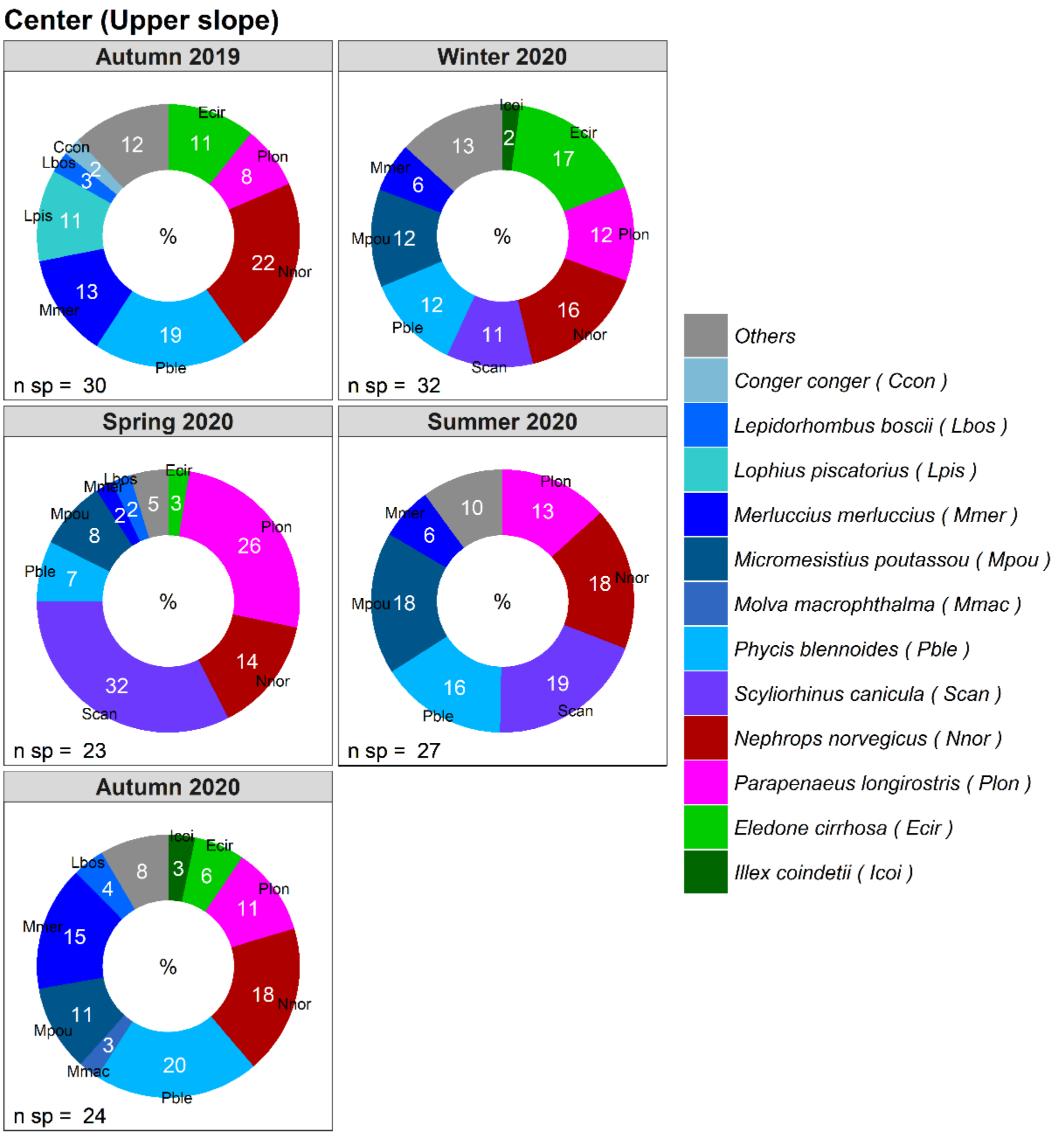


Figure 66. Species with most biomass within the landed catch in the upper slope for all hauls conducted in center zone for each season from October 2019 to December 2020.

The composition and proportion of landed species in the lower slope of the center zone is shown in Figure 67. There, between 21 and 30 species were landed. Target species selected for its market value (*A. antennatus*, *N. norvegicus*, *M. merluccius* and *E. cirrhosa*) represented more than the 40% of the landed catch through all seasons, which percentatge was mainly composed by the blue and red shrimp (*A. antennatus*). Other landed species with a high biomass were *P. blennoides*, *G. melastomus* and *G. longipes*.

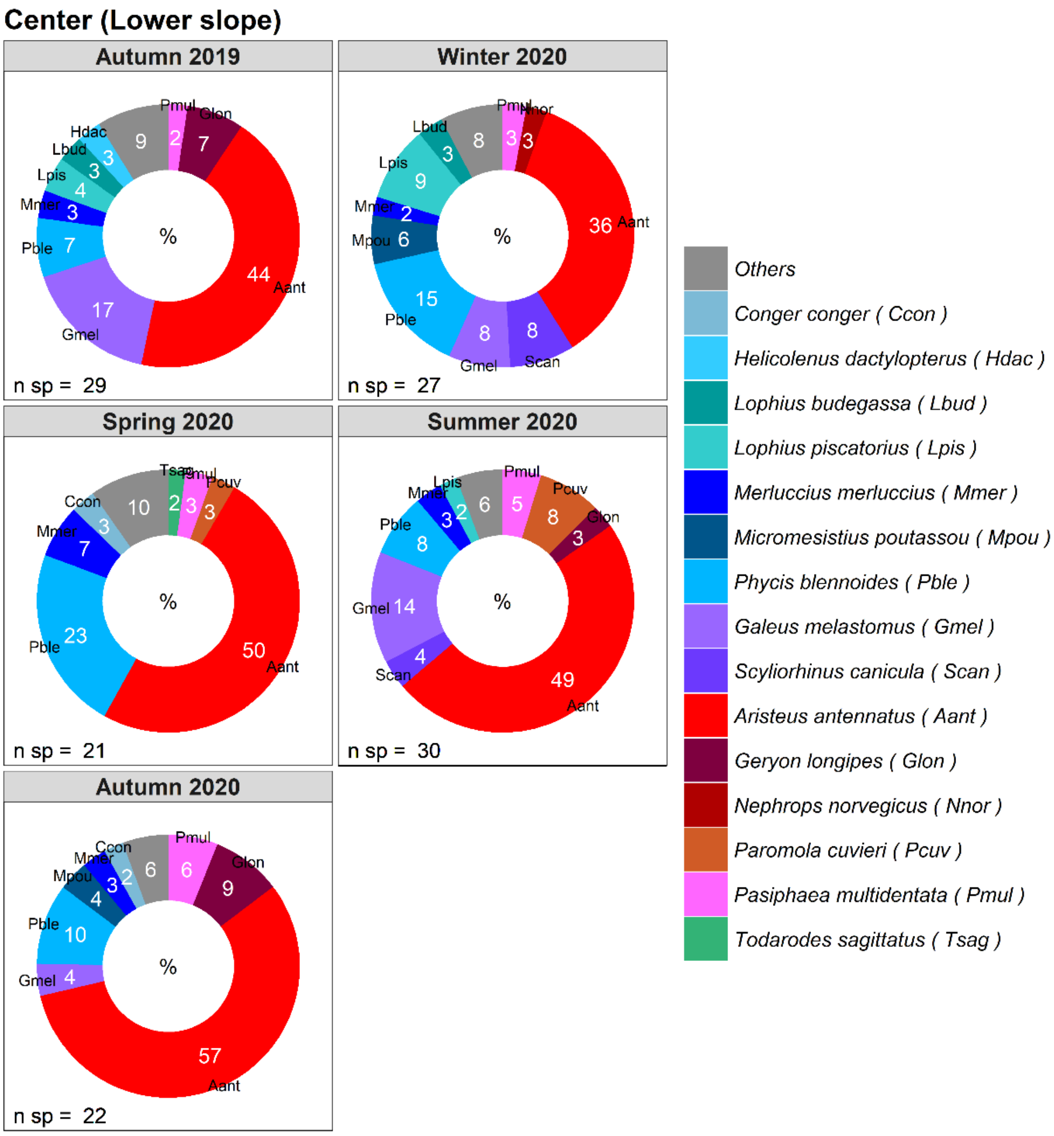


Figure 67. Species with most biomass within the landed catch in the lower slope for all hauls conducted in center zone for each season from October 2019 to December 2020.

In the center zone, the most important taxonomic group within the landing catch were Actinopterygii for most of the fishing grounds except for the lower slope, where the most important group was the crustaceans (Table 14). Chondrichthyes were more important in the upper slope, and Cephalopoda were abundant in the continental shelf. Other Mollusca (Bivalvia and Gasteropoda) with commercial value were present in all fishing grounds except in the lower slope. Echinodermata were present only in the continental shelf.

Table 14. Biomass (kg/km^2) and abundance (ind/km^2) of taxonomic groups present in the landed catch in the center zone. Mean and standard deviation in each fishing ground, including all hauls from October 2019 to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	389.78	373.26	88.70	58.32	37.68	28.06
Chondrichthyes	2.53	5.25	25.55	50.10	19.46	23.87
Crustacea	15.02	23.18	65.44	43.01	95.18	51.43
Cephalopoda	64.22	67.21	19.80	19.64	2.36	2.93
Other Mollusca	0.17	0.45	0.03	0.06		
Echinodermata	1.52	3.15				
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	7386.33	7017.79	1098.14	917.87	221.81	150.31
Chondrichthyes	5.17	12.48	134.85	274.36	63.80	86.42
Crustacea	2759.97	4317.22	4539.68	2928.95	5163.98	2634.01
Cephalopoda	1347.81	1679.34	106.38	84.56	8.03	7.28
Other Mollusca	7.10	19.81	1.00	1.84		
Echinodermata	10.35	22.27				

The proportion of species with the most biomass within the discarded catch in the continental shelf of the center zone is shown in Figure 68. There, between 45 and 120 species were discarded. The most important fishes from the discarded catch were *B. boops*, *S. canicula* and *S. flexuosa*. Target species including *M. merluccius*, discarded for not reaching the minimum conservation reference size, accounted for less than 11%. Benthic invertebrates such as *L. phalangium* represented a high proportion of the discarded catch during winter 2020.

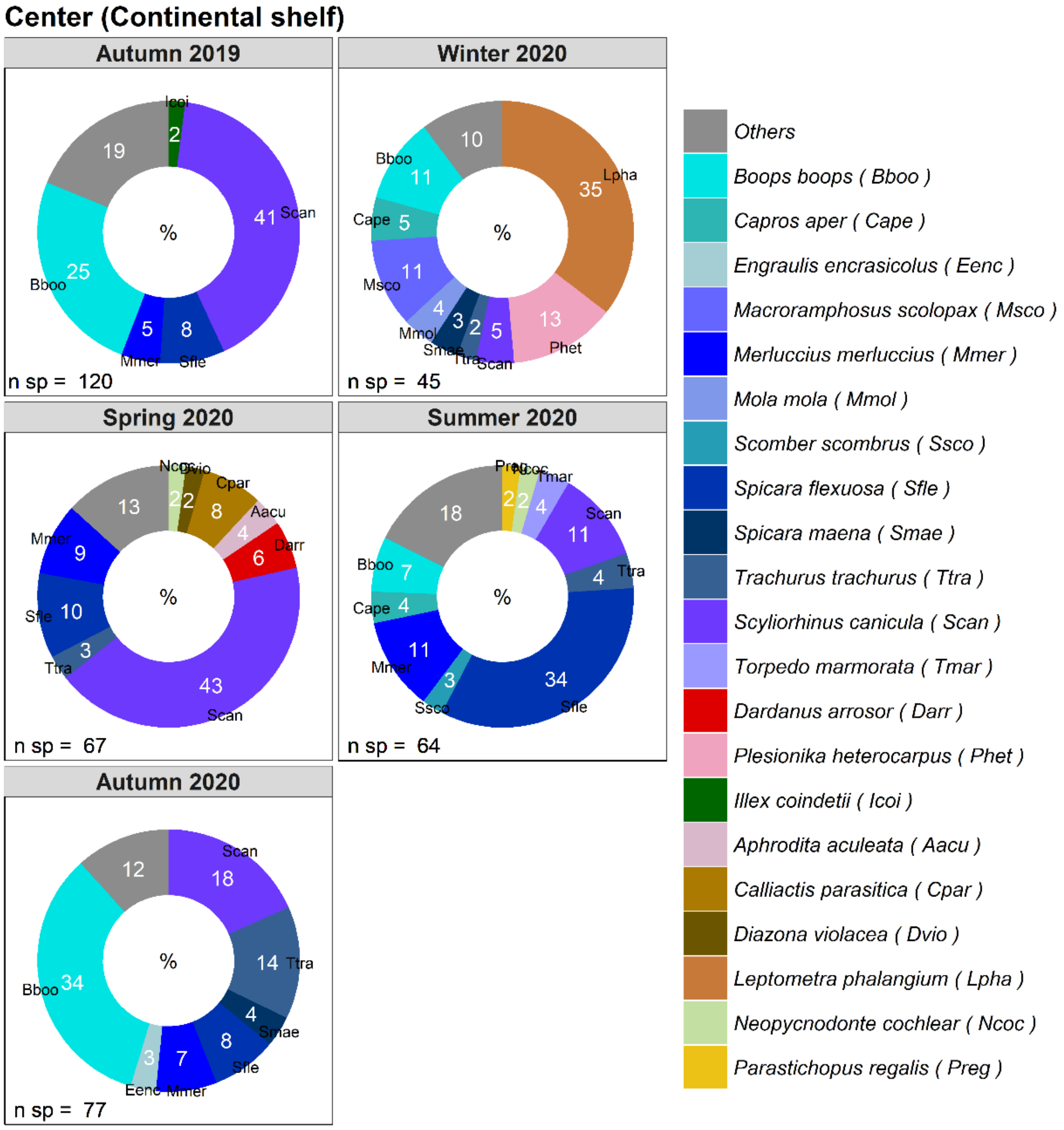


Figure 68. Species with most biomass of the discarded catch in the continental shelf for all hauls conducted in the center zone for each season from October 2019 to December 2020.

The proportion of species with most biomass within the discarded catch in the upper slope of the center zone is shown in Figure 69 . There, between 43 and 98 species were discarded. Most of the discarded catch was composed by sharks, mainly *S. canicula* and *G. melastomus*. Other species of fish present within the discarded catch were *C. coelorhincus*, *C. conger*, *L. caudatus*, and *G. argenteus*. cephalopod species accounted for less than 12% of the discarded catch and crustacean, for less than 5%.

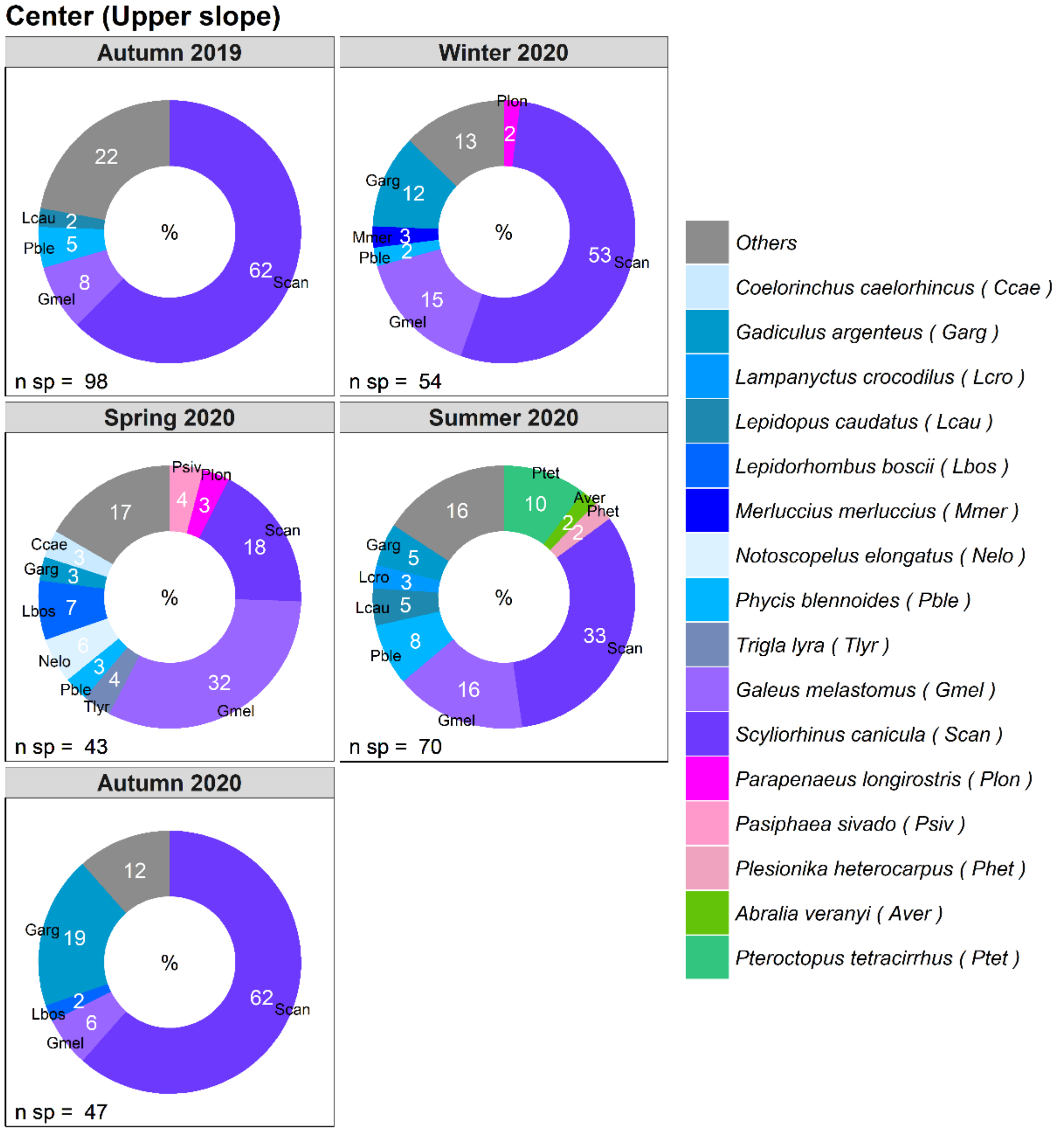


Figure 69. Species with most biomass within the discarded catch in the upper slope for all hauls conducted in center zone for each season from October 2019 to December 2020.

The proportion of species with most biomass within the discarded catch in the lower slope of the center zone is shown in Figure 70. There, between 43 and 69 species were discarded. The most important fish discarded were *G. melastomus, T. scabrus,* and *L. crocodilus.* During autumn 2019, a high proportion of the species *M. mola* was observed in the discarded catch, which corresponded to a single large individual caught in one haul. Cephalopod species accounted for less than 24% of the discarded catch with the most important species being *H. bonnellii* and *H. reversa*. Crustacean species accounted for less than 15% and the most important species were *P. multidentata*, *G. longipes*, and *P. cuvieri*.

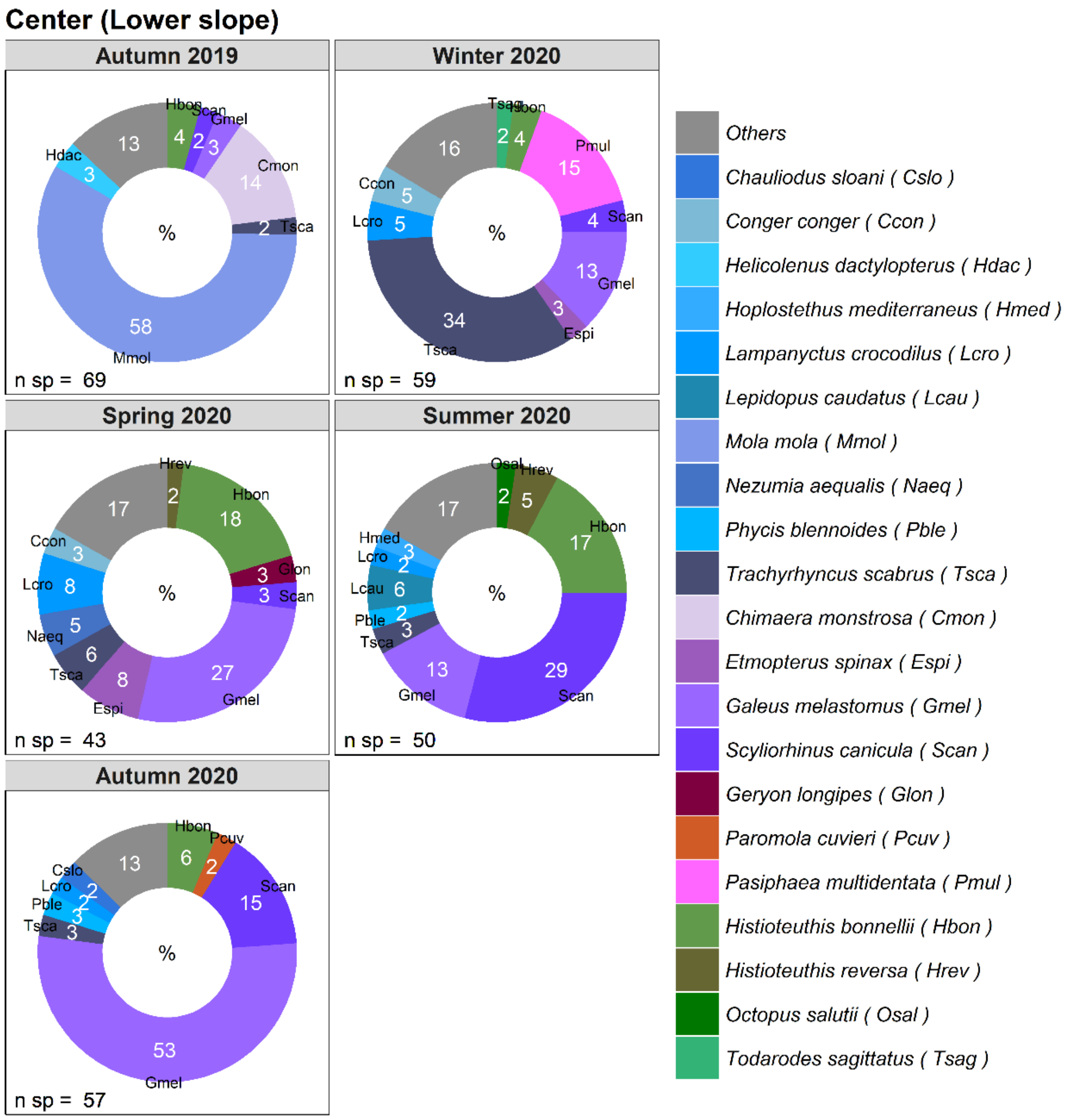


Figure 70. Species with most important biomass within the discarded catch in the lower slope for all hauls conducted in center zone for each season from October 2019 to December 2020.

In the center zone, the most important taxonomic group within the discarded catch in the continental shelf and in the lower slope were actinopterygii but in the upper slope, the most important group were chondrichthyes (Table 15). Within the discarded crustacea, the highest biomass was recorded in the continental shelf. Discarded Cephalopoda were present in all fishing grounds but other Mollusca (Bivalvia and Gasteropoda) discarded were only abundant in the continental shelf. Cnidaria were present in all fishing grounds, with a higher biomass in the continental shelf. Echinodermata had higher biomasses and abundances in the continental shelf but presented a high standard deviation, indicating that the catch was very variable among samplings.

See Annex VI for the complete list of species' biomass in each fishing ground and Annex VII for species' abundances.

Table 15. Biomass (kg/km^2) and abundance (ind/km^2) of the taxonomic groups present in the discarded catch in the center zone. Mean and standard deviation in each fishing ground, including all hauls from October 2019 to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	216.41	295.23	13.72	12.29	14.29	27.54
Chondrichthyes	64.89	124.56	34.37	45.32	14.02	22.65
Crustacea	43.04	145.95	2.64	2.62	1.85	2.47
Cephalopoda	4.27	5.11	3.60	8.47	4.64	7.88
Other Mollusca	5.60	11.56	0.12	0.16	0.01	0.03
Porifera	0.14	0.34	0.01	0.02		
Cnidaria	3.68	4.50	0.22	0.30	0.07	0.11
Annelida	0.91	1.62	0.02	0.04	0.01	0.05
Sipuncula	0.00	0.01	0.02	0.06		
Echinodermata	112.98	403.37	0.19	0.15	0.05	0.09
Tunicata	1.71	2.31	0.07	0.07	0.01	0.02
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	19674.72	54418.75	941.20	888.22	343.61	390.11
Chondrichthyes	573.61	712.47	617.23	759.91	113.23	147.03
Crustacea	19792.15	71342.05	717.92	474.97	386.96	819.36
Cephalopoda	308.90	180.83	177.58	334.07	37.83	66.94
Other Mollusca	313.24	353.50	16.77	28.67	5.59	10.93
Porifera	5.44	12.90	2.37	4.33		
Cnidaria	590.25	582.08	55.72	70.37	21.18	29.88
Annelida	23.31	35.96	1.45	3.05	0.63	2.61
Sipuncula	4.61	13.79	6.94	12.90		
Echinodermata	871.85	1409.06	51.25	41.36	21.31	40.83
Tunicata	340.26	446.72	15.65	17.58	1.27	3.33

The composition of debris in the continental shelf of the center zone is shown in Figure 71. Anthropogenic debris varied between 36 and 66%. The most important anthropogenic debris was wet wipes, mainly in spring 2020 and autumn 2020, when they represented between 4 and 46% of the total debris. This type of debris was more frequent near populated areas with cities such as Barcelona, Vilanova i la Geltrú and Tarragona. Other anthropogenic debris were clinker, plastic, lumber, and textiles. Natural debris was between 28 and 64%, being terrestrial plants the category with most biomass, ranging 13 to 30%. Other natural debris was marine organic debris, marine plants, shells, calcified remains, and the algae *C. bursa*.

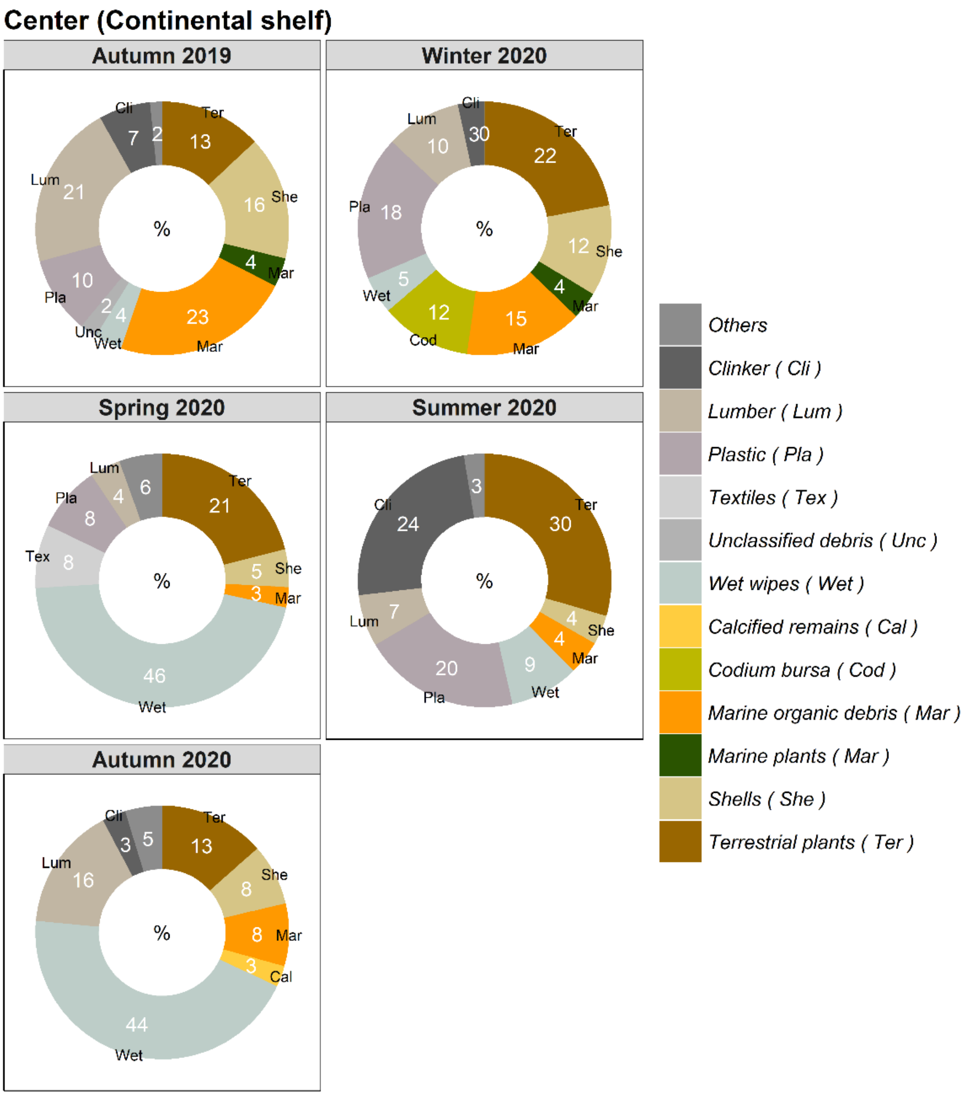


Figure 71. Items with most biomass within the debris fraction of the catch in the continental shelf for all hauls conducted in the center zone for each season from October 2019 to December 2020.

The composition of the debris in the upper slope of the center zone is shown in Figure 72. Anthropogenic debris ranged between 15 and 63%. The most important anthropogenic debris was wet wipes, which were present in all seasons sampled ranging between 5 to 41% of the total debris, but were more abundant during spring and winter 2020. Plastic ranged between 4 and 22% of total fraction of debris. Other anthropogenic debris was clinker, lumber, glass, and textiles. Natural debris was between 35 and 80% of the total debris being terrestrial plants the most important category representing between 20 and 34% of the fraction. Other natural debris was marine organic debris, marine plants, shells, and calcified remains.

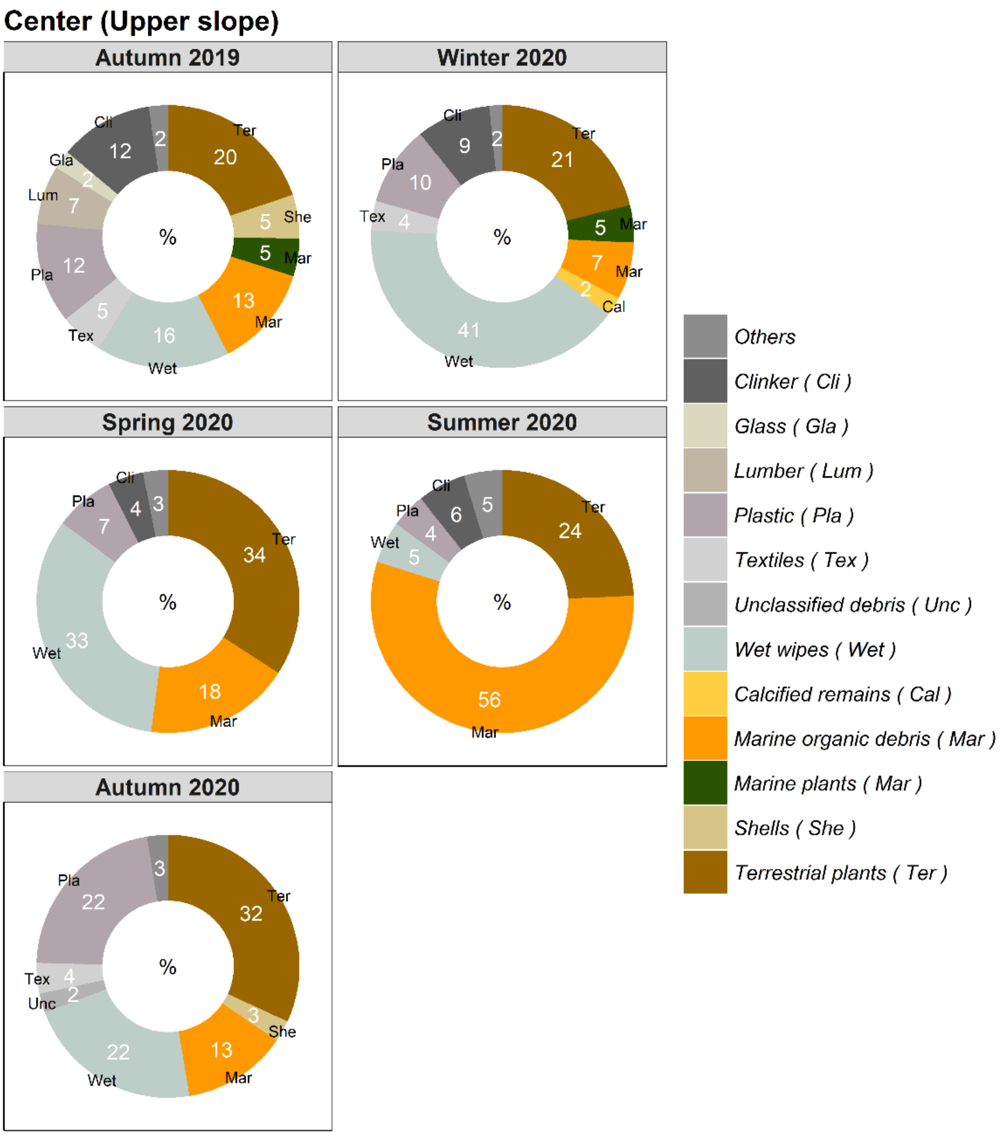


Figure 72. Items with most biomass within the debris fraction of the catch in the upper slope for all hauls conducted in the center zone for each season from October 2019 to December 2020.

The composition of the debris in the lower slope of the center zone is shown in Figure 73. Anthropogenic debris ranged between 40 and 76%. The most important anthropogenic debris was wet wipes, which accounted for 5 to 41% of the total debris, whereas plastic represented from 3 to 17% of the debris. Other anthropogenic debris was clinker, lumber, fishing gear, metal, and textiles. Natural debris ranged between 20 and 57%, being terrestrial plants the most abundant category, ranging between 13 and 28%. Other natural debris was marine organic debris, marine plants, and shells.

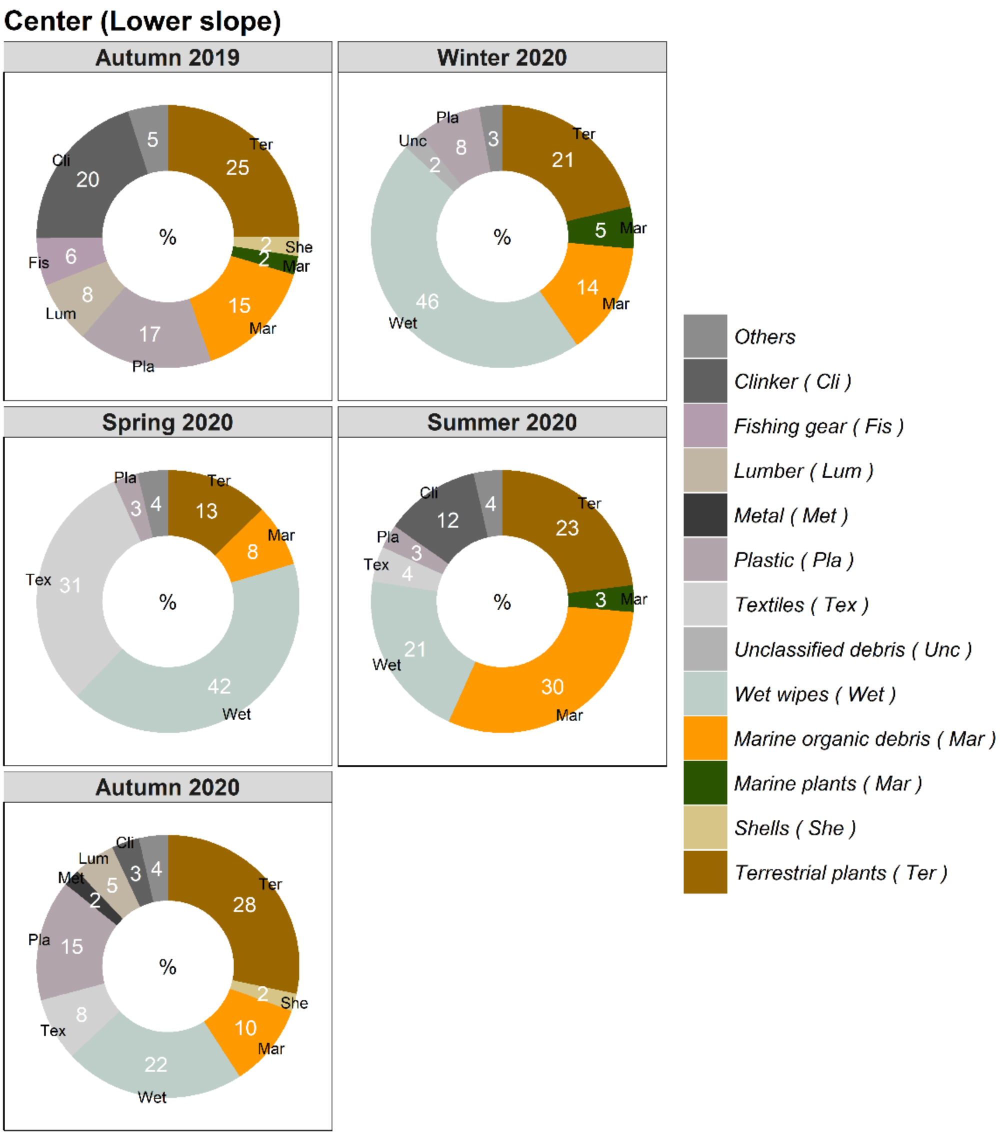


Figure 73. Items with most biomass within the debris fraction of the catch in the lower slope for all hauls conducted in the center zone for each season from October 2019 to December 2020.

The biomass of the different type of debris present in the catch in the center zone is +, including terrestrial and marine plants, had a higher biomass in the continental shelf. This kind of debris is frequent near river mouths or coastal areas after torrential rains. Antrhopogenic debris such as plastic, clinker, and wet wipes had higher masses in the continental shelf.

Table 16. Mass (Kg/Km^2) of the items present in the debris fraction of the catch in the center zone. Mean and standard deviation in each fishing ground, including all hauls from October 2019 to December 2020.

	Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd
Wet wipes	21.99	47.88	5.13	5.74	3.94	8.36
Terrestrial plants	19.64	25.73	7.79	6.34	2.73	3.32
Marine organic debris	8.09	6.87	10.15	26.22	2.06	2.39
Plastic	11.28	16.71	2.69	2.54	0.99	1.16
Clinker	7.96	22.14	2.27	1.87	0.85	1.87
Lumber	9.24	8.37	0.63	1.45	0.26	0.67
Shells	7.09	7.91	0.72	0.92	0.19	0.37
Textiles	2.32	7.94	0.74	1.52	1.63	5.38
Marine plants	1.87	2.04	0.73	0.89	0.32	0.40
Codium bursa	1.86	4.87	0.00	0.01		
Metal	0.71	1.22	0.02	0.04	0.05	0.15
Calcified remains	0.38	1.37	0.17	0.42	0.05	0.19
Ropes	0.45	1.38	0.08	0.19	0.03	0.05
Unclassified debris	0.34	1.08	0.15	0.19	0.07	0.24
Fishing gear	0.07	0.24	0.13	0.40	0.12	0.39
Glass			0.19	0.69	0.09	0.19
Rubber	0.00	0.01	0.05	0.17	0.01	0.03
Terrestrial animals	0.01	0.04				
Codium tomentosum			0.01	0.02		
Other marine algae			0.00	0.01		

2.1.2.3 South zone

Figure 74 shows the bottom trawl commercial fishing activities and bottom trawl hauls conducted in the South zone between October 2019 and December 2020.

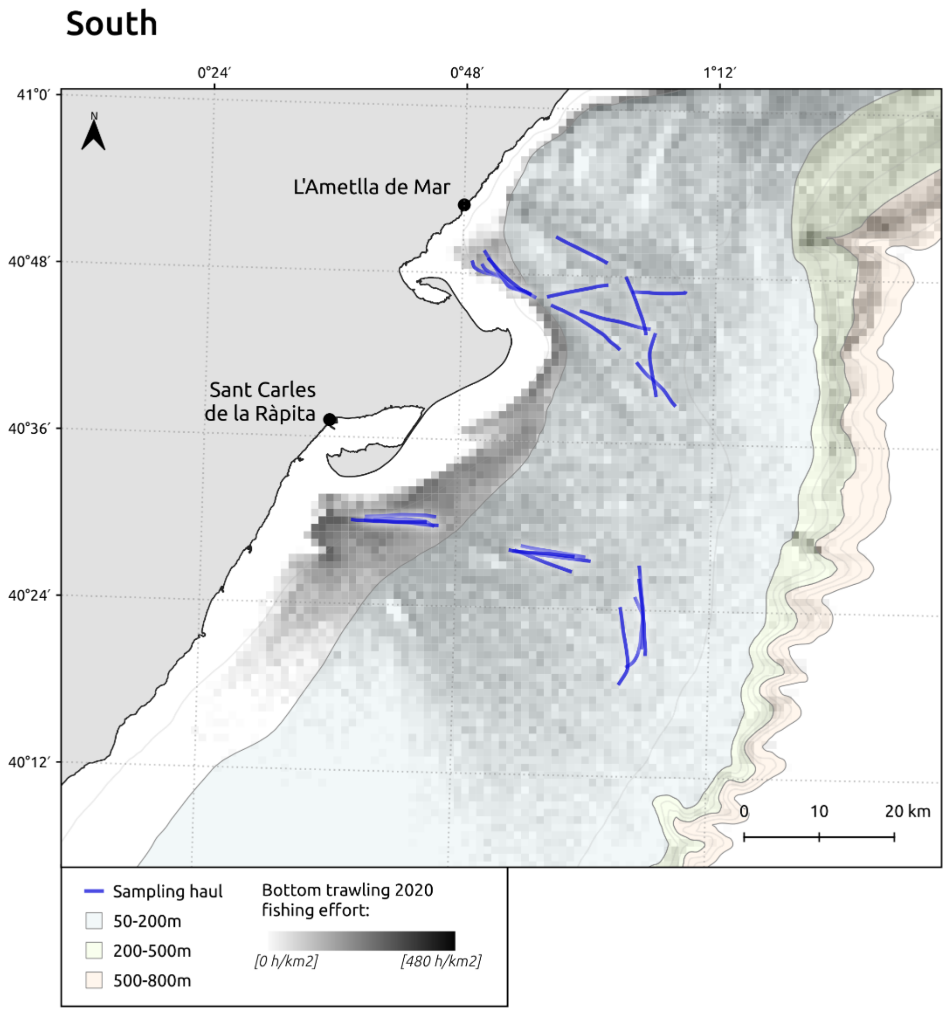


Figure 74. Map of bottom trawling hauls conducted in the south (Ebre delta) zone from October 2019 to December 2020.

Given the influence of the Ebre delta shelf, and its special fisico-quemical characteristics (type of bottom, nutrient inputs, depth, etc ...) sampling in this zone includes more coastal fishing grounds, that is, shallow (<40 m) and middle continental shelf(41-75 m). Catch composition in the southern zone per each season and fishing ground is shown in Figure 75. The percentage of landed catch ranged between 26 and 84%. The discarded catch was between 11 and 66%, with the highest discarded ratio observed in the middle continental shelf in spring

2020. The percentatge of debris fraction ranged from 7 to 40%, with the highest debris fraction observed in Autumn 2019 and winter 2020, mainly in shallow continental shelf. This high proportion of debris was caused by terrestrial plants, carried down by the river after torrential rains.

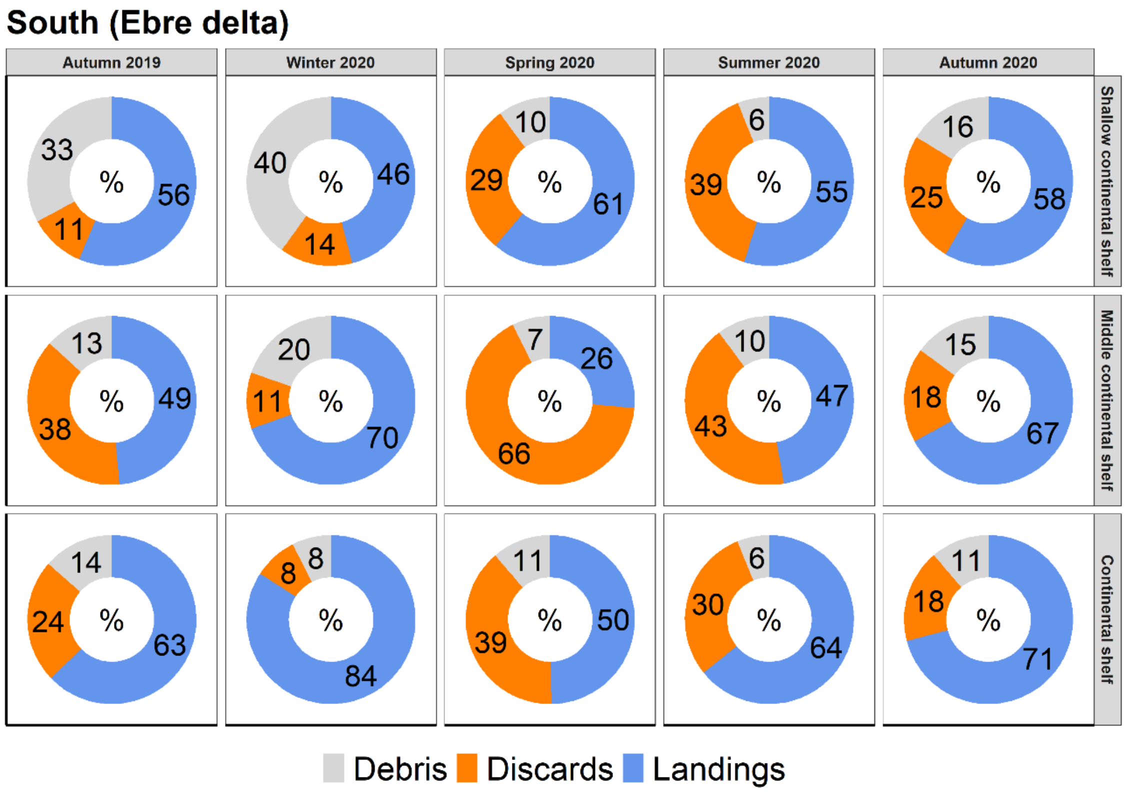


Figure 75. Catch composition in the south zone. Percentage by weight of landings, discarded and, debris fraction in each season and each fishing graund including all hauls in all ports sampled from October 2019 to December 2020.

The composition and proportion of landed species in the shallow continental shelf of the southern zone is shown in Figure 75. There, between 20 and 41 species were landed. Target species selected for its market value (*S. mantis*, *P. kerathurus* and *E. cirrhosa*) represented between 6 and 39% of the landed catch. Landings of *P. kerathurus* were highly variable seasonally. In contrast, landings of *S.mantis* were more constant between seasons. Other landed species with an important biomass were *M. barbatus*, *S. aurata*, *T. mediterraneus*, *L. budegassa*, *S. shyraena,* and *S. officinalis*.

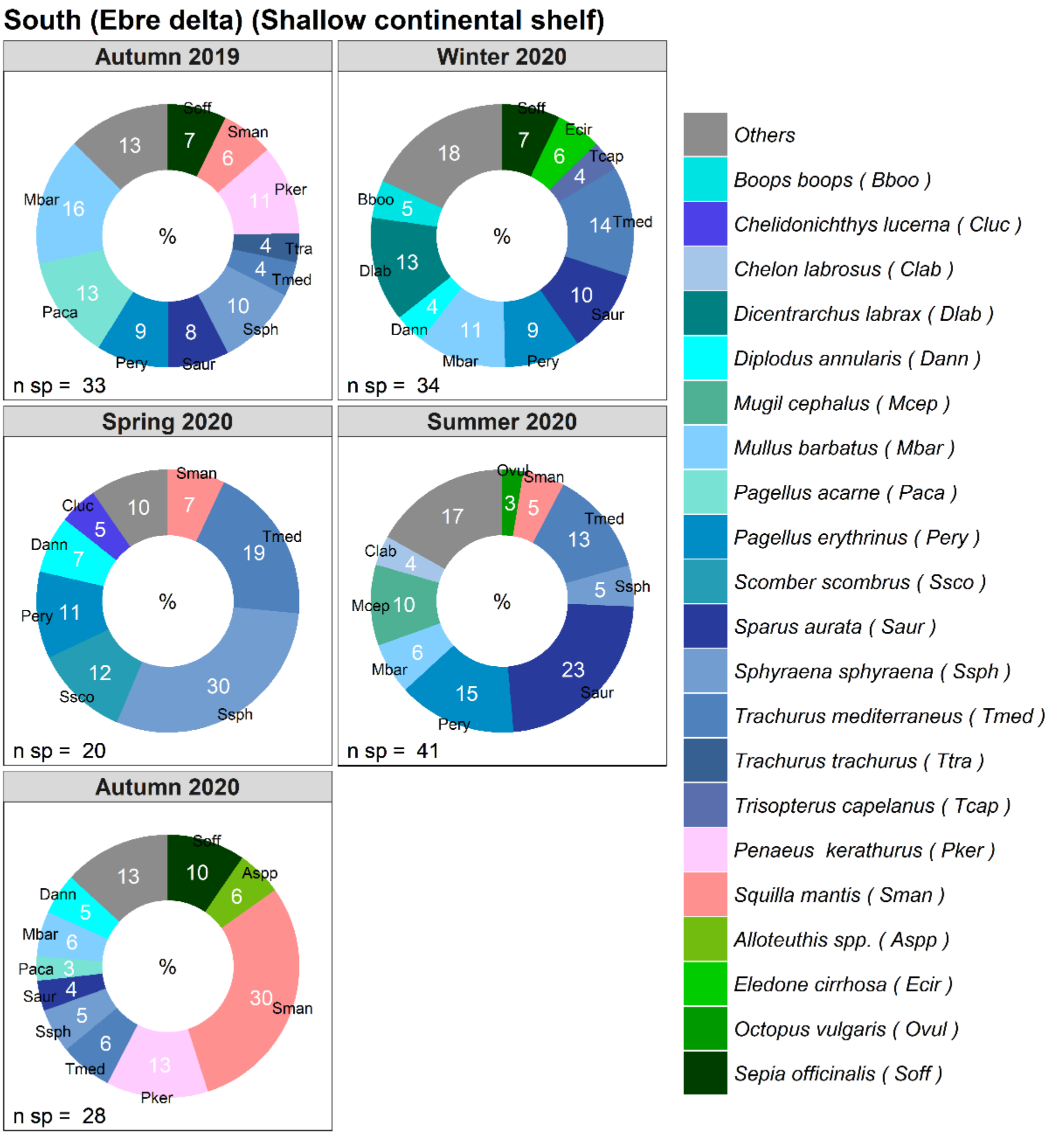


Figure 76.Species with most biomass within the landed catch in the shallow continental shelf for all hauls conducted in south zone for each season from October 2019 to December 2020.

The composition and proportion of landed species in the middle continental shelf of the southern zone is shown in Figure 77. There, between 29 and 48 species were landed. Target species selected for its market value (*S. mantis*, *M. merluccius* and *E. cirrhosa*) accounted for 19 to 33% of the landed catch. Landings of *S.mantis* were higher during winter 2020. Other landed species with an important biomass were *P. longirostris*, *I. coindetii*, *M. barbatus*, and *T. capelanus*. The proportion of the crustacean *L. depurator* was specially high during summer 2020, when reached up to 15% of the total catch.

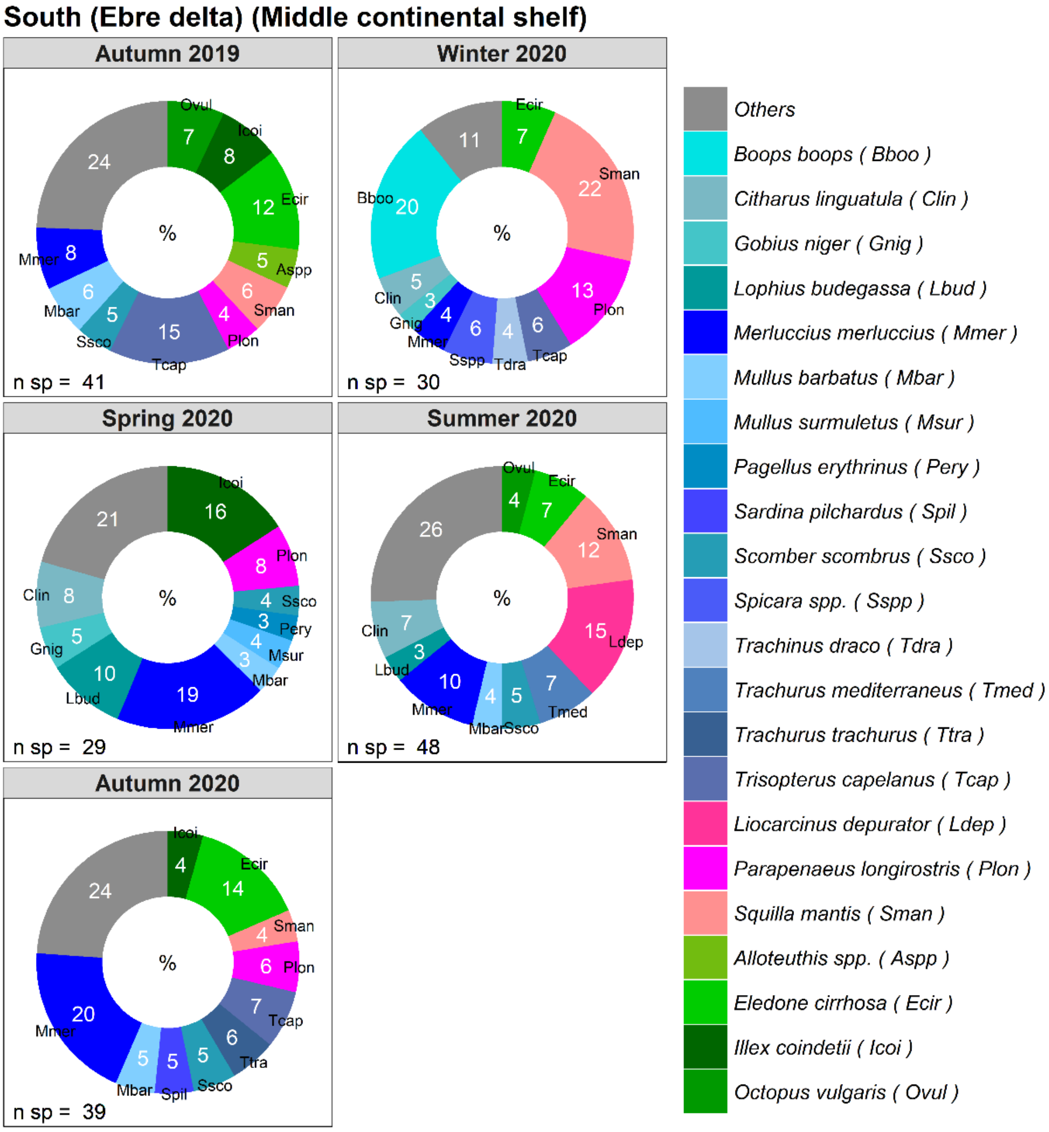


Figure 77. Species with most biomass within the landed catch in the middle continental shelf for all hauls conducted in south zone for each season from October 2019 to December 2020.

The composition and proportion of landed species in the continental shelf of the southern zone is shown in Figure 78. There, between 27 and 43 species were landed. Target species selected for its market value (*S. mantis*, *M. merluccius*, and *E. cirrhosa*) accounted for 13 to 37% of the landed catch. Other landed species with an important biomass were *L. budegassa*, *I. coindetii*, *M. barbatus*, *T. trachurus*, and *L. depurator*.

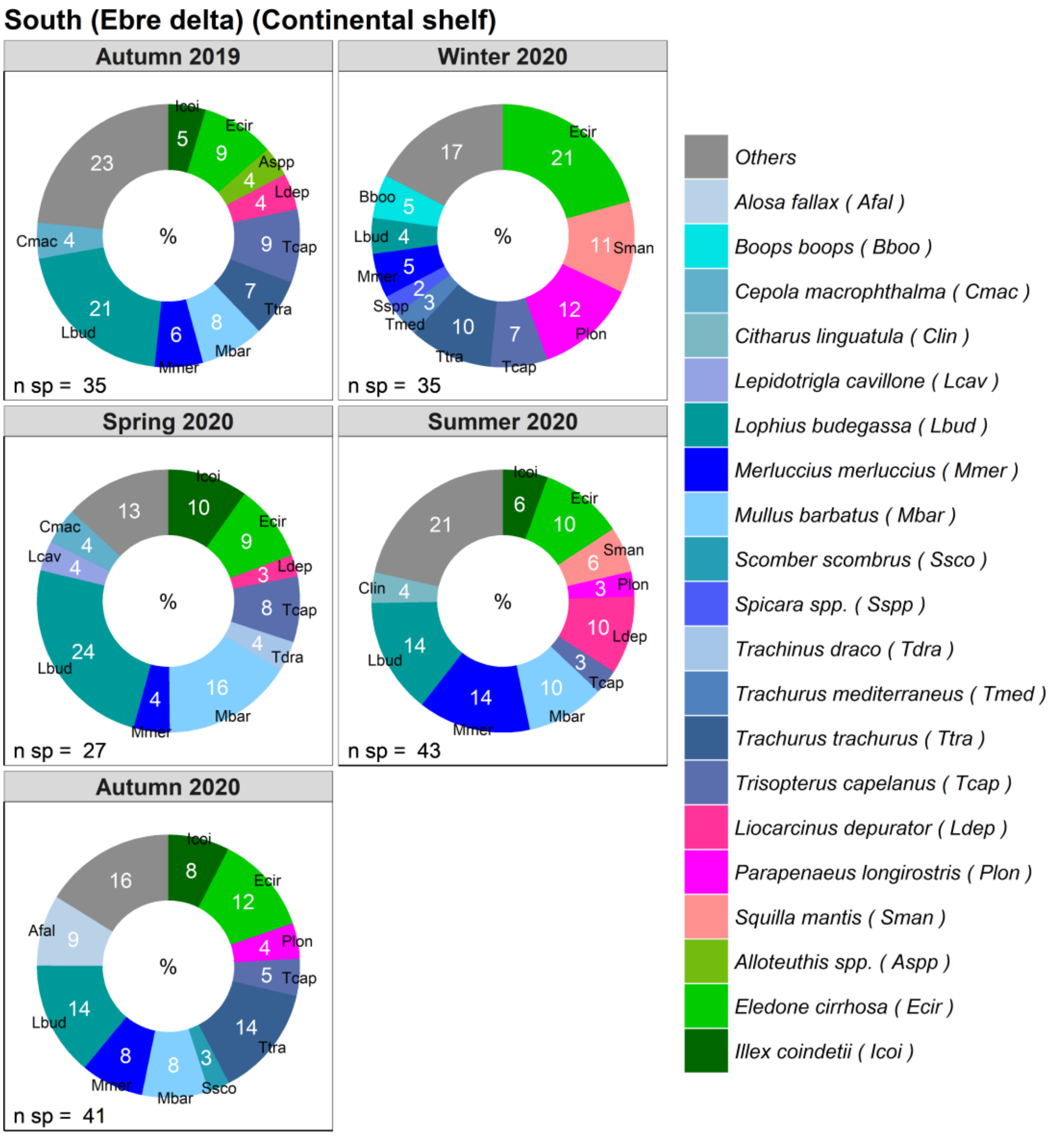


Figure 78. Species with most biomass within the landed catch in the continental shelf for all hauls conducted in south zone for each season from October 2019 to December 2020.

In the south zone, the most important taxonomic group among the landed catch were actinopterygii in all fishing grounds (Table 17). Chondrichthyes had a low biomass in all depths and were absent in the continental shelf. Crustaceans were abundant in all fishing grounds sampled. Cephalopoda were more abundant in the continental shelf. Other Mollusca (Bivalvia and Gasteropoda) with commercial value were present in all fishing grounds. On the contrary, echinodermata were only present in the middle and continental shelf.

Table 17. Table 26. Biomass (Kg/Km2) and abundance (ind./Km2) of the taxonomic groups present in the landed fraction of the catch in the port of Blanes. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Shallow continental shelf		Middle continental shelf		Continental shelf	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	239.68	170.88	151.16	45.77	222.21	136.92
Chondrichthyes	1.10	2.04	0.10	0.27		
Crustacea	41.83	30.77	54.79	51.23	41.96	26.84
Cephalopoda	29.52	15.09	59.47	33.45	76.66	17.48
Other Mollusca	2.38	1.95	2.23	1.37	3.03	3.69
Echinodermata			0.35	0.94	0.14	0.37
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	2721.09	1863.25	3163.90	1083.22	4695.06	3704.44
Chondrichthyes	12.11	21.80	1.03	2.71		
Crustacea	1545.24	1190.55	4945.36	4487.29	4097.21	2699.41
Cephalopoda	377.49	139.72	1039.12	663.70	1207.51	604.66
Other Mollusca	257.53	205.04	129.27	71.55	162.27	274.50
Echinodermata			2.71	7.18	2.30	6.08

The proportion of species with most biomass within the discarded catch in the shallow continental shelf of the south zone is shown in Figure 79. There, between 35 and 62 species were discarded. Most of the discarded catch was composed by pelagic fish such as *S. aurita*, *E. encrasicolus*, *S. pilchardus*, *B. boops*, and *T. mediterraneus*. A small proportion of crustacean species were discarded, less than 8%. Benthic invertebrates including *A. irregularis*, *O. canalifera*, and *A. serresiana* had a relative importance in some hauls becoming an important fraction in autumn 2019 and autumn 2020. Commercialized species such as *O. vulgaris*, *D. annularis*, and *S. mantis*, discarded mainly for not reaching the minimum conservation reference size, accounted for an important fraction of the discarded catch in some hauls during autumn for both 2019 and 2020, and winter 2020.

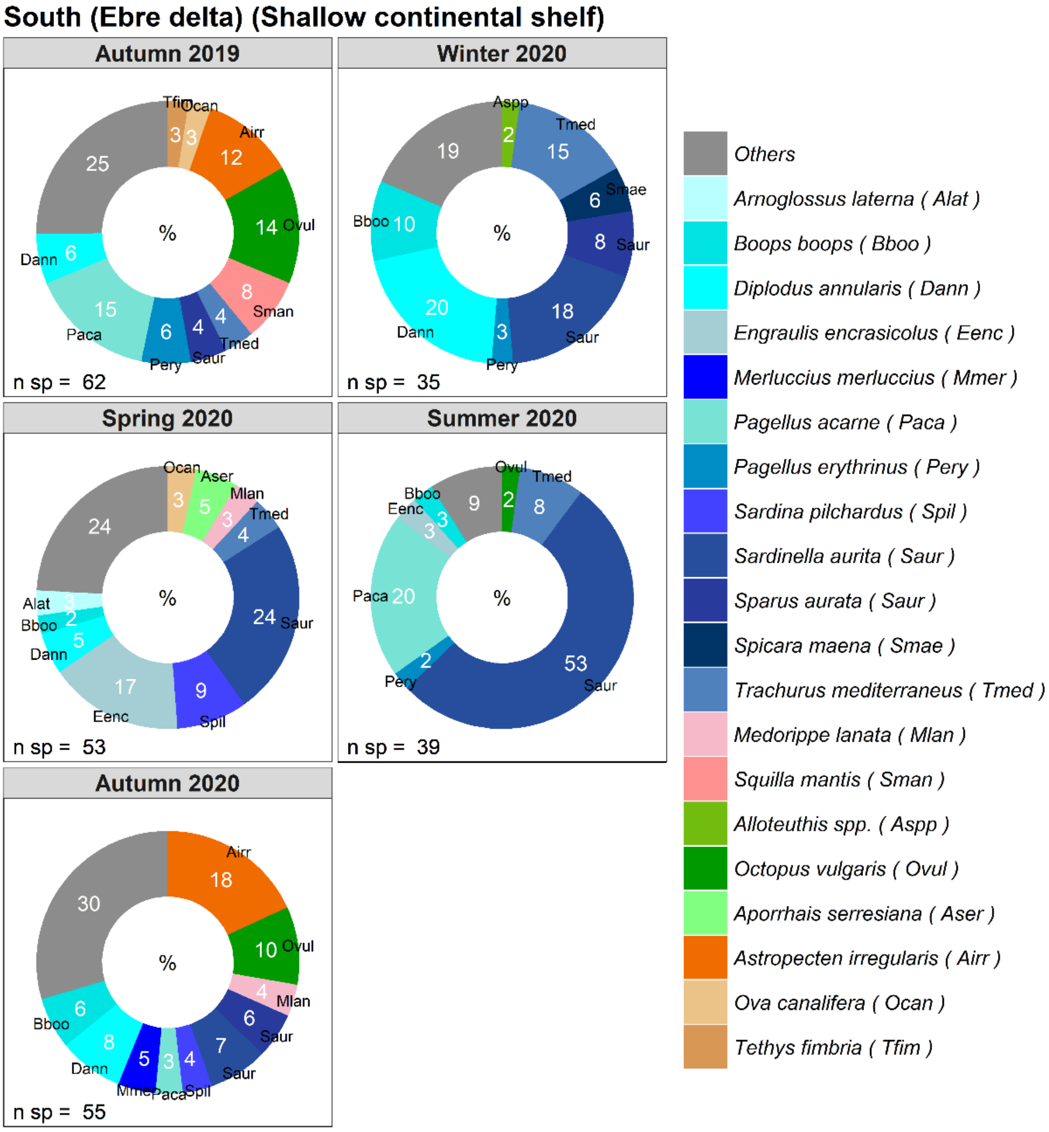


Figure 79. Species with most biomass within the discarded catch in the shallow continental shelf for all hauls conducted in south zone for each season from October 2019 to December 2020.

The proportion of species with most biomass within the discarded catch in the middle continental shelf is shown in Figure 80. There, between 37 and 57 species were discarded. Most of the discarded catch was composed by pelagic fish such as *E. encrasicolus*, *S. pilchardus*, *S. aurita*, *B. boops*, and *T. mediterraneus*. Target species including *M. merluccius* were present in the discarded catch, mainly during autumn 2020. However, crustacean species, such as *S. mantis*, were important in the discarded catch in winter 2020. Benthic invertebrates including *A. irregularis*, *H. tubulosa*, *P. mammillata*, *Spongosorites spp.*, and *Suberites spp.* accounted for a small fraction of the discarded catch.

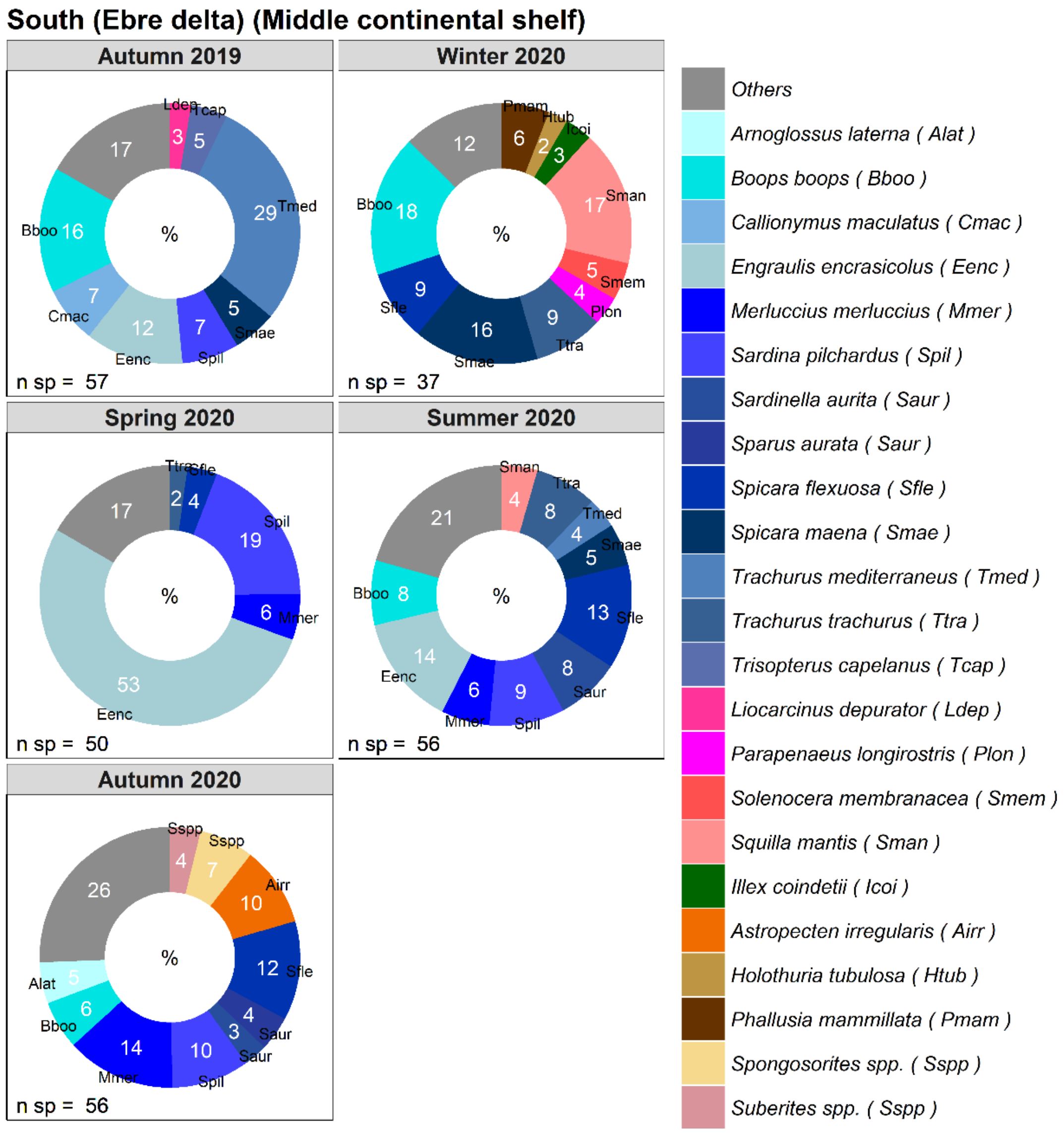


Figure 80. Species with most biomass within the discarded catch in the middle continental shelf for all hauls conducted in south zone for each season from October 2019 to December 2020.

The proportion of species with most biomass within the discarded catch in the continental shelf of the south zone is shown in Figure 81. There, between 34 and 65 species were discarded. The most important fish species from the discarded catch were *E. encrasicolus*, *B. boops*, *T. trachurus*, and *S. flexuosa*. Target species, such as *M. merluccius*, discarded for not reaching the minimum conservation reference size, represented a 28% of the discarded catch during autumn 2020. Crustacean species, including *S. mantis*, had the highest biomass in the discarded catch in winter 2020, mainly small individuals. Benthic invertebrates, including *A. irregularis*, accounted for less than 14% of the discarded catch but they were present in all seasons.

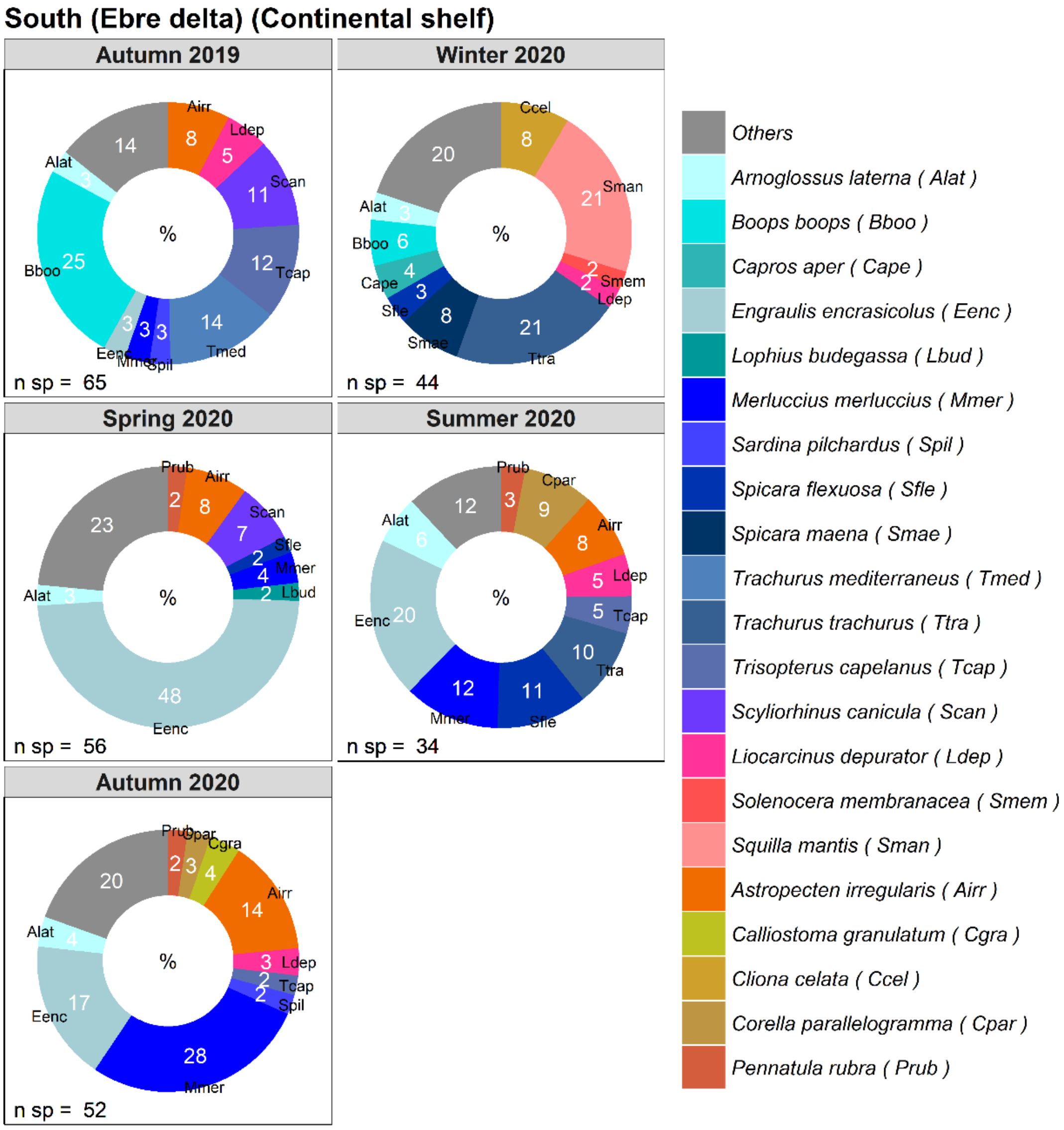


Figure 81. Species with most biomass within the discarded catch in the continental shelf for all hauls conducted in south zone for each season from October 2019 to December 2020.

In the south zone, the most important taxonomic group within the discarded catch in all fishing grounds sampled were Actinopterygii (Table 18). The highest biomass of discarded crustacea was recorded in the middle continental shelf. Discarded Cephalopoda were present in all fishing grounds. Cnidaria were present in all fishing grounds but with higher biomass in the continental shelf. Echinodermata and Tunicata had higher biomases and abundances in the continental shelf than in the other two fishing grounds, although the standard deviation was high, indicating variability among the catches.

See Annex VIII for the complete list of species' biomass in each fishing ground and Annex IX for species' abundances.

Table 18. Biomass (kg/km^2) and abundance (ind/km^2) of taxonomic groups present in the discarded catch in the south zone. Mean and standard deviation in each fishing ground, including all hauls from October 2019 to December 2020.

	Shallow continental shelf		Middle continental shelf		Continental shelf	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	120.08	151.47	187.61	175.99	92.50	100.30
Chondrichthyes	0.34	0.47	0.41	0.34	9.69	17.68
Crustacea	6.47	5.20	13.92	17.03	9.73	8.59
Cephalopoda	5.74	5.83	5.00	7.55	2.35	1.99
Other Mollusca	5.26	5.82	3.98	4.98	3.36	3.48
Porifera	0.18	0.31	2.20	3.30	1.13	1.11
Cnidaria	2.43	2.42	5.06	6.02	7.29	8.50
Annelida	0.00	0.01	0.04	0.10	0.07	0.10
Sipuncula					0.02	0.06
Echinodermata	6.22	7.19	3.97	3.90	12.39	12.10
Tunicata	0.21	0.35	0.62	0.57	4.16	6.06
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	6181.13	6295.76	17430.28	18107.30	6633.38	6615.62
Chondrichthyes	106.05	129.87	203.25	165.97	384.33	373.84
Crustacea	879.61	629.30	2484.63	2571.15	1820.06	1661.51
Cephalopoda	49.05	41.44	190.09	253.30	272.70	310.91
Other Mollusca	486.80	504.04	386.17	430.86	644.89	636.18
Porifera	14.11	29.81	44.23	48.23	78.18	108.14
Cnidaria	417.58	437.59	1255.38	1498.93	1828.75	1944.32
Annelida	6.64	10.79	19.59	34.16	58.57	153.42
Sipuncula					15.40	40.76
Echinodermata	2125.88	2534.99	1691.64	1731.38	6358.43	6683.05
Tunicata	7.62	12.82	104.65	58.31	2366.12	3381.46

The composition of debris in the shallow continental shelf of the south zone is shown in Figure 82. Anthropogenic debris was scarce in this fishing ground, less than 17%, and the most important anthropogenic categories found were fishing gear, clinker, and plastic. Natural debris represented most of the items in mass, mainly terrestrial plants, which accounted for as high as 97% of the debris in autumn 2019. These large proportions of terrestrial plants corresponded to tree trunks, especially abundant after torrential rains. Other natural debris was marine plants, marine organic debris, shells, *C. bursa*, and calcified remains. Marine plants were especially abundant during autumn and winter 2020, when accounted for the 54 - 47% of the total debris.

Figure 82. Items with most biomass within the debris fraction of the catch in the shallow continental shelf for all hauls conducted in the south zone for each season from October 2019 to December 2020.

The composition of the debris in the middle continental shelf of the south zone is shown in Figure 83. Anthropogenic debris was scarce in this fishing ground, less than 21%, and the most important anthropogenic litter items were glass, lumber, and clinker. Natural debris accounted for most of the items in mass, mainly terrestrial plants, adding up to 71% in autumn 2019. Other natural debris was *C. bursa*, marine organic debris, marine plants, and shells.

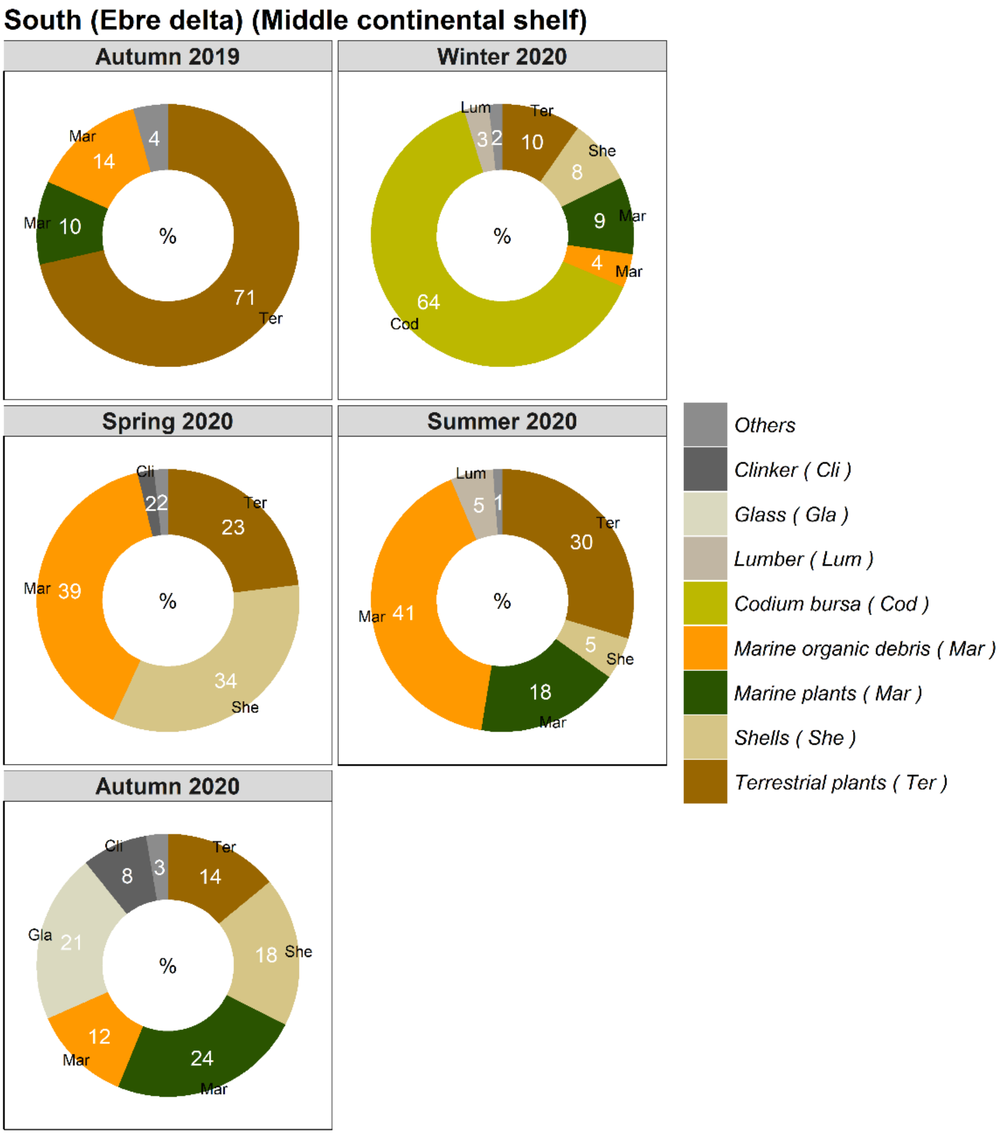


Figure 83. Items with most biomass within the debris fraction of the catch in the middle continental shelf for all hauls conducted in the south zone for each season from October 2019 to December 2020.

The composition of debris in the continental shelf of the south zone is shown in Figure 84. Anthropogenic debris was scarce in this fishing ground, less than 11%, with the most anthropogenic debris found being clinker, plàstic, and wet wipes. Natural debris represented most of the debris mass, mainly terrestrial plants, which ranged between 33 and 66%. Other natural debris was marine organic debris, marine plants, *C. bursa*, and shells.

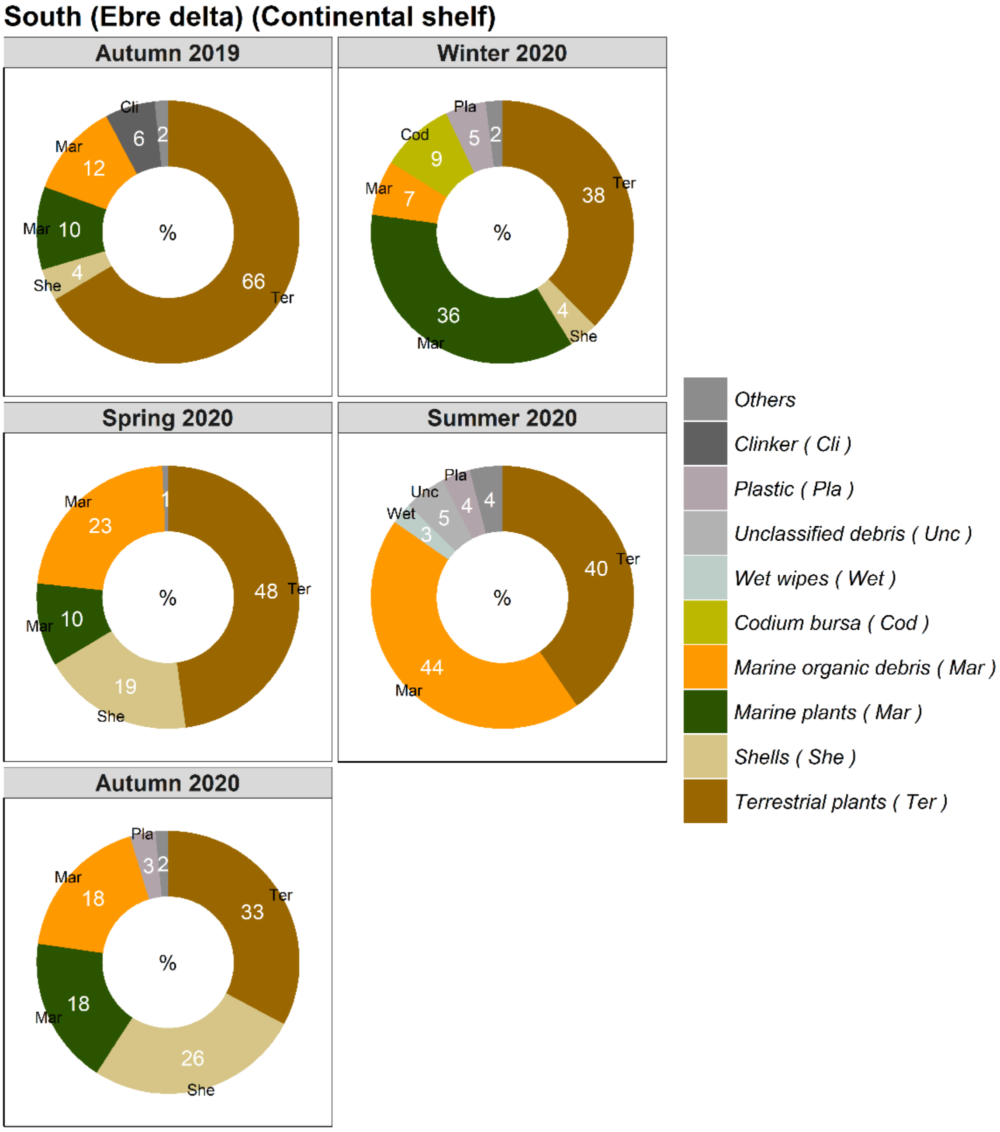


Figure 84. Items with most biomass within the debris fraction of the catch in the continental shelf for all hauls conducted in the south zone for each season from October 2019 to December 2020.

The biomass of the different types of debris present in the catch in the south zone is shown in Table 19. Natural debris, including terrestrial and marine plants, had a higher biomass in the shallow and middle continental shelves. Antropogenic debris such as plastic, clinker, and wet wipes were present in all fishing grounds sampled.

Table 19. Mass (Kg/Km^2) of the debris present in this fraction of the catch in the south zone. Mean and standard deviation in each fishing ground, including all hauls from October 2019 to December 2020.

	Shallow continental shelf		Middle continental shelf		Continental shelf	
	mean	sd	mean	sd	mean	sd
Terrestrial plants	76.50	179.19	18.93	13.44	28.76	36.36
Marine plants	24.46	45.17	7.84	7.78	6.81	5.67
Marine organic debris	9.71	8.53	12.82	12.92	10.00	7.24
Shells	10.66	10.03	6.63	6.94	5.86	7.37
Codium bursa	1.12	2.05	5.07	12.86	0.33	0.86
Fishing gear	5.26	14.05	0.02	0.04	0.06	0.16
Coal	1.01	1.27	1.40	2.72	1.63	3.29
Glass			2.75	7.27		
Plastic	0.86	1.02	0.46	0.36	0.87	0.74
Lumber	0.06	0.15	1.01	1.93		
Chalk debris	0.66	1.75				
Ropes	0.16	0.35	0.12	0.14	0.13	0.20
Unclassified debris	0.04	0.12			0.29	0.77
Wet wipes	0.08	0.20	0.03	0.07	0.16	0.41
Textiles	0.01	0.02			0.22	0.59
Other marine algae	0.03	0.05	0.09	0.21	0.07	0.18
Codium tomentosum	0.04	0.09	0.03	0.08		
Rhodophyta			0.00	0.01		

2.1.2.4 Comparative analysis of bottom trawling and catch by zone

In general, the composition of the landed catch differed between zones. The northern zone was characterized by a significant weight of bycatch species, mainly in the continental shelf and upper slope, where the bycatch accounted for more than 64%. The most important species were *T. trachurus*, *M. barbatus, I. coindetii*, and *L. budegassa*. In the center zone, the importance of the target species of this study (*M. merluccius*, *A. antennatus*, *N. norvegicus*, and *E. cirrhosa*) was higher than in the other zones. The crustacean *P. longirostris* had a higher biomass within the landed catch in the upper slope in all zones. In the lower slope, of all zones, the most important species was *A. antennatus*, accounting for more than 40% of the total landed catch. The southern zone included hauls in shallower fishing grounds, heavily influenced by the Ebre Delta, which has a marked seasonality. This zone was highlighted for the highest number of species in the landed catch, mainly during summer in both shallow and middle continental shelves, where sparidae species such as *D. annularis* and *S. aurata* accounted for an important fraction of the landed catch.

The specific composition of the discarded catch in the continental shelf of the north and center zones was characterized by a high proportion of the species *B. boops*, which was present in all seasons. Echinodermata, such as *L. phalangium*, was abundant in the discarded fraction in some hauls from the continental shelf, which is considered a recruitment area for some fish species, for example, *M. merluccius*. In the upper slope, the discarded catch was characterized by a predominance of cartilaginous fishes, mainly *S. canicula* and *G. melastomus*. In the southern zone, the relative wheight of pelagic fish species including *E. encrasicolus*, *S. pilchardus*, and *S. aurita* was higher than in the other zones.

The debris fraction of the catch was highly variable between zones and sampling periods. Anthropogenic debris were more important in weight in the north and center zones. Items like wet wipes were specially important in the center zone near the biggest cities (Barcelona, Vilanova i la Geltrú, and Tarragona). In the southern zone, natural debris was the most important category. In detail, terrestrial plants dominated the fraction during autumn 2019 and winter 2020, where a great number of tree trunks were carried down by the river or water runoff due to torrential rains.

2.1.2.5 Status of the target species by zone

North zone Hake (Merluccius merluccius)

The annual catch rates of hake during the period 2000-2020 in the north zone indicated a progressive decline of the catch (Figure 85), following a similar pattern as the one observed for the whole area of study (Catalonia). From a maximum of

1000 tons registered in 2009, hake catch continuously decreased in the last 5 years.

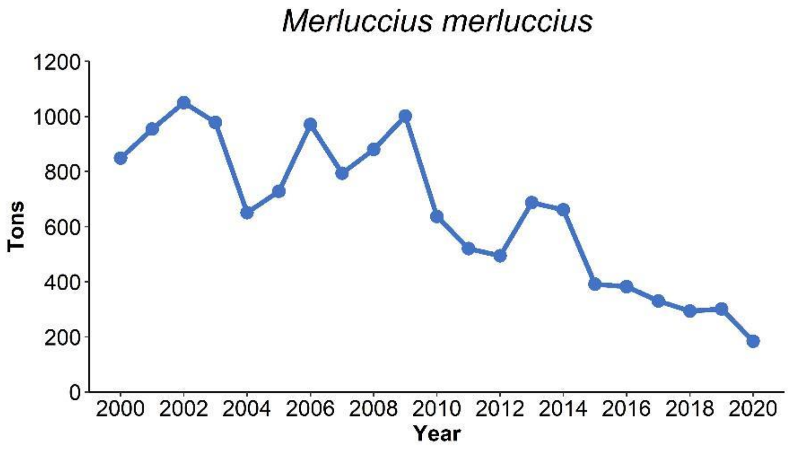


Figure 85. Time series of hake annual catch rates (tons) in the north zone for the period 2000-2020.

The seasonal length-frequency distribution of hake from October 2019 to December 2020 in the north zone showed an important proportion of individuals below the minimum conservation reference size (MCRS) in the continental shelf, especially in summer 2020 (Figure 86). Small-sized individuals from 7 to 15 cm were captured throughout the year on the continental shelf whereas the largest-sized individual (60 cm) was captured in the lower slope. The main modal values in the continental shelf were located between 10 and 20 cm except in winter and spring 2020 when the mode moved towards larger sizes. In the upper slope the main mode was placed between 25 and 30 cm.

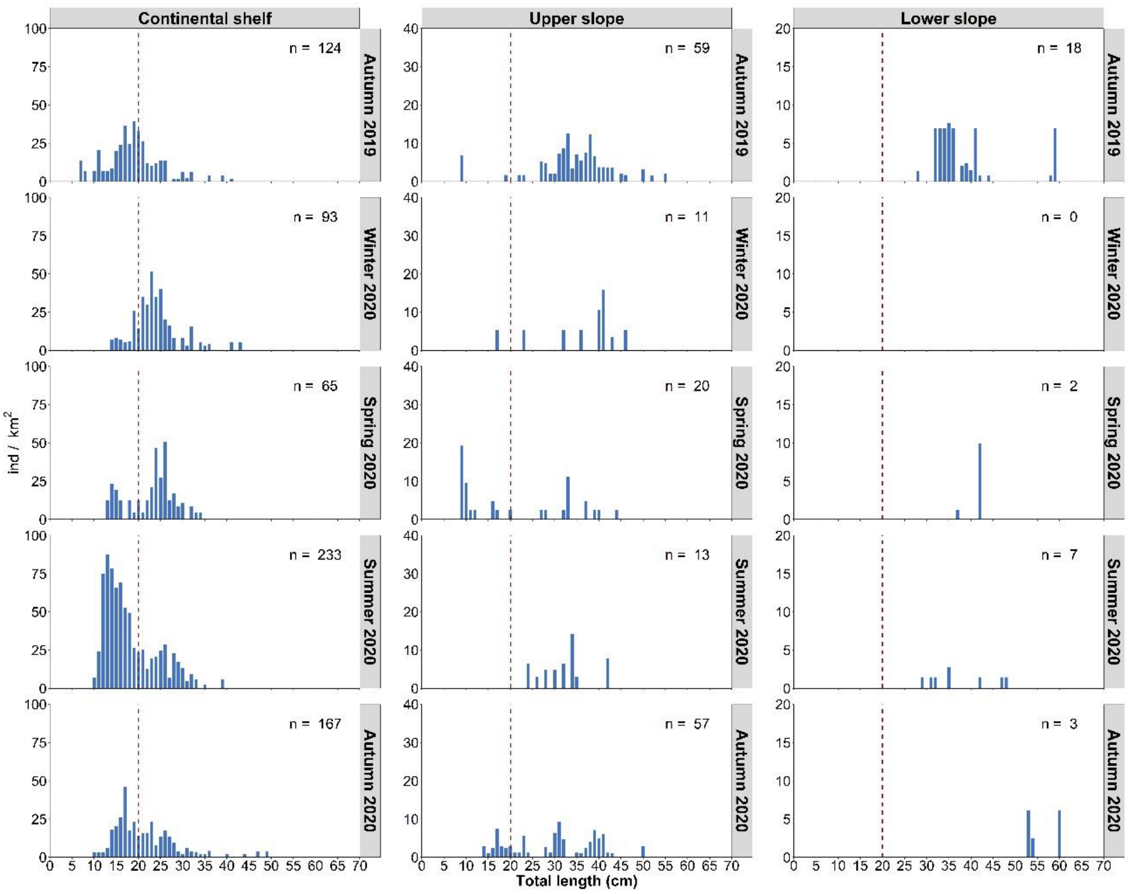


Figure 86. Seasonal length-frequency distribution of hake (*Merluccius merluccius*) for depth stratum from October 2019 to December 2020 in the north zone. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 20 cm.

Center zone Hake (Merluccius merluccius)

The annual catch rates of hake during the period 2000-2020 in the center zone showed a progressive decline of the catch (Figure 87).

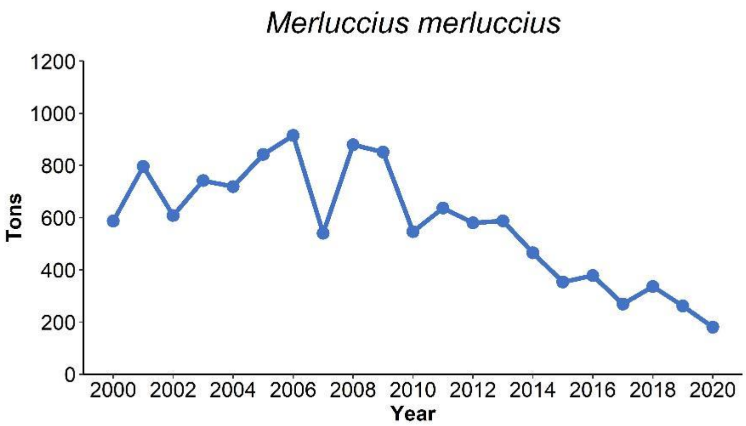


Figure 87. Time series of hake annual catch rates (tons) in the center zone for the period 2000-2020.

The seasonal length-frequency distribution of hake from October 2019 to December 2020 in the center zone showed an important proportion of individuals below the minimum conservation reference size (MCRS) in the continental shelf for all seasons, being the main mode located between 12 and 20 cm (Figure 88). In the upper slope, the catch size was mainly above the MCRS with a mode located at 28 cm. The presence of hake in the lower slope was scarce.

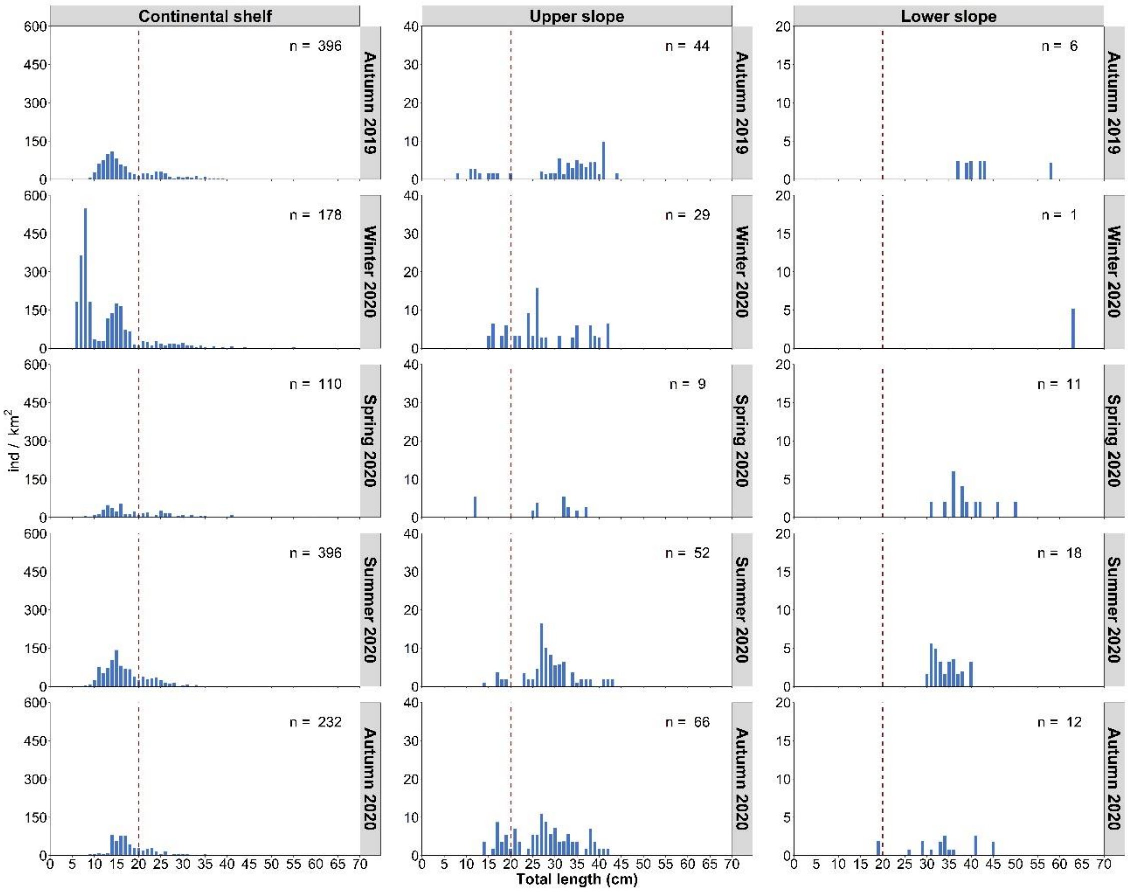


Figure 88. Seasonal length-frequency distribution of hake (*M. merluccius*) at each depth stratum from October 2019 to December 2020 in the center zone. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 20 cm.

South zone Hake (Merluccius merluccius)

The annual catch rates of hake during the period 2000-2020 in the south zone showed a progressive decline of the catch. Hake catch rates fluctuated between 400 and 600 tons during the first decade whereas, since 2010, catches have continuously decreased (Figure 89).

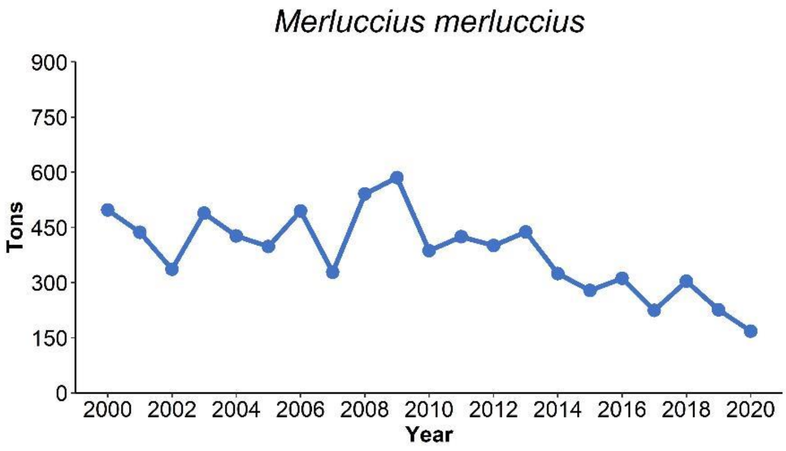


Figure 89. Time series of hake annual catch rates (tons) in the south zone for the period 2000-2020.

The seasonal length-frequency distribution of hake from October 2019 to December 2020 in the south zone showed an important proportion of individuals below the minimum conservation reference size (MCRS) in the continental shelf (Figure 90). Small-sized individuals from 10 to 15 cm were captured throughout the year on the continental shelf but especially in spring and summer of 2020, indicating a great abundance of hake recruits. Size range extended from 5 to 48 cm but a few larger-sized individuals were exclusively found in the lower slope at very low abundances.

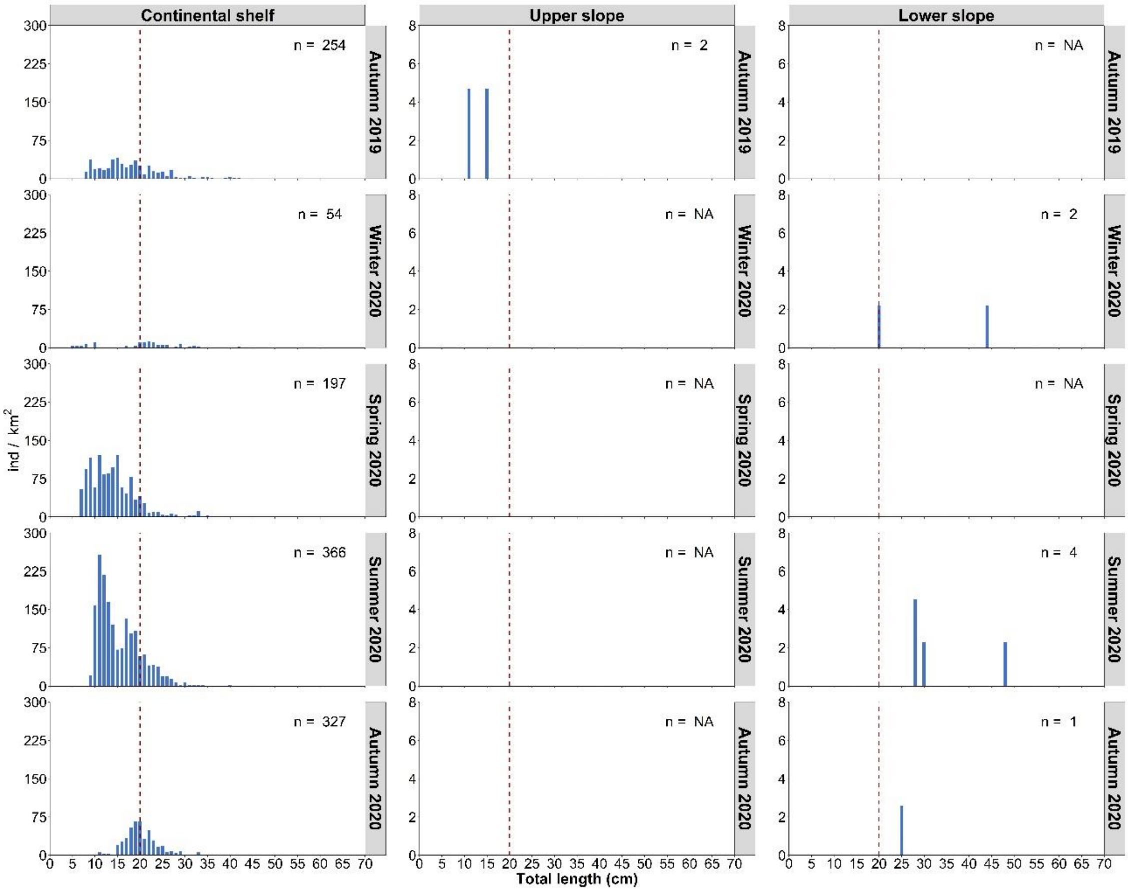


Figure 90. Seasonal length-frequency distribution of hake (*Merluccius merluccius*) for depth stratum from October 2019 to December 2020 in the south zone. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 20 cm.

North zone Norway lobster (Nephrops norvegicus)

The catches of Norway lobster follow the same trend as those of Catalonia, with a negative trend as of 2014 (Figure 91). The highest records occurred in 2009, clearly exceeding 200 t, and the lowest catches are registered from 2015 to now, where it remained around 100 t.

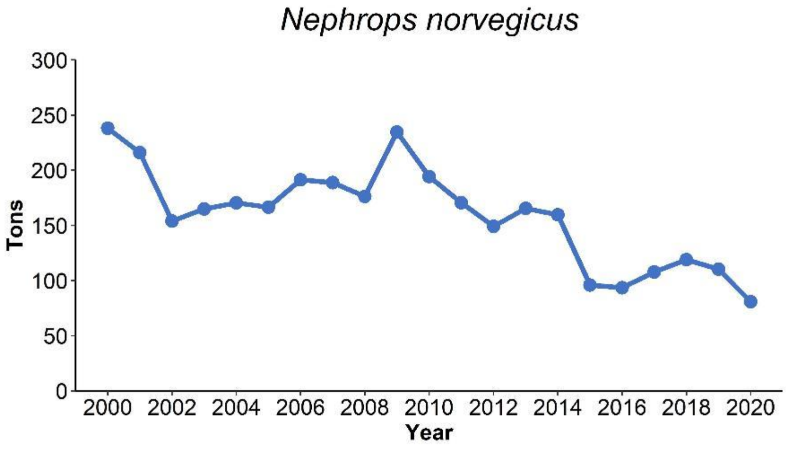


Figure 91. North Zone., *Nephrops norvegicus*. Time series of Norway lobster annual catch rates (tons) for the time period 2000-2020 in the north zone.

The seasonal length-frequency distribution of the Norway lobster from October 2019 to December 2020 in the north zone (Figure 92) showed greater abundances from winter to summer, coinciding with the reproductive cycle of the species. This pattern was observed during both studied years, but with greater abundances in the upper slope. In terms of catch size, some individuals, especially on the upper slope, were captured below the minimum conservation reference size (MCRS). The length ranges with the highest abundance in both depth strata were 25 and 30 mm, coinciding with the global data for Catalonia.

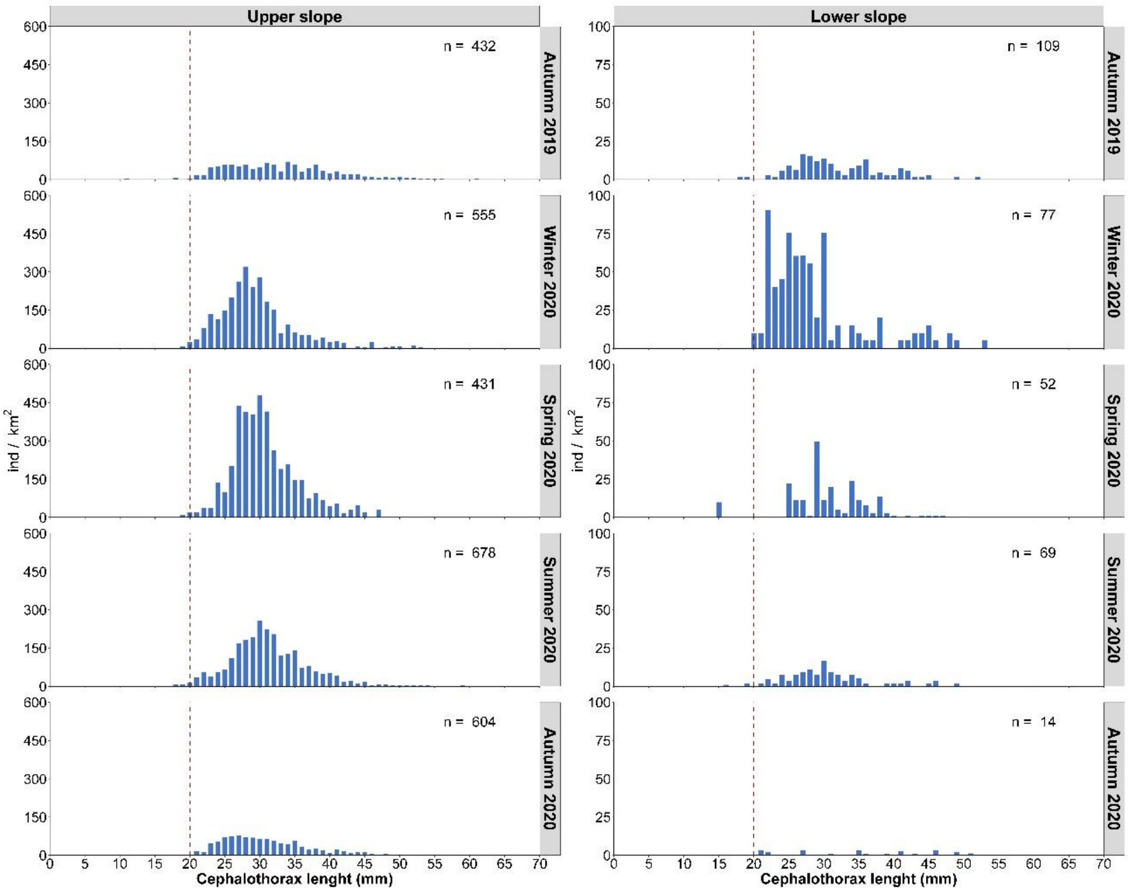


Figure 92. Seasonal length-frequency distribution of Norway lobsters (*N. norvegicus*) for depth stratum from October 2019 to December 2020 in the north zone. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 20 mm.

Center zone Norway lobster (Nephrops norvegicus)

The catches of Norway lobster in the central zone remained more stable than in the north, but the level of catches was notably lower (Figure 93). Even so, the trend was negative since 2014 to now.

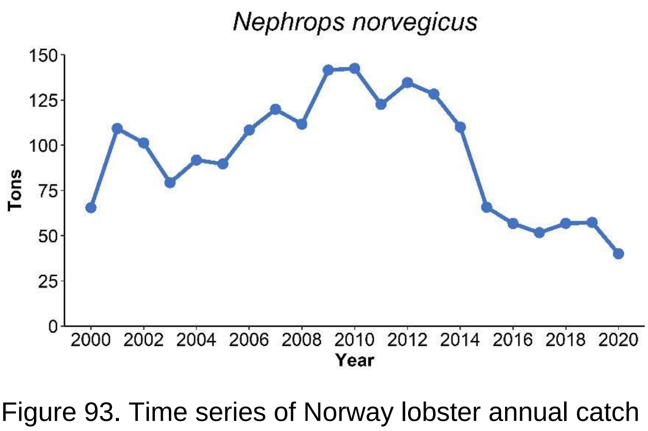


Figure 93. Time series of Norway lobster annual catch rates (tons) for the time period 2000-2020 in the center zone.

The seasonal length-frequency distribution of the Norway lobster from October 2019 to December 2020 in the center zone showed a proportion of individuals below the minimum conservation reference size (MCRS) in both strata, for all seasons (Figure 94). Similar to what found in the north zone, there was a greater abundance on the upper slope, but with the difference that there were a large number of individuals in autumn and the lowest abundances in spring.

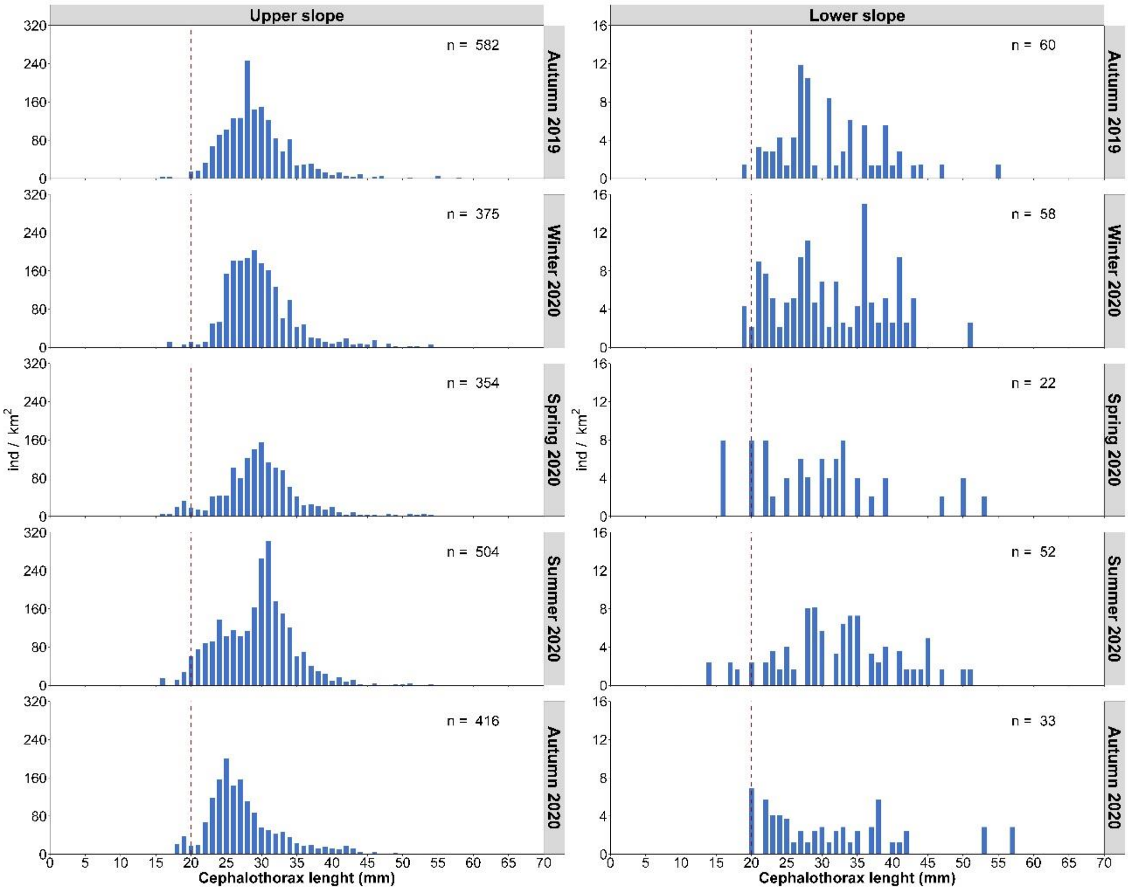


Figure 94. Seasonal length-frequency distribution of Norway lobster (*N. norvegicus*) for depth stratum from October 2019 to December 2020 in the center zone. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 20 mm.

South zone Norway lobster (Nephrops norvegicus)

The southern area was the one with the least catches, oscillating between 20 and 60 t. The highest catches were achieved between 2013 and 2014, and similar to what observed in the north and center of Catalonia, there was a clear decrease in catches as of 2014, with a minimum in 2020 (< 20 t) (Figure 95).

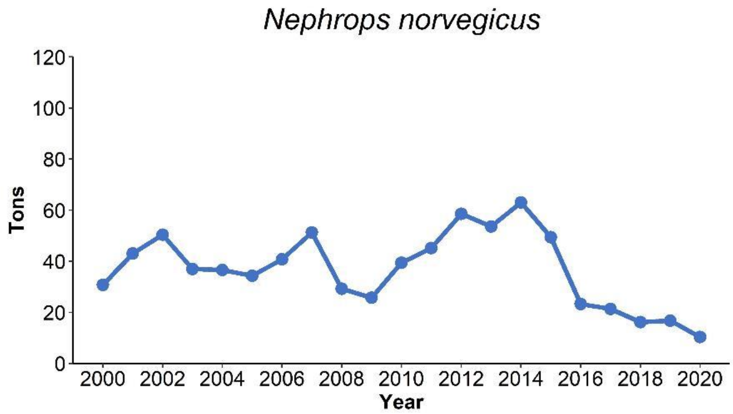


Figure 95. Time series of Norway lobster annual catch rates (tons) for the time period 2000-2020 in the south zone.

Norway lobsters are found in deep strata therefore, in the southern zone, the data from the port of Ametlla del Mar was the only one considered because the port of Sant Carles de la Ràpita has much shallow depths were the species is barely found. When using a specialized shrimp fishing boat, most of the catches belonged to the lower slope meaning that there were less samples than in the upper slope. In addition, there were stations that were not sampled, as was the case of spring and autumn 2020.

The seasonal length-frequency distribution of the Norway lobster from October 2019 to December 2020 in the south zone showed that all individuals were above the minimum conservation reference size (MCRS) in both strata (Figure 96). All specimens captured were larger in size than those sampled in the other areas, with greater abundances in size ranges above 30 mm CL.

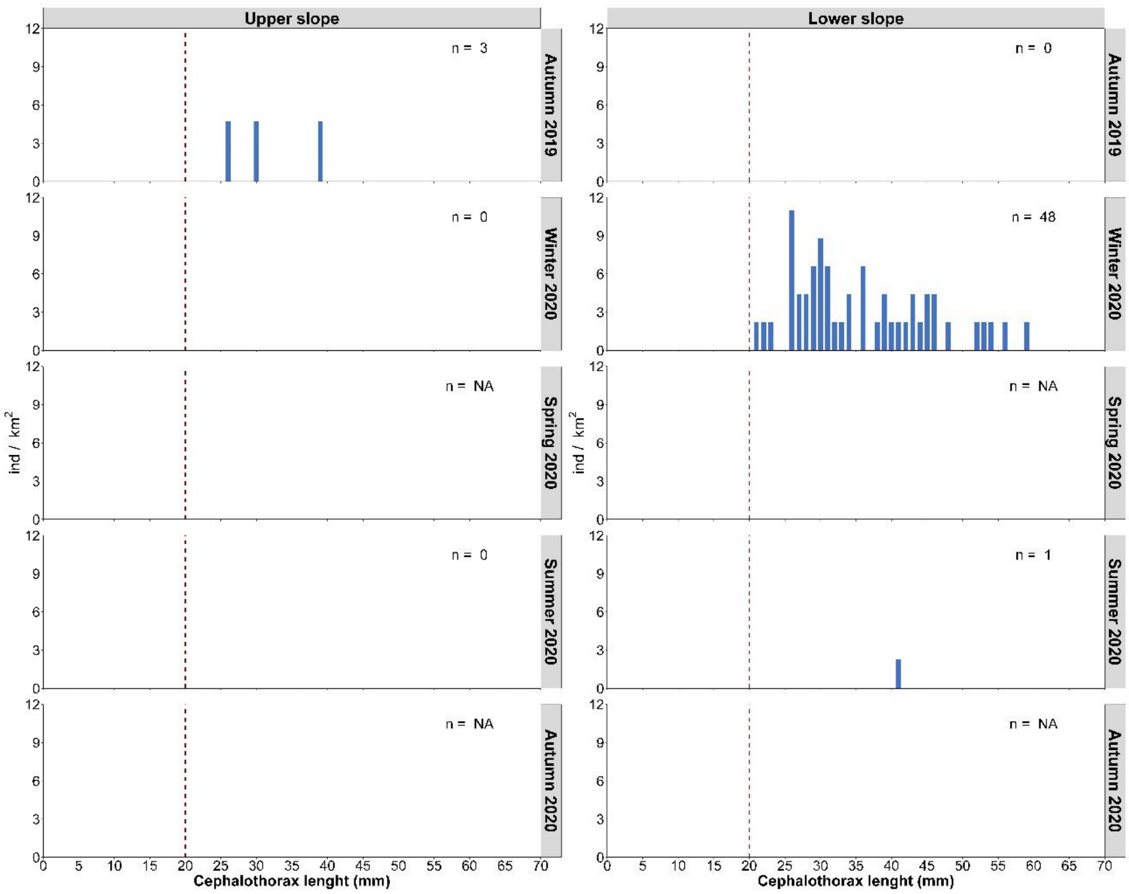


Figure 96. Seasonal length-frequency distribution of norway lobster (*N. norvegicus*) for depth stratum from October 2019 to December 2020 in the south zone. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 20 mm.

North zone blue and red shrimp (Aristeus antennatus)

The annual catch rates of blue and red shrimp (*Aristeus antennatus*) during the period 2000-2020 in the north zone (Figure 97) followed a similar pattern to that observed for the whole of Catalonia. From a maximum of 500 tons registered in 2009, shrimp catches remained stable the following years with values ranging 350 and 450 tons.

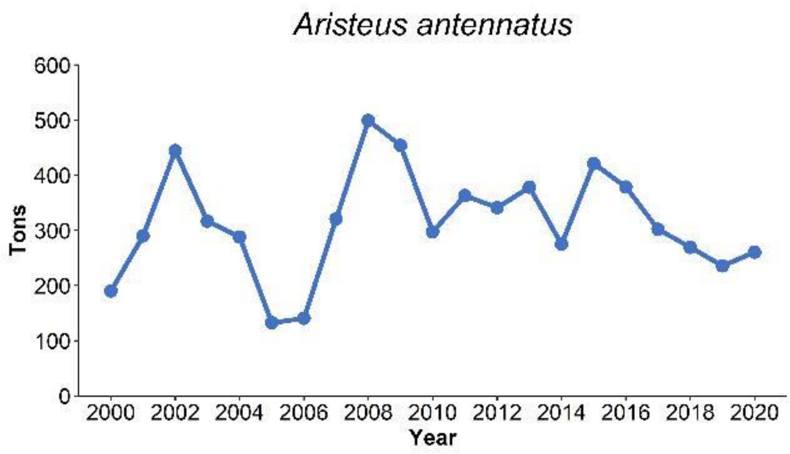


Figure 97. Time series of blue and red shrimp annual catch rates (tons) for the time period 2000-2020 in the north zone.

The seasonal length-frequency distribution of blue and red shrimp from October 2019 to December 2020 in the north zone showed an important proportion of individuals below the length at first maturity (21 mm CL) in the lower slope at all seasons (Figure 98), with the highest abundance in autumn 2019 (23 mm CL). In contrast, the abundance for this length reduced by half in autumn 2020. Small-sized individuals from 13.5 to 28 mm were captured throughout the year on the lower slope whereas the largest-sized individuals of 71.9 mm were captured in summer 2020 in the lower slope. In the upper slope, catches were recorded in summer and autumn of 2020, although less abundantly. The size of the individuals caught on the upper slope were mostly larger than the size at first maturity.

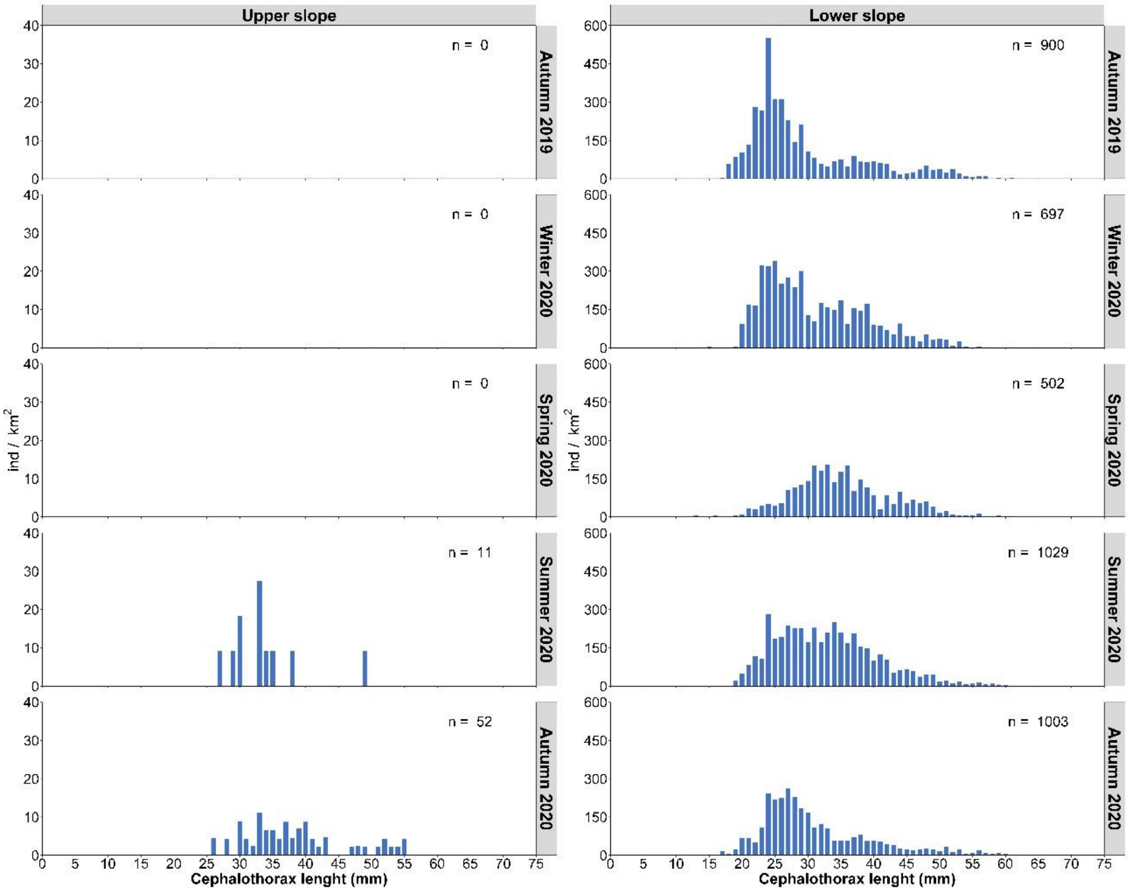


Figure 98. Seasonal length-frequency distribution of blue and red shrimp (*A. antennatus*) for depth stratum from October 2019 to December 2020 in the north zone.

Center zone blue and red shrimp (Aristeus antennatus)

The annual catch rates of blue and red shrimp (*A. antennatus*) during the period 2000-2020 in the center zone were stable since 2014, although a slight decrease in catches were observed in the last two years (Figure 99). The maximum abundance of catches were registered in 2012 with 260 tons, half of the amount for the north zone. The blue and red shrimp catches remained stable between 120 and 200 tons.

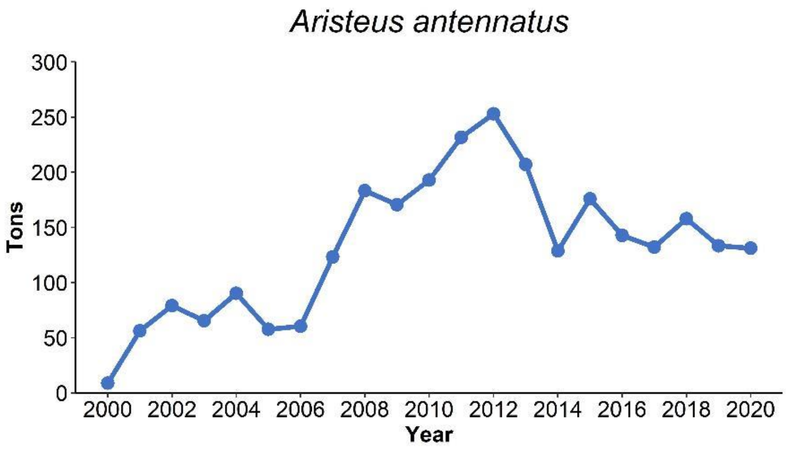


Figure 99. Center Zone., *Aristeus antennatus*. Time series of blue and red shrimp annual catch rates (tons) for the time period 2000-2020 in the center zone.

The seasonal length-frequency distribution of blue and red shrimps from October 2019 to December 2020 in the center zone had the same trend as in the north zone, with maximum catches in the lower slope (

Figure 100). On the upper slope, unlike in the north zone, no individuals were caught in the center zone. Small-sized individuals from 17 to 28 mm were captured throughout the year on the lower slope whereas the largest-sized individual of 63 mm was captured in autumn 2020 on the lower slope.

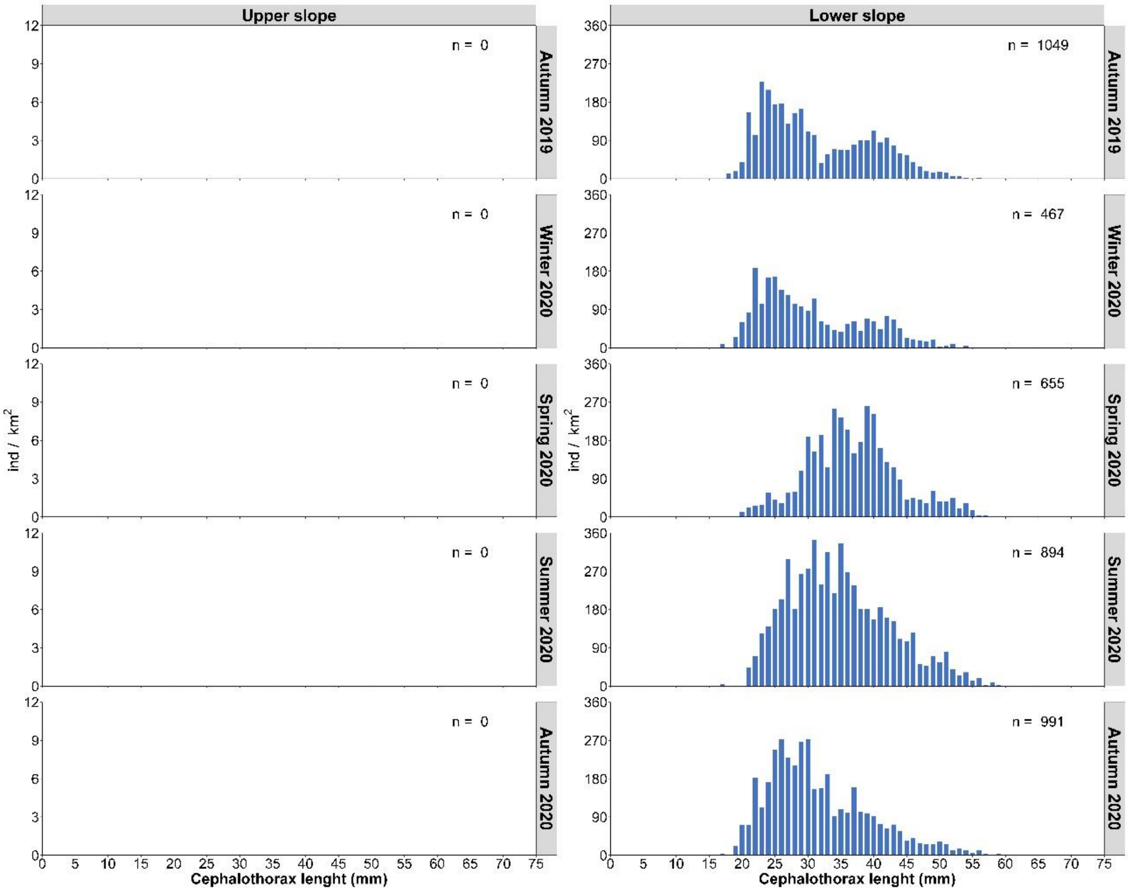


Figure 100. Seasonal length-frequency distribution of blue and red shrimp (*A. antennatus*) for depth stratum from October 2019 to December 2020 in the center zone.

South zone blue and red shrimp (Aristeus antennatus)

The annual catch rates of blue and red shrimp during the period 2000-2020 in the south zone were much lower compared to the other zones (north and center), considering that in the south zone, the data recorded correspond to one port (L'Ametlla de Mar). The trend is similar to the other zones within Catalonia, with a stability of catches (Figure 101) althoguh there were bigger oscillations. The highest catches were recorded in 2018 (almost 12 tons). In the last year, catches decreased, probably due to the reduction in fishing during the Covid-19 pandemic confinement.

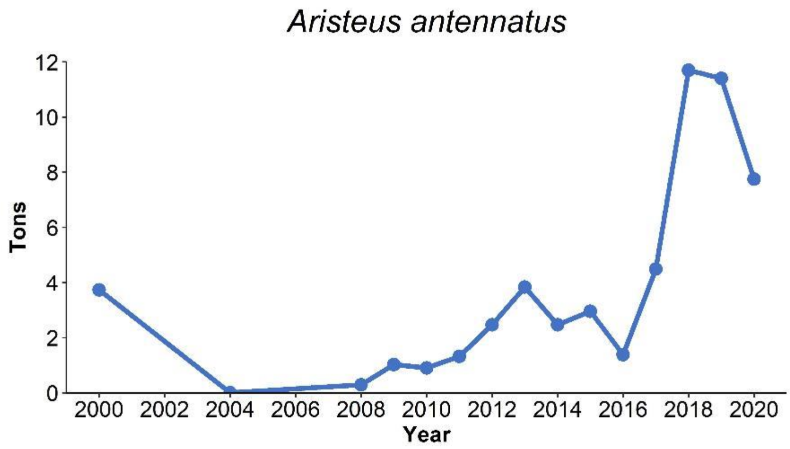


Figure 101. Time series of blue and red shrimp annual catch rates (tons) for the time period 2000-2020 in the south zone.

The seasonal length-frequency distribution of blue and red shrimp from October 2019 to December 2020 in the south zone showed the same trend as in the north zone, with maximum catches on the lower slope (Figure 102). There, most of the sizes of the individuals measured were below the size at first maturity, being more abundant in winter. The catches of adult individuals were recorded in summer. On the upper slope, individuals were captured in samplings carried out in autumn 2019, where two population structures were observed with a maximum abundance of small sizes of 25 mm CL and a maximum abundance of large sizes, up to 40 mm CL.

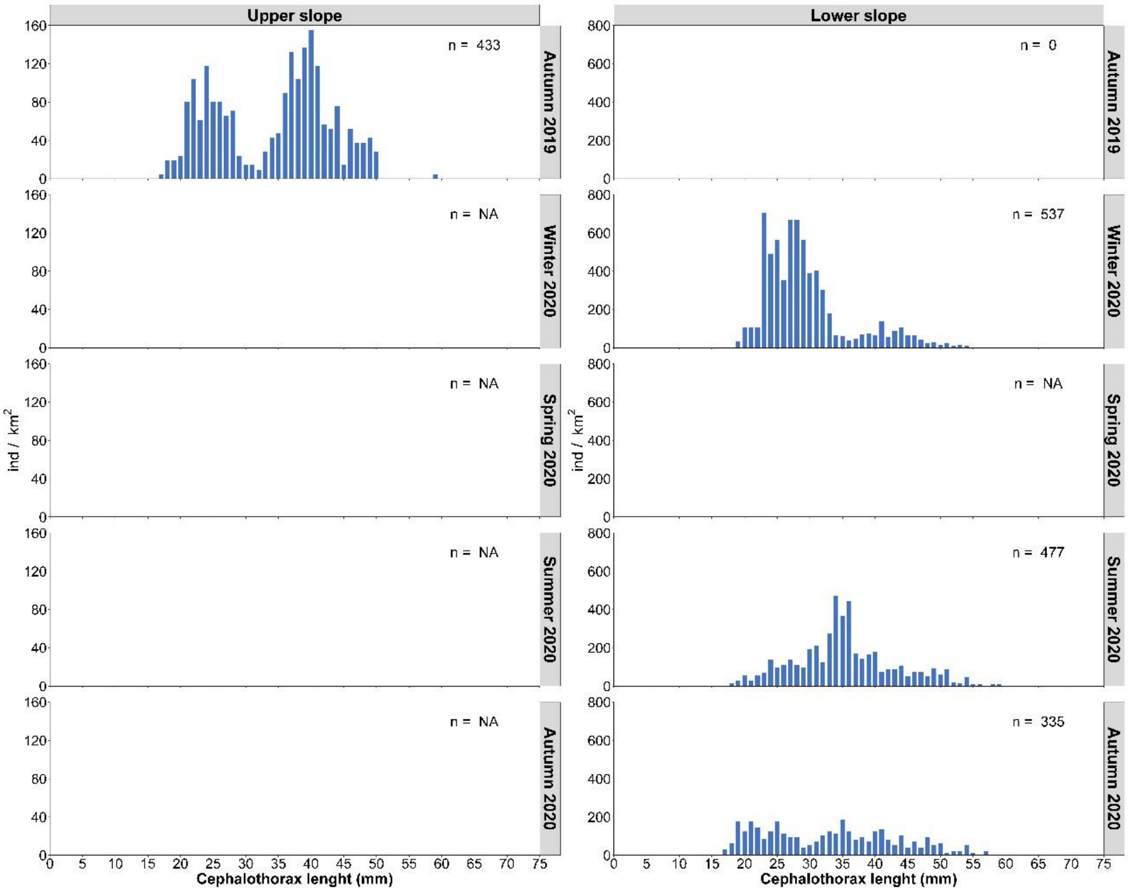


Figure 102. Seasonal length-frequency distribution of blue and red shrimp (*A.*) for depth stratum from October 2019 to December 2020 in the south zone.

North zone horned octopus (Eledone cirrhosa)

The annual catch rates of horned octopus during the period 2000-2020 in the north zone indicated a progressive decline in catches since the beginning of the time series (Figure 103). Despite the oscillations, the data denoted a negative trend in the last six years. The highest catches were obtained in 2006, with 600 tons, and the lowest catches were recorded in the last years (2019-20), with less than 150 tons. The horned octopus is a target species which, in Catalonia, is caught both on the continental shelf and on the upper slope (Figure 104). The sizes of the individuals caught were very similar in both depth strata.

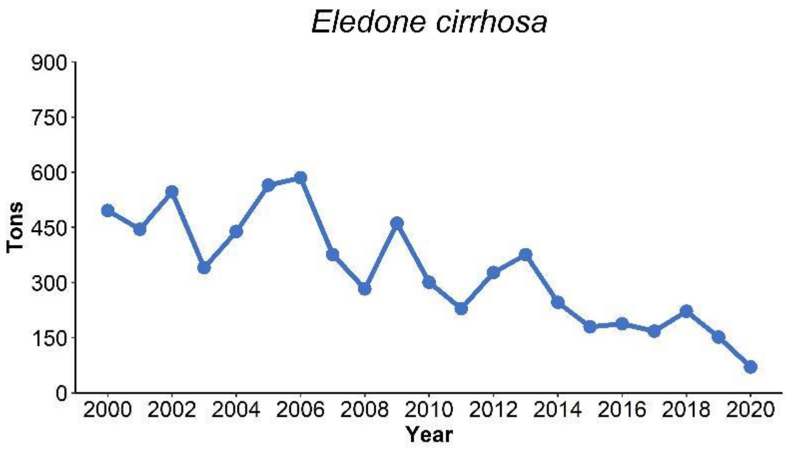


Figure 103. Time series of horned octopus annual catch rates (tons) for the time period 2000-2020 in the north zone.

The seasonal distribution of the size frequency of horned octopus between October 2019 and December 2020 in the north zone showed that the highest abundance of the species was in autumn and the lowest was in summer, both on the continental shelf and on the upper slope (Figure 104). In summer, recruits were incorporated on the continental shelf. In autumn 2019, the abundance of horned octopus catches was higher on the upper slope, but in autumn 2020 the abundance was higher on the continental shelf. The size distribution between both depth strata was very similar. The mode of the lengths of the individuals measured on the continental shelf was 8 cm and the mode on the upper slope was 9 cm ML (mantle length).

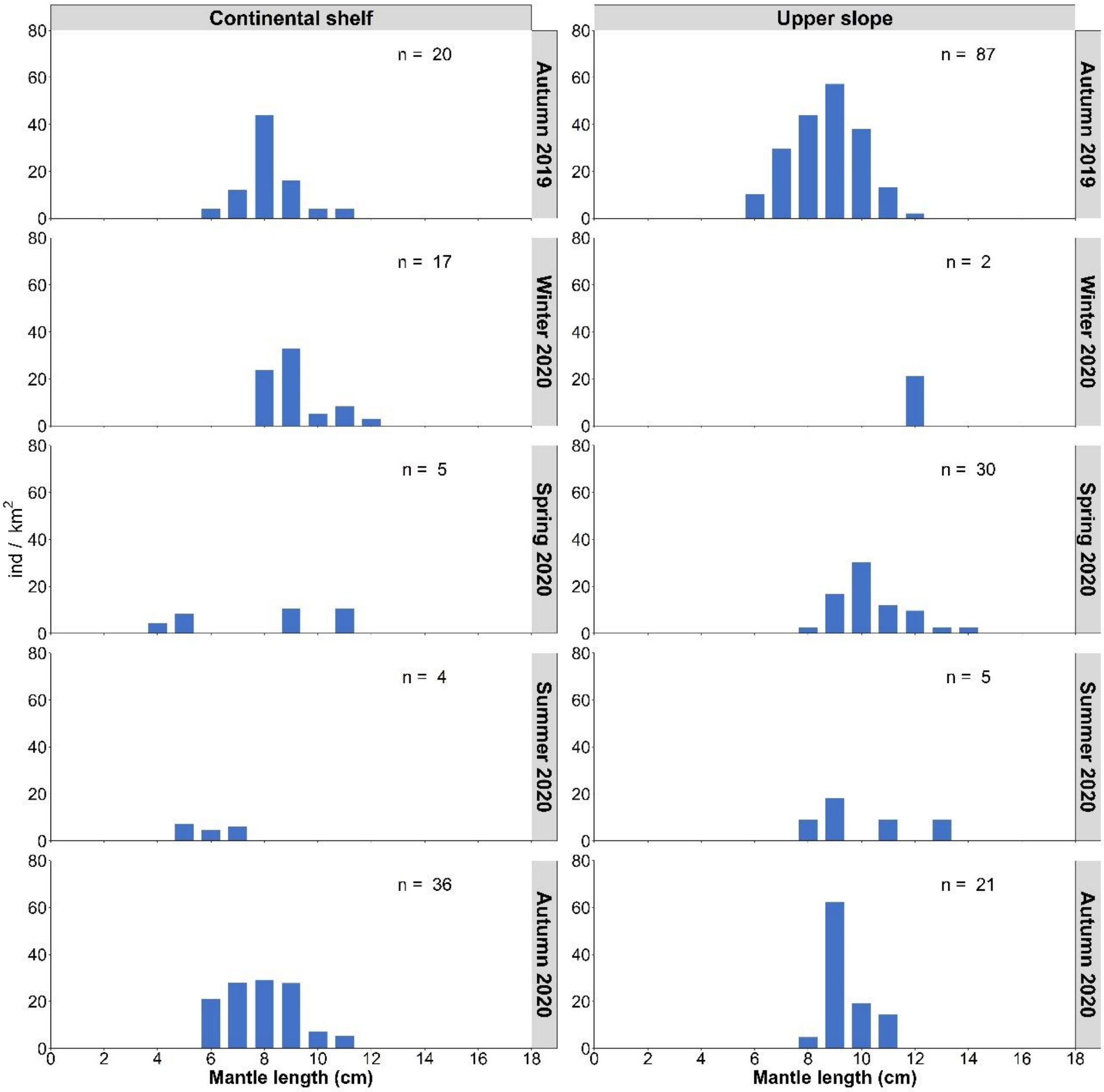


Figure 104. Seasonal length-frequency distribution of Horned octopus (*E. cirrhosa*) for depth stratum from October 2019 to December 2020 in the north zone.

Center zone horned octopus (Eledone cirrhosa)

Annual catch rates of horned octopus during the period 2000-2020 in the center zone also indicated a progressive decline (Figure 105).

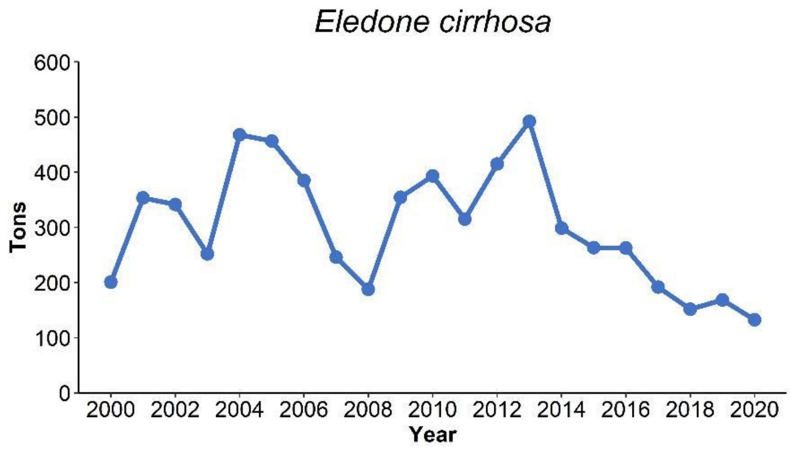


Figure 105. Time series of horned octopus annual catch rates (tons) for the time period 2000-2020 in the center zone.

The seasonal distribution of the horned octopus' size frequency between October 2019 and December 2020 in the center zone showed a similar trend to that in the north zone. In the center zone, similar abundances were also obtained, both on the continental shelf and on the upper slope (Figure 106). The highest abundance of horned octopus in both depth strata was obtained in winter and autumn. On the upper slope, the sizes of the individuals were larger throughout the seasons. In autumn, and especially in summer, smaller individuals were caught, with mantle lengths between 4 and 5 cm.

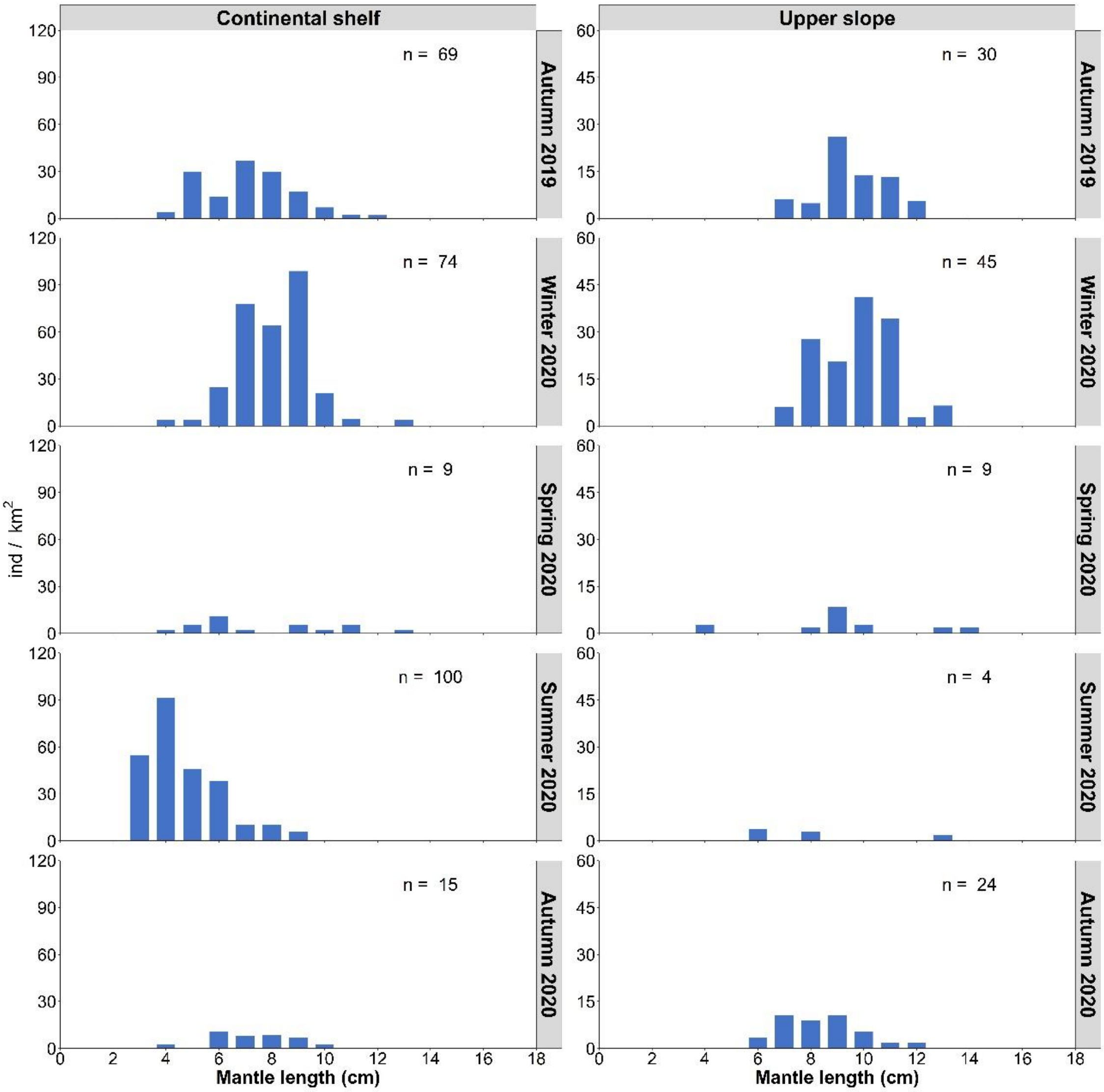


Figure 106. Seasonal length-frequency distribution of Horned octopus (*E. cirrhosa*) for depth stratum from October 2019 to December 2020 in the center zone.

South zone horned octopus (Eledone cirrhosa)

The annual catch rates of horned octopus during the period 2000-2020 in the south zone indicated a similar trend to the center zone. However, in the recent years catches seem to have slightly increased (Figure 107). The maximum abundance was obtained in 2013 with more than 500 tons but, thereafter, catches decreased more sharply until 2018.

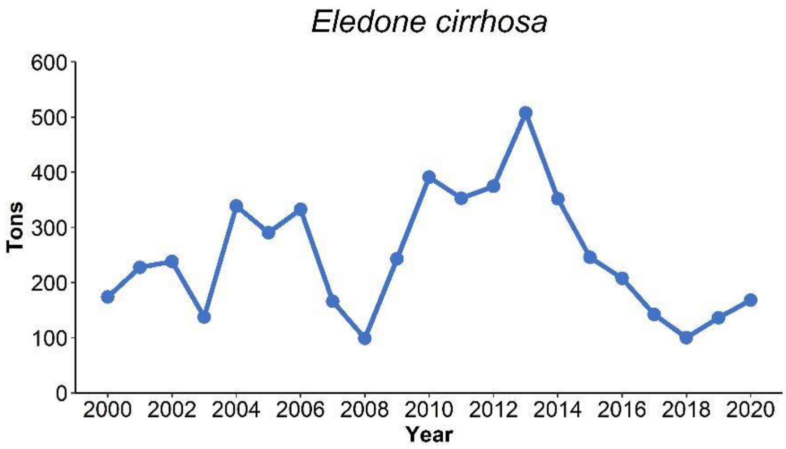


Figure 107.Time series of horned octopus annual catch rates (tons) for the time period 2000-2020 in the south zone.

The seasonal distribution of the size frequency of horned octopus between October 2019 and December 2020 in the south zone was more representative as more individuals were caught in the samplings. There were no catches on the upper slope because, in the south zone, the samplings were carried out along the continental shelf. The individuals caught on the continental shelf were mostly small. The maximum abundance of the species was in summer, when the species was recruiting (Figure 108). In autumn and winter, the sizes of the individuals were larger (up to 15 cm) with the exception of some individuals captured in winter, which were very small (2 to 3 cm). In spring and summer most of the individuals measured were smaller with values rangin 5 to 7 cm respectively. The wide range of sizes recorded throughout the sampling period is difficult to explain because there is insufficient information available on the biology of this species.

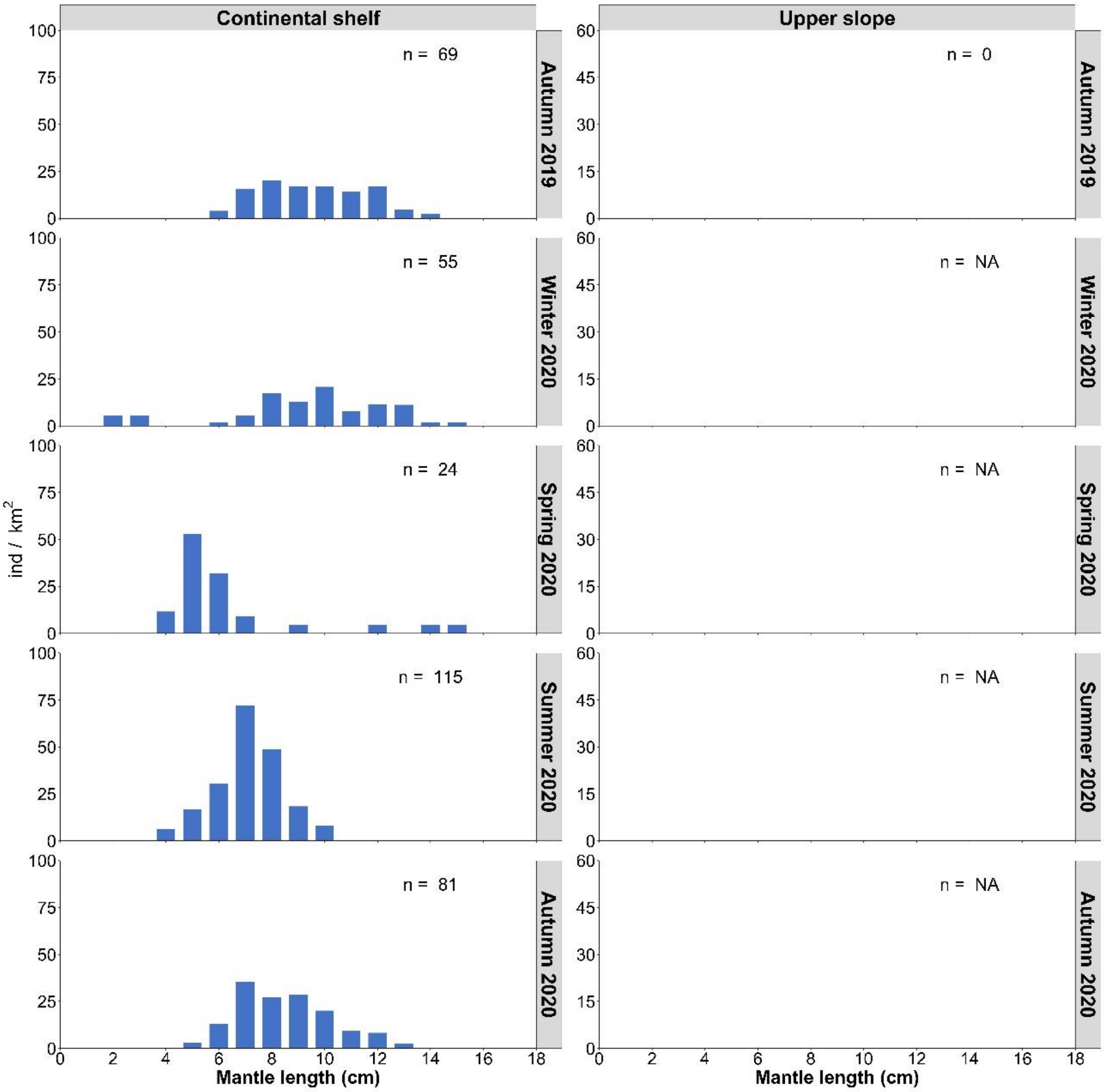


Figure 108. Seasonal length-frequency distribution of Horned octopus (*E. cirrhosa*) for depth stratum from October 2019 to December 2020 in the south zone.

South zone spottail mantis shrimp (Squilla mantis)

The annual catch rates of the spottail mantis shrimp during the period 2000-2020 in the south zone showed a clear stabilization of catches. As mentioned in the case of Catalonia, this shrimp has biological factors that help its conservation. The spottail mantis shrimp catch rates fluctuated between 300 and 600 tons during the first decade whereas, since 2010, catches remained over 450 t (Figure 109).

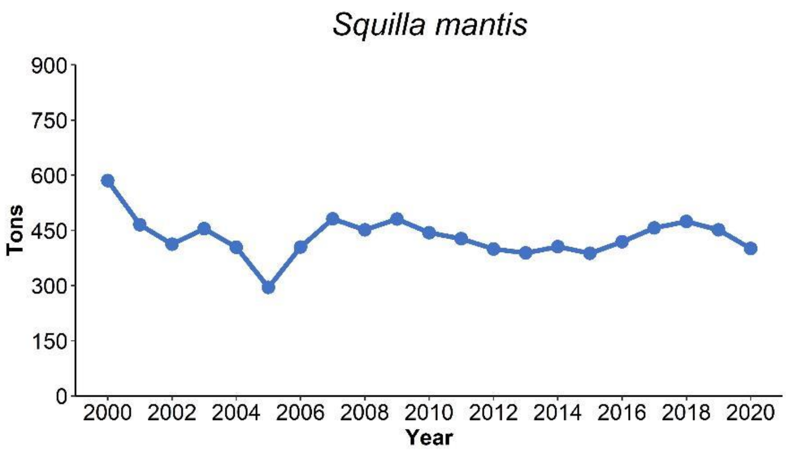


Figure 109. Time series of spottail mantis shrimp annual catch rates (tons) for the time period 2000-2020 in the south zone.

In the absence of a more detailed analysis, there were no notable differences in lengths by depth strata neither by abundances (Figure 110). The sizes ranged between 8.5 and 37.5 mm CL, with the highest abundances around 25 mm. The largest sizes seem to concentrate in the winter months, and the smallest individuals were caught in summer. We had little data in spring, which in turn, is the most important season in terms of reproduction. Thus, we must wait to have more data from all seasons to observe patterns in the structure of the population. In the spottail mantis shrimp there is no minimum conservation reference size (MCRS) established yet.

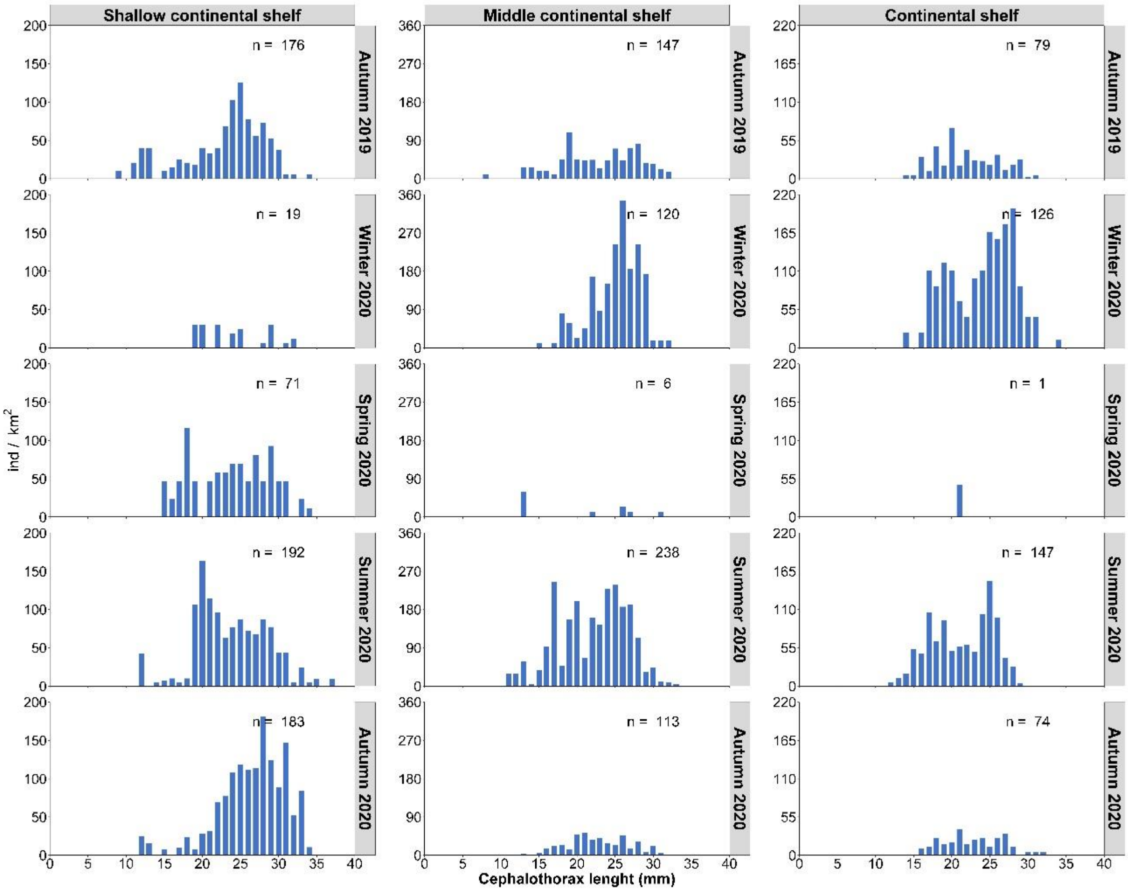


Figure 110. Seasonal length-frequency distribution of spottail mantis shrimp (*S. mantis)* for depth stratum from October 2019 to December 2020 in the south zone.

South zone caramote prawn (Penaeus kerathurus)

The analysis at the zone level was exactly the same as that of Catalonia because the caramote prawn catches were mainly obtained in the ports of the southern Catalan coast (l'Ametlla de Mar and Sant Carles de la Ràpita). Total catches were low and did not reach 100 t (Figure 111). Similar to what observed for the spottail mantis shrimp, the catches for the caramote prawn seemed to remain stable as of 2010, with a considerable decrease in 2020, which was probably influenced by the Covid-19 pandemic.

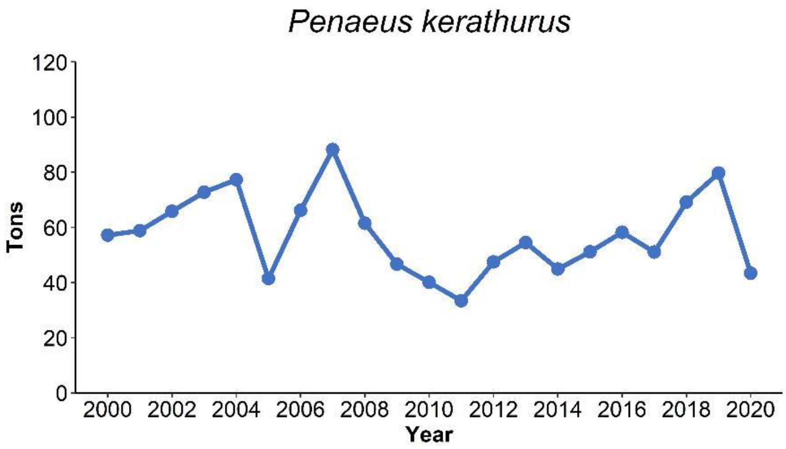


Figure 111.Time series of caramote prawn annual catch rates (tons) for the time period 2000-2020 in the south zone.

The results of the caramote prawn trawl catches for the south zone are not conclusive due to the low number of samples collected in certain seasons of the year. It is expected that in the coming years the number of individuals measured will be higher allowing to address a more detailed study of the biology of this species. Similar to the spottail mantis shrimp sampling protocol, this species was sampled shortly after the start of fishing monitoring throughout Catalonia. The highest abundances were recorded in the coastal and median shelf, coinciding with the range of the distribution of the species (Figure 112). Comments on the seasonal distribution are complicated, a lot of data was missing at certain times of the year because in spring and summer, the species move closer to the coast and was not caught in our trawl sampling.

No notable differences in lengths by depth strata were found with the collected data. The sizes ranged 26 to 50 mm, with the highest abundances around 30 mm. The largest sizes concentrated in autumn, but more data is needed to confirm that this observation did not ocurre in other periods of time. It is important, in future years, to reinforce the sampling in the spring and summer, coinciding with the reproductive period of the species.

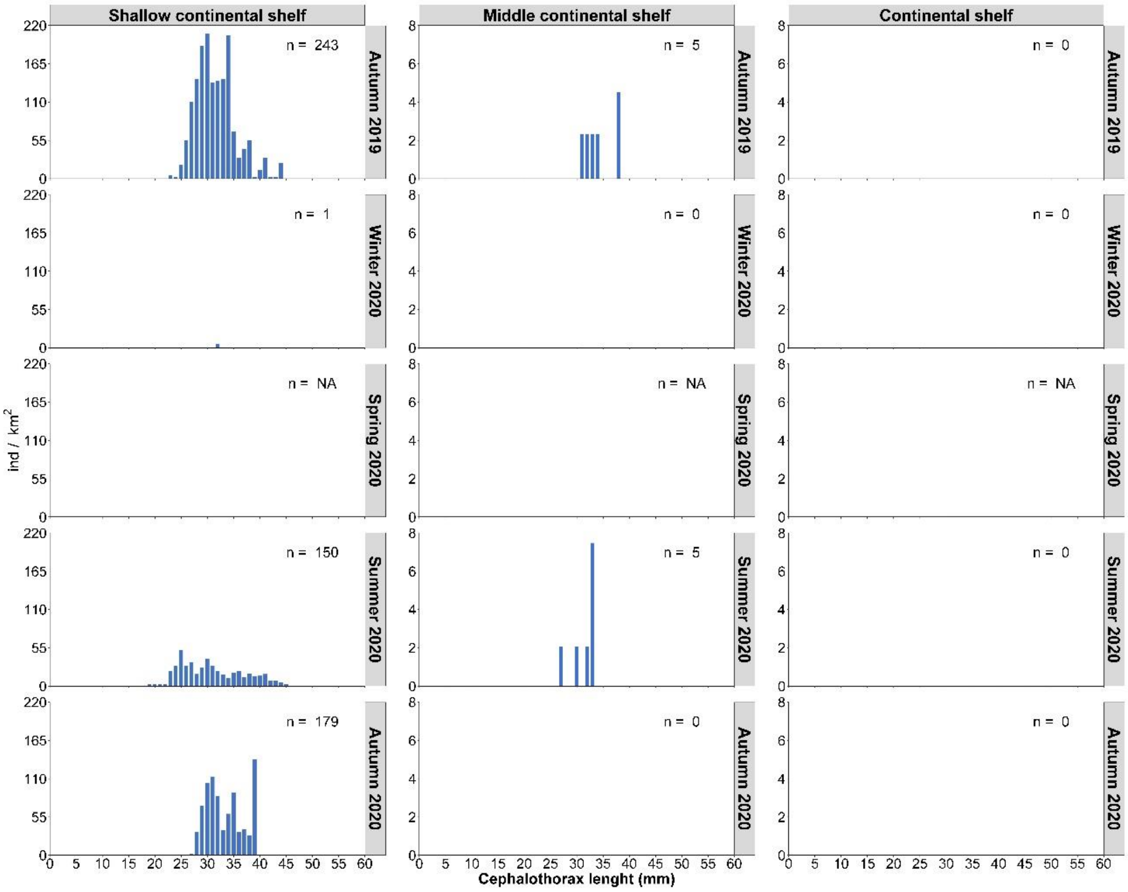


Figure 112. Seasonal length-frequency distribution of caramote prawn (*P. kerathurus)* for depth stratum from October 2019 to December 2020 in the south zone.

2.1.2.6 Comparative analysis of the length frequency of the target species by zones

Hake (Merluccius merluccius)

Several differences were observed when comparing the seasonal length-frequency distributions of hake (*M. merluccius*) among zones from October 2019 to December 2020. The south zone exhibited the main abundance of the species in the continental shelf throughout seasons. However, a great proportion of individuals were captured below the minimum conservation reference size (MCRS), indicating that the composition of the capture was dominated by juveniles and recruits of the species, specially in spring and summer. The north and center zones had lower abundances in the continental shelf, with a mode located slightly below the MCRS. The main abundance of recruits (individuals <

10 cm) was observed in spring and autumn, suggesting hake recruitment in the area. The highest abundances of hake in the upper slope were observed in autumn and the mode was located between 25 and 30 cm in all zones. The abundances of hake's catch in the lower slope were scarce in all zones and throughout the year. However, major abundances were observed in autumn and the capture was dominated by large-sized individuals (> 30 cm), mainly adults.

Norway lobster (Nephrops norvegicus)

Comparing the size range of the Norway lobster by zones, it is evidenced that a longer annual series is needed to elucidate if there are significant differences among the three areas of the Catalan coast (North, Center, and South). With the data obtained, it does not seem that the size range was different among zones, despite the North zone had higher abundances. In the three zones, individuals were mostly sampled above the MCRS, which is 20 mm CL, obtaining the highest abundances in sizes about 35 mm CL. In the south area, there were fewer records of the species, due to the lack of sampling during some periods of the year. This issue should be solved when having a longer sampling period.

Blue and red shrimp (Aristeus antennatus)

Comparing the length frequency in the three studied zones of the Catalan coast, a similar pattern was observed. Juvenile individuals, below the size at first maturity (28 mm CL), were caught during autumn and winter months, with a higher abundance in the south zone during the studied period. Larger individuals were caught during the summer months in all three zones, with the highest abundance also in the south zone. It is worth mentioning that a smaller number of individuals were measured in the south zone. In addition, the small blue and red shrimp individuals measured in the winter were caught on the upper slope, wereas in the north and central zones they were caught in the lower slope.

Horned octopus (Eledone cirrhosa)

In all three areas, subadult recruits were fished during the summer on the continental shelf. As they grew, the adult individuals moved to the upper slope, where they completed their sexual maturity and life cycle. In the south area, there are no data on the upper slope because no samples could be taken. In general, the greatest abundance of individuals was observed in the center and south zone. Although a similar pattern was found in the three zones, the data obtained during the period studied were not enough and more surveys would be necessary to get more consistent results.

2.1.3 Bottom trawling per port

This section presents, for each port, the composition of the community (landed catch, discarded catch, and debris) and the length-frequency distribution of the target species, based on the data obtained from the trawl hauls carried out from October 2019 to December 2020.

For the analysis of the communities, the species analysed were the 10 with highest weight and which percentage of catch was higher than 2%.

The biomass and abundance tables by port include data for all the taxonomic groups found in all the hauls of 2020 (all seasons). Note that in the biomass and abundance tables, very high values of biomass, abundance, and standard deviations were found in some cases. This phenomenon was a consequence of a high variability in biomass caught among the different hauls throughout the sampling period. This occured, for example, in the case of species that live aggregated (i.e. *T. trachurus*) or those that, for some reason, were caught in extraordinary high values (i.e. *P. heterocarpus* discarded in Tarragona) in one particular haul.

2.1.3.1 Roses

Figure 112 shows the bottom trawl commercial fishing activities and sampling bottom trawls conducted in the Roses port between October 2019 and December 2020.

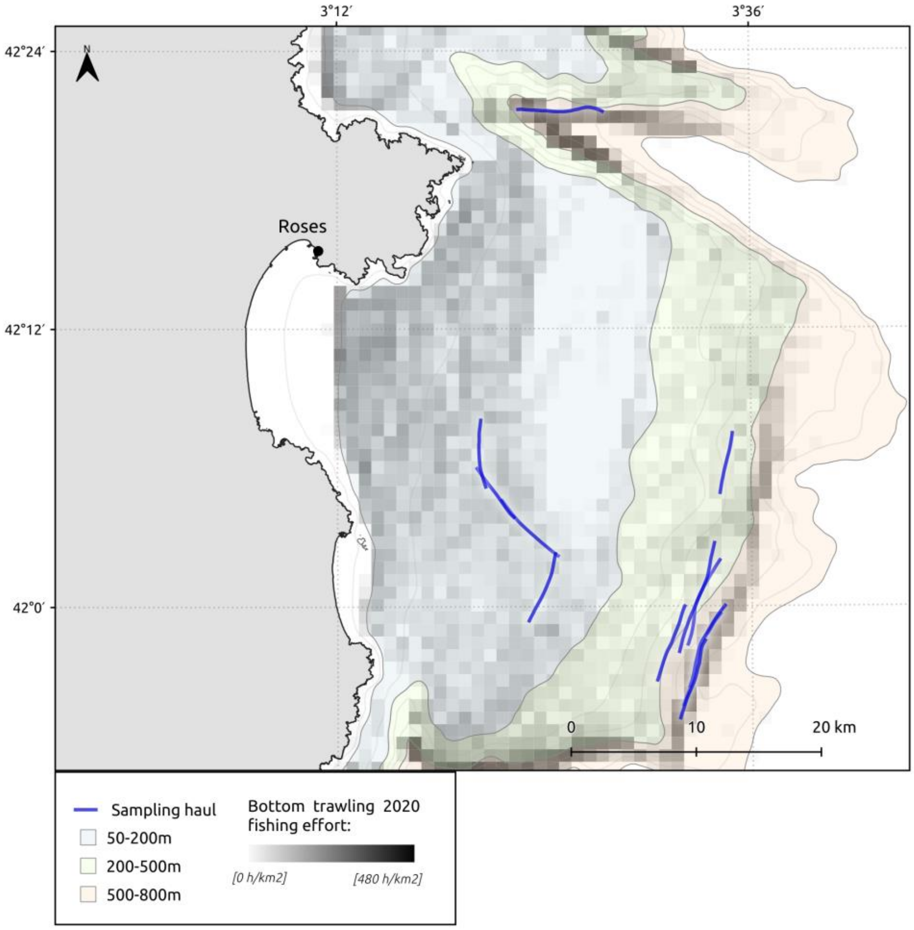


Figure 112. Map of bottom trawling hauls conducted in the port of Roses from October 2019 to December 2020.

The characterization of the catches for the 12 bottom trawling hauls conducted in Roses from October 2019 to December 2020 is shown in Figure 113 per year and fraction of catch (landed, discarded, and debris). In autumn 2019 the landed catches represented, depending on the fishing ground, from 50 to 98% of the total catches. The discarded fraction ranged between 2 and 36% of the total biomass and the debris between 0 and 14%. In 2020, the landed catches represented, depending on the fishing ground, from 59 to 71% of the total catches. The discarded fraction ranged between the 24 and 31% of the total biomass, and the debris between 5 and 10%.

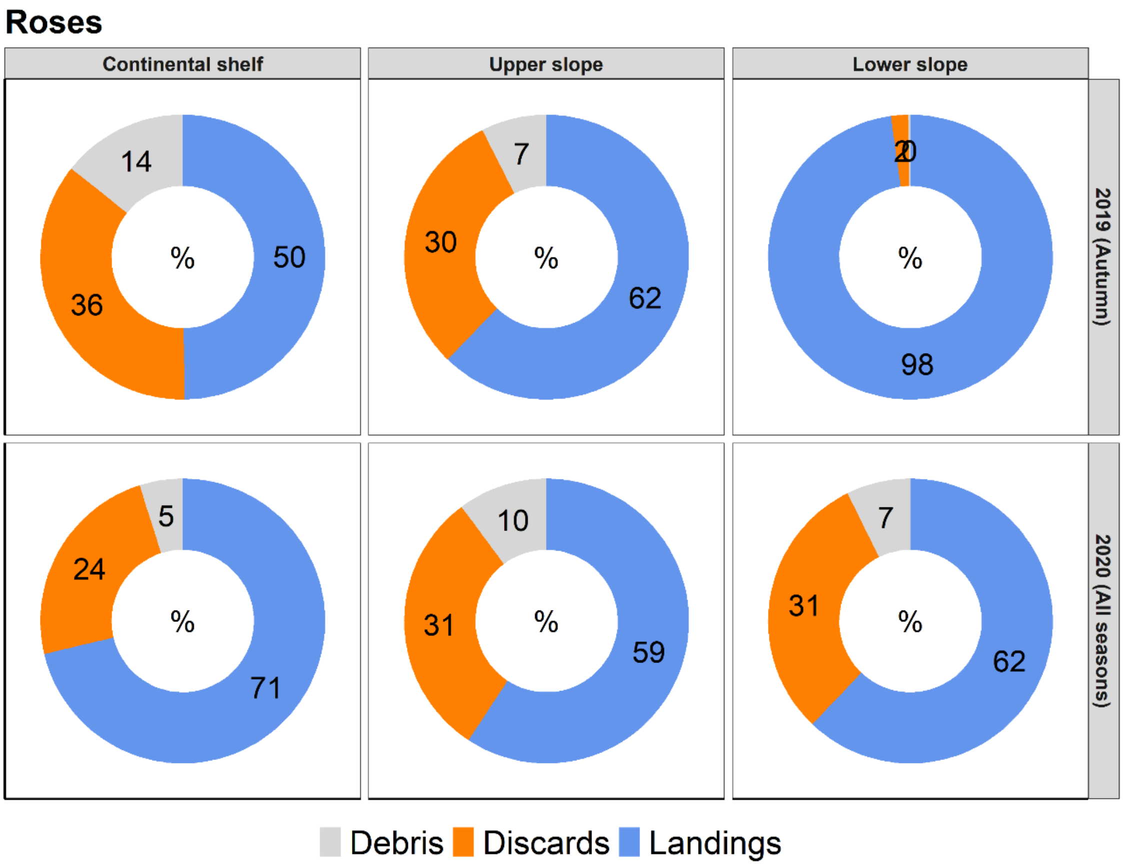


Figure 113. Catch composition in the port of Roses. Percentage by weight of landings, discarded and debris fraction in each year and fishing ground, including all hauls from October 2019 to December 2020.

The proportion of species with more biomass from the landed catch for year and fishing ground is shown in Figure 114. A total of 41 species were landed in Roses from October 2019 to December 2020 (35 in the continental shelf, 25 in the upper slope, and 16 in the lower slope). In 2020, the target species found in this port (*M. merluccius*, *N. norvegicus*, *A. antennatus*, and *E. cirrhosa*) represented the 14% of the landed catch in the continental shelf, the 44% in the upper slope, and the 58% in the lower slope. In autumn 2019, *L. budegassa* was the main catch in the continental shelf (61%) whereas in the upper slope *E. cirrhosa*, *M. merluccius*, and *L. piscatorius* were the main landed species (28%, 24%, and 13%, respectively) and *A. antennatus* dominated in the lower slope (87%). In 2020, in the continental shelf, many fish species were caught with percentages between 4 and 12%. Other types of organisms, such as the Cephalopoda *I. coindetii* and the Crustacea *P. longirostris* were also important in this same depth stratum. The catches of the target species in the lower slope in 2020 were only 50% of the landed catch, being also important *P. blennoides, M. poutassou*, and *C. conger.*

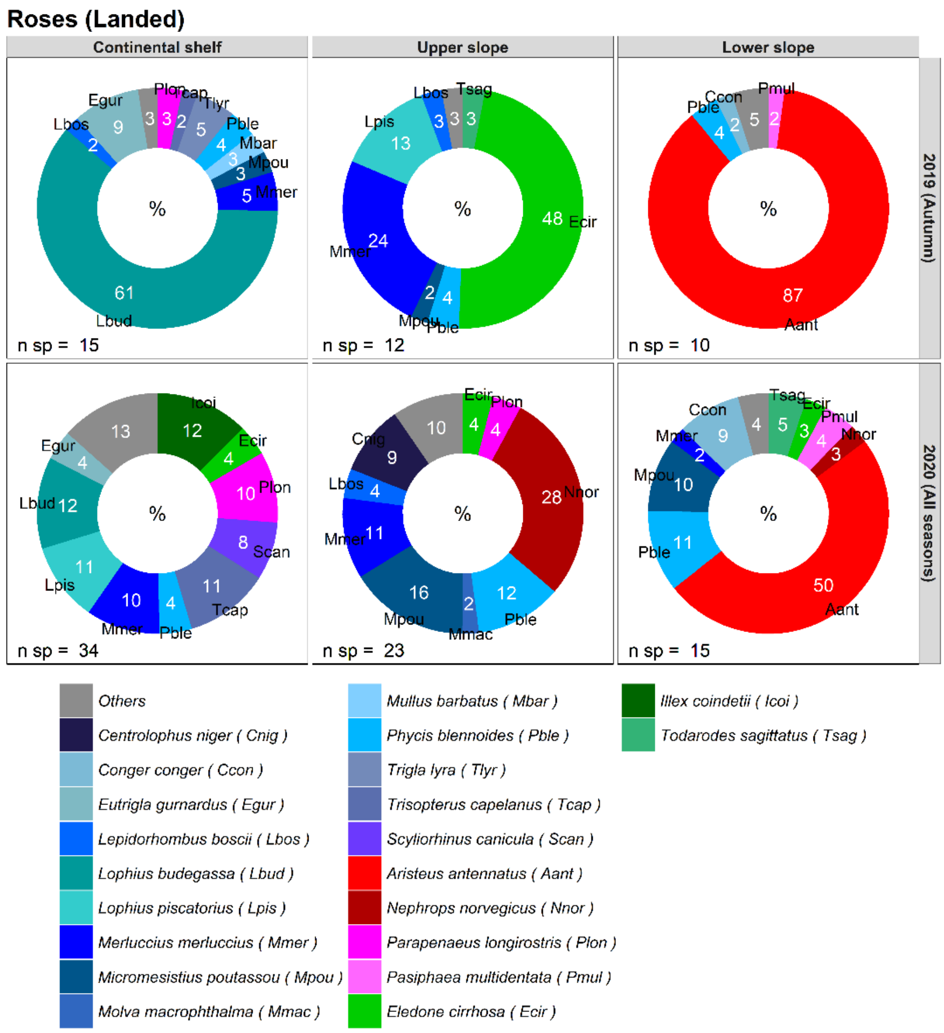


Figure 114. Species with most biomass within the landed catch in the port of Roses. Percentage by weight of the landed fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

Of the landed species, Actinopterygii was the group with greater biomass in the continental shelf and upper slope, while Crustacea had the highest biomass in the lower slope. In terms of abundance, Crustacea had the highest in all fishing grounds, with its maximum in the lower slope. The continental shelf had the highest diversity of taxonomic groups and greater biomass (Table 20).

Table 20. Biomass (Kg/Km2) and abundance (ind./Km2) of the taxonomic groups present in the landed fraction of the catch in the port of Roses. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	263.81	83.61	124.92	97.40	42.31	42.67
Chondrichthyes	32.08	45.37				
Crustacea	39.43	11.30	70.34	68.93	72.23	20.84
Cephalopoda	76.43	59.58	13.52	7.47	10.32	12.51
Other Mollusca	0.56	0.38				
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	3318.41	1274.99	895.91	495.91	342.73	413.80
Chondrichthyes	168.87	238.82				
Crustacea	4603.80	2178.87	3506.09	3433.17	4636.64	1575.92
Cephalopoda	1908.15	2068.26	144.49	185.61	29.32	27.88
Other Mollusca	18.57	13.08				

The proportion of species with most biomass of discarded catch for each year and fishing ground is shown in Figure 115. A total of 147 species were discarded in Roses from October 2019 to December 2020 (102 in the continental shelf, 80 in the upper slope, and 46 in the lower slope). In autumn 2019, *S. canicula* was the main discard in the continental shelf (64%) and upper slope (35%). In the lower slope the main species discarded were *I. coindetii* (21%), *N. aequalis* (18%), and *C. caelorhincus* (17%). In 2020, *S. canicula* was discarded in all fishing grounds (19 - 84% of the discarded catch). In the continental shelf, the fish *T. trachurus* and the cnidaria *A. palmatum* were also important species. In the upper and lower slope chondrichthyes represent bwteen 84 and 86% of the total discards.

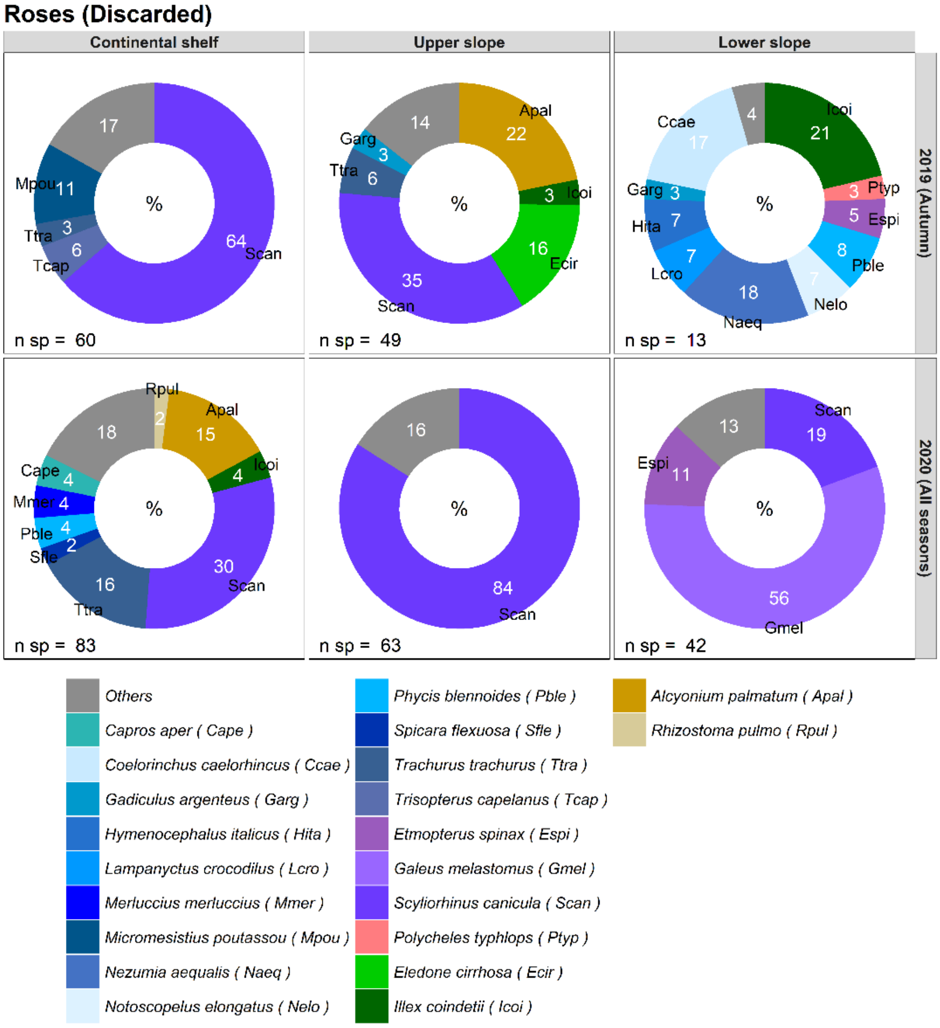


Figure 115. Species with most biomass within the discarded catch in the port of Roses. Percentage by weight of the discarded fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

Considering all the discarded species, chondrichthyes was the group with the highest biomass in the upper and lower slopes wereas Actinopterygii had the highest biomass in the continental shelf. When analysing the abundance results for the discarded fraction, Actinopterygii had the highest abundance in the continental shelf, followed by Cnidaria and Crustacea. In the upper slope, Cnidaria was the most abundant group followed by fish and Crustacea. In the lower slope, Crustacea was the most abundant group (Table 21).

Table 21. Biomass (Kg/Km^2) and abundance (ind./Km^2) of the taxonomic groups present in the discarded fraction of the catch in the port of Roses. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	59.41	45.99	9.69	5.96	6.73	2.12
Chondrichthyes	43.46	37.37	105.44	102.73	89.21	131.54
Crustacea	4.28	1.31	2.31	2.03	3.56	2.47
Cephalopoda	6.27	2.02	4.58	2.03	2.62	2.76
Other Mollusca	0.59	0.62				
Porifera	0.21	0.21	0.13	0.14	0.03	0.05
Cnidaria	25.97	12.33	1.34	2.20	0.43	0.61
Annelida	0.09	0.09	0.03	0.03	0.00	0.01
Sipuncula					0.00	0.00
Echinodermata	1.76	1.36	0.21	0.27		
Tunicata	0.73	0.56	0.07	0.10		
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	3927.09	2453.00	582.03	377.77	414.32	428.48
Chondrichthyes	424.36	264.31	643.90	467.38	380.24	555.06
Crustacea	802.19	618.48	639.06	631.39	562.98	697.38
Cephalopoda	369.75	203.75	90.75	34.02	18.02	11.17
Other Mollusca	50.41	23.62				
Porifera	8.26	7.15	12.05	14.97	3.40	4.81
Cnidaria	2523.46	1433.24	180.56	293.20	211.02	298.43
Annelida	16.48	26.05	17.65	27.91	3.40	4.81
Sipuncula					3.40	4.81
Echinodermata	315.22	308.92	30.19	29.29		
Tunicata	236.55	291.75	10.59	14.98		

The debris composition is shown in Figure 116. In 2019, the main types of debris varied according to each fishing ground. In the continental platform abunded the calcified remains (75%). In the upper slope, terrestrial plants (53%) and marine organic debris (20%) were the most abundant categories. Finally, in the lower slope, clinker, which is released from steamships as a residu of coal-burning (Ramirez-Llodra et al, 2013) was highly present in the samples (76%). In 2020, terrestrial plats were the main debris in the three fishing grounds (39 - 78%). Shells, marine organic debris, and clinker were also important but abundance depended on the fishing ground. The mass of debris (kg of debris by km^2) is presented in Table 22.

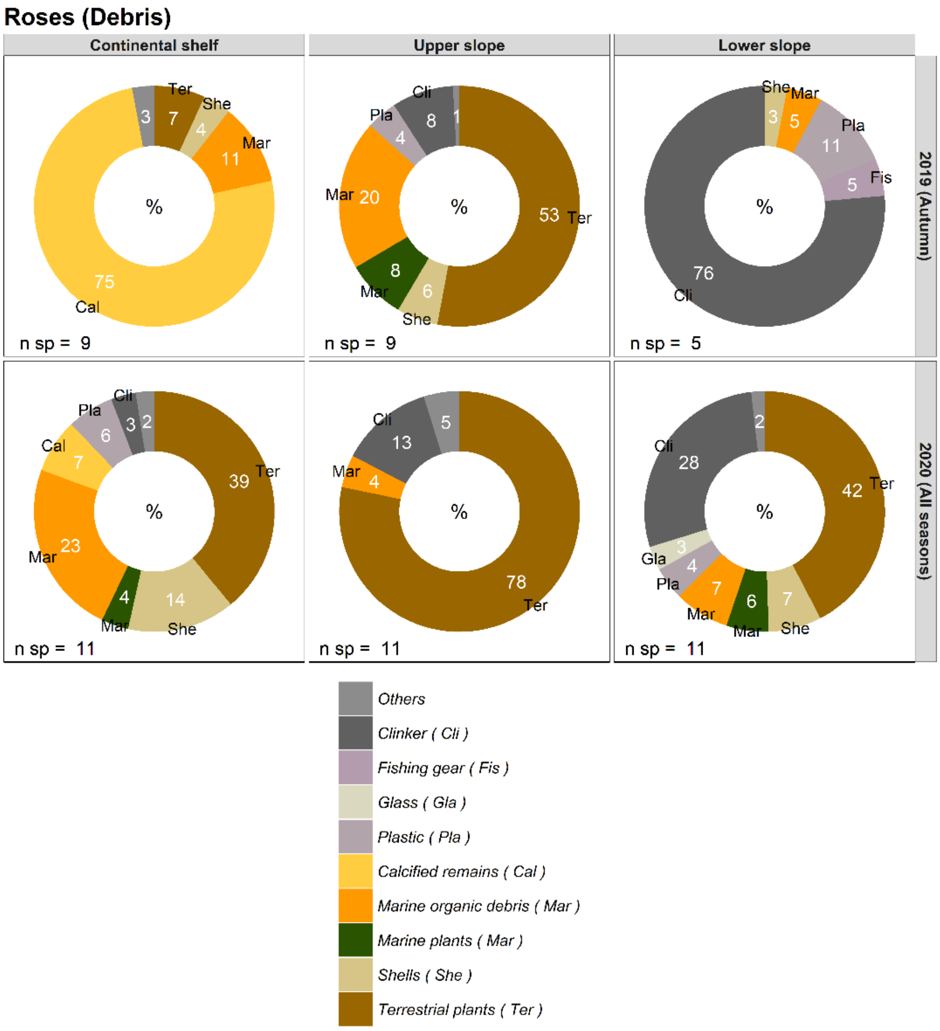


Figure 116. Items with most weight within the debris fraction of the catch in the port of Roses. Percentage by weight in each year and fishing ground, including all hauls from October 2019 to December 2020.

Table 22. Mass (Kg/Km^2) of the debris present in the debris fraction of the catch in the port of Roses. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd
Terrestrial plants	11.05	11.07	33.11	42.69	8.92	11.43
Clinker	0.95	0.35	5.31	3.22	5.89	4.61

	Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd
Marine organic debris	6.64	4.25	1.85	1.96	1.57	1.92
Shells	4.10	1.88	0.59	0.53	1.50	2.08
Marine plants	1.03	1.46	0.80	1.13	1.19	1.88
Plastic	1.77	1.02	0.31	0.29	0.93	0.57
Calcified remains	2.07	2.92				
Glass			0.05	0.07	0.68	0.96
Fishing gear	0.35	0.55			0.16	0.23
Rhodophyta	0.19	0.27				
Ropes	0.02	0.03	0.01	0.01	0.14	0.20
Wet wipes	0.14	0.20			0.00	0.00
Metal			0.13	0.19		
Other marine algae			0.05	0.06	0.08	0.12
Unclassified debris			0.09	0.12		

The annual catch rates of hake during the period 2000-2020 in the port of Roses showed a progressive decline (Figure 117) However, the decreasing pattern was not as pronounced as the one observed for all the catch in Catalonia. In Roses, catches fluctuated notably, being 2009 the year with the highest catch rate (nearly 400 tons) and 2020 when the minimum catches were recorded (100 tons).

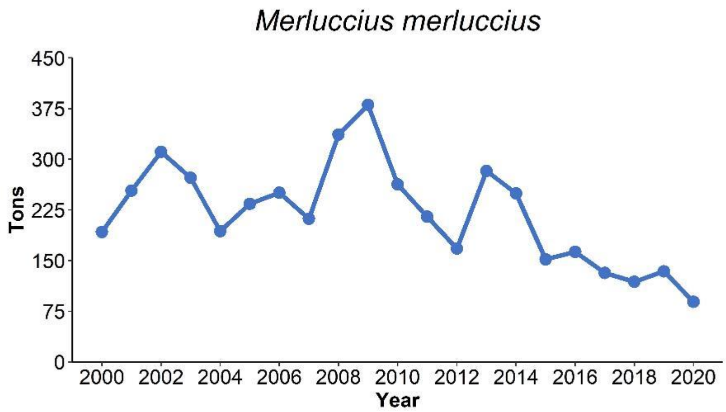


Figure 117. Time series of hake annual catch rates (tons) for the period 2000-2020 in the port of Roses.

The annual catch rates of horned octopus in the port of Roses showed a progressive decline in catch (Figure 118). The decreasing pattern was similar to that of hake. Since 2013, a decrease was recorded from 200 tons to less than 50 tons in 2020, when the lowest catch was observed.

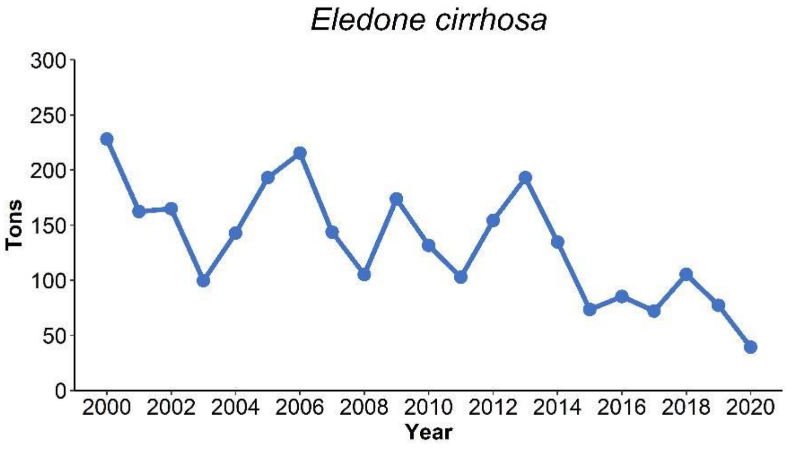


Figure 118. Time series of horned octopus annual catch rates (tons) for the time period 2000-2020 in Roses.

The anual catch rates of Norway lobster in the port of Roses also showed a progressive decline (Figure 119). The pattern of decline was similar to that observed for all catches in Catalonia, with notable fluctuactions through time. The large decline was observed in the last six years.

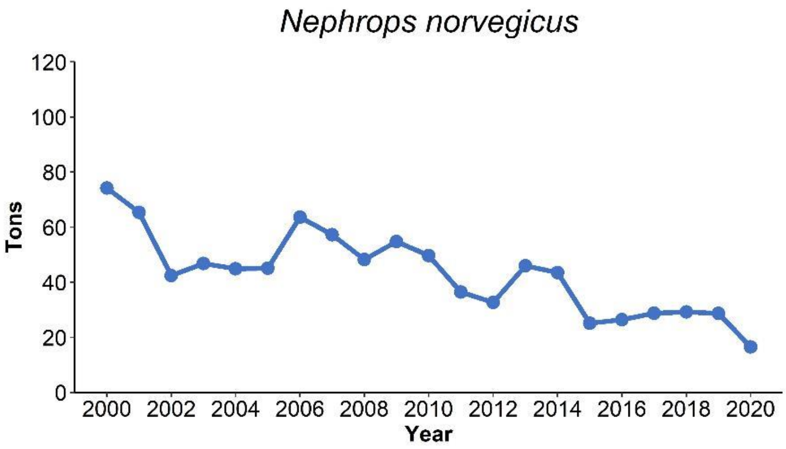


Figure 119. Time series of Norway lobster annual catch rates (tons9 for the time period 2000-2020 in Roses.

The anual catch rates of blue and red shrimp in the port of Roses showed a stability in catches since 2020, with the typical oscillations for this species (Figure 120). This pattern of stability was similar to catches in Catalonia as a whole. In the last year, 2020, an increase in catches was observed.

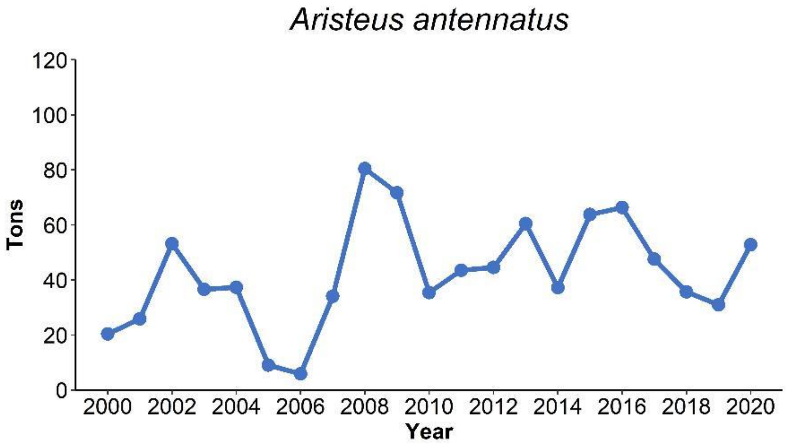


Figure 120. Time series of blue and red shrimp annual catch rates (tons) for the time period 2000-2020) in Roses.

The length-frequency distribution of hake from October 2019 to December 2020 in the port of Roses corresponded to catches in the common fishing grounds where the bottom trawl fleet operated (Figure 121). Hake length extended from 7 to 56 cm. The majority of the catch in the continental shelf was composed of small-sized individuals, below the MCRS, with a mode of 12 cm, which corresponded to juvenile and immature individuals. In the upper slope, catches were dominated by large-sized individuals, with a mode of 35 and 40 cm, associated with mature males and early mature females. Horned octopus (*Eledone cirrhosa*) was captured in the continental shelf and upper slope with a mode of 9 cm for both depth stratum. The length-frequency distributions of the Norway lobster (*Nephrops norvegicus*) and the blue and red shrimp (*Aristeus antennatus*) indicated a dominance of small-sized individuals. Size range of the Norway lobster extended from 11 to 53 mm with a mode of 31 mm whereas the size range of the blue and red shrimp extended from 15 to 61 mm with a mode of 24 mm.

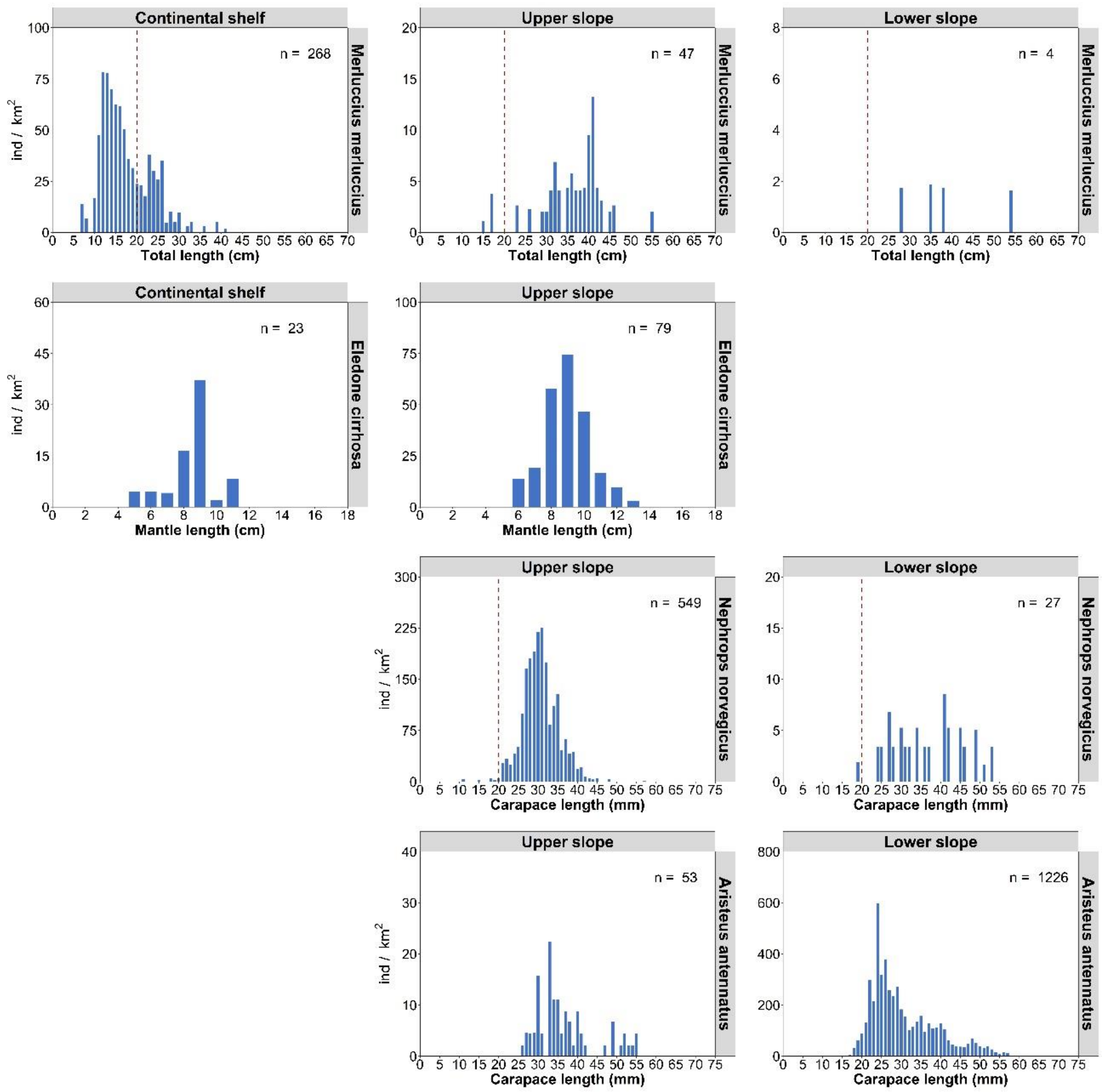


Figure 121. Length-frequency distribution of target species captured by bottom trawl at different depth stratum from October 2019 to December 2020 in the port of Roses. The red dashed line indicates the minimum conservation reference size (MCRS).

2.1.3.2 Palamós

Figure 122 shows the bottom trawl commercial fishing activities and sampling bottom trawls conducted in the Palamós port between October 2019 and December 2020.

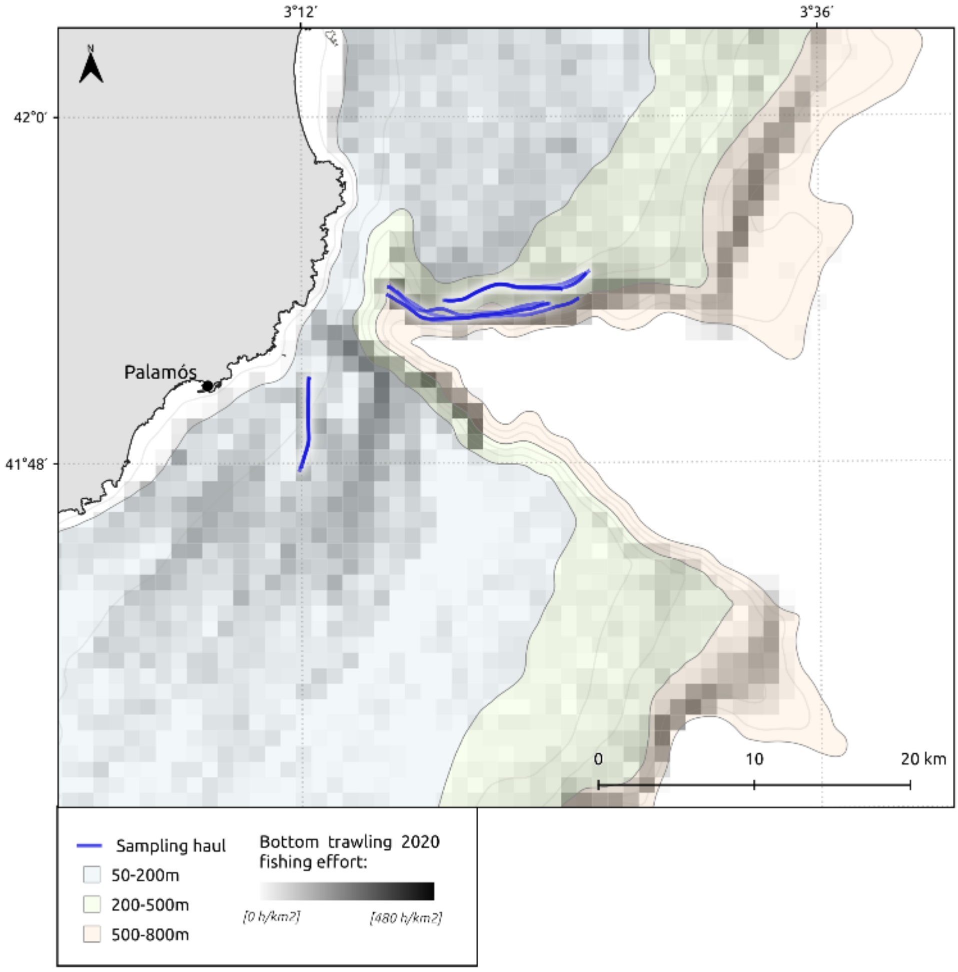


Figure 122. Map of bottom trawling hauls conducted in the port of Palamós from October 2019 to December 2020.

The characterization of the catches for the 12 bottom trawling hauls conducted in Palamós from October 2019 to December 2020 is shown in Figure 123 per each year and fraction of catch (landed, discarded and debris). In autumn 2019 the landed catches represented, depending on the fishing ground, from 70 to 79% of the total catches. The discarded fraction ranged between 17 and 23% of the total biomass and the debris fraction varied between 4 and 7%. In 2020, the landed catches represented, considering all fishing grounds, from 55 to 81% of the total catches. The discarded fraction ranged between the 18 and 30% of the total biomass and the debris fraction varied between 1 and 14%.

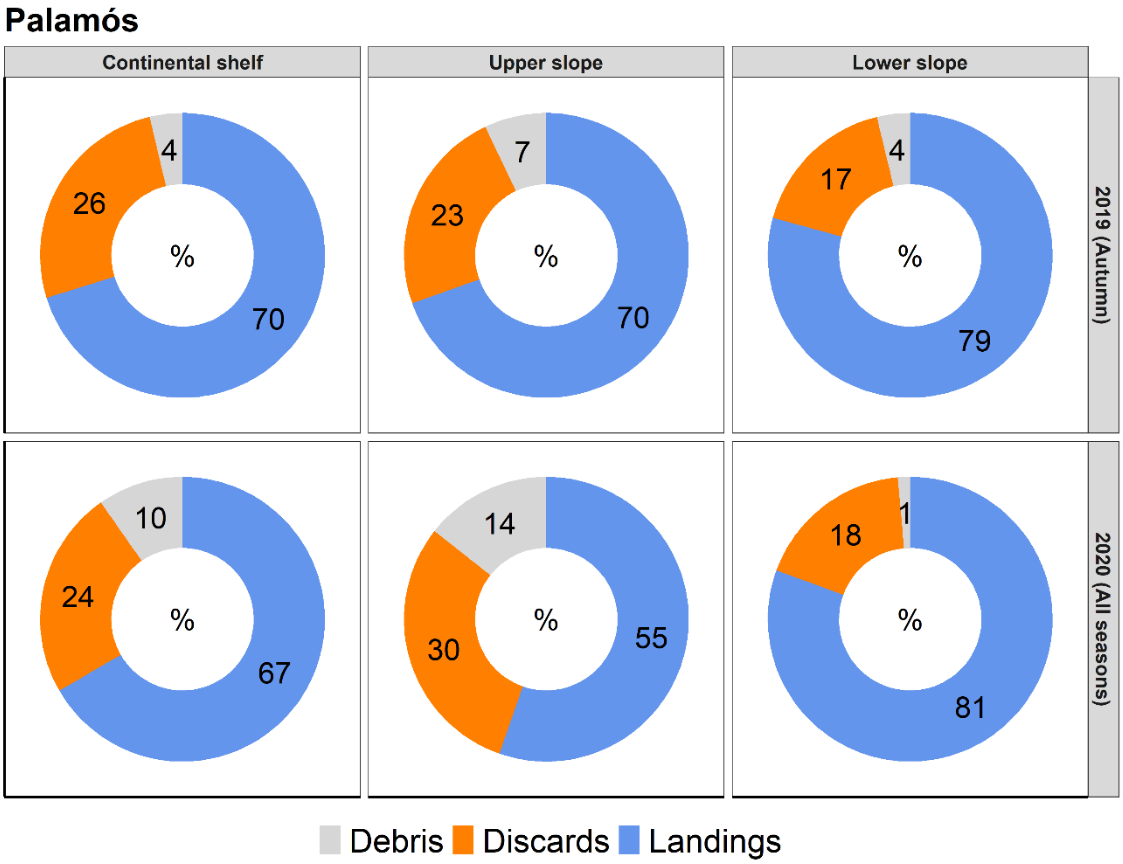


Figure 123. Catch composition in the port of Palamós. Percentage by weight of landings, discarded and debris fraction in each year and fishing ground, including all hauls from October 2019 to December 2020.

The proportion of species with most biomass within the landed catch for each year and fishing ground is shown in Figure 124. A total of 61 species were landed in Palamós from October 2019 to December 2020 (44 in the continental shelf, 32 in the upper slope, and 18 in the lower slope). In autumn 2019, the main landed species were, depending on the fishing ground, *T. trachurus, L. budegassa, M. merluccius, S. canicula, P. blennoides*, and *A, antennatus*. In 2020, the target species found in this port (*M. merluccius*, *N. norvegicus*, *A. antennatus*, and *E. cirrhosa*) represented the 10% of the landed catch in the continental shelf, the 30% in the upper slope, and the 85% in the lower slope. *T. trachurus* accounted for the 40% of the landed catch in the continental shelf, followed by *L. budegassa* (13%), and *M. merluccius* (8%). The most landed species in the upper slope were *P. blennoides* (19%) and the target species *N. norvegicus* (16%). *A. antennatus* was a 70% of the landed catch in the lower slope.

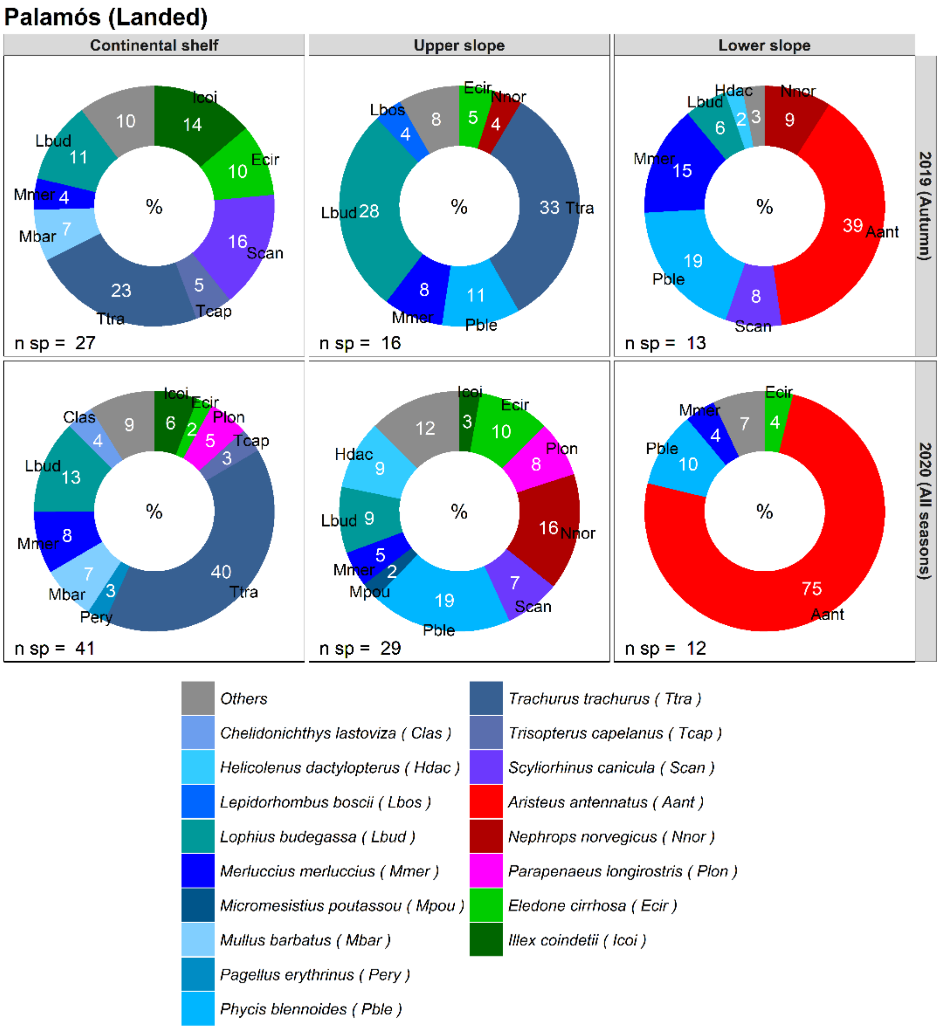


Figure 124. Species with most biomass within the landed catch in the port of Palamós. Percentage by weight of the landed fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

When analysing the landed species, Actinopterygii was the group with the highest biomass in the continental shelf and upper slope, while Crustacea had the highest biomass in the lower slope. In terms of abundance, Crustacea had the highest abundances in the upper and lower slopes wereas Actinopterygii was the most abundant in the continental shelf Table 23.

Table 23. Biomass (Kg/Km^2) and abundance (ind./Km^2) of the taxonomic groups present in the landed fraction of the catch in the port of Palamós. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	327.43	217.92	139.32	52.59	11.43	2.94
Chondrichthyes			19.81	28.02		
Crustacea	21.73	25.75	62.29	58.89	56.62	15.34
Cephalopoda	38.16	2.89	43.62	24.03	3.86	3.83
Other Mollusca			0.45	0.62		
Echinodermata	4.64	2.46				
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	6546.68	4921.80	1725.21	750.14	68.52	15.84
Chondrichthyes			128.41	181.60		
Crustacea	3475.35	4936.57	3447.27	4062.24	3130.69	1059.22
Cephalopoda	619.33	180.00	529.27	506.53	10.60	9.03
Other Mollusca			24.13	33.47		
Echinodermata	34.67	19.80				

The proportion of species with most biomass within the discarded catch for each year and fishing ground is shown in Figure 125. A total of 140 species were discarded in Palamós (86 in the continental shelf, 78 in the upper slope, and 35 in the lower slope). In 2019 in the continental shelf, the main discards were *B. boops* (20%) and *T. trachurus* (15%). In the upper slope, *S. canicula* represented 59% of the discarded biomass, followed by *C. conger* (13%) and *R. pulmo* (5%). In the lower slope, the Cephalopoda *H. reversa* was the main discard (49%), followed by *G. melastomus* (37%). In 2020, *B. boops* (29%) and *S. canicula* (23%) were the main discards in the continental shelf. The 61% of the discarded catch in the upper slope was *S. canicula* and, in the lower slope, the species *S. canicula* (52%) and *G. melastomus* (24%).

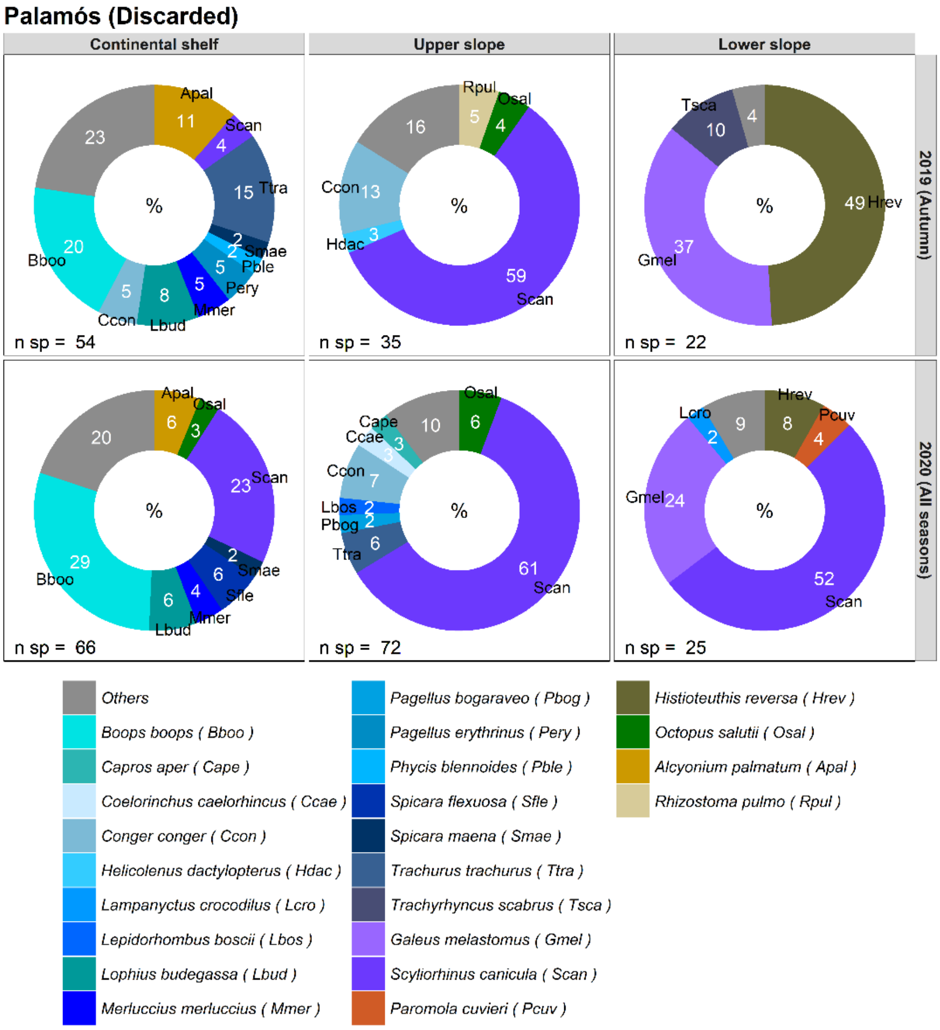


Figure 125. Species with most biomass within the discarded catch in the port of Palamós. Percentage by weight of the discarded fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

Of the discarded species, Actinopterygii and chondrichthyes were the most abundant taxonomic groups in the continental shelf and upper slope. In the lower slope, chondrichthyes and Cephalopoda had the highest biomass. In terms of abundance, Actinopterygii was the most important group in all fishing grounds, followed by Cnidaria and Crustacea n the continental shelf and upper slope. The abundance in the lower slope was much lower than in the other two depths (Table 24.

Table 24. Biomass (Kg/Km^2) and abundance (ind./Km^2) of the taxonomic groups present in the discarded fraction of the catch in the port of Palamós. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	75.64	41.59	32.84	32.39	1.41	0.92
Chondrichthyes	31.60	26.17	75.12	62.72	12.18	4.32
Crustacea	3.29	3.43	2.63	1.22	0.76	0.51
Cephalopoda	4.16	6.46	8.94	12.82	1.53	1.29
Other Mollusca	0.67	1.05	0.28	0.29		
Porifera	2.84	2.42	0.02	0.02		
Cnidaria	10.71	2.04	2.55	0.51	0.02	0.02
Annelida	0.82	1.10	0.36	0.21		
Sipuncula			0.01	0.01		
Echinodermata	3.60	3.44	0.71	0.83		
Tunicata	3.53	0.85	0.32	0.24		
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	1835.20	1330.18	1411.84	937.64	59.43	61.71
Chondrichthyes	140.65	108.53	451.85	279.39	39.25	24.37
Crustacea	825.18	1202.65	361.85	232.88	22.91	30.40
Cephalopoda	72.02	51.38	133.88	52.00	31.09	36.66
Other Mollusca	97.88	149.37	24.20	12.47		
Porifera	143.76	168.87	4.99	7.05		
Cnidaria	1494.11	471.29	453.58	90.78	0.93	1.32
Annelida	27.64	35.43	40.60	3.71		
Sipuncula			12.82	6.41		
Echinodermata	125.11	95.11	24.23	12.56		
Tunicata	235.32	71.25	22.79	6.18		

The debris composition is shown in Figure 126. In 2019, terrestrial plants (11 - 23%), terrestrial animals (0 - 30%), shells (0 - 15%), and marine organic debris (11 - 26%) were the most abundant types. In 2020, terrestrial plants (18 - 52%), shells (3 - 29%), plastic (6 - 15%), and marine organic debris (9 - 43%) were present in all fishing grounds. The mass of debris (kg of debris by km^2) is presented in Table 25.

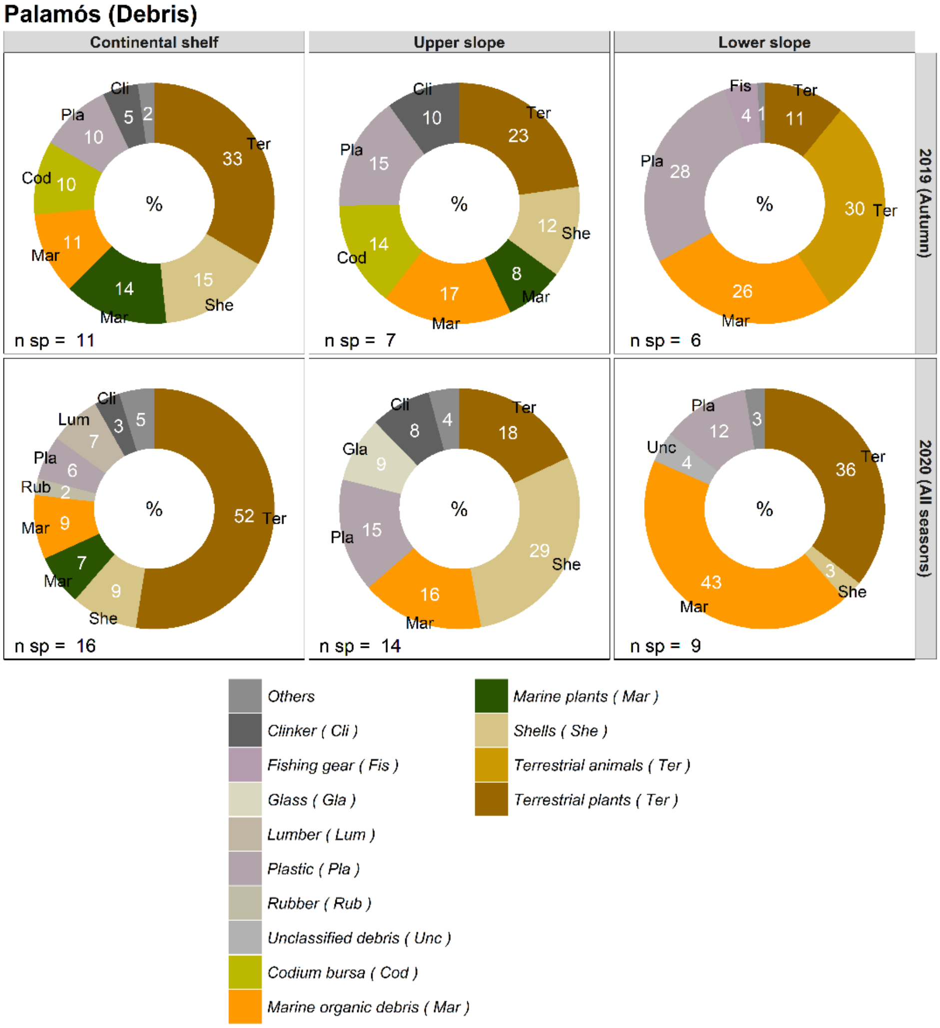


Figure 126. Debris fraction with most weight in the port of Palamós. Percentage by weight in each year and fishing ground, including all hauls from October 2019 to December 2020.

Table 25. Mass (Kg/Km^2) of the items present in the debris fraction of the catch in the port of Palamós. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd
Terrestrial plants	21.58	10.57	10.89	11.76	0.40	0.60
Shells	3.69	2.14	17.62	15.55	0.03	0.02
Marine organic debris	3.55	3.04	9.98	10.98	0.48	0.68
Plastic	2.43	2.88	9.26	9.67	0.13	0.17
Clinker	1.42	0.99	4.93	5.10		

	Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd
Glass			5.32	6.05		
Marine plants	2.79	1.68	0.46	0.31		
Lumber	2.83	4.00				
Rubber	0.91	1.29	0.16	0.14		
Metal	0.08	0.12	0.94	1.27		
Codium bursa	0.47	0.24	0.42	0.59		
Textiles	0.31	0.44	0.22	0.32	0.01	0.02
Calcified remains	0.39	0.55				
Unclassified debris	0.31	0.36			0.05	0.07
Fishing gear	0.27	0.40	0.01	0.02	0.00	0.00
Wet wipes			0.28	0.39	0.00	0.00
Other marine algae	0.08	0.09			0.01	0.02
Rhodophyta	0.03	0.04				
Ropes			0.02	0.03		

Regarding species, the annual catch rates of hake during the period 2000-2020 in the port of Palamós indicated a progressive and continuous decline in catches, following the same pattern observed for the catch in Catalonia (Figure 127) Maximum hake catch rates were registered in 2003 (130 tons) and the minimum from 2015 to now (< 50 tons).

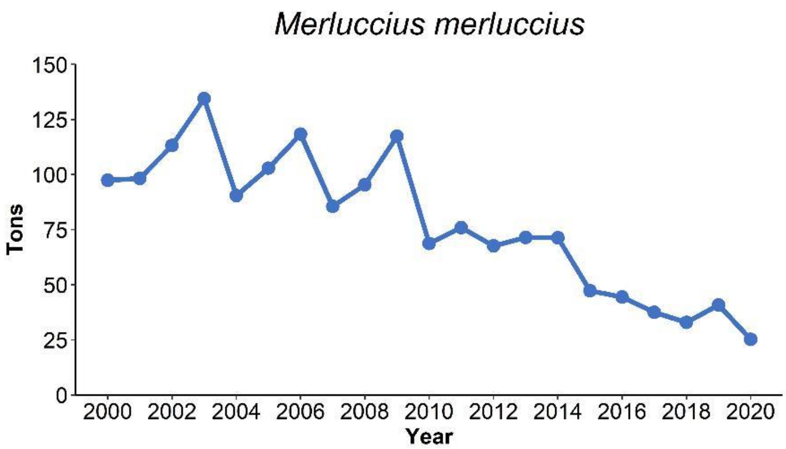


Figure 127. Time series of annual catch rates (tons) for the period 2000-2020 in the port of Palamós.

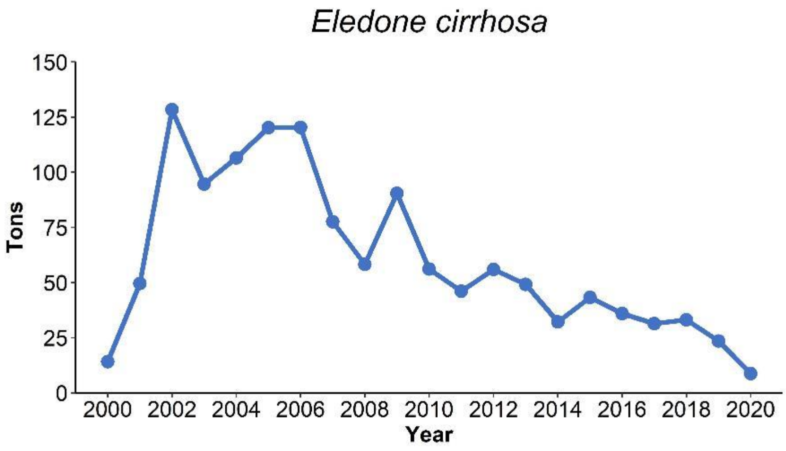


Figure 128. Time series of horned octopus annual catch rates (tons) for the time period 2000-2020 in Palamós.

A trend similar to that of the hake (decreased catches) was observed for the horned octopus (Figure 128).

The annual catch rates of Norway lobster and blue and red shrimp in the port of Palamós indicated a trend that we also detected in the port of Roses. The decrease in Norway lobster catches was evident from 2015 to now (Figure 129). For the blue and red shrimp, a negative trend was clearly observed since 2015 to now (Figure 130).

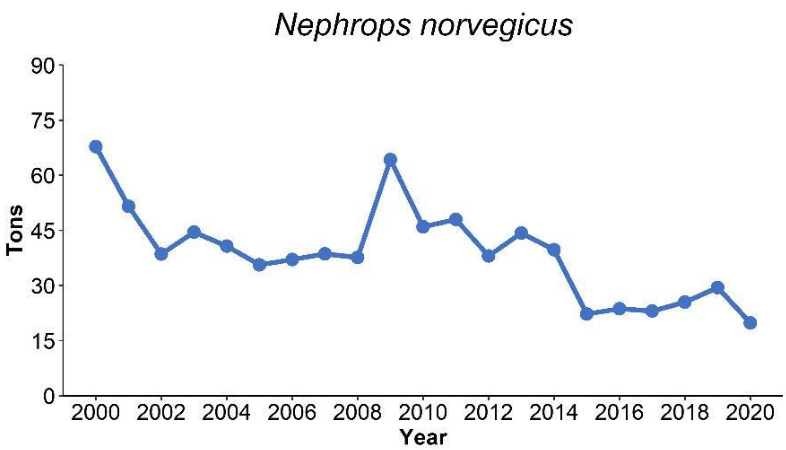


Figure 129.. Time series of Norway lobster annual catch rates (tons) for the time period 2000-2020 in Palamós.

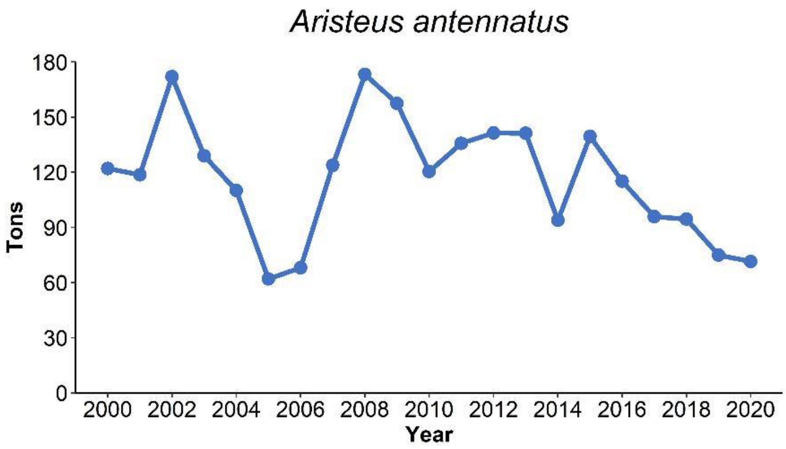


Figure 130. Time series of blue and red shrimp annual catch rates (tons) for the time period 2000-2020 in Palamós.

The length-frequency distribution of hake from October 2019 to December 2020 in the port of Palamós corresponded to catches in the common fishing grounds where the bottom trawl fleet operated. Hake size range extended from 9 to 57 cm. The majority of the catch in the continental shelf was composed of individuals sized 20-30 cm, lengths associated with immature females and early mature males (Figure 131). The proportion of hake catches below the MCRS was lower than in Roses but appeared both in the continental shelf and upper slope. Horned octopus (*E. cirrhosa*) was captured in the continental shelf and upper slope with a mode located at 8 and 9 cm respectively. The length-frequency distributions of the Norway lobster (*N. norvegicus*) and the blue and red shrimp (*A.antennatus*) indicated a dominance of small-sized individuals. Size range of the Norway lobster extended from 16 to 56 mm with a mode located at 31 mm in the upper slope whereas the size range of the blue and red shrimp extended from 13 to 63 mm with a mode of 24 mm in the lower slope.

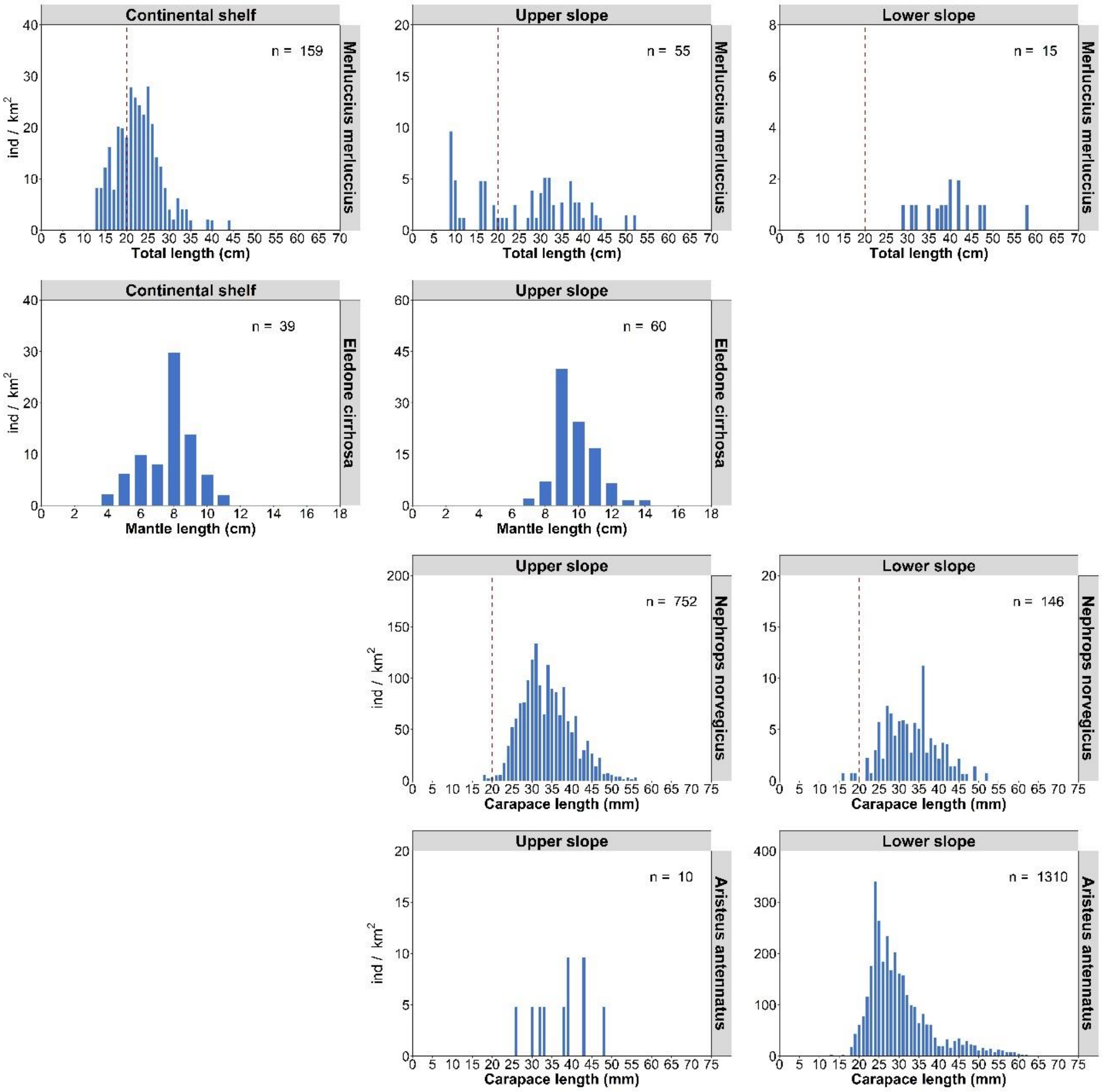


Figure 131. Length-frequency distribution of target species captured by bottom trawl at each depth stratum from October 2019 to December 2020 in the port of Palamós. The red dashed line indicates the minimum conservation reference size (MCRS).

2.1.3.3 Blanes

Figure 132 shows the bottom trawl commercial fishing activities and sampling bottom trawls conducted in the Blanes port between October 2019 and December 2020.

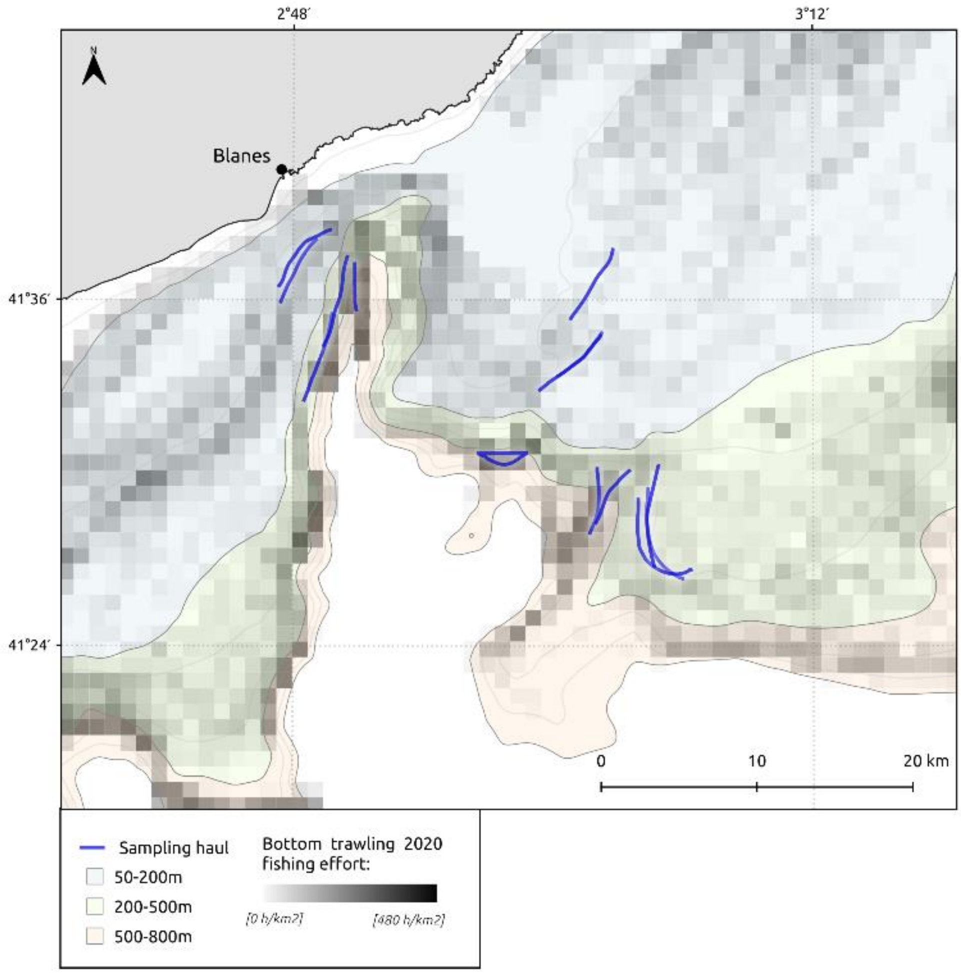


Figure 132. Map of bottom trawling hauls conducted in the port of Blanes from October 2019 to December 2020.

The characterization of the catches for the 14 bottom trawling hauls conducted in Blanes from October 2019 to December 2020 is shown in Figure 133 per each year and fraction of the catch (landed, discarded, and debris). In autumn 2019 the landed catches represented, depending on the fishing ground, from 57 to 86% of the total catches. The discarded fraction ranged between the 13 and 22% of the total biomass and the debris between 1 and 21%. In 2020, the landed catches represented, depending on the fishing ground, from 52 to 65% of the total catches whereas the discarded fraction ranged between the 27 and 41% and the debris ranged between between 3 and 8%.

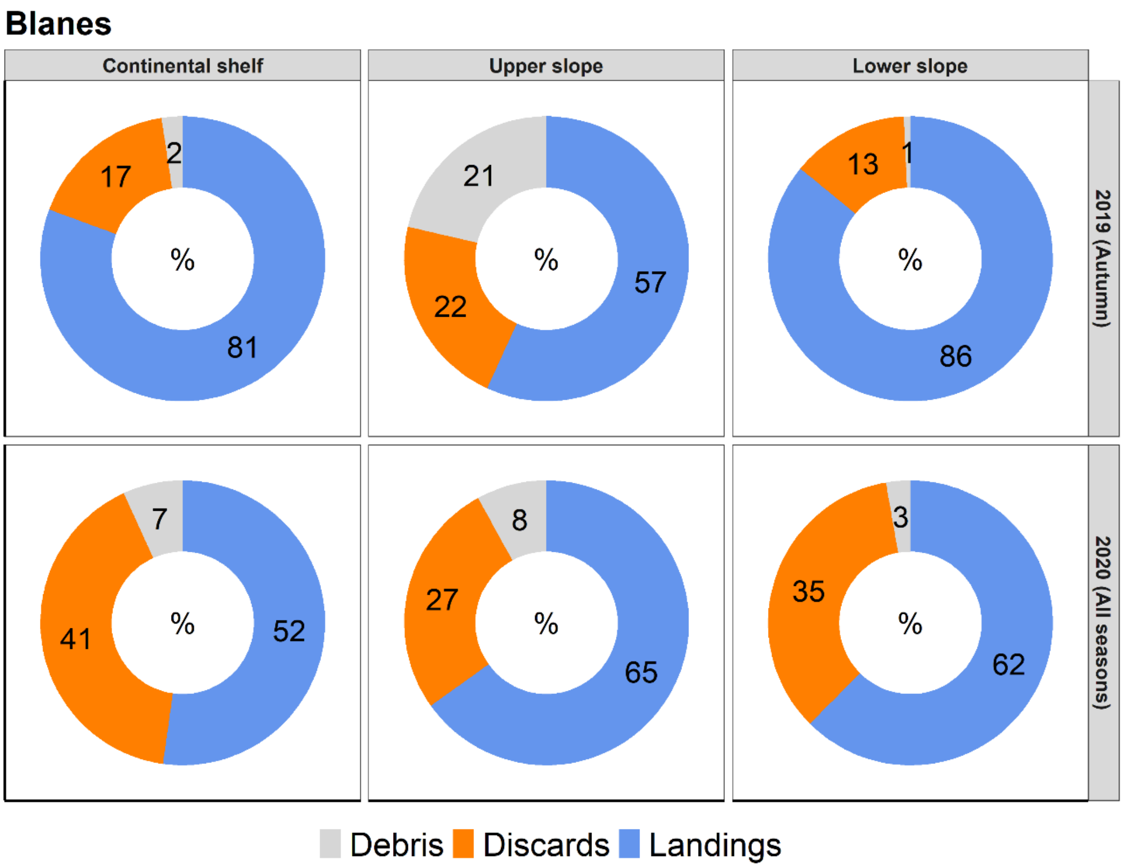


Figure 133. Catch composition in the port of Blanes. Percentage by weight of landings, discarded and debris fraction in each year and fishing ground, including all hauls from October 2019 to December 2020.

The proportion of species with most biomass within the landed catch for each year and fishing ground is shown in Figure 134. A total of 61 species were landed in Blanes from October 2019 to December 2020 (46 in the continental shelf, 33 in the upper slope, and 18 in the lower slope). In autumn 2019, the main landed species from the continental shelf were *T. trachurus* (17%) and *I. coindetii* (16%). In the upper slope, abunded *P. blennoides* (22%) and *L. budegassa* (23%). In the lower slope, the target species *M. merluccius* accounted for the 47% of the landed catch, followed by *P. blennoides* (25%). However, the biomass of the target species *A. antennatus* was low (12%). In 2020, the target species found in this port (*M. merluccius*, *N. norvegicus*, *A. antennatus*, and *E. cirrhosa*) represented the 9% of the landed catch in the continental shelf, the 25% in the upper slope, and the 55% in the lower slope. The main landed species in the continental shelf were *T. trachurus* (19%) and *Mullus* spp. (26%). In the upper slope abunded catches of the target species *N. norvegicus* (19%), *P. longirostris* (19%), and *P. blennoides* (23%). In the lower slope *A. antennatus* was the main species (38%), being *P. blennoides* also important.

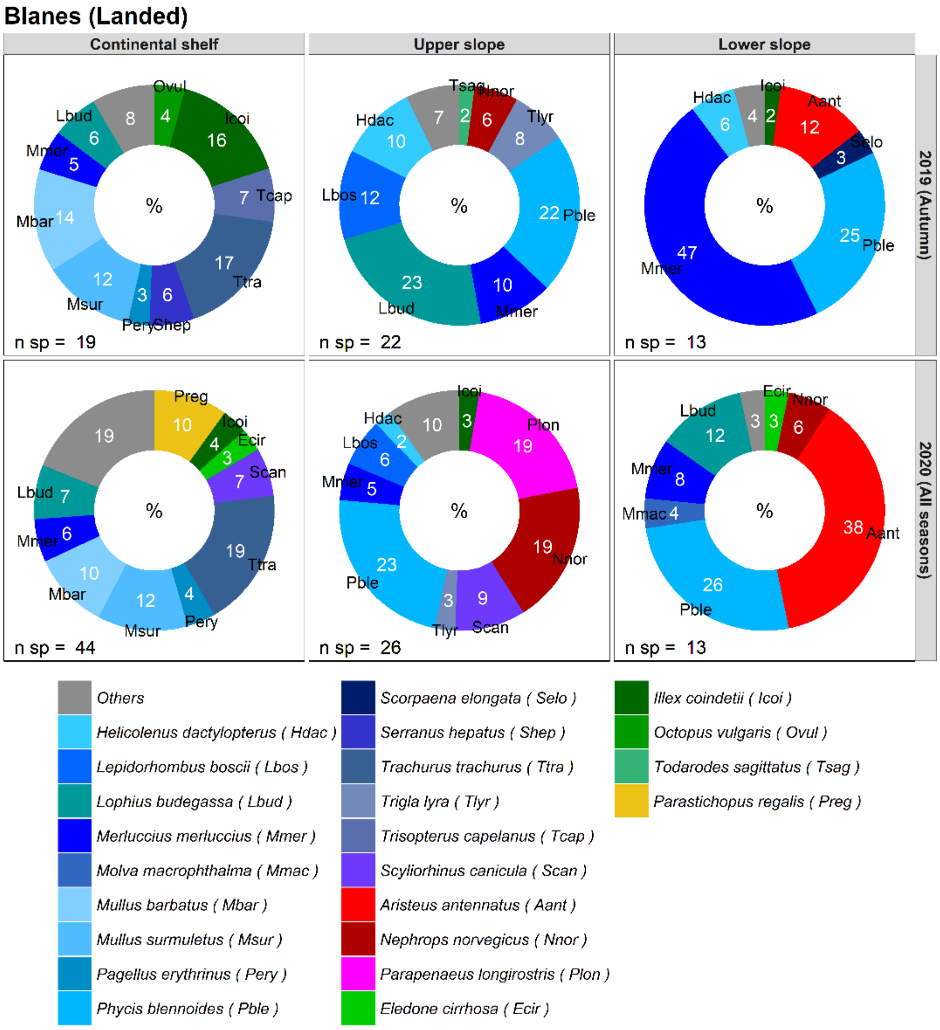


Figure 134. Species with most biomass within the landed catch in the port of Blanes. Percentage by weight of the landed fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

Within the landed species, Actinopterygii was the group with highest biomass in all fishing grounds. In terms of abundance, Crustacea had the highest abundances in the upper and lower slopes, with its maximum in the upper slope; in contrast, Actinopterygii was the most abundant group in the continental shelf (Table 26).

Table 26. Biomass (Kg/Km^2) and abundance (ind./Km^2) of the taxonomic groups present in the landed fraction of the catch in the port of Blanes. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	384.88	134.53	152.43	50.24	86.67	29.97
Chondrichthyes	48.09	83.30	30.02	52.00		
Crustacea	0.45	0.37	122.82	98.33	77.90	65.42
Cephalopoda	40.14	23.40	11.60	13.52	5.48	7.75
Echinodermata	52.34	19.39				
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	6550.66	2927.04	2265.61	693.17	470.11	75.86
Chondrichthyes	175.66	304.25	217.35	376.46		
Crustacea	69.51	69.13	9894.39	9839.13	5109.32	4198.27
Cephalopoda	807.47	774.03	170.48	293.19	19.77	27.96
Echinodermata	427.52	133.87				

The proportion of species with most biomass within the discarded catch for each year and fishing ground is shown in Figure 135. A total of 169 species were discarded in Blanes (112 in the continental shelf, 83 in the upper slope, and 53 in the lower slope). In 2019, the species *E. melo, S. canicula*, and *T. scabrus* were the main discards in the continental shelf, upper slope, and lower slope, respectively. In 2020, a high percentage of invertebrates were discarded from the continental shelf (41% of the discards were of *L. phalangium, G. acutus*, and *E. melo*). The species *S. canicula* represented 72% of the discards in the upper slope. The 82% of the discarded catch in the lower slope was composed of *S. canicula* and *G. melastomus.*

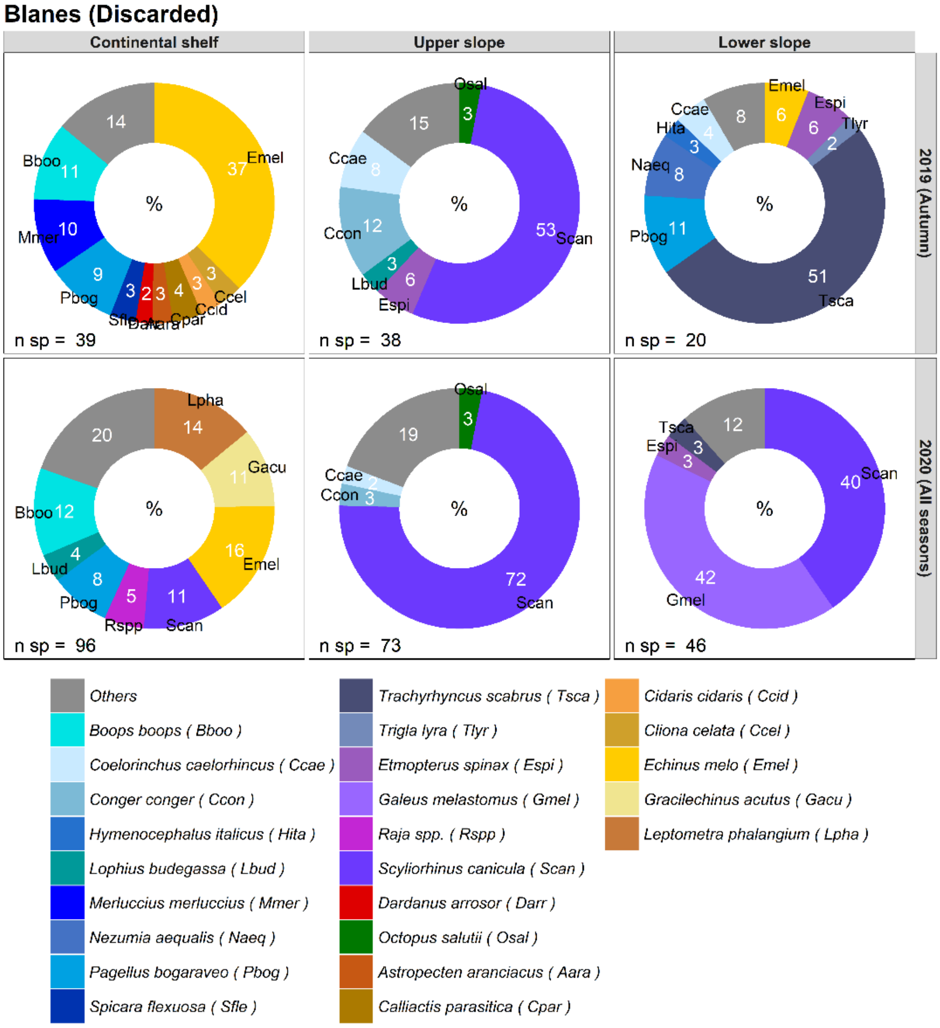


Figure 135. Species with most biomass within the discarded catch in the port of Blanes. Percentage by weight of the discarded fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020

From the discarded species, fishes (Actinopterygii + chondrichthyes) and Echinodermata had the highest biomass and abundance in the continental shelf. Despite the low biomass of cnidaria, its abundance was high in the continental shelf (Table 27).

Table 27. Biomass (Kg/Km^2) and abundance (ind./Km^2) of the taxonomic groups present in the discarded fraction of the catch in the port of Blanes. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	141.61	48.50	16.66	11.23	8.70	5.10
Chondrichthyes	71.76	82.44	88.40	92.29	94.21	94.59
Crustacea	4.15	6.79	4.24	3.35	2.86	1.68
Cephalopoda	6.33	4.12	7.08	5.29	3.93	1.46
Other Mollusca	0.97	0.91	1.03	1.05	0.04	0.05
Porifera	2.56	3.09	0.04	0.03		
Cnidaria	9.43	11.69	1.26	1.53	0.55	0.60
Annelida	0.02	0.03	0.00	0.01	0.04	0.05
Echinodermata	190.12	200.53	1.98	1.48		
Tunicata	3.68	2.57	0.22	0.19		
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	4307.87	1848.44	947.79	1064.04	279.09	74.90
Chondrichthyes	440.23	401.86	638.59	416.49	513.81	455.84
Crustacea	700.17	449.94	747.85	498.11	482.35	335.24
Cephalopoda	394.37	333.86	106.82	63.16	45.57	12.93
Other Mollusca	142.63	124.60	83.71	69.67	13.42	18.99
Porifera	158.85	160.49	5.94	4.87		
Cnidaria	1399.80	1403.33	271.46	264.94	41.73	43.43
Annelida	0.00	0.00	3.12	5.40	4.08	5.78
Echinodermata	103301.39	142137.57	178.79	123.25		
Tunicata	126.92	33.98	17.40	23.11		

The debris composition is shown in Figure 136. The debris in Blanes was mainly composed of terrestrial plants (0 - 43%) and shells (6 - 42%). Also plastics, marine organic debris, lumber, fishing gears, and clinker were present in different proportions according to fishing ground and year. The mass of debris (kg of debris by km^2) is summarized in Table 28.

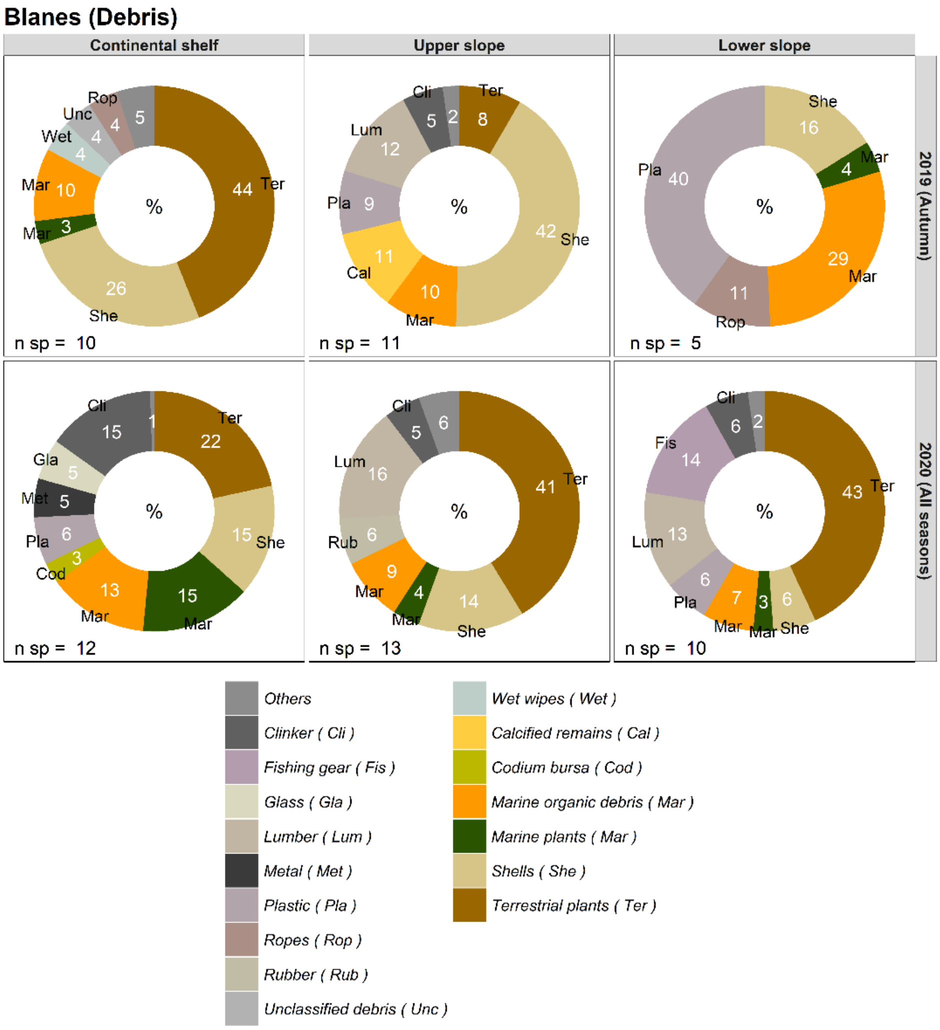


Figure 136. Most important items in weight of the debris fraction of the catch in the port of Blanes. Percentage by weight in each year and fishing ground, including all hauls from January to December 2020.

Table 28. Mass (Kg/Km^2) of the debris present in the catch in the port of Blanes. Mean and standard deviation in each fishing ground, including all hauls from October 2019 to December 2020.

	Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd
Terrestrial plants	12.95	7.10	13.80	7.09	2.84	4.38
Shells	9.03	9.27	4.77	7.92	0.38	0.51
Marine organic debris	8.09	5.55	2.88	2.03	0.45	0.28
Clinker	8.73	6.46	1.64	1.68	0.39	0.25
Marine plants	8.92	15.45	1.22	2.16	0.18	0.16
Lumber			5.22	9.03	0.86	0.90
Plastic	3.85	4.29	0.63	0.52	0.40	0.46

	Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd
Glass	3.28	5.68				
Metal	3.12	5.41				
Rubber	0.05	0.08	2.09	3.63		
Codium bursa	1.69	2.92				
Fishing gear			0.32	0.30	0.95	1.43
Wet wipes			0.63	0.57		
Calcified remains	0.21	0.17			0.10	0.14
Ropes	0.10	0.10	0.11	0.12	0.05	0.07
Other marine algae			0.13	0.22		
Textiles			0.03	0.04		

Regarding species, the annual catch rates of hake during the period 2000-2020 in the port of Blanes showed a progressive decline in catch rates, following the same pattern observed for all the catch in Catalonia (Figure 137). Maximum hake catch rates were registered in 2006 (110 tons) and the minimum ones were recorded from 2015 to now (<40 tons).

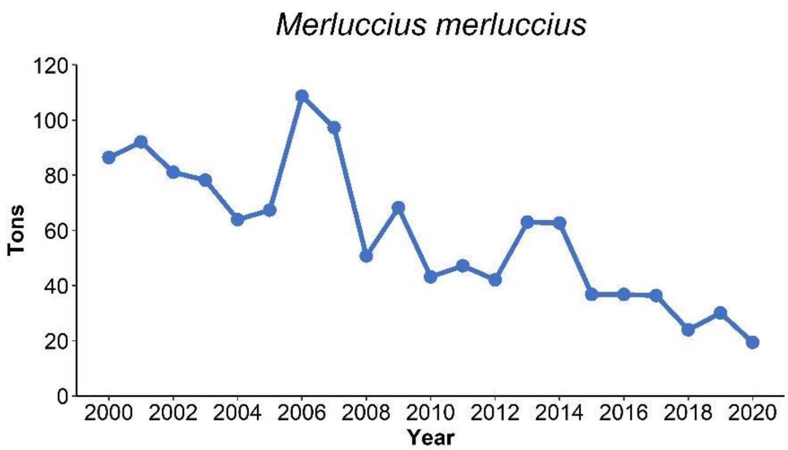


Figure 137. Time series of hake annual catch rates (tons) for the period 2000-2020 in the port of Blanes.

A similar trend to that of hake (decreased catches) was also observed in the horned octopus in the last two years. Previously, and until 2018, catches were stable (Figure 138). In the case of Norway lobster, throughout the historical time series we see that, despite it presented a general negative trend, in certain periods of time the catches remained stable. In the last two years, there was a considerable decrease in catches (Figure 139). As for the blue and red shrimp, the trend was exactly the same as in the rest of Catalonia, with a slight upward trend in the last two years (Figure 140).

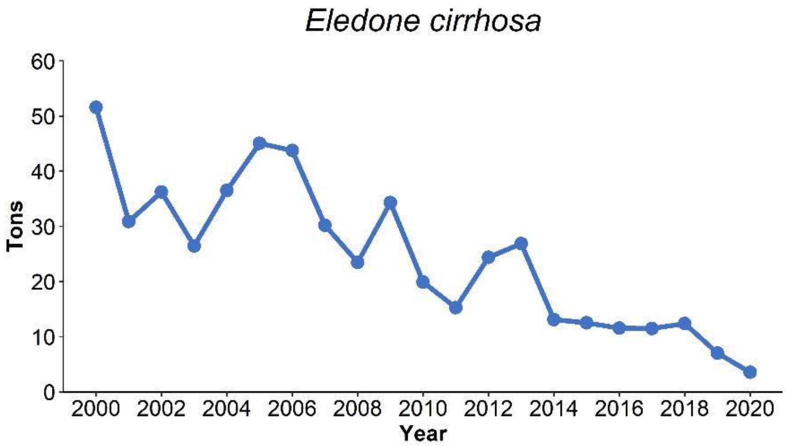


Figure 138. Time series of horned octopus annual catch rates (tons) for the time period 2000-2020 in Blanes.

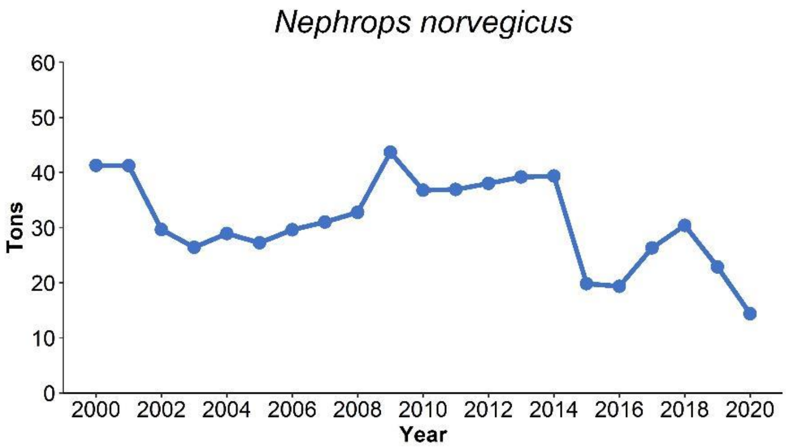


Figure 139. Time series of Norway lobster annual catch rates (tons) for the time period 2000-2020 in Blanes.

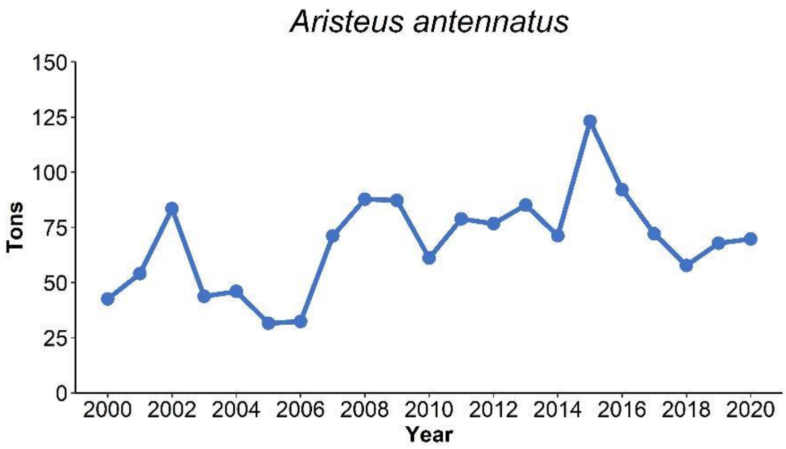


Figure 140. Time series of blue and red shrimp annual catch rates (tons) for the time period 2000-2020 in Blanes.

The length-frequency distribution of hake from October 2019 to December 2020 in the port of Blanes corresponded to catches in the common fishing grounds where the bottom trawl fleet operated. Size range extended from 9 to 59 cm (Figure 141). The majority of the catch in the continental shelf was composed of individuals measuring 15 to 20 cm, associated with juvenile and immature specimens, whereas in the upper slope hakes had larger sizes with a mode of 34 cm. The proportion of hake catches below the MCRS was high but restricted in the continental shelf. Horned octopus (*E. cirrhosa*) was scarce in the continental shelf and upper slope with a mode of 7 cm. The length-frequency distributions of the Norway lobster (*N. norvegicus*) and the blue and red shrimp (*A. antennatus*) indicated a predominance of small-sized individuals. Size range of the Norway lobster extended from 15 to 59 mm with a mode between 27 and 30 mm in the upper slope whereas the size range of the blue and red shrimp extended from 18 to 59 mm with a modebetween 23 and 27 mm in the lower slope.

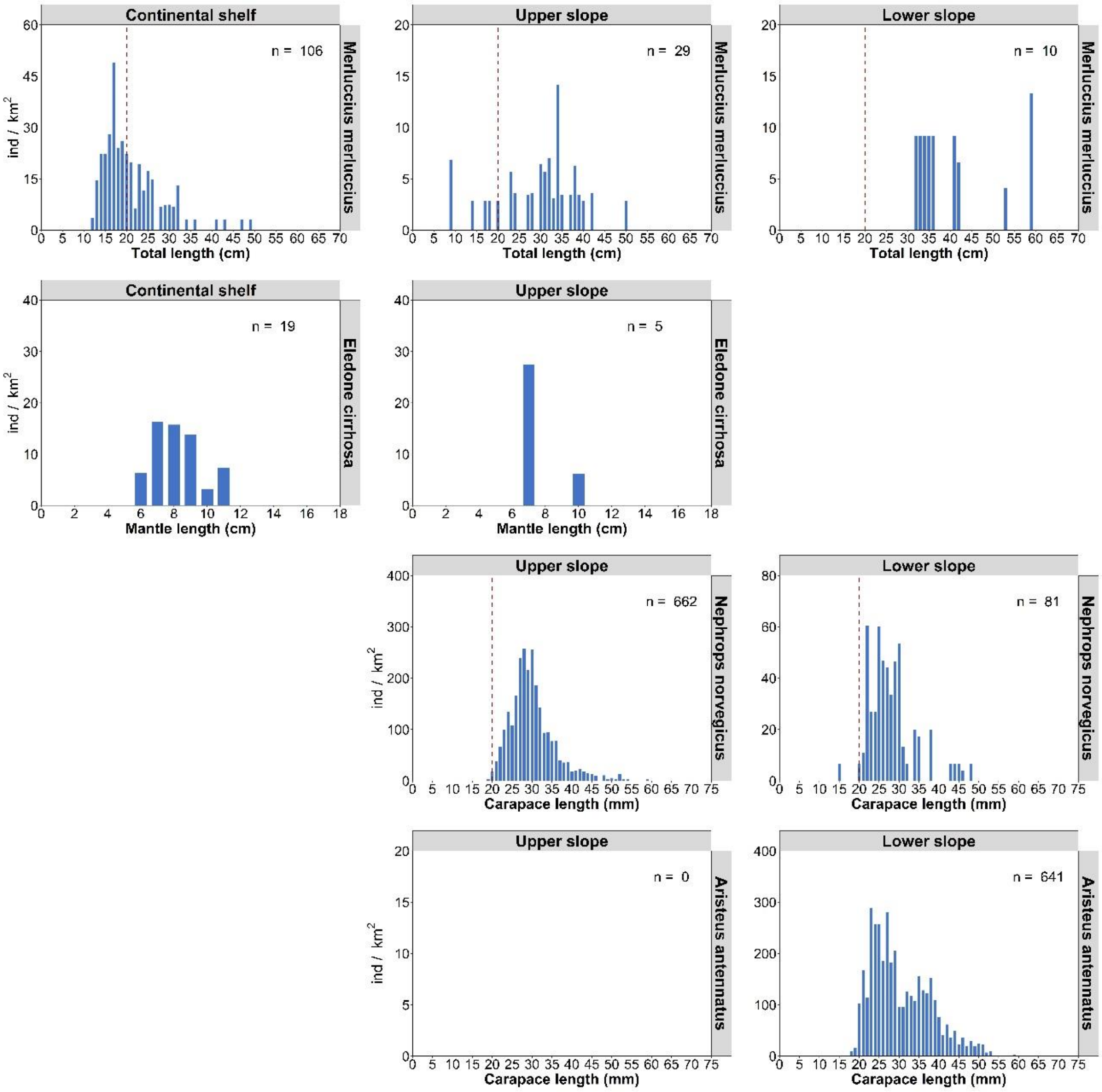


Figure 141. Length-frequency distribution of target species captured by bottom trawl for depth stratum from October 2019 to December 2020 in the port of Blanes. The red dashed line indicates the minimum conservation reference size (MCRS).

2.1.3.4 Arenys de Mar

Figure 142 shows the bottom trawl commercial fishing activities and sampling bottom trawls conducted in the Arenys de Mar port between October 2019 and December 2020.

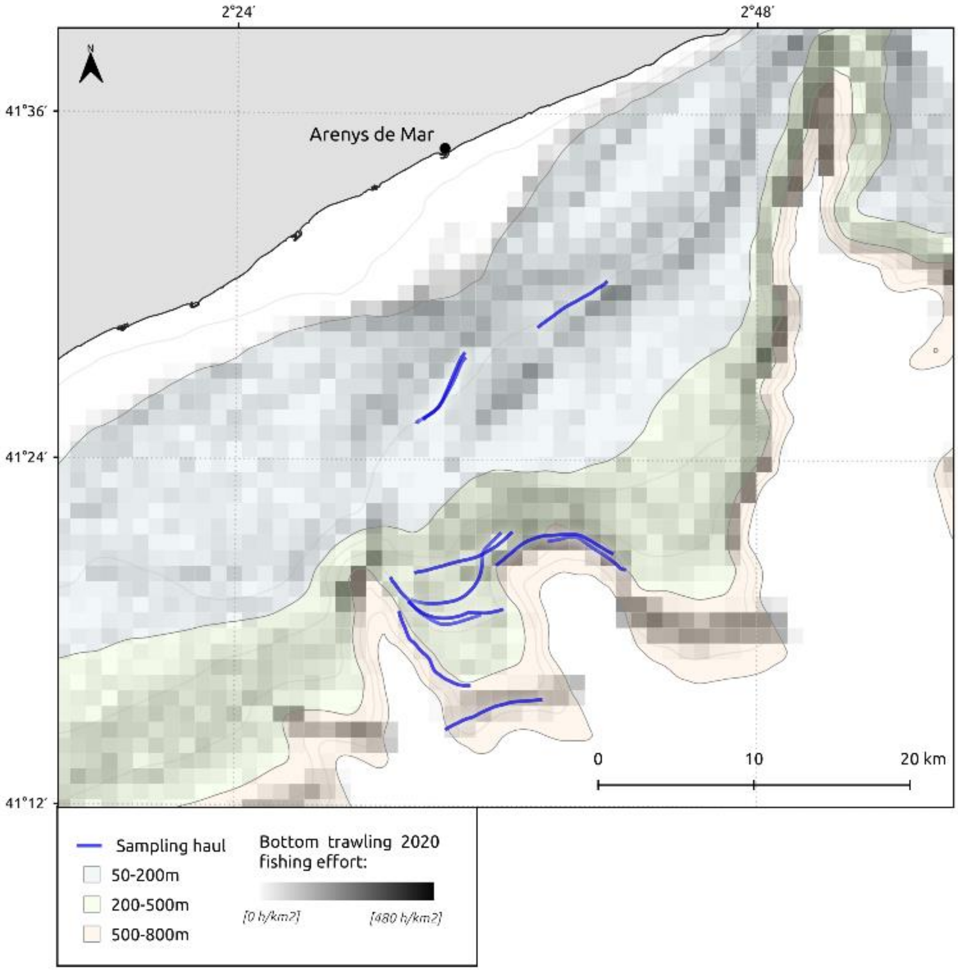


Figure 142. Map of bottom trawling hauls conducted in the port of Arenys de Mar from October 2019 to December 2020.

The characterization of the catches for the 12 bottom trawling hauls conducted in Arenys de Mar from October 2019 to December 2020 is shown in Figure 143 per each year and fraction of the catch (landed, discarded, and debris). In autumn 2019, the landed catches ranged between 61 to 92% of the total catches. The discarded fraction ranged between the 7 and 38% of the total biomass whereas the debris fraction was about 1% in all fishing grounds. In 2020, the landed catches represented, depending on the fishing ground, from 45 to 91% of the total catches. The discarded fraction ranged between the 9 and 54% of the total biomass and the debris fraction was as high as 1% .

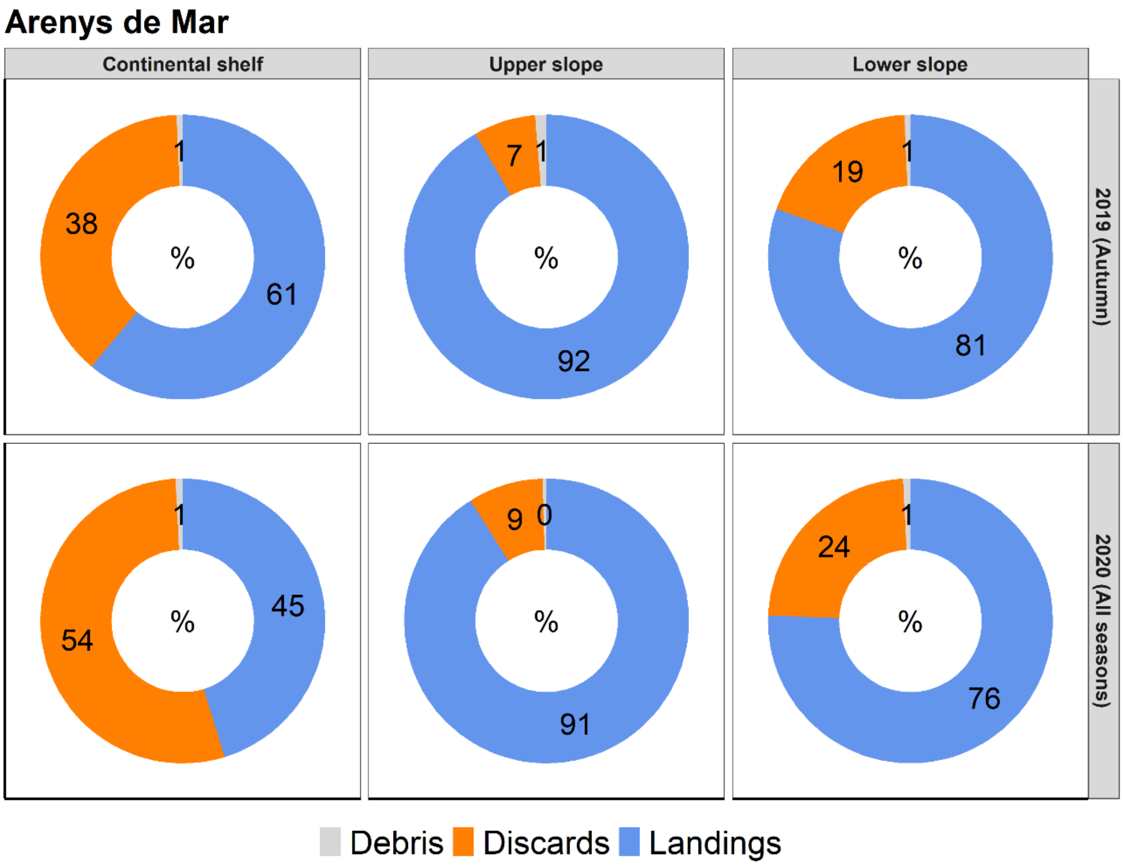


Figure 143. Catch composition in the port of Arenys de Mar. Percentage by weight of landings, discarded and debris fraction in each year and fishing ground, including all hauls from October 2019 to December 2020.

The proportion of the most important species in biomass for the landed catch for each year and fishing ground is shown in Figure 144. A total of 55 species were landed in Arenys de Mar from October 2019 to December 2020 (34 in the continental shelf, 25 in the upper slope, and 22 in the lower slope). In autumn 2019, *T. trachurus, T. capelanus, M. merluccius, L. piscatorius, P. blennoides, A. antennatus*, and *P. longirostris* were the most landed species. In 2020, the target species found in this port (*M. merluccius*, *N. norvegicus*, *A. antennatus*, and *E. cirrhosa*) represented the 26% of the landed catch in the continental shelf, the 10% in the upper slope, and the 70% in the lower slope. In the continental shelf, the main catches were from the species *M. merluccius* (25%) but the species *P. erythrinus* and *M. barbatus* were also important. In the upper slope, the target species *N. norvegicus* represented only a 9% of the total landed catches whereas

P. blennoides and *M. poutassou* were the most abundant. In the lower slope, *A. antennatus* was the main landed catch (68%).

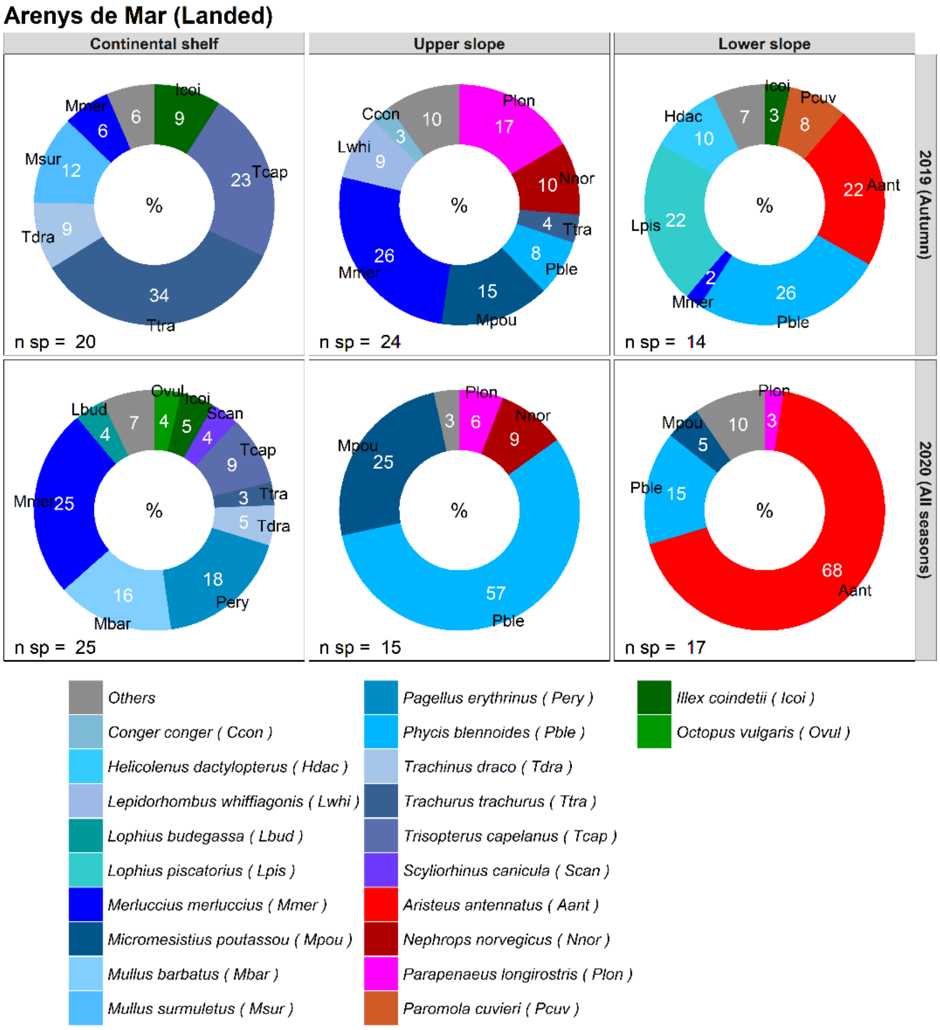


Figure 144. Species with most biomass within the landed catch in the port of Arenys de Mar. Percentage by weight of the landed fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

Considering all the landed species, Actinopterygii was the group with the highest biomass in the continental shelf and the upper slope, while Crustacea had the highest biomass in the lower slope. Fish abundance decreased with depth therefore crustaceans were more abundant in the slope (Table 29).

Table 29. Biomass (Kg/Km^2) and abundance (ind./Km^2) of the taxonomic groups present in the landed fraction of the catch in the port of Arenys de Mar. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	143.15	33.57	504.41	450.74	30.28	34.65
Chondrichthyes	6.10	3.06				
Crustacea			89.85	27.95	100.98	26.39
Cephalopoda	14.81	17.33	2.19	1.32	1.41	0.97
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	1957.84	498.44	1781.36	1709.16	224.34	196.28
Chondrichthyes	36.17	22.37				
Crustacea			5193.93	1534.58	5255.43	1663.51
Cephalopoda	233.20	315.55	28.89	22.50	4.20	2.25

The proportion of species with most biomass within the discarded catch for each year and fishing ground is shown in Figure 145. A total of 120 species were discarded in Arenys de Mar from October 2019 to December 2020 (59 in the continental shelf, 76 in the upper slope, and 52 in the lower slope). In autumn 2019, the species most discarded in the continental shelf was *B. boops* (85%), in the upper slope *S. canicula* (31%), and in the lower slope *G. melastomus* (63%). In 2020, the main discards were composed by the species *B. boops* (45%) in the continental shelf, *S. canicula* (31%) in the upper slope and *G. melastomus* (26%), and *L. crocodilus* (22%) in the lower slope.

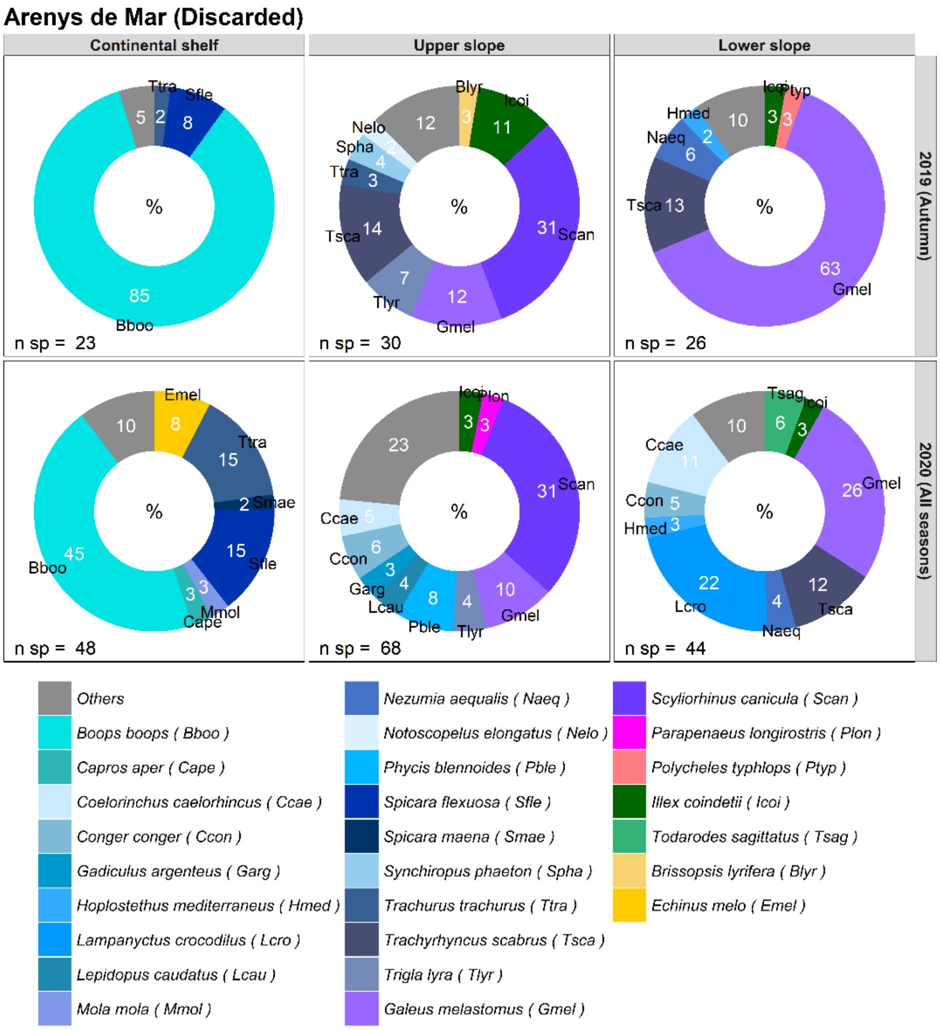


Figure 145. Species with most biomass within the discarded catch in the port of Arenys de Mar. Percentage by weight of the discarded fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

Within the discarded species, Actinopterygii was the group with the highest biomass and abundance in all fishing grounds. Echinodermata abundance and biomass had its maximum in the continental shelf. The biomass and abundance peak of crustaceans was found in the upper slope (Table 30).

Table 30. Biomass (Kg/Km^2) and abundance (ind./Km^2) of the taxonomic groups present in the discarded fraction of the catch in the port of Arenys de Mar. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	175.61	90.75	12.28	6.29	28.29	27.99
Chondrichthyes	3.47	1.76	11.08	7.92	12.49	16.03
Crustacea	0.03	0.04	1.76	1.29	0.79	0.40
Cephalopoda	0.84	0.66	1.83	0.60	5.07	5.72
Other Mollusca	0.01	0.02	0.12	0.12	0.06	0.08
Porifera	0.15	0.02				
Cnidaria	0.03	0.02	0.00	0.00	0.01	0.01
Echinodermata	20.96	21.65	0.33	0.49		
Tunicata	0.04	0.05				
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	6825.60	4443.81	888.53	486.30	1158.12	1191.61
Chondrichthyes	20.76	18.00	131.32	19.99	38.88	36.64
Crustacea	9.63	13.62	442.83	224.07	176.40	84.78
Cephalopoda	93.66	94.28	99.57	89.67	71.76	50.79
Other Mollusca	3.06	4.32	3.67	5.81	18.93	26.77
Porifera	30.85	23.35				
Cnidaria	32.18	15.74	1.84	2.60	11.01	15.57
Echinodermata	3725.27	5535.69	10.87	7.59		
Tunicata	3.06	4.32				

The debris composition is shown in Figure 146. The main component of the debris fraction was marine organic debris, being present between 38 and 62% in 2019 (autumn) and between 59 and 99% in 2020. In the upper slope, in 2020, terrestrial plants and plastic were present in higher percentages (18% and 14%, respectively) than in the other fishing grounds. The mass of debris (kg of debris by km^2) is presented in Table 31.

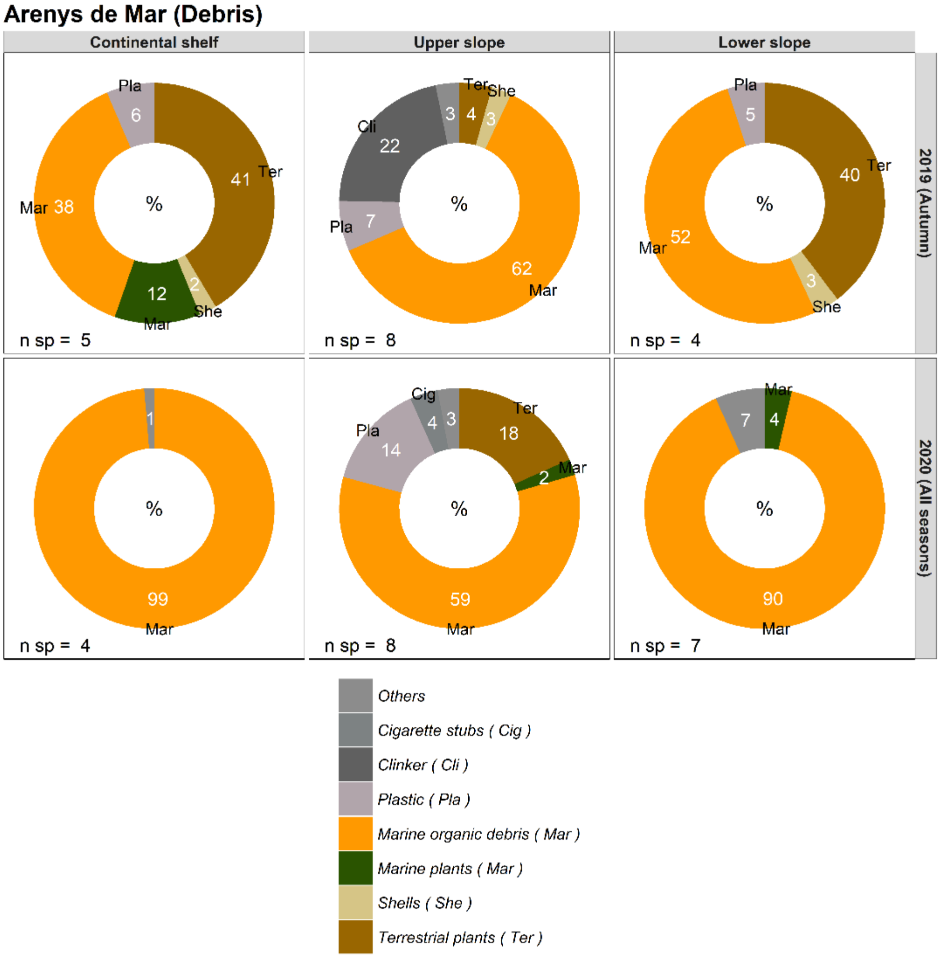


Figure 146. Items with most weight within the debris fraction of the catch in the port of Arenys de Mar. Percentage by weight in each year and fishing ground, including all hauls from October 2019 to December 2020.

Table 31. Mass (Kg/Km^2) of the items present in the debris fraction of the catch in the port of Arenys de Mar. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd
Marine organic debris	3.53	3.99	1.52	1.28	1.25	0.97
Terrestrial plants			0.48	0.58		
Plastic	0.01	0.01	0.36	0.43	0.02	0.02
Marine plants			0.06	0.05	0.05	0.03
Cigarette stubs			0.10	0.14		
Shells	0.03	0.04	0.01	0.01	0.03	0.04
Wet wipes			0.05	0.07		

	Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd
Clinker			0.02	0.02	0.02	0.03
Ropes					0.02	0.03
Lumber					0.01	0.02
Textiles	0.01	0.01				

Regarding species, the annual catch rates of hake during the period 2000-2020 in the port of Arenys de Mar showed a progressive decline, following the same pattern observed for the catch of Catalonia (Figure 147). Maximum hake catch rates were registered in 2006 (110 tons) and the minimum ones were recorded in the last years (< 40 tons).

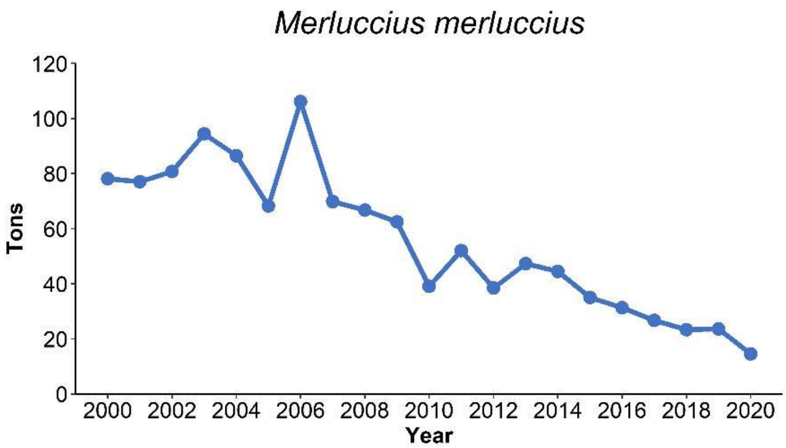


Figure 147. Time series of hake annual catch rates (tons) for the time period 2000-2020 in Arenys de Mar.

The historical series of horned octopus catches in the port of Arenys de Mar indicated a gradual decrease in catches since 2009 (Figure 148). The same trend was observed in the Norway lobster and the blue and red shrimp (Figure 149, Figure 150 respectively), although the level of catches in the blue and red shrimp was somewhat higher.

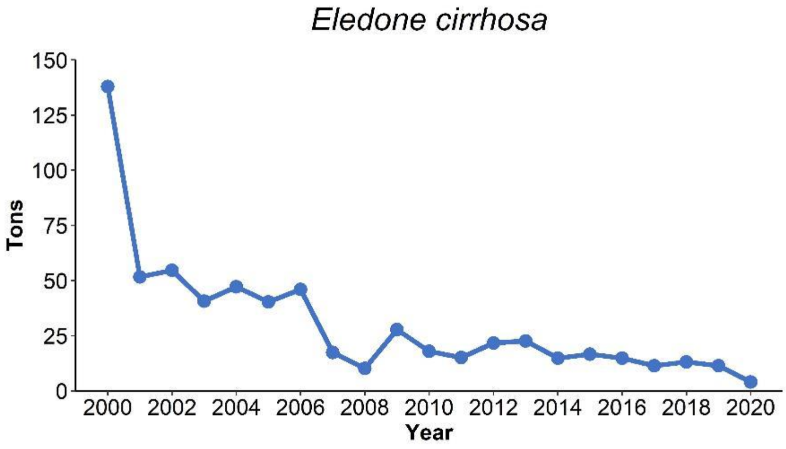


Figure 148. Time series of horned octopus annual catch rates (tons) for the time period 2000-2020 in Arenys de Mar.

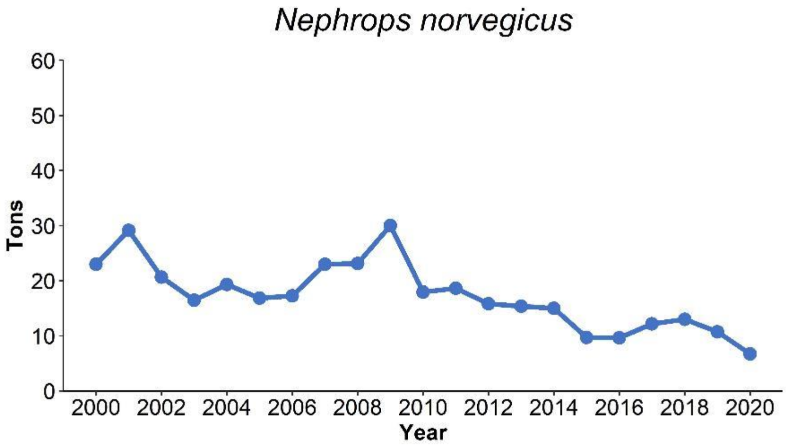


Figure 149. Time series of Norway lobster annual catch rates (tons) for the time period 2000-2020 in arenys de Mar.

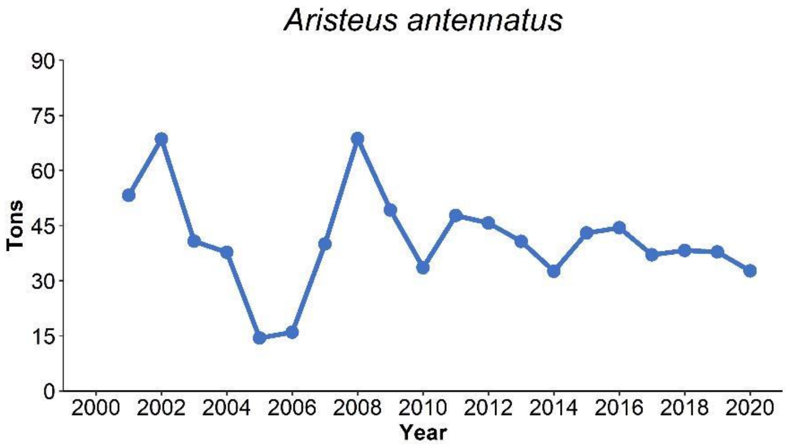


Figure 150. Time series of blue and red shrimp annual catch rates (tons) for the time period 2000-2020 in Arenys de Mar.

The length-frequency distribution of hake from October 2019 to December 2020 in the port of Arenys de Mar corresponded to catches in the common fishing grounds, where the bottom trawl fleet operated. Size range extended from 10 to 50 cm (Figure 151). The majority of the catch in the continental shelf was composed of individuals sized between 14 and 28 cm, conforming two modes: one located between 14 and 17 cm, corresponding to juvenile individuals and another mode located between 24 and 27 cm, corresponding to immature females and early adult males. Horned octopus (*E. cirrhosa*) was captured at low levels of abundance in both the continental shelf and upper slope. The length-frequency distributions of the Norway lobster (*N. norvegicus*) and the blue and red shrimp (*A. antennatus*) indicated a dominance of small-sized individuals. Size range of the Norway lobster extended from 13 to 61 mm with a mode of 28 mm in the upper slope whereas the size range of the blue and red shrimp extended from 17 to 60 mm with a mode of 33 mm in the lower slope.

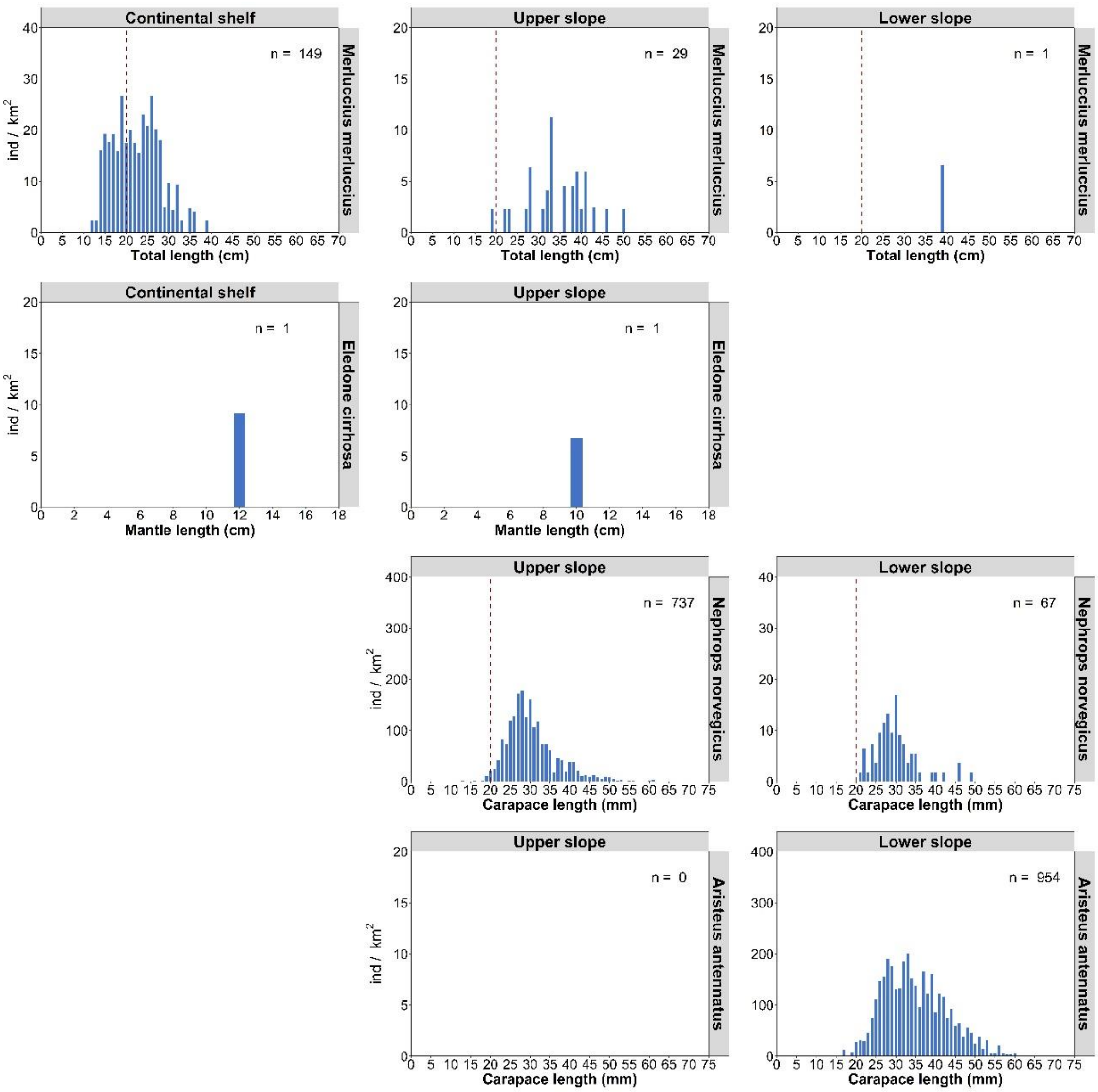


Figure 151. Length-frequency distribution of target species captured by bottom trawl at each depth stratum from October 2019 to December 2020 in the port of Arenys de Mar. The red dashed line indicates the minimum conservation reference size (MCRS).

2.1.3.5 Barcelona

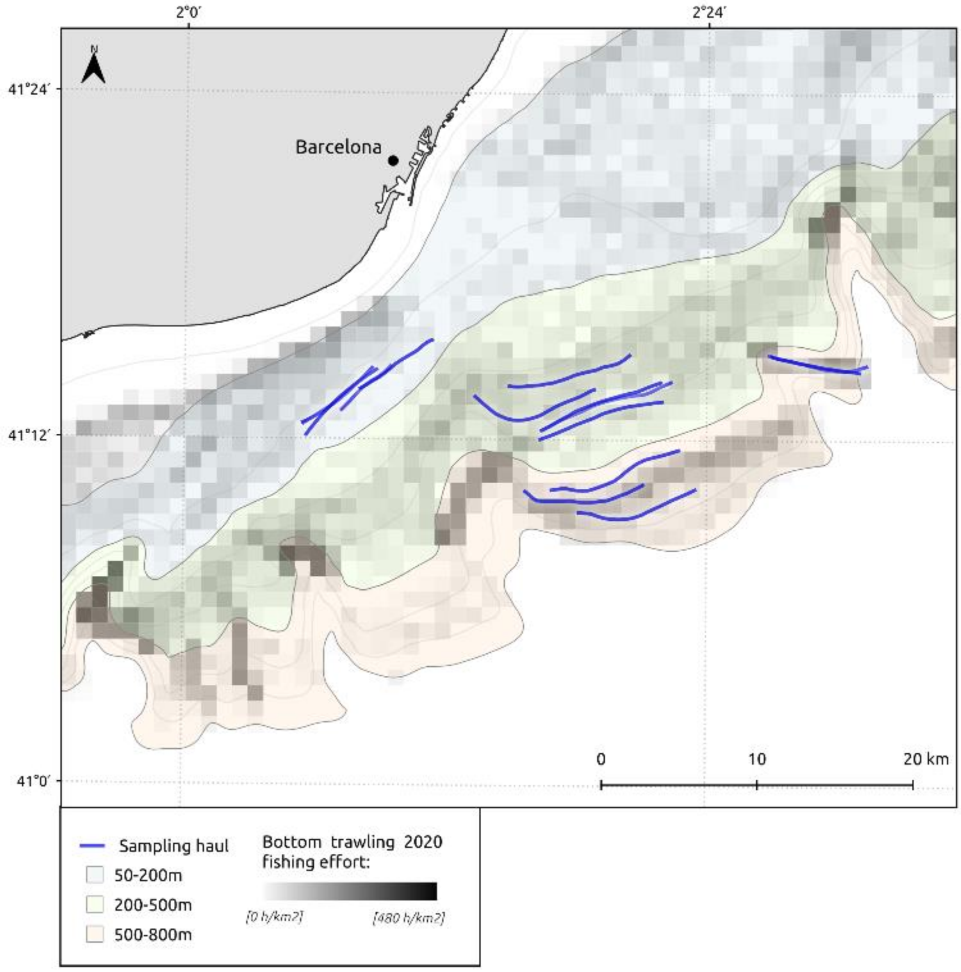


Figure 152 shows the bottom trawl commercial fishing activities and sampling bottom trawls conducted in the Barcelona port between October 2019 and December 2020.

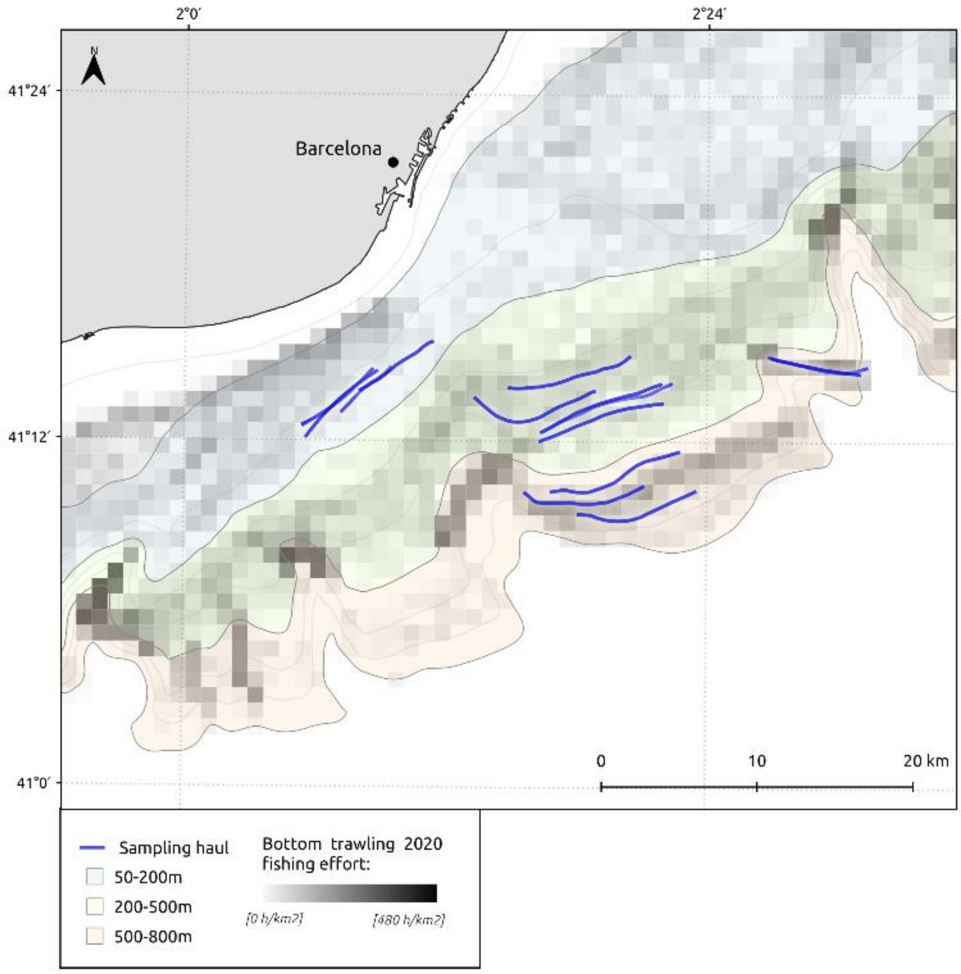


Figure 152. Map of bottom trawling hauls conducted in the port of Barcelona from October 2019 to December 2020.

The characterization of the catches for the 15 bottom trawling hauls conducted in Barcelona from October 2019 to December 2020 is shown in Figure 153 per each year and fraction of the catch (landed, discarded, and debris). In autumn 2019, the landed catches represented from 30 to 73% of the total catches. The discarded fraction ranged between the 13 and 57% of the total biomass and the debris between 10 and 14%. In 2020, the landed catches represented, depending on the fishing ground, from 42 to 74% of the total catches. The discarded fraction ranged between the 16 and 36% of the total biomass and the debris between 10 and 22%.

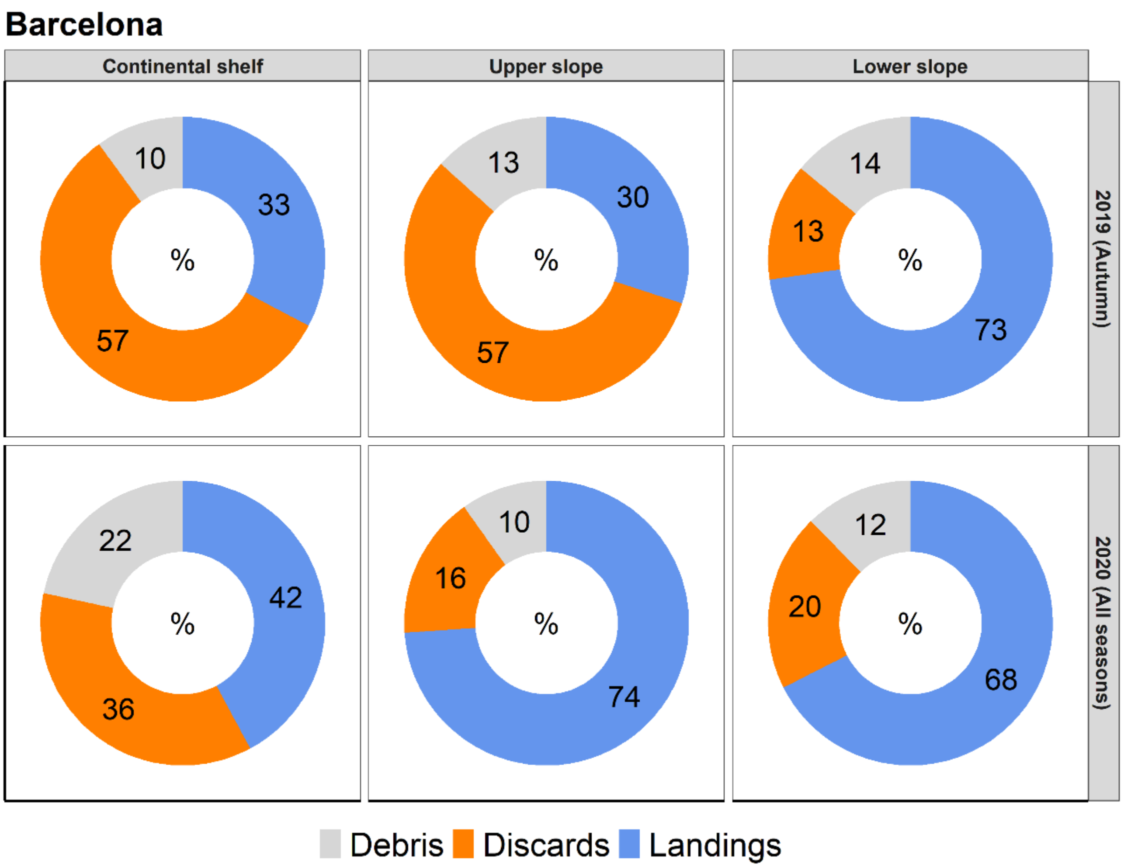


Figure 153. Catch composition in the port of Barcelona. Percentage by weight of landings, discarded and debris fraction in each year and fishing ground, including all hauls from October 2019 to December 2020.

The proportion of species with most of the biomass within the landed catch for each year and fishing ground is shown in Figure 154. A total of 66 species were landed in Barcelona from October 2019 to December 2020 (46 in the continental shelf, 28 in the upper slope, and 25 in the lower slope). In autumn 2019, *M. merluccius* represented 17% of the landed catch in the continental shelf and 34% in the upper slope. The species *T. trachurus* and *L. budegassa* were important catches in the continental shelf. In the upper slope, *P. longirostris* and *P. blennoides* represented, both species together, the 44 % of the landed catches. In the lower slope, the main species landed were *A. antennatus* (40%) and *G. longipes* (28%). In 2020, the target species found in this port (*M. merluccius*, *N. norvegicus*, *A. antennatus*, and *E. cirrhosa*) represented the 11% of the landed catch in the continental shelf, the 21% in the upper slope and the 46% in the lower slope. In the continental shelf dominated *T. trachurus*, with the 34% of the landed catches. In the upper slope, *S. canicula* was the main species (33%) followed by *P. longirostris* and *N. norvegicus*. In the lower slope, the main species landed were *A. antennatus* and *P. blennoides.*

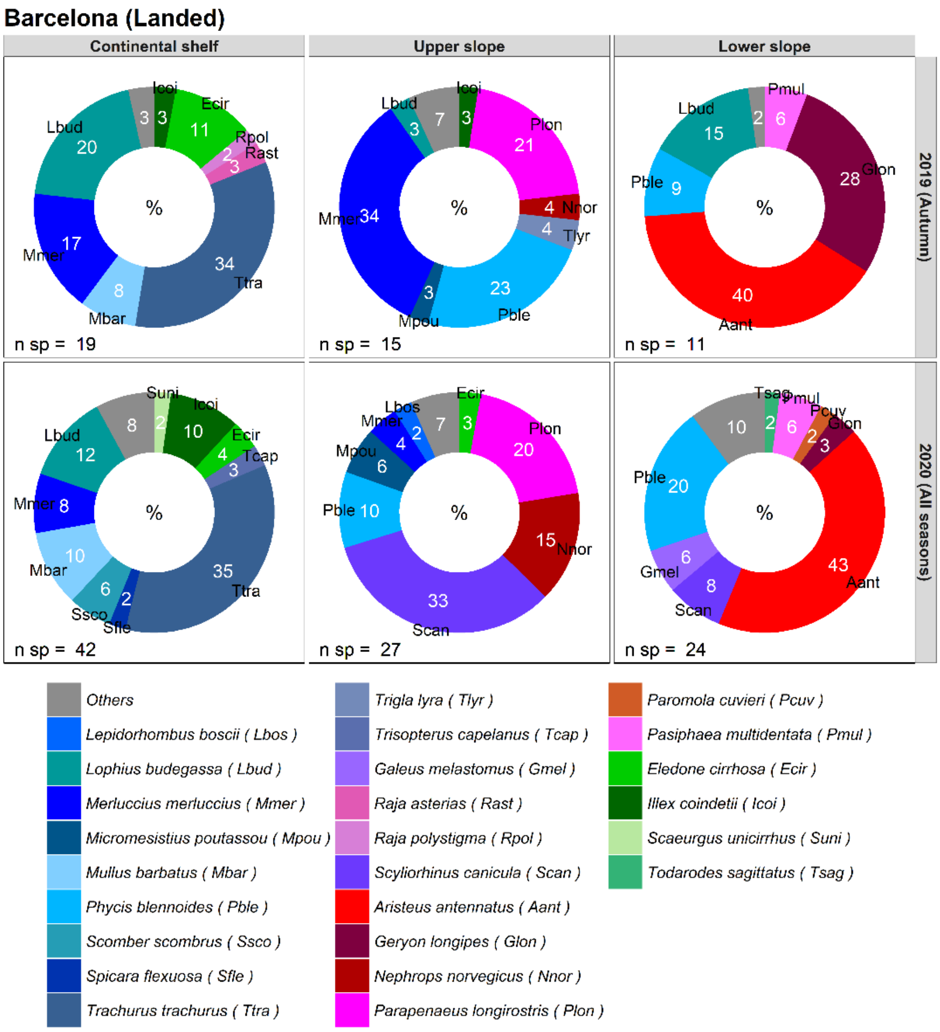


Figure 154. Species with most biomass within the landed catch in the port of Barcelona. Percentage by weight of the landed fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

Within the landed species, Actinopterygii prevailed in biomass and abundance in the continental shelf, followed by Cephalopoda. In the upper and lower slope Crustacea were in first place in terms of biomass and abundance, followed by Actinopterygii and chondrichthyes (Table 32).

Table 32. Biomass (Kg/Km^2) and abundance (ind./Km^2) of the taxonomic groups present in the landed fraction of the catch in the port of Barcelona. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	449.97	303.32	69.98	31.45	59.62	25.68
Chondrichthyes	2.56	4.43	89.41	54.71	30.85	29.81
Crustacea	0.67	0.58	95.28	36.33	131.54	49.36
Cephalopoda	95.15	106.23	13.05	9.02	5.32	3.40
Echinodermata	0.68	1.18				
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	8079.39	7385.46	801.24	463.98	370.34	142.75
Chondrichthyes	1.84	3.19	471.96	326.29	112.87	99.24
Crustacea	44.95	39.66	6768.80	2726.13	7937.18	3369.34
Cephalopoda	1250.34	1940.38	97.11	66.94	12.54	7.82
Echinodermata	2.70	4.67				

The proportion of species with most of the biomass within the discarded catch for each year and fishing ground is shown in Figure 155. A total of 164 species were discarded in Barcelona from October 2019 to December 2020 (89 in the continental shelf, 93 in the upper slope, and 77 in the lower slope). Chondrichthyes (mainly *S. canicula*, and *G. melastomus*) were discarded in most fishing grounds in autumn 2019 and in 2020. In 2020, *B*. *boops* was the most discarded species (31% of the discarded catch) in the continental shelf.

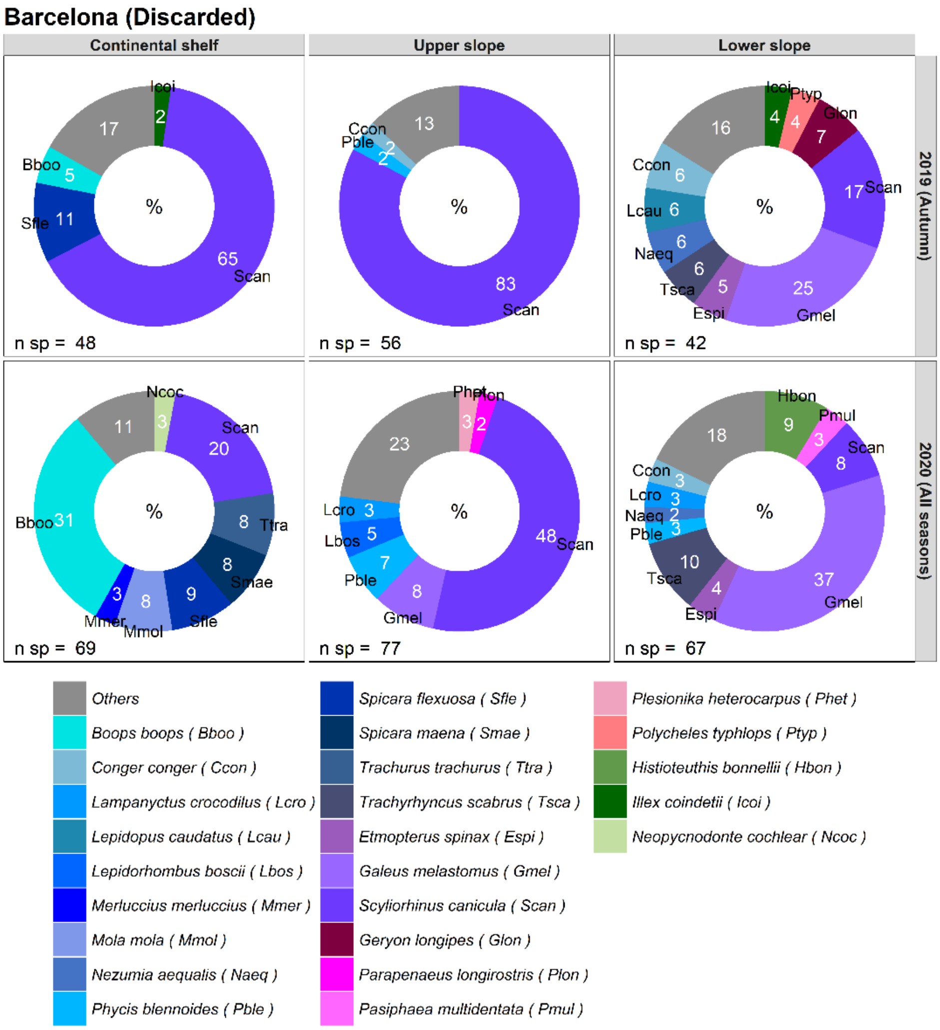


Figure 155. Species with most biomass within the discarded catch in the port of Barcelona. Percentage by weight of the discarded fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

Considering all the discarded species, fish (Actinopterygii + chondrichthyes), Mollusca (Cephalopoda + other Mollusca), Echinodermata, and Cnidaria were the most abundant taxonomic groups on the continental shelf. Fish had the highest biomass in the upper and lower slope, but considering abundance, Crustacea was the most important group in the lower slope (Table 33).

Table 33. Biomass (Kg/Km^2) and abundance ($ind./Km^2$) of the taxonomic groups present in the discarded fraction of the catch in the port of Barcelona. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	364.59	353.29	14.35	12.55	21.23	2.89
Chondrichthyes	107.00	55.92	29.43	43.80	33.79	40.44
Crustacea	6.79	4.01	4.61	3.99	5.50	2.76
Cephalopoda	4.14	1.92	2.27	4.08	8.16	6.27
Other Mollusca	15.33	20.06	0.19	0.25	0.03	0.03
Cnidaria	6.93	6.62	0.30	0.21	0.14	0.16
Annelida	2.97	2.26	0.05	0.07	0.05	0.09
Sipuncula	0.00	0.00				
Echinodermata	6.43	6.42	0.16	0.16	0.12	0.10
Tunicata	2.08	2.75	0.03	0.03	0.01	0.01
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	8179.07	5631.23	1012.08	771.06	985.19	285.61
Chondrichthyes	1124.33	113.35	385.55	256.11	255.97	208.05
Crustacea	527.62	247.30	1101.25	631.58	1297.12	1529.77
Cephalopoda	227.50	83.65	184.29	296.79	107.79	127.77
Other Mollusca	634.55	574.41	30.24	50.45	18.29	15.42
Cnidaria	1004.38	667.69	70.08	47.66	52.07	39.21
Annelida	68.72	49.85	2.75	5.26	2.85	4.93
Sipuncula	13.49	23.36				
Echinodermata	493.19	655.72	60.80	62.33	53.68	57.03
Tunicata	221.62	137.05	11.00	12.69	3.56	6.17

The debris composition is shown in Figure 156. The main debris in 2019 were terrestrial plants, lumber, and clinker. In 2020, a large quantity of wet wipes was found in all fishing grounds (31 - 43%). Terrestrial plants were also found in the three fishing grounds (20 - 30%). Plastic was present in all studied depths, being 12% of the debris in both the continental shelf and upper slope, and 5% in the lower slope. Results of debris in the port of Barcelona in terms of biomass are shown in the Table 34.

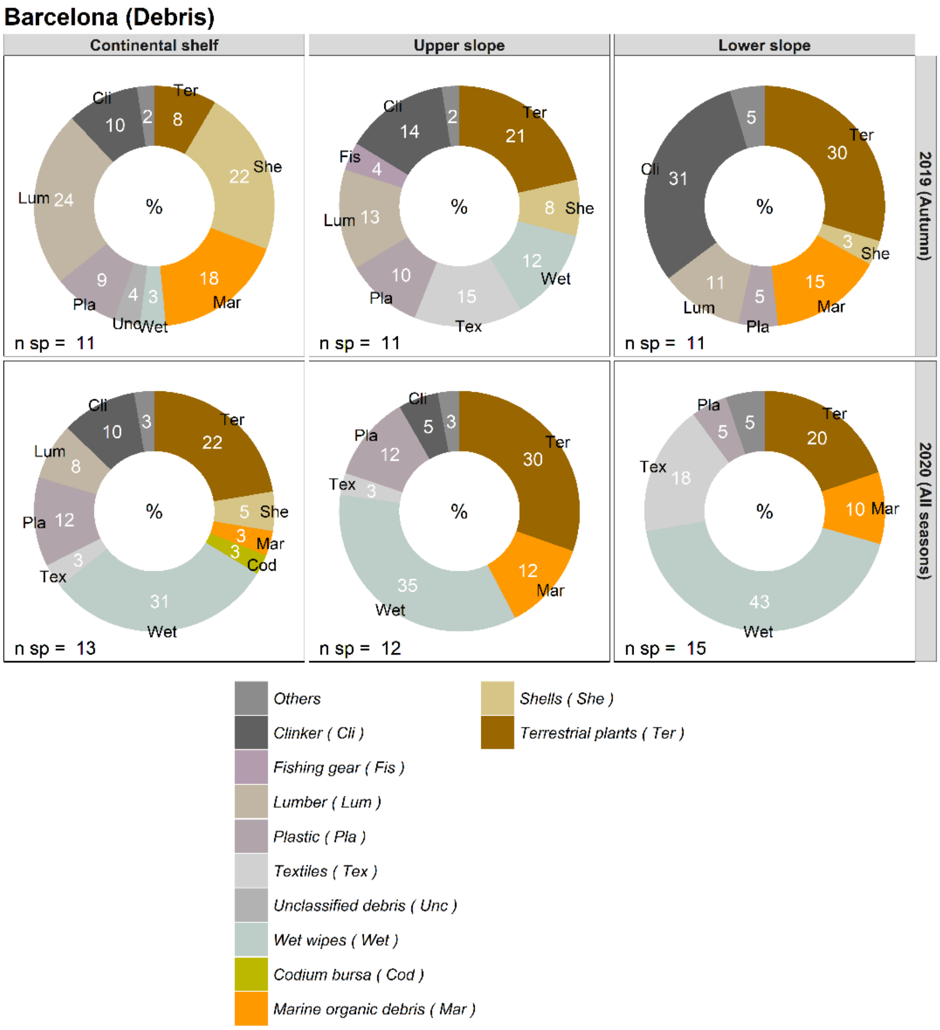


Figure 156. Items with most weight within the debris fraction of the catch in the port of Barcelona. Percentage by weight in each year and fishing ground, including all hauls from October 2019 to December 2020.

Table 34. Mass (Kg/Km^2) of the debris present in the debris fraction of the catch in the port of Barcelona. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd
Wet wipes	72.04	75.60	11.97	6.24	17.49	11.07
Terrestrial plants	52.64	31.33	10.43	8.77	8.04	1.12
Plastic	28.21	25.13	3.97	0.76	1.99	0.79
Clinker	23.87	38.82	1.85	0.91	0.41	0.50
Lumber	17.94	3.31			0.02	0.03
Textiles	7.69	13.32	1.02	0.68	7.17	11.05
Marine organic debris	7.82	1.94	4.11	3.13	3.94	1.28

	Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd
Shells	12.46	5.04	0.31	0.45	0.45	0.62
Codium bursa	6.36	7.92				
Marine plants	2.35	3.18	0.15	0.14	0.51	0.21
Metal	2.34	0.97			0.17	0.29
Ropes	1.42	2.52	0.19	0.34	0.07	0.07
Unclassified debris			0.17	0.29	0.26	0.45
Fishing gear	0.24	0.42	0.01	0.01	0.01	0.01
Calcified remains					0.20	0.36
Rubber			0.17	0.29	0.03	0.06

Regarding species the annual catch rates of hake during the period 2000-2020 in the port of Barcelona showed a fluctuation between 40 and 60 tons until 2015 (Figure 157). Onwards, from 2016 to 2020, hake catches tended to slightly decrease. Maximum hake catch rates were registered in 2011 (>100 tons) and the minimum rates were recorded in last years.

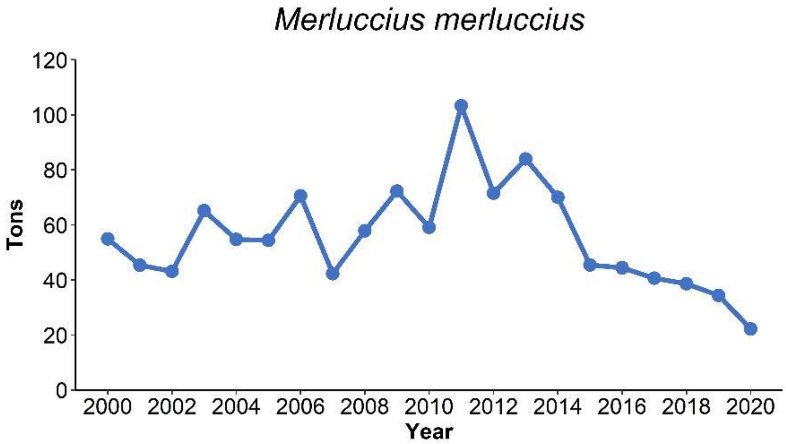


Figure 157. Time series of hake annual catch rates (tons) for the time period 2000-2020 in Barcelona.

The historical series of catches from 2000 to 2020 for both species, the horned octopus (Figure 158) and the Norway lobster (Figure 159), was practically the same. They remained constant as of 2016, but dropped in the last two years. In the case of the blue and red shrimp, the catches peaked in 2012, then the trend was unstable until 2016, when from this point on, it switched to a slight upward trend (Figure 160).

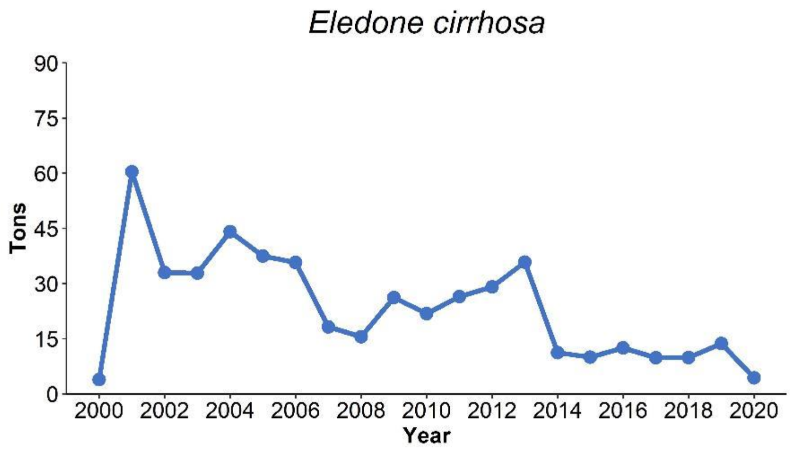


Figure 158. Time series of horned octopus annual catch rates (tons) for the time period 2000-2020 in Barcelona.

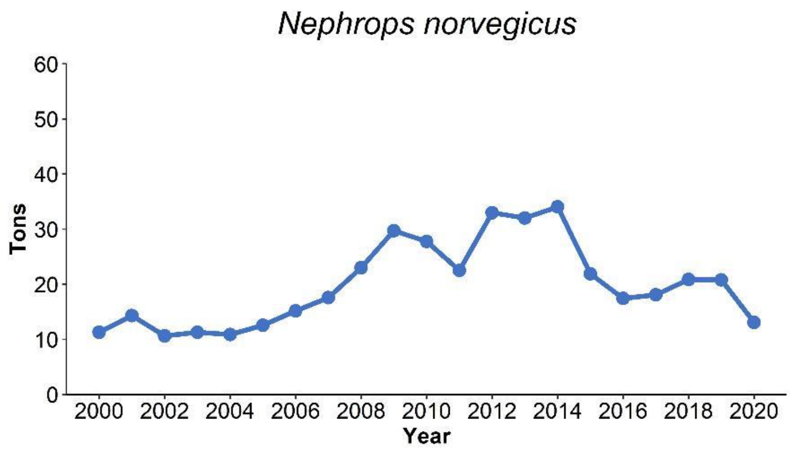


Figure 159. Time series of Norway lobster annual catch rates (tons) for the time period 2000-2020 in Barcelona.

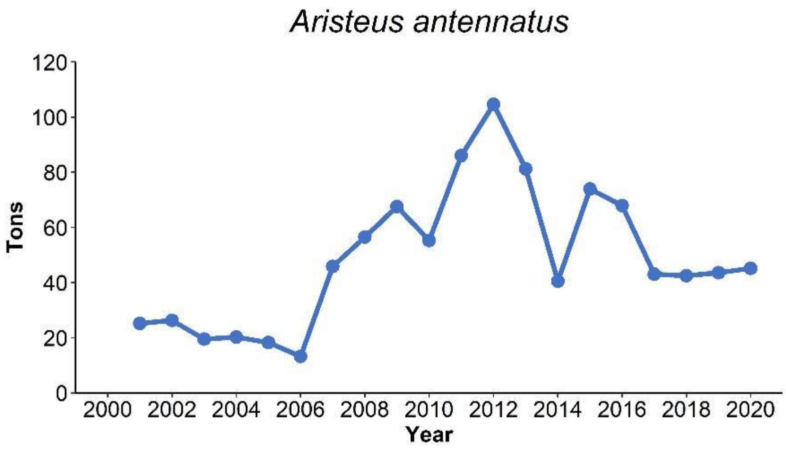


Figure 160. Time series of blue and red shrimp annual catch rates (tons) for the time period 2000-2020 in Barcelona.

The length-frequency distribution of hake from October 2019 to December 2020 in the port of Barcelona corresponded to catches in the common fishing grounds where the bottom trawl fleet operated. Size range extended from 8 to 59 cm (Figure 161). The majority of the catch in the continental shelf was composed of individuals sized between 14 and 18 cm, below the MCRS, and associated to juvenile and immature specimens. However, in the upper slope, hake catches moved towards larger sizes but their presence was scarce. Horned octopus (*E. cirrhosa*) was captured at low levels of abundance in the continental shelf and upper slope with a mode of 7 and 9 cm, respectively. The length-frequency distributions of the Norway lobster (*N. norvegicus*) and the blue and red shrimp (*A. antennatus*) indicated a dominance of small-sized individuals. Size range of the Norway lobster extended from 14 to 57 mm with a mode between 25 and 30 mm in the upper slope whereas the size range of the blue and red shrimp extended from 18 to 57 mm with a mode between 27 and 31 mm in the lower slope.

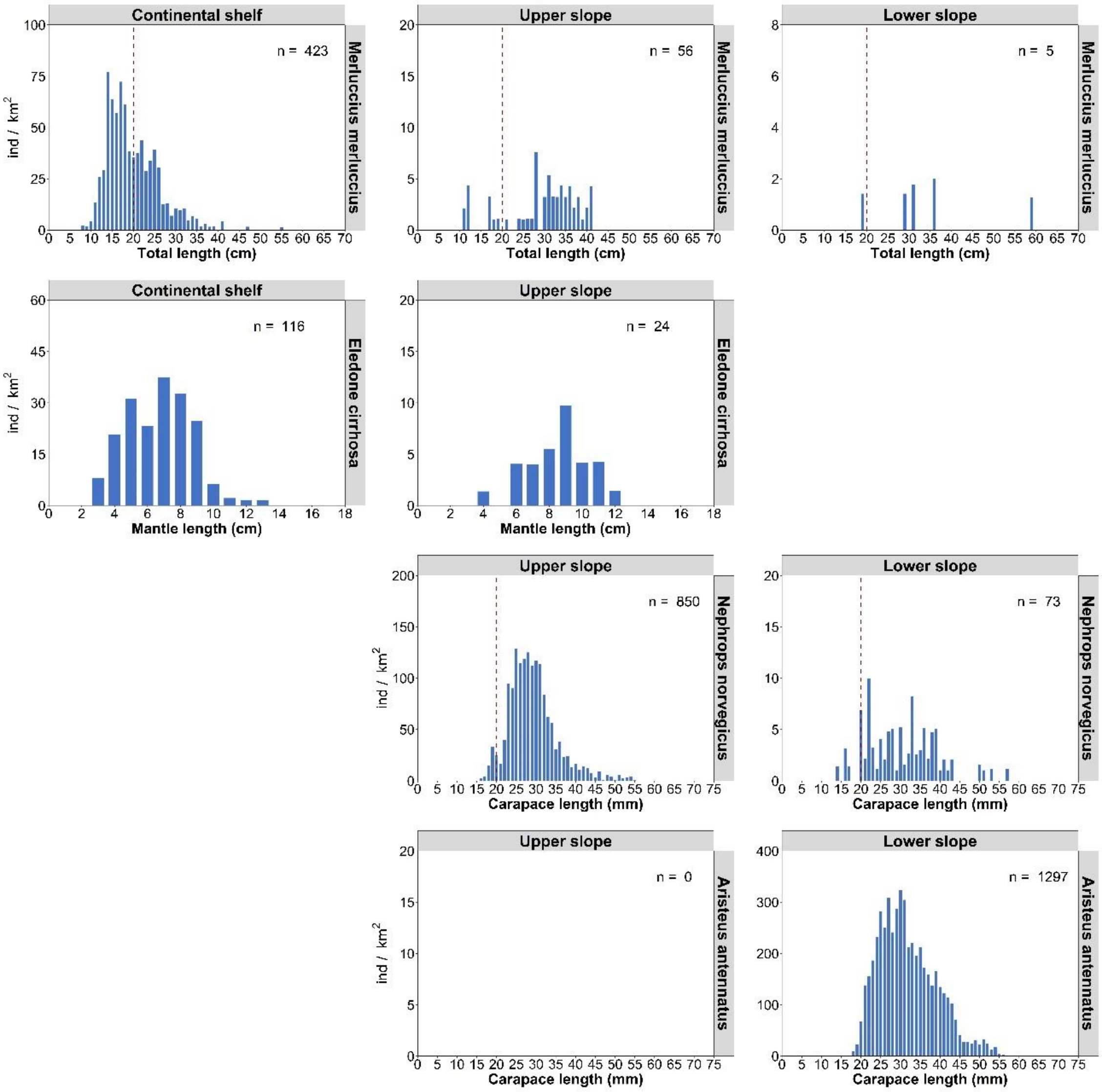


Figure 161. Length-frequency distribution of the target species captured by bottom trawl at each depth stratum from October 2019 to December 2020 in the port of Barcelona. The red dashed line indicates the minimum conservation reference size (MCRS).

2.1.3.6 Vilanova i la Geltrú

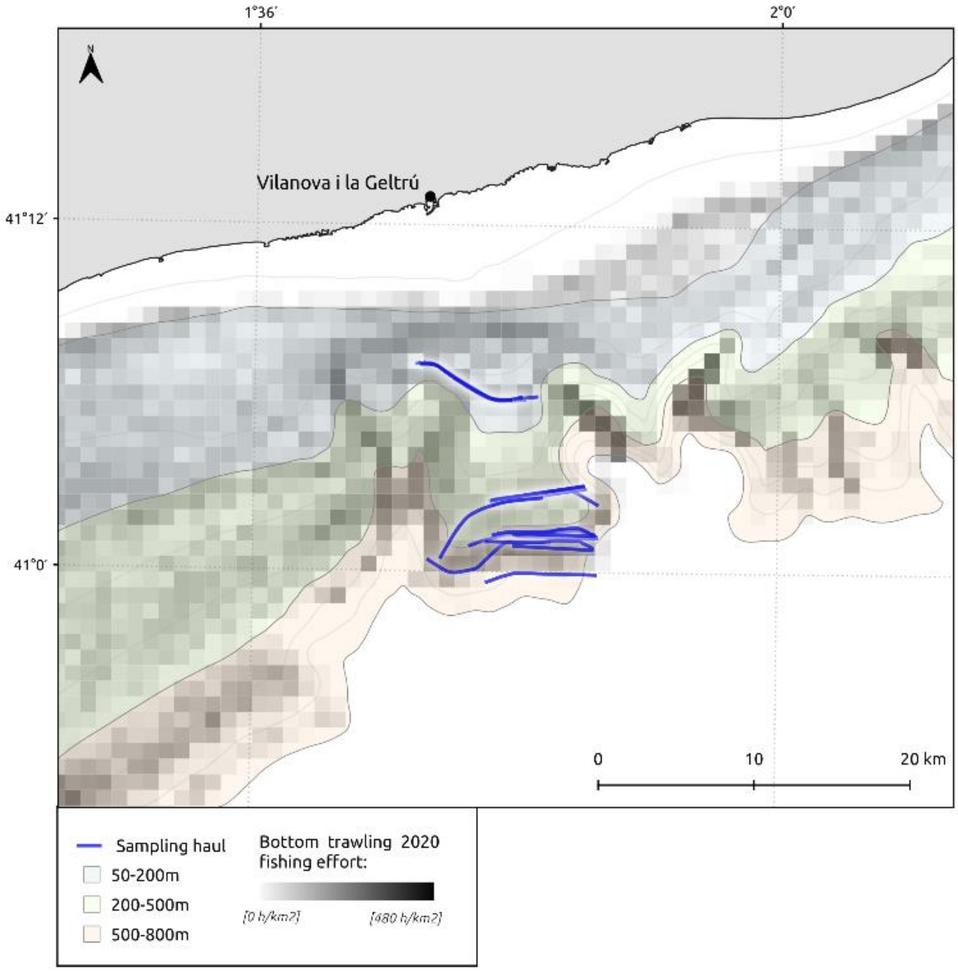


Figure 162 shows the bottom trawl commercial fishing activities and sampling bottom trawls conducted in the Vilanova i la Geltrú port between October 2019 and December 2020.

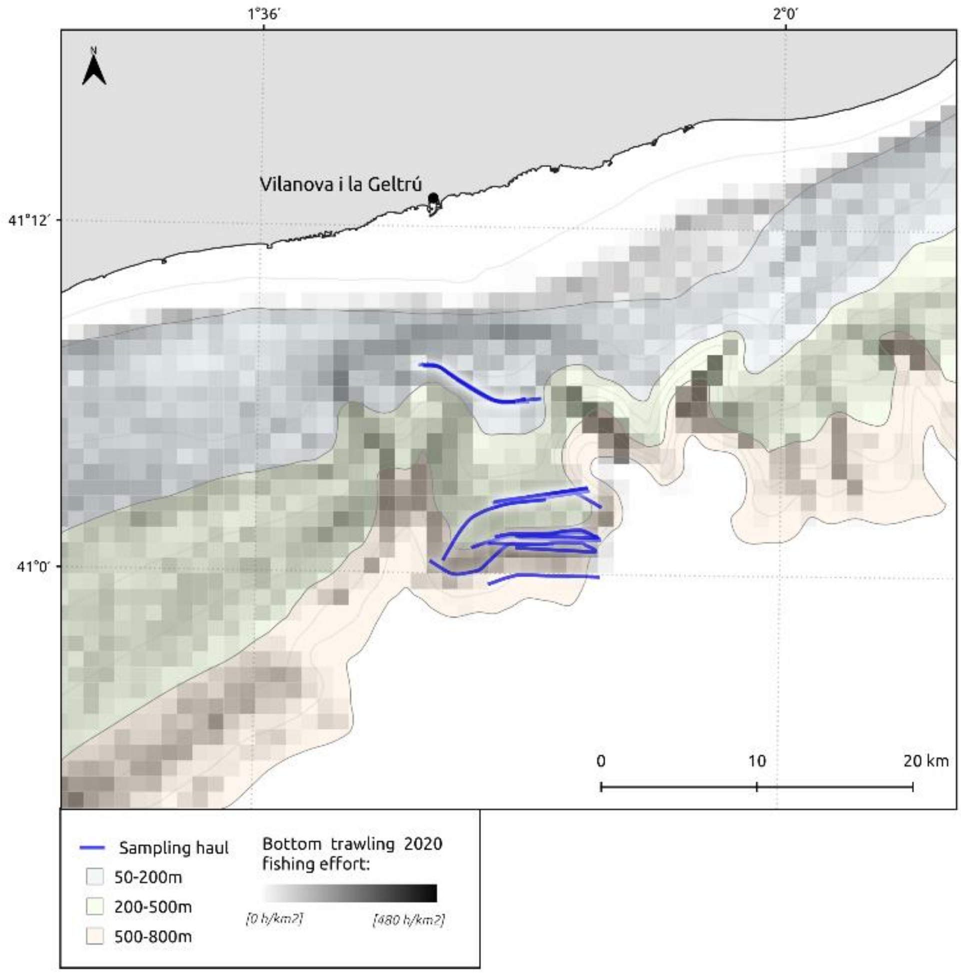


Figure 162. Map of bottom trawling hauls conducted in the port of Vilanova I la Geltrú from October 2019 to December 2020.

The characterization of the catches for the 15 bottom trawling hauls conducted in Vilanova i la Geltrú from October 2019 to December 2020 is shown in Figure 163, per each year and fraction of catch (landed, discarded, and debris). In autumn 2019, the landed catches represented, depending on the fishing ground, 74 to 90% of the total catches. The discarded fraction ranged between the 9 and 17% of the total biomass wereas the debris ranged between 1 and 12%. In 2020, the landed catches represented, according to each fishing ground, from 66 to 83% of the total catches. The discarded fraction ranged between 14 and 23% of the total biomass and the debris ranged between 3 and 15%.

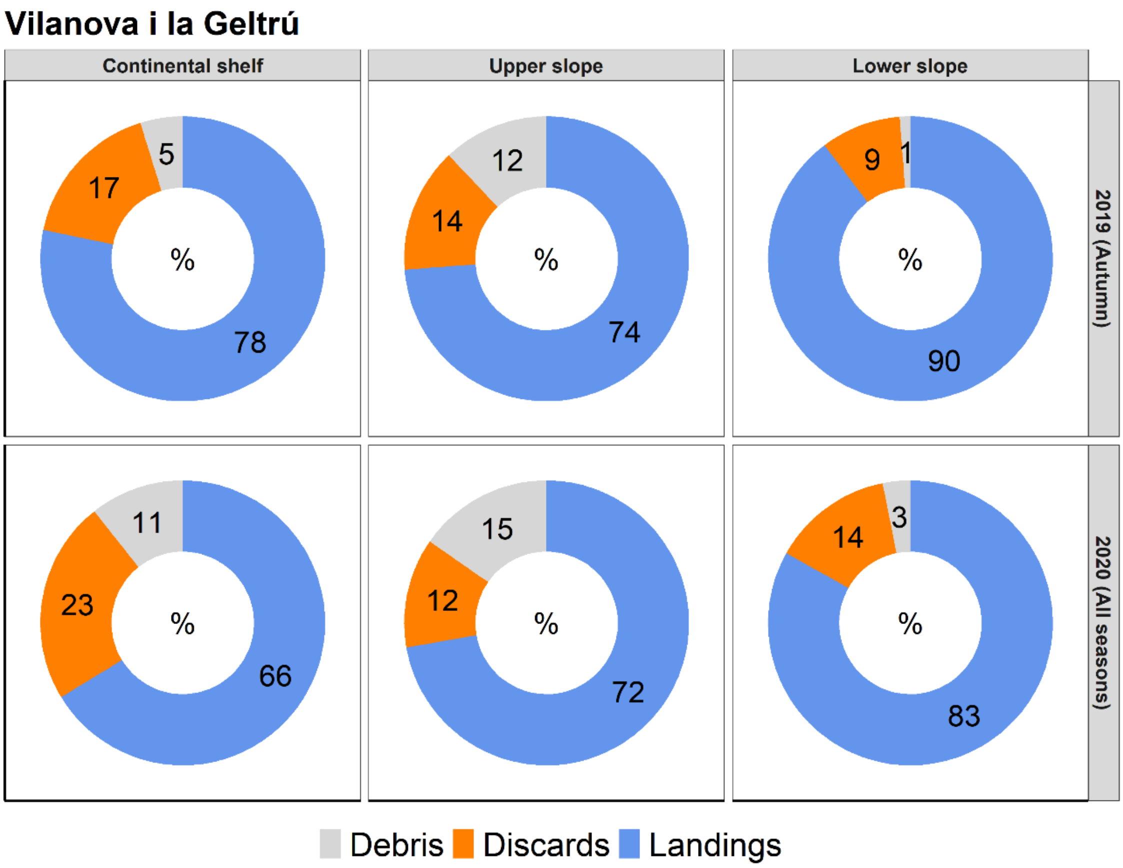


Figure 163. Catch composition in the port of Vilanova i la Geltrú. Percentage by weight of landings, discarded and debris fraction in each year and fishing ground, including all hauls from October 2019 to December 2020.

The proportion of species with most biomass within the landed catch for each year and fishing ground is shown in Figure 164. A total of 67 species were landed in Vilanova i la Geltrú from October 2019 to December 2020 (45 in the continental shelf, 30 in the upper slope, and 22 in the lower slope). In autumn 2019, *T. trachurus* and *T. picturatus* accounted for 80% of the landed catch in the continental shelf. In the upper slope, *N. norvegicus* was the 27% of the landed catch, where *L. piscatorius, P. blennoides,* and *E. cirrhosa* were also abundant. In the lower slope, 55% of the catch was the species *A. antennatus*. In 2020, the target species found in this port (*M. merluccius*, *N. norvegicus*, *A. antennatus*, and *E. cirrhosa*) represented the 14% of the landed catch in the continental shelf, the 43% in the upper slope, and the 75% in the lower slope. *Trachurus* spp. were the 37% of the landed catch but *L. budegassa* and *M. merluccius* were also important species. In the upper slope, *M. merluccius* represented the 21% of the landed catch, followed by *N. norvegicus* (16%). In addition, in the same depth, *P. blennoides, P. longirostris*, and *M. poutassou* represented the 40% of the landings counting the three species together. In the lower slope, *A. antennatus* accounted for the 64% of the landed catch.

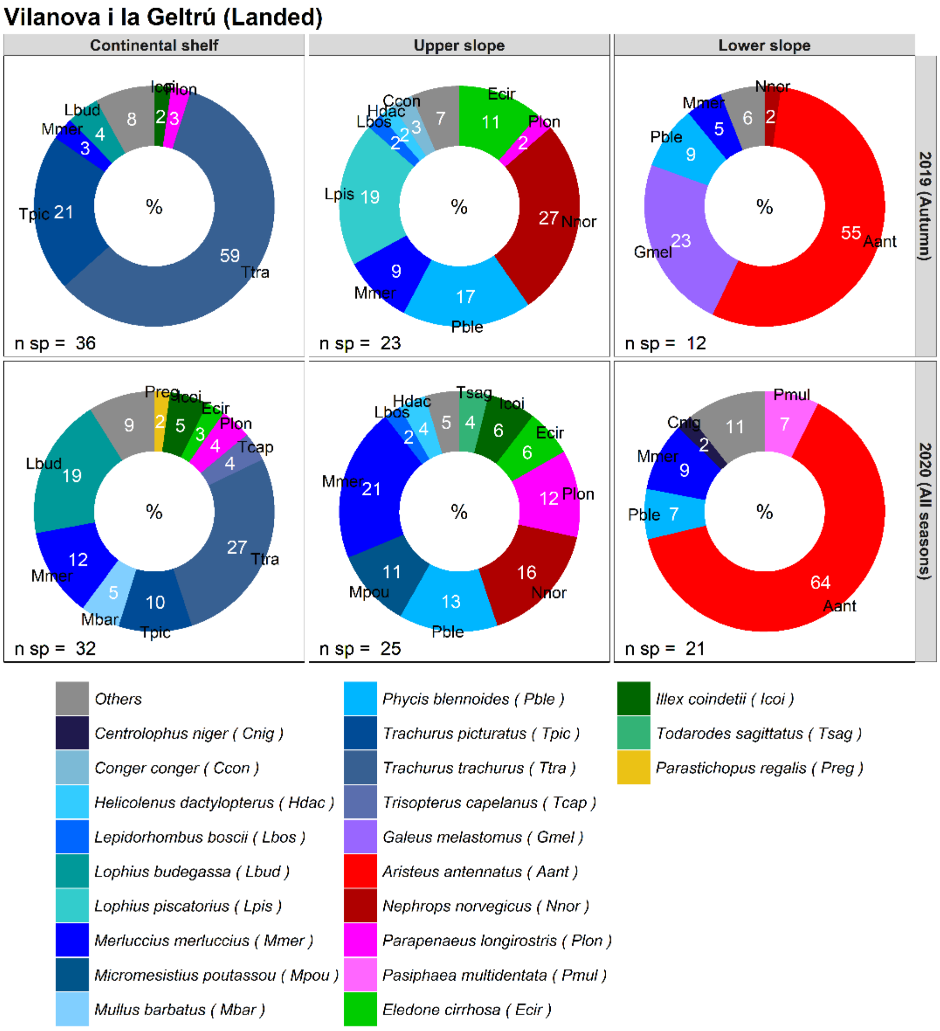


Figure 164. Species with most biomass within the landed catch in the port of Vilanova i la Geltrú. Percentage by weight of the landed fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

For the landed species, the continental shelf had the highest diversity of taxonomic groups. In the upper slope, Actinopterygii had the highest biomass and abundance followed by Cephalopoda and Crustacea. In the lower slope, Crustacea was the most abundant group, also having with the highest biomass (Table 35).

Table 35. Biomass (Kg/Km^2) and abundance (ind./Km^2) of the taxonomic groups present in the landed fraction of the catch in the port of Vilanova I la Geltrú. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	97.91	45.91	34.10	9.40	21.19	11.23
Chondrichthyes	1.87	2.65			0.59	0.84
Crustacea	5.03	5.50	18.67	9.43	74.64	33.69
Cephalopoda	10.82	7.63	10.65	4.40	2.75	2.67
Other Mollusca	0.04	0.05	0.10	0.06		
Echinodermata	2.47	3.49				
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	1537.66	1314.73	348.17	66.97	99.71	32.68
Chondrichthyes	16.23	22.96			1.64	2.31
Crustacea	1198.35	1651.72	1088.38	620.23	3810.47	1839.75
Cephalopoda	288.05	337.48	61.78	36.77	12.66	14.12
Other Mollusca	1.62	2.30	2.89	1.88		
Echinodermata	23.39	33.08				

The proportion of species the most biomass within the discarded catch for each year and fishing ground is shown in Figure 165. A total of 184 species were discarded in Vilanova i la Geltrú from October 2019 to December 2020 (130 in the continental shelf, 90 in the upper slope, and 51 in the lower slope). In autumn 2019, in the continental shelf and upper slope, the main discards were fish (*B. boops* and *P. blennoides*) and chondrichthyes (*S. canicula* and *G. melastomus*). In the lower slope, cephalopoda *H. bonnellii* and *H. reversa* accounted for the 14% of the discards wereas the crustacean *P. cuvieri*accounted for the 9%. In 2020, *S. flexuosa* (36%) and *M. merluccius* (18%) were the main discards in the continental shelf. In the upper slope, the main species discarded was *S. canicula* (66%) and in the lower slope, *H. bonnellii* (41%).

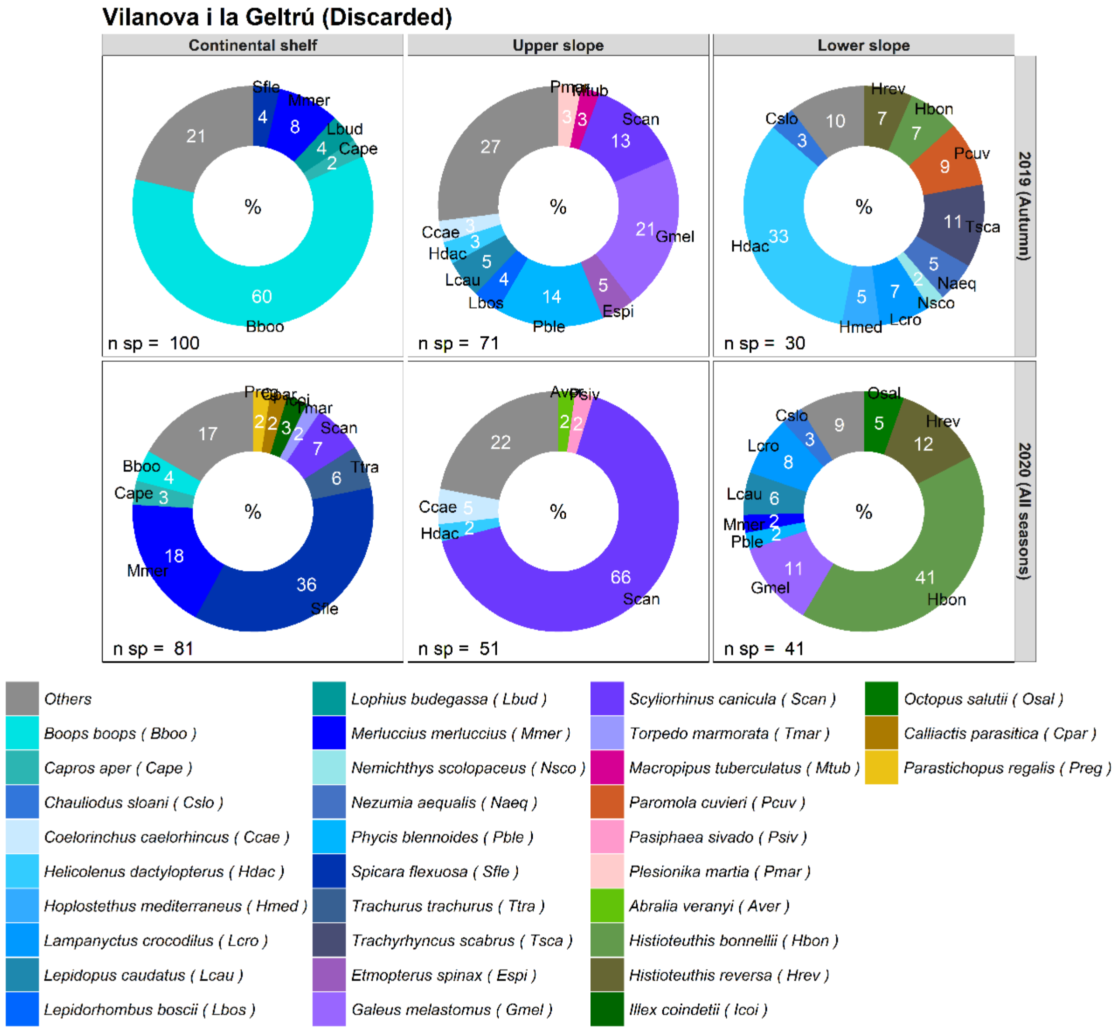


Figure 165. Species with most biomass within the discarded catch in the port of Vilanova I la Geltrú. Percentage by weight of the discarded fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

For the discarded species, actinopterygii and chondrichthyes had the highest biomass in the continental shelf and upper slope. In terms of abundance, actinopterygii was the most abundant group in the continental shelf and lower slope, while in the upper slope, crustacea was the most abundant group (Table 36).

Table 36. Biomass (Kg/Km^2) and abundance ($ind./Km^2$) of the taxonomic groups present in the discarded fraction of the catch in the port of Vilanova I la Geltrú. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	28.74	4.92	1.90	0.90	4.87	3.76
Chondrichthyes	3.40	2.65	7.97	10.12	2.32	2.07
Crustacea	1.24	0.42	0.82	0.49	1.02	0.46
Cephalopoda	1.63	0.39	0.48	0.27	12.01	17.72
Other Mollusca	0.66	0.30	0.06	0.04		
Porifera	0.21	0.29	0.00	0.00		
Cnidaria	1.06	0.79	0.07	0.10	0.02	0.03
Annelida	0.24	0.24	0.03	0.05	0.00	0.00
Echinodermata	1.41	0.96	0.19	0.29		
Tunicata	0.54	0.26	0.09	0.12		
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	1159.89	365.19	133.21	86.09	270.85	215.48
Chondrichthyes	51.58	36.90	64.57	28.17	16.73	4.19
Crustacea	282.93	168.37	321.37	391.92	145.92	34.26
Cephalopoda	205.01	93.40	64.23	94.39	48.61	21.08
Other Mollusca	100.49	93.89	3.33	2.08		
Porifera	21.87	25.77	1.25	1.77		
Cnidaria	162.88	102.35	36.84	51.16	10.63	15.03
Annelida	9.36	14.80	1.04	1.47	0.00	0.00
Echinodermata	118.14	52.88	10.34	6.80		
Tunicata	132.25	68.72	5.63	2.96		

The debris composition is shown in Figure 166. In all fishing grounds, considering both autumn 2019 and all 2020, marine organic debris (13 - 49%) and plastic (6 - 38%) were always present. Lumber, wet wipes and terrestrial plants were also present in high percentages depending on the fishing ground. The mass of debris (kg of debris by km2) is presented in Table 37.

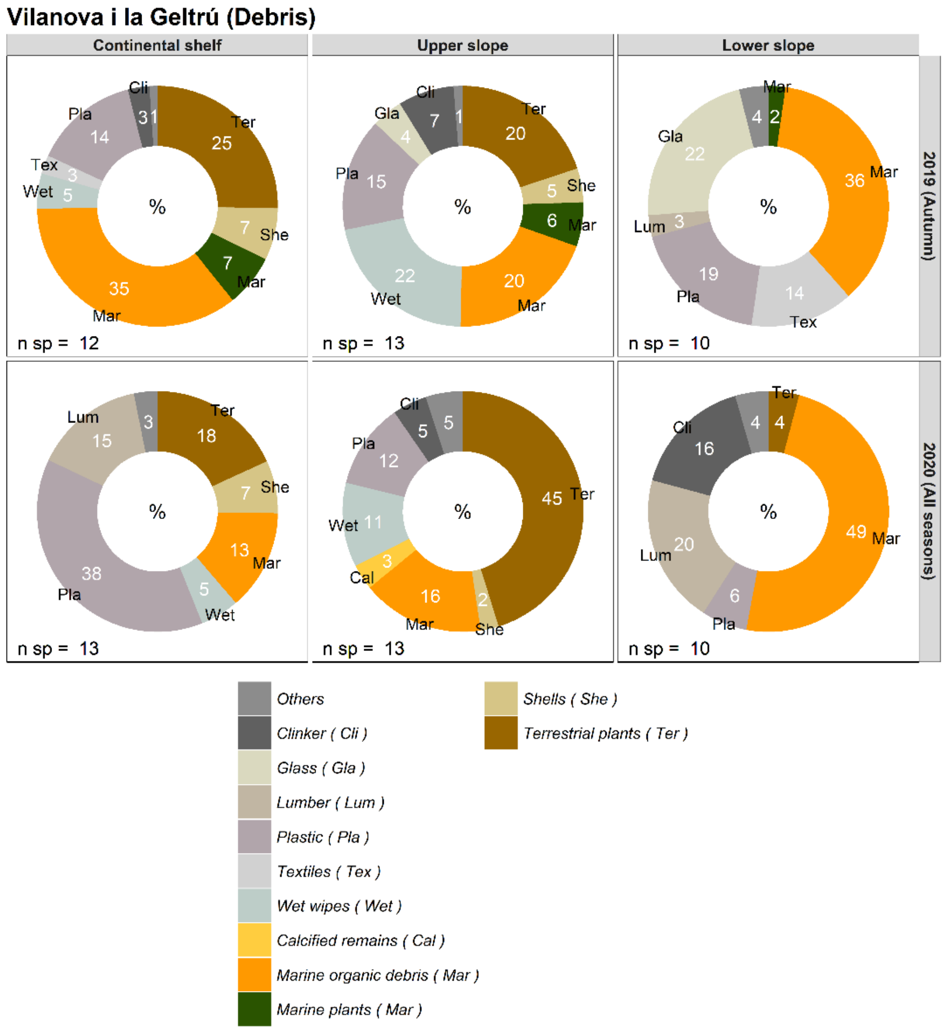


Figure 166. Items with most weight within the debris fraction of the catch in the port of Vilanova i la Geltrú. Percentage by weight in each year and fishing ground, including all hauls from October 2019 to December 2020.

Table 37. Mass (Kg/Km^2) of the debris present in the debris fraction of the catch in the port of Vilanova I la Geltrú. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd
Terrestrial plants	3.20	2.18	6.33	3.81	0.12	0.18
Plastic	6.72	3.06	1.61	1.25	0.19	0.12
Marine organic debris	2.38	2.26	2.30	2.39	1.49	0.92
Lumber	2.62	3.85	0.20	0.10	0.61	0.75
Wet wipes	0.92	0.69	1.59	1.37	0.05	0.06
Shells	1.25	1.16	0.34	0.29	0.05	0.07
Clinker	0.10	0.06	0.65	0.80	0.50	0.39

	Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd
Calcified remains			0.48	0.68		
Marine plants	0.29	0.19	0.15	0.19	0.03	0.04
Unclassified debris	0.08	0.11	0.26	0.19		
Metal	0.04	0.06	0.04	0.06		
Textiles	0.01	0.01	0.05	0.06		
Rubber	0.02	0.02				
Ropes	0.01	0.01			0.00	0.00
Fishing gear			0.00	0.00	0.00	0.01

Regarding species the historical series of hake catches during the period 2000-2020 in the port of Vilanova i la Geltrú showed a general decreasing trend (Figure 167). The maximum catch ocurred in 2006 (> 200 tons), whereas the minimum catch was recorded in last years (around 40 tons).

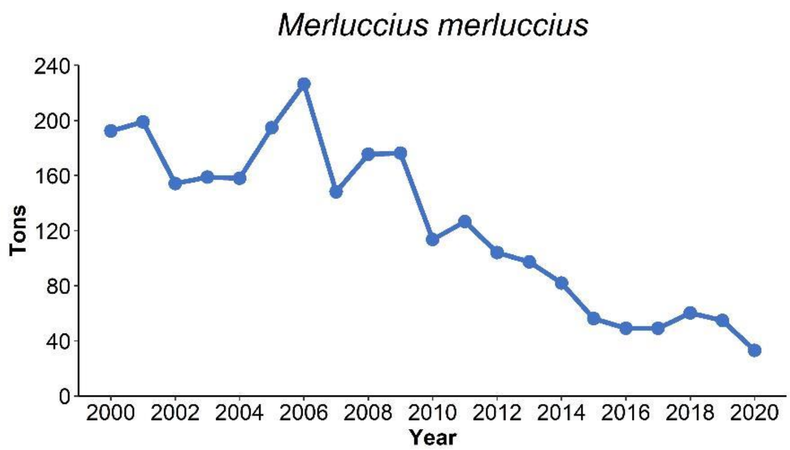


Figure 167. Time series of hake annual catch rates (tons) for the time period 2000-2020 in Vilanova i la Geltrú.

The historical series of horned octopus catches in the port of Vilanova i la Geltrú indicated a progressive decrease (Figure 168), following the same pattern as for Catalonia as a whole, with a sharp decline since 2013. Norway lobster (Figure 169), which peaked in 2010, showed a negative trend until 2016, as of this year it remained constant, only decreasing in the last two years. The case of the blue and red shrimp was different, with fluctuations throughout the historical series (Figure 170).

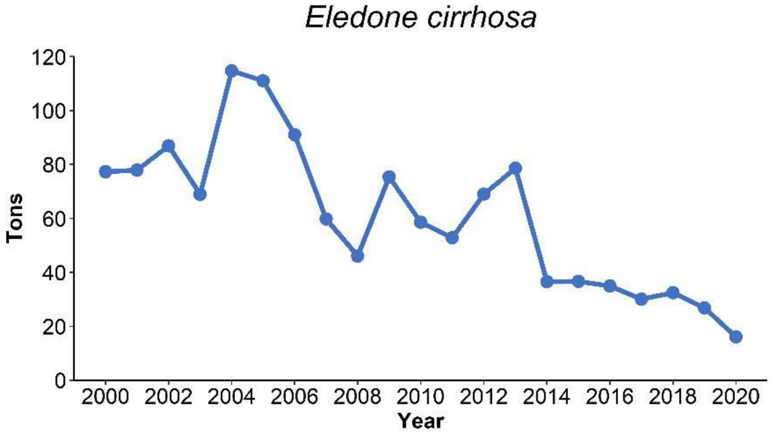


Figure 168. Time series of horned octopus annual catch rates (tons) for the time period 2000-2020 in Vilanova i la Geltrú.

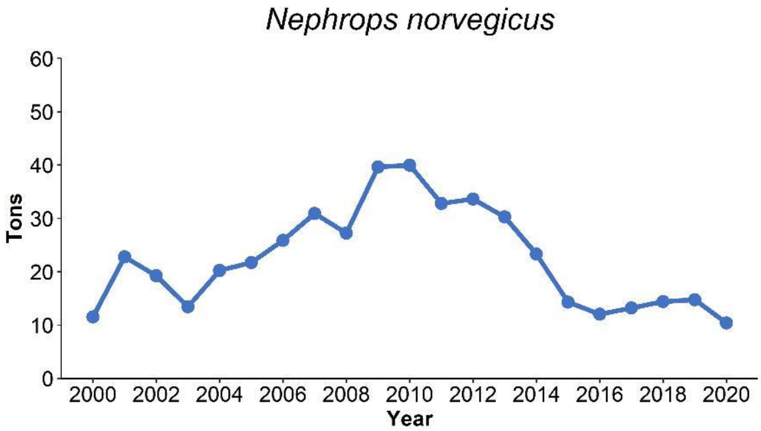


Figure 169. Time series of Norway lobster annual catch rates (tons) for the time period 2000-2020 in Vilanova i la Geltrú.

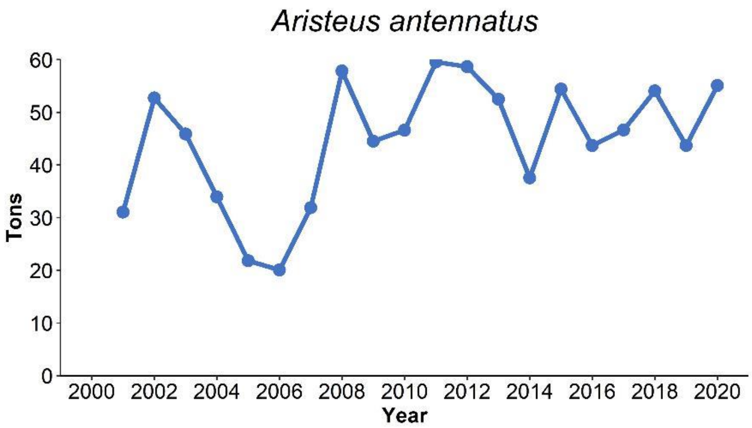


Figure 170. Time series of blue and red shrimp annual catch rates (tons) for the time period 2000-2020 in Vilanova i la Geltrú.

The size frequency distribution of hake from October 2019 to December 2020 in the port of Vilanova i la Geltrú corresponded to the catches in the common fishing ground where the bottom trawl fleet operated. The size-range threshold was 7 to 58 cm (Figure 171). Most of the catches on the continental shelf consisted of individuals with sizes between 12 and 17 cm, below the MCRS, which was associated with juveniles and immature specimens. However, on the upper slope hake catches shifted towards larger sizes (29 and 33 cm) with lower abundances observed. The horned octopus was caught at low levels of abundance on the continental shelf and upper slope with a mode at 7 and 9 cm respectively. Length frequency distributions of Norway lobster indicated a dominance of small individuals. For the blue and red shrimp , its distribution was dominated by larger individuals. The size range of Norway lobster ranged from 16 to 60 mm with a mode at 28 on the upper slope whereas, on the lower slope, the size range of blue and red shrimp ranged from 17 to 61 mm with a mode at 40 mm.

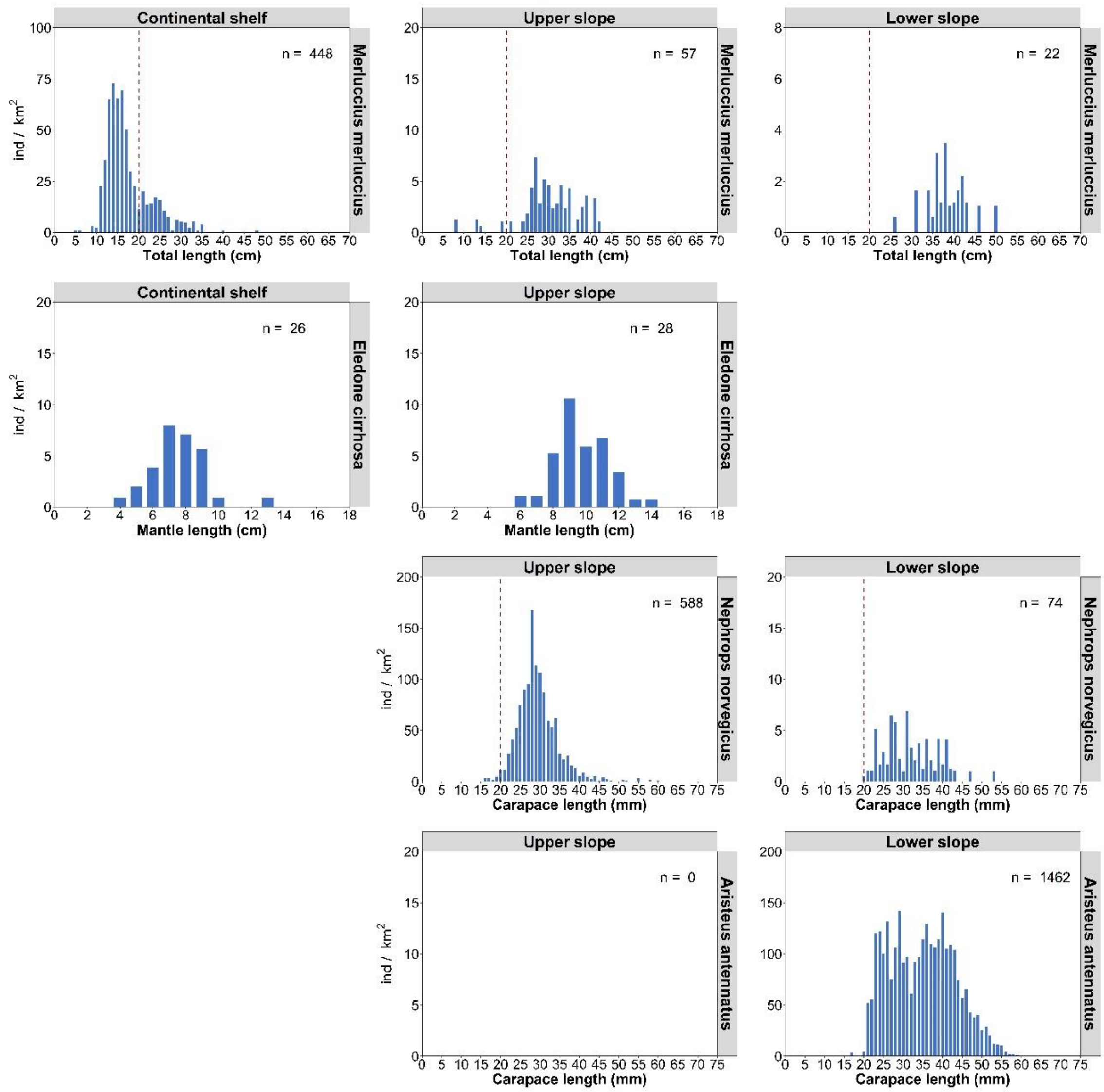


Figure 171. Length-frequency distribution of target species captured by bottom trawl for depth stratum from October 2019 to December 2020 in the port of Vilanova i la Geltrú. The red dashed line indicates the minimum conservation reference size (MCRS).

2.1.3.7 Tarragona

Figure 172 shows the bottom trawl commercial fishing activities and sampling bottom trawls conducted in the Tarragona port between October 2019 and December 2020.

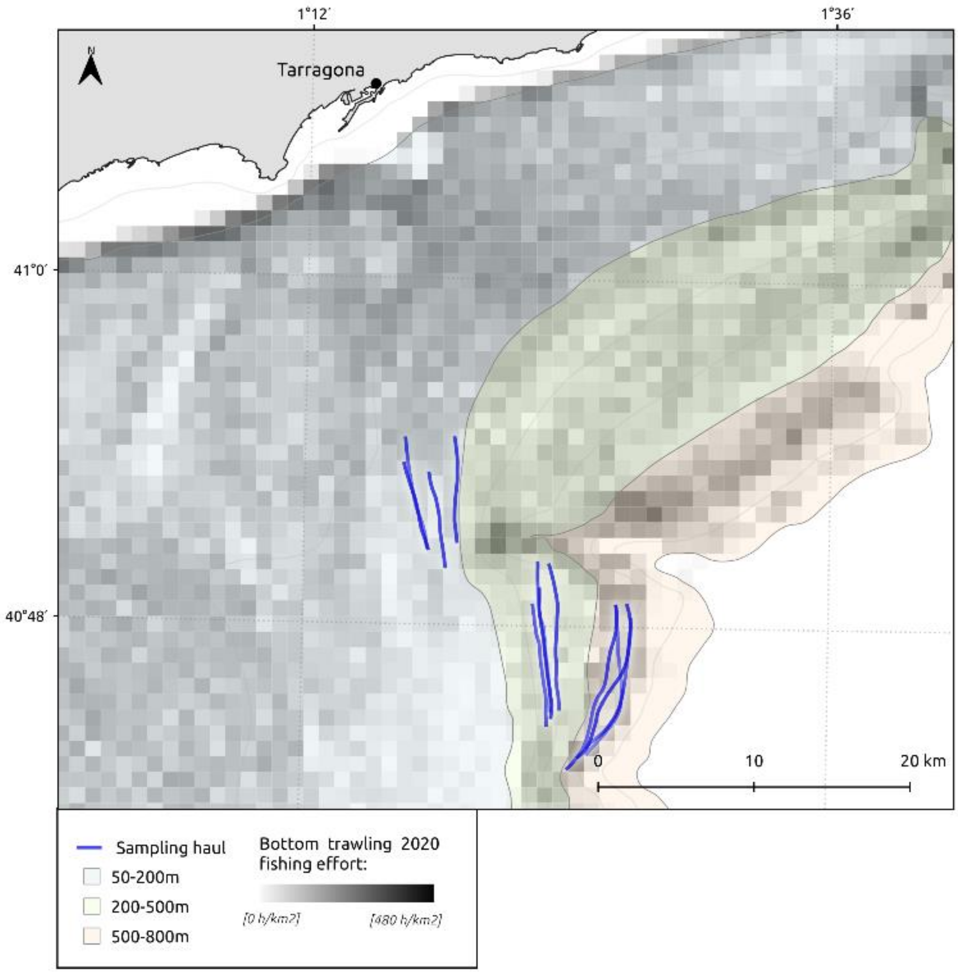


Figure 172. Map of bottom trawling hauls conducted in the port of Tarragona from October 2019 to December 2020.

The characterization of the catches for the 12 bottom trawling hauls conducted in Tarragona from October 2019 to December 2020 is shown in Figure 173 per each year and fraction of catch (landed, discarded, and debris). In autumn 2019, the landed catches represented, depending on the fishing ground, from 87 to 95% of the total catches. The discarded fraction ranged between the 2 and 7% of the total biomass and the debris ranged between 3 and 6%. In 2020, the landed catches represented, depending on the fishing ground, from 59 to 86% of the total catches. In the same year, the discarded fraction ranged between the 10 and 35% of the total biomass and the debris ranged between 4 and 8%.

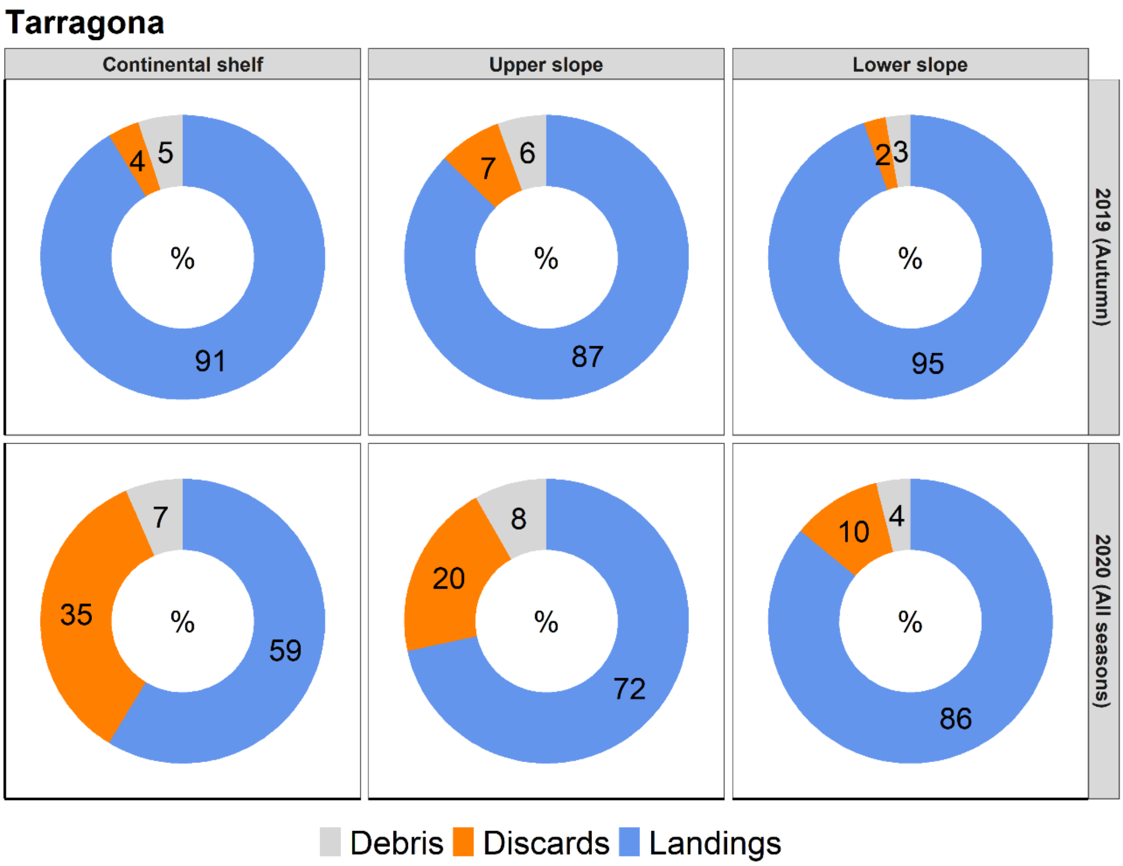


Figure 173. Catch composition in the port of Tarragona. Percentage by weight of landings, discarded and debris fraction in each year and fishing ground, including all hauls from October 2019 to December 2020.

The proportion of species with most biomass within the landed catch for each year and fishing ground is shown in Figure 174. A total of 76 species were landed in Tarragona from October 2019 to December 2020 (50 in the continental shelf, 41 in the upper slope, and 30 in the lower slope). In autumn 2019, the main landed species differed in each depth being *T. trachurus* the dominant species from the continental shelf was, *N. norvegicus, P. blennoides* and *E. cirrhosa* from the upper slope, and *G. melastomus, A. antennatus* and *L. piscatorius* from the lower slope. In 2020, the target species found in this port (*M. merluccius*, *N. norvegicus*, *A. antennatus*, and *E. cirrhosa*) represented the 13% of the landed catch in the continental shelf, the 36% in the upper slope and the 43% in the lower slope. The species *T. trachurus* was the main landed species in the continental shelf (33%) wereas, in the upper slope, *M. poutassou* accounted for 21% of the total landed biomass, followed by *N. norvegicus* (19%) and *P.* blennoides (19%). In the lower slope, the main landed species was *A. antennatus* (37%), followed by *G. melastomus* (17%).

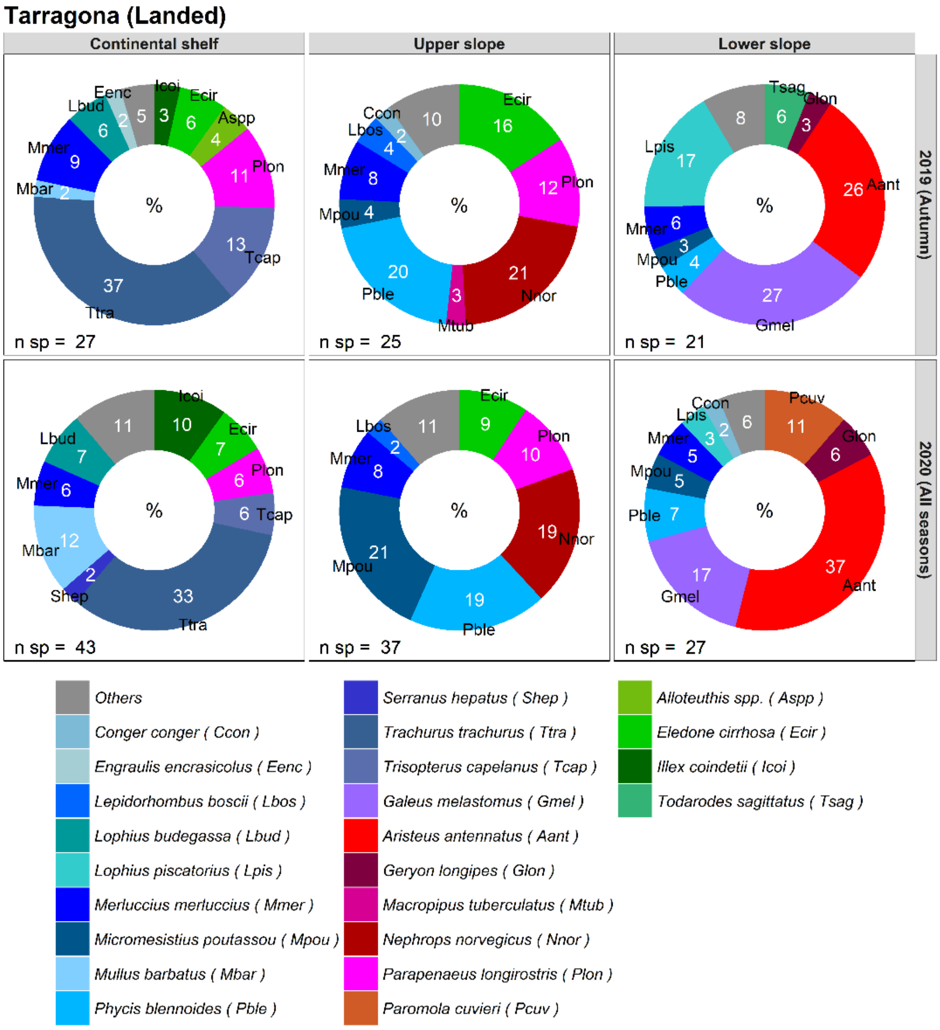


Figure 174. Species with most biomass within the landed catch in the port of Tarragona. Percentage by weight of the landed fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

For the landed species, Actinopterygii had the highest biomass in both the continental shelf and upper slope but only the highest abundance in the continental shelf. On the contrary, Crustacea had the highest biomass in the lower slope and the highest abundance in the upper and lower slope (Table 38).

Table 38. Biomass (Kg/Km^2) and abundance (ind./Km^2) of the taxonomic groups present in the landed fraction of the catch in the port of Tarragona. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	394.50	402.57	177.71	44.13	47.57	27.91
Chondrichthyes					33.25	36.02
Crustacea	33.35	35.99	95.44	45.61	115.98	96.18
Cephalopoda	95.12	65.65	37.32	37.75	0.45	0.23
Other Mollusca	0.76	0.74	0.05	0.07		
Echinodermata	3.73	5.27				
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	10083.73	9183.08	2669.61	159.86	319.67	114.00
Chondrichthyes					116.73	154.49
Crustacea	3826.86	3135.38	6605.23	1790.10	4994.08	1968.12
Cephalopoda	2843.85	2643.28	181.28	154.68	5.29	4.02
Other Mollusca	31.52	34.38	1.79	2.54		
Echinodermata	21.30	30.12				

The proportion of species with most biomass within the discarded catch for each year and fishing ground is shown in Figure 175. A total of 127 species were discarded in Tarragona from October 2019 to December 2020 (64 in the continental shelf, 68 in the upper slope, and 53 in the lower slope). In autumn 2019, 52% of the discards were *M. merluccius* in the continental shelf, In the upper slope, *G. melastomus* represented the 43% of the discards wereas *H. reversa* accounted for the 16%. In the lower slope, *S. canicula* and *G. melastomus* accounted for the 37% of the discarded catch, followed by *T. scabrus*.

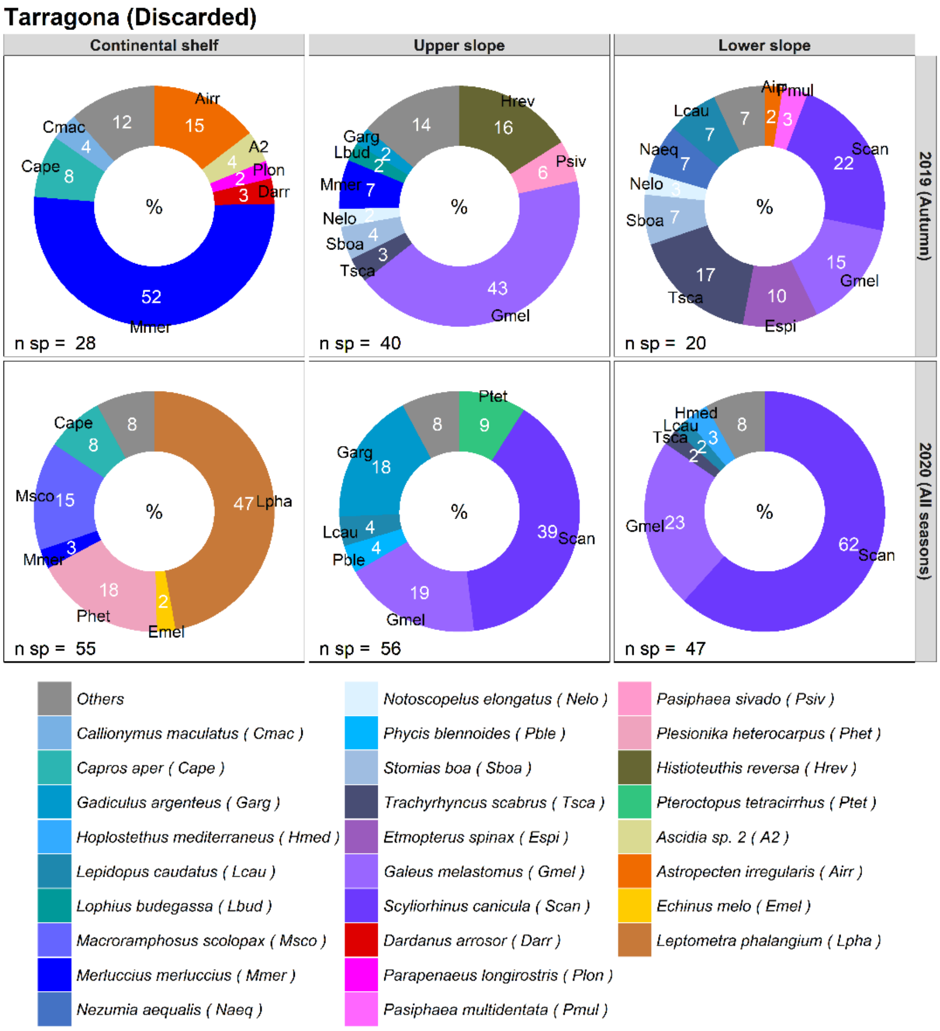


Figure 175. Species with most biomass within the discarded catch in the port of Tarragona. Percentage by weight of the discarded fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

From the discarded species, Actinopterygii wase the group with the highest biomass in the continental shelf, followed by Echinodermata and Crustacea. In this fishing ground, Crustacea was the most abundant group followed by Actinopterygii and Echinodermata. In the upper slope, chondrichthyes was the most abundant group while Actinopterygii had a lower biomass, followed by Cephalopoda. In the lower slope, chondrichthyes had the highest biomass and abundance (Table 39).

Table 39. Biomass (Kg/Km^2) and abundance (ind./Km^2) of the taxonomic groups present in the discarded fraction of the catch in the port of Tarragona. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	315.37	473.59	27.37	12.89	3.13	3.03
Chondrichthyes	0.38	0.53	55.12	35.49	20.99	18.85
Crustacea	184.63	316.40	1.82	0.83	0.40	0.25
Cephalopoda	2.18	0.55	10.95	18.38	0.06	0.05
Other Mollusca	0.77	0.62	0.10	0.14	0.03	0.04
Porifera			0.01	0.01		
Cnidaria	1.40	1.89	0.01	0.02	0.06	0.08
Annelida	0.00	0.00				
Sipuncula			0.08	0.12		
Echinodermata	511.73	871.96	0.18	0.16	0.10	0.15
Tunicata	1.12	1.50	0.03	0.04	0.02	0.03
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	73278.29	116896.79	2074.75	996.36	158.76	99.35
Chondrichthyes	138.43	172.03	1516.37	1260.68	236.06	129.64
Crustacea	89854.64	153975.65	606.49	128.56	121.36	67.44
Cephalopoda	376.54	131.80	446.00	661.98	3.25	1.73
Other Mollusca	176.19	133.91	7.01	9.91	2.86	4.04
Porifera			2.15	3.04		
Cnidaria	343.65	336.51	4.30	6.09	8.57	12.11
Annelida	7.78	11.01				
Sipuncula			14.01	19.82		
Echinodermata	2666.35	2472.30	56.00	28.00	42.83	60.57
Tunicata	703.12	976.50	4.30	6.09	1.43	2.02

The debris composition is shown in Figure 176. In 2019, the main discards were lumber (76% in the continental shelf), clinker (27% in the upper slope), fishing gears (40% in the lower slope), and terrestrial plants (39% in the lower slope). In 2020, marine organic debris (26 - 39%) and terrestrial plants (17 - 27%) were found in large proportions in the three fishing grounds. In the lower slope, the

19% of the debris was clinker. The mass of debris (kg of debris by km2) is presented in Table 40.

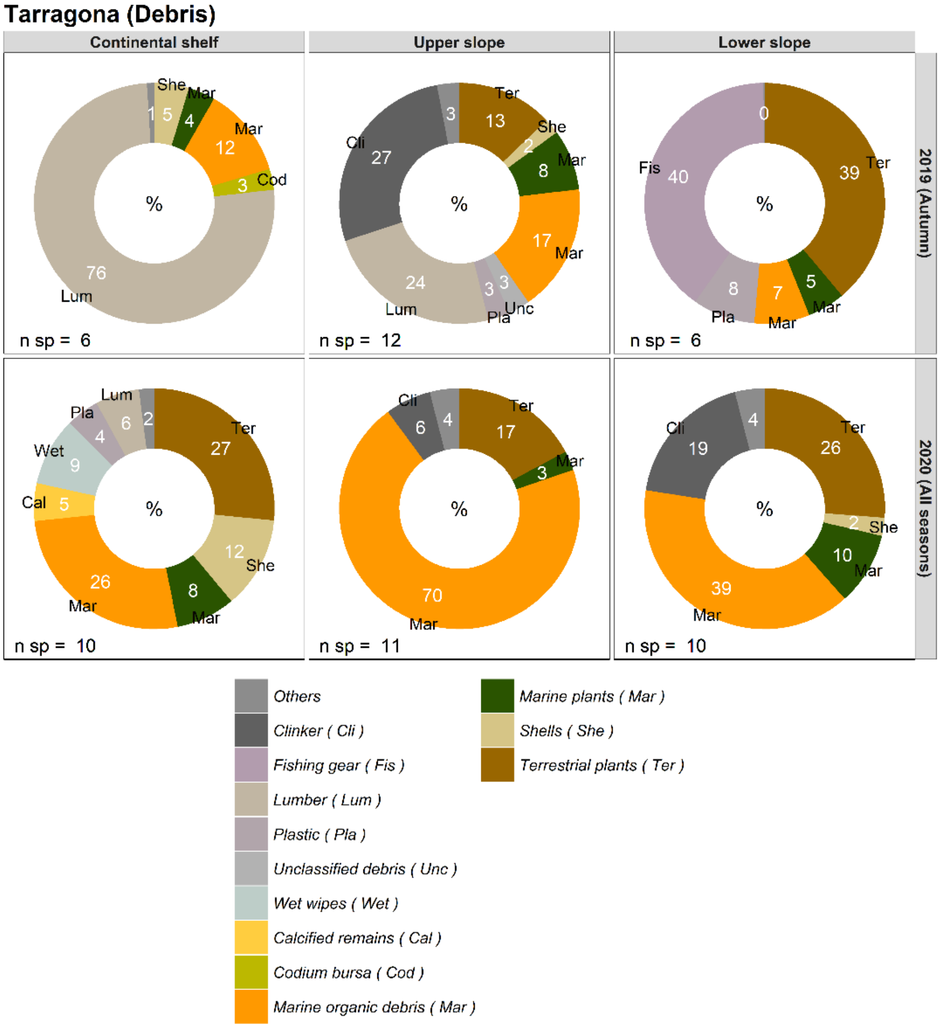


Figure 176. Items with most weight within the debris fraction of the catch in the port of Tarragona. Percentage by weight in each year and fishing ground, including all hauls from October 2019 to December 2020.

Table 40. Mass (Kg/Km^2) of the debris present in the debris fraction of the catch in the port of Tarragona. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd
Marine organic debris	9.28	9.62	34.76	57.49	3.55	4.82
Terrestrial plants	9.30	7.52	8.50	7.23	2.38	2.65
Clinker	0.67	0.68	3.05	2.80	1.69	2.62
Shells	4.33	0.64	0.53	0.24	0.22	0.22

	Continental shelf		Upper slope		Lower slope	
	mean	sd	mean	sd	mean	sd
Marine plants	2.79	2.23	1.29	0.74	0.89	0.51
Wet wipes	3.23	4.57	0.12	0.17	0.12	0.17
Plastic	1.53	2.12	0.90	0.51	0.17	0.13
Calcified remains	1.78	2.51	0.33	0.46		
Lumber	2.08	1.91				
Metal	0.05	0.07			0.05	0.07
Ropes			0.05	0.06	0.02	0.02
Fishing gear			0.02	0.03	0.00	0.01
Unclassified debris			0.02	0.03		

Regarding species the annual catch rates of hake during the period 2000-2020 in the port of Tarragona showed a progressive decline, similar to that observed in the catch of Catalonia (Figure 177). Maximum hake catch rates were registered in 2006 (350 tons) and the minimum were recorded in last years.

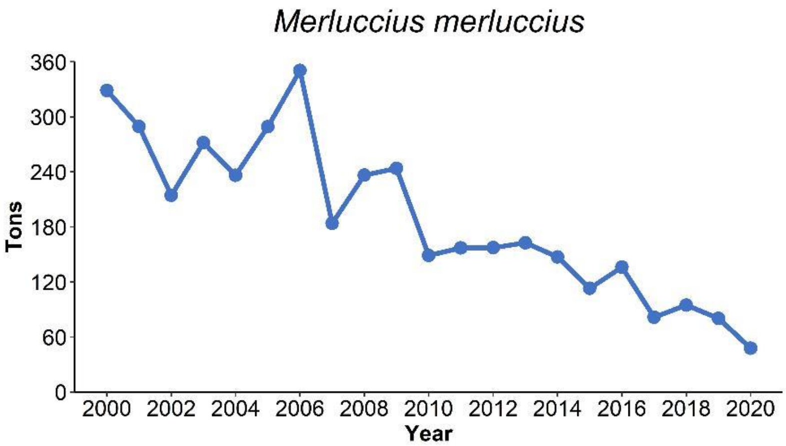


Figure 177. Time series of annual catch rates (tons) for the time period 2000-2020 in Tarragona.

The historical series of catches of horned octopus in the port of Tarragona showed a progressive decrease over the last 4 years, following the same pattern as for Catalonia (Figure 178). The Norway lobster catches showed a sharp decline from 2013 onwards (Figure 179). The blue and red shrimp follows the same pattern of stability in catches with very similar oscillations as those of the port of Barcelona (Figure 180). The blue and red shrimp, despite the lack of data, follows the same pattern of stability in catches with oscillations practically the same as those of the port of Barcelona.

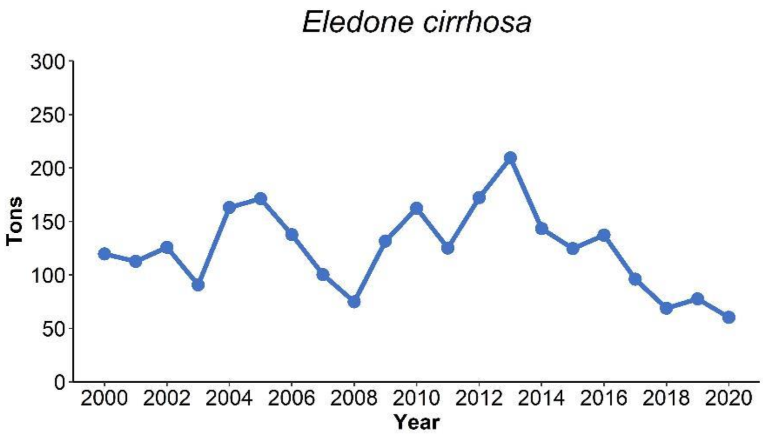


Figure 178. Time series of horned octopus annual catch rates (tons) for the time period 2000-2020 in Tarragona.

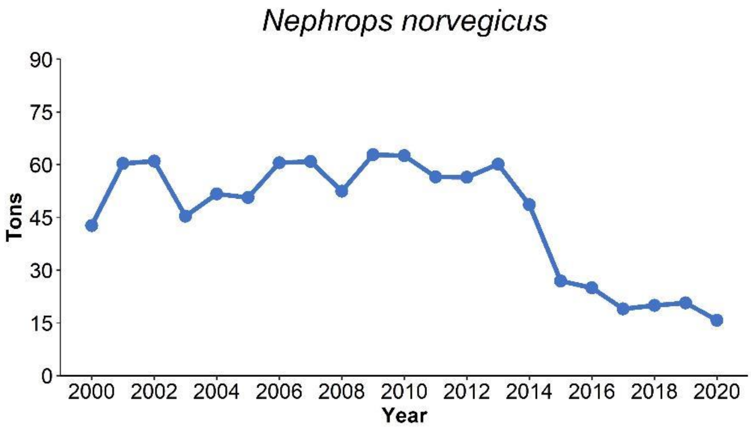


Figure 179. Time series of Norway lobster annual catch rates (tons) for the time period 2000-2020 in Tarragona.

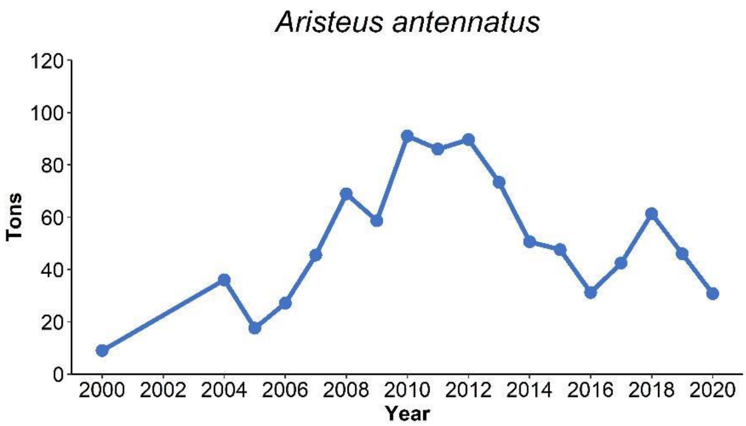


Figure 180. Time series of blue and red shrimp annual catch rates (tons) for the time period 2000-2020 in Tarragona.

The size frequency distribution of hake from October 2019 to December 2020 in the port of Tarragona ranged from 6 to 44 cm on the continental shelf (Figure 181). Individuals of hake caught undersized (> 20 cm) corresponded to immature individuals with a mode at 7 cm. The sizes of hake on the upper slope and lower slope were larger than the MCRS, although some small individuals were also caught on the upper slope. Horned octopus was very small on the continental shelf (3 cm) and the largest individuals (13 cm) were caught on the upper slope. The length-frequency distributions of the Norway lobster had a modal size close to the MCRS. The maximum abundance size was 30 cm for both depth strata. The size range of blue and red shrimp extended from 18 to 63 mm cephalothorax length. The size frequency was bimodal with a higher abundance of small individuals on the lower slope.

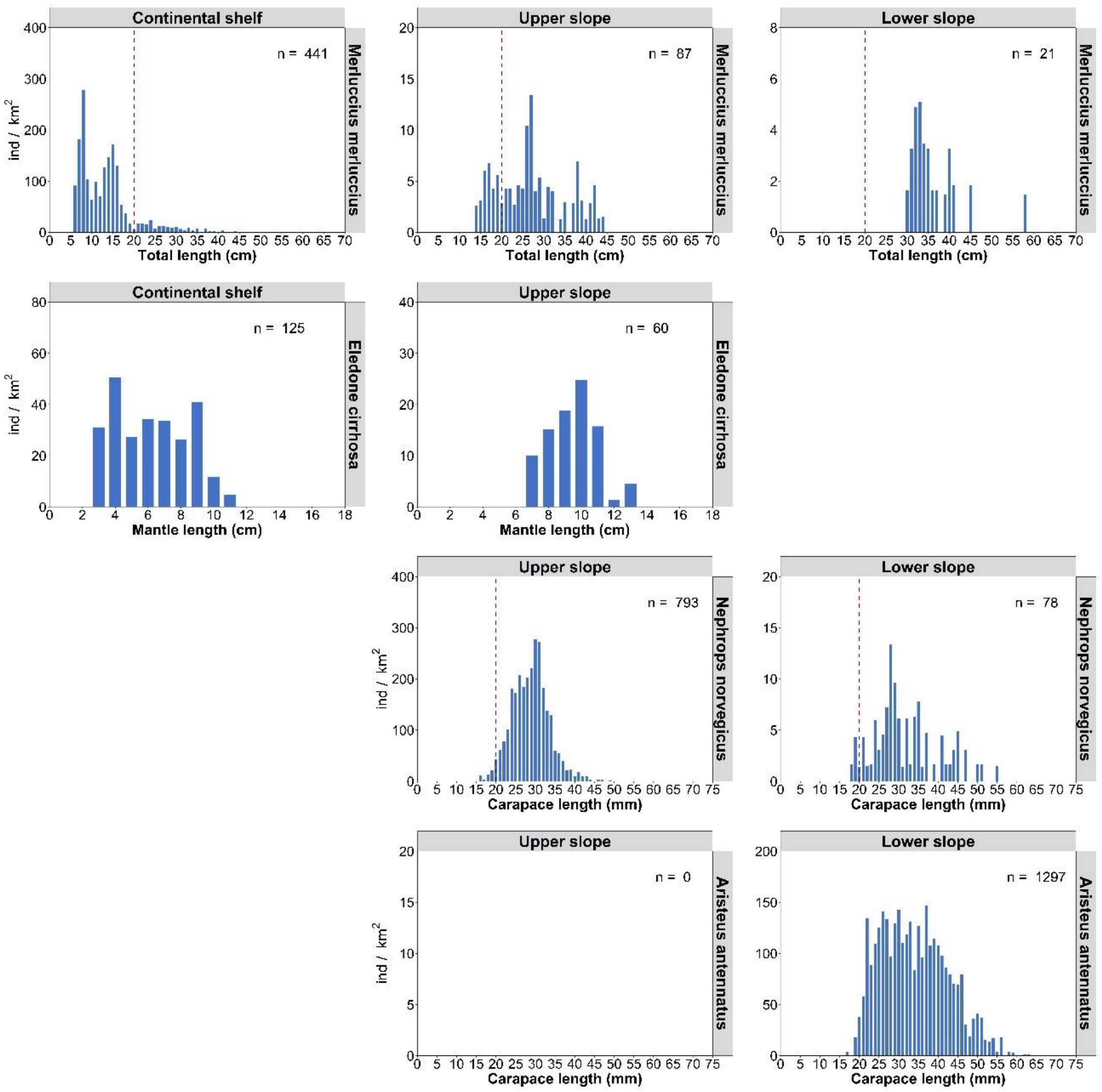


Figure 181. Length-frequency distribution of target species captured by bottom trawl for depth stratum from October 2019 to December 2020 in the port of Tarragona. The red dashed line indicates the minimum conservation reference size (MCRS).

2.1.3.8 L'Ametlla de Mar

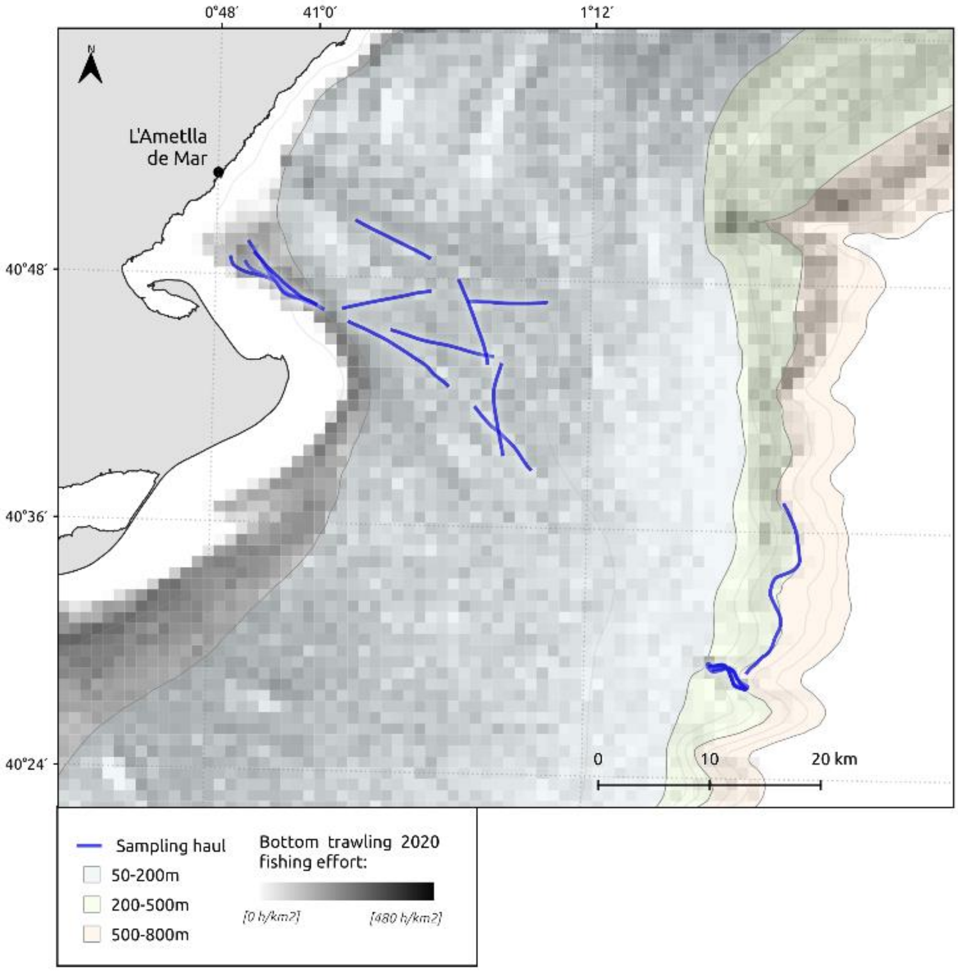


Figure 182 shows the bottom trawl commercial fishing activities and sampling bottom trawls conducted in the L'Ametlla de Mar port between October 2019 and December 2020.

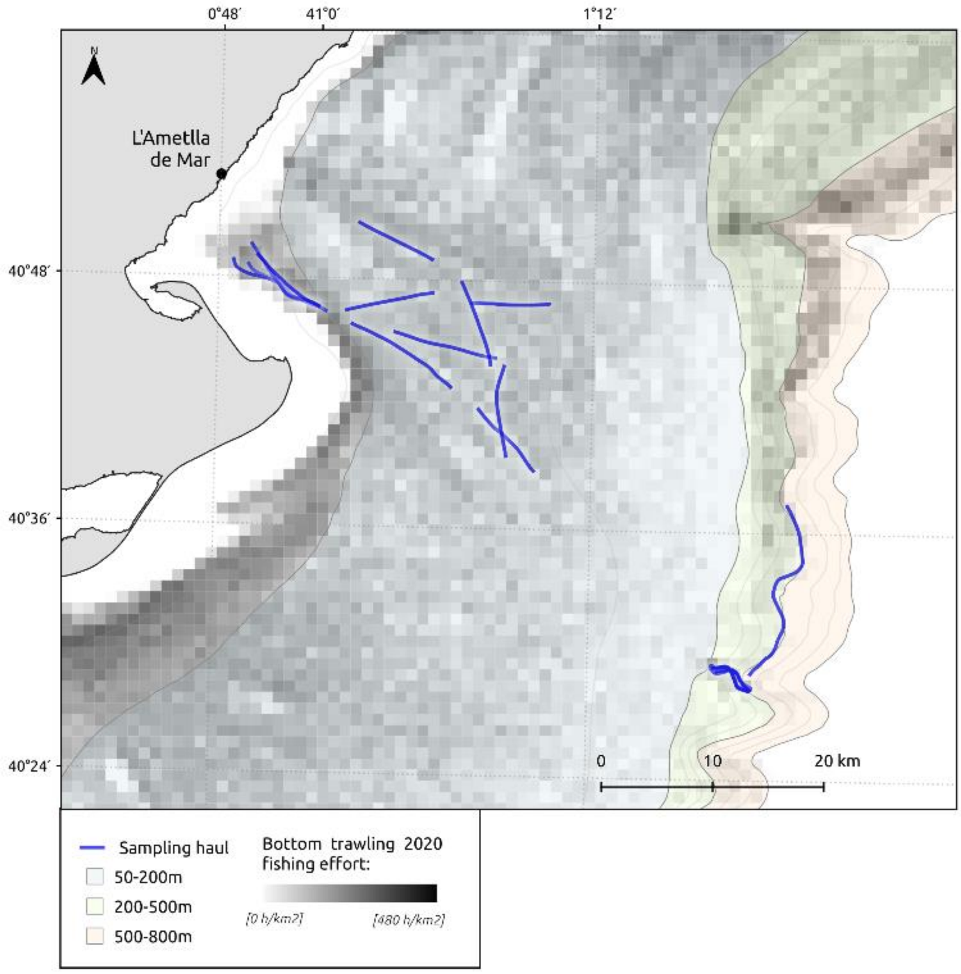


Figure 182. Map of bottom trawling hauls conducted in the port of l'Ametlla de Mar from October 2019 to December 2020.

The characterization of the catches for the 16 bottom trawling hauls conducted in 4 fishing grounds (shallow continental shelf, middle continental shelf, continental shelf, and lower slope) in l'Ametlla de Mar from October 2019 to December 2020 is shown in Figure 183 per each year and fraction of catch (landed, discarded, and debris). In autumn 2019, the landed catches represented, depending on the fishing ground, from 34 to 73% of the total catches. The discarded and debris fractions had a wide ranged being 4 - 64% and 2 - 53%) of the total biomass, respectively . In 2020, the landed catches represented, depending on the fishing ground, from 57 to 95% of the total catches. The discarded fraction ranged between the 4 and 22% of the total biomass and the debris between 2 and 24%.

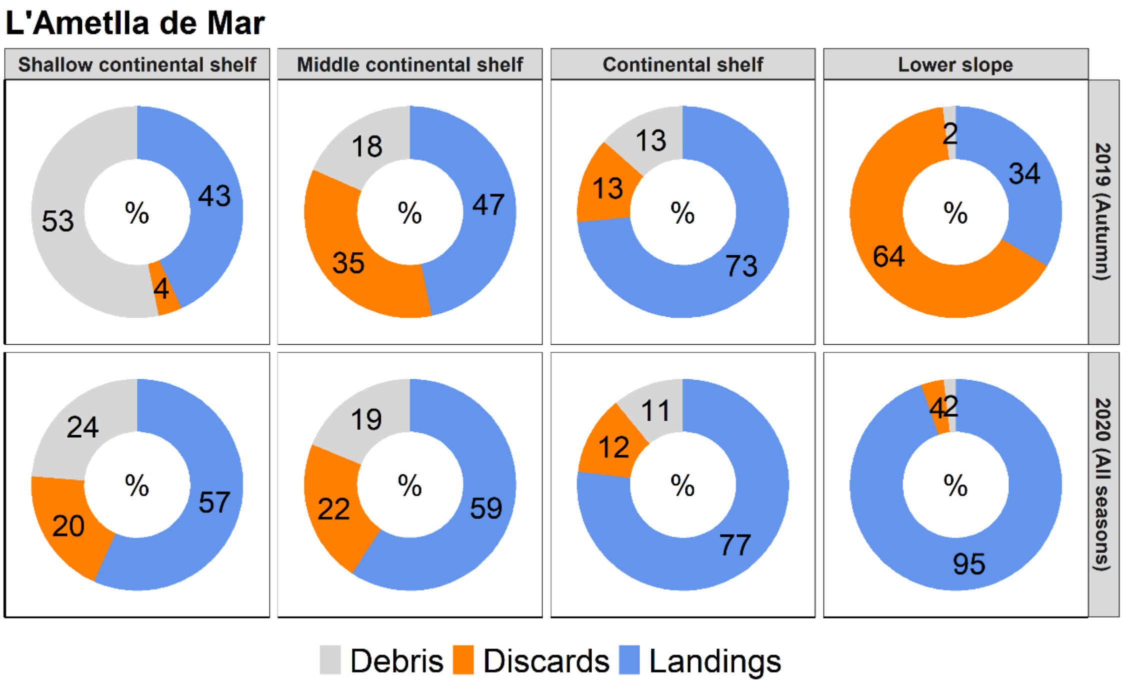


Figure 183. Catch composition in the port of l'Ametlla de Mar. Percentage by weight of landings, discarded and debris fraction in each year and fishing ground, including all hauls from October 2019 to December 2020.

The proportion of species with most of the biomass within the landed catch for each year and fishing ground is shown in Figure 184. A total of 104 species were landed in l'Ametlla de Mar from October 2019 to December 2020 (57 in the shallow continental shelf, 30 in the middle continental shelf, 52 in the continental shelf, and 32 in the lower slope). This port had the highest number of landed species. In the three fishing grounds within the continental shelf, the landed catches were composed of many species, representing each a small percentage of the total amount. In autumn 2019, in the continental shelf, fish were the predominant landed catches. In the middle and upper continental shelf, fish were also important, where the presence of cephalopoda (*E. cirrhosa* and *Alloteuthis* spp.) increased. In the lower slope, the target species *A. antennatus* dominated the landings. In 2020, the target species found in the continental fishing grounds of this port (*M. merluccius*, *N. norvegicus*, *E. cirrhosa, P. kerathurus, S. mantis*, and *A. antennatus*) represented 11% of the landed catch in the shallow continental shelf, 26% in the middle continental shelf, 33% in the continental shelf and, 64% in the lower slope. In the continental shelf fishing grounds, the target species *S. mantis* represented between 9 and 12% of the landed catches. In the shallow continental shelf, *S. aurata* (26%) and *P. erythrinus* (17%) abunded among other fishes. In the lower and continental shelf, the biomass of cephalopoda increased with *P. longirostris* representing between 7 and 11% of the landed catch. In the lower slope, the target species *A. antennatus* dominated the landings (62%).

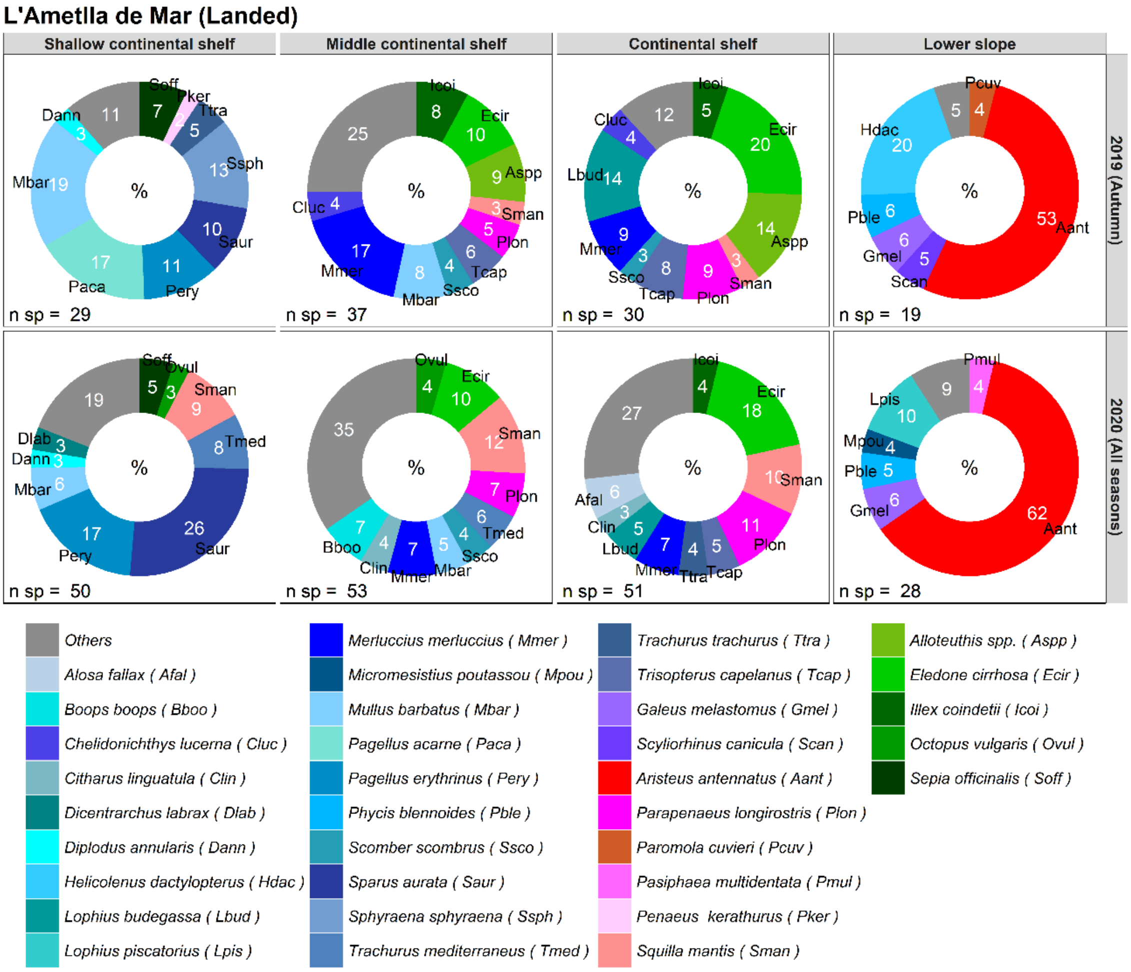


Figure 184. Species with most biomass within the landed catch in the port of l'Ametlla de Mar. Percentage by weight of the landed fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

Of the landed species, Actinopterygii was the group with the highest biomass on the three fishing grounds of the continental shelf, while Crustacea had the highest biomass in the lower slope. In terms of abundance, Crustacea had the highest abundance in all the fishing grounds, except in the shallow continental shelf (Table 41).

Table 41. Biomass (Kg/Km^2) and abundance ($ind./Km^2$) of the taxonomic groups present in the landed fraction of the catch in the port of l'Ametlla de Mar. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Shallow continental shelf		Middle continental shelf		Continental shelf		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd	mean	sd
Actinopterygii	268.73	206.42	125.03	6.05	118.02	36.86	32.88	50.40
Chondrichthyes	0.81	1.15	0.27	0.38			9.95	12.07
Crustacea	36.93	41.80	40.76	31.62	59.10	26.69	100.64	20.64
Cephalopoda	42.14	4.74	41.91	24.41	66.54	10.56	0.79	0.64
Other Mollusca	0.96	0.39	2.68	2.21	4.31	3.90		
Abundance	mean	sd	mean	sd	mean	sd	mean	sd
Actinopterygii	3190.51	2129.73	2926.29	575.57	2456.44	1169.84	127.64	190.22
Chondrichthyes	9.97	14.09	2.74	3.87			29.64	34.23
Crustacea	1131.15	1044.51	3151.41	2805.05	5528.90	3029.96	5806.35	1601.56
Cephalopoda	414.98	109.12	408.28	327.90	630.46	82.61	6.12	4.64
Other Mollusca	135.60	72.14	117.68	103.72	135.64	99.92		

The proportion of species with most of the biomass within the discarded catch for each year and fishing ground is shown in Figure 185. A total of 164 species were discarded in l'Ametlla de Mar from October 2019 to December 2020 (63 in the shallow continental shelf, 80 in the middle continental shelf, 68 in the continental shelf, and 39 in the lower slope). In autumn 2019, in the shallow continental shelf, the species *O. vulgaris, P. acarne D. annularis,* and *P. erythrinus* were the most important discards. The middle continental shelf and the continental shelf discards were clearly different from those in the shallow continental shelf, with *E. encrasicolus* and *B. boops* as the most discarded species. In the lower slope, the main discards *were M. mola and C. monstrosa*. In 2020, *P. acarne* (40%) was the main discard in the shallow continental shelf. In the middle continental shelf, two species, *E. encrasicolus* (34%) and *S. pilchardus* (15%), were the main discards. Differently, *M. merluccius* (24%) and *E. encrasicolus* (18%) were the main discarded species in the continental shelf. The main discards in the lower slope were *G. melastomus* (32%) and the cephalopoda *T. sagittatus* (12%) and *H. bonnellii* (12%).

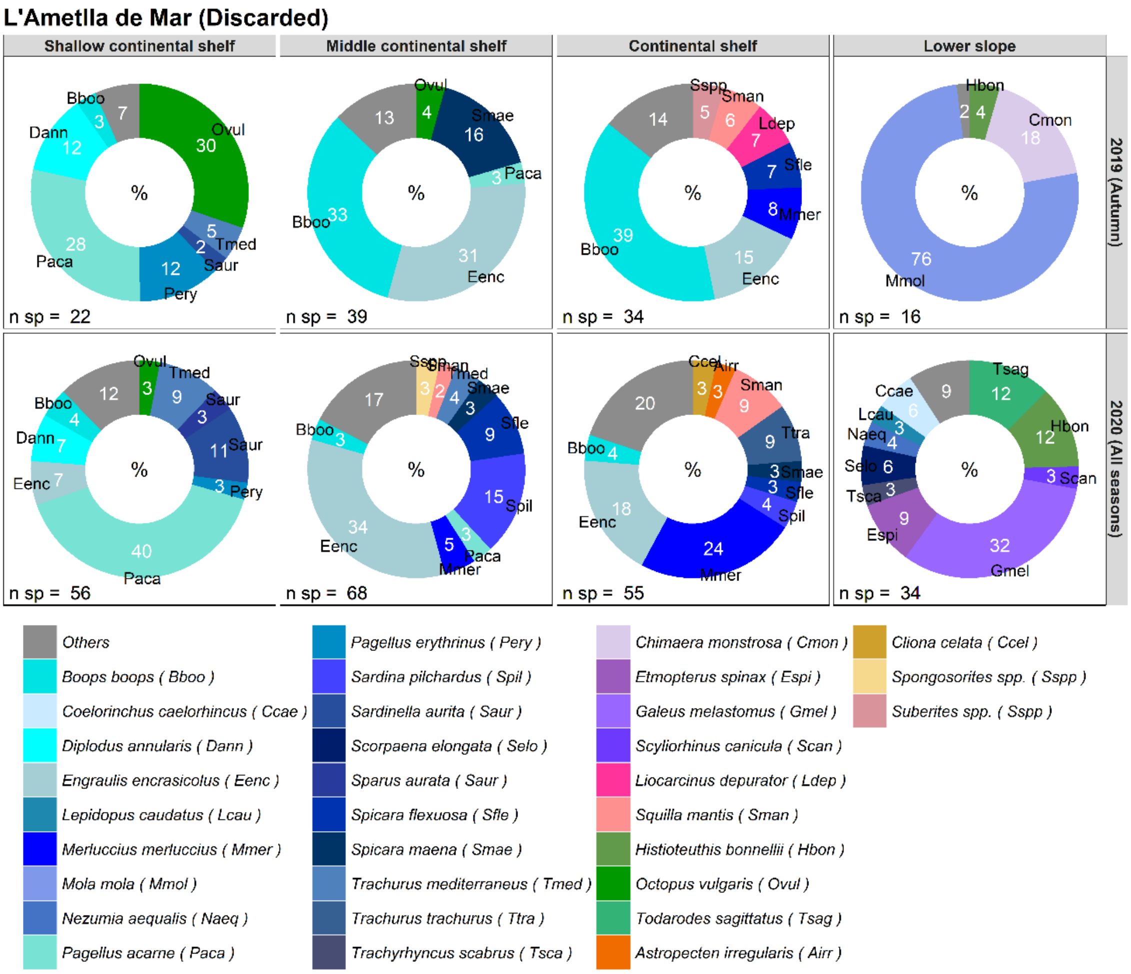


Figure 185. Species with most biomass within the discarded catch in the port of l'Ametlla de Mar. Percentage by weight of the discarded fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

Of the discarded species, fish, Crustacea, Echinodermata, Cnidaria and Mollusca were the most important taxonomic groups in terms of abundance and biomass. The highest diversity of taxonomic groups, as well as the highest diversity of discarded species, was found in the middle continental shelf (Table 42).

Table 42. Biomass (Kg/Km^2) and abundance (ind./Km^2) of the taxonomic groups present in the discarded fraction of the catch in the port of l'Ametlla de Mar. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Shallow continental shelf		Middle continental shelf		Continental shelf		Lower slope	
Biomass	mean	sd	mean	sd	mean	sd	mean	sd
Actinopterygii	117.19	105.98	73.18	78.57	19.45	19.10	1.41	0.98
Chondrichthyes	0.10	0.06	0.39	0.38	0.03	0.03	2.35	2.15
Crustacea	2.51	1.57	4.29	4.58	3.56	4.64	0.17	0.12
Cephalopoda	4.48	5.42	1.45	0.69	0.33	0.47	1.29	1.01
Other Mollusca	0.90	0.46	1.18	1.15	0.18	0.20	0.01	0.01
Porifera			3.21	5.19	0.95	1.37		
Cnidaria	2.41	3.38	2.21	2.67	0.42	0.28		
Annelida	0.01	0.01	0.11	0.17	0.09	0.13		
Echinodermata	2.12	1.98	2.26	2.17	1.29	1.14	0.00	0.01
Tunicata			0.84	0.94	0.60	0.31	0.00	0.01
Abundance	mean	sd	mean	sd	mean	sd	mean	sd
Actinopterygii	7394.56	7480.74	10104.39	15339.81	1408.25	1262.06	47.06	40.09
Chondrichthyes	41.09	19.05	117.51	48.41	24.15	18.49	31.47	39.58
Crustacea	438.09	234.44	921.64	582.21	601.50	740.09	62.02	43.76
Cephalopoda	20.61	10.32	49.44	14.16	8.37	11.84	3.92	2.09
Other Mollusca	111.79	14.88	139.57	50.95	67.66	83.53	4.40	6.22
Porifera			34.04	22.97	12.08	9.24		
Cnidaria	232.50	197.37	680.87	763.27	53.80	40.64		
Annelida	9.97	14.09	52.24	49.84	3.71	5.24		
Echinodermata	672.27	587.08	473.44	214.92	435.87	434.52	0.86	1.22
Tunicata			67.75	33.96	163.59	176.55	1.46	2.07

The debris composition is shown in Figure 186. In autumn 2019, the main discards in the three continental shelf fishing grounds were terrestrial plants (5 - 99%), while in the lower slope abunded plastics (77%). In 2020, marine plants (3 - 46%) and terrestrial plants (9 - 36%) were present in all fishing grounds. The algae *C. bursa* was the 19% of the debris in the middle continental shelf. In the lower slope, plastics accounted for the 47% of the debris. The mass of debris (kg of debris by km2) is presented in Table 43.

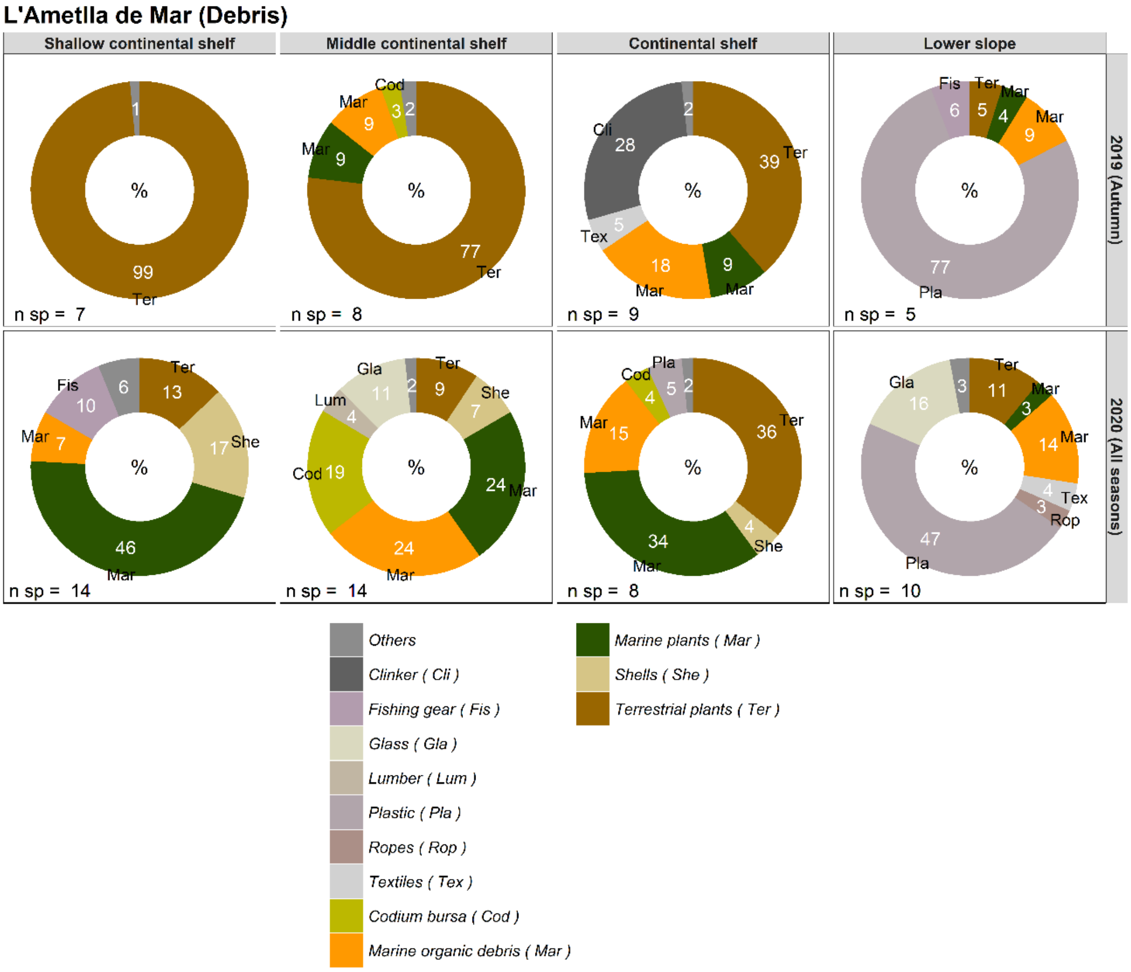


Figure 186. Items with most weight within the debris fraction of the catch in the port of l'Ametlla de Mar. Percentage by weight in each year and fishing ground, including all hauls from October 2019 to December 2020.

Table 43. Mass (Kg/Km^2) of the debris present in the debris fraction of the catch in the port of l'Ametlla de Mar. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Shallow continental shelf		Middle continental shelf		Continental shelf		Lower slope	
	mean	sd	mean	sd	mean	sd	mean	sd
Marine plants	61.44	62.03	16.04	9.66	8.08	4.42	0.06	0.04
Terrestrial plants	17.15	9.27	6.34	4.79	8.44	4.61	0.23	0.20
Marine organic debris	9.94	4.8	16.57	20.51	3.62	3.93	0.29	0.12
Shells	22.1	4.53	4.96	1.61	0.98	0.66		

	Shallow continental shelf		Middle continental shelf		Continental shelf		Lower slope	
	mean	sd	mean	sd	mean	sd	mean	sd
Codium bursa	2.11	2.99	12.98	18.35	0.87	1.23		
Fishing gear	13.91	19.67	0.04	0.05			0.01	0.01
Glass			7.32	10.36			0.33	0.17
Plastic	1.47	1.48	0.41	0.39	1.23	0.74	1	1.42
Lumber			2.69	2.96				
Clinker	2.06	1.94	0.4	0.56				
Calcified remains	1.76	2.49					0.03	0.05
Ropes	0.36	0.51	0.13	0.19	0.21	0.3	0.06	0.08
Wet wipes	0.21	0.29	0.07	0.1			0.02	0.01
Other marine algae	0.02	0.03			0.19	0.26		
Codium tomentosum	0.09	0.13	0.08	0.12				
Unclassified debris	0.12	0.17						
Textiles							0.09	0.12
Rhodophyta			0.01	0.01				

Regarding species the annual catch rates of hake during the period 2000-2020 in the port of l'Ametlla de Mar showed a progressive decline, similar to that observed for catch in Catalonia (Figure 187). However, a slight recovery was detected in 2018 in the fishing ports of Vilanova i la Geltrú and Tarragona. Maximum hake catch rates were registered in 2008 (250 tons) and the minimum were recorded in 2020 (60 tons).

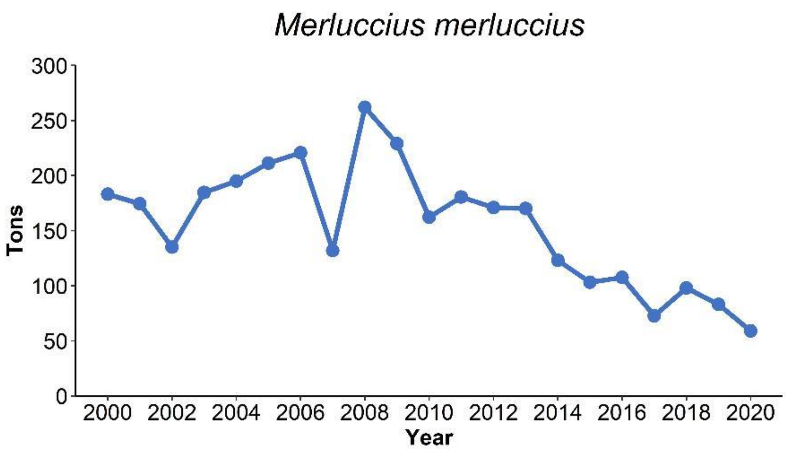


Figure 187.Time series of annual catch rates (tons) of hake for the time period 2000-2020 in l'Ametlla de Mar.

The historical series of catches of horned octopus from the port of l'Ametlla de Mar indicates a progressive decrease in catches since 2013. The minimum catches were recorded in 2018 (< 50 tons) but they increased in the last two years again. More data are expected to be analysed in the coming years to see what this trend will look like (Figure 188). Catches of caramote prawn (*P. kerathurus*) are very low and on a declining trend (Figure 189). Catches of spottail mantis shrimp (*S. mantis*) were stable with slight oscillations (Figure 190). Similar to the rest of the ports, catches of Norway lobster showed a downward trend since 2013 (Figure 191). In the port of l'Ametlla de Mar, blue and red shrimp began to be caught in 2012, with very low catch values, as only one or two boats caught this species (Figure 192). The maximum catches of blue and red shrimp were obtained in 2018.

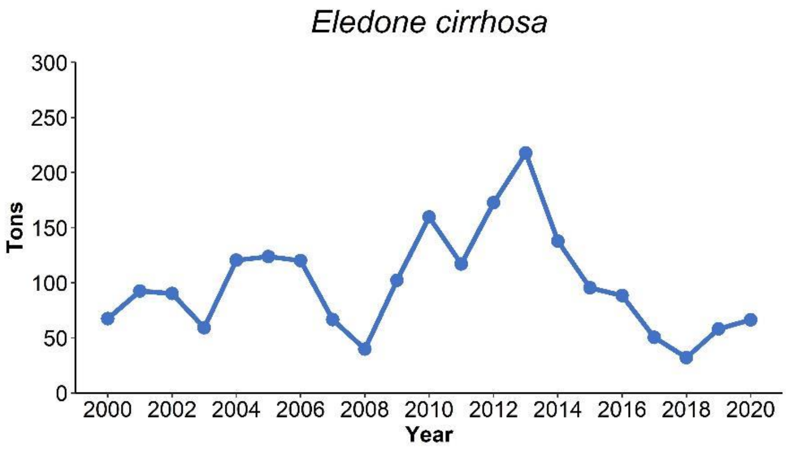


Figure 188. L'Ametlla de Mar., *Eledone cirrhosa*. Time series of horned octopus annual catch rates (tons) for the time period 2000-2020 in l'Ametlla de Mar.

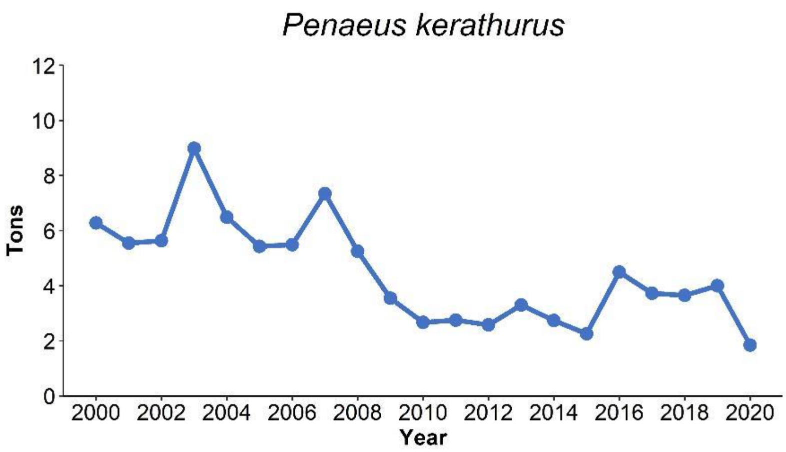


Figure 189. Time series of caramote prawn annual catch rates (tons) for the time period 2000-2020 in l'Ametlla de Mar.

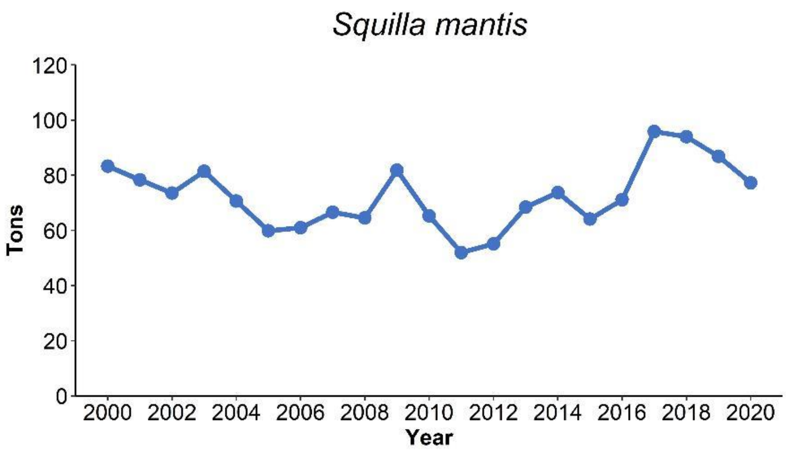


Figure 190. Time series of spottail mantis shrimp annual catch rates (tons) for the time period 2000-2020 in l'Ametlla de Mar.

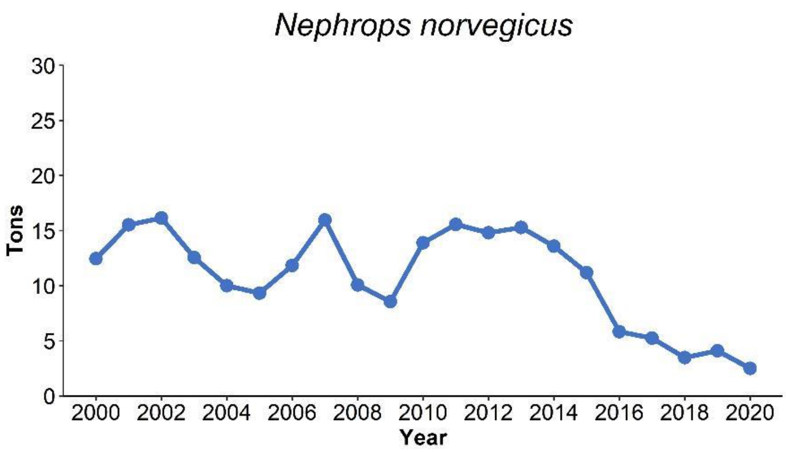


Figure 191. Time series of Norway lobster annual catch rates (tons) for the time period 2000-2020 in l'Ametlla de Mar.

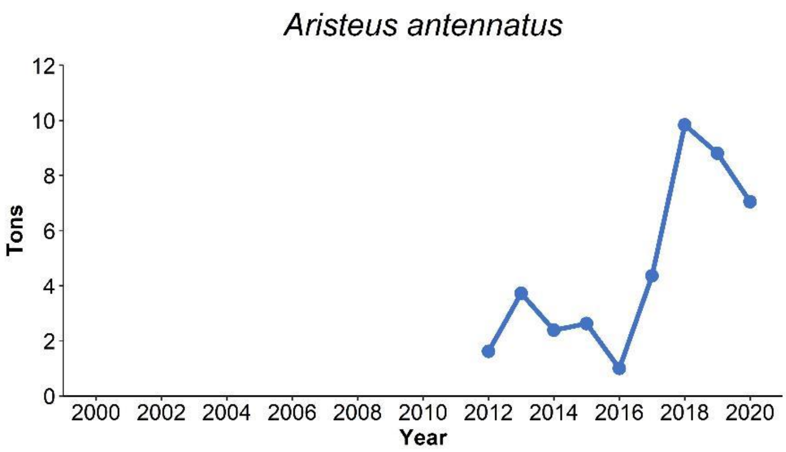


Figure 192. Time series of blue and red shrimp annual catch rates (tons) for the time period 2000-2020 in l'Ametlla de Mar.

The size frequency distribution of hake from October 2019 to December 2020 in the port of l'Ametlla de Mar (Figure 193) ranged between 5 and 42 cm, meaning that most females were caught below the size at first maturity (38 cm) on the continental shelf, being the depth stratum with the most abundant catches. Most of the hake individuals caught are below to the MCRS (> 20 cm), which corresponded to immature individuals in the three depth strata. On the continental shelf, the lengths were about 20 cm, right at the MCRS size. The number of horned octopus measured in the samplings was high. Most individuals were between 7 and 10 cm in mantle length and were most abundant on the middle continental shelf and continental shelf. Individuals of caramote prawn were mostly caught on the shallow continental shelf where the size range was wider between 19 mm and 48 mm cephalothorax length, compared to the middle continental shelf, where they ranged 26-34 mm. The spottail mantis shrimp was caught from the shallow continental shelf to the continental shelf where the size range was 12-34 mm cephalothorax length. Smaller individuals were caught more often on the shallow continental shelf whereas larger individuals were caught on the deeper shelf. On the continental shelf, a bimodal distribution was observed with a mode at size 17 mm and another at size 25 mm. Norway lobster individuals were less abundant but the size was larger than the MCRS (> 20 CM) on the continental shelf.

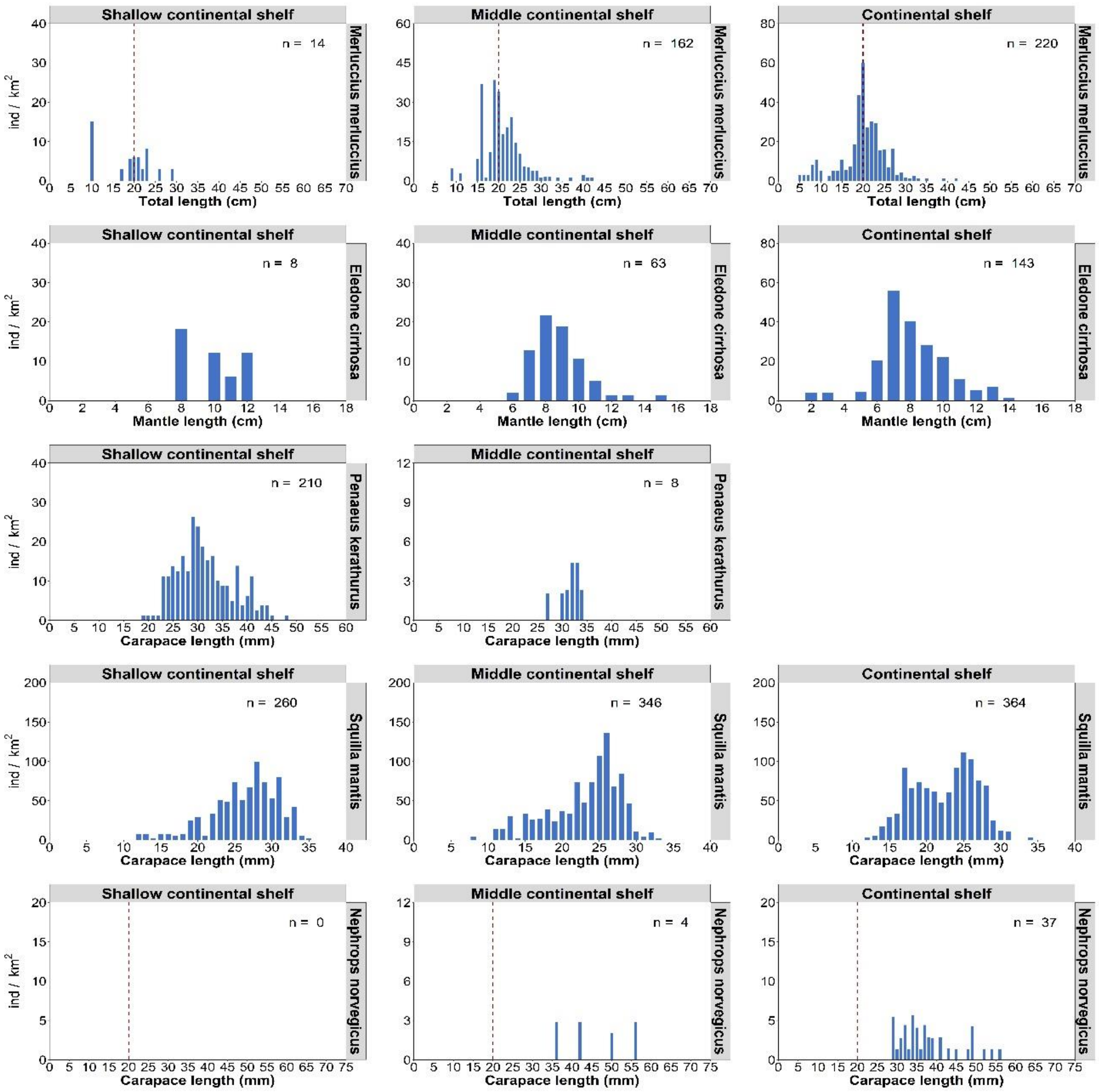


Figure 193. Length-frequency distribution of target species captured by bottom trawl for depth stratum from October 2019 to December 2020 in the port of L'Ametlla de Mar. The red dashed line indicates the minimum conservation reference size (MCRS).

2.1.3.9 Sant Carles de la Ràpita

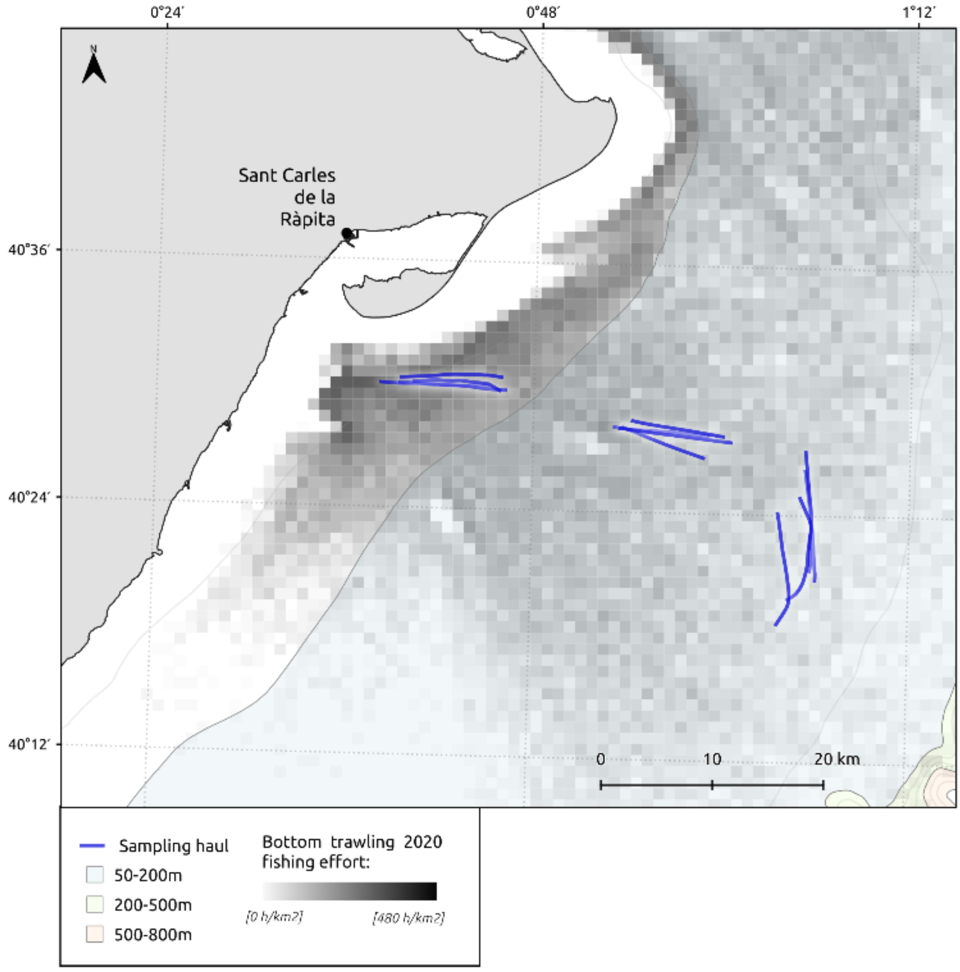


Figure 194 shows the bottom trawl commercial fishing activities and sampling bottom trawls conducted in the Sant Carles de la Ràpita port between October 2019 and December 2020.

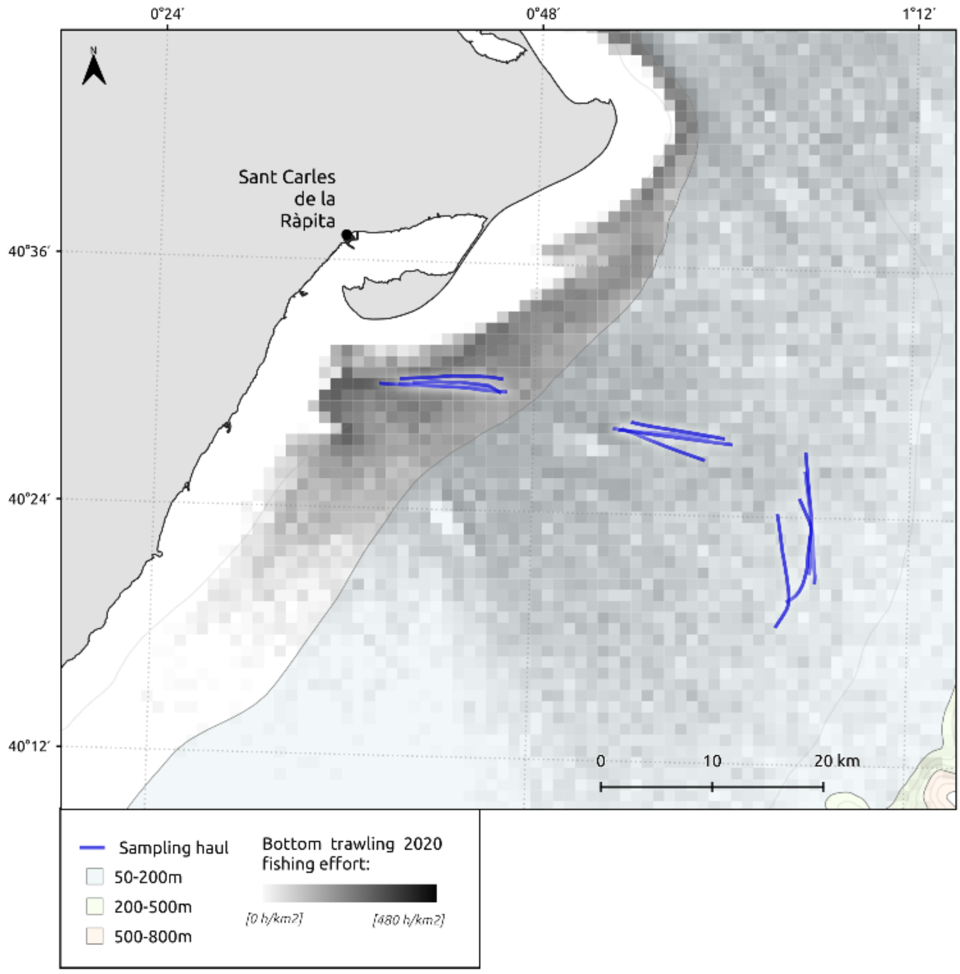


Figure 194. Map of bottom trawling hauls conducted in the port of Sant Carles de la Ràpita from October 2019 to December 2020.

The characterization of the catches for the 12 bottom trawling hauls conducted in Sant Carles de la Ràpita from October 2019 to December 2020 is shown in Figure 195 per each year and fraction of catch (landed, discarded, and debris). In autumn 2019, the landed catches represented, depending on the fishing ground, from 50 to 70% of the total catches. The discarded fraction ranged between 18 and 42% of the total biomass and the debris, ranged between 8 and 14%. In 2020, the landed catches accounted for, depending on the fishing ground, from 49 to 62% of the total catches. The discarded fraction ranged between 29 and 44% of the total biomass wereas the debris ranged between 7 and 9%.

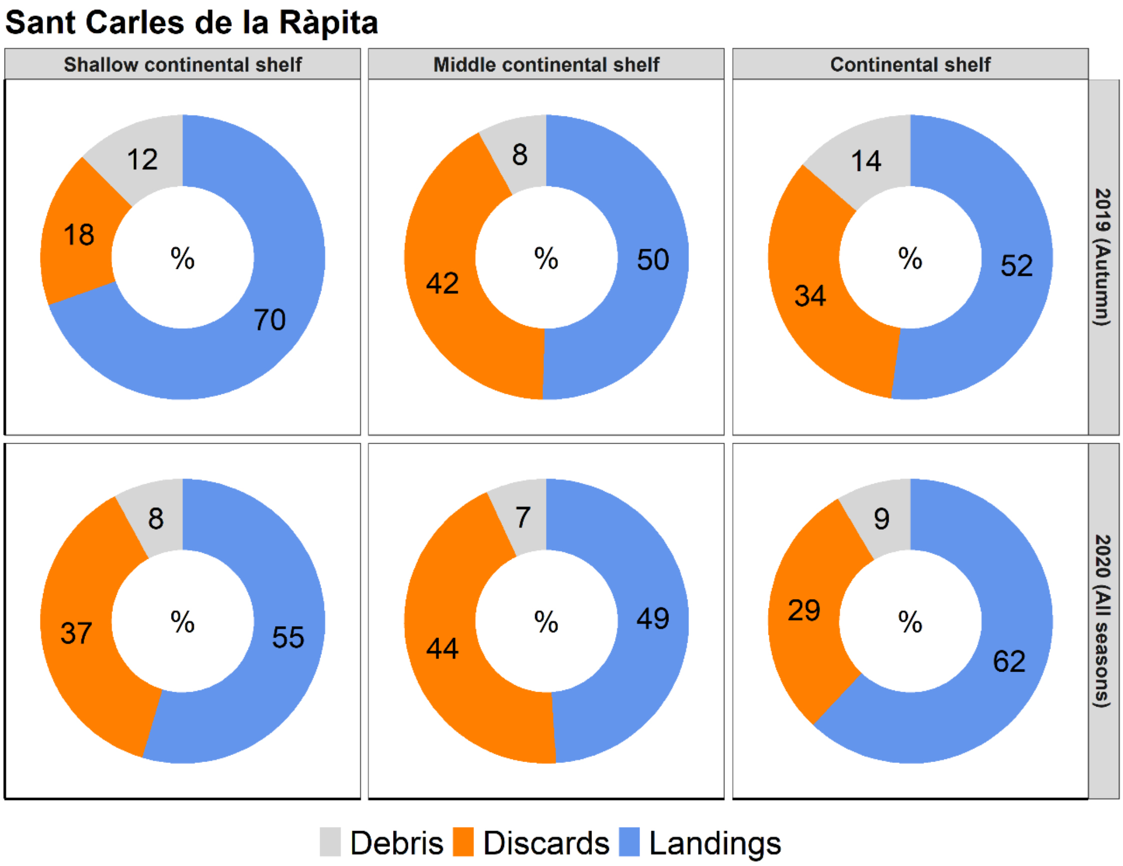


Figure 195. Catch composition in the port of Sant Carles de la Ràpita. Percentage by weight of landings and debris fraction in each year and fishing ground, including all hauls from October 2019 to December 2020.

The proportion of species with most of the biomass within the landed catch for each year and fishing ground is shown in Figure 196. A total of 66 species were landed in Sant Carles de la Ràpita from October 2019 to December 2020 (39 in the shallow continental shelf, 44 in the middle continental shelf, and 43 in the continental shelf). In autumn 2019, the most landed species were *P. kerathurus* and *S. mantis* in the shallow continental shelf, *T. capelanus* and *E. cirrhosa* in the middle continental shelf, and *L. budegassa* in the continental shelf. In 2020, the target species found in this port (*M. merluccius*, *N. norvegicus*, *E. cirrhosa, P. kerathurus,* and *S. mantis*) accounted for 8% of the landed catch in the shallow continental shelf, 31% in the middle continental shelf and, 20% in the continental shelf. The landed fraction in the shallow continental shelf was composed mainly by *T. mediterraneus* (19%), *S. sphiraena* (17%), and *M. cephalus* (12%). In the middle continental shelf, *M. merluccius* (18%) and *L. depurator* (13%) were the main landed species. In the continental shelf, the main landed species was *L. budegassa* (20%), followed by *M. barbatus* (14%) and *M. merluccius* (10%).

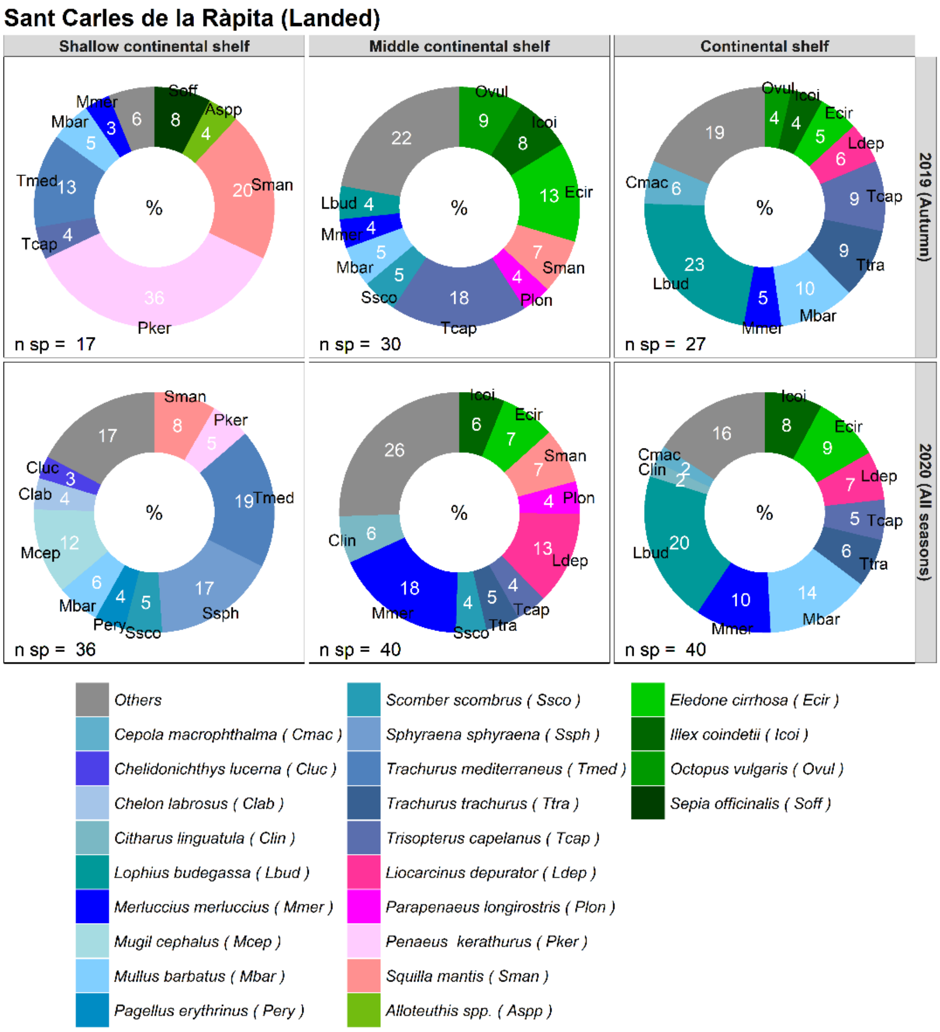


Figure 196. Species with most biomass within the landed catch in the port of Sant Carles de la Ràpita. Percentage by weight of the landed fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

Of the landed species, in the shallow continental shelf and in the continental shelf, actinopterygii was the group with the highest biomass and abundance. In the middle continental shelf, actinopterygii had the highest biomass but the most abundant group was crustacea. In the middle continental shelf and continental shelf, cephalopoda had high biomass and abundance (Table 44).

Table 44. Biomass (Kg/Km^2) and abundance (ind./Km^2) of the taxonomic groups present in the landed fraction of the catch in the port of Sant Carles de la Ràpita. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Shallow continental shelf		Middle continental shelf		Continental shelf	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	232.65	178.28	188.55	37.15	288.82	37.11
Chondrichthyes	2.11	2.99				
Crustacea	40.29	15.40	82.20	77.07	29.87	32.18
Cephalopoda	15.75	8.88	58.26	17.72	78.37	25.01
Other Mollusca	3.78	1.59	2.48	0.43	0.07	0.10
Echinodermata			0.95	1.34	0.38	0.53
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	2201.94	1620.90	3286.22	723.25	5374.37	1243.04
Chondrichthyes	22.32	31.57				
Crustacea	1446.48	690.26	7874.25	6204.09	2693.74	2975.12
Cephalopoda	293.28	88.57	1540.61	580.19	1644.29	636.49
Other Mollusca	356.75	156.36	170.55	47.00	3.05	4.31
Echinodermata			7.23	10.23	6.13	8.67

The proportion of species with the most biomass within the discarded catch for each year and fishing ground is shown in Figure 197. A total of 140 species were discarded in Sant Carles de la Ràpita from October 2019 to December 2020 (92 in the shallow continental shelf, 79 in the middle continental shelf, and 85 in the continental shelf). In autumn 2019, the main species for the discarded fraction were *A. irregularis* and *S. mantis* in the continental shelf. In the middle continental shelf and in the continental shelf the main discards were *T. mediterraneus* and *B. boops*, respectively. In 2020, the species with the highest discard percentages in this port were *E. encrasicolus* (3 - 33%), *S. aurata* (0 - 57%), *S. pilchardus* (0 - 13%), and *M. merluccius* (0 - 9%) although there was a great variability according to each fishing ground.

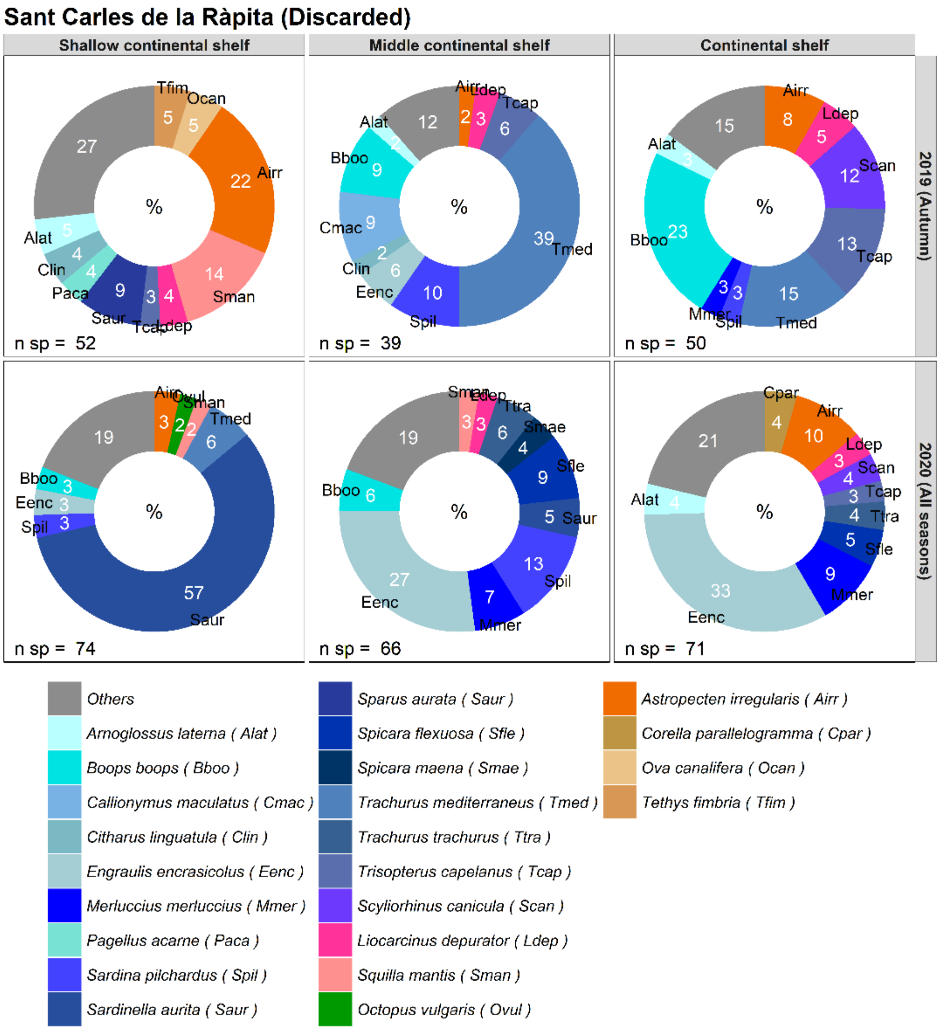


Figure 197. Species with most biomass within the discarded catch in the port of Sant Carles de la Ràpita. Percentage by weight of the discarded fraction of catch in each year and fishing ground, including all hauls from October 2019 to December 2020.

For the discarded species, Actinopterygii was the group with the highest biomass and abundance in the three fishing grounds. Crustacea, Echinodermata and Mollusca were also relevant in terms of both, biomass and abundance (Table 45).

Table 45. Biomass (Kg/Km^2) and abundance (ind./Km^2) of the taxonomic groups present in the discarded fraction of the catch in the port of Sant Carles de la Ràpita. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Shallow continental shelf		Middle continental shelf		Continental shelf	
Biomass	mean	sd	mean	sd	mean	sd
Actinopterygii	191.01	225.97	304.08	233.68	129.86	87.23
Chondrichthyes	0.75	0.63	0.56	0.33	9.40	13.32
Crustacea	11.67	2.48	25.28	24.52	10.74	3.21
Cephalopoda	6.63	8.45	9.69	10.36	4.74	1.45
Other Mollusca	11.75	3.82	8.14	6.42	6.20	2.46
Porifera	0.32	0.45	2.59	2.24	1.06	1.56
Cnidaria	3.46	2.12	10.27	7.27	15.93	8.34
Annelida	0.00	0.01			0.08	0.11
Echinodermata	10.89	9.65	5.86	5.49	20.44	3.55
Tunicata	0.57	0.32	0.59	0.12	9.18	8.63
Abundance	mean	sd	mean	sd	mean	sd
Actinopterygii	8367.52	6883.13	24666.85	26279.75	9230.95	6490.13
Chondrichthyes	221.58	176.86	309.23	168.82	746.02	236.83
Crustacea	1451.31	397.01	4401.51	3434.63	2069.81	646.15
Cephalopoda	71.63	61.39	313.90	336.15	502.26	416.09
Other Mollusca	1072.31	236.39	811.09	460.03	1155.56	418.66
Porifera	30.92	43.73	77.66	66.91	131.25	139.70
Cnidaria	827.36	520.44	2569.63	1720.18	3768.28	1426.63
Annelida	7.73	10.93			152.48	215.63
Echinodermata	3071.06	2990.46	2643.74	1850.44	10038.10	731.17
Tunicata	20.31	12.50	186.37	37.74	5565.00	4188.82

The debris composition is shown in Figure 198. In autumn 2019, terrestrial plants (63 - 73%), marine plants (11 - 16%), and marine organic debris (10 - 19%) were the main components of the debris fraction. In 2020, the main components of this fraction were terrestrial plants (21 - 42%), shells (18 - 26%), and marine organic debris (27 - 49%). The mass of debris (kg of debris by km^2) is presented in Table 46.

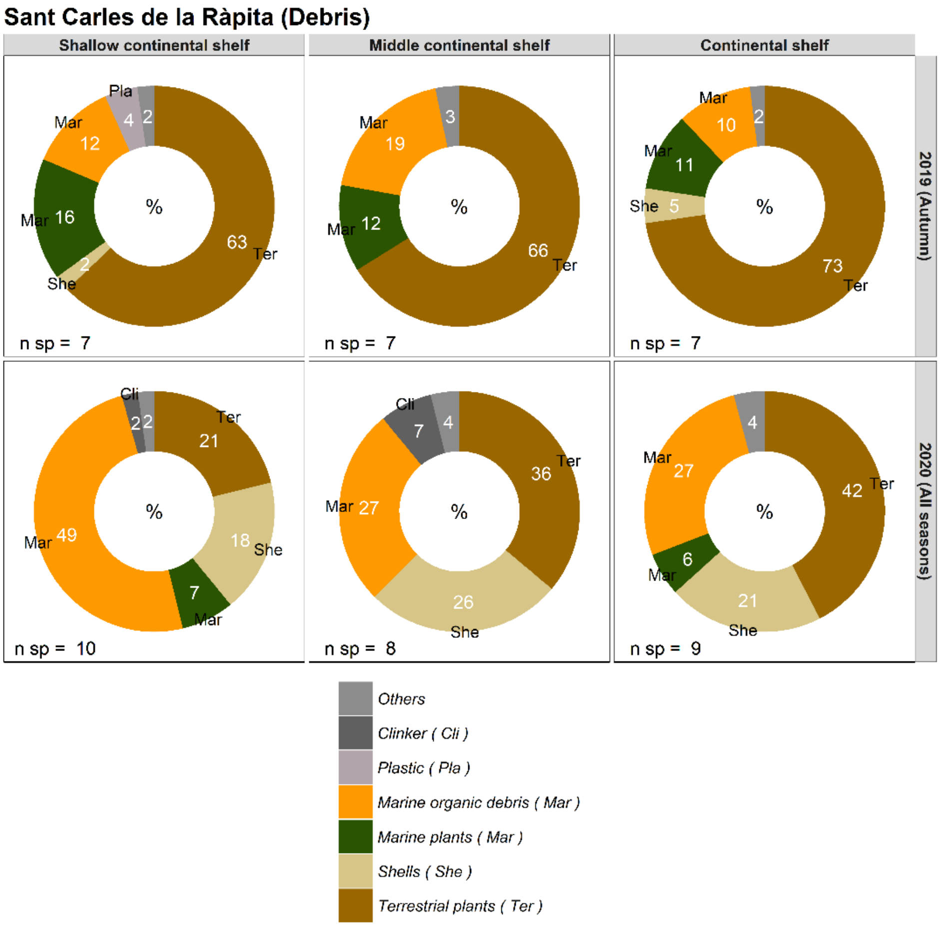


Figure 198.Items with most weight of the debris fraction of the catch in the port of Sant Carles de la Ràpita. Percentage by weight in each year and fishing ground, including all hauls from October 2019 to December 2020.

Table 46. Mass (Kg/Km^2) of the debris present in the debris fraction of the catch in the port of Sant Carles de la Ràpita. Mean and standard deviation in each fishing ground, including all hauls from January to December 2020.

	Shallow continental shelf		Middle continental shelf		Continental shelf	
	mean	sd	mean	sd	mean	sd
Terrestrial plants	6.13	3.77	16.57	3.52	24.43	17.38
Marine organic debris	14.35	12.03	12.20	10.55	15.39	9.03
Shells	5.22	2.94	12.11	9.18	12.02	9.83
Marine plants	2.06	2.40	0.91	1.29	3.34	4.72
Clinker	0.63	0.52	3.25	3.96	0.27	0.22
Plastic	0.40	0.37	0.60	0.50	0.78	0.76
Unclassified debris					0.78	1.10

	Shallow continental shelf		Middle continental shelf		Continental shelf	
	mean	sd	mean	sd	mean	sd
Wet wipes					0.42	0.59
Other marine algae	0.06	0.07	0.25	0.31		
Ropes	0.07	0.09	0.02	0.03	0.14	0.15
Fishing gear	0.08	0.11				
Textiles	0.02	0.04				

Regarding species the annual catch rates of hake during the period 2000-2020 in the port of Sant Carles de la Ràpita showed a constant fluctuation ranging 180 and 300 tons (Figure 199). Maximum hake catch rates were registered in 2009 (> 300 tons) and the minimum were recorded in last years (< 120 tons).

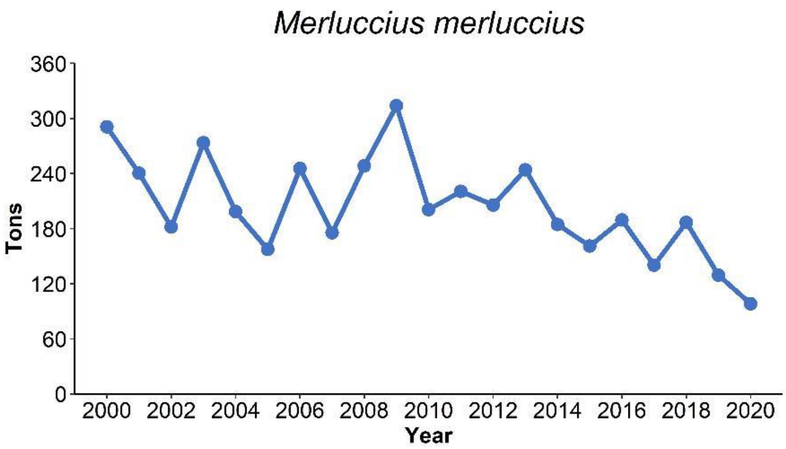


Figure 199.Time series of annual catch rates (tons) for the time period 2000-2020 in Sant Carles de la Ràpita.

The annual catch rates of horned octopus in the port of Sant Carles de la Ràpita indicated a progressive decline after the peak year (2013). However, in the last two years there was a slight increase in catches (Figure 200). Catches of caramote prawn and spottail mantis shrimp were stable throughout the time series (Figure 201 and Figure 202, respectively). Norway lobster catches decreased from 2014 onwards, reaching the lowest values of the entire historical series in the last year (Figure 203).

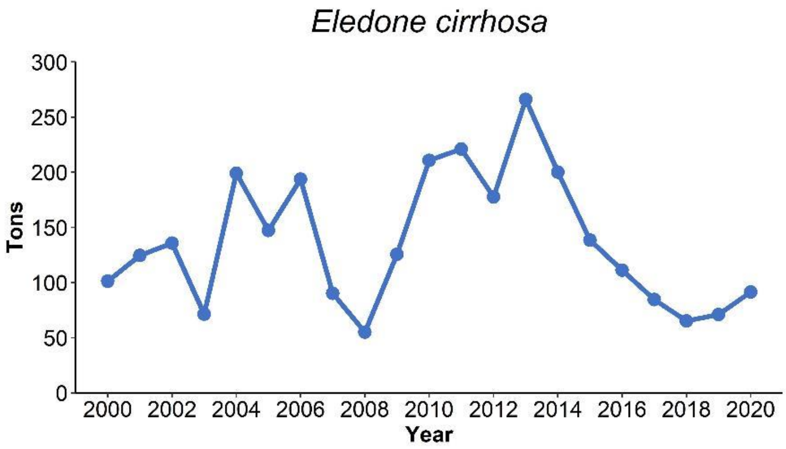


Figure 200.Time series of horned octopus annual catch rates (tons) for the time series 2000-2020 in Sant Carles de la Ràpita.

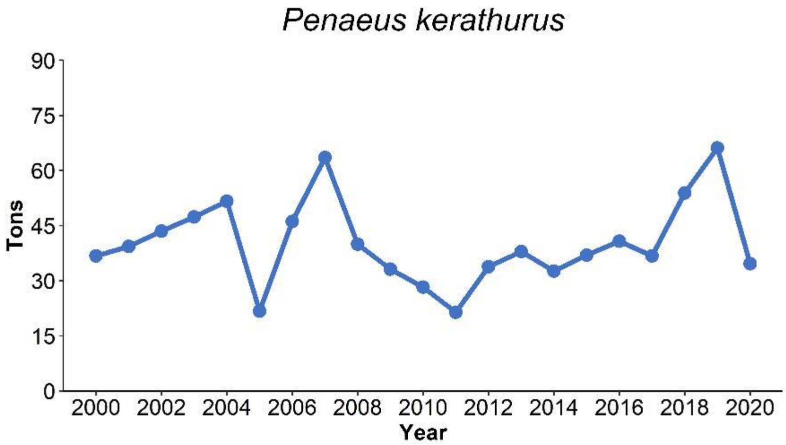


Figure 201. Time series of caramote prawn annual catch rates (tons) for the time period 2000-2020 in Sant Carles de la Ràpita.

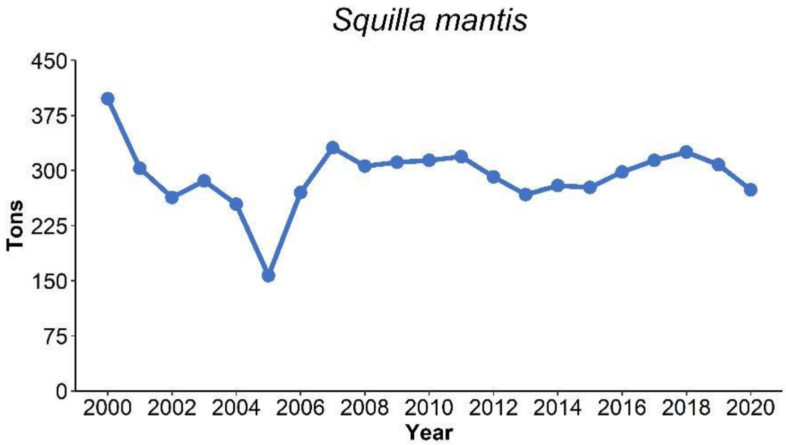


Figure 202. Time series of spottail mantis shrimp annual catch rates (tons) for the time period 2000-2020 in Sant Carles de la Ràpita.

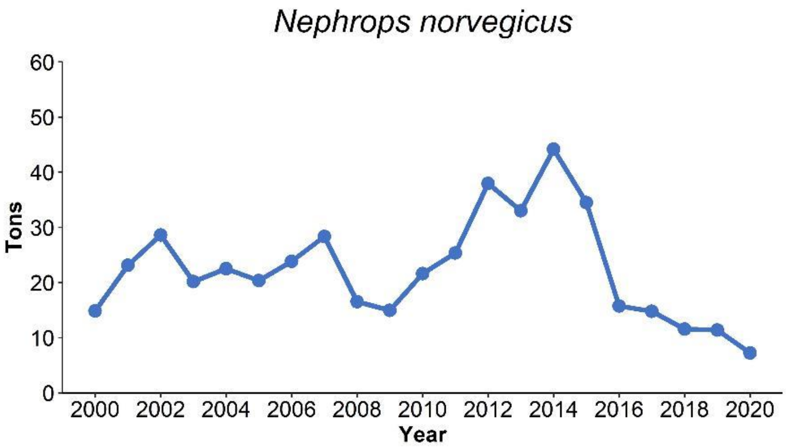


Figure 203. Time series of Norway lobster annual catch rates (tons) for the time period 2000-2020 in Sant Carles de la Ràpita.

The size frequency distribution of hake from October 2019 to December 2020 in the port of Sant Carles de la Ràpita (Figure 204) ranged between 7 and 43 cm, with a greater abundance of individuals on the continental shelf, a similar pattern than that in the port of l'Ametlla de Mar. The hake individuals measured in the three depth strata were abundant below the MCRS, that is, immature hake was caught in the port of Sant Carles de la Ràpita. Horned octopus was also abundant in the middle continental shelf and continental shelf, where the sizes of the individuals measured were slightly larger than the individuals from l'Ametlla de Mar. The size range was between 4 and 15 cm of mantle length. The size frequency of camarote prawn and spottail mantis shrimp were very similar to the individuals measured in l'Ametlla de Mar, although the mantis shrimp was more abundant on the shallow continental shelf in Sant Carles de la Ràpita and the frequency was more stable in each depth stratum. Norway lobster catches were very low and it was not possible to analyze the population structure for this port.

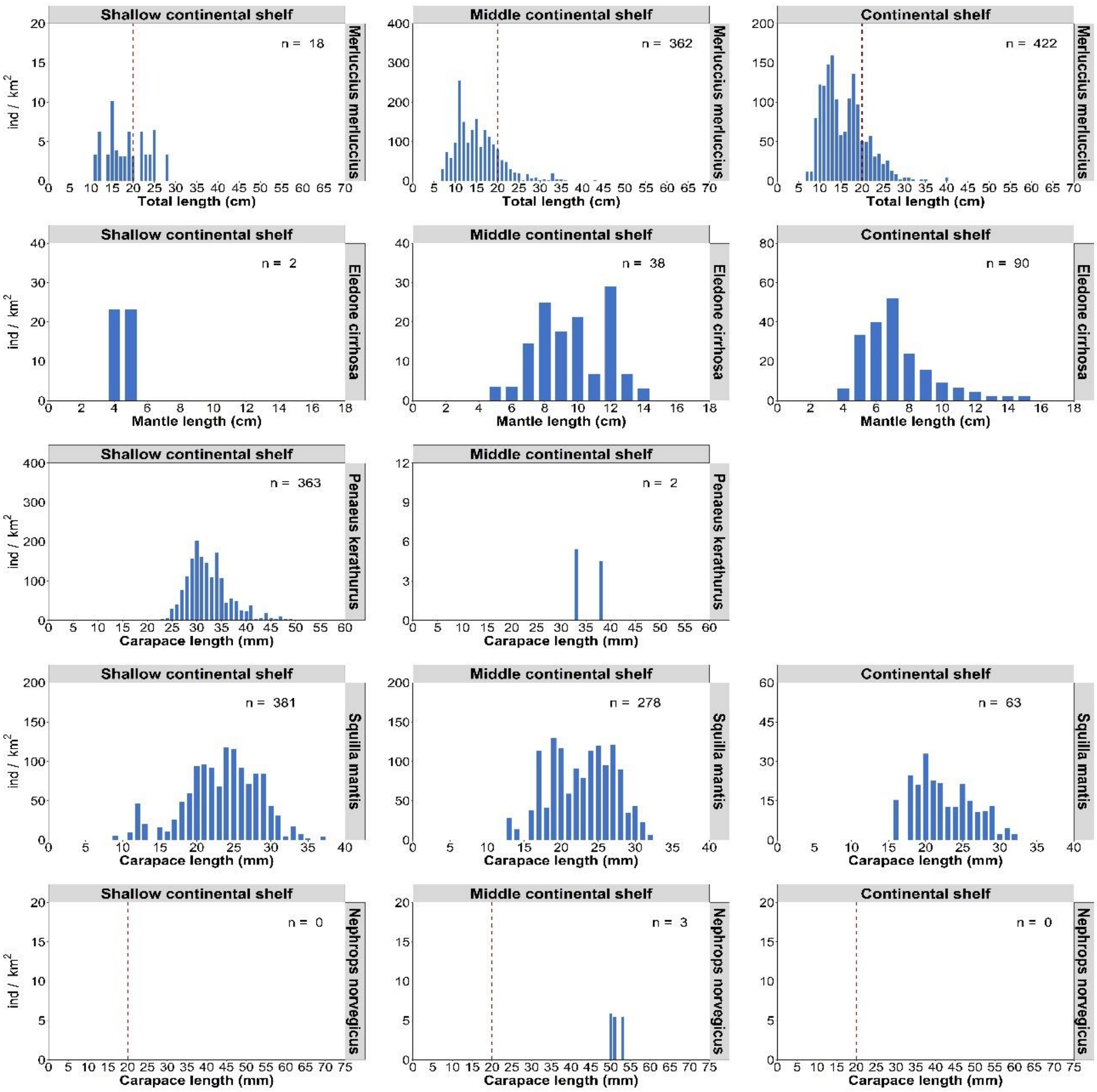


Figure 204. Length-frequency distribution of target species captured by bottom trawl for depth stratum from October 2019 to December 2020 in the port of Sant Carles de la Ràpita. The red dashed line indicates the minimum conservation reference size (MCRS).

2.2 PURSE SEINE FISHING

2.2.1 Purse seine fishing in Catalonia

Two species are main targets for this type of fishery, the European sardine, *Sardina pilchardus* (Walbaum, 1792), and The European anchovy, *Engraulis encrasicolus* (Linnaeus, 1758). Both species are small pelagic clupeoid widely distributed in the Mediterranean Sea, inhabiting the continental shelf (Tsikliras & Koutrakis, 2013). Figure 205 shows the sampling localization of sardine and anchovy hauls along the catalan coast from October 2019 to December 2020.

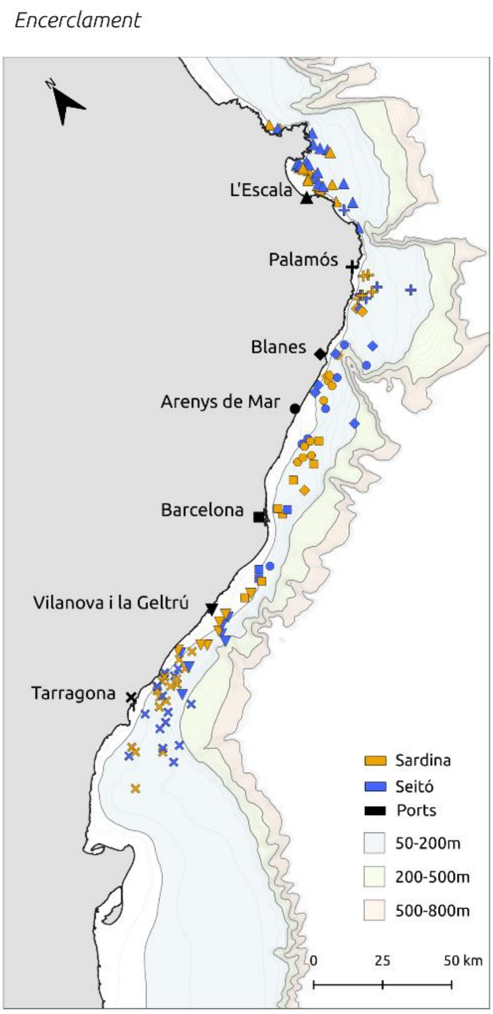


Figure 205. Map of purse seine hauls performed in Catalonia from October 2019 to December 2020.

2.2.1.1 Target species monitoring: European sardine (*Sardina pilchardus*)

Annual catch history

The annual catch rates of sardine during the period 2000-2020 in Catalonia showed an early drastic decline (2000-2002), followed by a slow and progressive recuperation until 2007. Then, the catches were sharply reduced until 2010. From here on, the situation tended to stabilize at low levels of catch, with values around 6000 tons per year (Figure 206).

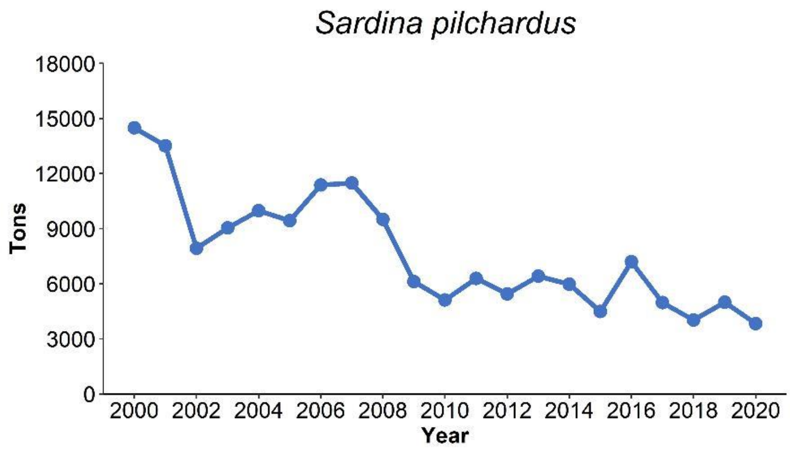


Figure 206. *Sardina pilchardus.* Time series of sardine annual catch (tons) in Catalonia for the period 2000-2020.

Population structure

The monthly length-frequency distribution of sardine from October 2019 to December 2020 indicated that an important proportion of individuals captured were below the size at first maturity (10 cm) and the minimum conservation reference size (MCRS) (11 cm). Therefore, these were immature and small-sized individuals that had not bred yet (Figure 207). Size range extended from 7.5 to 18.5 cm total length. Small-sized individuals appeared from November to February when the mode remained at 11.5 cm, close to the MCRS. Conversely, large-sized individuals were mainly captured from June to August when the mode increased to 13.5 cm.

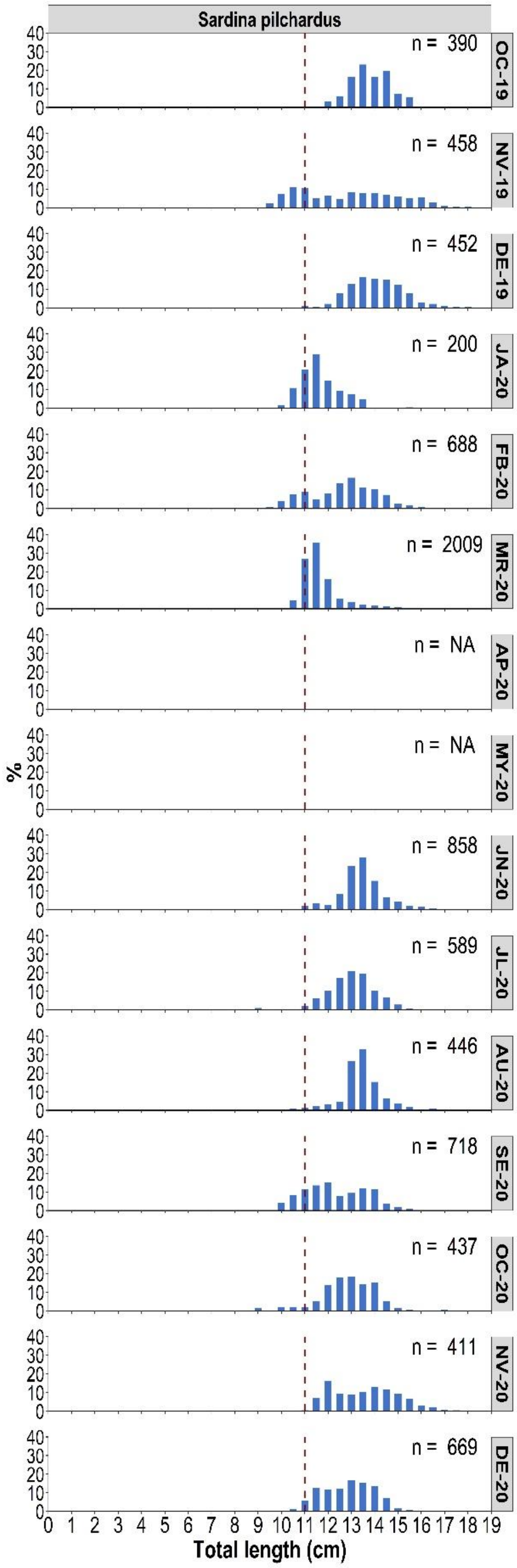


Figure 207. Monthly length-frequency distribution of sardine (*S. pilchardus*) from October 2019 to December 2020 along the Catalan coast. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 11 cm.

Sexual morphology and sex ratio

Different growth rates between sexes have been previously described and resulted in different length-frequency distributions between sexes, with a dominance of males in the smaller length classes and their absence from the larger ones (Silva et al., 2008).

Length-weight relationship

The parameters of the length-weight relationship for sardine population were calculated using the relationship $W = a*TL^b$, where W is weight (g) and TL is total length (cm) (Table 47). According to length-weight relationship parameters for both sexes combined, sardine displayed a positive allometric growth (b > 3) for both years (Figure 208). Likewise, growth curves applied separately by sex showed that both sexes grew positive allometrically, and males exhibited the highest *b* value in 2019 whereas females showed the highest in 2020. In general terms, sardine *b* values in 2019 were higher than 2020 for all sex aggregations, suggesting that the gain of weight during the sardines' growth was higher in 2019.

Table 47. Sardine length-weight relationship parameters in 2019 and 2020.

2019	a	b	R^2	n
Combined	0.0034	3.3136	0.9510	1640
Females	0.0042	3.2360	0.9432	831
Males	0.0029	3.3819	0.9476	799
2020	a	b	R^2	n
Combined	0.0060	3.0234	0.9559	1360
Females	0.0055	3.0369	0.9539	658
Males	0.0064	2.9262	0.9243	621

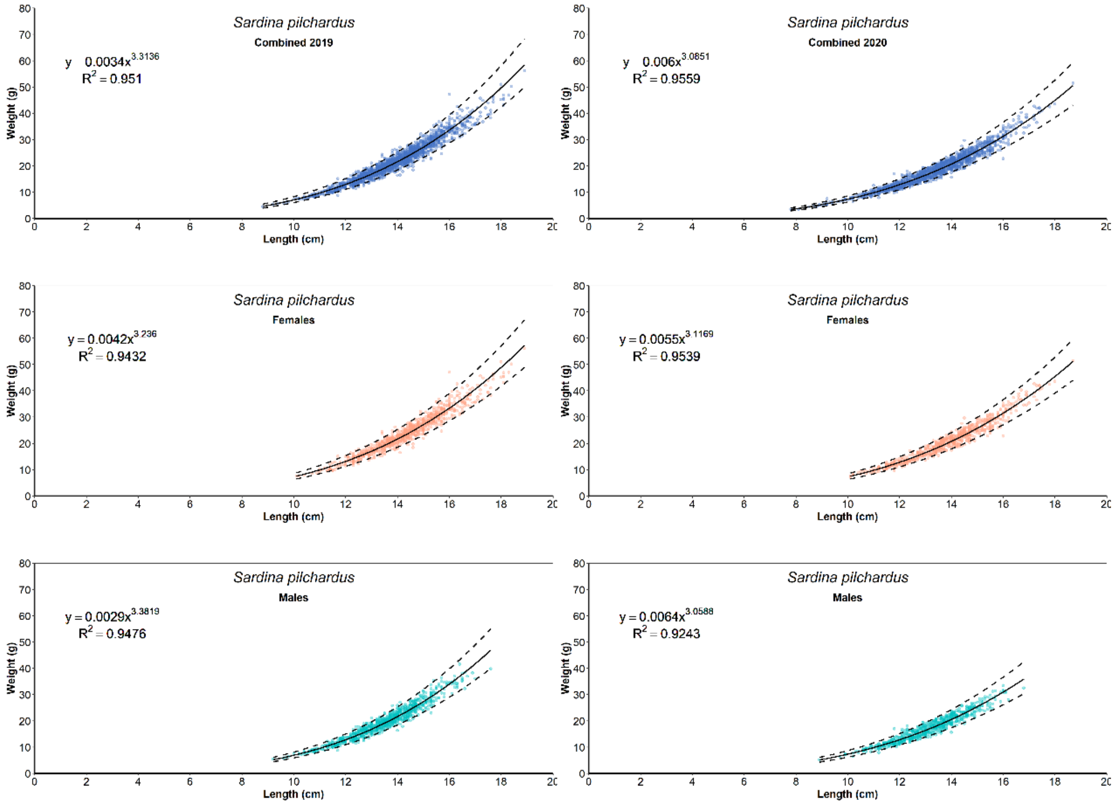


Figure 208. Length-weight relationship for sardine population (*S. pilchardus*) in 2019 and 2020. Parameters *a* and *b* were calculated for both sexes combined (blue), females (red) and males (green).

Reproductive cycle and gonadosomatic index

The reproductive cycle of sardines was analyzed for 2019 and 2020, gathering data for two full years (Figure 209) (Figure 210). The reproductive period for the sardine was detected from October to April when males and females in active maturity phases (stages II – V) were present. However, the reproductive peak seemed to concentrate from December to January when the major proportion of spawners were detected. These results agreed with the evolution of the gonadosomatic index (GSI) throughout both years, increasing in October, reaching maximum values in December and January (> 4), and declining in March. The proportion of individuals in a resting stage (II) was high from May to September, corresponding to the period when GSI exhibited the minimum values.

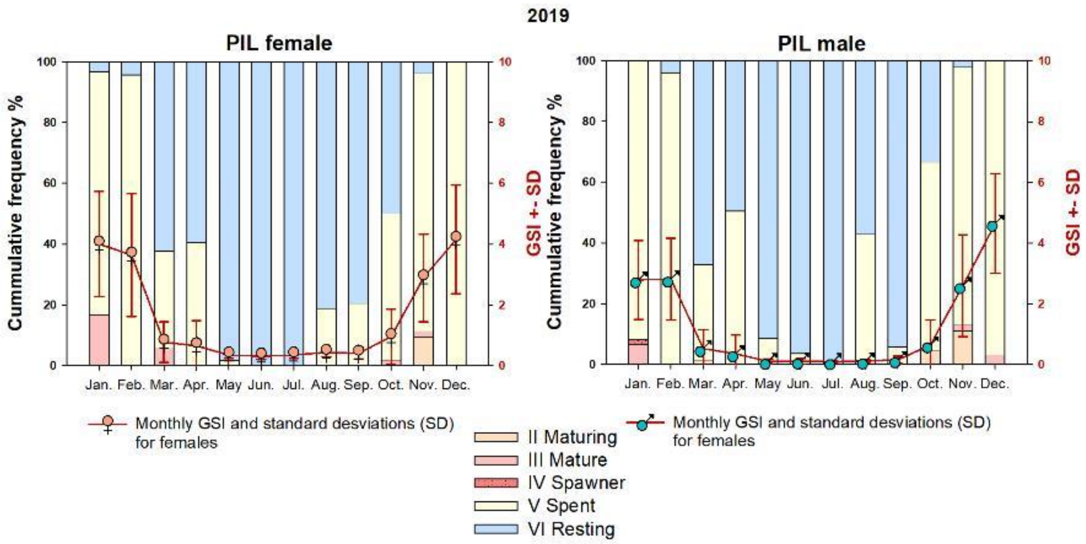


Figure 209. Sardine (PIL) monthly gonadal maturation cycle for females and males in 2019. Gonadosomatic index (GSI+/-SD) and percentage of different maturity stages.

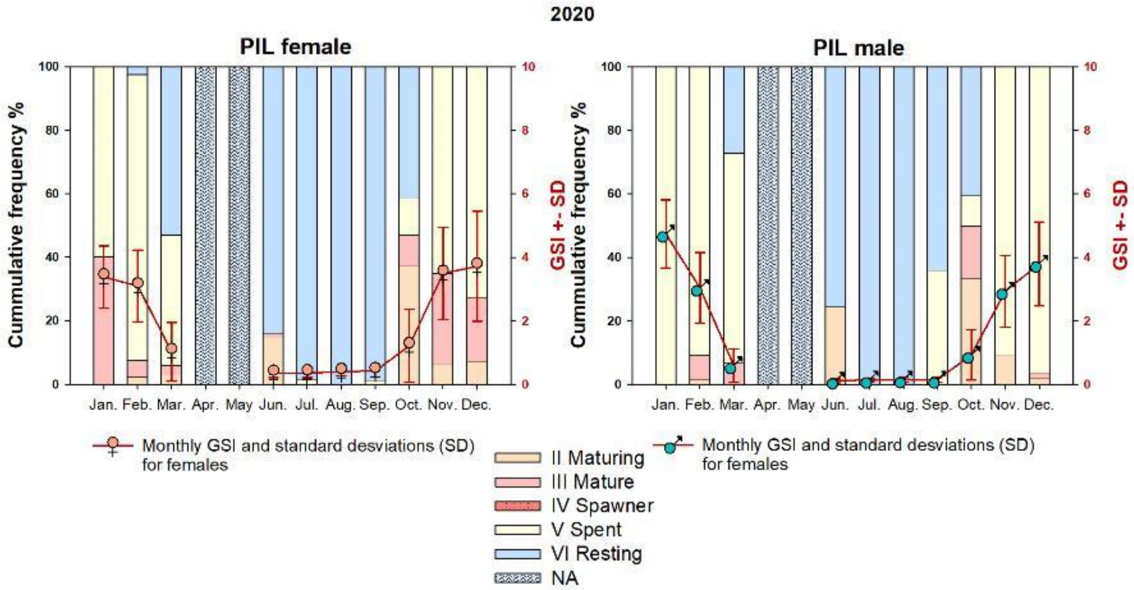


Figure 210. Sardine (PIL) monthly gonadal maturation cycle for females and males in 2020. Gonadosomatic index (GSI+/-SD) and percentage of different maturity stages.

Summary factsheet of the biological parameters and fishing activity in 2019-2020 of European sardine in Catalonia

2.2.1.2 Target species monitoring: anchovy (*Engraulis encrasicolus*)

Annual catch history

The annual catch rates of anchovy during the period 2000-2020 in Catalonia showed an increase between 2000 and 2002, followed by a significant decline reaching minimum values in 2008. From 2009 to 2020, the catch rates partially recovered, with values fluctuating between 5000 and 10000 tons (Figure 211).

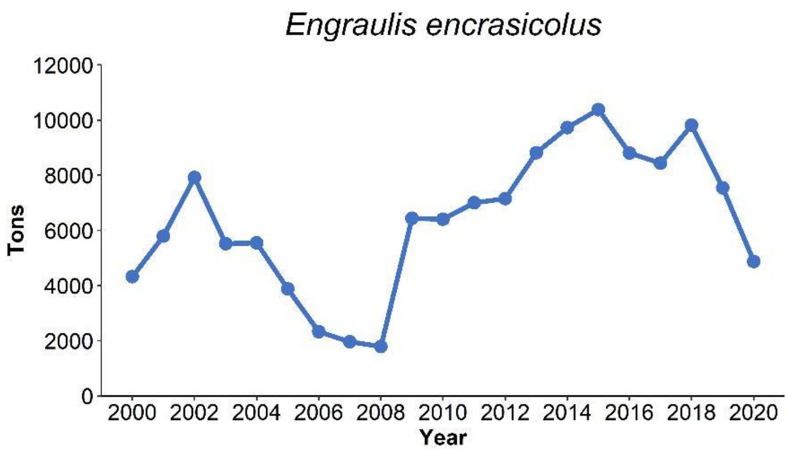


Figure 211. *Engraulis encrasicolus.* Time series of anchovy annual catch (tons) in Catalonia for the period 2000-2020.

Population structure

The monthly length-frequency distribution of anchovy from October 2019 to December 2020 indicated that an important proportion of individuals captured were below the size at first maturity (10 cm) and the minimum conservation reference size (MCRS) (9 cm). Therefore, these corresponded to immature and small-sized individuals (Figure 212). Size range extended from 6.5 to 16 cm total length. The main proportion of small-sized individuals appeared in December, but the modes kept close to the MCRS until March. Alternatively, between June and August, coinciding with the spawning period, the catch was mainly composed of large-sized and mature individuals, with modes around 12 cm (Figure 212).

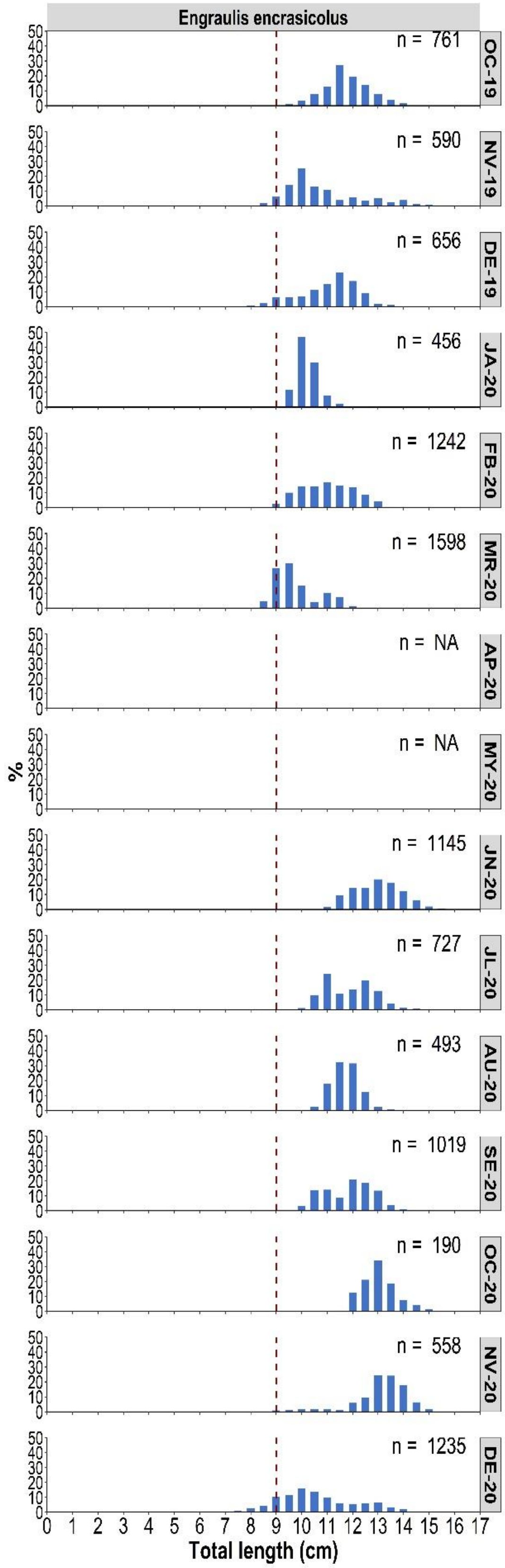


Figure 212. Monthly length-frequency distribution of anchovy (*E. encrasicolus*) from October 2019 to December 2020 along the Catalan coast. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 9 cm.

Sexual morphology and sex ratio

The presence of sexual dimorphism in anchovy regarding different morphometric variables is still unclear despite several studies performed on the topic. Some studies revealed no sexual dimorphism neither in morphometric variables or between zones (Traina et al., 2011), although these results contradict other studies from the Mediterranean. Another study analyzed the sex ratio by length class and suggested an increase in the percentage of females with size, specifically for the largest sizes. Likewise, seasonal and spatial differences in sex ratio were detected by sex (Millán, 1999).

Length-weight relationship

The parameters for the length-weight relationship for the anchovy population were calculated using the relationship $W = a*TL^b$, where W is weight (g) and TL is total length (cm) (Table 48). According to length-weight relationship parameters for both sexes combined, anchovy displayed a positive allometric growth (b > 3) in both years (Figure 213). Likewise, growth curves applied separately by sex showed that both sexes grew positive allometrically, and females exhibited the highest *b* value in both years. In general terms, anchovies' *b* value for males in 2019 was higher than 2020 whereas in females there was no difference observed between years.

Table 48. Anchovy length-weight relationship parameters in 2019 and 2020.

2019	a	b	R^2	n
Combined	0.0041	3.1833	0.9707	1480
Females	0.0039	3.2060	0.9691	753
Males	0.0044	3.1542	0.9609	662
2020	a	b	R2	n
Combined	0.0044	3.1484	0.9716	1200
Females	0.0037	3.2086	0.9686	681
Males	0.0059	3.0259	0.9553	428

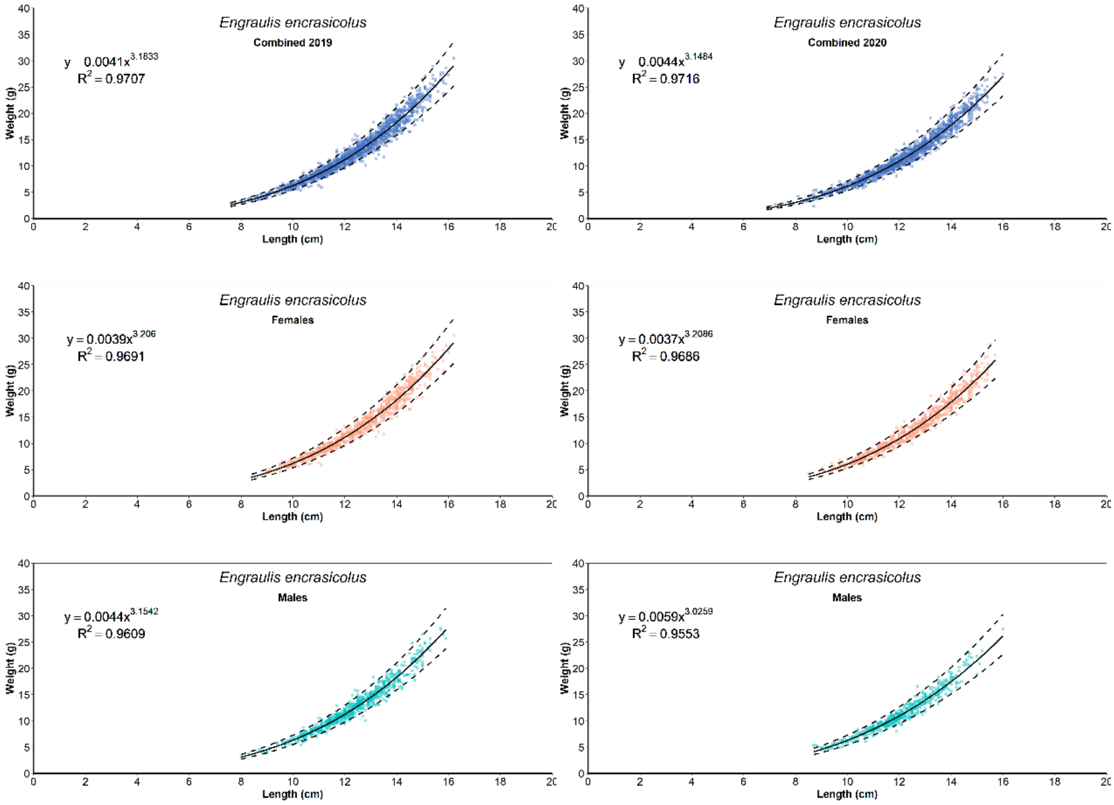


Figure 213. Length-weight relationship for anchovy population (*E. encrasicolus*) in 2019 and 2020. Parameters *a* and *b* were calculated for both sexes combined (blue), females (red) and males (green).

Reproductive cycle and gonadosomatic index

The reproductive cycle of anchovy was analyzed for 2019 and 2020, including data for two full years of monitoring (Figure 214 and Figure 215). The reproductive period for the anchovy was detected from April to October when males and females in maturity activity (stages II–V) were present. However, the reproductive peak seemed to concentrate from June to August, coinciding with summer months, when the main proportion of spawners were detected. These results agreed with the evolution of the gonadosomatic index (GSI) throughout both years, increasing in April, reaching maximum values from June to August (~3), and declining in September. The proportion of individuals in a resting stage (II) was high from November to March, corresponding to the period when GSI exhibited the minimum values.

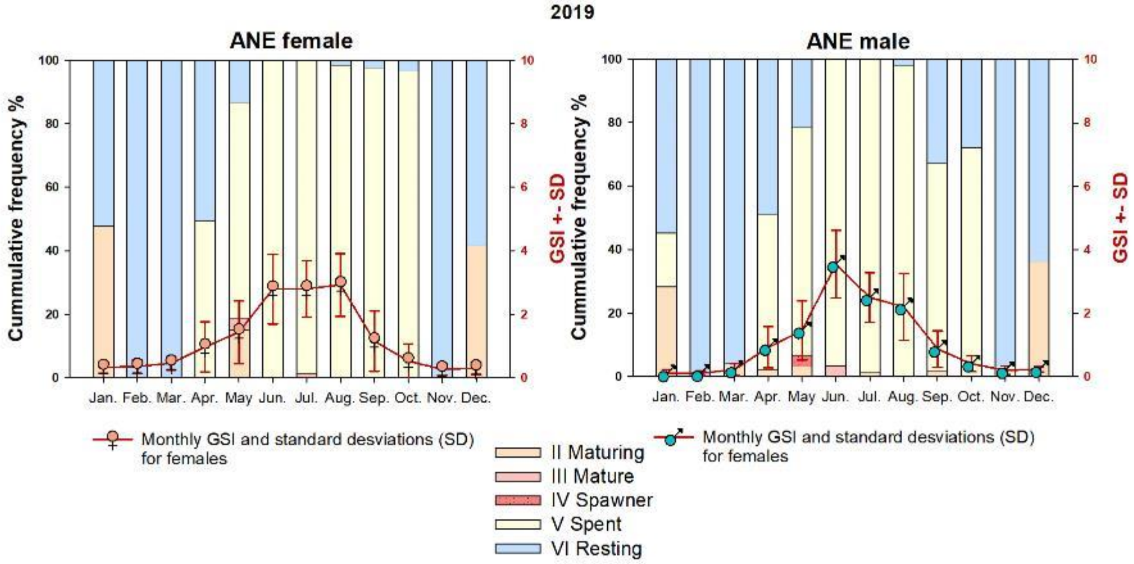


Figure 214. Anchovy (ANE) monthly gonadal maturation cycle for females and males in 2019. Gonadosomatic index (GSI+/-SD) and percentage of different maturity stages.

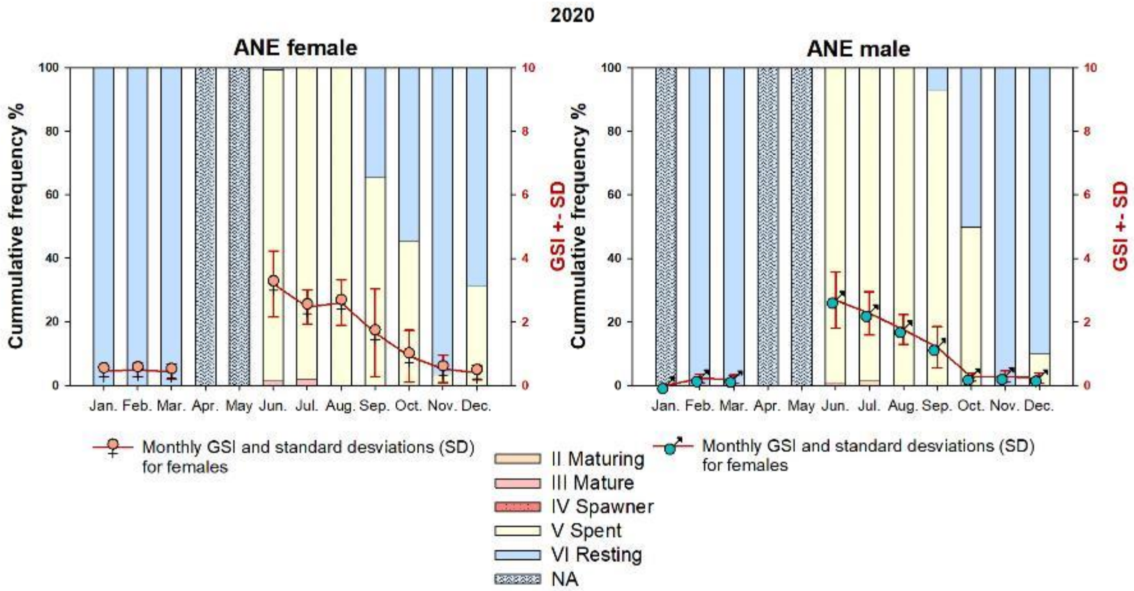


Figure 215. Anchovy (ANE) monthly gonadal maturation cycle for females and males in 2020. Gonadosomatic index (GSI+/-SD) and percentage of different maturity stages.

Summary factsheet of the biological parameters and fishing activity in 2019-2020 of anchovy in Catalonia

2.2.2 Purse seine fishing by zone

2.2.2.1 Status of target species by zones

Figure 216 shows the sampling localization of sardine and anchovy hauls performed in the North zone from October 2019 to December 2020.

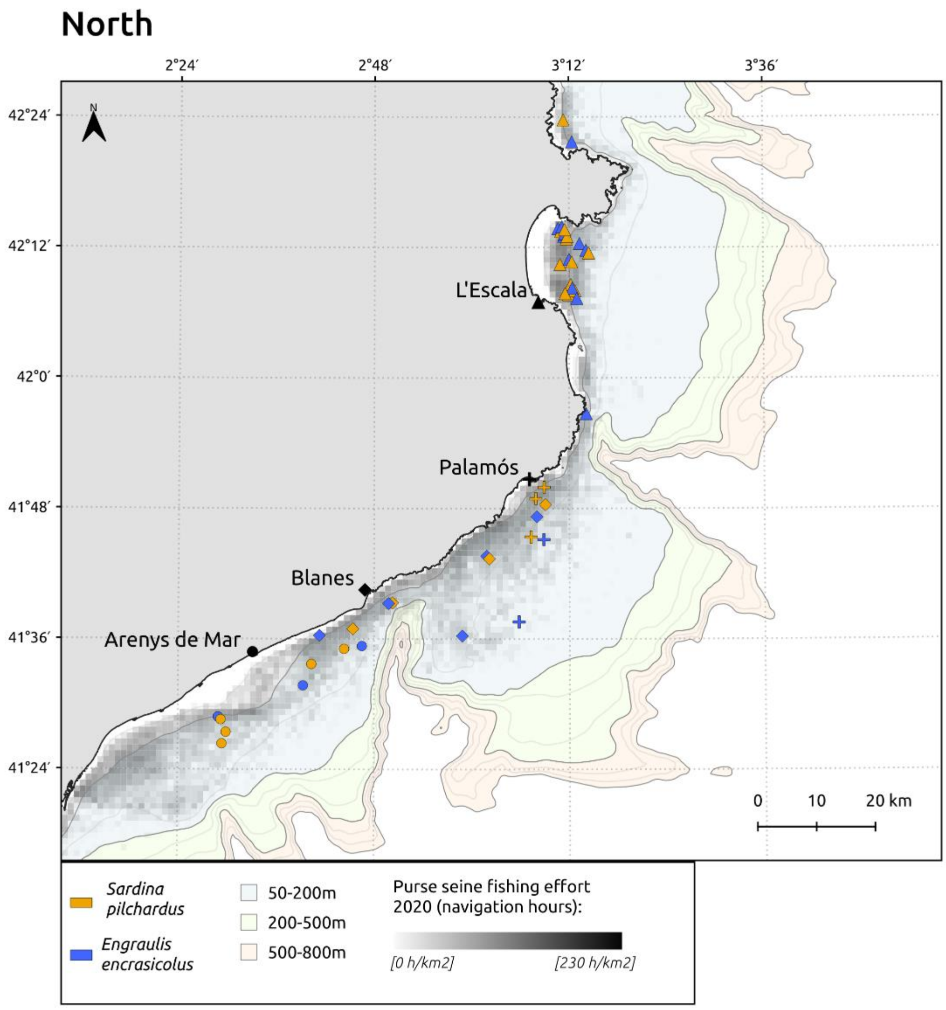


Figure 216. Map of purse seine hauls performed in the north zone from October 2019 to December 2020.

North zone sardine (Sardina pilchardus)

The annual catch rates of sardine during the period 2000-2020 in the north zone indicated that values have fluctuated widely during the first decade, reaching its maximum catch in 2007. However, since 2009, catches tended to stabilize at low levels, showing values between 2000 and 3000 tons (Figure 217).

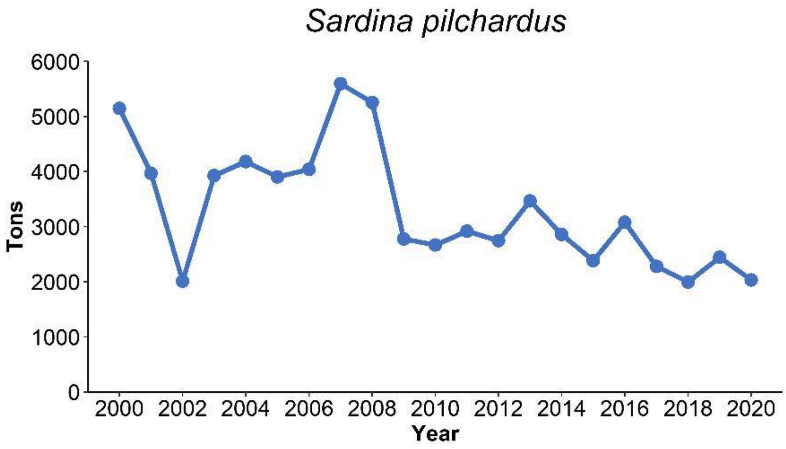


Figure 217. *Sardina pilchardus.* Time series of sardine annual catch rates (tons) for the period 2000-2020 in the north zone.

The seasonal length-frequency distribution of sardine from October 2019 to December 2020 in the north zone indicated that small-sized individuals were mainly captured in autumn and winter, coinciding with the spawning period, whereas in spring the mode moved towards larger sizes, with values close to 14 cm. Size range extended from 7.5 to 18 cm total length (Figure 218).

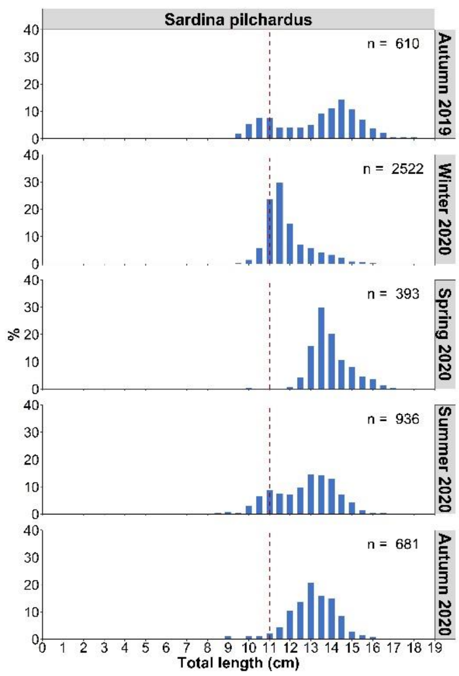


Figure 218. Seasonal length-frequency distribution of sardine (*Sardina pilchardus*) from October 2019 to December 2020 in the north zone. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 11 cm.

North zone anchovy (Engraulis encrasicolus)

The annual catch rates of anchovy during the period 2000-2020 in the north zone showed a maximum value in 2002, followed by a drastic decline, which reached the minimum value in 2008 (< 1000 tons). However, catches recovered progressively since 2009, displaying values around 3000 tons each year (Figure 219).

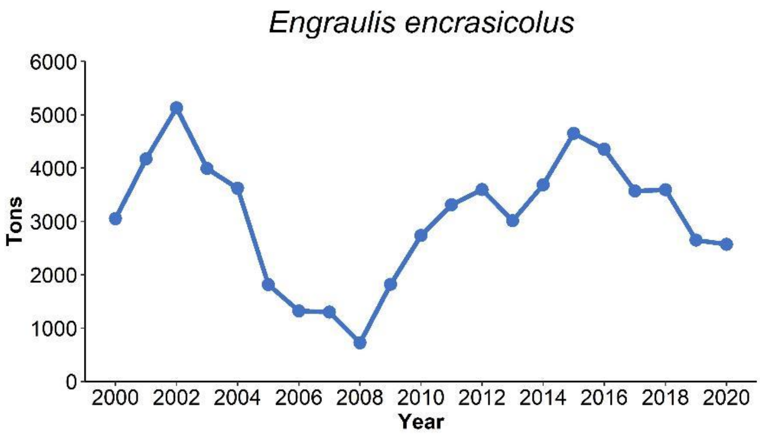


Figure 219. *Engraulis encrasicolus.* Time series of anchovy annual catch (tons) for the period 2000-2020 in the north zone.

The seasonal length-frequency distribution of anchovy from October 2019 to December 2020 in the north zone indicated that small-sized individuals were captured especially in autumn and winter, with a mode of 9.5 cm, whereas in spring and summer the mode moved towards larger sizes, with values of 12 and 11 cm, respectively. Size range extended from 7 to 16 cm total length (Figure 220).

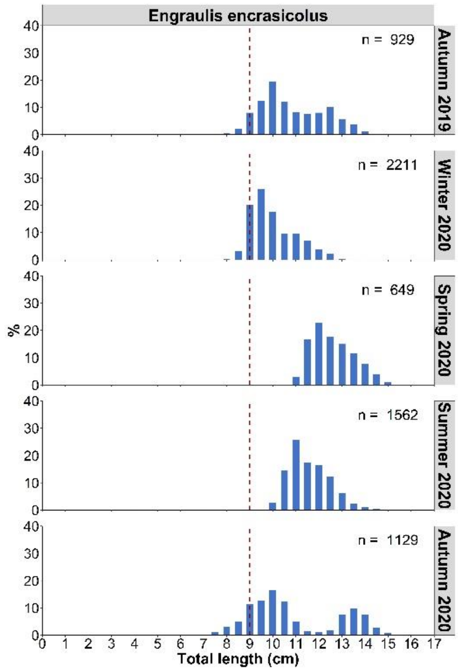


Figure 220. Seasonal length-frequency distribution of anchovy (*E. encrasicolus*) from October 2019 to December 2020 in the north zone. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 9 cm.

Figure 221 shows the sampling localization of sardine and anchovy hauls performed in the Center zone from October 2019 to December 2020.

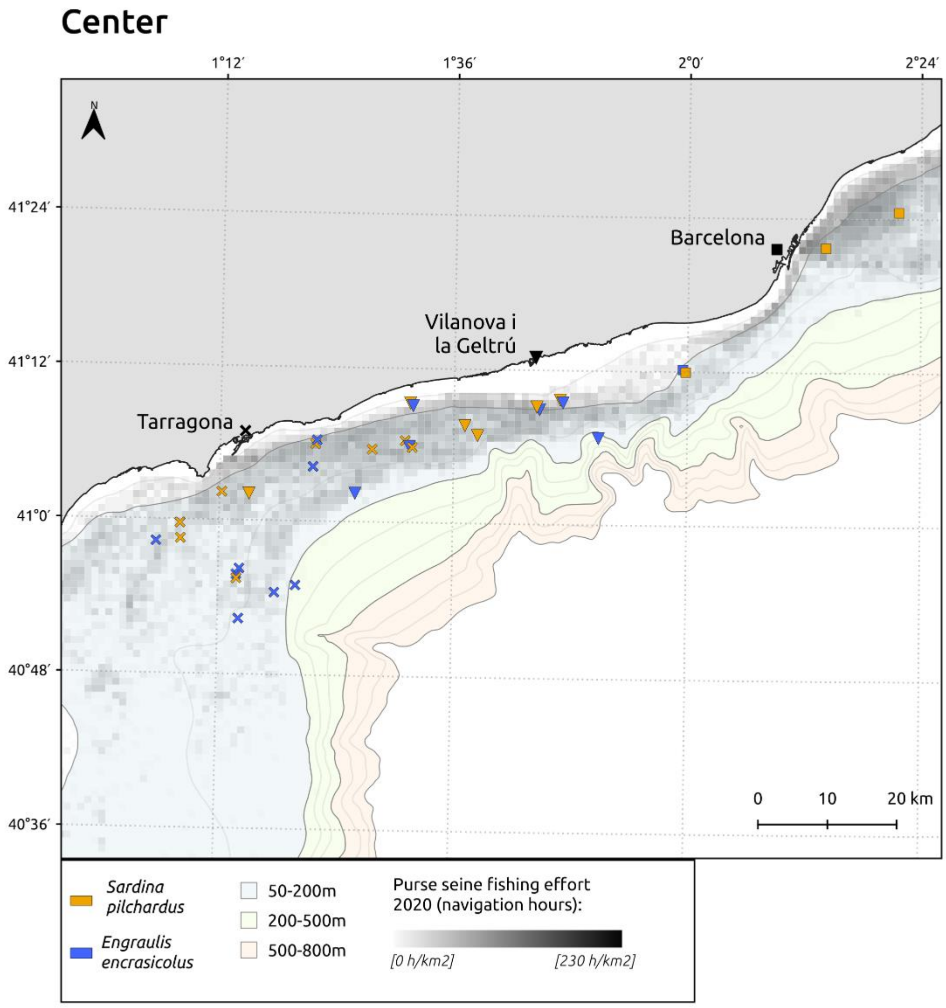


Figure 221. Map of purse seine hauls performed in the center zone from October 2019 to December 2020.

Center zone sardine (Sardina pilchardus)

The annual catch rates of sardine during the period 2000-2020 in the center zone indicated that values have drastically declined until 2010 and, since then, catches tended to stabilize at low levels, with values around 3000 tons each year (Figure 222).

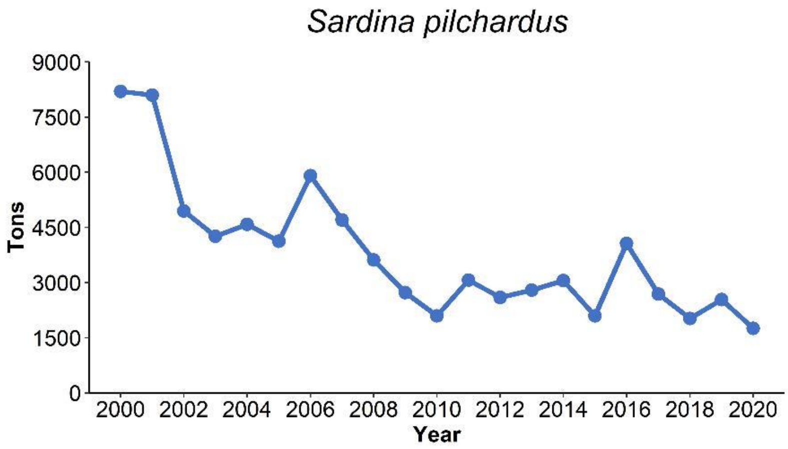


Figure 222. Time series of sardine annual catch rates (tons) for the time period 2000-2020 in the center zone.

The seasonal length-frequency distribution of sardine from October 2019 to December 2020 in the center zone indicated that the majority of the capture was composed of large-sized individuals, especially in spring and summer, when the mode was close to 14 cm. Even in winter, when the smallest sizes were captured, the mode was above the MCRS. Size range extended from 9.5 to 18.5 cm total length (Figure 223).

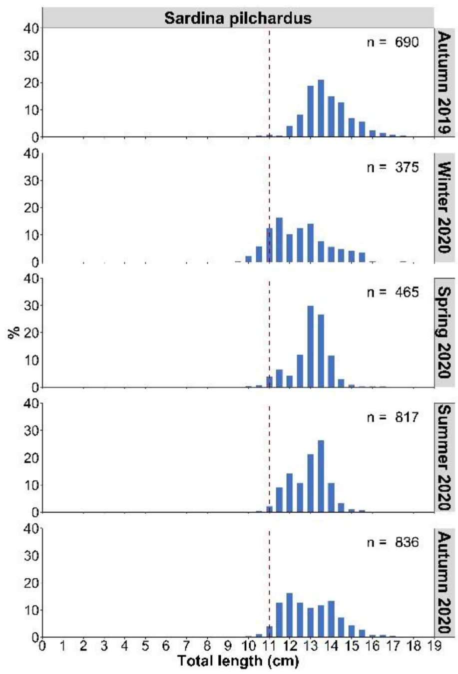


Figure 223. Seasonal length-frequency distribution of sardine (*S. pilchardus*) from October 2019 to December 2020 in the center zone. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 11 cm.

Center zone anchovy (Engraulis encrasicolus)

The annual catch rates of anchovy during the period 2000-2020 in the center zone showed low values of catches until 2008 (< 2000 tones). However, the tendency after 2009 indicated an increase in anchovy catches, exhibiting values above 3000 tons except for 2020 (Figure 224).

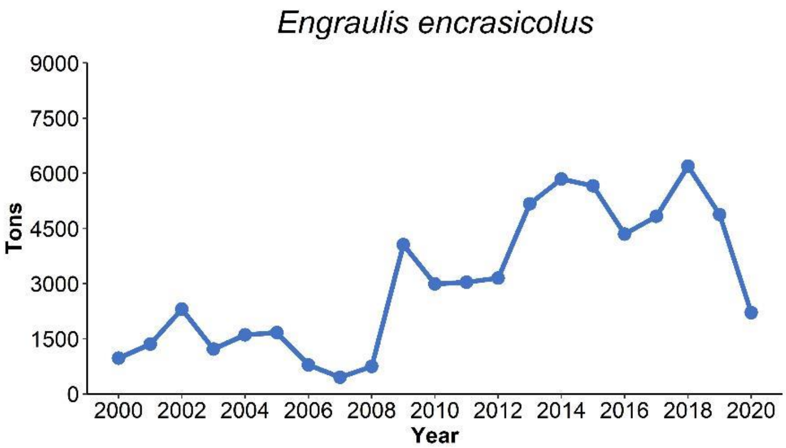


Figure 224. *Engraulis encrasicolus*. Time series of anchovy annual catch (tons) for the period 2000-2020 in the center zone.

The seasonal length-frequency distribution of anchovy from October 2019 to December 2020 in the center zone indicated that small-sized individuals were mainly captured in winter, with a mode at 10 cm, whereas, especially in spring but also in summer and autumn, the mode moved towards larger sizes (> 12 cm). Size range extended from 6.5 to 15.5 cm total length (Figure 225).

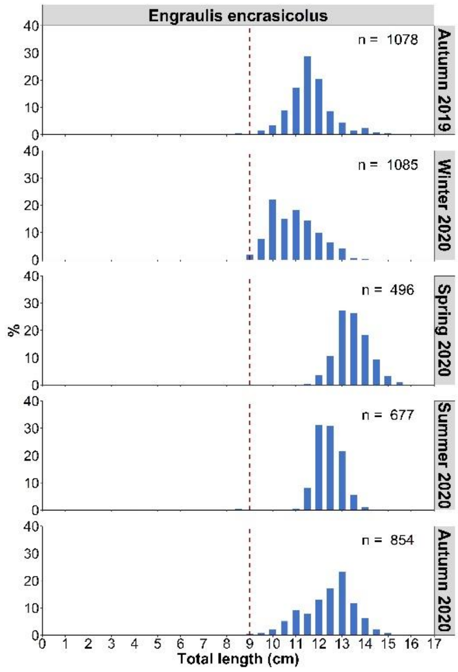


Figure 225. Seasonal length-frequency distribution of anchovy (*E. encrasicolus*) from October 2019 to December 2020 in the center zone. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 9 cm.

2.2.2.2 Comparative analysis of the size frequency of the target species by zones

Sardine (Sardina pilchardus)

The seasonal length-frequency distribution of sardine (*S. pilchardus*) from October 2019 to December 2020 in both zones showed that the smallest individuals captured were below the size at first maturity and the minimum conservation reference size (MCRS). In both zones, small-sized individuals were captured, especially in winter, coinciding with the spawning period of the species. On the contrary, in spring, the mode shifted towards much largest sizes.

When comparing between zones, in the north zone, the percentage of small individuals captured was higher, particularly in summer and autumn. Conversely, large-sized individuals dominated in the center zone, especially in spring and summer, when the mode reached its maximum values.

Anchovy (Engraulis encrasicolus)

The seasonal length-frequency distribution of anchovy (*E. encrasicolus*) from October 2019 to December 2020 in both zones showed that the smallest individuals captured were below the size at first maturity and the minimum conservation reference size (MCRS). In both zones, small-sized individuals were captured in autumn and winter whereas, in spring and summer, the mode moved towards the largest sizes, coinciding with the spawning period of the species.

When comparing between zones, in the north zone, the percentage of small individuals captured was higher for all seasons whereas, in the center zone, a high percentage of the catch was composed by large-sized individuals. Likewise, in the center zone, the mode shifted towards large sizes, reaching maximum values in spring (> 13cm).

2.2.3 Purse seine by port

2.2.3.1 L'Escala

The annual catch rates of sardine during the period 2000-2020 in the port of l'Escala showed a similar trend to the one observed in the north zone, displaying its minimum and maximum catches in 2002 and 2007, respectively. Despite both peaks, annual catches remained stable, fluctuating between 600 and 1000 tons. (Figure 226).

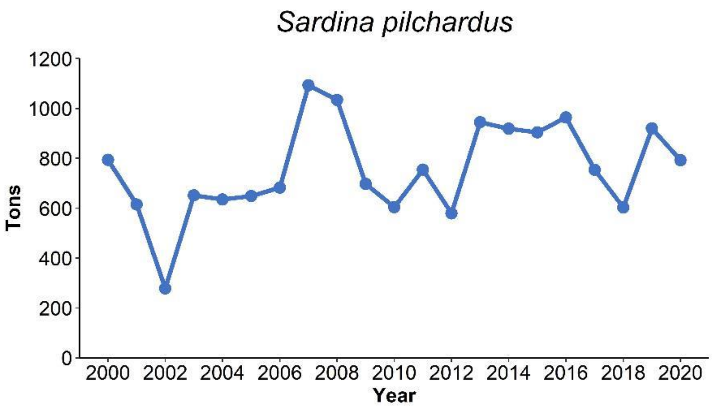


Figure 226. *Sardina pilchardus.* Time series of sardine annual catch (tons) for the period 2000-2020 in l'Escala.

The length-frequency distribution of sardine from October 2019 to December 2020 in the port of l'Escala had a mode of 11,5 cm and a size range extended from 7,5 to 17 cm total length (Figure 227).

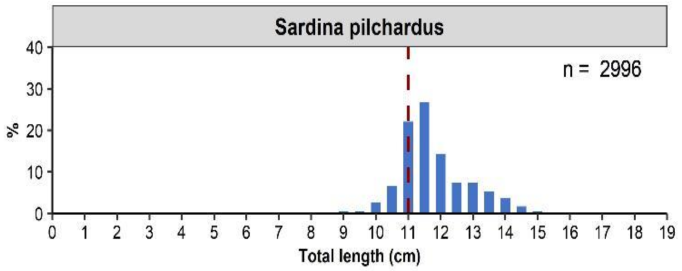


Figure 227. Length-frequency distribution of sardine (*S. pilchardus*) from October 2019 to December 2020 in L'Escala. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 11 cm.

The annual catch rates of anchovy during the period 2000-2020 in the port of l'Escala showed a first period where catches remained stable around 450 tons, followed by a significant increase with maximum values in 2012 (750 tons), and a sharp decrease from 2017 to 2020, when values remained low, around 300 tons (Figure 228).

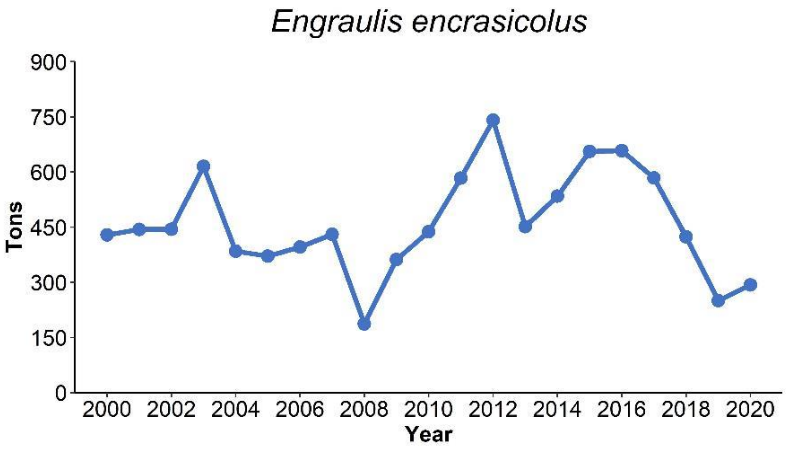


Figure 228. *Engraulis encrasicolus.* Time series of anchovy annual catch (tons) for the period 2000-2020 in l'Escala.

The length-frequency distribution of anchovy from October 2019 to December 2020 in the port of l'Escala showed a mode of 9,5 cm and a size range between 7 to 14 cm total length (Figure 229).

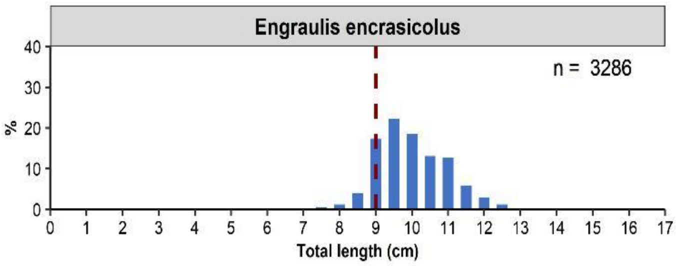


Figure 229. Length-frequency distribution of anchovy (*E. encrasicolus*) from October 2019 to December 2020 in L'Escala. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 9 cm.

2.2.3.2 Palamós

The annual catch rates of sardine during the period 2000-2020 in the port of Palamós showed catch rates significantly lower than those recorded in l'Escala. Despite values were particularly low from 2001 to 2004 (< 50 tons), catches recovered progressively, exhibiting values close to 350 tons (Figure 230).

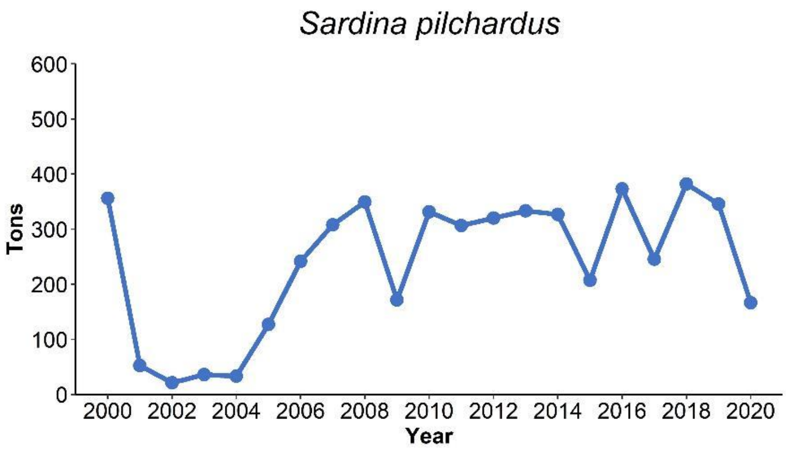


Figure 230. *Sardina pilchardus.* Time series of sardine annual catch (tons) for the time period 2000-2020 in Palamós.

The length-frequency distribution of sardine from October 2019 to December 2020 in the port of Palamós had a size range from 10 to 18 cm, with a mode at 13,5 cm (Figure 231).

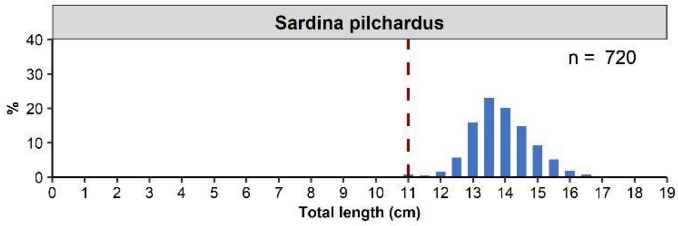


Figure 231. Length-frequency distribution of sardine (*S. pilchardus*) from October 2019 to December 2020 in Palamós. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 11 cm.

The annual catch rates of anchovy during the period 2000-2020 in the port of Palamós showed extremely low values (< 100 tons) at the beginning of the time series, followed by a progressive increase in catch numbers since 2008, as similarly observed at the north zone and Catalonia level. Catches tended to stabilize around 500 tons from 2015 to 2020 except in 2018, when a maximum catch of nearly 1000 tons occurred (Figure 232).

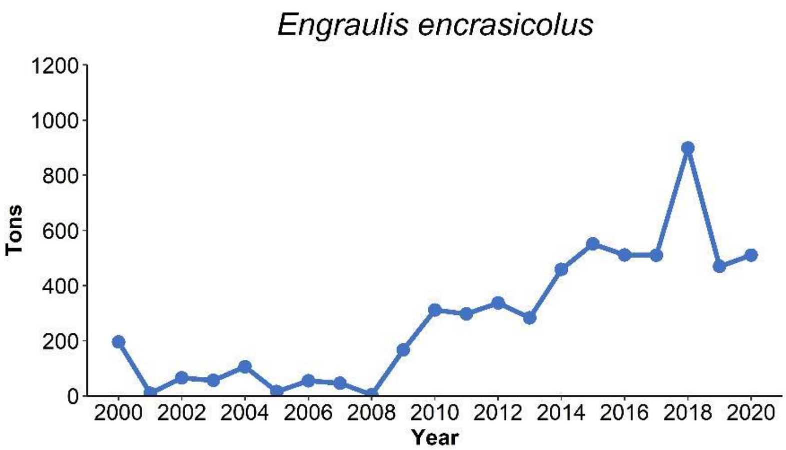


Figure 232. *Engraulis encrasicolus.*Time series of anchovy annual catch (tons) for the period 2000-2020 in Palamós.

The length-frequency distribution of anchovy from October 2019 to December 2020 in the port of Palamós had a mode of 11,5 cm and a size range extended from 8 to 15,5 cm total length (Figure 233).

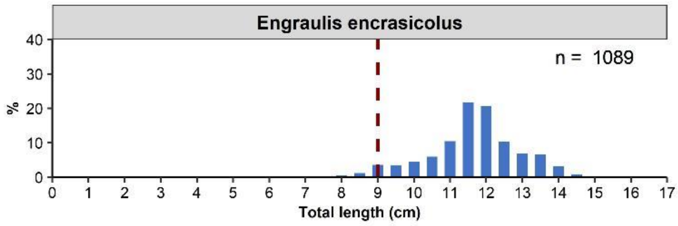


Figure 233. Length-frequency distribution of anchovy (*E. encrasicolus*) from October 2019 to December 2020 in Palamós. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 9 cm.

2.2.3.3 Blanes

The annual catch rates of sardine during the period 2000-2020 in the port of Blanes showed a similar pattern as the one observed in the north zone but differed significantly from the one detected when accounting for all Catalonia catches. Maximum sardine catches were recorded in 2007 and 2008 (> 800 tons), but values tended to stabilize during the rest of the time series and fluctuated from 300 to 600 tons (Figure 234).

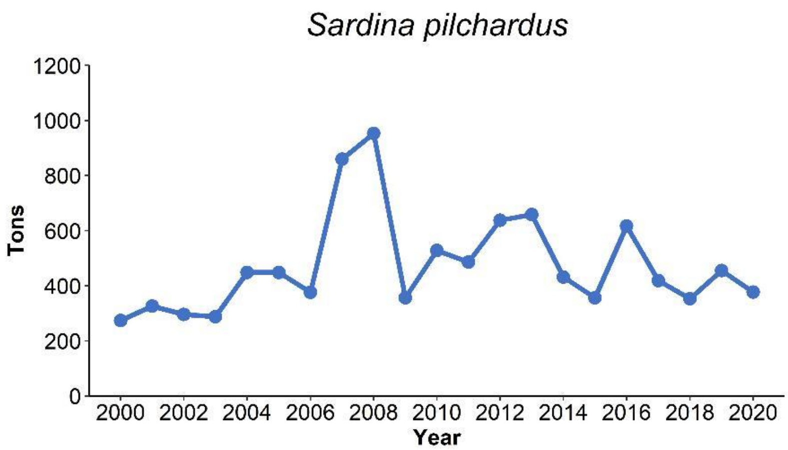


Figure 234. *Sardina pilchardus.* Time series of sardine annual catch (tons) for the period 2000-2020 in Blanes.

The length-frequency distribution of sardine from October 2019 to December 2020 in the port of Blanes exhibited a wide size range extended from 9 to 17 cm, with a primary mode of 14 cm and a secondary one of 13 cm. Interestingly, the proportion of small-sized individuals below the secondary modal size was high, representing approximately 50% of the whole capture (Figure 235).

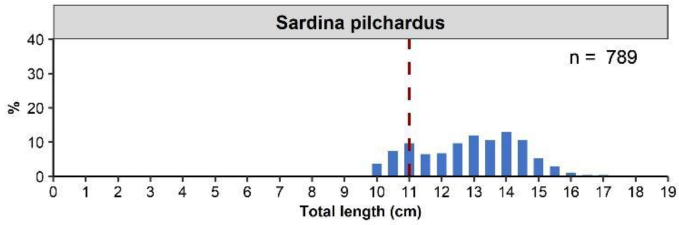


Figure 235. Length-frequency distribution of sardine (*S. pilchardus*) from October 2019 to December 2020 in Blanes. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 11 cm.

The annual catch rates of anchovy during the period 2000-2020 in the port of Blanes showed the same pattern observed when gathering the catches at north zone and Catalonia level. Low catches were detected at the first part of the series (< 600 tons), followed by a progressive increase in catch numbers since 2008 and maximum values in 2018 of approximately 1500 tons (Figure 236).

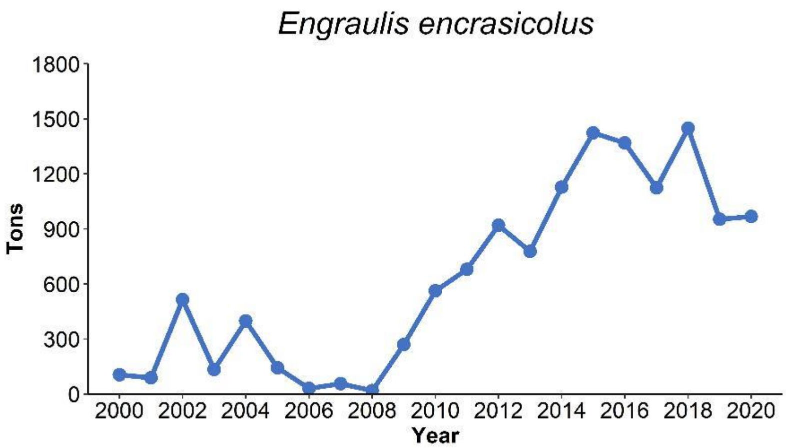


Figure 236. *Engraulis encrasicolus.* Time series of anchovy annual catch (tons) for the time period 2000-2020 in Blanes.

The length-frequency distribution of anchovy from October 2019 to December 2020 in the port of Blanes showed two modes, one at 10,5 and another at 12,5 cm. The size range extended from 8 to 16 cm total length (Figure 237).

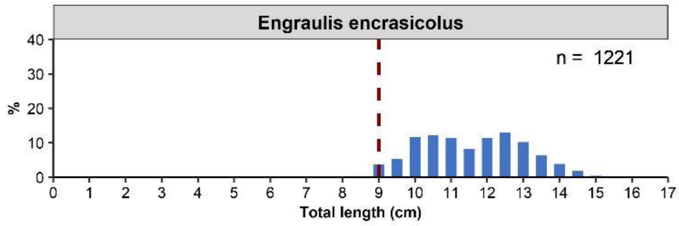


Figure 237. Length-frequency distribution of anchovy (*Engraulis encrasicolus*) from October 2019 to December 2020 in Blanes. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 9 cm.

2.2.3.4 Arenys de Mar

The annual catch rates of sardine during the period 2000-2020 in the port of Arenys de Mar showed a continuously decreasing trend through the whole period despite some relatively high catches in 2000 and 2008, with values above 1200 tons (Figure 238).

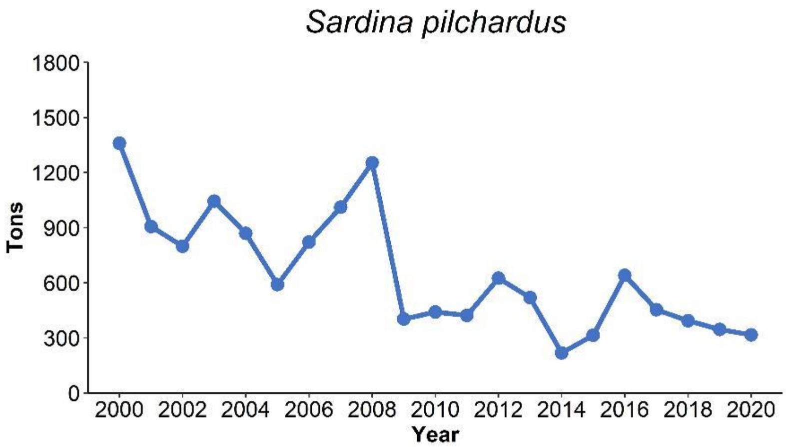


Figure 238. *Sardina pilchardus.* Time series of sardine annual catch (tons) for the period 2000-2020 in Arenys de Mar.

The length-frequency distribution of sardine from October 2019 to December 2020 in the port of Arenys de Mar showed a size range from 10,5 to 18 cm and a mode at 13,5 cm. In this case, large-sized individuals were dominant in number as the majority of the capture was placed above the MCRS (Figure 239).

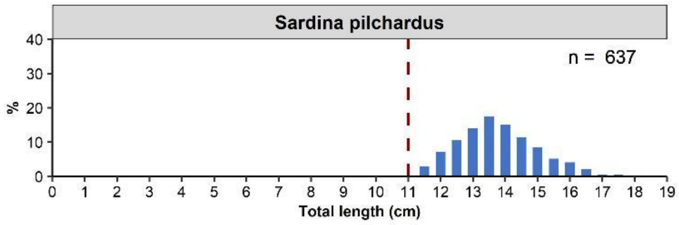


Figure 239. Length-frequency distribution of sardine (*S. pilchardus*) from October 2019 to December 2020 in the port of Arenys de Mar. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 11 cm.

The annual catch rates of anchovy during the period 2000-2020 in the port of Arenys de Mar exhibited important fluctuations especially, during the first part of the time series. Anchovy catches increased as of 2008, fluctuating between 400 and 600 tons except for three years (2015-2017), when nearly 1000 tons were caught (Figure 240).

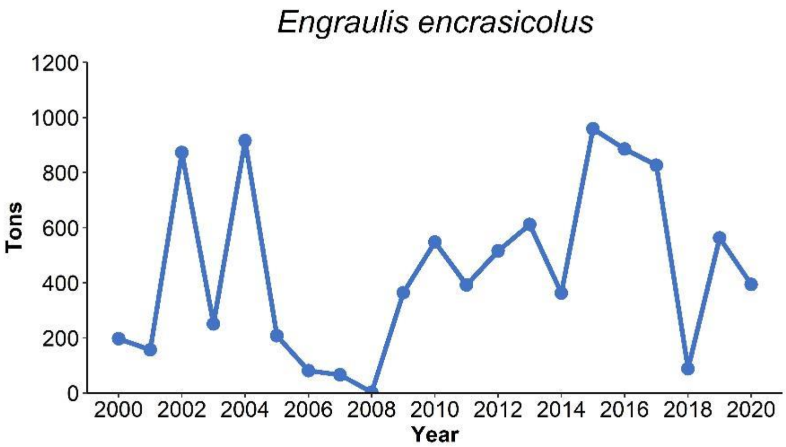


Figure 240. *Engraulis encrasicolus.* Time series of anchovy annual catch (tons) for the period 2000-2020 in Arenys de Mar.

The length-frequency distribution of anchovy from October 2019 to December 2020 in the port of Arenys de Mar showed a mode at 12,5 cm. The size range extended from 9,5 to 15 cm total length (Figure 241).

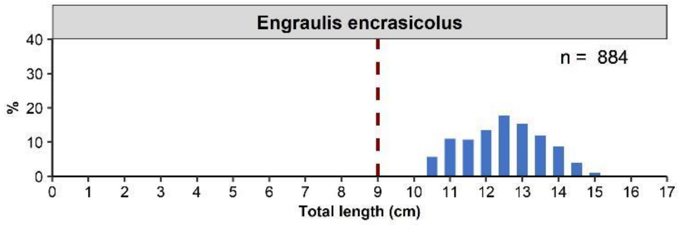


Figure 241. Length-frequency distribution of anchovy (*E. encrasicolus*) from October 2019 to December 2020 in the port of Arenys de Mar. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 9 cm.

2.2.3.5 Barcelona

The annual catch rates of sardine during the period 2000-2020 in the port of Barcelona showed a continuously decreasing trend until 2009 when minimum catches were detected, followed by a slight increase and stabilization of the catches around 1000 tons in the last decade (Figure 242).

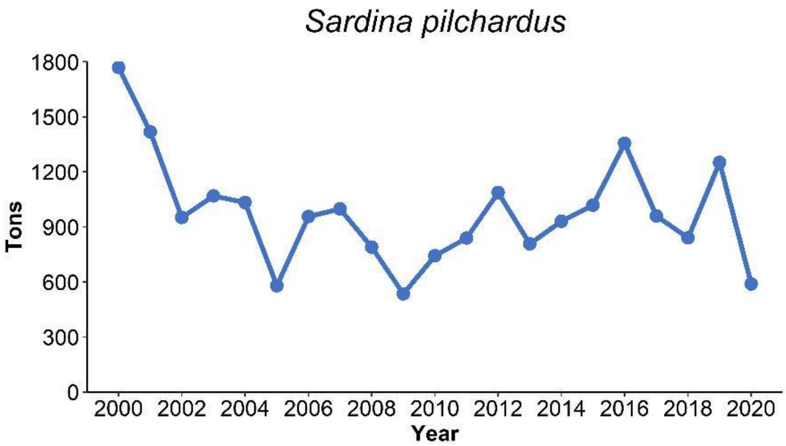


Figure 242. *Sardina pilchardus.* Time series of sardine annual catch (tons) for the period 2000-2020 in Barcelona.

The length-frequency distribution of sardine from October 2019 to December 2020 in the port of Barcelona had a size range from 10,5 to 18,5 cm and a mode at 13,5 cm. Nearly all the individuals captured were placed above the MCRS (Figure 243).

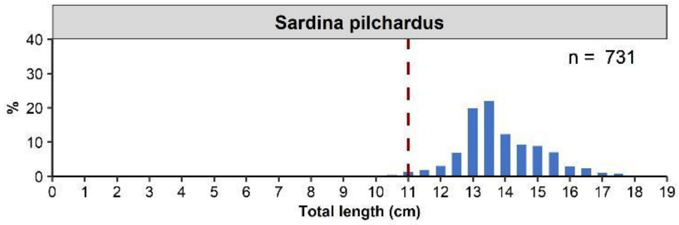


Figure 243. Length-frequency distribution of sardine (*S. pilchardus*) from October 2019 to December 2020 in the port of Barcelona. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 11 cm.

The annual catch rates of anchovy during the period 2000-2020 in the port of Barcelona showed the same pattern observed when gathering the catches at center zone and Catalonia level. Low catches were detected at the first part of the time series (< 500 tons), followed by a progressive increase in catch numbers since 2008 and peaking maximum values in 2018 of approximately 1500 tons (Figure 244).

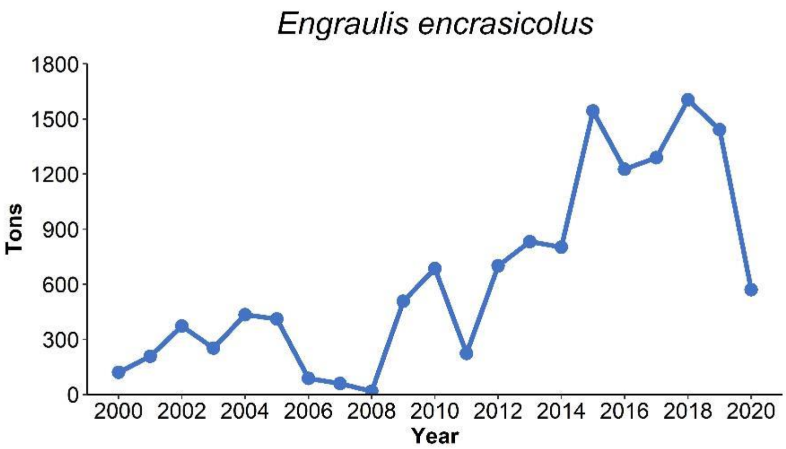


Figure 244. *Engraulis encrasicolus.* Time series of anchovy annual catch (tons) for the period 2000-2020 in Barcelona.

The length-frequency distribution of anchovy from October 2019 to December 2020 in the port of Barcelona had a mode at 11 cm. The size range extended from 10 to 15,5 cm total length. Small-sized individuals dominated in number and represented more than 50% of the total catch (Figure 245).

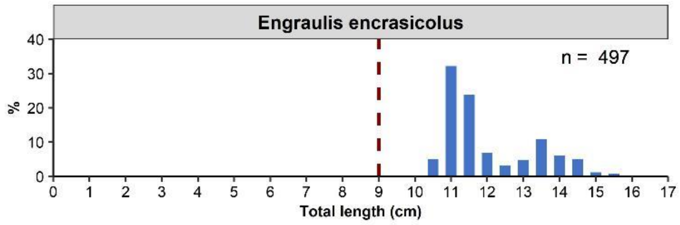


Figure 245. Length-frequency distribution of anchovy (*E. encrasicolus*) from October 2019 to December 2020 in the port of Barcelona. The red dashed line indicates the minimum conservation reference size (MCRS), determined at 9 cm.

2.2.3.6 Vilanova i la Geltrú

The annual catch rates of sardine during the period 2000-2020 in the port of Vilanova i la Geltrú showed a slightly decreasing trend until 2010, when minimum catches were detected (500 tons), followed by a stabilization of catches around 1000 tons in the last decade (Figure 246).

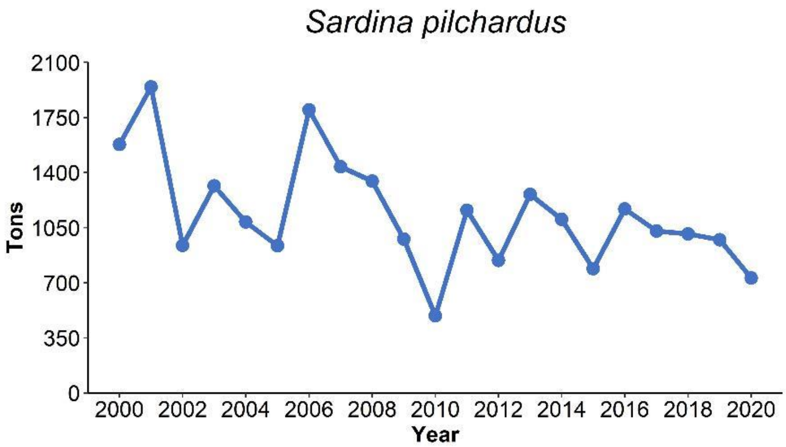


Figure 246. *Sardina pilchardus.* Time series of sardine annual catch (tons) for the period 2000-2020 in Vilanova i la Geltrú.

The length-frequency distribution of sardine from October 2019 to December 2020 in the port of Vilanova i la Geltrú had a size range from 9,5 to 17,5 cm, with two modes: a primary mode of 13,5 cm corresponding to large-sized individuals and a secondary mode of 11,5 cm, belonging to small-sized individuals (Figure 247).

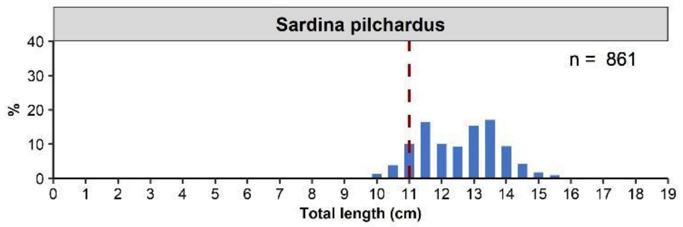


Figure 247. Length-frequency distribution of sardine (*S. pilchardus*) from October 2019 to December 2020 in the port of Vilanova i la Geltrú. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 11 cm.

The annual catch rates of anchovy during the period 2000-2020 in the port of Vilanova i la Geltrú showed the same pattern observed when gathering the catches at Catalonia level. Low catches were detected in the first part of the series (< 500 tons), followed by a significant increase in catch numbers since 2008, and maximum values in 2014 of approximately 2000 tons (Figure 248).

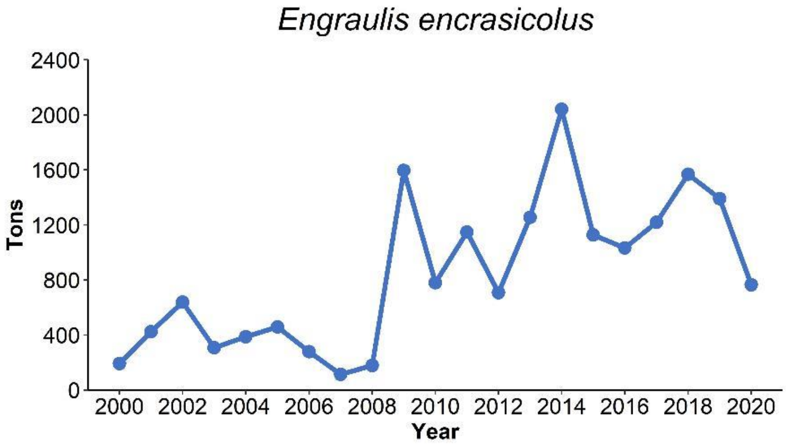


Figure 248. *Engraulis encrasicolus.*Time series of anchovy annual catch (tons) for the period 2000-2020 in Vilanova i la Geltrú.

The length-frequency distribution of anchovy from October 2019 to December 2020 in the port of Vilanova i la Geltrú had a primary mode at 10 cm and a secondary mode at 11,5 cm. The size range extended from 9 to 15 cm total length (Figure 249).

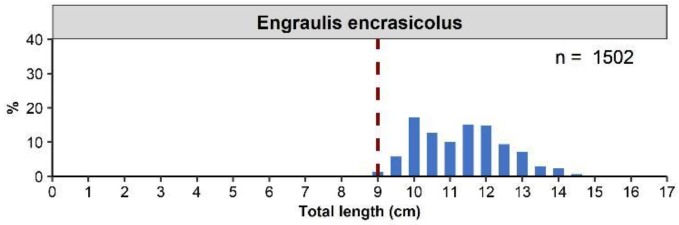


Figure 249. Length-frequency distribution of anchovy (*E. encrasicolus*) from October 2019 to December 2020 in the port of Vilanova i la Geltrú. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 9 cm.

2.2.3.7 Tarragona

The annual catch rates of sardine during the period 2000-2020 in the port of Tarragona showed a similar pattern as the one observed when analyzing the catch in the whole Catalonia area. Maximum values appeared at the beginning of the time series, in 2000 and 2001, with values close to 5000 tons, followed by a drastic decline and a stabilization at low catches, reaching a minimum of 500 tons in 2018 (Figure 250).

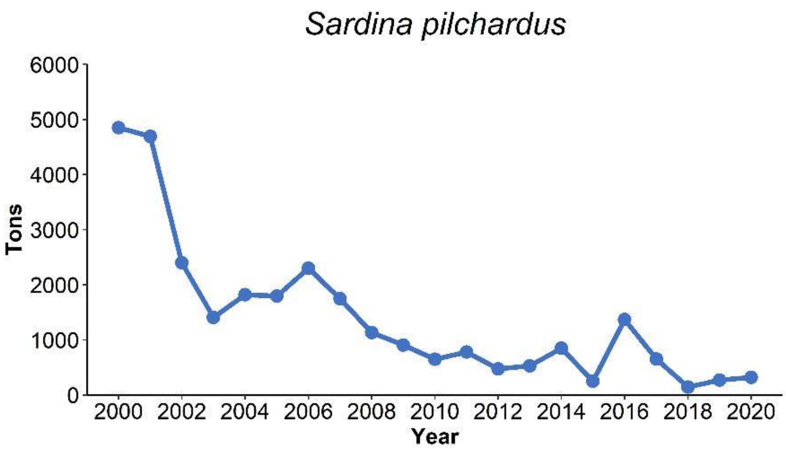


Figure 250. *Sardina pilchardus.* Time series of sardine annual catch rates (tons) for the time period 2000-2020 in Tarragona.

The length-frequency distribution of sardine from October 2019 to December 2020 in the port of Tarragona exhibited a size range extended from 10 to 17 cm and a mode of 13 cm. Approximately 50% of the capture was composed of large-sized individuals, being above the modal size (Figure 251).

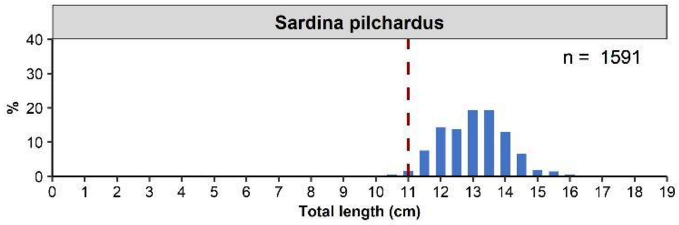


Figure 251. Length-frequency distribution of sardine (*S. pilchardus*) from October 2019 to December 2020 in the port of Tarragona. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 11 cm.

The annual catch rates of anchovy during the period 2000-2020 in the port of Tarragona (Figure 252) showed the same pattern observed when gathering the catches at Catalonia level. Low catches were detected at the first part of the time series (< 1000 tons), followed by a significant increase in catch numbers since 2008 and maximum values in 2015 of nearly 3000 tons.

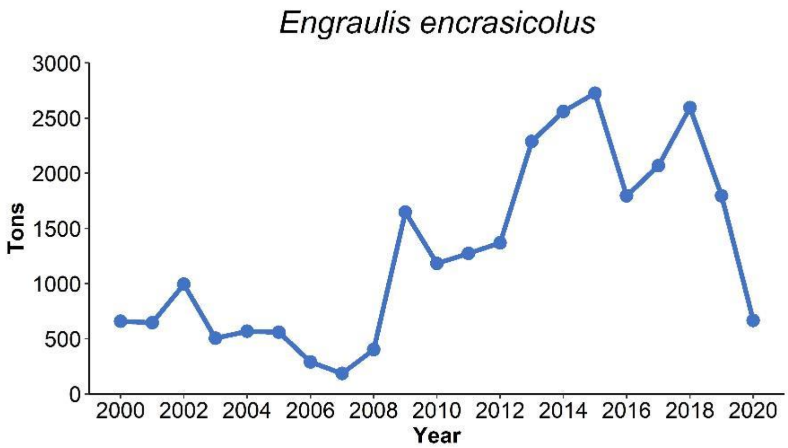


Figure 252. *Engraulis encrasicolus.* Time series of anchovy annual catch (tons) for the period 2000-2020 in Tarragona.

The length-frequency distribution of anchovy from October 2019 to December 2020 in the port of Tarragona had a mode at 13 cm. The size range extended from 6,5 to 15,5 cm total length. Approximately, 60% of the catch belonged to individuals that sized 12-13 cm in length (Figure 253).

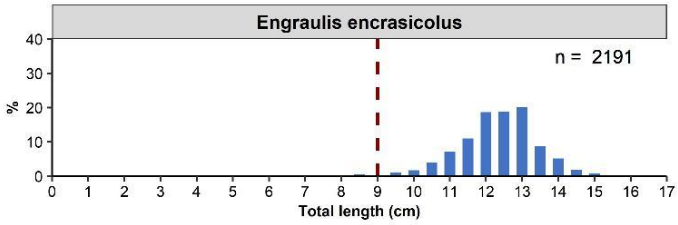


Figure 253. Length-frequency distribution of anchovy (*E. encrasicolus*) from October 2019 to December 2020 in the port of Tarragona. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 9 cm.

2.2.3.8 Comparative summary by port

When comparing the length-frequency distribution of sardine (*S. pilchardus*) from October 2019 to December 2020 among ports, several differences were observed. In the port of l'Escala, the composition of the capture was dominated by small-sized individuals, exhibiting the lowest mode (11,5 cm) close to the minimum conservation reference size (MCRS). The ports of Palamós, Arenys de Mar, Barcelona, and Tarragona showed similar length-frequency distributions, with a great proportion of individuals captured above the MCRS. Likewise, the mode in these ports moved towards larger sizes (13 cm) and the size range extended from 12 to 16 cm. Finally, the ports of Blanes and Vilanova i la Geltrú showed a wide size range with a high proportion of small-sized individuals below the MCRS.

When comparing the length-frequency distribution of anchovy (*E. encrasicolus*) from October 2019 to December 2020, differences were observed between ports. In the port of l'Escala, the composition of the capture was dominated by small-sized individuals, exhibiting the lowest mode (9,5 cm) close to the MCRS. The ports of Arenys de Mar and Tarragona showed similar length-frequency distributions, with all individuals captured above the MCRS and a shift of the mode towards larger sizes (13 cm). Finally, the ports of Palamós, Blanes, Barcelona, and Vilanova i la Geltrú exhibited similar distribution patterns, with the majority of the individuals captured ranging from 9 to 14 cm, and a mode located at 11 cm.

2.3 SAND EEL FISHERY

2.3.1 Sand eel fishery in Catalonia

In Catalonia, the main target species in the sand eel fishery are *Gymnammodites cicerelus* (Rafinesque, 1810), *Gymnammodites semisquamatus* (Jourdain, 1879), and *Aphia minuta* (Risso, 1810). The two species for the genus *Gymnammodites* are coastal species found on the continental shelf on shallow sand, shells and fine gravel bottoms, inhabiting burrows dug on sandy substrates and living in large groups, burying themselves headfirst in the sediment.

The sand eel fishery is regulated by quotas and fishing effort limitations (number of vessels and fishing days per vessel) and submitted to an European Management Plan. Management decissions are discussed in a co-management committee (CMC) that includes the fishing sector, administration, NGOs and scientists (Lleonart et al., 2014). Fisheries monitoring, which began with the preparation of the management plan and its implementation, started in 2012 (Sabates et al., 1990). Fishing has a regulated closure during the spawning season, from 15 December to 1 March. However, the transparent goby (*A. minuta*) is only allowed to be fished during the closed fishing period for the sand eels (Iglesias et al., 2001).

The characterisation of the sand eel fishery in Catalonia throughout the sampling period (October 2019 to December 2020) is shown in Figure 254, plotting two fractions, the proportion of *Gymnammodytes spp*. and the proportion of bycatch species. It can be observed that in Catalonia the proportion of accompanying species ranged between 10 and 45% of the total biomass caught, recording higher values in autumn in both years (Figure 255).

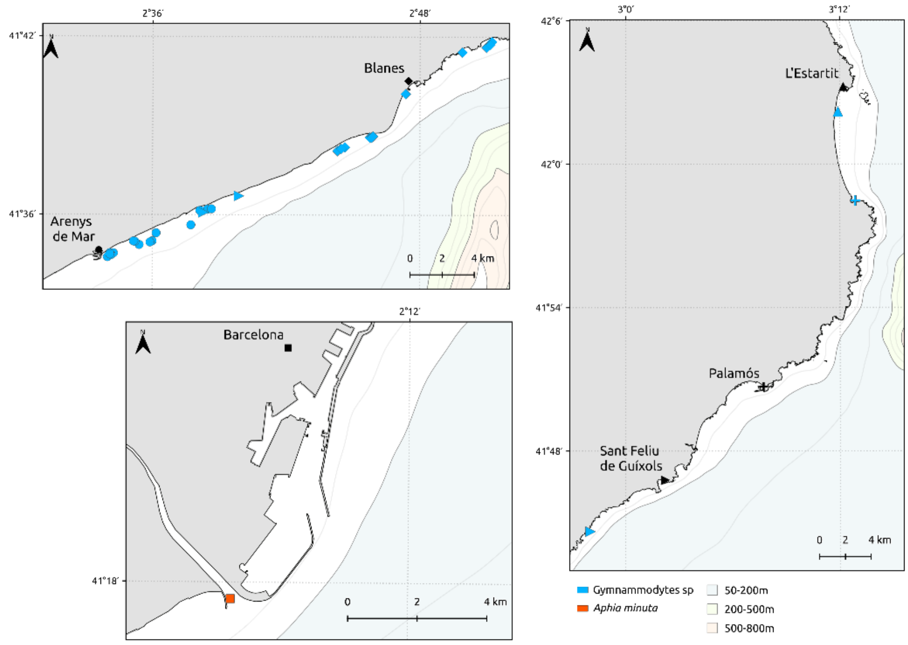


Figure 254. Map of the sampling points on sand eel fishery carried out in Catalonia in the period from October 2019 to December 2020.

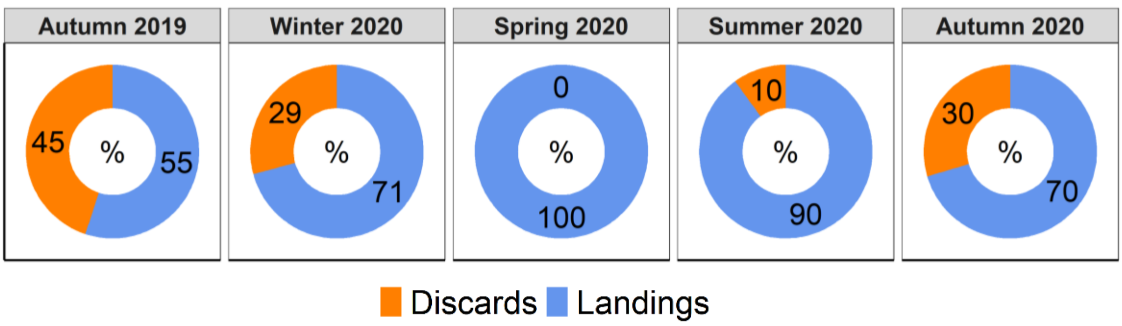


Figure 255. Catch composition in Catalonia. Percentage by weight of discards and landings in each season and each fishing ground including all hauls in all ports sampled from October 2019 to December 2020.

The proportion in biomass of the most important accompanying species in the fishery is shown in Figure 256 and Table 49. Data for the most important species in number and weight of landed catch in sand eel for all hauls conducted in Catalonia from October 2019 to December 2020.There were 35 companion species identified during the sampling period but the appearance of the different species varied throughout the seasons. In number of individuals, the most abundant species was *Pagellus erythrinus* and, in biomass, *Rhizostoma pulmo*. Other species accompanying the target species of the fishery were *Coryphaena* *hippurus*, *Trachurus mediterraneus*, *Bothus podas*, *Xyrichtys novacula*, and *Diplodus annularis*.

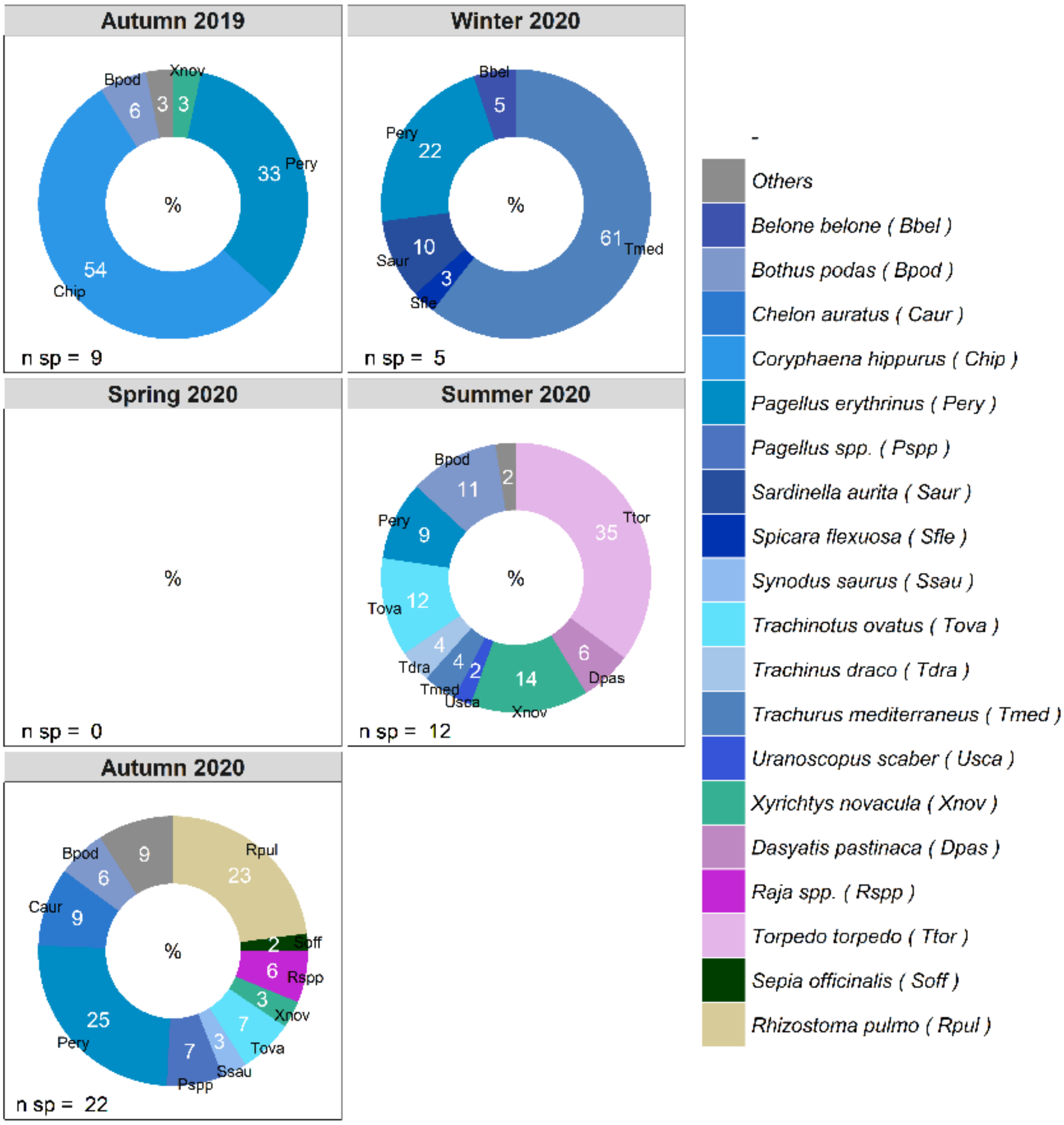


Figure 256. Graphs plotting the most important species in biomass of landed catch in sand eel fishery for all hauls conducted in Catalonia at each season from October 2019 to December 2020.

Table 49. Data for the most important species in number and weight of landed catch in sand eel for all hauls conducted in Catalonia from October 2019 to December 2020.

	2019						2020																Total	
	October		November		December		February		March		July		August		September		October		November		December			
	N	Weight (g)	N	Weight (g)	N	Weight (g)	N	Weight (g)	N	Weight (g)	N	Weight (g)	N	Weight (g)	N	Weight (g)	N	Weight (g)	N	Weight (g)	N	Weight (g)	N	Weight (g)
Rhizostoma pulmo	20	9016,60																	3	2705,00			23	11721,60
Pagellus erythrinus	17	2290,76	10	651,60	1	42,50	12	196,81	8	1008,06	3	189,60	95	199,36			14	1823,90	3	18,64	6	1099,82	169	7521,05
Coryphaena hippurus	2	4853,77																					2	4853,77
Trachurus mediterraneus							9	150,34	24	3420,00	1	164,48							1	211,11			35	3945,93
Bothus podas	7	510,97									4	236,02	5	201,20			9	673,48	2	12,98			27	1634,65
Torpedo torpedo											2	1442,00											2	1442,00
Trachinotus ovatus															1	484,68	1	286,64	1	482,44			3	1253,76
Chelon auratus																			2	1113,94			2	1113,94
Xyrichtys novacula	6	299,94											10	182,28			3	215,70	2	5,07	2	163,54	23	866,53
Pagellus spp.																	2	0,42	3	800,00			5	800,42
Raja spp.																	1	739,00					1	739,00
Sardinella aurita			1	9,24					4	584,01											4	17,94	9	611,19
Diplodus annularis							35	378,33															35	378,33
Sarpa salpa							1	346,46															1	346,46
Dasyatis pastinaca											1	253,04											1	253,04
Sepia officinalis							1	200,00													1	236,90	2	436,90
Octopus vulgaris																	1	224,22					1	224,22
Seriola dumerili																			1	200,00			1	200,00
Belone belone									2	198,73													2	198,73
Chelidonichthys lucerna																					1	197,48	1	197,48
Synodus saurus	1	158,28																	4	11,71			5	169,99
Trachinus draco											5	116,30	2	45,16									7	161,46
Mullus surmuletus			2	102,20	1	12,80					7	24,00	6	20,59									16	159,59
Spicara flexuosa									2	155,88													2	155,88
Boops boops																					1	134,86	1	134,86
Uranoscopus scaber											1	84,88											1	84,88
Engraulis encrasicolus																					19	68,96	19	68,96
Chelidonichthys lastoviza											1	32,00											1	32,00
Sepia elegans													1	24,57									1	24,57
Echiichthys vipera																			2	9,02			2	9,02
Alloteuthis spp.																					1	7,86	1	7,86
Loligo vulgaris					1	7,10																	1	7,10
Pomatoschistus spp.																			1	0,63			1	0,63
Larves spp.																	1	0,07					1	0,07
Sepiola spp.																	1	1,08					1	1,08

Biological sampling of the sand eel. Monthly samples were taken on board of fishing boats in the ports of Girona coastline (Blanes, Palamós and L'Estartit) and Barcelona (Arenys de Mar). Twice a month, once per province, an observer on board the commercial boats recorded the characteristics of the fishing trip: boat, gear, equipment, start-end location of the fishing, start-end time, depth, type of substrate, environmental data, and meteorological conditions: sea state, type and intensity of the wind, and number coverage. A 1 kg sample of the target species and a representative sample of the companion species were taken from each haul.

One sample of specimens of the two species of sand eel per haul were taken to the laboratory in order to study the biological cycle of the species.

Biological measures were taken on the specimens and consisted of: total size to the bottom half centimetre, total weight in grams and individual weight and gonad weight with a precision of 0.001 gr. Sex and sexual status were also determined.

Biological sample of the transparent goby (*Aphia minuta*). Monthly samples are taken from the port of Barcelona during the fishing season. The procedure is the same as in the case of the sand eel. In the ports of Arenys de Mar and Blanes another species of reedfish was caught sporadically, the white reed (*Crystallogobius linearis*), which appeared irregularly and was not caught this year during reedfish fishing season (15 December-28 February).

Annual catch history

Figure 257 shows the evolution of catches of the target species (*Gymnammodites* spp.) from 2000 to 2020, in which we can see that catches were variable from 2000 to 2006. From then onwards there was a considerable and constant increase in catches, peaking with 800 tonnes in 2013. In the following few years, catches decreased again but from 2015 onwards they progressively increased until the present day.

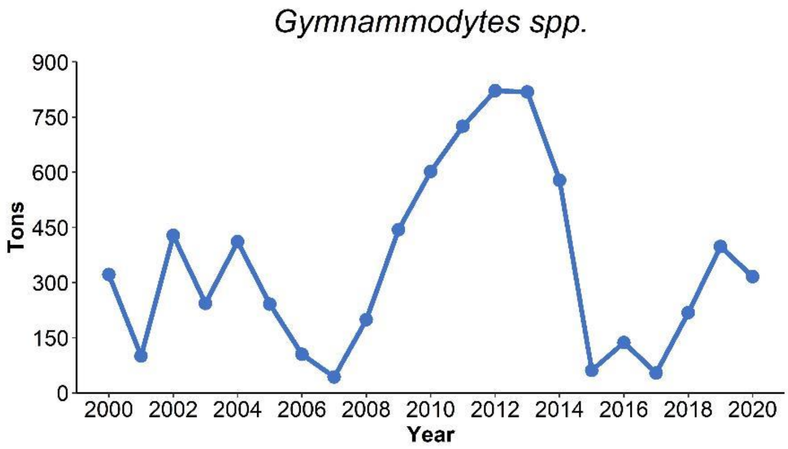


Figure 257. Time series of sand eel (*Gymnammodytes* spp.) annual catch rates (tons) for the time period 2000-2020 in Catalonia.

2.3.1.1 Target species monitoring: Mediterranean sand eel (*Gymnammodytes cicerelus*)

Population structure

The size frequency distribution of *Gymnammodytes cicerelus* during the sample period (October 2019-December 2020) ranged from 3.5 to 14 cm with an average size that increased monthly. Small specimens were observed in March with two size modes observed during this month, indicating the beginning of recruitment (Figure 258).

In April and May 2020 no individuals were caught because the fisheries could not work due to the COVID-19 pandemic.

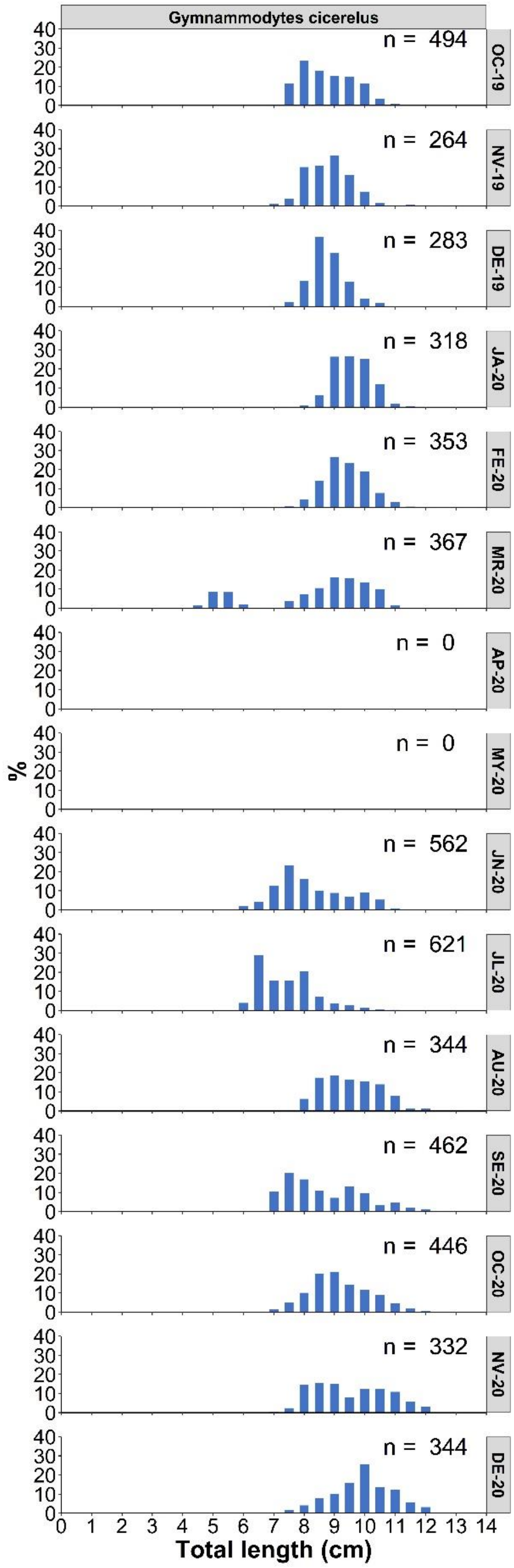


Figure 258. Monthly length-frequency distribution of Mediterranean sand eel (*Gymnammodytes cicerelus*) from October 2019 to December 2020 in Catalonia.

Sexual morphology and sex ratio

Gymnammodites cicerelus (Rafinesque, 1810) is a coastal species found on the continental shelf on shallow sand, shells and fine gravel bottoms, inhabiting burrows dug on sandy substrates and living in large groups, burying themselves headfirst in the sediment (Lleonart, et al., 2014). The species presents sexual dimorphism (Sanchez, P. et al., 2016) and the ratio between males and females found in the years 2019 and 2020 is shown in Figure 259, where it is clearly seen that, in 2019, this ratio was almost 1:1. However, in 2020, the proportion of females increased considerably.

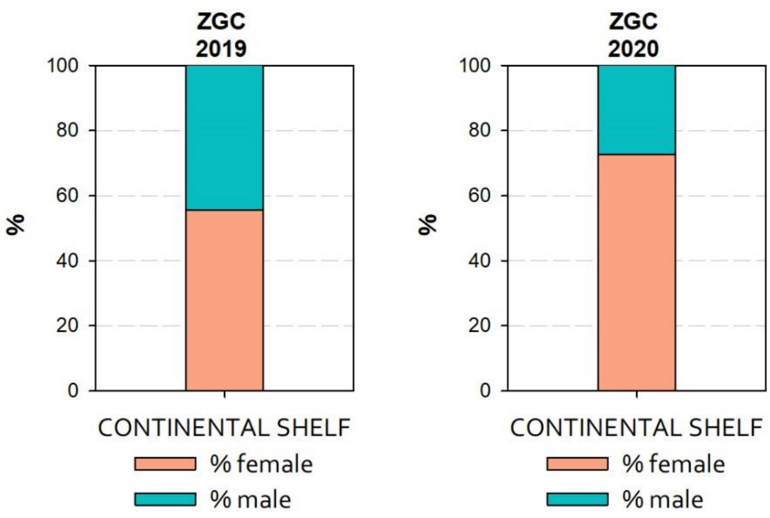


Figure 259. Sex ratio between males and females of *G. cicerelus* during 2019 (left) and during 2020 (right).

Length-weight relationship

The parameters of the length-weight relationship for Mediterranean sand eel population were calculated using the relationship $W = a*TL^b$, where W is weight (g) and TL is total length (cm). Figure 260 and Table 50 illustrates the length-weight relationship of *G. cicerelus*, where a positive allometric growth is observed.

Table 50. Mediterranean sand-eel length-weight relationship parameters in 2019 and 2020.

2019	a	b	R^2	n
Combined	0.0018	3.1890	0.9844	1216
Females	0.0020	3.1389	0.9455	276
Males	0.0011	3.3676	0.9625	220
2020	a	b	R^2	n
Combined	0.0025	3.0382	0.9294	850
Females	0.0031	2.9410	0.8589	394
Males	0.0032	2.9024	0.8500	149

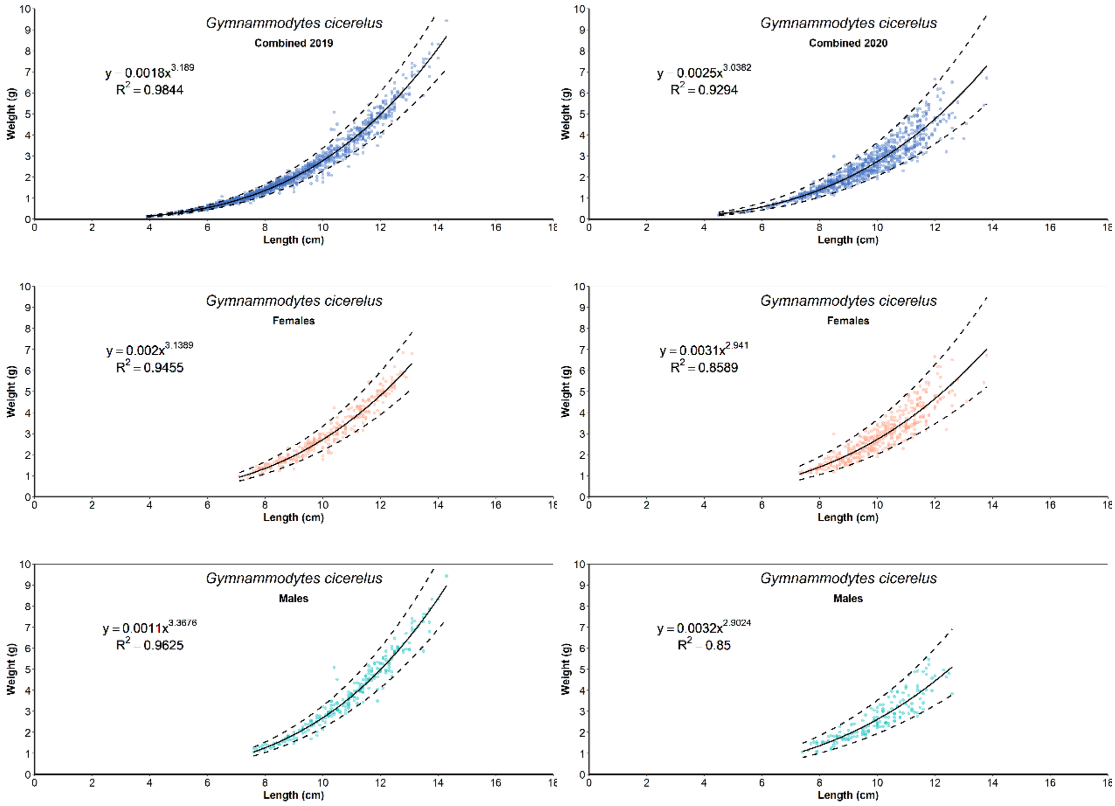


Figure 260. Length-weight relationship for the Mediterranean sand eel population (*G. cicerelus*) in 2019 and 2020. Parameters a and b were calculated for both sexes combined (blue), females (red) and males (green).

Cicle reproductiu i índex gonadosòmatic

G. cicerelus individuals had their sex and sexual status determined by assigning six stages of maturity: I = immature; II = resting; III = early maturation; IV = advanced maturation; V = mature; VI = post-mature. Sex is easily distinguishable macroscopically in adult individuals. The gonads of juvenile animals were very difficult to differentiate, therefore they were defined as indeterminate. The spawning season was established by means of the analysis of the monthly variation of the gonadosomatic index (GSI) by sex, which was calculated as: GSI=(GNW/TW)*100

TW being the total weight and GNW the gonad weight.

As in previous studies, it was observed that the highest occurrence of females in advanced stage of maturation or spawning occurred in March (Figure 261, Figure 262).

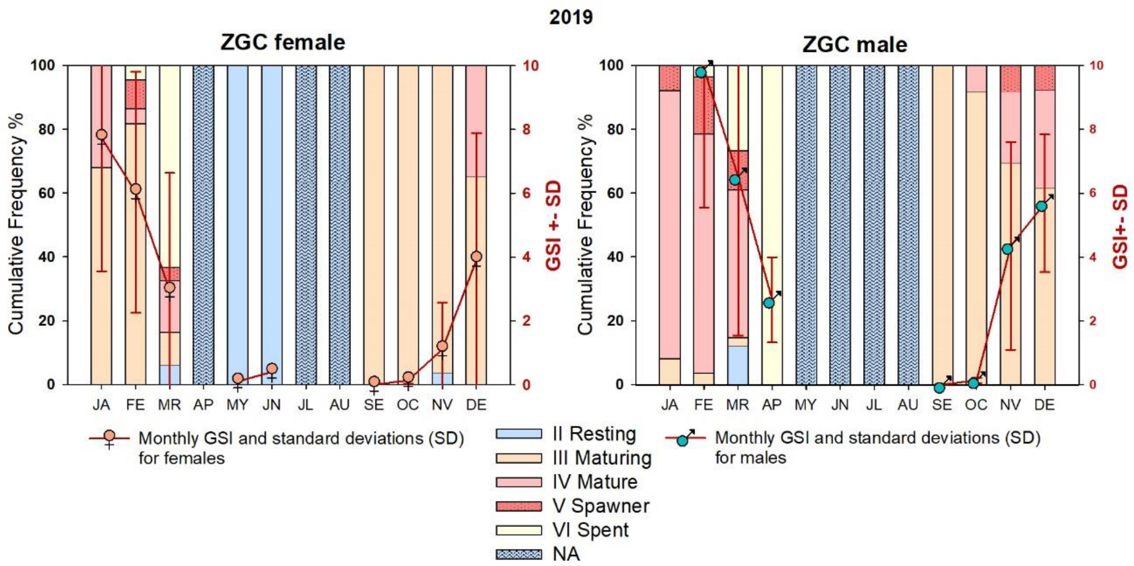


Figure 261. Mediterranean sand eel (ZGC) monthly gonadal cycle for females and males in 2019. Gonadosomatic index (GSI+/-SD) and percentage of different maturity stages.

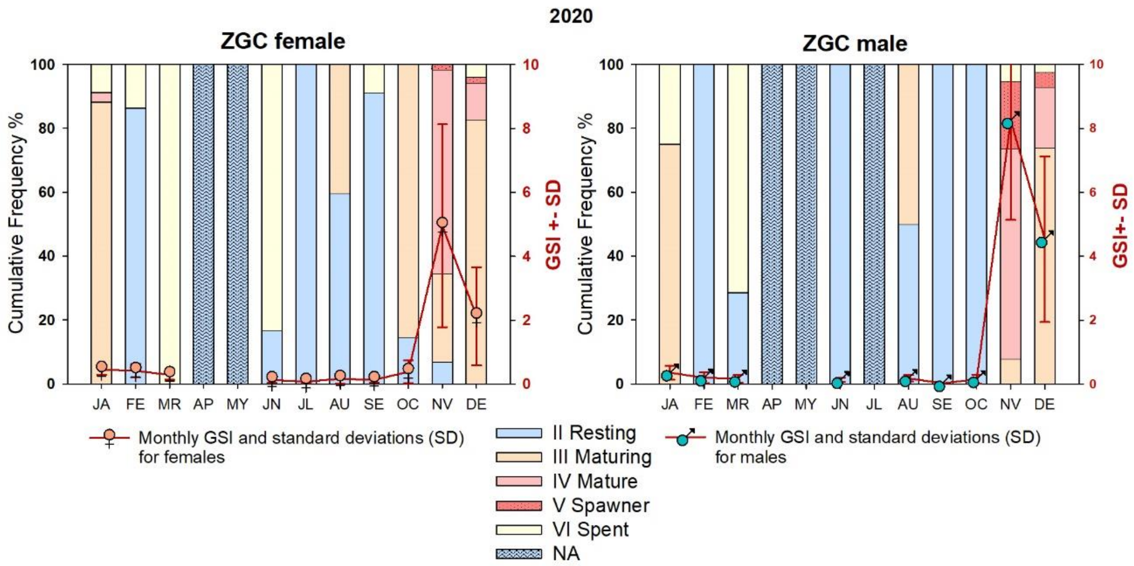


Figure 262. Mediterranean sand eel (ZGC) monthly gonadal cycle for females and males in 2020. Gonadosomatic index (GSI+/-SD) and percentage of different maturity stages.

Figure 263 and Figure 264 shows the gonadosomatic index (GSI) for *G. cicerelus* in 2019 and 2020. The GSI varied according to the stages of gonadal maturity, reaching maximum values when the spawning peak occured for both males and females.

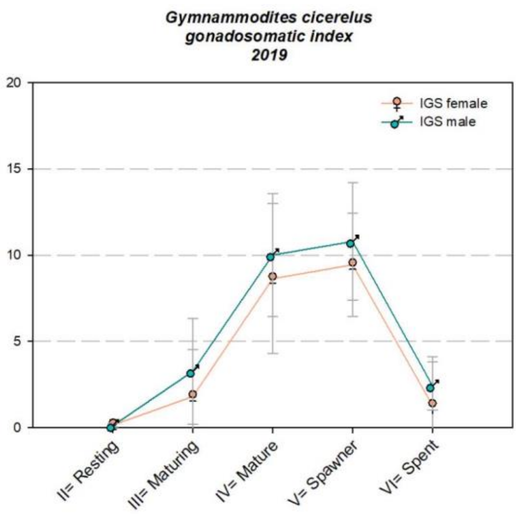


Figure 263. Gonadosomatic index (GSI) of Mediterranean sand eel (*G. cicerelus*) for males and females separately according to gonadal maturity stages in 2019.

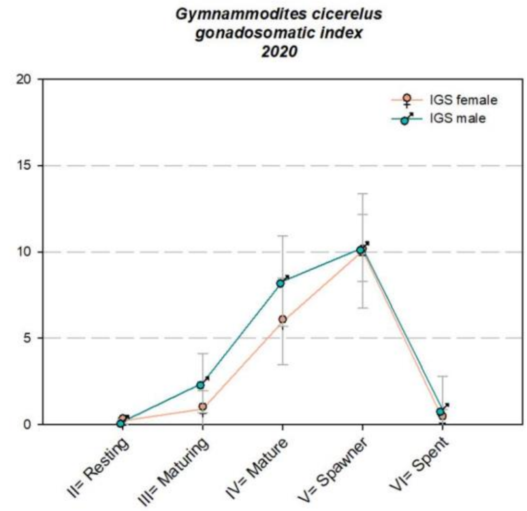


Figure 264. Gonadosomatic index (GSI) of Mediterranean sand eel (*G. cicerelus*) for males and females separately according to gonadal maturity stages in 2020.

Summary factsheet of the biological parameters and fishing activity in 2019-2020 of Mediterranean sand eel in Catalonia

2.3.1.2 Target species monitoring: Smooth sand eel (*Gymnammodytes semisquamatus*)

Population structure

The annual distribution of *Gymnammodytes semisquamatus* size frequencies ranged from 3 to 13 cm (Figure 265), with small specimens observed in March. Regarding the size distribution of *G. semisquamatus* throughout this period in Catalonia, the pattern is very similar to that of *G. cicerelus*. In summary, two modes were recorded in March 2020, and the maximum and minimum values were sustained between 3 and 14 cm. However, the number of specimens captured was much lower for *G. semisquamatus* than for *G. cicerelus*.

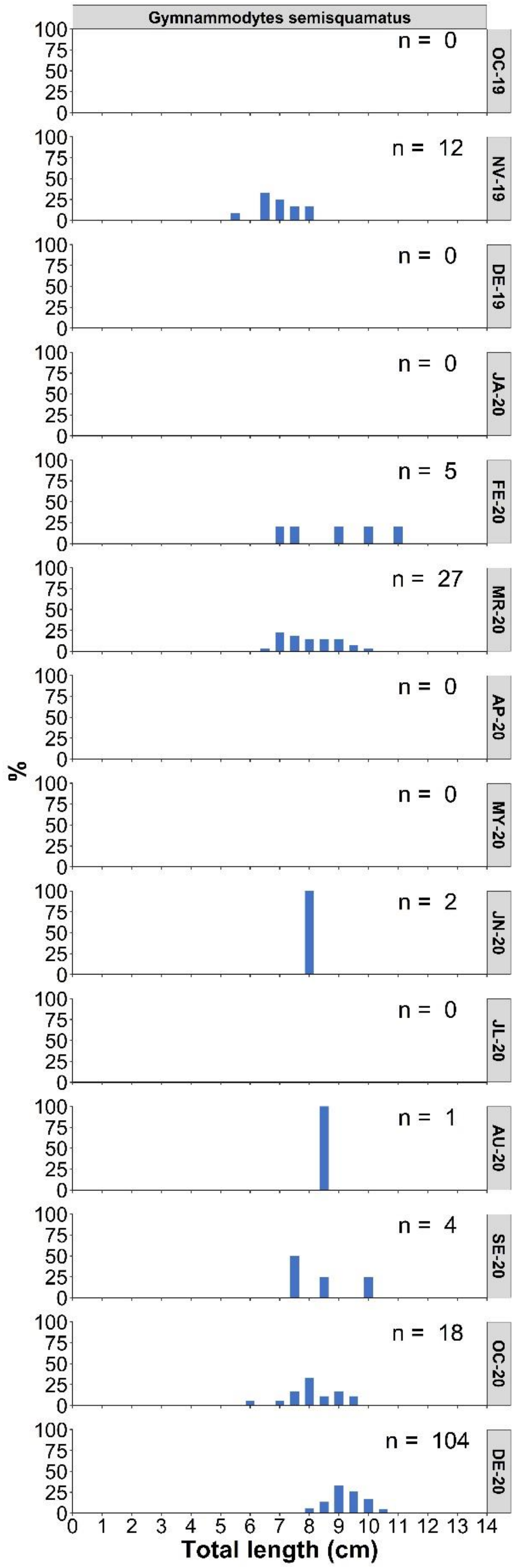


Figure 265. Monthly length-frequency distribution of smooth sand eel (*G. semisquamatus*) from October 2019 to December 2020 in Catalonia.

Sexual morphology and sex ratio

Gymnammodites semisquamatus (Jourdain, 1879) is a coastal species found on the continental shelf on shallow sand, shells and fine gravel bottoms, inhabiting burrows dug on sandy substrates and living in large groups, burying themselves headfirst in the sediment (Lleonart, J. et al., 2014). It presents sexual dimorphism (Sanchez, P. et al., 2016) and the ratio between males and females was maintained at almost 1:1 for both years, 2019 and 2020 Figure 266.

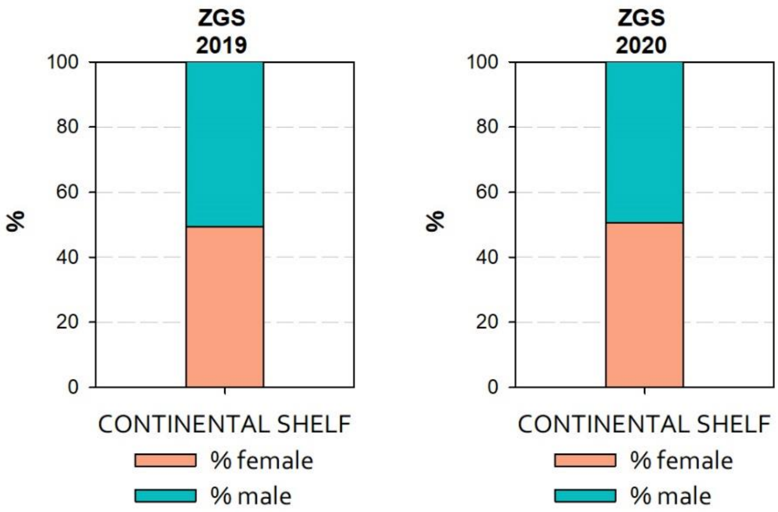


Figure 266. Sex ratio between males and females of *G. semisquamatus* found in 2019 (left) and in 2020 (right).

Length-weight relationship

The parameters of the length-weight relationship for the sand eel population were calculated using the relationship $W = a*TL^b$, where W is weight (g) and TL is total length (cm). Figure 267 and Table 51 illustrate the length-weight relationship of *G. semisquamatus*, showing a positive allometric growth.

Table 51. Smooth sand-eel length-weight relationship parameters in 2019 and 2020.

2019	a	b	R^2	n
Combined	0.0016	3.1675	0.9891	274
Females	0.0023	3.0253	0.9550	36
Males	0.0025	2.9814	0.9734	37
2020	a	b	R^2	n
Combined	0.0033	2.7868	0.8643	107
Females	0.0042	2.6755	0.8683	45
Males	0.0021	2.9671	0.8844	44

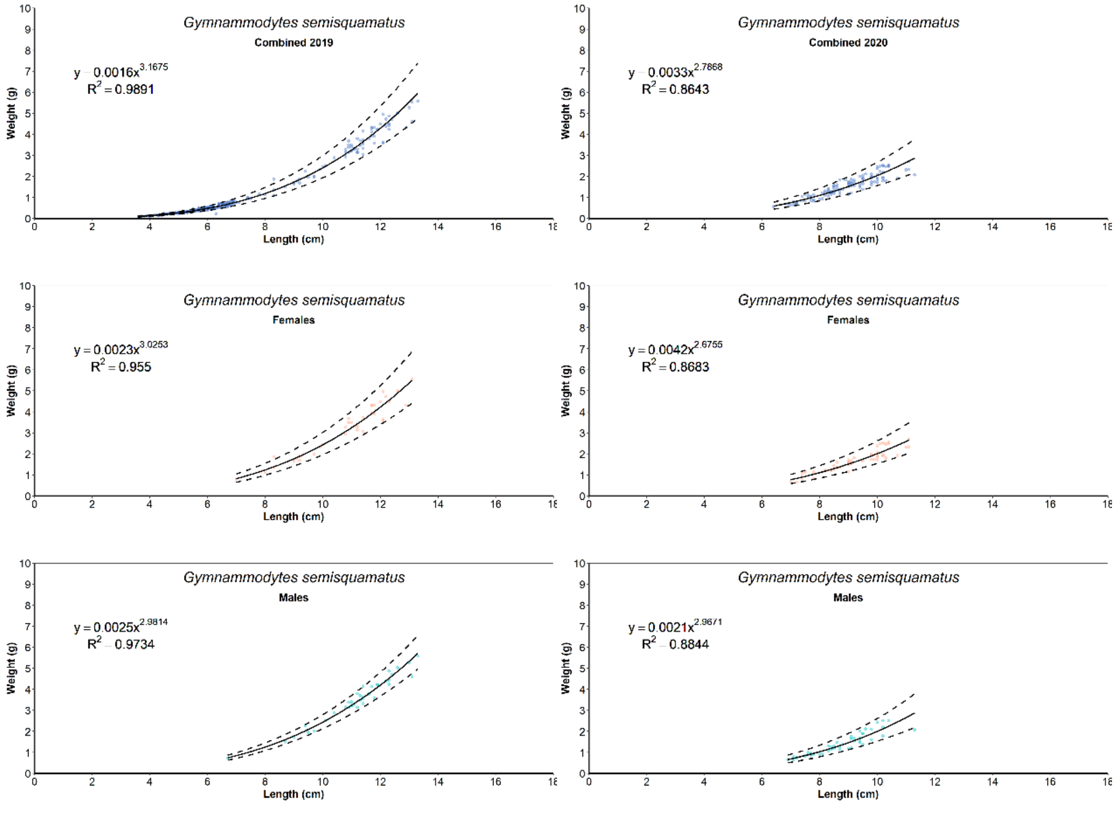


Figure 267. Length-weight relationship for sand eel population (*G. semisquamatus*) in 2019 and 2020. Parameters a and b were calculated for both sexes combined (blue), females (red) and males (green).

Reproductive cycle and gonadosomatic index

Sex and sexual status of *G. semisquamatus* was determined by assigning six stages of maturity: I = immature; II= resting; III = early maturation; IV = advanced maturation; V = mature; VI = post-mature. Sex is easily distinguishable macroscopically in adult individuals. The gonads of juvenile sand eels are very difficult to differentiate, thus they were defined as indeterminate. The spawning season was established by means of the analysis of the monthly variation of the gonadosomatic index (GSI) by sex, which was calculated as: GSI=(GNW/TW)*100

TW being the total weight and GNW the gonad weight.

As observed in previous studies, the highest occurrence of females in advanced stage of maturity or spawning occurred in March (Figure 268, Figure 269).

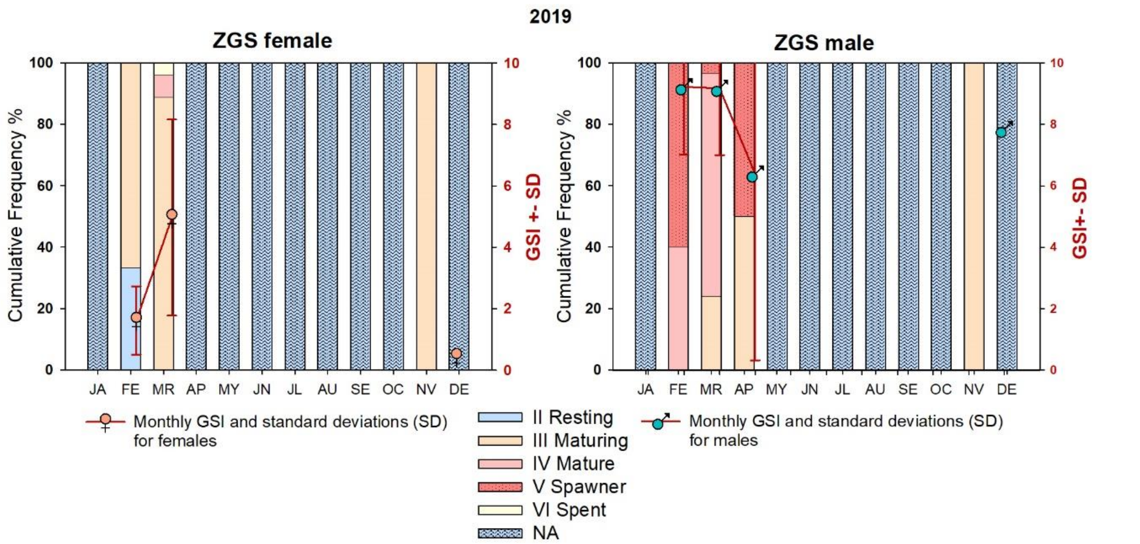


Figure 268. Smooth sand eel (ZGS) monthly gonadal cycle for females and males in 2019. Gonadosomatic index (GSI+/-SD) and percentage of different maturity stages.

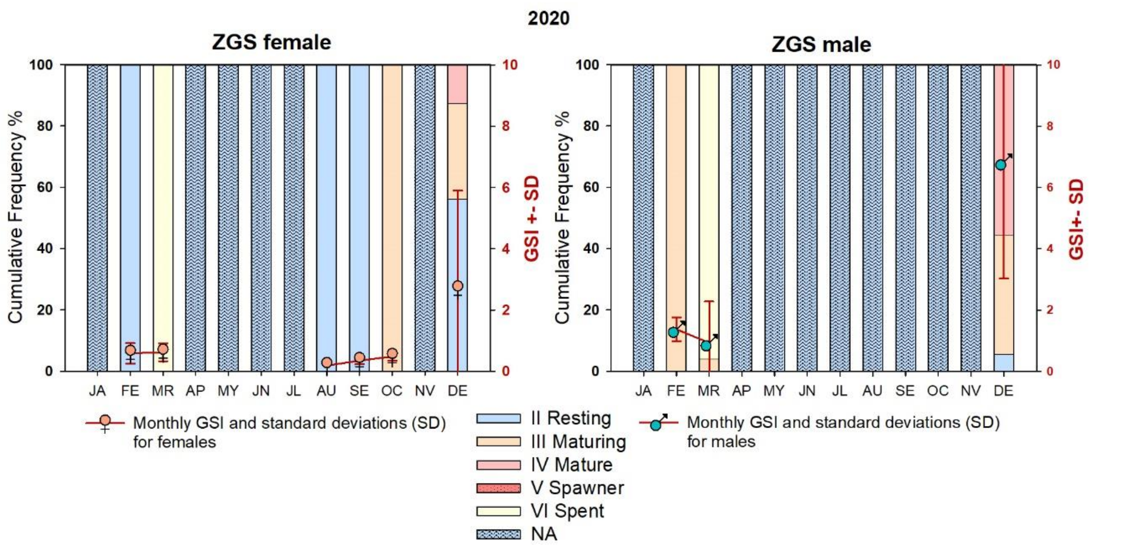


Figure 269. Smooth sand eel (ZGS) monthly gonadal cycle for females and males in 2020. Gonadosomatic index (GSI+/-SD) and percentage of different maturity stages.

Summary factsheet of the biological parameters and fishing activity in 2019-2020 of Smooth sand eel in Catalonia

2.3.1.3 Target species monitoring: Transparent goby (*Aphia minuta*)

Annual catch history

Figure 270 shows the evolution of catches of the target species (*Aphia minuta*) from 2000 to 2020, with peaks of maximum catches in 2006, 2008 and 2011 with values of approximately 4 tonnes each year. In the years 2005, 2010 and 2012, the catch values decreased to minimum values around half a tonne. From 2012 onwards, catches stabilised on 2 tonnes per year but, in 2020, catches decreased again.

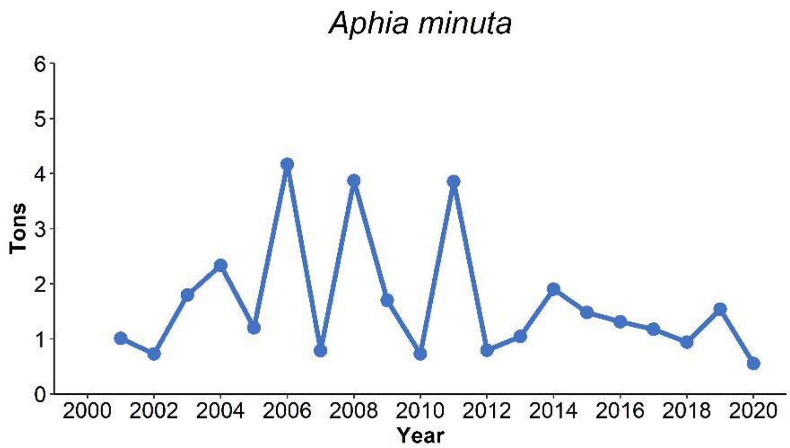


Figure 270. Time series of transparent goby annual catch rates (tons) for the time period 2000-2020 in Catalonia.

Population structure

During the study period (October 2019-December 2020) only 325 specimens were obtained during the month of February 2020 with a size range between 2 cm and 4.5 cm, despite most individuals measured 3.5 cm (Figure 271).

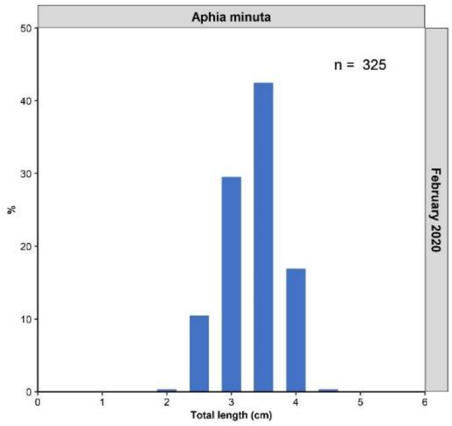


Figure 271. Length-frequency distribution of the transparent goby (*A. minuta*) in February 2020 in Catalonia.

Sexual morphology and sex ratio

The transparent goby *Aphia minuta* (Risso, 1810) a is a pelagic neritic goby widely distributed in inshore and estuarine waters from the surface to 80–100 m depth over sand, mud, eel grass and sea-weed (*Zostera marina* and *Cystoseira* respectively), and sea-grass (*Posidonia oceanica*). This goby is the object of an important small-scale fishery during the winter months (December to March/May) in the Mediterranean Sea (La Mesa et al., 2005). This species presents sexual dimorphism with males having a larger head, uneven teeth, a higher caudal peduncle, and more developed fins, especially the ventral ones. Reproduction occurres from December to March in the western Mediterranean, with males and females being present all year round. Overall, females are more abundant than males, mainly in winter and early spring (December– March), in the other months, however, the sex ratio is close to 1:1 (Iglesias & Morales-Nin, 2001). Life cycle of the pelagic goby Aphia minuta (Pisces: Gobiidae). Scientia Marina 65 (3) 183-192.).

Length-weight relationship

The parameters of the length-weight relationship for the transparent goby population were calculated using the relationship W = a*TL^b, where W is weight (g) and TL is total length (cm). Figure 272 and Table 52 illustrates the length-weight relationship of *A. minuta*, where positive allometric growth can be observed in this species.

Table 52. Transparent goby length-weight relationship parameters in 2019 and 2020.

2019	a	b	R^2	n
Combined	0.0018	3.8183	0.8925	96
2020	a	b	R^2	n
Combined	0.0031	3.3644	0.9617	50

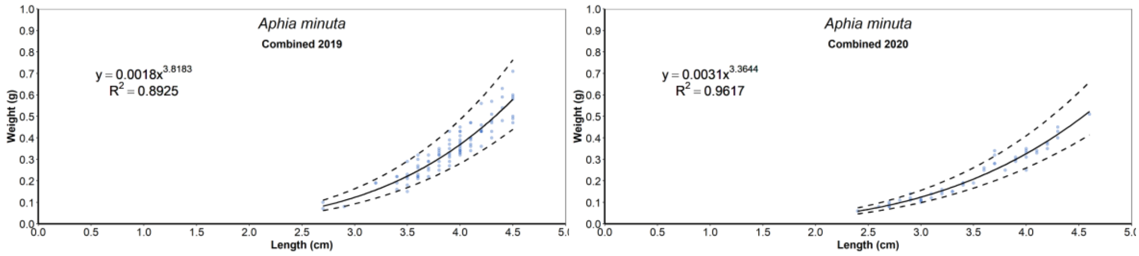


Figure 272. Length-weight relationship for the transparent goby population (*A. minuta*) in 2019 and 2020. Parameters *a* and *b* were calculated for both sexes combined (blue), females (red) and males (green).

2.3.2 Sand eel fishery by zone

2.3.2.1 North zone

Figure 273 shows the sampling localization of sand eel seiner fishery hauls performed in the North zone from October 2019 to December 2020.

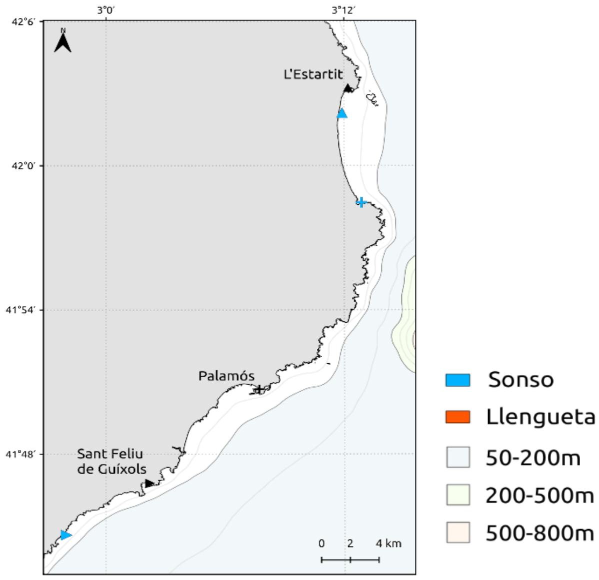


Figure 273. Map of of the sand eel seiner fishery performed in the north zone from October 2019 to December 2020.

2.3.2.2 Center zone

Figure 274 shows the sampling localization of sand eel seiner fishery hauls performed in the Center zone from October 2019 to December 2020.

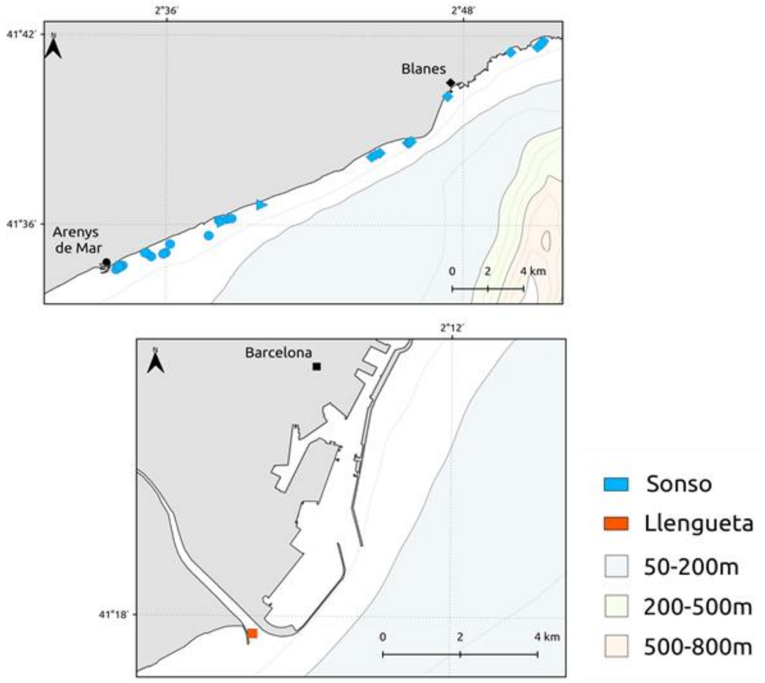


Figure 274. Map of of the sand eel sainer fishery performed in the center zone from October 2019 to December 2020.

2.3.2.3 Status of target species by zone

Sand eel north zone (Gymnammodytes *spp.*)

Figure 275 show the time series of annual commercial catch of sand eels in the north zone.

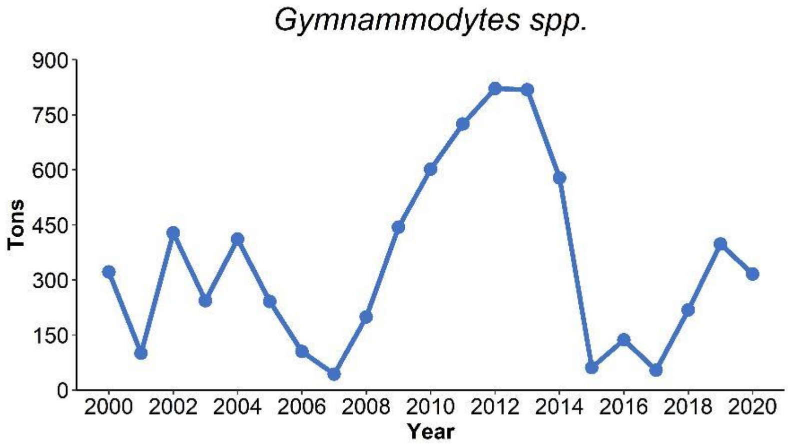


Figure 275. Time series of sand eels (*Gymnammodytes* spp.) annual catch (tons) for the period 2000-2020 in the north zone.

Mediterranean sand eel north zone (Gymnammodytes cicerelus)

The north area is the only one in Catalonia where there is a sand eel fishery. During the period of the study the effect of confinement due to the COVID-19 pandemic was observed and in spring 2020, the number of fish caught felt drastically, reducing it to half for the rest of the periods. During the winter, two size classes were detected, and the variation in mean size over the whole studied period was higher in autumn and winter than in spring and summer (Figure 276).

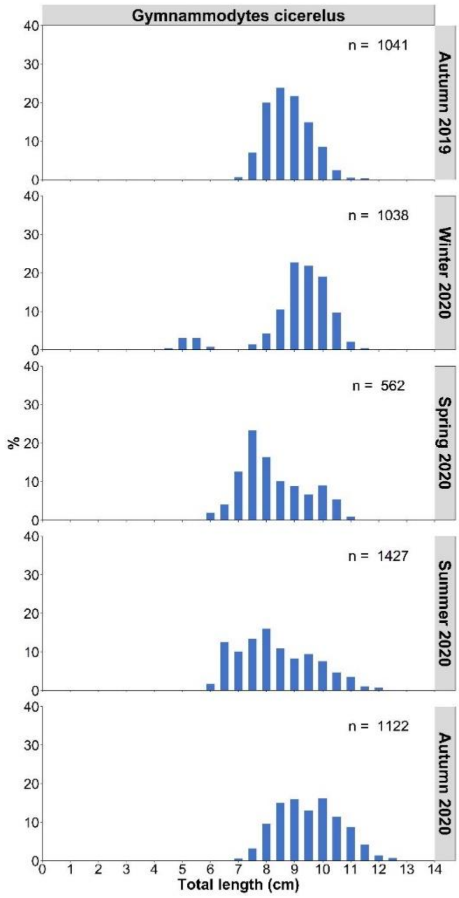


Figure 276. Seasonal length-frequency distribution of Mediterranean sand eel (*G. cicerelus)* from October 2019 to December 2020 in the north zone.

Smooth sand eel north zone (Gymnammodytes semisquamatus)

There was a considerable increase in catches of this species in autumn 2020 (122 individuals) compared to the same period the previous year (12 individuals). The average size of the individuals changed throughout the period studied, with maximum values recorded in autumn 2020 (Figure 277). Nevertheless, 2020 data should be taken with caution due to COVID-19 pandemic situation.

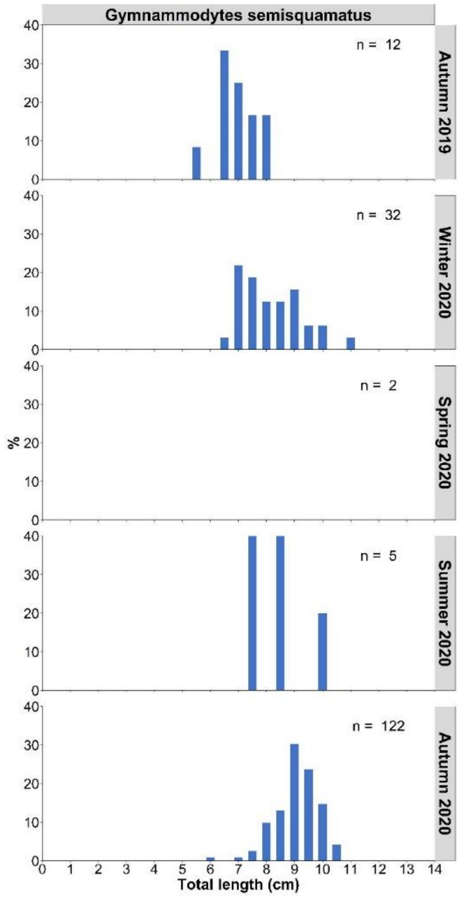


Figure 277. Seasonal length-frequency distribution of smooth sand eel (*G. semisquamatus*) from October 2019 to December 2020 in the north zone.

Transparent goby center zone (*Aphia minuta*)

The center zone is the only one in Catalonia where there is a transparent goby fishery. Figure 278 show the time series of annual commercial catch of transparent goby in the center zone.

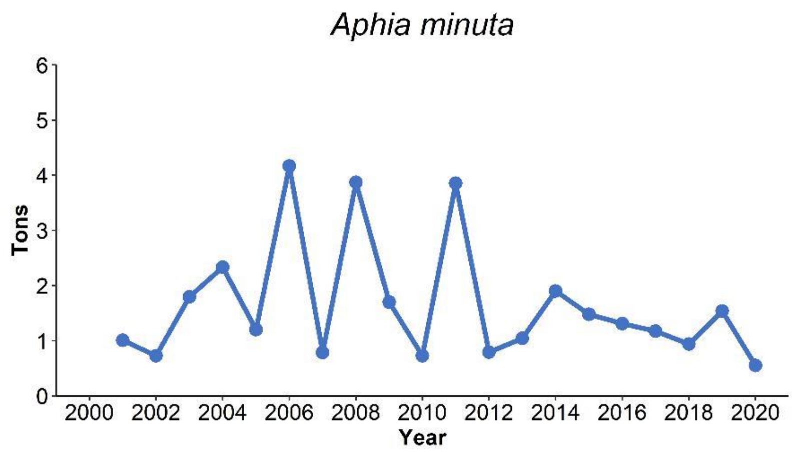


Figure 278. Time series of transparent goby annual catch rates (tons) for the time period 2000-2020 in the center zone.

In the size frequency of *A. minuta* in the central zone most of the individuals were 3.5 cm in length (Figure 279).

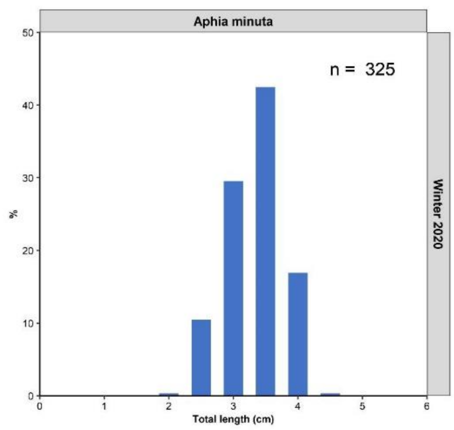


Figure 279. Seasonal length-frequency distribution of transparent goby (*A. minuta*) from October 2019 to December 2020 in the north zone.

2.3.3 Sand eel fishery per port

2.3.3.1 L'Estartit

In the port of l'Estartit, no *G. semisquamatus* were caught. The *G. cicerelus* most represented size was 7 cm (Figure 280).

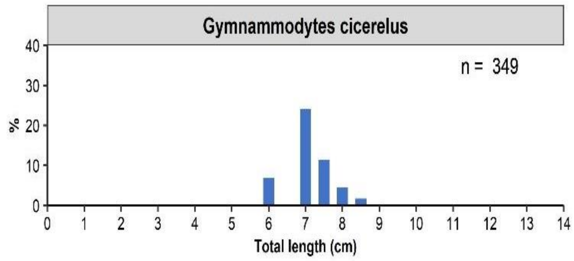


Figure 280. Length-frequency distribution of target species captured by sand eel from October 2019 to December 2020 in the port of L'Estartit.

2.3.3.2 Palamós

The historical distribution of catches in the port of Palamós for the years 2000-2020 showed two peaks with minimum catches in 2007 and 2017 and a maximum catch in 2010, when catches reached about 150 tonnes, as shown in Figure 281 .

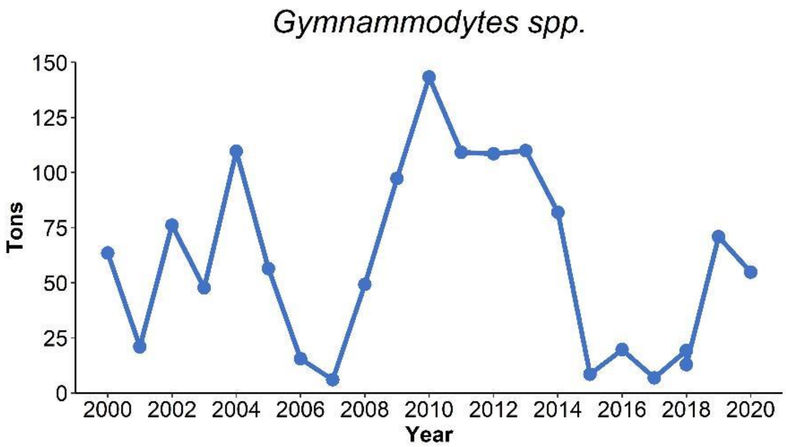


Figure 281. Time series of sand eel (*Gymnammodytes* spp.) annual catch (tons) for the period 2000-2020 in Palamós port.

The number of individuals caught for both *Gymnammodites* species in the port of Palamós followed a diferent pattern and only 4 individuals of *G. semisquamatus* were caught throughout the whole period of study, whereas the catches of *G. cicerelus* accounted for 181 individuals with an average size of 9.5 cm (Figure 282, Figure 283).

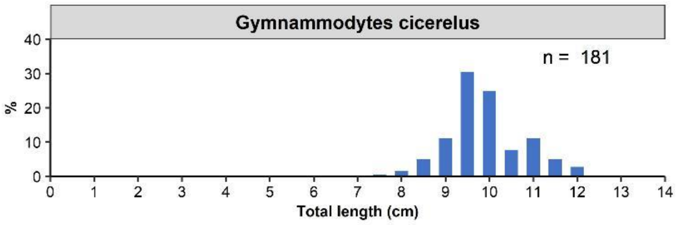


Figure 282. Length-frequency distribution of *G. cicerelus* captured by sand eel fishery from October 2019 to December 2020 in the port of Palamós.

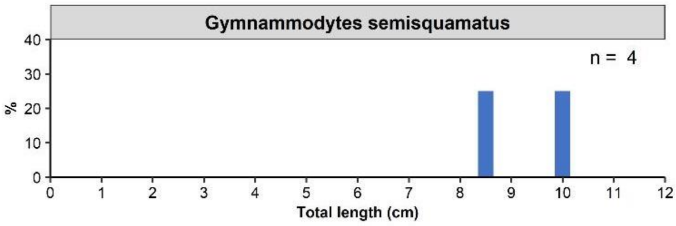


Figure 283. Length-frequency distribution of *G. semisquamatus* captured by sand eel fishery from October 2019 to December 2020 in the port of Palamós.

2.3.3.3 Sant Feliu de Guíxols

Figure 284 plots historical catches of both *Gymnammodytes* spp. in the port of Sant Feliu de Guíxols. Maximum catches were recorded in 2013 reaching about 150 tonnes but decreasing thereafter until 2015. From then onwards, the catches have been increasing until the present time.

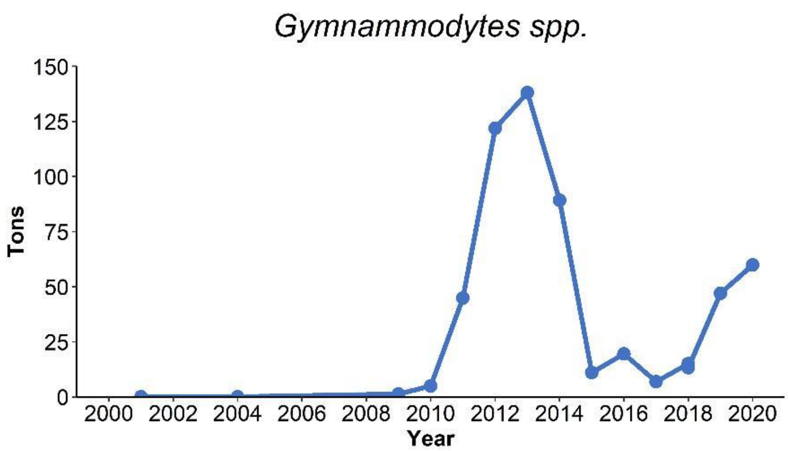


Figure 284.Time series of sand sand eel (*Gymnammodytes* spp.) annual catch (tons) for the period 2000-2020 in Sant Feliu de Guíxols.

During the study period (October 2019-December 2020) only one individual of *G. semisquamatus* was caught in the port of Sant Feliu de Guixols, while 206 individuals of *G. cicerelus* were caught and had two length frequency modes, at 8.5 cm and 10 cm (Figure 285).

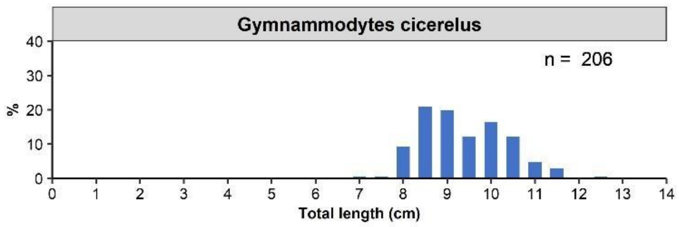


Figure 285 Length-frequency distribution of *G. cicerelus* captured by sand eel from October 2019 to December 2020 in the port of Sant Feliu de Guíxols.

2.3.3.4 Blanes

The distribution of sand eels catches in the port of Blanes between the years 2000-2020 showed several peaks and troughs, with the highest values corresponding to year 2002 (> 250 tonnes) and the lowest catches were recorded in 2007 (< 50 tonnes) (Figure 286).

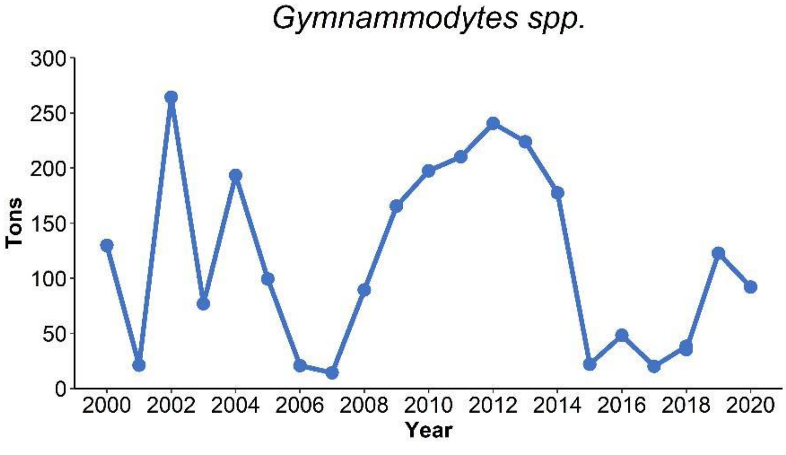


Figure 286. Time series of sand eel Gymnammodytes spp annual catch (tons) for the period 2000-2020 in the port of Blanes.

No *G.semisquamatus* were catched in samples of the port of Blanes during the study period. A total of 1207 individuals of *G. cicerelus* were caught with a size frequency averaging 8 cm (Figure 287).

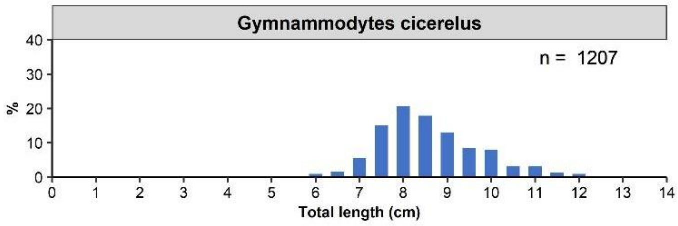


Figure 287. Length-frequency distribution of *G. cicerelus* captured by sand eel fishery from October 2019 to December 2020 in the port of Blanes.

2.3.3.5 Arenys de Mar

The distribution of *Gymnammodites* spp. catches in the port of Arenys is quite similar to the distribution of the species in Catalonia as a whole. A maximum was observed in 2013 with almost 360 tonnes. Thereafter, catches droped until 2015, when they reached a minimum of less than 60 tonnes, but raised from this year on until the present day (Figure 288).

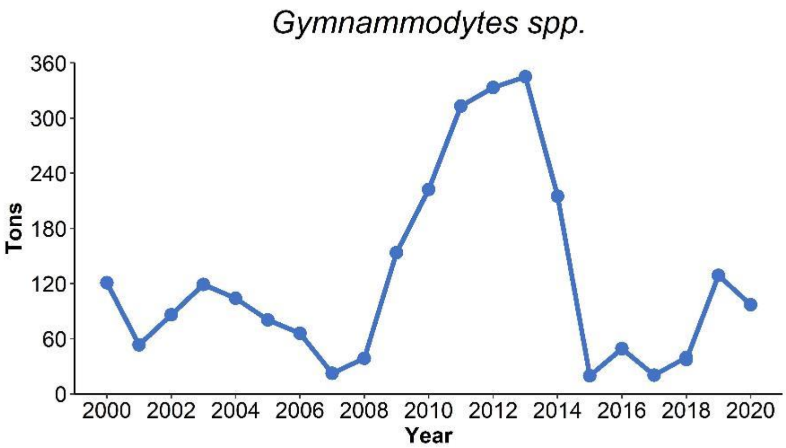


Figure 288. Arenys de Mar. Sand eel, *Gymnammodytes spp*. time series of annual catch in tons (2000-2020).

In the port of Arenys de Mar, the catches of *G. cicerelus* and *G. semisquamatus* have very different values, as 3,247 individuals of *G. cicerelus* have been caught in ours samples compared to 168 of *G. semisquamatus*. The size frequencies of both species have similar values, with an average size of 9 cm. (Figure 289, Figure 290)

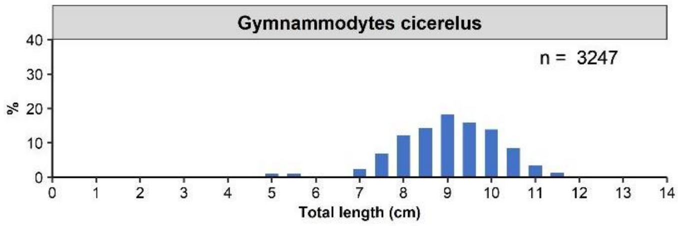


Figure 289. Length-frequency distribution of *Gymnammodytes cicerelus* captured by sand eel fishery from October 2019 to December 2020 in the port of Arenys de Mar.

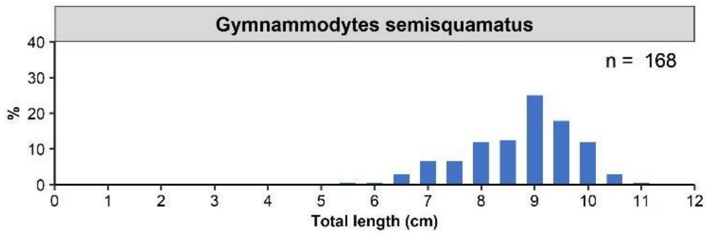


Figure 290. Length-frequency distribution of *Gymnammodytes semisquamatus* captured by sand eel fishery from October 2019 to December 2020 in the port of Arenys de Mar.

2.3.3.6 Barcelona

The catches distribution for *Aphia minuta* studied from 2000 to 2020 showed several peaks and troughs between 2004 and 2012. Then, the catches increased to around 2 tonnes and remain stable until 2020, when they decreased again to half a tonne (Figure 291)

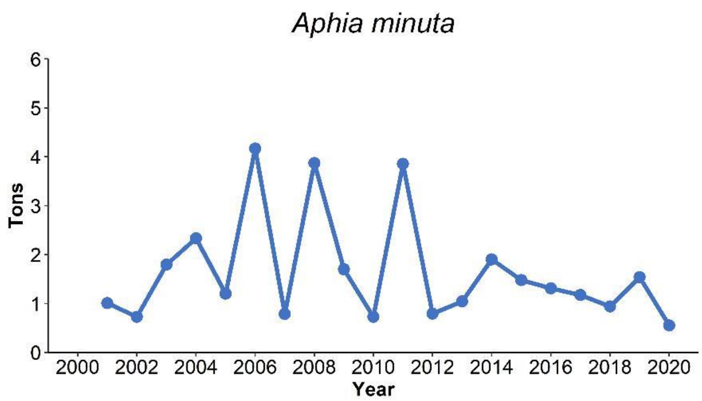


Figure 291. Time series of transparent goby annual catch (tons) for the period (2000-2020) in Barcelona.

The size frequency distribution of the 325 individuals of transparent goby caught in the samples obtained in the port of Barcelona had an average size of 3.5 cm (Figure 292).

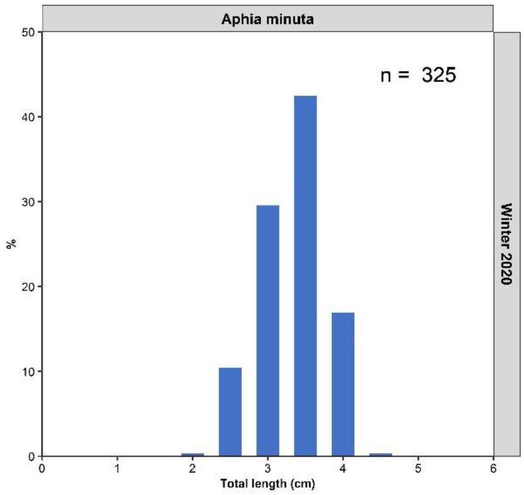


Figure 292. Length-frequency distribution of *A. minuta* captured by sand eel fishery from October 2019 to December 2020 in the port of Barcelona.

2.3.3.7 Comparative summary by port

Analysing the data from the different ports from October 2019 to December 2020, the size frequencies in *G. cicerelus*, the most abundant species, had the same trend throughout the year in all studied locations. At the ports of Arenys de Mar and Blanes the size distribution was wider because there also were smaller individuals, over 5 cm, that could be considered as a representation of recruitment.

G. semisquamatus, the other target species, were only caught in the ports of Palamós and Arenys de Mar. The size frequency of the individuals also had one single mode.

2.4 COMMON OCTOPUS FISHERY (*Octopus vulgaris*)

2.4.1 Common octopus (*Octopus vulgaris*) fishery in Catalonia

Figure 293 shows the sampling localization of common octopus (*Octopus vulgaris*) biological sampling hauls performed in the Center zone from October 2019 to December 2020.

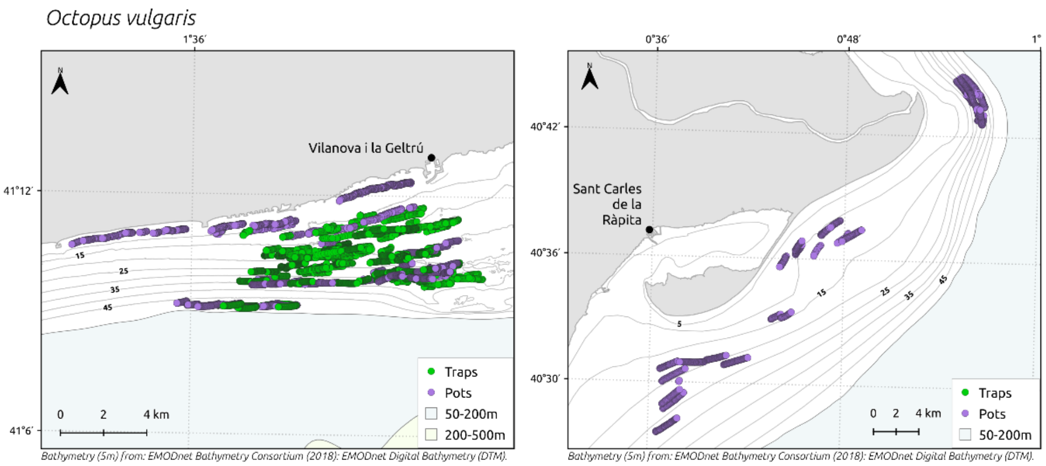


Figure 293. Map of location from biological sampling of Octopus vulgaris performed in Catalonia from October 2019 to December 2020.

Annual catch history

The total anual catch rates of common octopus (*Octopus vulgaris*) during the period 2000-2020 in Catalonia for the trawling fleet and artisanal's fishery fleet (pots and traps) indicated a decrease in catches (Figure 294). The maximum catches were obtained in the first year of recorded data (> 1200 tons). As of 2002 the catches decreased although they remained stable (between 750 and 500 tons) throughout the years. In 2020, the minimum catches (300 tons) were recorded.

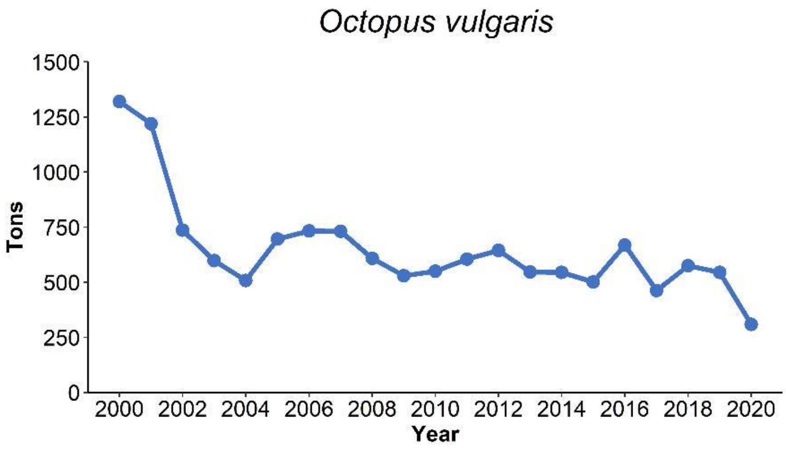


Figure 294.Time series of common octopus annual catch (tons) of trawling and artisanal fisheries fleet for the period 2000-2020 in Catalonia.

Population structure

To determinate the weight range of the common octopus caught with pots and traps in Catalonia, monthly samplings were carried out on board artisanal fishery boats during the years 2019 and 2020. The weight range included the fraction of common octopus discarded by the artisanal fleet, therefore the whole size range population was monitored. The monthly weight-frequency distribution of common octopus in 2019 and in 2020 (Figure 295) showed that, in general, more individuals were captued below the MCRS (< 1 Kg). Thus, the majority of individuals captured were immature, prevailing in abundance from August to December, with 25 % of them weighing 600 g and some did not even reach 100 g. Adult individuals were catched in abundance in late spring and summer, although the mode was 1200 g, so they were newly mature octopuses. The heavier indivuals (3 to 5 Kg) were already adults, captured in the winter months where the range of weights was wider, from 200 g to 4800 g. If we compare two years, the weight-frecuency distribution was similar throughout the months, although more immature individuals were registered in 2020.

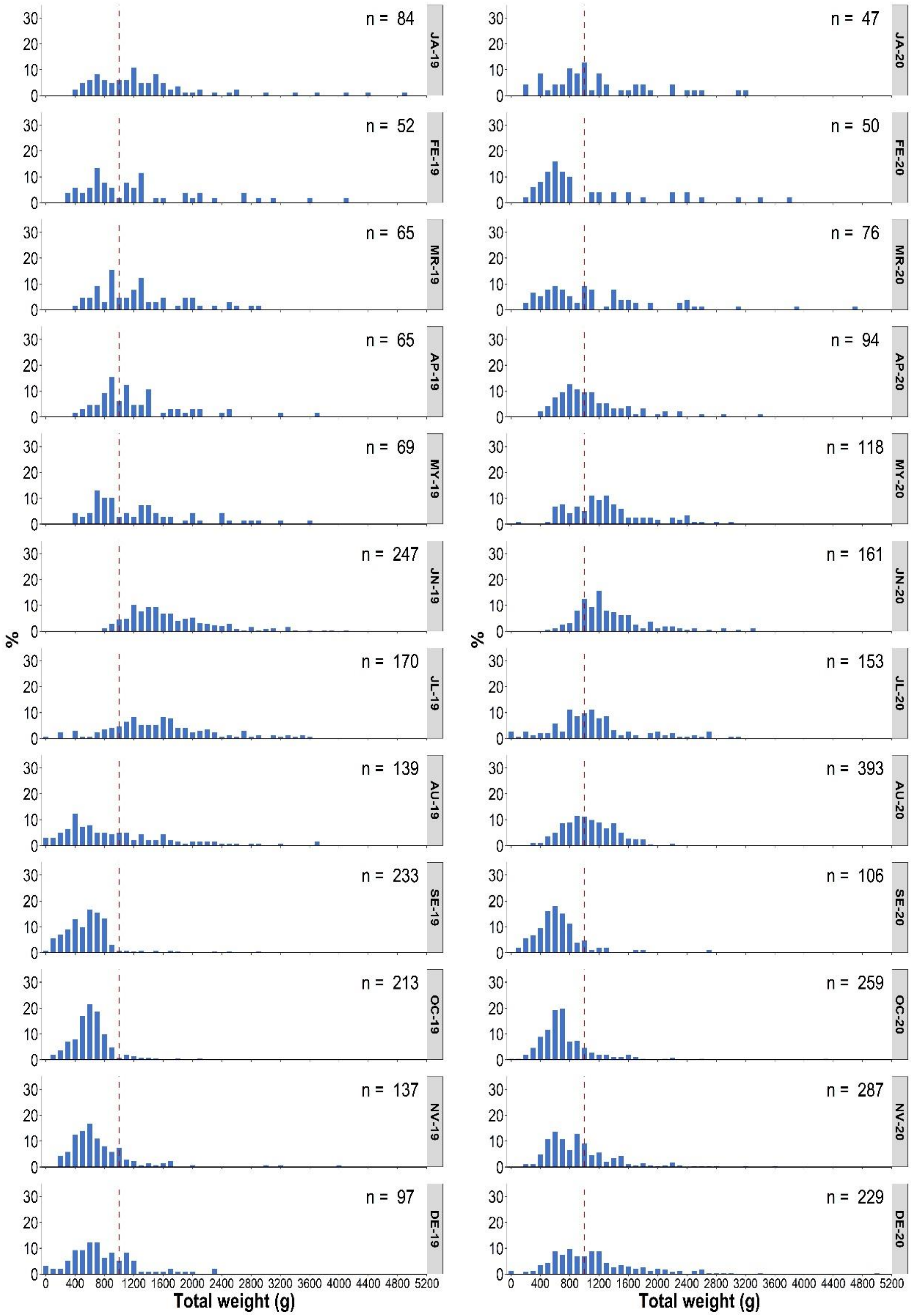


Figure 295. Monthly weight-frequency distribution in percentage of individuals of common octopus (*O. vulgaris*) captured by the artisanal fleet (pots and traps) in 2019 and 2020. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 1 kg.

Sexual morphology and sex ratio

The common octopus, *Octopus vulgaris* (Cuvier, 1797), is caught in north-western Iberian waters by trawling fleet and artisanal fleet. Their external morphology is different between sexes. The common octopus has sexual dimorphism. Males are distinguished by having the third pair of right arm hectocotilized for reproduction and the adult specimens usually show some suckers with disproportionate size. The sex ratio depends on the depth and the season of the year in which they are caught. In spring and summer more females are caught, coinciding with the maturation period. In our samplings, during 2019 we measured more males than females but in 2020, a similar proportion of males and females were measured.

Length-weight relationship

The parameters of the length-weight relationship for the common octopus population were calculated using the relationship $W = a*ML^b$, where W is the weight (g) and ML is the mantle length (cm). According to the allometric parameter b of the length-weight relationship for both sexes combined, the common octopus showed negative allometric growth ($b < 3$) in both years (Figure 296 and Table 53). Analyzing by sex, there was also negative allometric growth in both, meaning that, as individuals grew, their body proportions changed and the individuals weighed less because of their length. The parameter b in males was higher than in females in both years. Therefore, the length-weight relationship showed that males reached higher sizes and weights than females. According to the biological characteristics, the common octopus had a very short biological cycle (1-2 years) being fast growing organisms so they matured quickly, doubling their weight in a few months. When reaching the adult phase, the females stop their growth earlier to allocate a large part of the energy to reproduction while males continue to grow, even after reaching sexual maturity. The greater weight of males can also be explained by the sexual dimorphism (males are heavier than the females). The numbers of individuals measured used to calculate this relationshiop was very high (over 1000 individuals in 2020), obtaining regression values greater than 0.7 in both years.

Table 53. Common octopus length-weight relationship parameters in 2019 and 2020.

2019	a	b	R^2	n
Combined	1.3143	2.5659	0.8364	906
Females	2.2639	2.3432	0.8130	387
Males	0.8679	2.7359	0.8620	517
2020	a	b	R^2	n
Combined	3.3901	2.2258	0.7484	1444
Females	5.2832	2.0503	0.7244	738
Males	1.9059	2.4539	0.7839	705

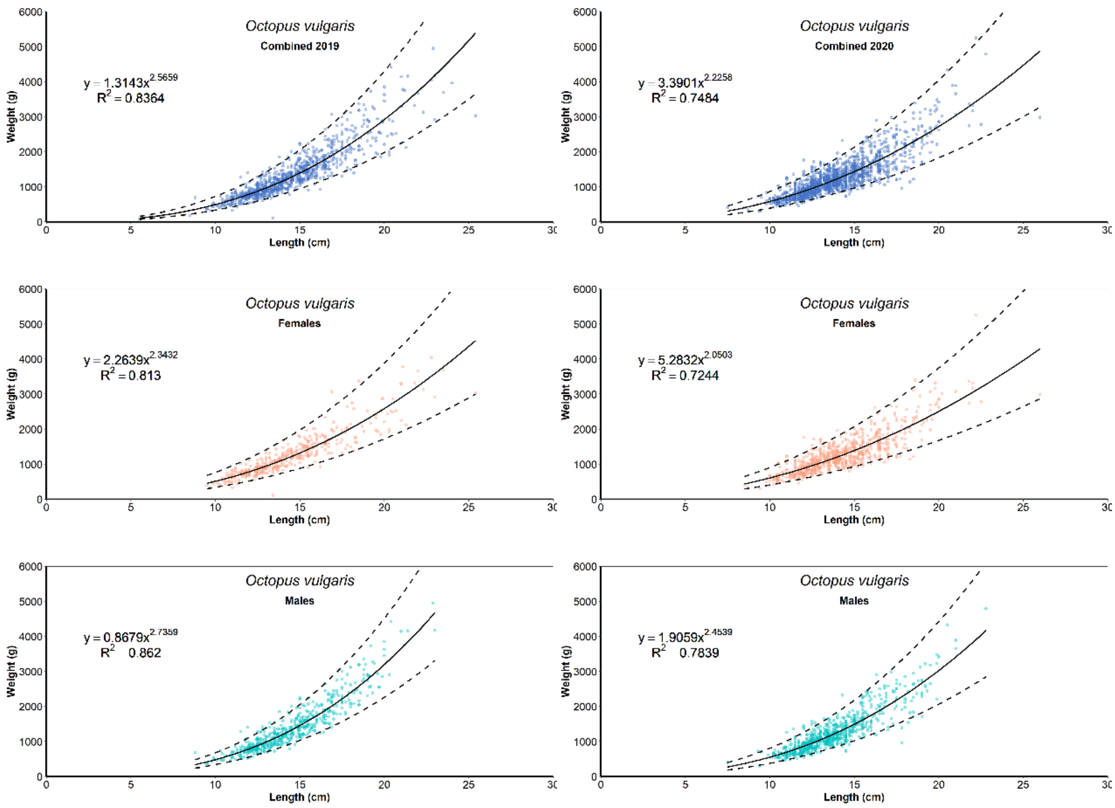


Figure 296. Length-weight relationship for common octopus population (*O. vulgaris*) in 2019 and 2020. Parameters *a* and *b* were calculated for both sexes combined (blue), females (red) and males (green).

Reproductive cycle

The reproductive cycle of common octopus showed a period of sexual maturity of different extensions in females and males in both years (Figure 297 and Figure

298). Mature males were observed during all months of the year (stage V), with a lower percentage between September and December, coinciding with the period of smaller sizes of the population. Mature females (stage IV) were mainly observed between May and August, rarely present the rest of the year. In this species, unlike the horned octopus, males deposit the spermatophores in the females' oviducts, where the sperm can be stored for weeks until the female uses them to fertilize the oocytes.

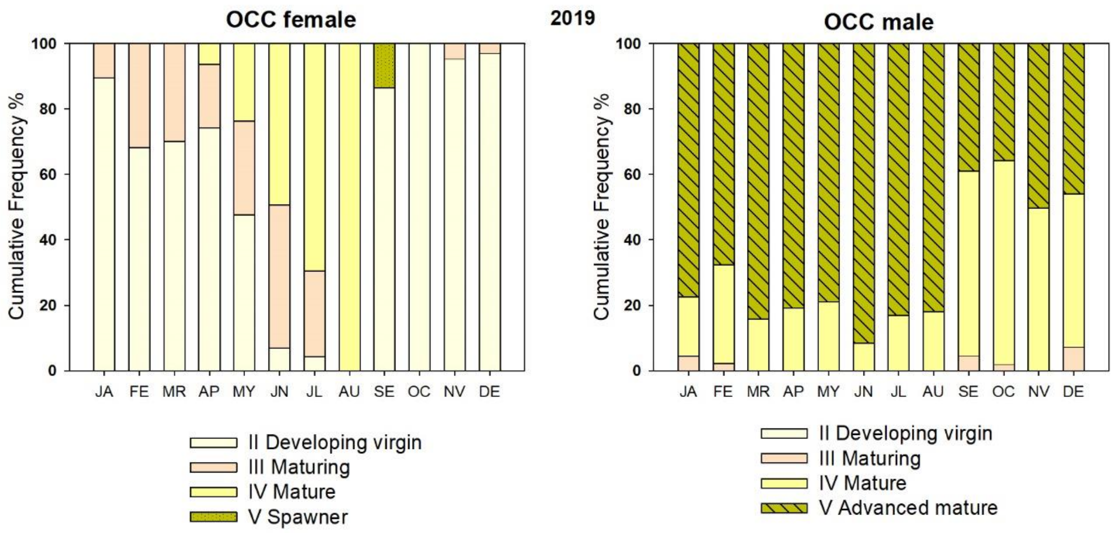


Figure 297. Common octopus (OCC) monthly gonadal cycle for males and females in 2019. Percentage of different maturity stages.

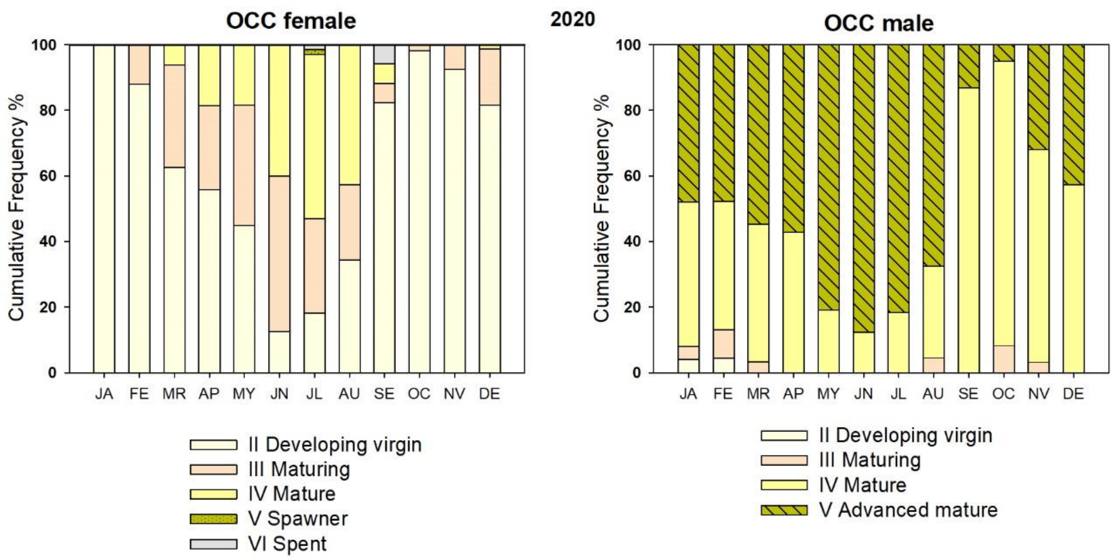


Figure 298. Common octopus (OCC) monthly gonadal cycle for males and females in 2020. Percentage of different maturity stages.

Summary factsheet of the biological parameters and fishing activity in 2019-2020 of Common octopus in Catalonia

2.4.2 Common octopus (*Octopus vulgaris*) fishery by zone

Common octopus (Octopus vulgaris) north zone

Annual catch history

Annual catches of common octopus during the period 2000-2020 in the north zone (Figure 299) followed a similar pattern to that observed for the whole of Catalonia, with a maximum of around 250 tons registered in 2000. Catches decreased from 2002 (< 150 t) and showed small fluctuations over the years, although, in general, catches remained low.

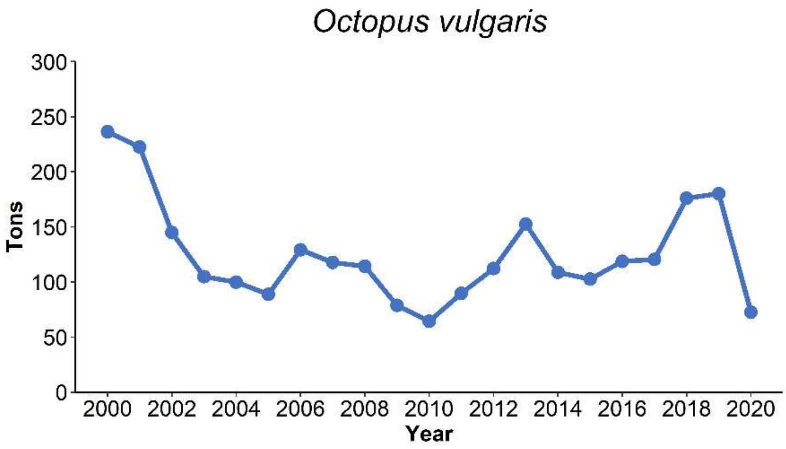


Figure 299. Time series of common octopus annual catch (tons) of trawling and artisanal fisheries fleet for the time period 2000-2020 in the north zone.

On the north zone it has not been done a biological sampling directed to this species.

Common octopus (Octopus vulgaris) center zone

Figure 300 shows the sampling localization of common octopus (*Octopus vulgaris*) biological sampling hauls performed in the Center zone from October 2019 to December 2020.

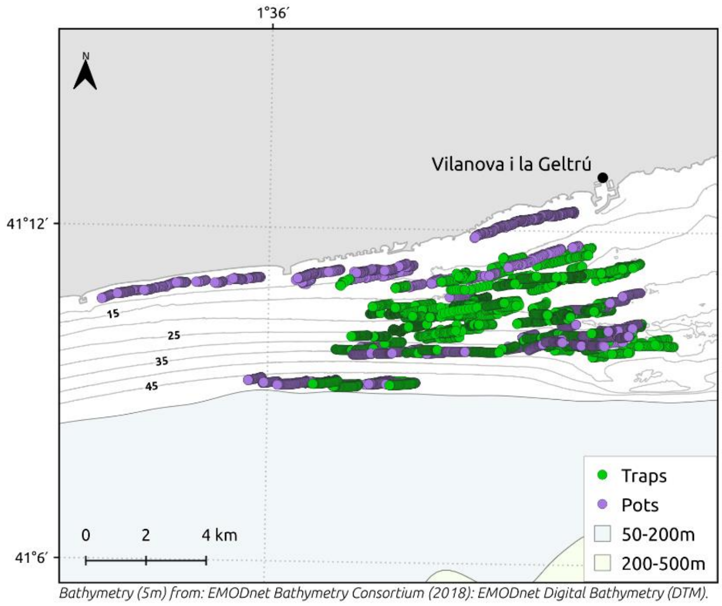


Figure 300. Map of location of biological sampling of *Octopus vulgaris* performed in the center zone from October 2019 to December 2020.

Annual catch history

Annual catch rates of common octopus during the period 2000-2020 in the center zone showed that catches were more abundant compared to the north zone. Maximum catches were recorded the first year of the study but from 2001 onwards, catches decreased (Figure 301), similar to the north zone and Catalonia, although these values remained more stable over the years.

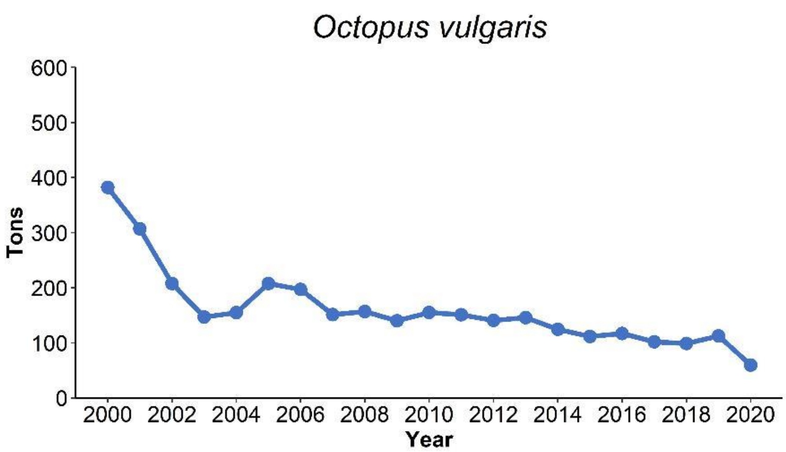


Figure 301. Time series of common octopus annual catch (tons) of trawling and artisanal fisheries fleet for the period 2000-2020 in the center zone.

Population structure

The seasonal weight-frequency distribution of common octopus in the center zone showed an important proportion of individuals below the length at first maturity in both years.

Figure 302), when a very similar number of individuals were measured each season for both years. The highest percentage of small individuals ocurred during autumn and the adult individuals were captured in spring, coinciding with the maturation period.

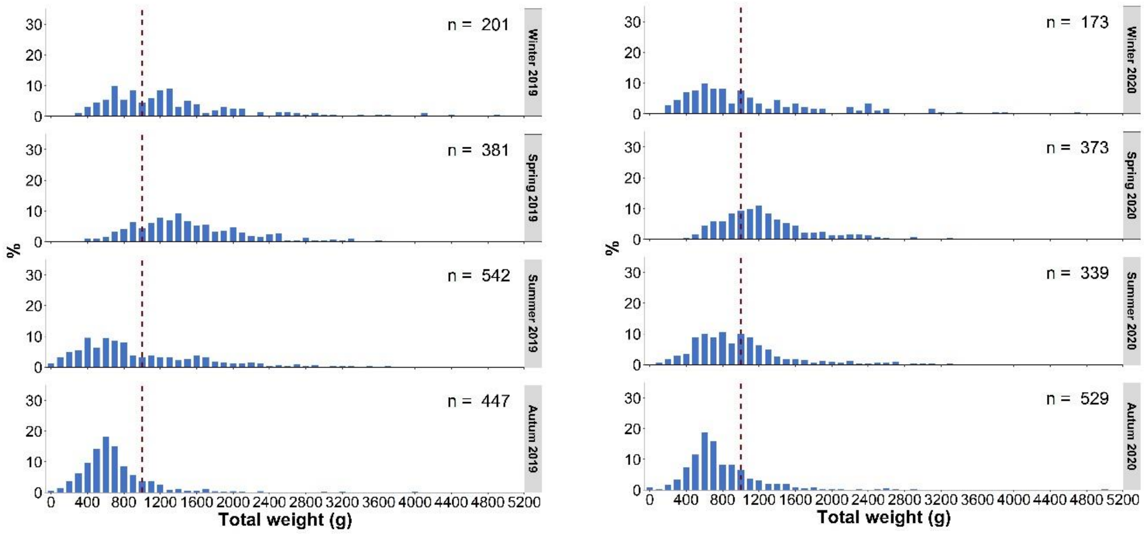


Figure 302. Seasonal weight-frequency distribution of common octopus (*O. vulgaris*) catches for artisanal fleet (pots and traps) in the center zone in 2019 and 2020. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 1 Kg.

Analyzing the catches for both years in the center zone, according to the type of fishing gear used, it was observed that the frequency of weights was similar using traps (Figure 303) or pots (Figure 304). However, in winter 2020, the individuals of common octopus caught with pots had a higher percentage of individuals with greater weight than using traps for the same season of the year.

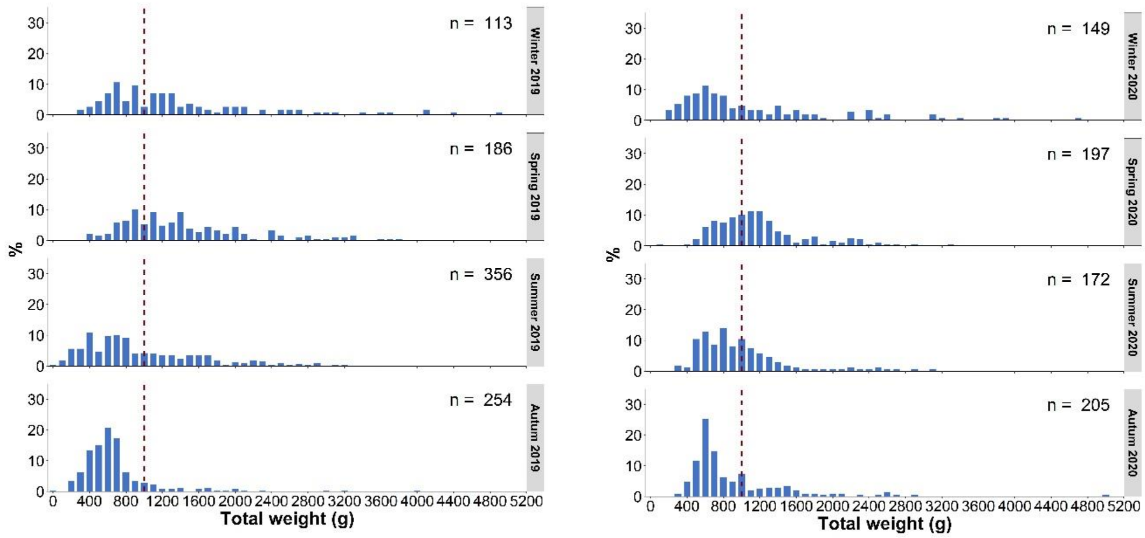


Figure 303. Seasonal weight-frequency in percentage of individuals of common octopus (O. vulgaris) catches for artisanal fleet (traps) in the center zone in 2019 and 2020. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 1 Kg.

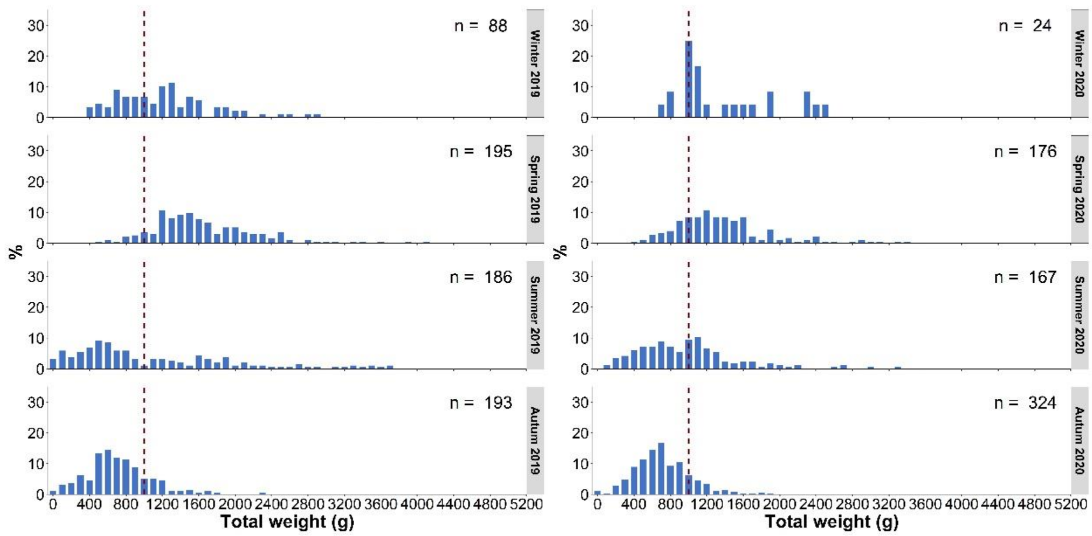


Figure 304. Seasonal weight-frequency in percentage of individuals of common octopus (O. vulgaris) catches for artisanal fleet (pots) in the center zone in 2019 and 2020. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 1 Kg.

Common octopus (Octopus vulgaris) south zone

Figure 305 shows the sampling localization of common octopus (*Octopus vulgaris*) biological sampling hauls performed in the south zone from October 2019 to December 2020.

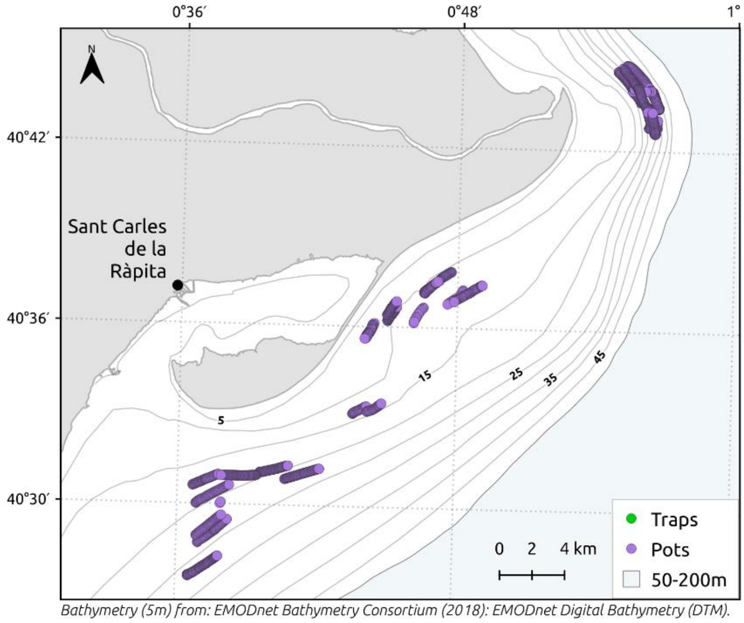


Figure 305. Map of location from biological sampling of *Octopus vulgaris* performed in the south zone from October 2019 to December 2020.

Annual catch history

Annual catch rates of common octopus during the period 2000-2020 in the south zone (Figure 306) showed a decreasing trend, similar to the rest of zones and Catalonia as a whole. Despite that in the south zone catches were more abundant, they remained stable with small fluctuations between 200 and 450 tons.

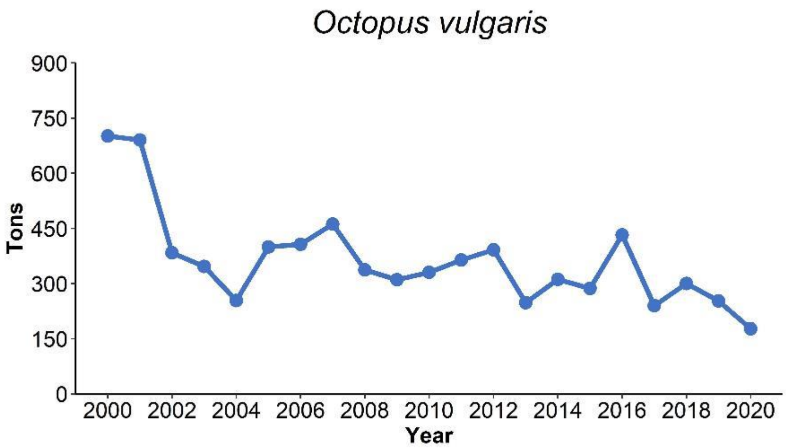


Figure 306. Time series of common octopus annual catch rates (tons) of trawling and artisanal fisheries fleet for the time period 2000-2020 in the south zone.

Population structure

The seasonal weight-frequency distribution of the common octopus was obtained in the samplings realized in 2020 using fishing pots. No data is provided for 2019 because the samplings started in summer of 2020. Figure 307 plots the only two seasons of data collection, when the common octopus catches showed a higher percentage of heavier individuals in summer, coinciding with maturity. In autumn, the percentage of catches was higher in individuals with lower weight, which were the recruits that did not yet reach the legal size (< 1 Kg).

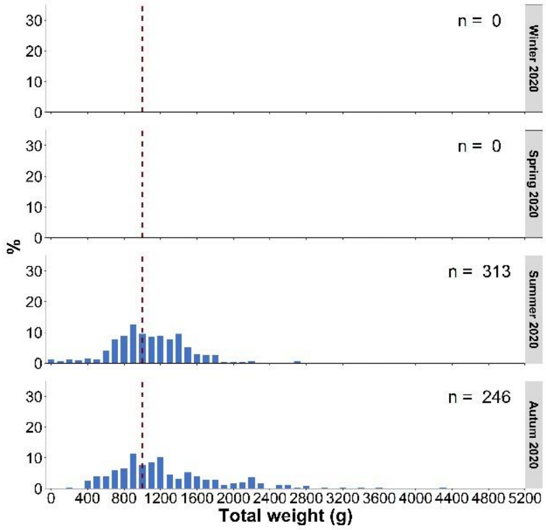


Figure 307. Seasonal weight-frequency in percentage of individuals of common octopus (O. vulgaris) catches for artisanal fleet (pots) in the south zone in 2019 and 2020. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 1 Kg.

2.4.3 Common octopus (*Octopus vulgaris*) fishery by port

2.4.3.1 Vilanova i la Geltrú

In Catalonia, a specific study was carried out on the common octopus artisanal fishery using pots and traps in the port of Vilanova i la Geltrú. The results are detailed below.

Annual catch history

Anual catch rates of common octopus during the period 2000-2020 in the port of Vilanova i la Geltrú for the trawling fleet and artisanal's fishery fleet indicated a decrease in catches (Figure 308). The maximum catches were obtained in the first year of data recording (> 250 tons). As of 2001, the catches decreased with values between 50 and 80 tons, obtaining the minimum catches in the last four years. The trend of catches in this port was very similar to Catalonia.

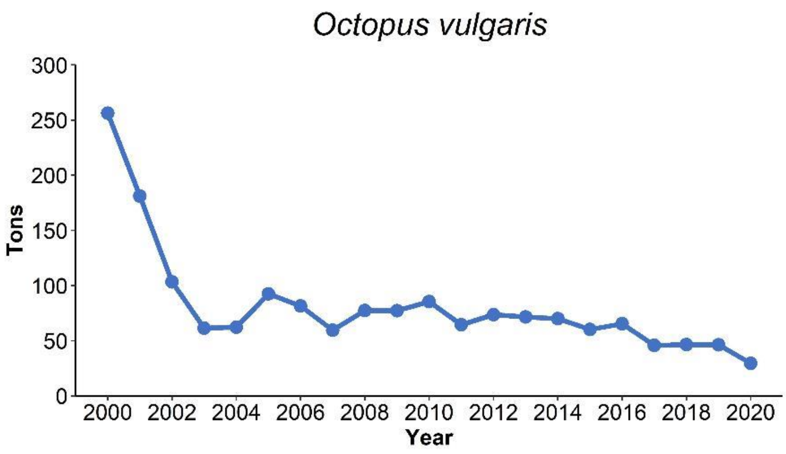


Figure 308.Time series of common octopus annual catch (tons) of trawling and artisanal fisheries fleet for the period 2000-2020 in Vilanova i la Geltrú.

Population structure

The specimens caught by the artisanal fleet (using pots and traps) in the port of Vilanova i la Geltrú obtained maximum weights at the end of spring and beginning of summer (Figure 309), from May to July, in 2019 and 2020. This fact coincided with the period of sexual maturity of this target species, which has an annual life cycle, exponential growth and a single post period located at the end of its life span. The new recruits, were observed at the end of summer, autumn and beginning of winter, where more individuals were below the legal fishing size (< 1 Kg).

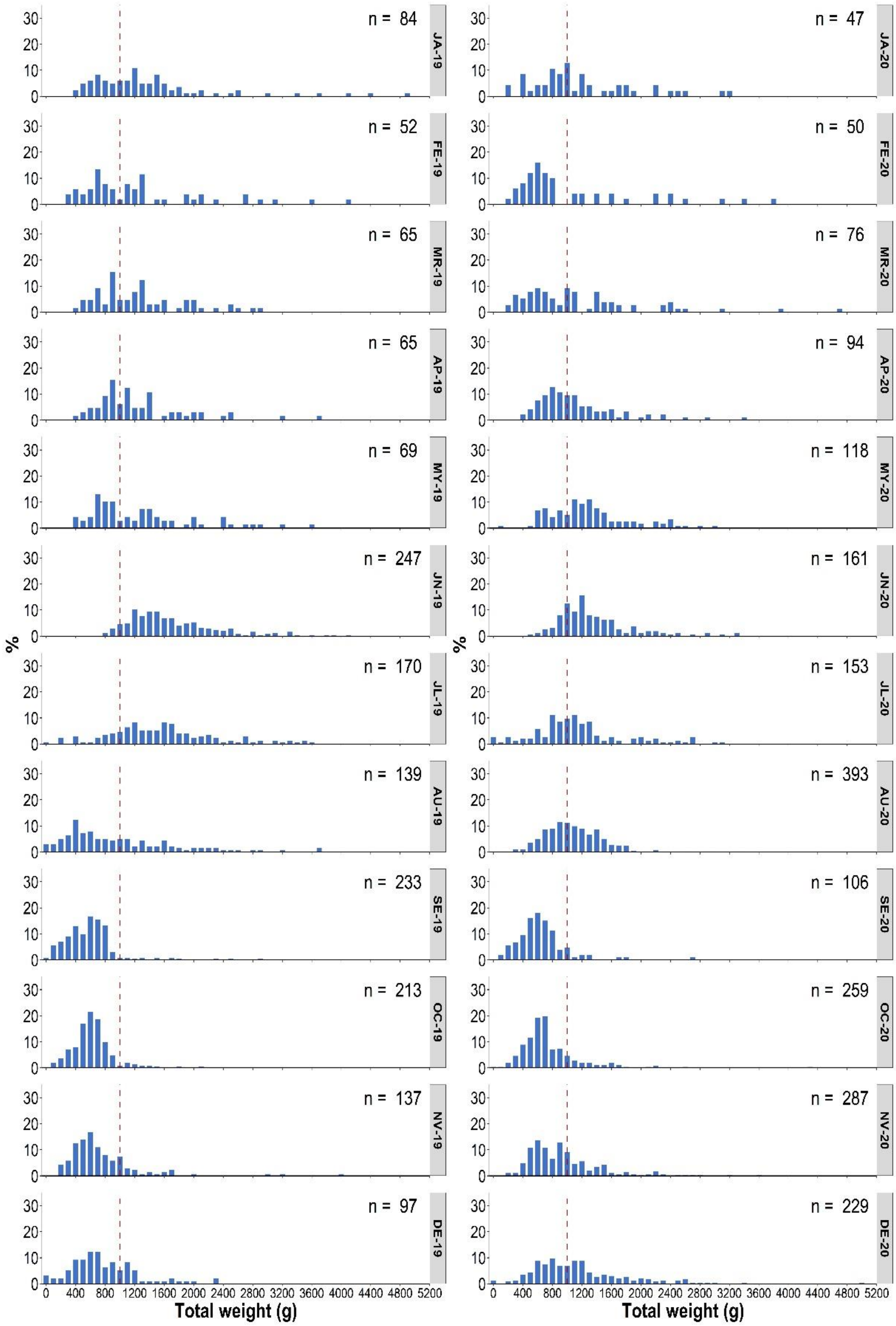


Figure 309. Seasonal weight-frequency in percentage of individuals of common octopus (*O. vulgaris*) catches for artisanal fleet (pots and traps) in the port of Vilanova i la Geltrú in 2019 and 2020. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 1 Kg.

From September to May, artisanal fishing using pots usually took place at shallow dephts (6-10 m). Later in the year, the pots were placed in deeper areas (35-40 m). The heavier individuals were caught at the end of spring and early summer (Figure 310. Seasonal weight-frequency in percentage of individuals of common octopus (*O. vulgaris*) catches for artisanal fleet (pots) in the port of Vilanova i la Geltrú in 2019 and 2020. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 1 Kg.). On the contrary, catches using traps remained between 10 and 40 m during all the seasons of the year (Figure 311). The samplings were done on board and all specimens with less than 1 Kg, below the legal size of catch, we were weighed immediately after the catch and returned alive to the sea.

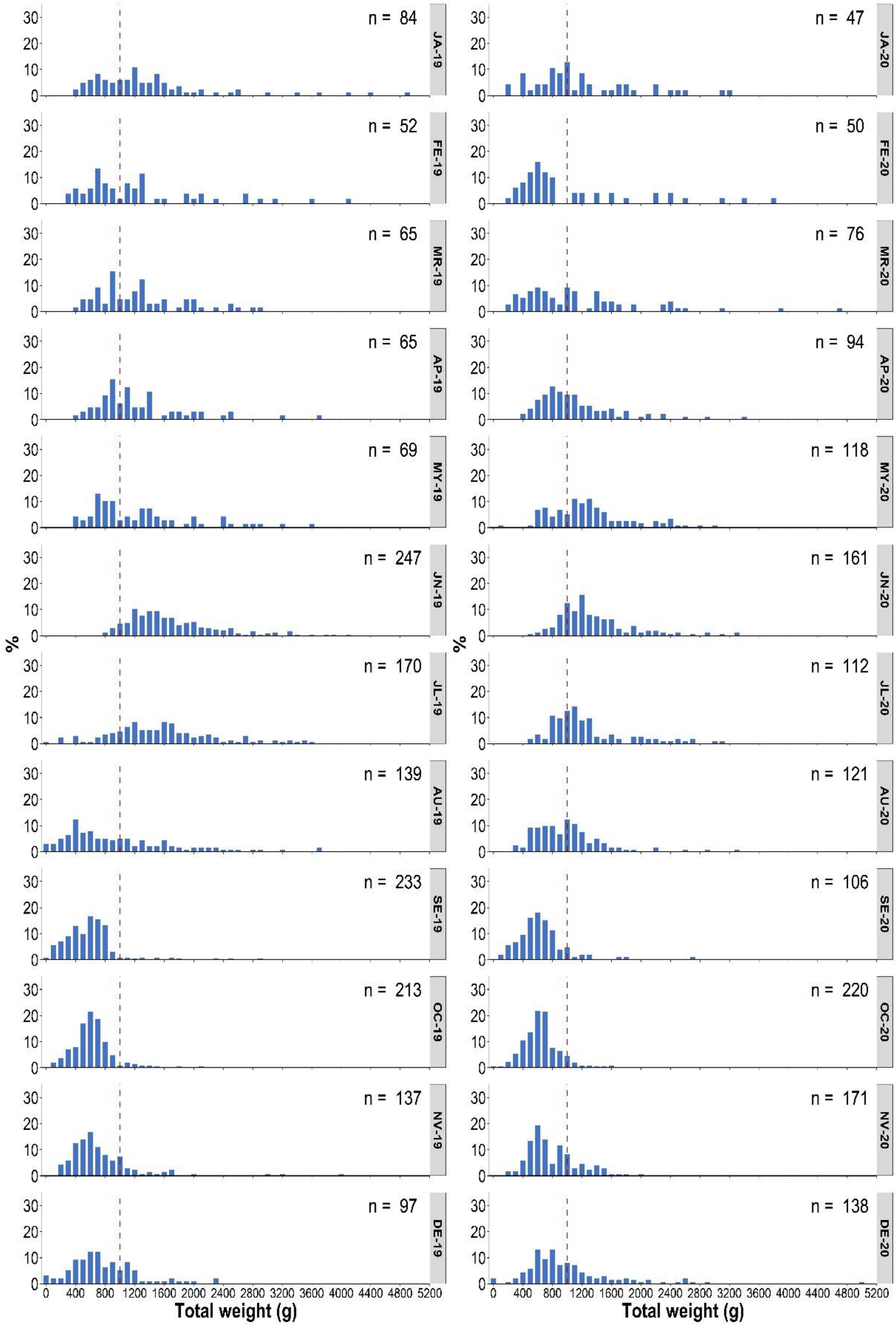


Figure 310. Seasonal weight-frequency in percentage of individuals of common octopus (*O. vulgaris*) catches for artisanal fleet (pots) in the port of Vilanova i la Geltrú in 2019 and 2020. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 1 Kg.

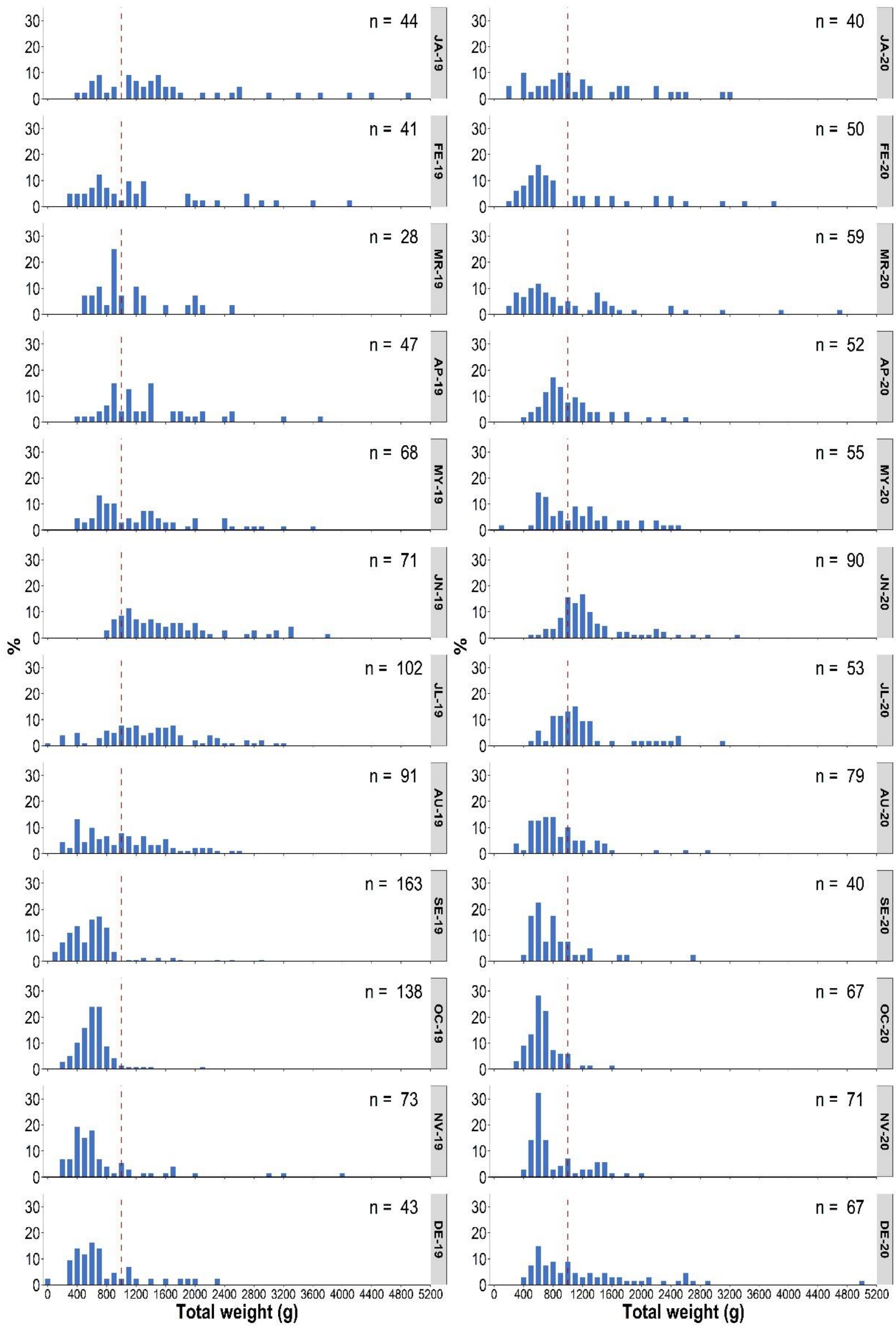


Figure 311. Seasonal weight-frequency in percentage of individuals of common octopus (*O. vulgaris*) catches for artisanal fleet (traps) in the port of Vilanova i la Geltrú in 2019 and 2020. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 1 Kg.

2.4.3.2 Deltebre

Population structure

In the port of Deltebre, data were only obtained for three months, corresponding to summer and autumn 2020 (Figure 312). The highest percentage of heavier individuals were capturated in October. In July, the period of sexual maturity, most individuals caught were immature finding very few specimens with high weight. It is necessary to obtain more data (at least for a whole year) to better study the population structure of the species.

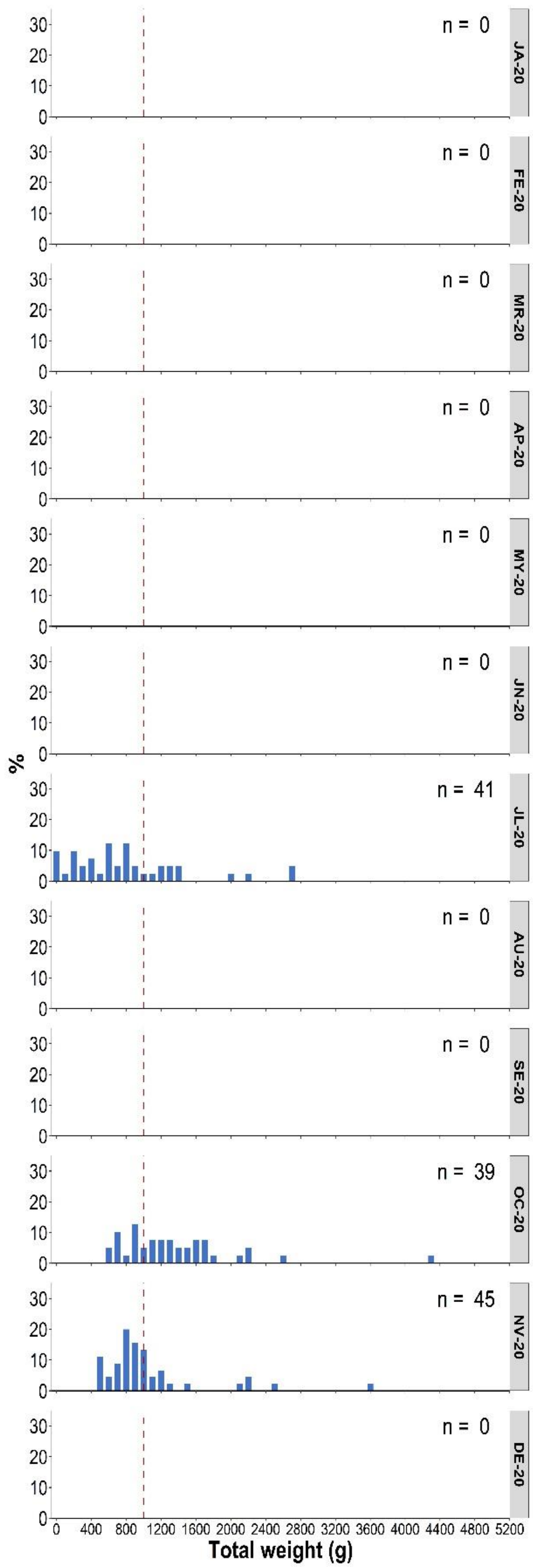


Figure 312. Seasonal weight-frequency in percentage of individuals of common octopus (*O. vulgaris*) catches for artisanal fleet (pots) in the port of Deltebre in 2020. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 1 Kg.

2.4.3.3 Sant Carles de la Ràpita

Population structure

In the port of Sant Carles de la Ràpita, data were only obtained for three months, corresponding to summer and autumn 2020 (Figure 313), similar to the port of Deltebre. The highest percentage of heavier individuals were capturated in August. In the other months, the highest percentage of individual catches were below the legal size. Compared to the port of Deltebre, more individuals were capturated and measured.

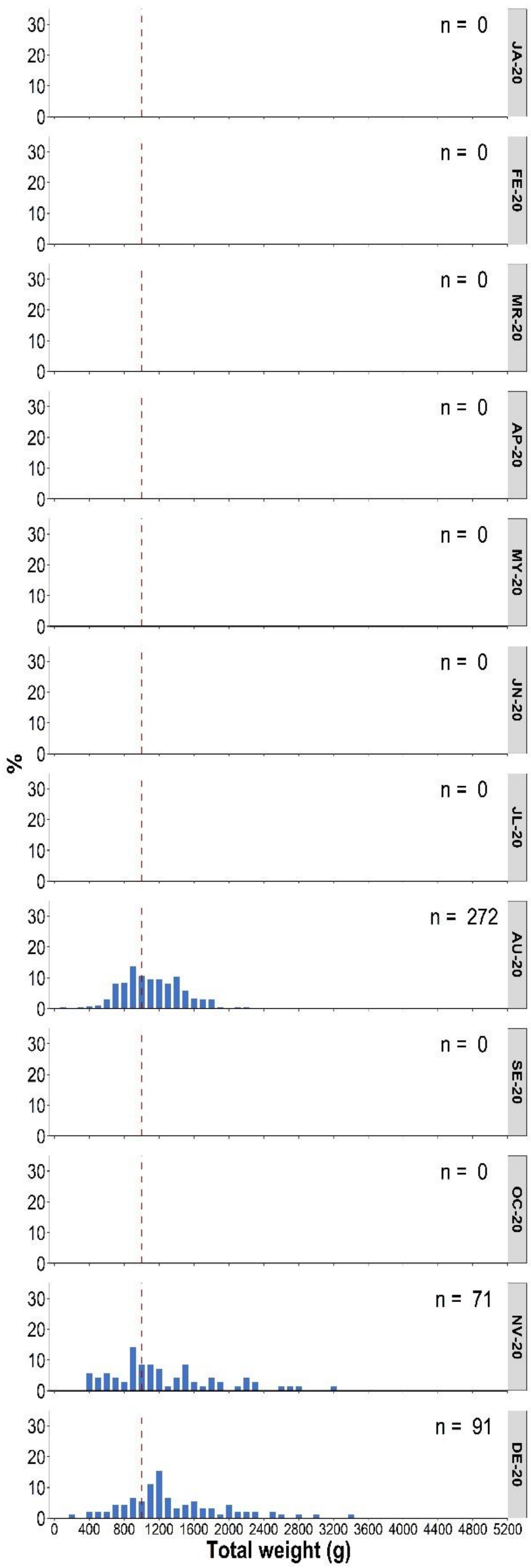


Figure 313. Seasonal weight-frequency in percentage of individuals of common octopus (*O. vulgaris*) catches for artisanal fleet (pots) in the port of Sant Carles de la Ràpita in 2020. The red dashed line indicates the minimum conservation reference size (MCRS), determined in 1 Kg.

2.4.3.4 Comparative summary by port

In the center zone, the sampling was carried out only in the port of Vilanova i la Geltrú, using different gears, pots and traps, since 2019. Sampling in the south zone was carried out in the ports of Deltebre and Sant Carles de la Ràpita using only pots for fishing from summer of 2020 onwards. The data collected has been previously discussed in the section "population structure". Data obtained in the south zone are still scarce to draw conclusions and cannot be compared with the data recorded in the center zone. With the continuity of samplings, the pertinent conclusions should be detailed in the future.

3. FISHERIES ASSESSM ENT

3.1 INTRODUCTION

A stock assessment is the process of collecting, analyzing, and reporting demographic information to determine changes in the abundance of fish stocks in response to fishing and, to the extent possible, predict future trends of stock abundance. Managers use stock assessments as a basis to evaluate and specify the present and potential future condition of a fishery (NOAA Fisheries). Catch, abundance and biology data are key data to perform a stock assessment. Depending on the data available for a given stock, a different type of model can be used for the assessment. Therefore, the more data available, the more complex model can be used. With available data from Catalan fisheries, only data-poor models can be utilized. Despite official landings data for the last twenty years are available, there are only a few years of fishery-independent data collection for the main stocks in this region.

Stock assessment is important to understand the Catalan fisheries and their stocks. Therefore, to achieve this knowledge, training was carried out in stock assessment methods, becoming part of official organizations such as the Scientific, Technical and Economic Committee for Fisheries (STECF), and the General Fisheries Commission for the Mediterranean (GFCM), and following their recommendations.

Fisheries in the northwestern Mediterranean are typically multi-gear and multi-species, finding both target and non-target species. For this, total allowable catches (TACs), also known as fishing opportunities, are not adequate. Within the current framework, a métier or fishing tactics study was done. A métier is a group of fishing operations targeting a similar (assemblage of) species, using similar gear, during the same period of year and/or within the same area, characterized by a similar exploitation pattern (ICES, 2003). After different analyses and case studies, a protocol to identify métiers and their temporal and geographical evolution was developed and is presented in this report.

Multivariate technics were applied on around 20 million daily trips reported by the Catalan Government since 2000 for 10 fishing ports along the Catalan coast, presenting in this document Vilanova i la Geltrú case study. Considering temporal persistence and spatial differentiation, both the impact of each métier on target species and different extension of métier area along the Catalan sea are needed information for good management practices.

3.2 SPATIAL AND TEMPORAL DEFINITION OF MÉTIERS FROM (RAW) FLEETS

3.2.1 Method comparison

The first analyses performed for this study were presented in the previous document of the project (ICATMAR, 2019). The old method used and presented was performed with PRIMER® 6^+ and Microsoft Excel but was not the best choice for this study. After different sensitive analyses, the conclusions were:

- PRIMER® 6^+ and Microsoft Excel softwares were not open access.
- Microsoft Excel was always needed during the process.
- PRIMER® 6^+ was slow and even had insufficient software capacity and timeliness.
- PRIMER® 6^+ had no Euclidean distance option.
- PRIMER® 6^+ had no K-medoids clustering (Kaufman & Rousseeuw, 1990), a method used to divided and compare groups by *k* between years or ports.

To improve the method used in 2019, a new protocol was designed in terms of simplicity and efficiency for any user interested in defining fishing métiers. In addition, the methodology used was in line with similar studies that identified métiers or fishing tactics (Pelletier & Ferraris, 2000 and Maynou et al., 2011). The advantages of this protocol were:

- R and R-Studio software were open access (R Core Team 2020).
- Microsoft Excel was not required.
- Euclidean distance was available.
- Partitioning around medoids was available.
- Improve in speed and efficiency due to big data.

3.2.2 Final protocol

Based on previous analyses and different case studies, a protocol was developed to define métiers and identify their temporal and spatial variations to determine changes in the fishery (from métiers) depending on the contribution of each of the species (Figure 314).

The first steps to create the protocol were to adapt the original database by adding the equivalences obtained with a list of reference species, simplified the nomenclature of several factors, and added a column that corresponded to the "trip" (fishing activity by vessel and day).

Once the raw data was modified, the next step was to choose a case study. A matrix was constructed with the species that contributed more than 95% in weight as columns and their corresponding trips as rows. This matrix was standardized and transformed to perform the cluster analysis to obtain the distance matrix to create the dendrogram. These steps were repeated as many times as necessary for the specific analysis.

With the dendrograms obtained, the number of groups (*k* value) in which to cut the tree was decided qualitatively. From these groups, the taxa contribution and composition of each métier were obtained. Sensitive analysis were necessary to decide a *k* value. Métiers' names were assigned taking into account all case studies (e.g., time series).

The next step was to perform a multivariate approach based on a generalized linear model (GLM). The data set was a matrix with rows denoting métier and columns denoting taxa. The content of the matrix was landings in kg. Variance, boxplots, standardization, transformation, and residuals were explored before statistical analysis. To continue developing the protocol, the differences between métiers had to be statistically significant (p-value < 0.005).

Original Database was completed with the métier factor to analyze the temporal evolution and geographical variation of the métiers, identifying different periods or regions respectively. For that, two case studies were developed, case study I Vilanova i la Geltrú bottom trawl (Bottom Otter Trawl, OTB) fleet, and case study II Vilanova i la Geltrú small-scale and bottom longline fisheries.

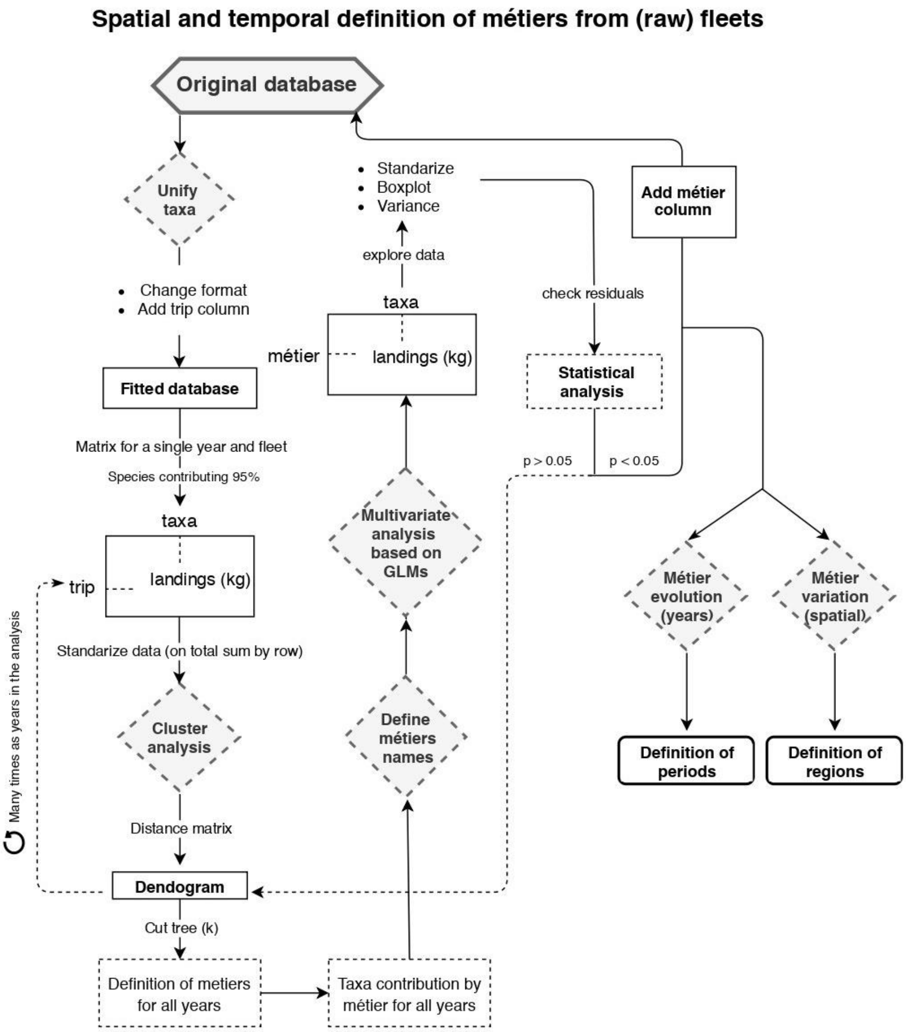


Figure 314. Flow chart with the spatial and temporal definition of métiers from (raw) fleets.

3.2.3 Unified list of taxa

To compare the results obtained over time and space and ensuring that differences between métiers were not caused by how taxa were named among ports or between years, the first step was to create a unified list of taxa (Figure 315). The steps to follow to create the list were:

1. List all taxa that appeared at least once in the Catalan Government database from 2000 to 2020 (N taxa= 295).
2. To verify the name for each taxon, the official documents of the Food and Agriculture Organization of the United Nations (FAO), the Boletín Oficial del Estado (BOE), and the Diari Oficial de la Generalitat de Catalunya (DOGC) were taken into account.
3. Experts from different taxonomic groups were asked to verify the list.
4. Taxa representing less than 1% of the landings were deleted.

The new list (Annex X) reduced the number of taxa by about 60% of the initial list (Table 54).

Grup	Nom del conjunt de taxa	Codi FAO	Taxon	Comentaris	Expert
Peixos	*Mugilidae* spp.	MGC	*Liza ramada*	Possible confusió/mala identificació.	A. Lombarte
Peixos	*Mugilidae* spp.	MLR	*Chelon labrosus*	Solament registrat el 2018 i 2019.	A. Lombarte
Peixos	*Mugilidae* spp.	MUF	*Mugil cephalus*	Possible confusió/mala identificació.	A. Lombarte
Peixos	*Mugilidae* spp.	MUL	Mugilidae	Possible confusió/mala identificació. Representa el 42% de la captura dintre del Subgrup Mugilidae spp. Durant el període 2000-2017.	A. Lombarte
Peixos	*Trachurus* spp.	HMM	*Trachurus mediterraneus*	Possible confusió/mala identificació.	A. Lombarte
Peixos	*Trachurus* spp.	HMY	*Caranx rhonchus*	Sorella. Possible confusió/mala identificació. Apareix l'any 2008.	A. Lombarte
Peixos	*Trachurus* spp.	HOM	*Trachurus trachurus*	Possible confusió/mala identificació. Representa el 50% de les captures del Subgrup *Trachurus* spp.	A. Lombarte
Peixos	*Trachurus* spp.	JAA	*Trachurus picturatus*	Possible confusió/mala identificació. Surt més a la zona centre.	A. Lombarte
Peixos	*Trachurus* spp.	JAX	*Trachurus* spp.	Possible confusió/mala identificació. Apareix l'any 2008.	A. Lombarte
Peixos	*Spicara* spp.	BPI	*Spicara maena*	Possible confusió/mala identificació. Apareix l'any 2018.	A. Lombarte
Peixos	*Spicara* spp.	PIC	*Spicara* spp.	Possible confusió/mala identificació. Desapareix el 2017.	A. Lombarte
Peixos	*Spicara* spp.	SPC	*Spicara smaris*	Possible confusió/mala identificació. Representa el 94 % de les captures durant el període 2000-20018	A. Lombarte
Peixos	*Symphodus* spp.	YFX	*Symphodus* spp.	Possible confusió/mala identificació. Codi nou per "Labridae". Apareix 2018	A. Lombarte
Peixos	*Symphodus* spp.	WRA	Labridae	Possible confusió/mala identificació. Codi antic per YFX. Desapareix 2017	A. Lombarte
Peixos	*Symphodus* spp.	WRX	*Labrus* spp.	Possible confusió/mala identificació. Apareix 2018	A. Lombarte
Peixos	*Mullus* spp.	MUR	*Mullus surmuletus*	Possible confusió/mala identificació	A. Lombarte
Peixos	*Mullus* spp.	MUT	*Mullus barbatus*	Possible confusió/mala identificació	A. Lombarte
Peixos	*Mullus* spp.	MUX	*Mullus* spp.	Possible confusió/mala identificació. Representa el 13% de les captures dintre del Subgrup *Mullus* spp.	A. Lombarte
Peixos	*Umbrina* spp.	COB	*Umbrina cirrosa*	O bé *U. canariensi*. Possible confusió/mala identificació. Subgrup representat la majoria a la zona sud.	A. Lombarte
Peixos	*Umbrina* spp.	UMO	*Umbrina ronchus*	Possible confusió/mala identificació. Més abundant. Subgrup representat la majoria a la zona sud i U. ronchus La Ràpita i meitat Arts Menors	A. Lombarte
Peixos	*Serranus* spp.	BAS	*Serranus* spp.	Possible confusió/mala identificació. Codi antic per [illegible]	[illegible]
Peixos	*Serranus* spp.	CBR	*Serranus cabrilla*	Possible confusió/mala identif[illegible] les captures [illegible]	
Peixos	*Serranus* spp.	SRJ	*Serranus hepatus*	Pos[illegible]	
Peixos	*Serranus* spp.	SRK	*Serranus scriba*		

Figure 315. Taxa unified list preview.

Table 54. Number of taxa by taxonomic' group at the begging and the end.

	Initial list	Final list
Cartilaginous	27	4
Cephalopods	18	12
Various mollusk	36	27
Invertebrates	8	7
Crustacea	35	27
Fishes	170	109
NA	1	1
Total	295	187

3.2.4 Case study I: Vilanova i la Geltrú bottom trawl (OTB) fleet

The fishing port and fleet selected for this case study was the bottom trawl fleet of Vilanova i la Geltrú, because it has a good representation of the Catalan fishing sector.

Following the protocol steps, cluster analyses were performed with their matrix per year, during the period 2002-2020, with Euclidean distance and WardD2 (Ward, 1963) linkage method to obtain dendrograms per year (Figure 316). Taken into account all the dendrograms, *k* was defined to obtain the number of different groups, which were temporally compared, a posteriori, to define their métier per group. In this case, after different sensitive analyses, *k* was defined as 4, and cluster plots were obtained for all years (Figure 317). These cluster plots, as in the case of the dendrograms, showed the same trend over the years, with four different groups.

The next step of the protocol was to know the taxa composition for these four groups within each year. The taxa composition helps to define future métiers. The different taxa composition can be found in Annex XI and Annex XII.

In the case of fishing bottom trawlers, métiers were grouped by bathymetric range, OTB1 being the shallowest followed by OTB2 and OTB3, and finally, OTB4 being the deepest.

Statistical Methods for Analysing Multivariate Abundance Data were used to confirm if there were significant differences between groups using the *mvabund* package, a set of tools for displaying, modelling, and analyzing multivariate abundance data in community ecology (Wang *et al*., 2012).

Figure 318 shows the transformed abundance values for all previously defined métiers. As shown, a great abundance of *A. antennatus* was found in OTB4, the deepest métier, where this taxon was the most abundant for this fishery. Another example was *N. norvegicus*, a typically OTB3 bathymetry taxon.

After verifying that the residues were okay (Figure 319), a statistical test, i.e. two-way ANOVA, was performed analysing métiers, years, and their interaction (métiers x years) (Table 55). The results showed that there were significant differences ($p < 0.001$) among métiers and among years, but there were no significant differences ($p > 0.05$) within the interaction of the two variables, showing a métier consistency during the time series. To further the differences found among métiers, a pairwise analysis was performed between pairs of métiers (Table 56), which also yielded significant differences. Following the established protocol, if there were differences, the métiers were validated.

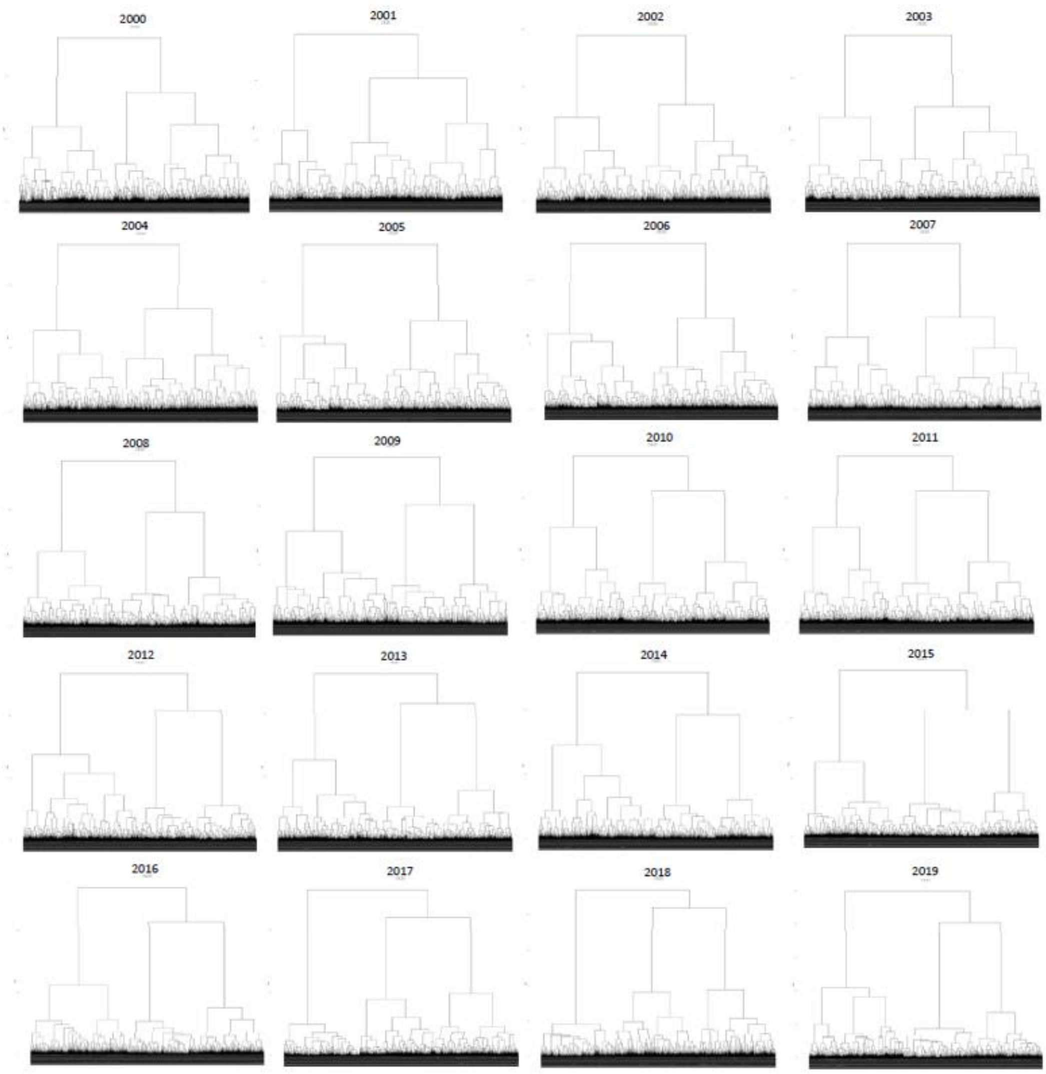


Figure 316. Dendrograms corresponding to previous cluster analysis (Euclidean and Ward.D2 for distances) for the time series 2000-2019, in the port of Vilanova i la Geltrú.

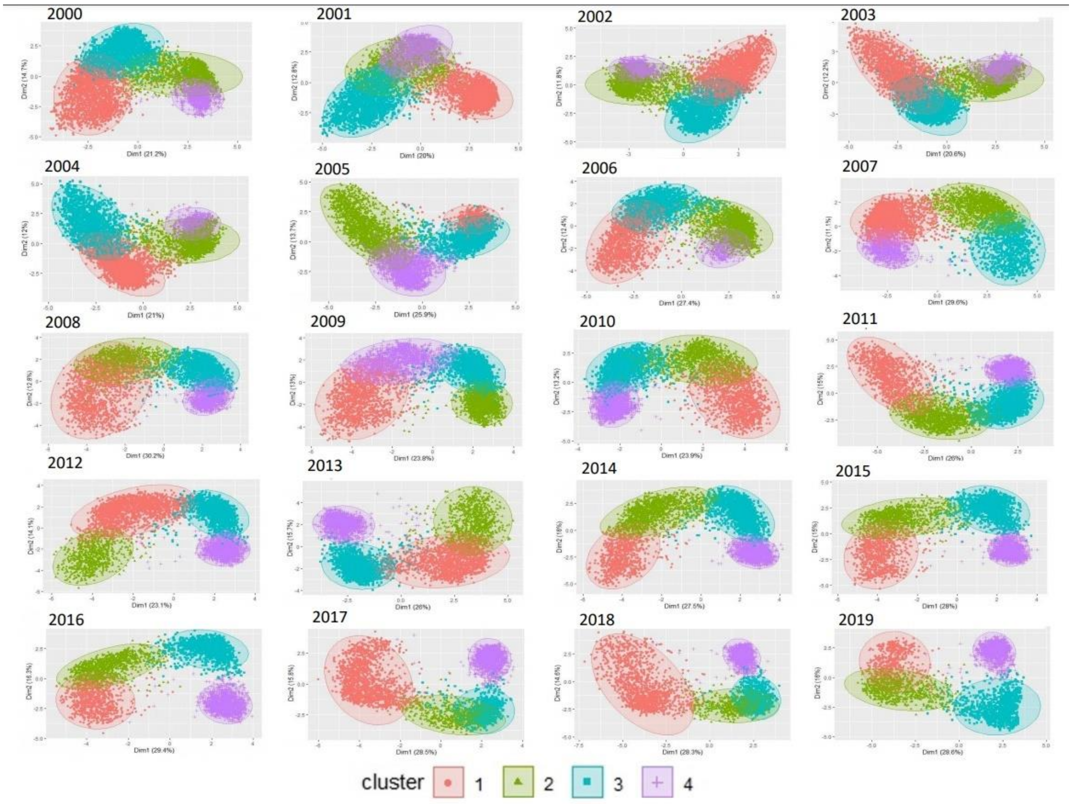


Figure 317. Cluster plots obtained from k = 4, for the time series 2000-2019, at the port of Vilanova i la Geltrú with the bottom trawling fleet.

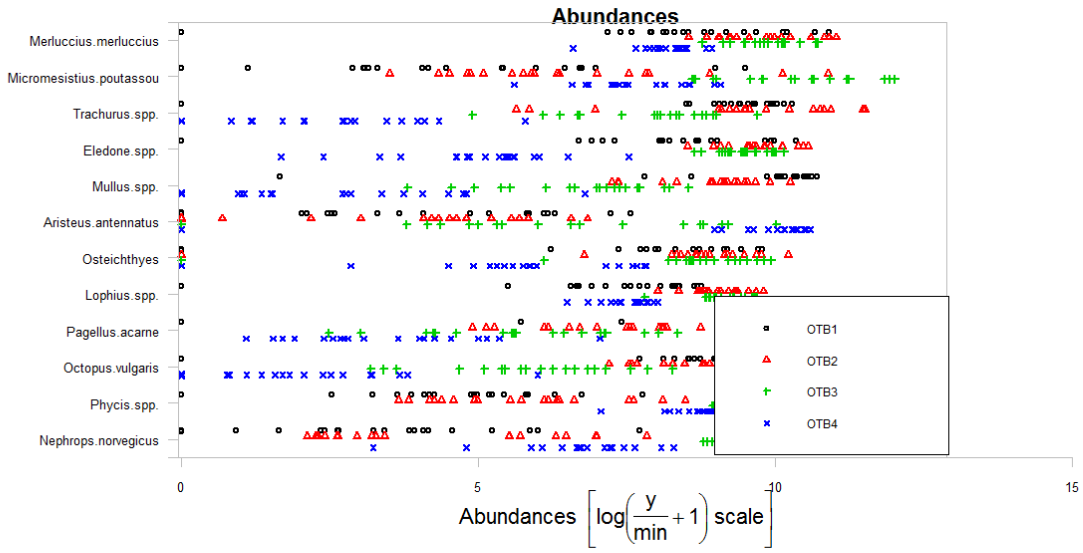


Figure 318. Standardized distribution of the abundance (transformation of log(x+1)) of the main taxa for bottom trawling métiers of Vilanova i la Geltrú.

Table 55. Statistical analysis results for bottom trawling métiers. Residuals, degrees of freedom, standard Deviation, and p-value are presented.

Multivariate test ANOVA	Res.Df	Df.diff	Dev	p-value
Métier-Métier	73	3	1849.0	0.001
Year-Year	72	1	309.3	0.001
Métier-Year	69	3	200.4	0.064

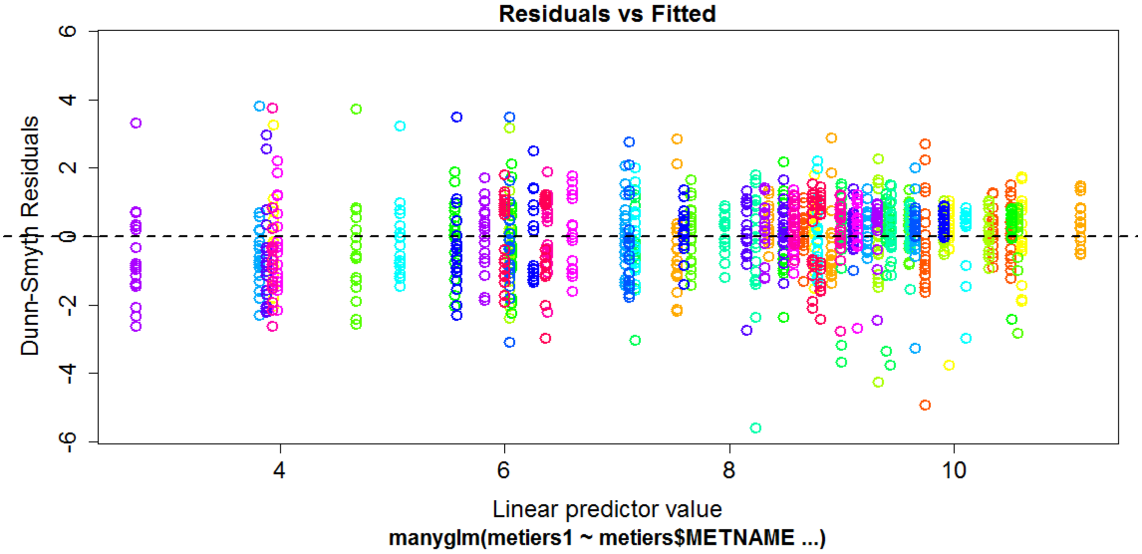


Figure 319. Residuals distribution and adjusted data using a negative binomial model for bottom trawler métiers.

Table 56. Statistical p-value results for a pairwise analysis between bottom trawler métiers. Asterisks denote significant differences.

Métiers	p-value
OTB1 vs OTB4	0.005**
OTB1 vs OTB3	0.005**
OTB2 vs OTB4	0.005**
OTB3 vs OTB4	0.005**
OTB2 vs OTB3	0.005**
OTB1 vs OTB2	0.005**

Once the métier factor was created, time trends were plotted for each métier (Figure 320,

Figure 321, Figure 322, Figure 323). To identify periods, graphs obtained with Principal Components Analisis (PCA) per year were presented where the Y-axis represents the highest percentage value of the dimensions and X-axis colors represents changes in secundary axis values for each year. The zero value of the Y-axis was taken into account as a reference for a new period. Each point represents the species' compositions as a function of the number of landings for that particular year. A point can change position in two different ways by either following the ordinate (main) or the abscissa (secondary) axis. Vertical movements are translated as changes in the composition of the main species, while horizontal movements are attributed to specific alterations.

OTB1, named “Coastal shelf”, had two periods being the first one from 2002 to 2003, and the second one from 2007 to 2020. Years from 2004 to 2006 were transitional. OTB2, named “Deeper shelf”, had two periods. The first from 2002 to 2008 and the second one from 2009 to 2020. OTB3, named “Upper slope” was divided into three different periods: 2002-2004, 2005-2010 and 2013-2020. The years 2011 to 2012 were transitional. OTB4, named “Lower slope”, was divided in two different periods: 2002-2007 and 2008-2020.

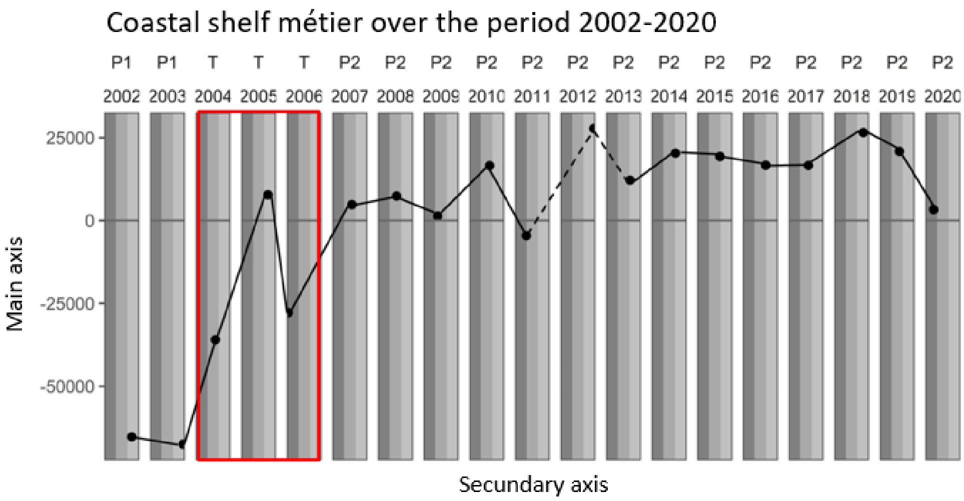


Figure 320. Variation of the composition by species of the Coastal shelf métier of Vilanova i la Geltrú for the time series 2002-2020. Vertical movements determine period changes (red line) whereas horizontal movements determine the anomalous years within the same period (dashed line).

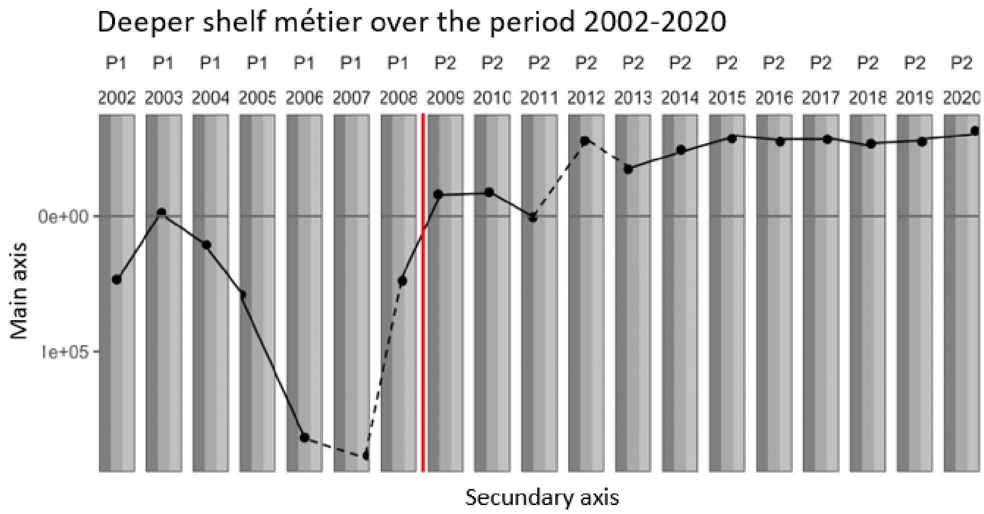


Figure 321. Variation of the composition by species of the Deeper shelf métier of Vilanova i la Geltrú for the time series 2002-2020. Vertical movements determine period changes (red line) whereas horizontal movements determine the anomalous years within the same period (dashed line).

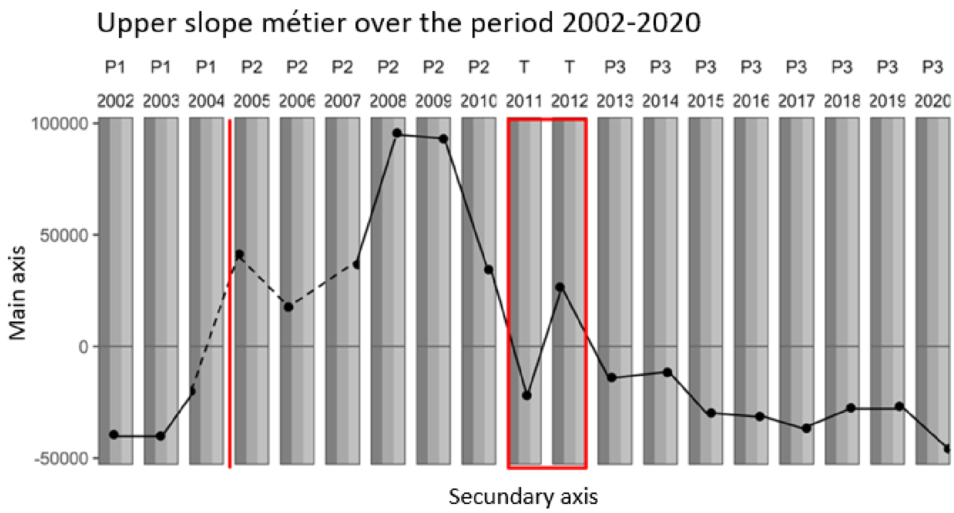


Figure 322. Variation of the composition by species of the Upper slope métier of Vilanova i la Geltrú for the time series 2002-2020. Vertical movements determine period changes (red line) whereas horizontal movements determine anomalous years within the same period (dashed line).

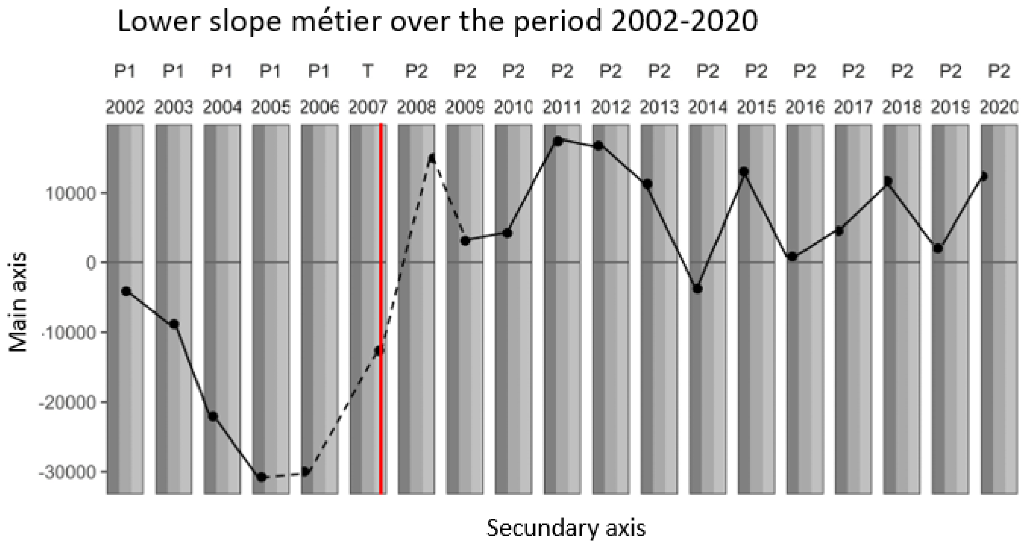


Figure 323. Variation of the composition by species of the Lower slope métier of Vilanova i la Geltrú for the time series 2002-2020. Vertical movements determine period changes (red line) whereas horizontal movements determine anomalous years within the same period (dashed line).

Finally, the temporal evolution of each of the métiers was described based on the composition of the species, the composition of the fleet (capacity of the vessels), the landings, and landings per unit of effort.

Relating to the species composition (Figure 324), *Mullus* spp. was the taxum with most abundance for the Coastal shelf métier, but with different contribution according to each period. This was a trend repeated in the other métiers, which maintained the same main species but their abundance differed. The Deeper shelf métier was characterized by *Eledone* spp. and *Trachurus* spp, but with opposed tendencies, when one species increased, the other diminished. At the beginning of the time series, *M. poutassou* and *M. merluccius* contributed to about 50% of the landings for the Upper slope metier; in the middle of the time series, *N. norvegicus* increased its contribution. The Lower slope métier was characterized by *A. antennatus*, with more than 50% of the contribution. This might be explained because this métier had a major fishing selectivity increasing the *A. antennatus* contribution. In addition, hake was present in all métiers, mackerel in Shelf métiers, and horned octopus was a typical species found in

Deeper shelf and Upper slope métiers. The species *M. poutassou* and *P. blennoides* were typical in Slope métiers. Except for the Deeper shelf métier, all métiers presented two different periods and some transitional years.

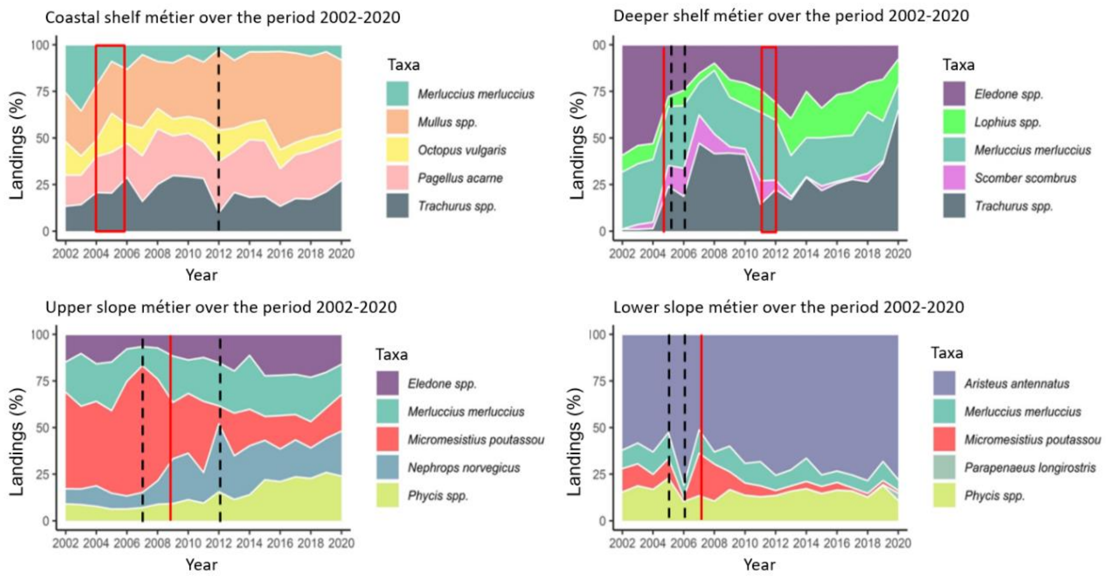


Figure 324. Composition of the most important species in terms of percentage of landings from each of the four métiers in the port of Vilanova i la Geltrú for the time series (2002-2020). The red lines represent the period change and the dashed black lines represent anomalous years within the same period, for the OTB fleet.

As for fleet composition (Figure 325), in the first métier (Coastal shelf), despite being a fishing ground nearby the coast, vessels with large capacity (18-24 m) were used, especially since 2012. During the first years of fishing on the Deeper shelf, vessels of 6-12 m were the ones that carried out the largest number of tasks. Afterwards, the 12-18 m vessels became more important. On the Upper slope, larger boats measuring 18-24 m were used. However, in the recent years there has been a transition towards smaller boats (12-18 m). In the fourth metier (Lower slope), the vessels with the greatest capacity (24-40 m) carried out a large number of tasks, as well as those vessels measuring 18-24 m in length.

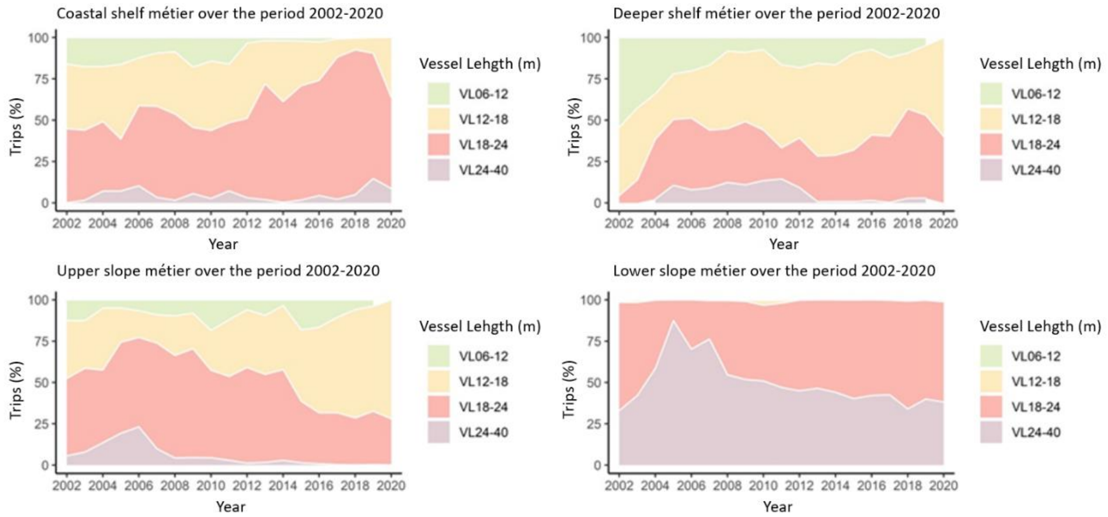


Figure 325. Vessel length (in meters) composition by métier for time series (2002-2020) for the OTB fleet in Vilanova i la Geltrú.

Concerning the number of vessels

Figure 326) it was detected that in the first three métiers (Coastal shelf, Deeper shelf and Upper slope) the trend was quite similar, starting with 30 vessels and decreasing up to 15, except for the first one, which increased in the last two years. In the Lower slope, a smaller number of vessels were present.

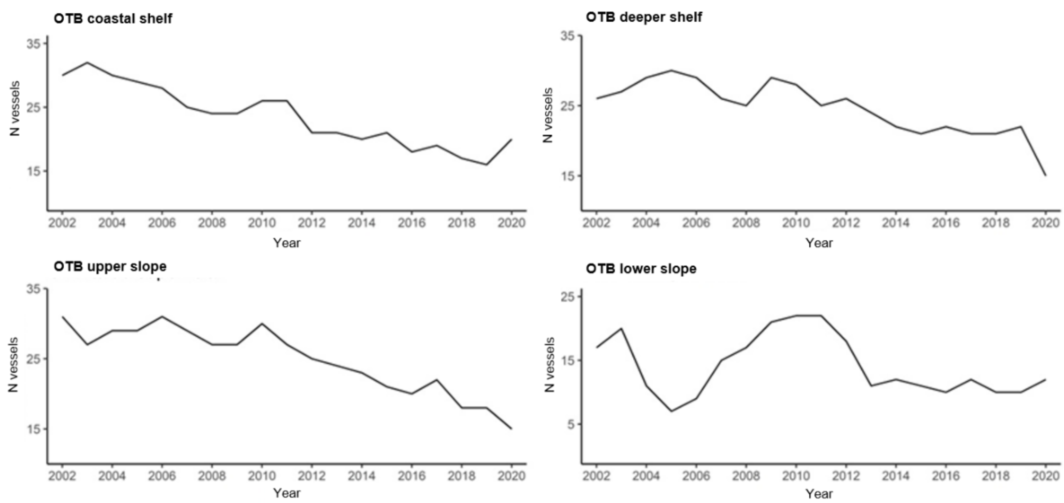


Figure 326. Number of vessels for the time series (2002-2020) by métier for the OTB fleet in Vilanova i la Geltrú.

Total landings declined over the years on the Coastal shelf, Deeper shelf and Upper slope métiers (

Figure 327). However, in the Lower slope, the trend was the opposite. On the coastal shelf, since 2008 landings varied about 200 t but in the last two years an increase was observed. In the second metier, total landings progressively increased to 500 t in 2009 and then declined. In the first years of the Upper slope, landings reached 450 t, then they decreased. In 2006 of the last metier, landings started to increase to 120 t.

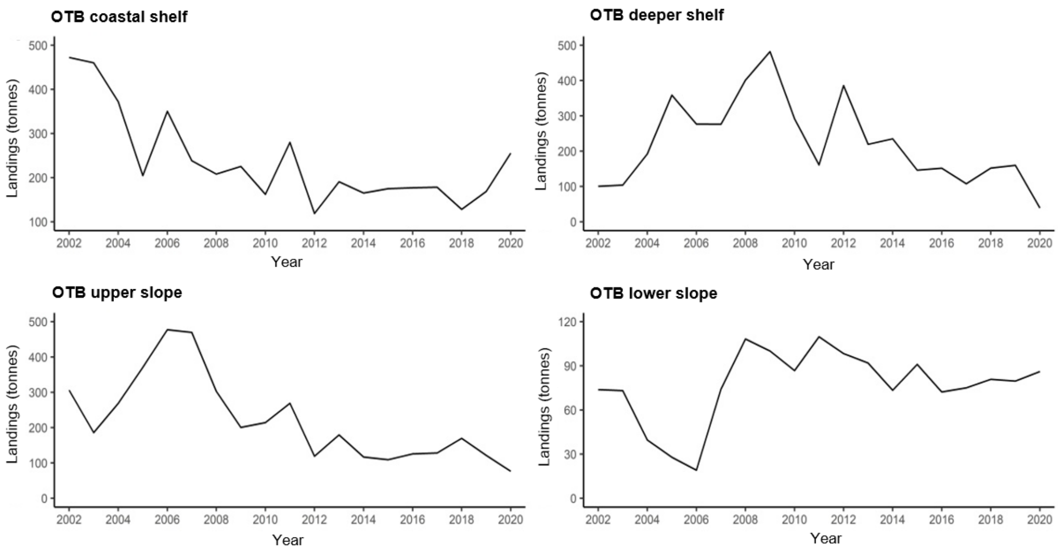


Figure 327. Landings (tons) evolution for the time series (2002-2020) by métier for the OTB fleet in Vilanova i la Geltrú.

Landings per unit of effort (LPUE), used as an index of relative abundance, followed the same trend as the previous graphs, except for the Upper slope (

Figure 328). Furthermore, the uncertainty (green shadow) was greater in the second and third metiers. The Lower slope was the one that received the most pressure from fishermen, especially since 2012.

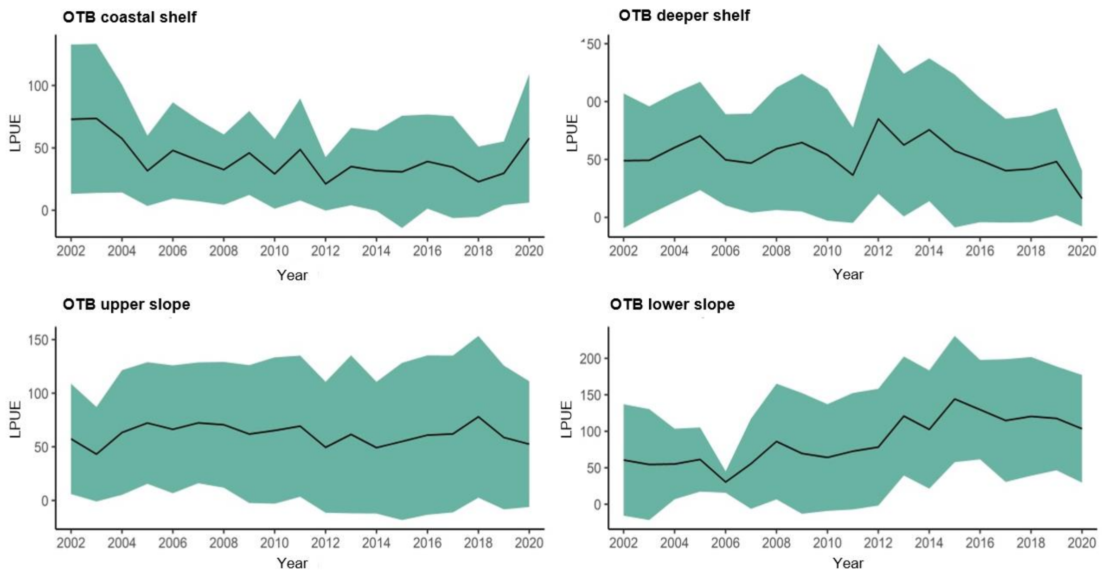


Figure 328. LPUE (Fishing day/vessel) with sd, for the time series (2002-2020) by métier for the OTB fleet in Vilanova i la Geltrú.

Finally, to explore the profitability of each métier, a euro per kg (€/kg) trawled was calculated (Figure 329) throughout the time series. It should be noted that the Coastal shelf métier was the least profitable in terms of euros per kg, and the Lower slope métier was the most profitable one, because of the high price of *A. antennatus* per kg. The trends were variable according to each metier. As a summary, the Coastal shelf métier tended to decrease, the Deeper shelf and the Upper slope métiers to increase, and the Lower slope métier was the most stable of them all. The uncertainty (gray shadow in Figure 329) was greater in the Lower slope metier, also due to *A. antennatus* high price versus other species like *P. blennoides*, that had lower prices.

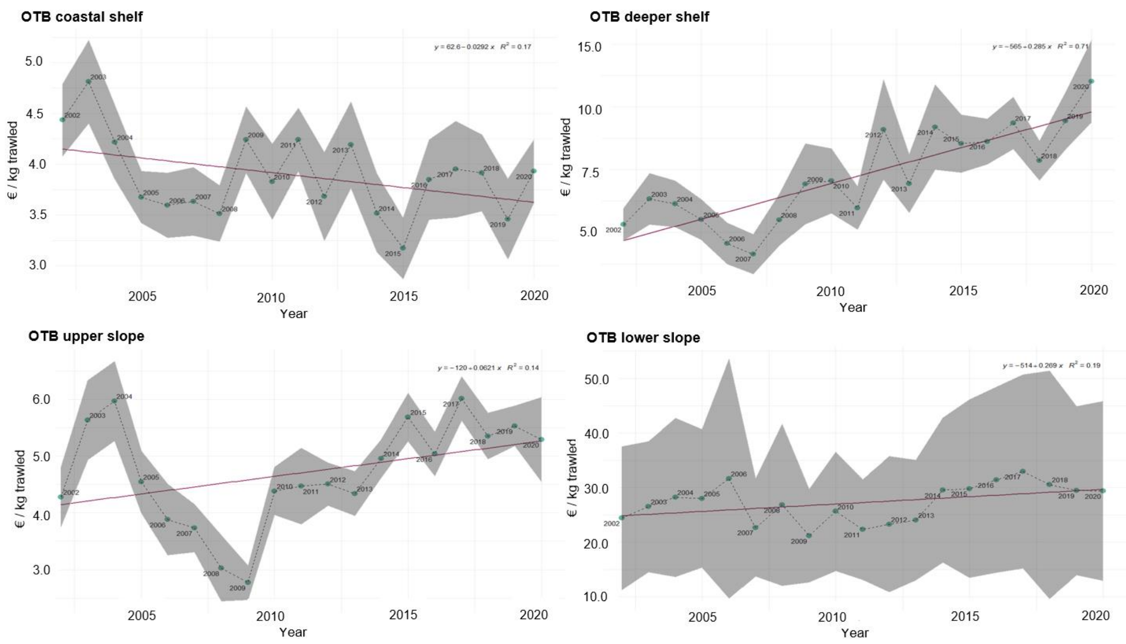


Figure 329. Euros per kilogram trawled for the time series (2002-2020) by métier for the OTB fleet in Vilanova i la Geltrú.

3.2.5 Case study II: Vilanova i la Geltrú small-scale and bottom longline fisheries.

The second case study was conducted for both small-scale and bottom longline fisheries. Due to the heterogeneity of these two fleets, the protocol was followed somewhat differently than the OTB fleet case study.

WardD linkage method and Euclidean distance were used to obtain dendrograms per year for the cluster analysis (Figure 330). After performing different sensitive analyses, *k* and the number of groups were defined as seven (Figure 331).

The main taxa were used to define métiers (Annex XI). Seven métiers for this fishing port were named, based on their main taxa. The métiers' names were defined as follows: "Hake", "Octopus", "Cuttlefish", "Bolinus", "Fish", Wedge clam", and "Mullus". For this case study, not all métiers were present throughout the years (Figure 332). Statistical analysis, i.e. two-way ANOVA were performed to test statistical differences between métiers, using the *mvabund* package. Figure 333 and Figure 334, showed transformed abundance for all métiers and residuals respectively. The results showed that there were significant differences (p < 0.001) among métiers and among years, but there were no significant differences (p > 0.05) within the interaction of the two variables (Table 57).

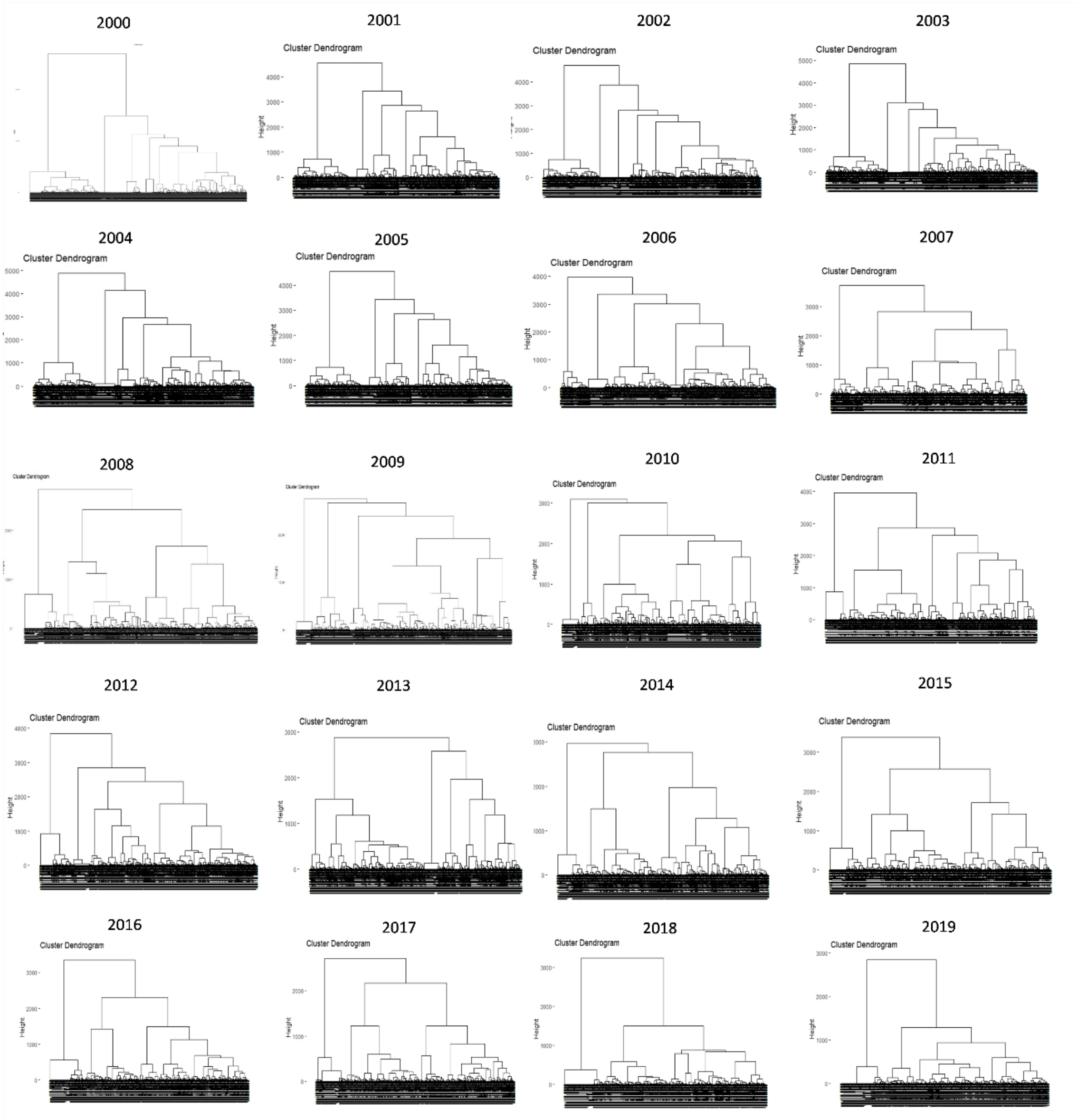


Figure 330. Dendrograms corresponding to previous Cluster analysis (Euclidean and Ward.D for distances) for the time series 2000-2019, in the port of Vilanova i la Geltrú and the small-scale and bottom longline fleets.

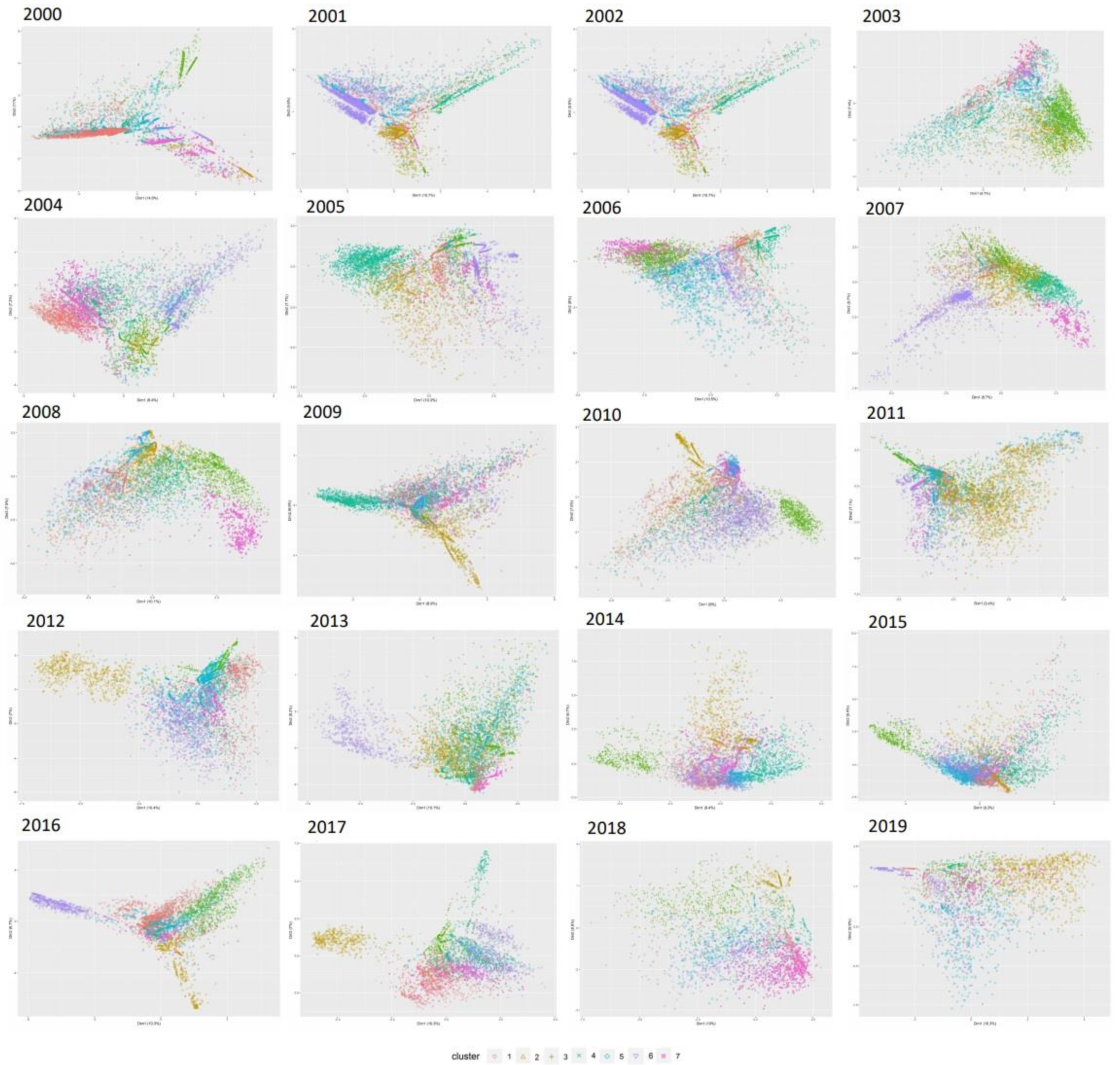


Figure 331. Cluster plots obtained from k = 7, for the time series 2000-2019, the port of Vilanova i la Geltrú and the small-scale and bottom longline fleets.

Figure 332. Presence/absence of the main métiers for small-scale and bottom longline fleets for the time series 2000-2019.

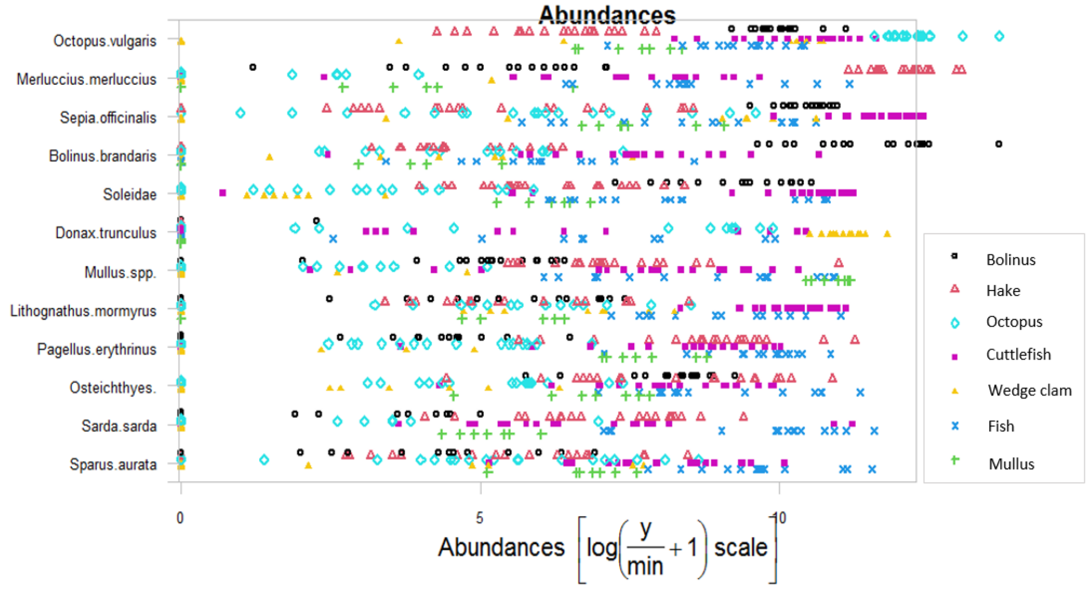


Figure 333. Standardized distribution of the abundance (transformation of log(x+1)) of the main taxa for small-scale and bottom longline métiers of Vilanova i la Geltrú.

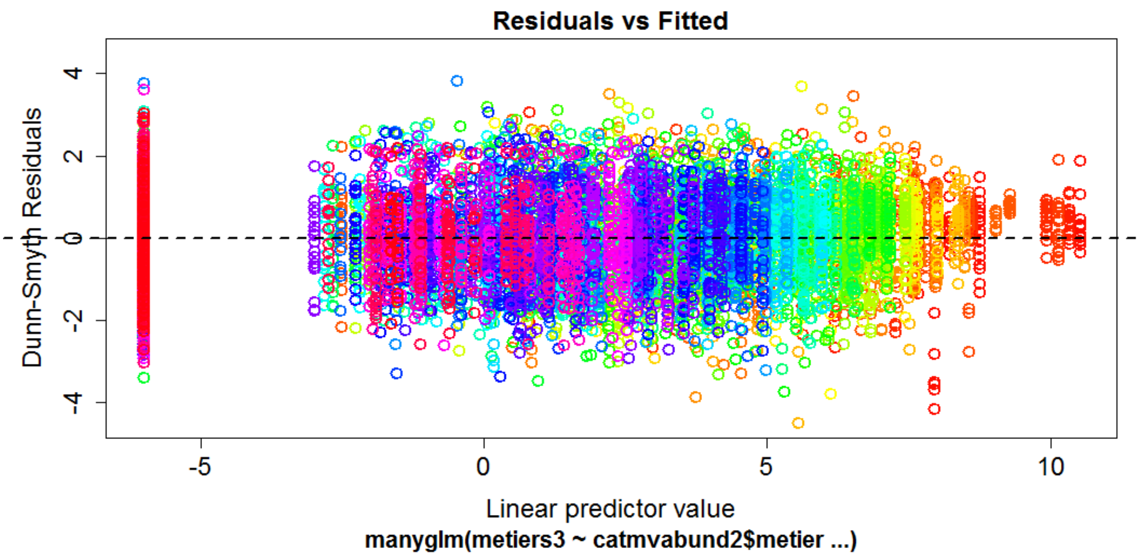


Figure 334. Residuals distribution and adjusted data using a negative binomial model for small-scale and bottom longline métiers.

Table 57. Statistical analysis results for small-scale and bottom longline métiers. Residuals, degrees of freedom, deviation and p-value respectively were presented.

Multivariate test ANOVA	Res.Df	Df.diff	Dev	p-value
Métier-Métier	101	6	7068	0.001
Year-Year	100	1	855	0.001
Métier-Year	94	6	1187	0.054

More than 50% of landings for the “Hake” métier were the species *M. merluccius* (Table 58) and hence its name. Two different periods were defined (Figure 335), from 2000 to 2007, and from 2008 to 2019. The differences were caused by the non-target species contribution. The bottom longline fleet is the main responsible for the "Hake" métier because it is a very selective fishery. It was important to note that what was reported as bottom longline may not be a hake longline but another small-scale fleet.

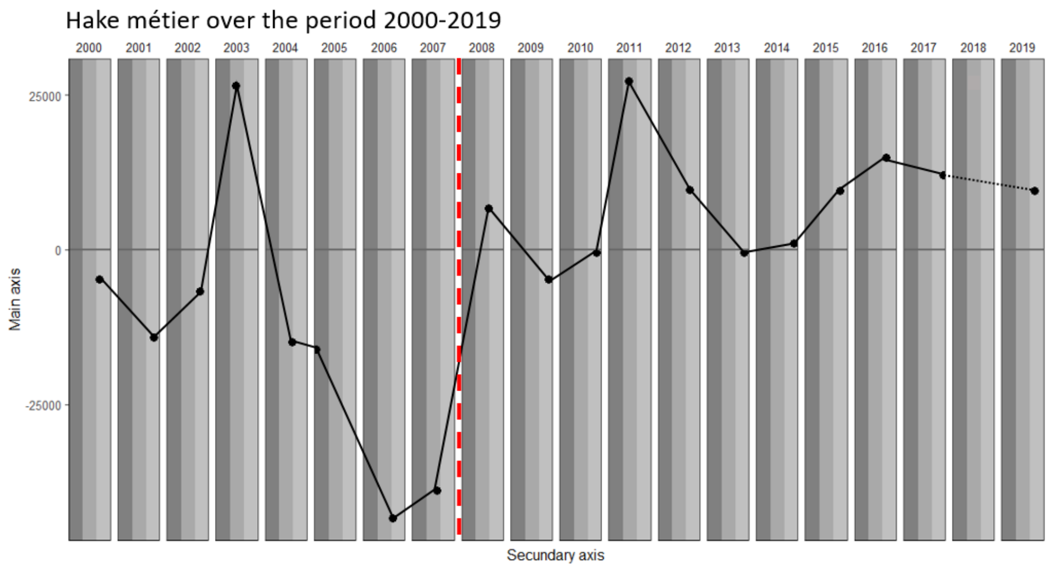


Figure 335. Variation of the composition by species of the Hake métier of Vilanova i la Geltrú for the time series 2000-2019. Vertical movements determine period changes (dashed red line) wereas horizontal movements determine the anomalous years within the same period (dashed black line).

Table 58. Main taxa contribution (%) for the Hake métier for each period for the time series (2000-2019).

	2000-2007	**2008-2019**
Merluccius merluccius	64.50%	56.03%
Pagellus erythrinus	1.82%	6.13%
Taurons	1.36%	6.08%
Conger conger	3.78%	3.79%
Trachurus spp.	1.68%	2.97%
Phycis spp.	2.61%	1.82%
Pagellus acarne	3.15%	1.23%
Scomber scombrus	3.14%	1.23%
Osteichthyes	5.36%	0.66%
Xiphias gladius	3.78%	0.56%

The cephalopod *S. officinalis* represented around 40% of the "Cuttlefish" métier landings (Table 59). Three different periods were defined (Figure 336), from 2000 to 2006, from 2007 to 2015, and from 2016 to 2019. Differences among periods were caused by the following three taxa, *O. vulgaris, Soleidae*, and *L. mormyrus*, which followed *S. officinalis* contribution.

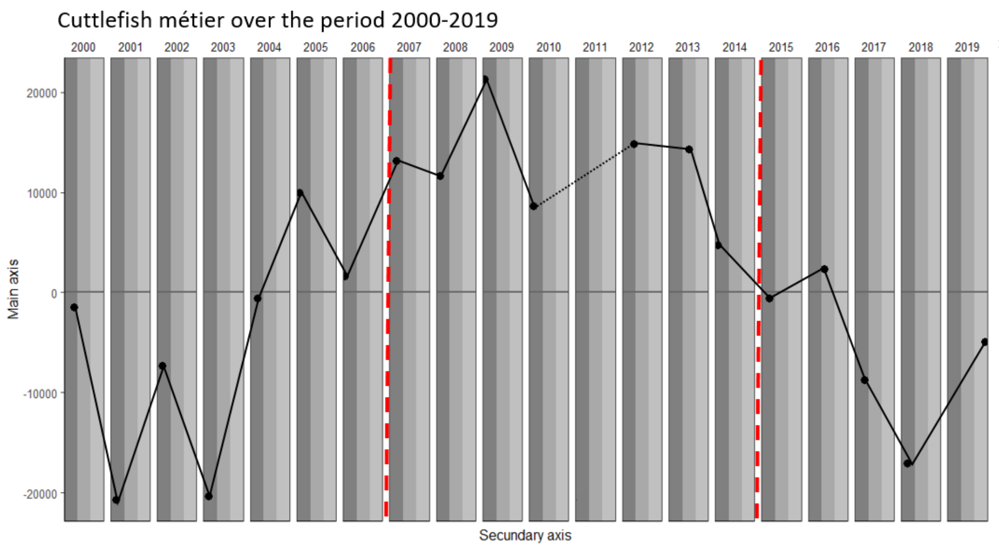


Figure 336. Variation of the composition by species of the Cuttlefish métier of Vilanova i la Geltrú for the time series 2000-2019. Vertical movements determine period changes (dashed red line) wereas horizontal movements determine the anomalous years within the same period (dashed black line).

Table 59. Main taxa contribution (%) for Cuttlefish métier for each period for the time series (2000-2019).

	2000-2007	**2008-2015**	**2016-2019**
Sepia officinalis	37.78%	40.37%	36.17%
Soleidae	8.59%	7.45%	11.09%
Octopus vulgaris	13.20%	10.18%	10.04%
Lithognathus mormyrus	6.91%	9.43%	7.26%
Rajades	0.25%	2.47%	3.32%
Pagellus erythrinus	1.35%	0.92%	2.90%
Sarda sarda	0.99%	3.47%	2.05%
Mugilidae spp.	1.13%	1.82%	1.36%
Mullus spp.	1.47%	1.55%	1.04%
Osteichthyes	3.24%	0.35%	0.25%

The “Octopus” métier was different (

Figure 337) and corresponded to traps and pots fishery, a very selective fishery with 80% of landings corresponding to octopusses. No periods were defined. Métier consistency was evaluated with a LPUE approximation (kg by trip) (Figure 338). Variation coefficient remained stable during the time series and below 0.3 (

Figure 339), showing consistency over the years.

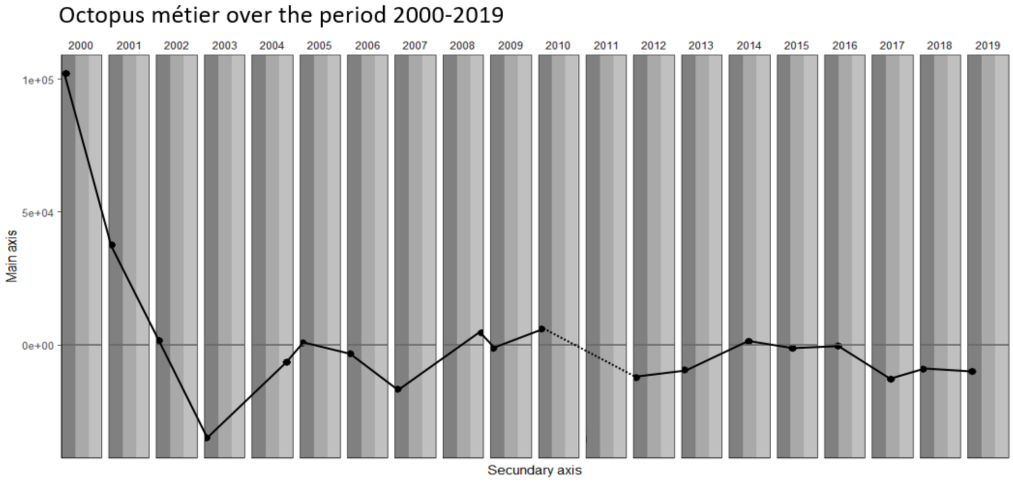


Figure 337. Variation of the composition by species of the Octopus métier of Vilanova i la Geltrú for the time series 2000-2019. Vertical movements determine period changes swereas horizontal movements determine the anomalous years within the same period.

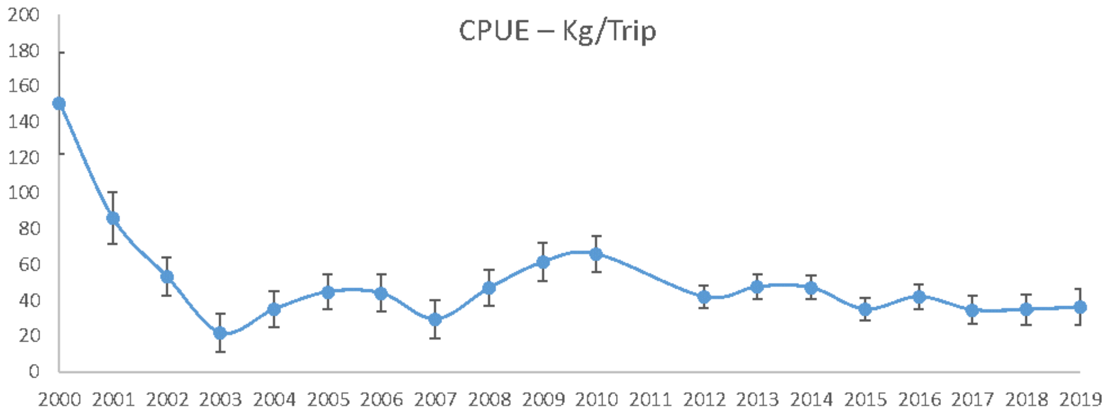


Figure 338. CPUE (kg/Trip) of Octopus métier for the time series 2000-2019.

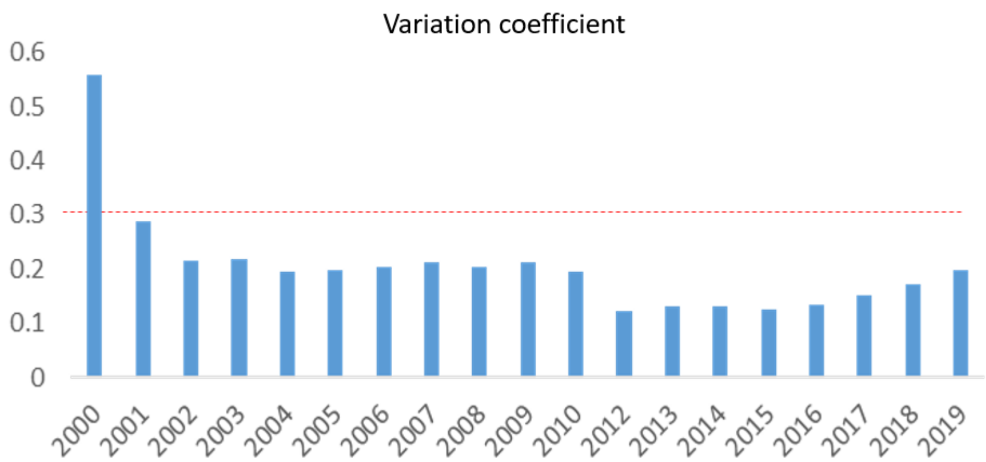


Figure 339. CPUE (kg/trip) variation coefficient of Octopus métier for the time series 2000-2019. The dashed red line means 0.3 reference value.

An example of a non-continuous métier, meaning that it was not always present throughout the time series, was the "Wedge clam" métier (Figure 340). This fact could be caused by two different reasons, a ban for part of the fishery or a decreasing trend in the taxa's landings. Two different periods were defined. During the first one, from 2000 to 2008, wedge clam represented more than 80% of the landings (Table 60), indicating a fleet specialization. But, in the second period, from 2009 to 2013, this specialization decreased to 47% of the landings.

The current dissapearance of the métier could be explained by a progressive decrease of wedge clam landings.

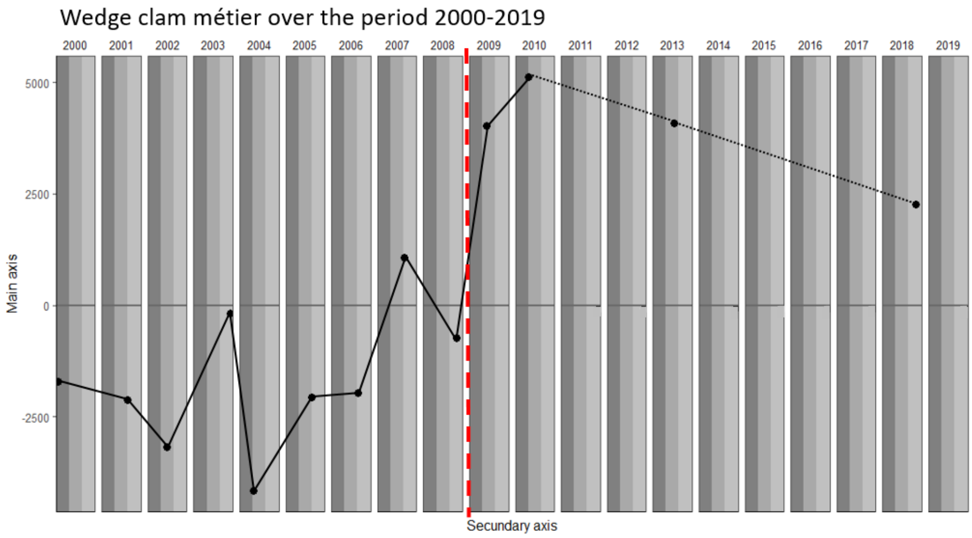


Figure 340. Variation of the composition by species of the "Wedge clam" métier of Vilanova i la Geltrú for the time series 2000-2019. Vertical movements determine period changes (dashed red line) wereas horizontal movements determine anomalous years within the same period (dashed black line). This métier disapear in 2018.

Table 60. Main taxa contribution (%) for "Wedge clam" métier for each period for the time series (2000-2013).

	2000-2008	2009-2013
Donax trunculus	85.90%	47.20%
Octopus vulgaris	4.50%	29.97%
Sepia officinalis	2.03%	14.66%
Nassarius mutabilis	0.85%	4.20%
Chamelea gallina	0.34%	0.52%
Bolinus brandaris	0.19%	0.00%
Lithognathus mormyrus	0.24%	1.37%
MolÂ·luscs varis	0.03%	0.00%

"Mullus" métier didn't appear at the beginning of the time series (Figure 341). The relevance to include this metier in the study lies in its constant present in the recent years and a potential stabilization in future years. *Mullus* spp. accounted for 65% of landings (Table 61) and shared the métier with other shallow water species, which could be fished with different types of fishing nets.

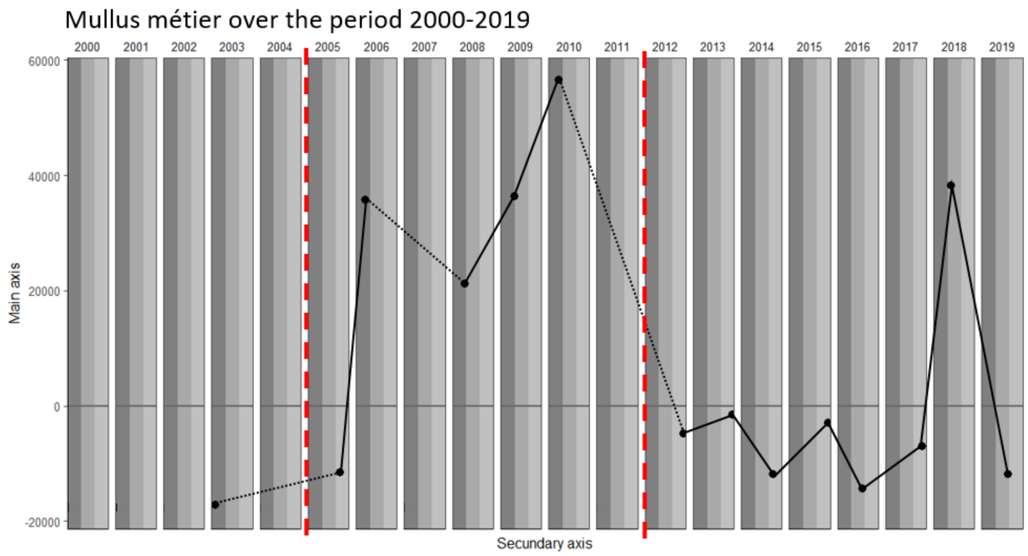


Figure 341. Variation of the composition by species of the “Mullus” métier of Vilanova i la Geltrú for the time series 2000-2019. Vertical movements determine period changes (dashed red line) wereas horizontal movements determine anomalous years within the same period (dashed black line). This métier appeared in 2003 but until 2012 wasn’t constant.

Table 61. Main taxa contribution (%) for “Mullus” métier for the time series (2012-2019).

	2012-2019
Mullus spp.	63.11%
Scorpaena spp.	7.39%
Pagellus acarne	4.58%
Pagellus erythrinus	3.70%
Sepia officinalis	3.12%
Sphyraena sphyraena	2.75%
Octopus vulgaris	2.53%

Another variable métier was “Fish”, due to its taxa composition (Figure 342). Three different periods were defined: from 2003 to 2007, from 2008 to 2013, and from 2014 to 2018 (Figure 342, Table 62). As in other cases, the differences were a consequence of taxa composition and contribution. Many of these taxa were *Osteichthyes*, hence the métier name. Fishing nets could also be present in this métier, but it was not a very selective métier.

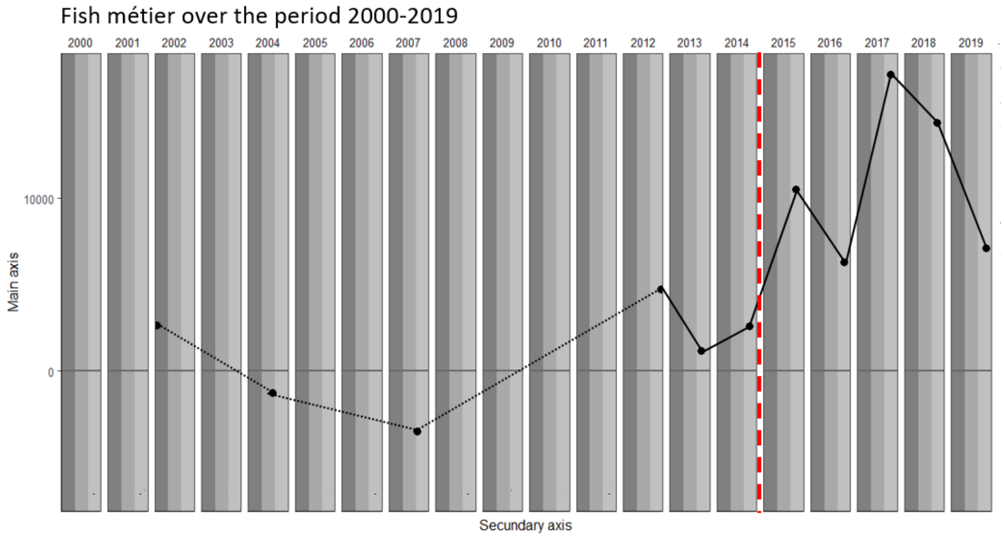


Figure 342. Variation of the composition by species of the Fish métier of Vilanova i la Geltrú for the time series 2000-2019. Vertical movements determine period changes (dashed red line) wereas horizontal movements determine anomalous years within the same period (dashed black line). This métier appeared in 2002.

Table 62. Main taxa contribution (%) for Fish métier for each period for the time series (2003-2018).

	2003-2007	2008-2013	2014-2018
Sparus aurata	2.46%	4.12%	12.37%
Sarda sarda	7.49%	8.33%	7.25%
Seriola dumerili	5.75%	6.27%	7.12%
Pagellus erythrinus	1.41%	6.54%	5.28%
Diplodus sargus	3.07%	6.81%	4.41%
Lithognathus mormyrus	3.61%	2.76%	3.88%
Trachurus spp.	3.07%	3.09%	3.35%
Octopus vulgaris	5.16%	4.31%	1.76%
Osteichthyes	8.29%	4.15%	1.32%
Mullus spp.	6.27%	5.53%	1.15%
Merluccius merluccius	3.33%	3.94%	0.70%

“Bolinus” métier was divided into two different periods (Figure 343): from 2000 to 2007 and from 2008 to 2017. During the first period, *Bolinus brandaris* dominated landings accounting for more than 50% (Table 63), but during the second period, *B. brandaris* landings fell to half, with increasing landings for cuttlefish and octopus. The reasons of this switch could be a change in the fishery, target species, fishing gear, declining Bolinus biomass, or a combination of them. In

2017, “rastell de cadenes”, a specific fishing gear to catch *Bolinus*, was banned in this fishing port.

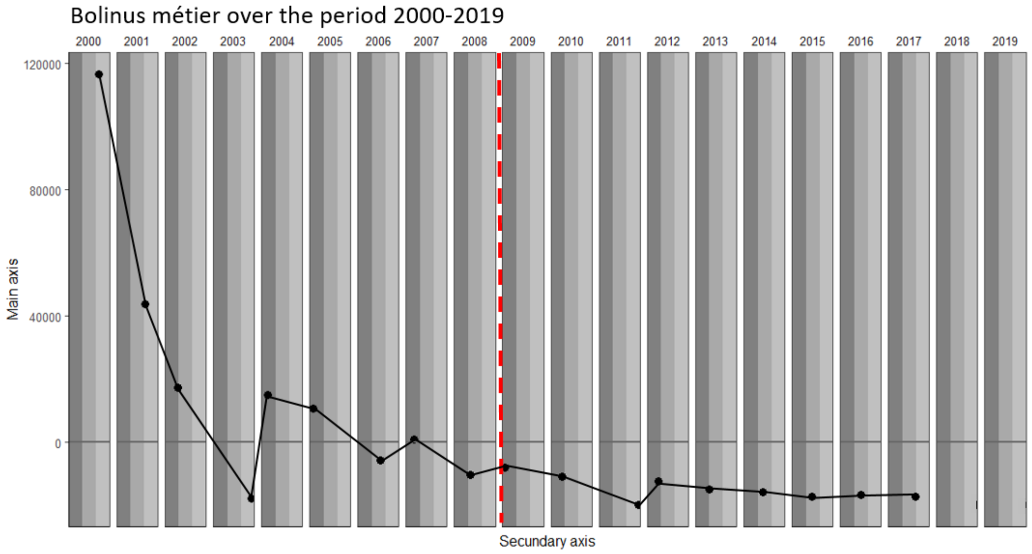


Figure 343. Variation of the composition by species of the Bolinus métier of Vilanova i la Geltrú for the time series 2000-2019. Vertical movements determine period changes (dashed red line) wereas horizontal movements determine anomalous years within the same period (dashed black line). This métier disapeared in 2017.

Table 63. Main taxa contribution (%) for Bolinus métier for each period for the time series (2000-2017).

	2000-2007	**2008**-2017
Bolinus brandaris	55.31%	25.21%
Sepia officinalis	9.97%	18.59%
Octopus vulgaris	7.04%	11.53%
Soleidae	5.74%	3.76%
Citharus linguatula	3.02%	9.54%
Penaeus kerathurus	3.61%	6.58%
Rajades	2.34%	1.52%

Figure 344 shows taxa composition by métier for time series (2002-2020) for the small-scale and bottom longline fisheries. The more specialized métiers were composted by only one or two different taxa, as in the case of the “Octopus” métier. Other métiers were more generalists, i.e. the “Fish” métier.

Figure 345 shows vessel length composition by métier for time series (2002-2020) for the small-scale and bottom longline fisheries. Dominant vessel lengths were 06-12 and 12-18 meters for most of the fleet.

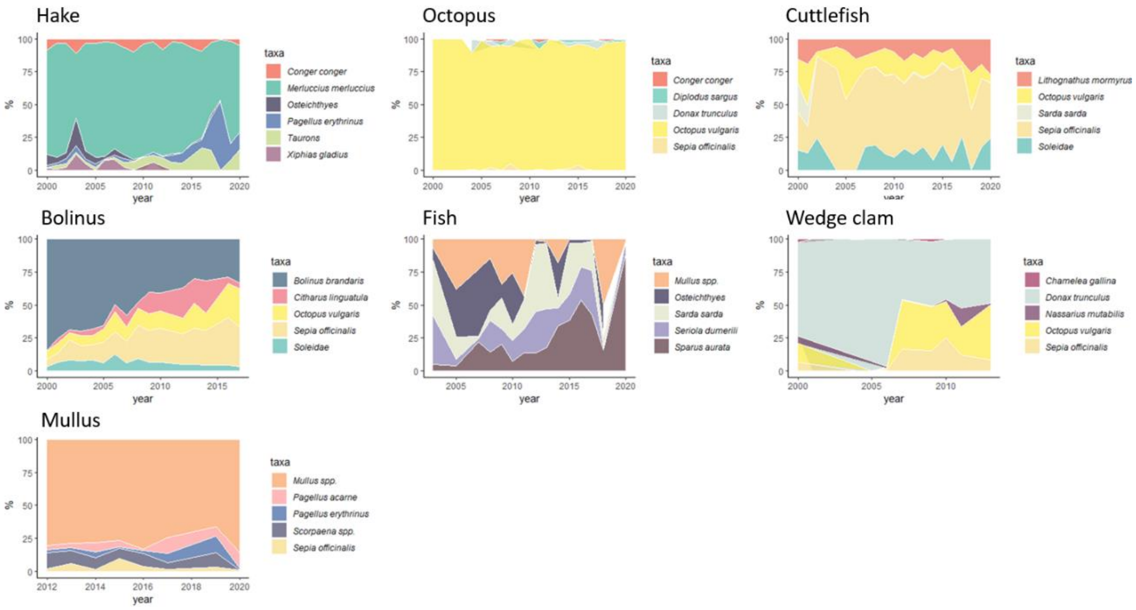


Figure 344. Taxa composition in terms of percentage of landings from each of the seven métiers in the port of Vilanova i la Geltrú for time series (2002-2020 and depending on each métier), for the artisanal fleet.

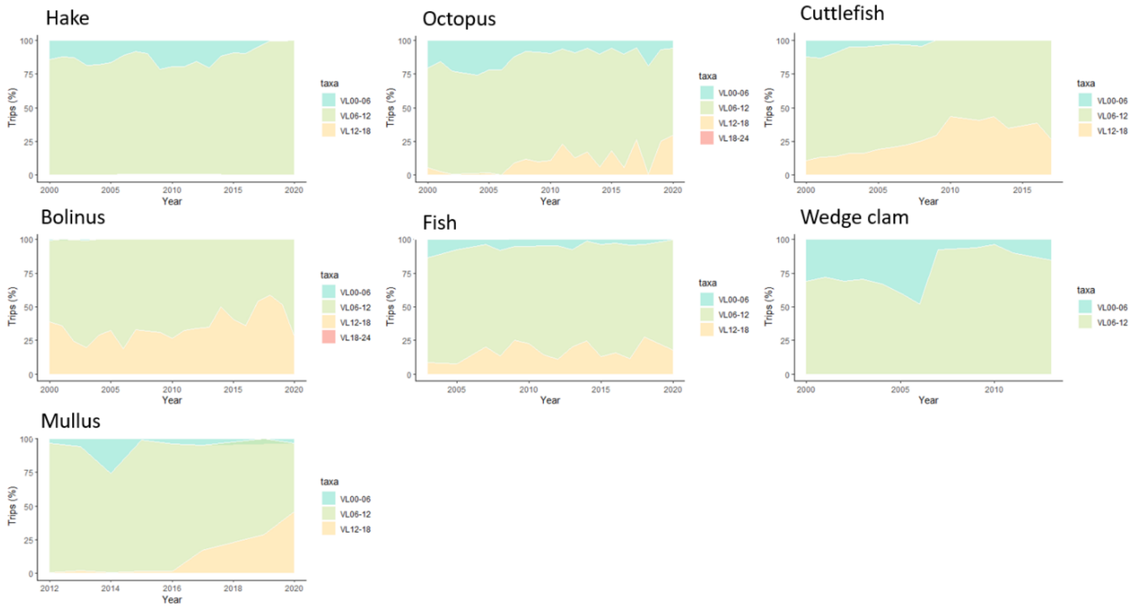


Figure 345. Vessel length composition by métier for time series (2002-2020 and depending on each métier) for the artisanal fleet.

Landings (Figure 346) for “Octopus”, “Bolinus” and “Hake” métiers tended to decrease in the recent years. The opposite happened with “Cuttlefish”, “Fish” and “Mullus” métiers. Trends in the number of vessels (Figure 347) were similar to the landing trends. Finally, LPUE (Figure 348) was rather stable in the case of “Octopus”, “Bolinus” (from the middle of time series), “Fish” (from the middle of the time series), “Wedge clam” and “Mullus”, but fluctuated in the other métiers. Uncertainty (green shadow) was higher depending on years and métier.

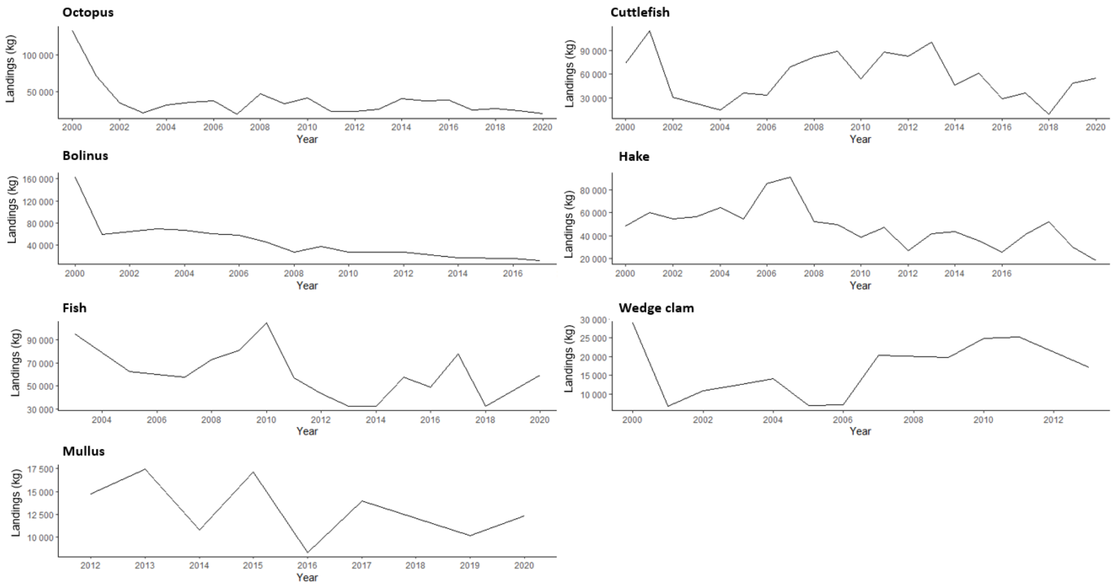


Figure 346. Landings (in kg) evolution for the time series (2002-2020) by métier for the artisanal fleet.

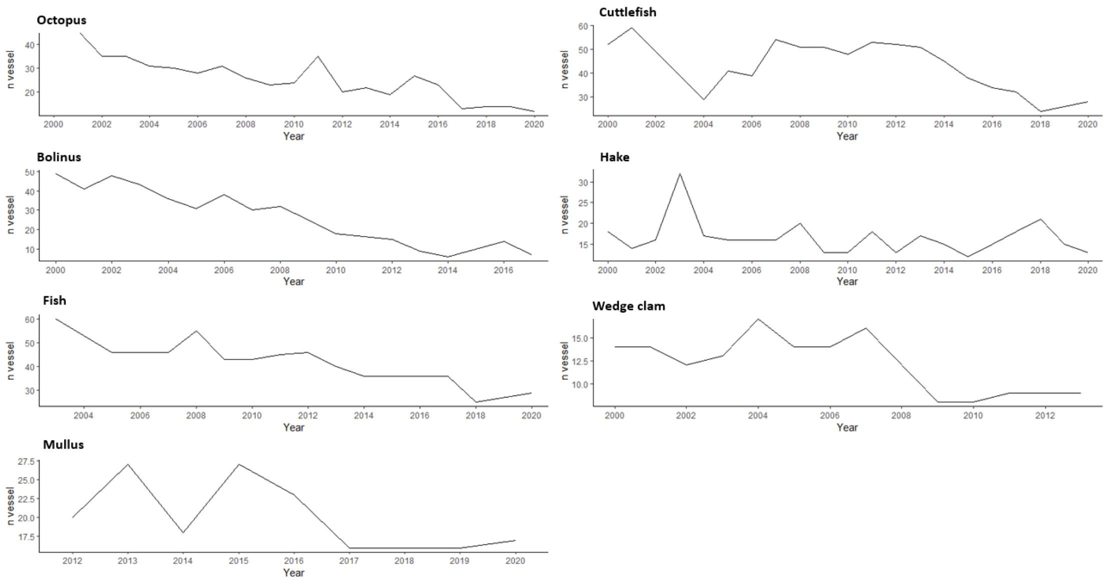


Figure 347. Number of vessels for the time series (2002-2020) by métier for the artisanal fleet.

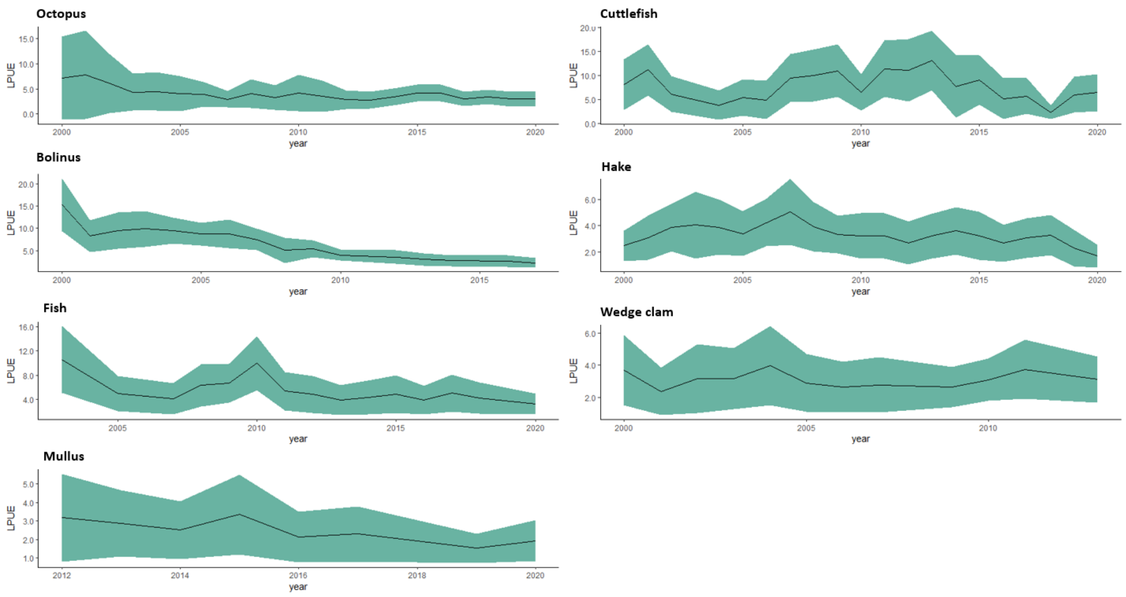


Figure 348. LPUE (Fishing day/vessel) with sd, for the time series (2002-2020) by métier for the artisanal fleet.

This case study was explored a bit differently than the OTB case study, due to its heterogeneity. Therefore, in the future, the protocol to identify métiers should adapt to these specific fleets (small-scale and bottom longline) and, in addition, different fishing ports should also be considered.

3.3 NEXT STEPS

After defining a protocol and testing it with two different case studies as shown, analyses are being carried out for all Catalan fishing ports to identify both temporal and spatial variations, for bottom trawlers. In the future, analyses will be carried out to identify métiers for all the Catalan artisanal fleets. Meanwhile, a Productive and Susceptibility Analysis (PSA) will be carried out taken into account the results of the exploration of métiers. This PSA will be necessary to elucidate the life history of many species, which compose the métiers, and to understand their vulnerability based on their catches in each métier. To check how comparable the sampling carried out within this project is with the official landing data (at species composition level), a comparative analysis will be carried out. A spatial representation of each metier will be presented, at the level of Catalonia and by port. Finally, participation in the working groups of the STECF and the GFCM will continue.

4. RECREATIONAL FISHING

Marine recreational fishing is an activity that has grown steadily over the last two decades, especially in the countries of Southern Europe (FAO 2016). The extraction of marine resources by recreational fishing has an overlap of unknown magnitude with the extraction of resources by commercial fishing, and the increase in activity has awaken the interest of both the administrations in charge of fisheries management as well as the scientific community (Hyder et al., 2017). For decades, there has been a broad consensus that new fisheries management models need to incorporate recreational fishing catches (Cooke & Cowx 2006). The legal framework of European legislation forces member nations to collect information on recreational fishing. Regulation of the European Parliament (EC) No 1004/2017 (Council of the European Union, 2017), which repeals Regulation (EC) No 199/2008, known as the “Data Collection Framework” (DCF), outlines the obligations of the Member States to collect information on catches of Recreational Fisheries, while Comission Implementing Decision (EU) 2019/909 (European Commission, 2019), which repeals Implementing Decision (EU) 2016/1251, establishes the species on which data needs to be collected.

In this context, the Directorate-General of Maritime Affairs and Fisheries has launched a program to monitor and advise on recreational marine fishing in Catalonia. Considering the recommendations issued by the ICES Working Group on Recreational Fisheries on the prioritization of obtaining information provided by the license register in cases where these are an exploitable asset (Ruiz et al., 2014; ICES 2017; Gordoa et al., 2019), a pilot test has been carried out to monitor marine recreational fishing based on obtaining telematic information through online surveys. These were made primarily for recreational fishing license holders, but also for other users of the activity who wished to provide information voluntarily. The information obtained by telematic means was complemented with a field data collection system. This document presents the results of the online survey of the pilot test.

4.1 METHODOLOGY

The data collection was gathered through an online survey developed using electronic survey creation software. The survey was disseminated to all available emails of recreational fishing practitioners who had obtained the license between January 1, 2014 and December 31, 2018, regardless of their status (whether licenses were issued, expired, revoked or disabled). Of the total of 253.483 marine surface recreational fishing (both on land and from boat) and spearfishing licenses issued during this period, a total of 73.761 license users had voluntarily given an email contact. Of these, there were a total of 41.644 unique emails, which were the final recipients of the survey. The survey was sent on June 14, 2019, followed by two more reminder submissions, on July 1 and August 5 of the same year. The survey application was open from June 14 to August 25, 2019.

The survey was further disseminated through a communication campaign that consisted of an official press release from the DGPAM website issued on June 21, 2019, and communications through their official twitter account. In parallel, the survey was communicated to the recreational fishing federations of marine and inland waters (Catalan Diving Federation FECDAS and Catalan Sport Fishing Federation FCPEiC), the International Forum for Sustainable Underwater Activities (IFSUA) and a total of 49 local recreational fishing associations.

The survey could be answered by computer as well as other digital platforms such as mobile phones and tablets, and was responsive to all web browsers. The survey was translated into 4 different languages, i.e. Catalan, Spanish, English, and French. The content of the survey included questions on the type of fishing practiced, the socio-economic profile, the fishing effort, the fishing performance, the composition of the catches and the daily and annual expenses for the practice of the activity.

4.2 STUDY ZONATION

The study divided the Catalan coast into 3 large regions (North, Center, and South) and 21 areas with similar characteristics in terms of substrate, and nutrient and sediment contributions (Figure 349). The areas were limited by specific physical structures such as lighthouses, ports, harbors, rivers, or streams. The areas between Portbou and port of Blanes composed the north region of the Catalan coast; from there to the port of Vilanova i la Geltrú, the center region, and from the port of Vilanova i la Geltrú to the river Sènia, the south region. When interpreting the results presented by regions and by zones, it should be noted that they all have heterogeneous lengths.

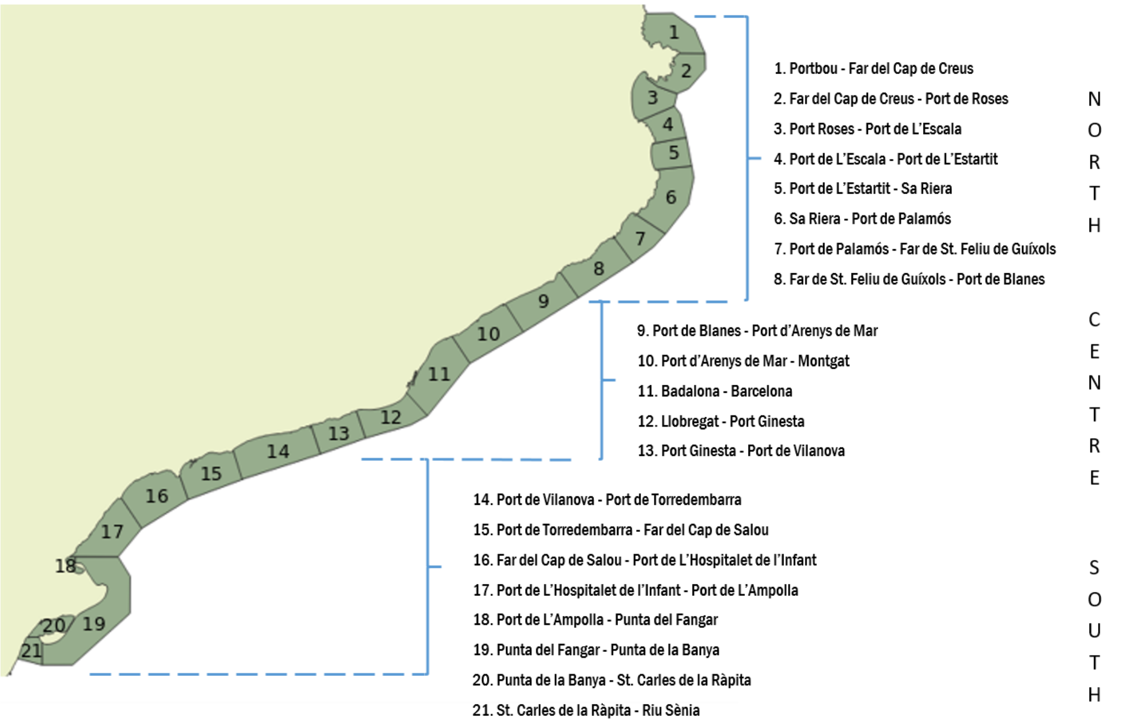


Figure 349. Division of the Catalan coast into 21 areas and in 3 regions, i.e. North, Centre and South.

4.3 SURVEY RESPONSE

The survey for users of recreational fishing in marine and inland waters received a total of 13.138 answers, corresponding to a 21% response rate. Of these, 8.180 respodents reported marine recreational fishing as their only activity, which accounted for 2.842 in inland recreational fishing (Figure 350). While there were a total of 2.116 results of practitioners of the two modalities, about half of them (1.037) practiced marine recreational fishing as their main activity, whereas the other half (1.079) mainly practiced inland recreational fishing.

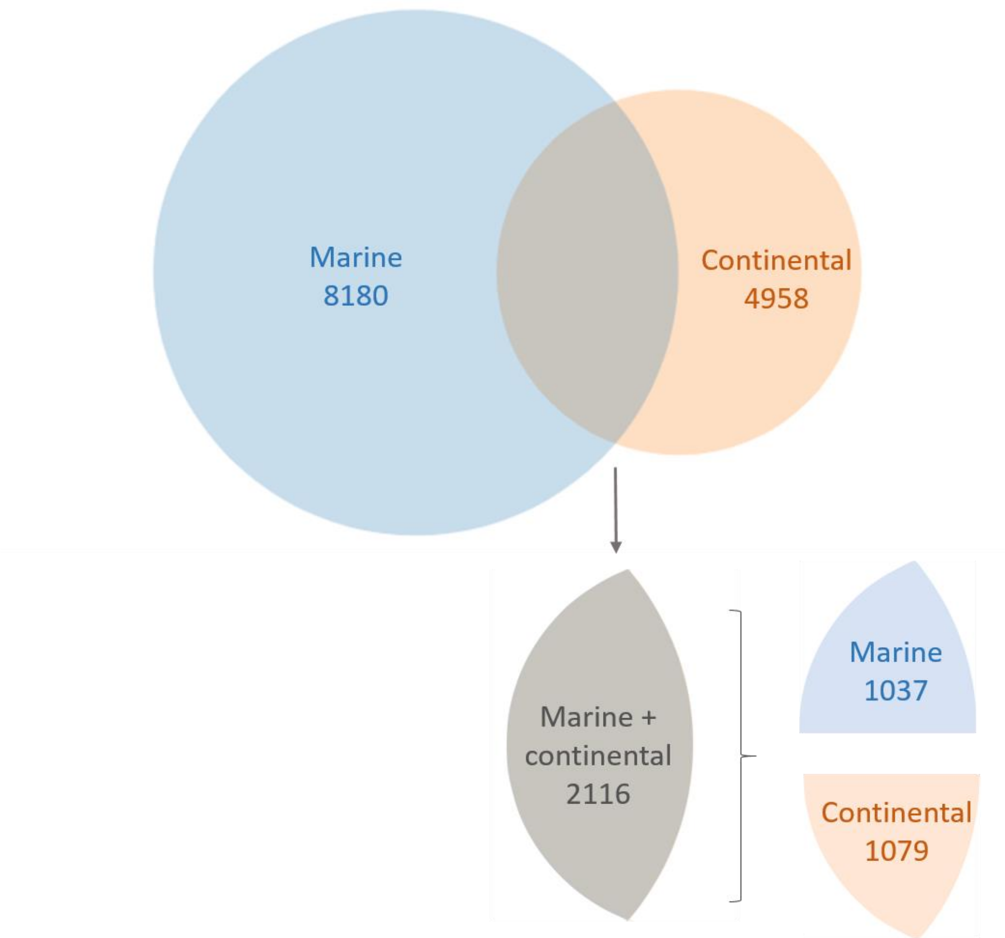


Figure 350. Top: Venn diagram with the number of responses from exclusive marine recreational fisheries and inland recreational fisheries. Bottom: total number of participants in the two modalities and separation by the modality declared as the main activity.

For data analysis, of the 13.138 total responses, 9.217 were classified as marine recreational fishing (8.180 as a single activity + 1.037 as a main activity), and 3.921 were classified as inland recreational fishing (2.842 as a single activity + 1.079 as a main activity; Figure 351).

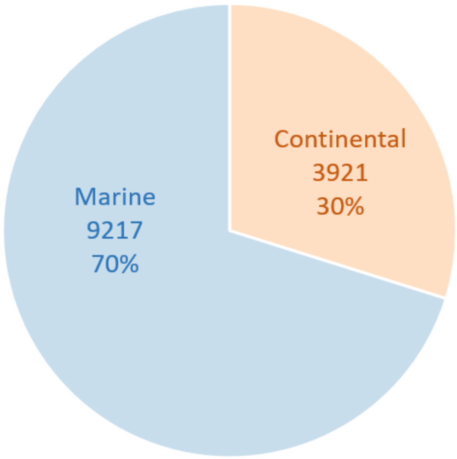


Figure 351. Number of responses and percentage regarding the total number of survey responses by marine recreational fisheries and inland recreational fisheries.

Most of the marine recreational fisheries responses were from Catalonia. There was also a significant amount of responses from other parts of Spain, as well as from other countries such as France, Switzerland, Belgium, the Netherlands, Germany, the United Kingdom, and Morocco (Figure 352).

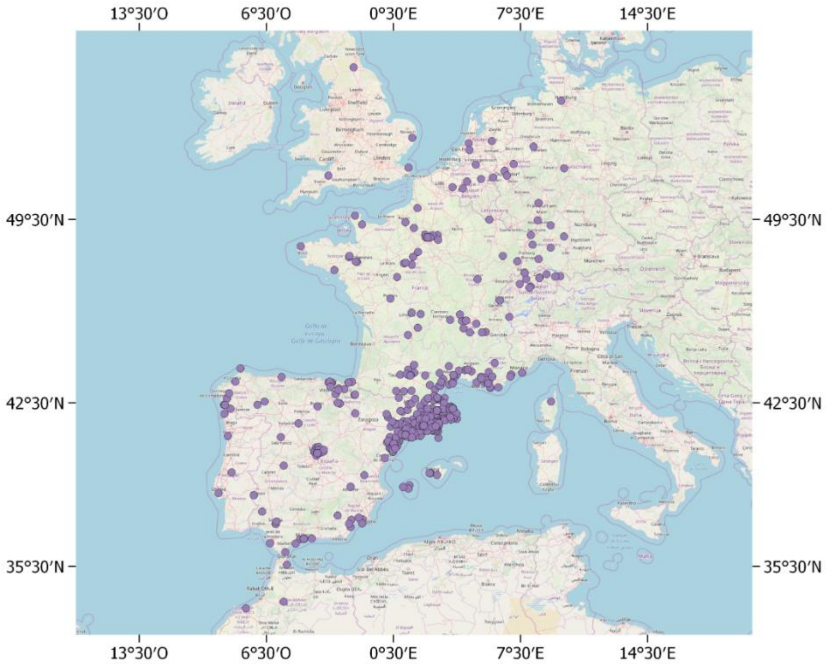


Figure 352. Geographic distribution of survey responses. Purple dots indicate the locations from which the survey was answered and may represent more than one response per location.

4.4 ACTIVITY VOLUME

Of the total of 9.217 surveys classified as marine recreational fishing, 605 were eliminated on suspicion of being duplicated answers, and an additional 115 failed to pass the classification questions by modality. The remaining 8.497 surveys provided valid information on recreational fishing. A total of 6.276 respondents fished from the coast, 2.942 fish on boat, and 1.498 practiced spearfishing (Figure 353). Moreover, 19% of all respondents practiced two of the recretional fishing modalities, and 3% practiced all 3 of them.

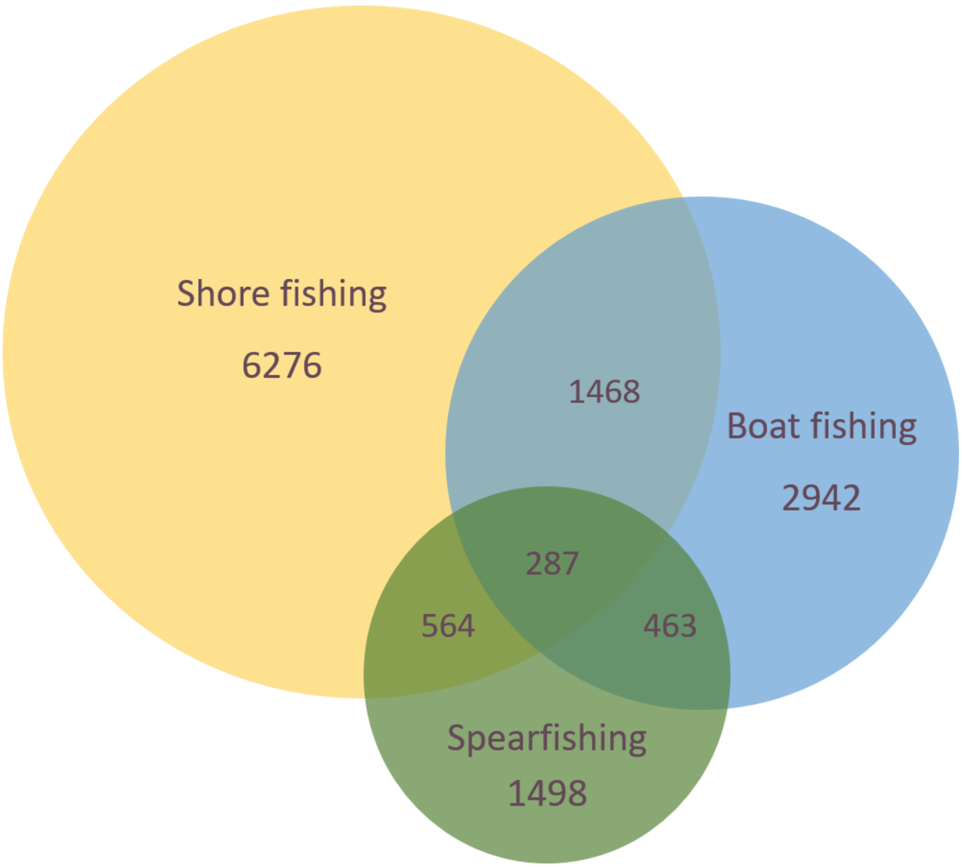


Figure 353. Venn diagram of the number of responses by marine recreational fishing modality.

Each answer was categorized by modality (Figure 354). Practitioners' answers to more than one modality were assigned to a single modality based on the answer to the question "Which modality do you practice most often?".

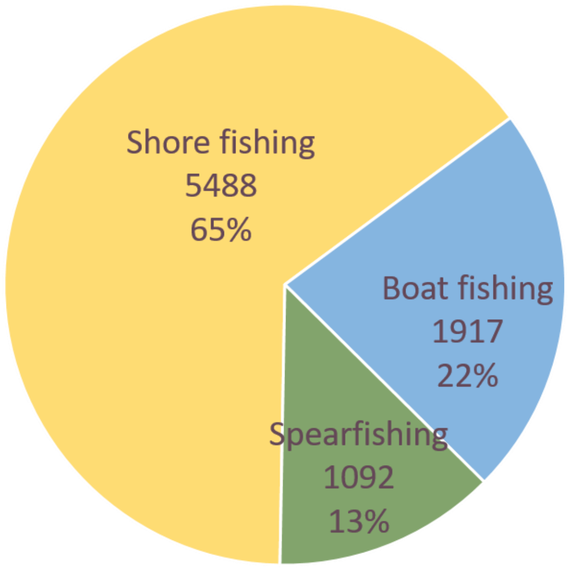


Figure 354. Categorization of responses by fishing modality.

The total number of active shallow water licenses valid until the end of 2018 was 60.588. The proportion of sea and inland recreational fishing practitioners in the survey (Figure 351) was used to estimate the number of licenses attributable to each activity (42.506 in marine recreational fishing and 18.082 in inland recreational fishing). The estimated volume of marine recreational fishing licenses has been divided between coastal and fishing from boat modalities using the relative proportion of respondents in both modalities (61,3% for coastal fishing and 38,7% for fishing from boat). The volume of spearfishing licenses (2.942) was obtained directly from the license register. The volume of licenses for use is estimated at 26.038 for coastal fishing from shore, 16.468 for fishing from boat and 2.942 for spearfishing (Figure 355).

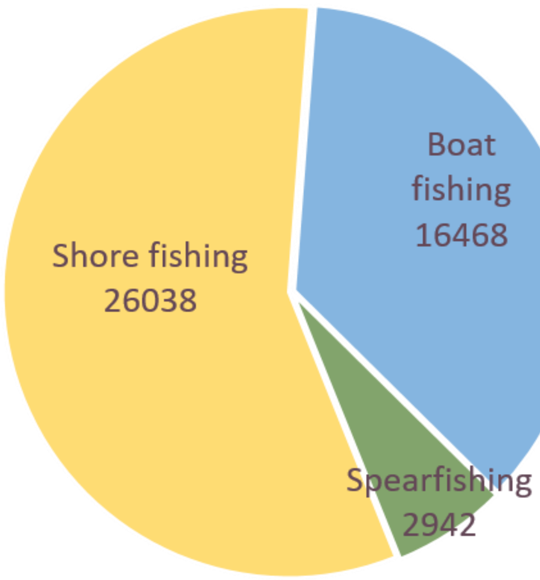


Figure 355. Volume of licenses assigned to each modality.

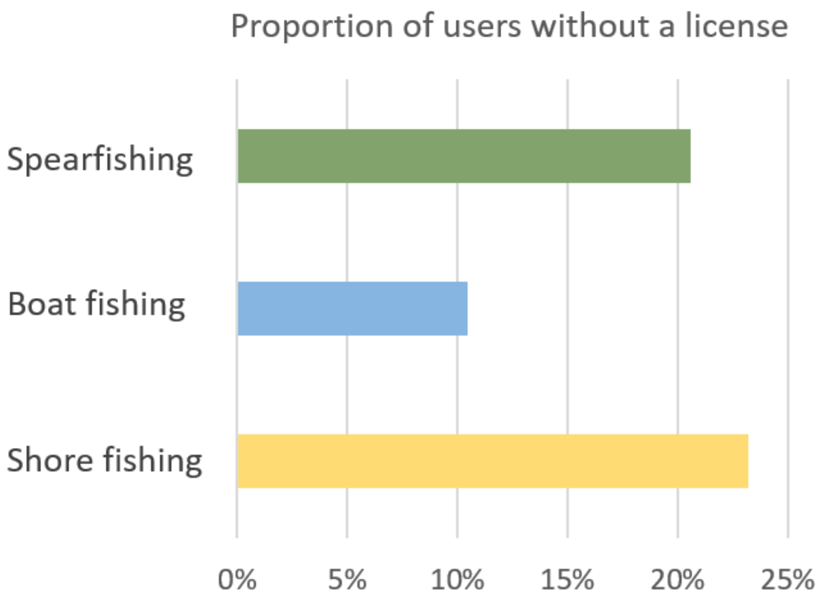


Figure 356. Percentage of responses from practitioners without a valid license to practice recreational fisheries from the coast (COS), from boat (EMB), and diving (SUB).

A significant proportion of responses reported recreational fishing without a valid license (23% for inshore fishing, 10% for boat fishing, and 21% for spearfishing;

Figure 356). Unlicensed user values are self-reported in surveys, and are probably lower than in reality.

The total volume of the activity (the one practiced with license in addition to the irregular activity) for each modality has been calculated as the result of adding the estimate of recreational fishing without license for each modality (6.048, 1.719 and 606 for the practitioners of fishing from coast, from boat and diving, respectively) to the licensed regular activity (Figure 357). These vàlues may have been underestimated, probably because of the underestimation of the proportion of unlicensed recreational fishermen.

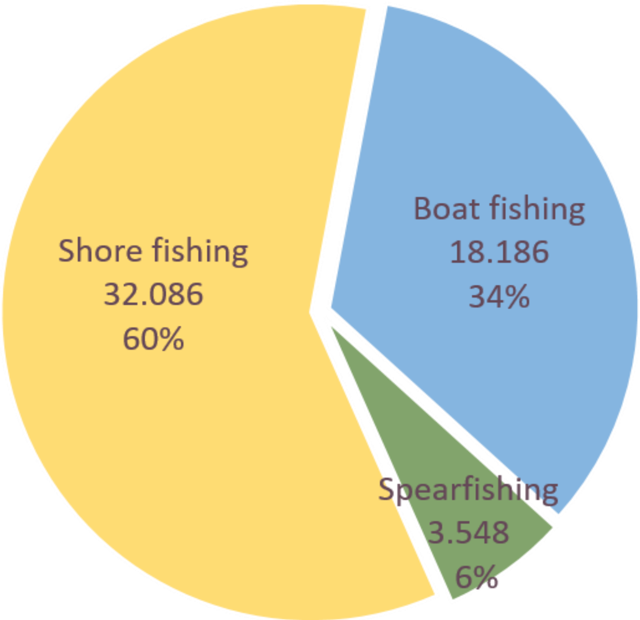


Figure 357. Estimation of the total volume of activity by modality. Values by modality have been obtained as the addition of the current licenses estimated by modality (or known volume of licenses in the case of spearfishing), and the practice estimatimation.

In relation to the Catalan population, the number of recreational marine fishing practitioners was less than 1% (Table 64) and was below other Autonomous Communities off the coast of Spain. In detail, in the other Autonomous Communities of the spanish Mediterranean basin, the participation in recreational marine fishing (according to the registration of licenses) was 2% in the Valencian

Community, 3,6% in Murcia, 3,4% in Andalusia and 4,7% in the Balearic Islands (Gordoa et al., 2019).

Table 64. Percentage of participation of the total Catalan population in recreational fishing on a regular basis (license participation rate), considering the irregular activity (activity participation rate).

	Participation rate of licensed users	Total activity participation rate (licensed + unlicensed users)
Shore fishing	0.34%	0.42%
Boat fishing	0.22%	0.24%
Spearfishing	0.04%	0.05%
Total	**0.60%**	**0.71%**

4.5 ACTIVITY SOCIAL PROFILE

The practice of recreational fishing was mostly a male activity with 94% of respondents being male and only 6% being female (Figure 358). When asked about gender, 0,2% of respondents answered the non-binary option "Other". Out of the four languages in which the survey could be answered, the prefered language (the one chosen to answer the questions) was Spanish for 59% of the respondents, followed by Catalan (34%), French (5 %) and finally, English (2%; Figure 359).

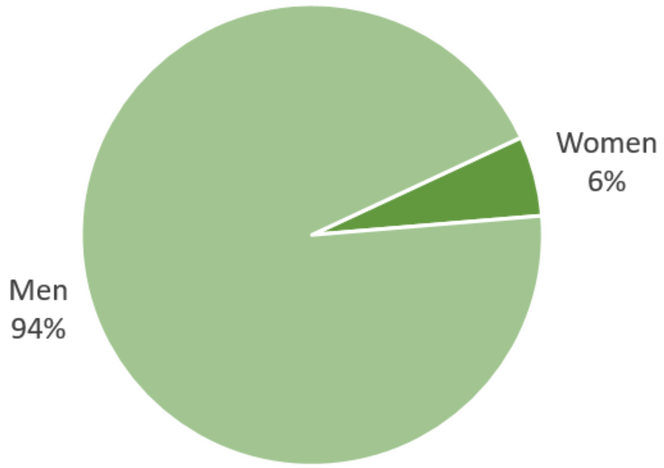


Figure 358. Percentage of responses by gender.

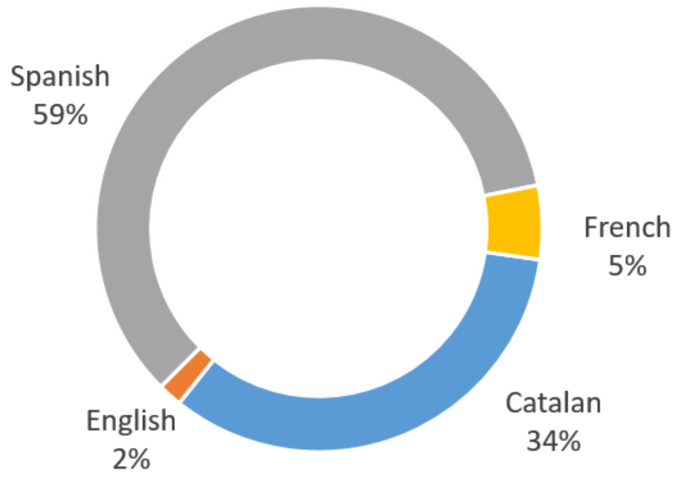


Figure 359. Preferred language of respondents to the marine recreational fishing survey.

An important indicator of the data quality obtained from the surveys using online platforms was age distribution. The use of electronic platforms could be a deterrent for the elderly, under-representing them compared to younger fishermen. However, the results of the pilot survey showed an unbiased representation of the Catalan population (Figure 360; Institut d'Estadística de Catalunya) supporting the validity of the methodology used by the population studied. The average age of the studied group was 46.07 years, and the median was 45.

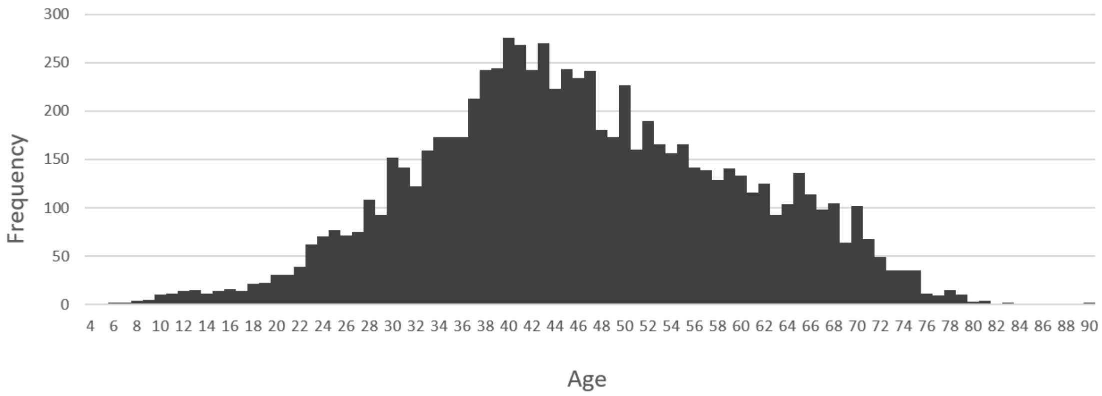


Figure 360. Age frequency of respondents practicing recreational marine fishing.

Regarding the educational level of the respondents, a significant proportion of the population (32%) had a degree in higher education. The majority (68%) had continued the education beyond secondary education and only 12% had not completed secondary education (Figure 361). On another hand, 78% of respondents were employed and the remaining 22% were students, retirees, unemployed, people on permanent leave, and people in other non-classified situations (Figure 361).

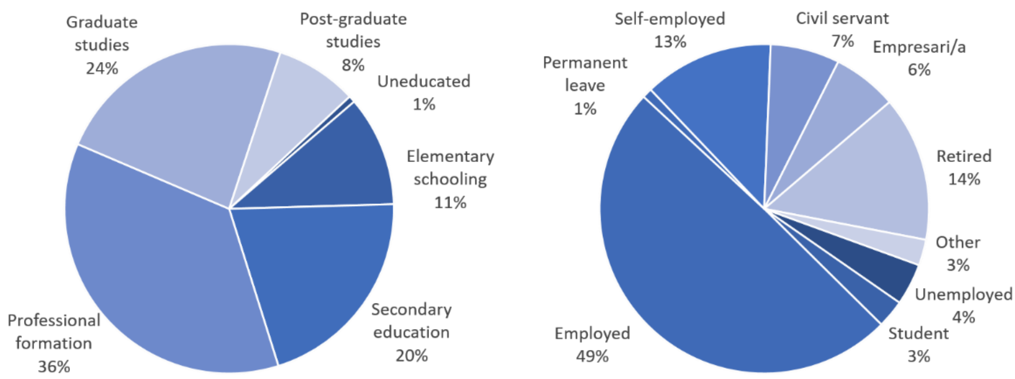


Figure 361. Left: Results of the proportion of respondents' level of education. Right: results of the proportion of working status of the respondents.

Regarding participation in groups and activities related to recreational fishing, 18% of respondents were part of a recreational fishing association, federation or entity and 11% participated in fishing competitions (Figure 362). These figures need to be taken with caution as they were likely to be overestimated because respondents who were more actively involved in the activity tended to more likely respond voluntary surveys.

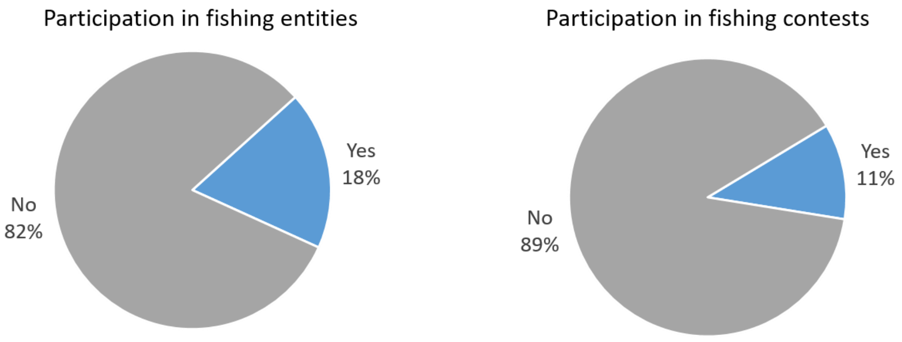


Figure 362. Left: Percentage of participation in federations, associations or entities related to recreational fishing. Right: percentage of participation in fishing competitions.

4.6 FISHING EFFORT

4.6.1 Anual fishing effort by modality

The results of fishing effort obtained in the pilot survey revealed that the activity was made up of very heterogeneous groups of practitioners. While half of the recreational coastal, boat, and submarine fishermen fished less than 15, 24, and 20 days per year, respectively, all three modalities had significant portions of practitioners that multiplied this effort by 4 (Figure 363;Table 65). The practice with the greatest fishing effort was from boats, followed by spearfishing and coastal fishing. The fishing effort data presented was, most likely overestimated, because the surveys were done during the summer, which is the busiest time for recreational fishermen (Figure 363), favoring memory and perception bias.

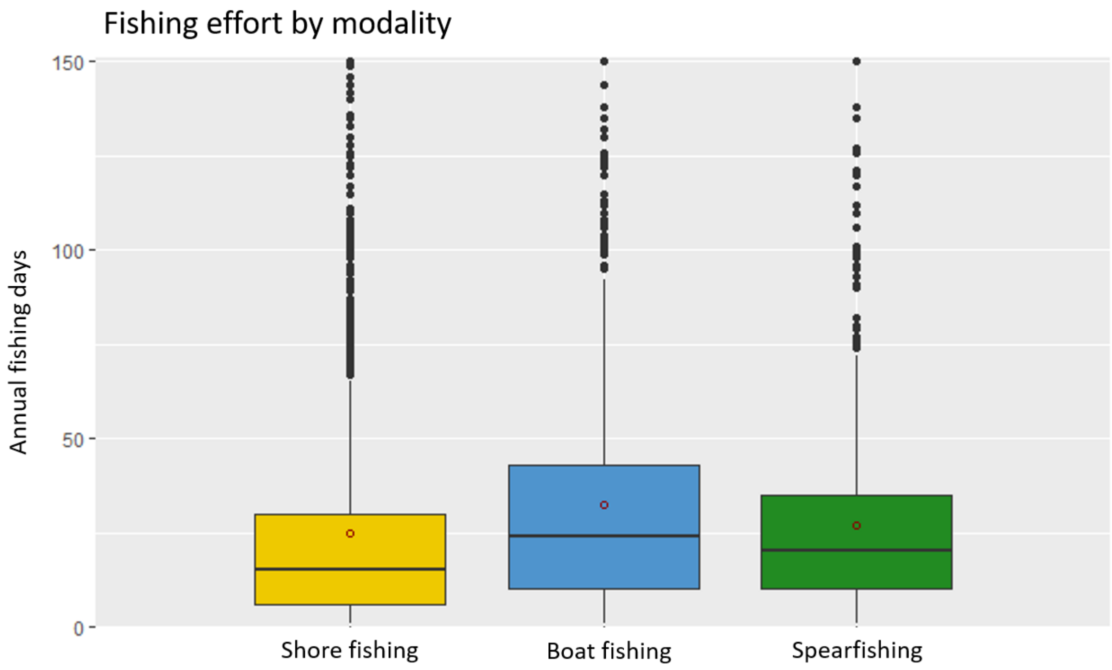


Figure 363. Box and whisker plot of effort by modality (in days * year-1). The red dot and the black horizontal stripe represent the mean and median, respectively (Table 65). The boundaries of the boxes represent the interquartile ranges. Vertical lines represent the 95% confidence interval extension. Black dots represent values that are outside the confidence interval. The upper limit of the question was set at 150 days per year.

Table 65. Median and average annual fishing departure days by modality.

	Median (days)	**Average (days)**
Shore fishing	15	24.87
Boat fishing	24	32.27
Spearfishing	20	27.08

4.6.2 Geographical distribution of effort

The effort of recreational fishing practiced from the coast was distributed heterogeneously throughout the Catalan territory. The most densely populated areas accumulated most of the fishing effort. Within these, coastal areas where the beaches abound concentrated greater efforts than those areas dominated by rocky coastlines (Figure 364).

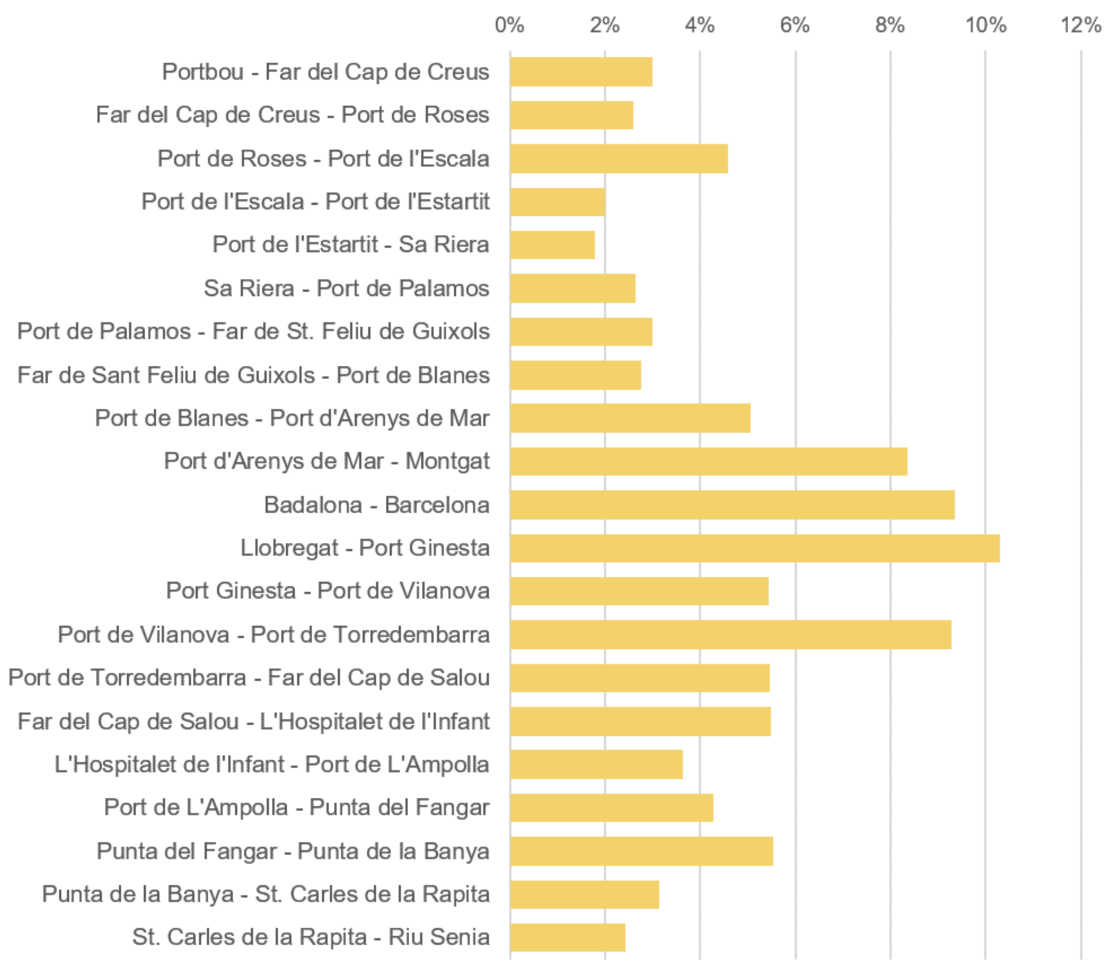


Figure 364. Proportion of total days of recreational fishing from the coast for each of the 21 areas.

The recreational fishing effort practiced from boat was distributed very differently depending on the studied port. The ports where the activity was comparatively more important were the following: St. Carles de la Ràpita, Torredembarra, Port Ginesta, Badalona, Mataró, L'Estartit and L'Escala (Figure 365). In a handful of ports and harbors (Port d'Aiguablava, Port de Llafranc, Marina Port Vell de Barcelona, Real Club Nàutic de Barcelona, Real Club Marítim de Barcelona, Port Vallcarca and Port d'Alcanar) the activity was only residual. There was no obvious relationship between fishing effort and population density.

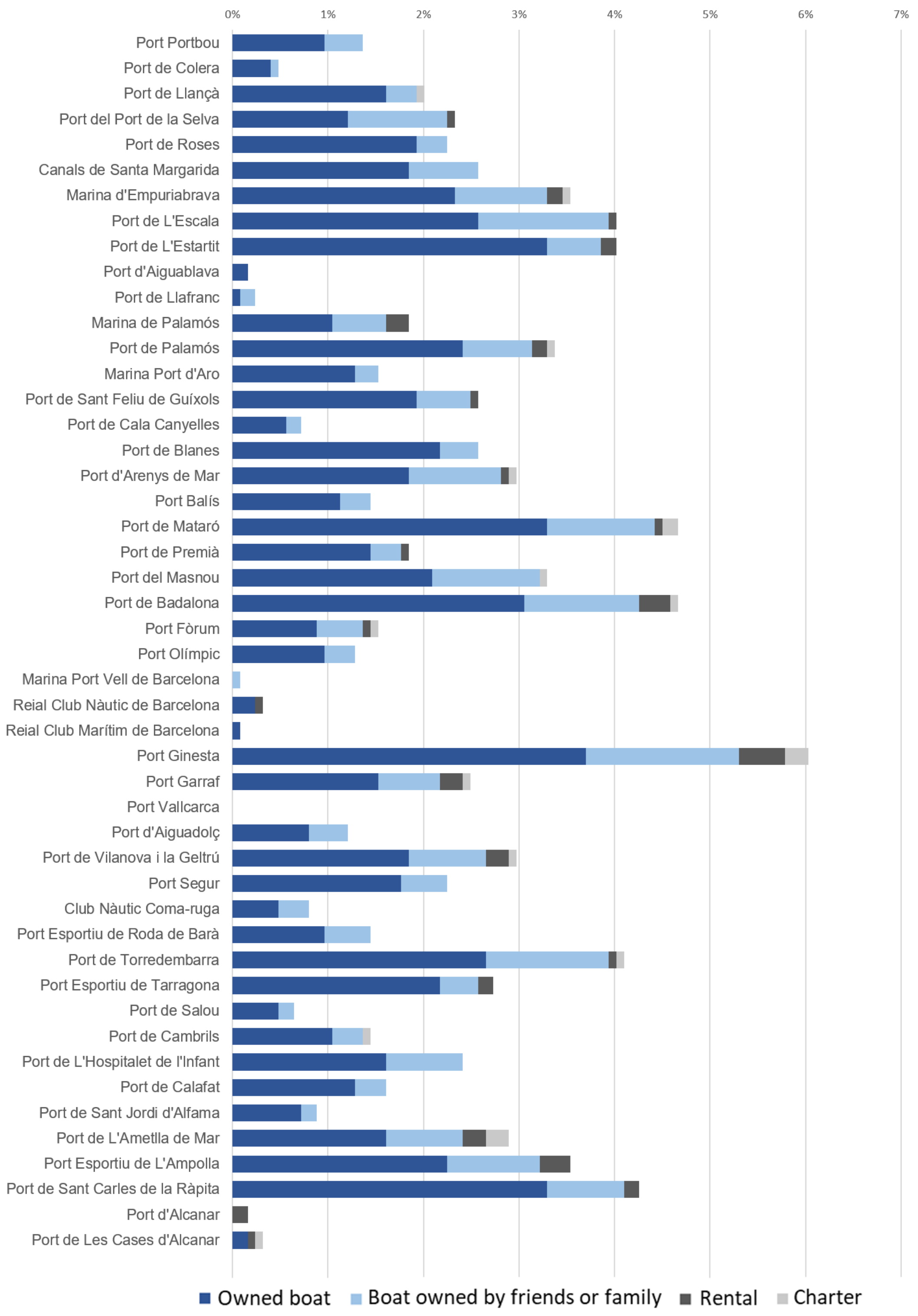


Figure 365. Proportion of total fishing days from boat corresponding to each port depending on whether the boat is owned, by friends or family, rented or chartered.

In spearfishing, the effort was mainly concentrated in rocky coastal areas and those containing submerged rocky bars (e.g. L'Ametlla de Mar, Cambrils, Torredembarra, Mataró and Vilassar de Mar; Figure 366). For this activity, the northern and central regions of Catalonia were much more important than southern Catalonia, where the activity was less important.

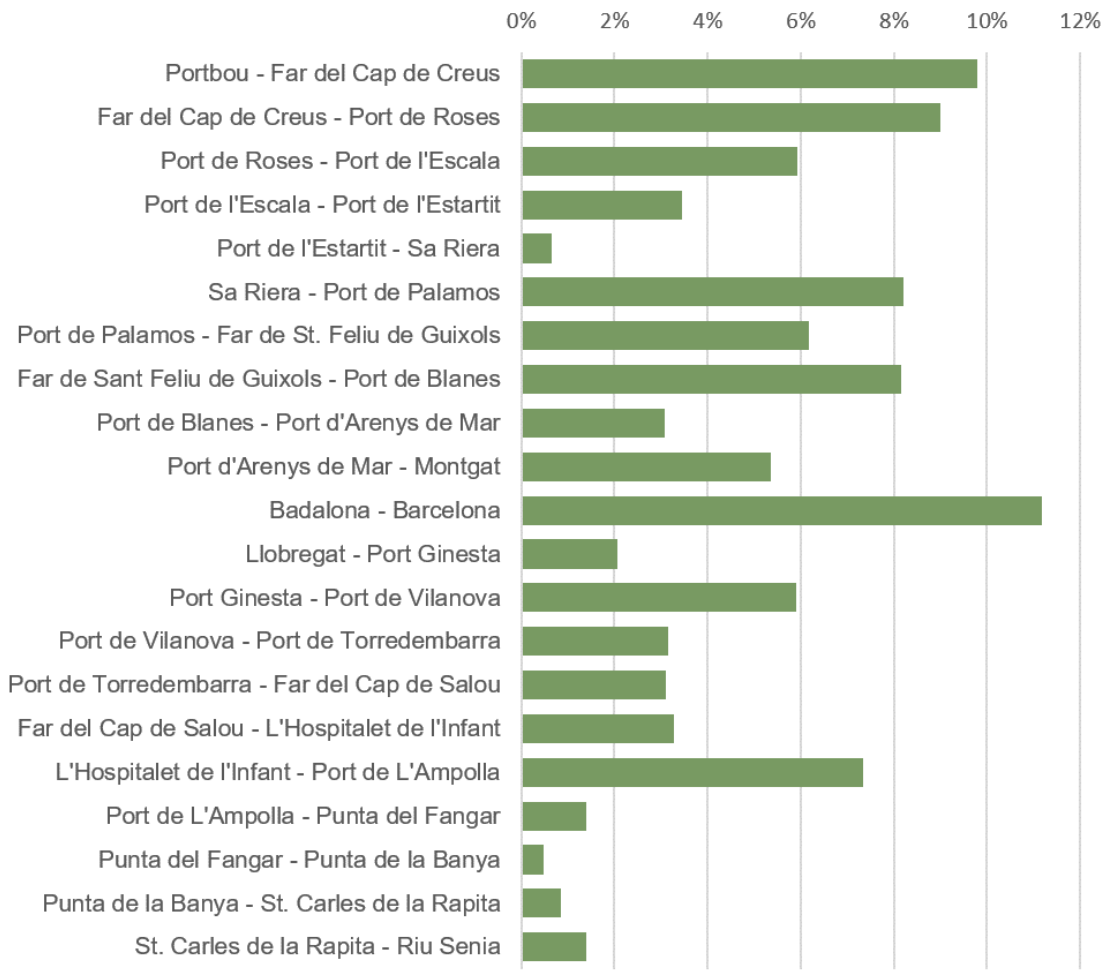


Figure 366. Proportion of total days of spearfishing for each of the 21 areas.

4.6.3 Activity temporality

In general, recreational fishing had a well defined seasonal pattern. Fishing effort peaked during summer months and declined during winter (Figure 367). Coastal fishing was the activity most influenced by seasonality, while spearfishing was comparatively the least seasonal activity.

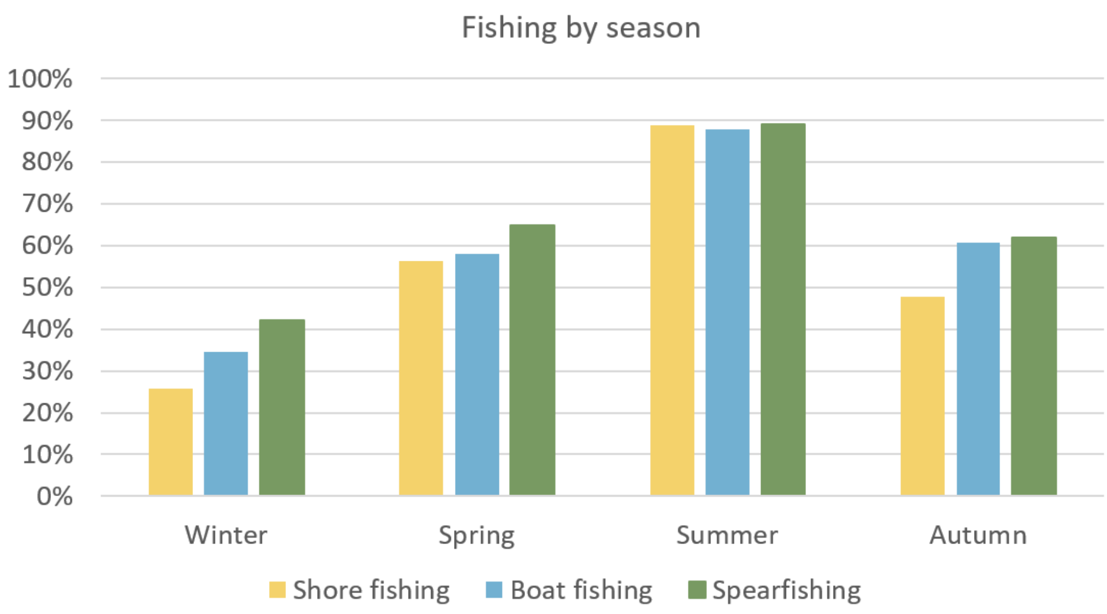


Figure 367. Percentage of coastal fishermen (yellow), boat fishing (blue) and spearfishing (green) who practice the activity at each season of the year.

All three modalities were practiced mainly on weekends. Approximately half of the users fished during the holidays, and less than 30% did so on weekdays (Figure 368).

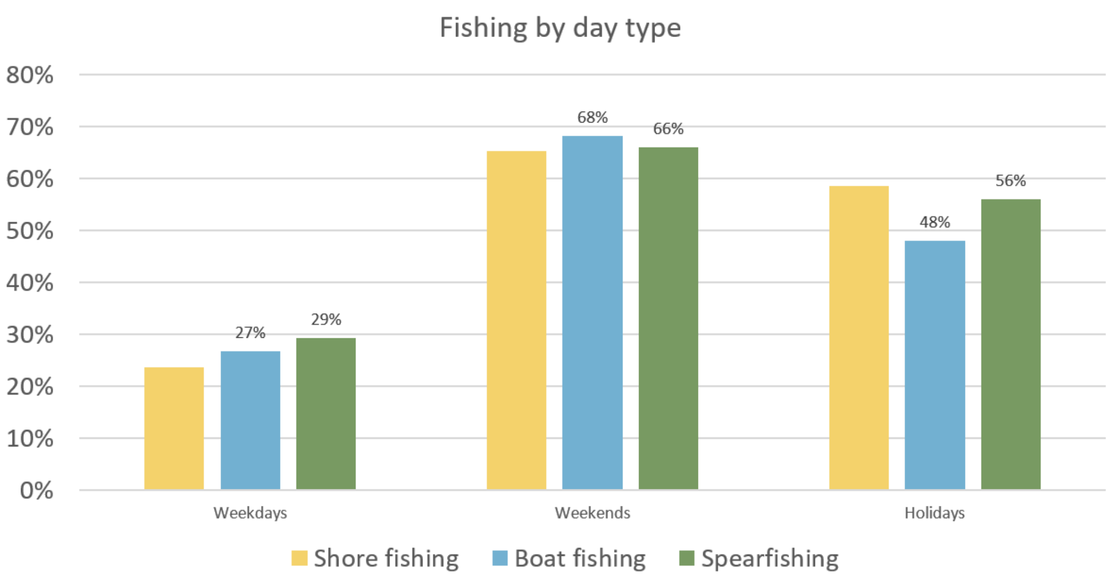


Figure 368. Percentage of coastal fishermen (yellow), boat fishing (blue) and spearfishing (green) who practice the activity on weekdays, weekends and holidays.

The most common recreational fishing schedule for coastal fishing was between afternoons and evenings (Figure 369). Boat and diving recreational fishing were mainly practiced during sunrise and morning, and secondarily, between afternoons and sunsets.

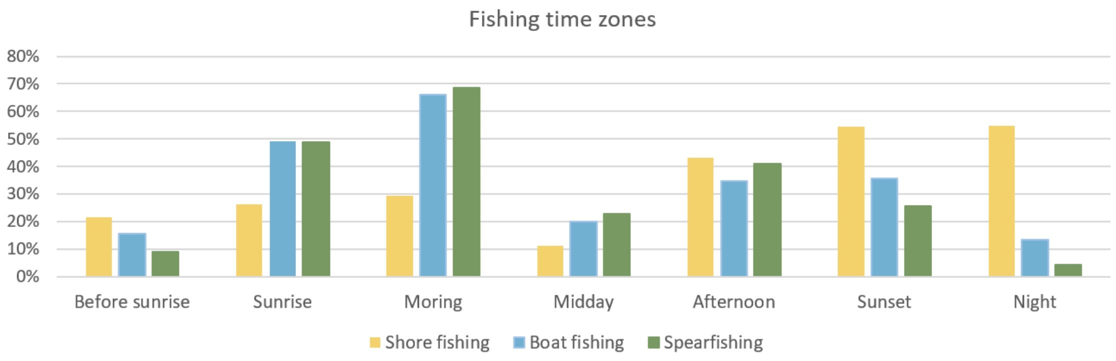


Figure 369. Percentage of coastal fishing (yellow), boat fishing (blue) and spearfishing (green) who practice the activity at different times of the day.

4.7 FISHING PRODUCTIVITY

4.7.1 Catch per Unit Effort

The catch per unit effort (CPUE) varied considerably between modalities (Figure 370) The most productive activity was fishing from boat (1,03 kg * day^{-1}), followed by spearfishing (0,87 kg * day^{-1}) and coastal fishing (0,53 kg * day^{-1}). Coastal fishing productivity was comparatively low with 50% of fishermen catching an average of 0,3 kg * day^{-1} or less.

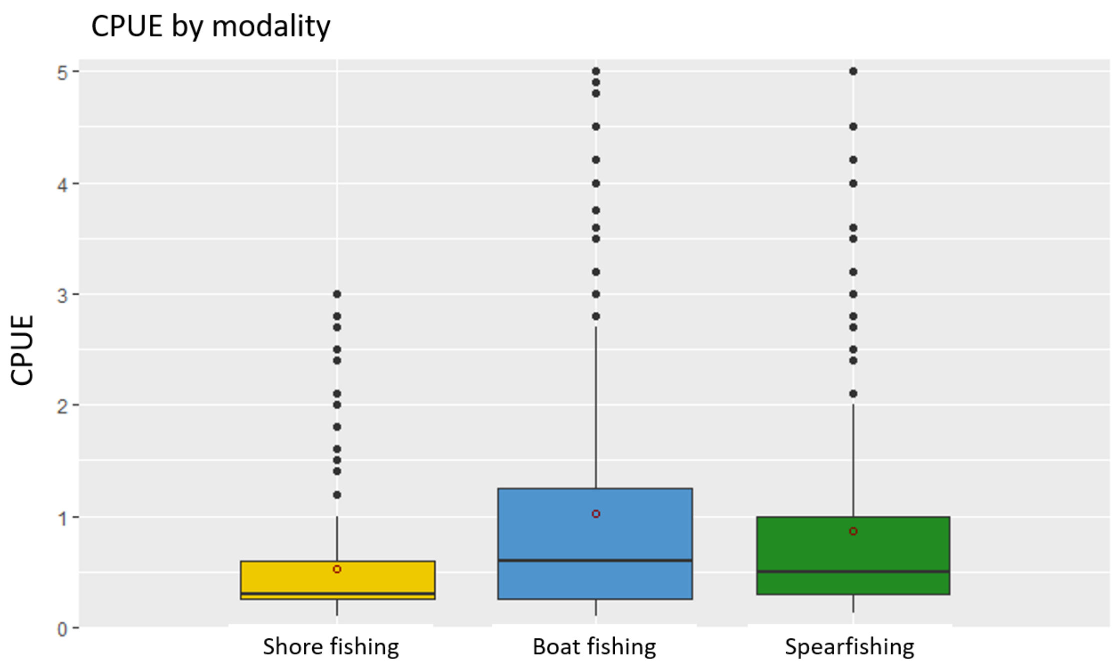


Figure 370. Box and whisker plot CPUE by modality (in kg * day^{-1}). Values are calculated as the product of weigth of the catch on successful fishing days by the percentage of fishing days. The red dot and the black horizontal line represent the mean and the median, respectively (Table 66. Median and mean of the CPUE for each recreational fishery modality.). The boundaries of the boxes represent the interquartile ranges. Vertical lines represent the 95% confidence interval extension. Black dots represent values that are outside the interval of confidence. Extreme values (2.5% upper and lower) were removed prior to analysis.

Table 66. Median and mean of the CPUE for each recreational fishing modality.

	Median (kg/day)	**Average (kg/day)**
Shore fishing	0.3	0.53
Boat fishing	0.6	1.03
Spearfishing	0.5	0.87

4.7.2 Distribution of fishing productivity

The average productivity of coastal recreational fishing according to area had small variations (Figure 371). The average values of CPUE varied between the minimum of 0,4 kg * fisherman-1 * day-1 at the mouth of the Ter river (area between L'Estartit and Sa Riera) and 0,6 kg * fisherman-1 * day-1 on the Costa

Daurada (area from L'Hospitalet de l'Infant to L'Ampolla). No relationship was observed between system productivity (e.g., eutrophication of areas influenced by river mouths) and recreational catch productivity.

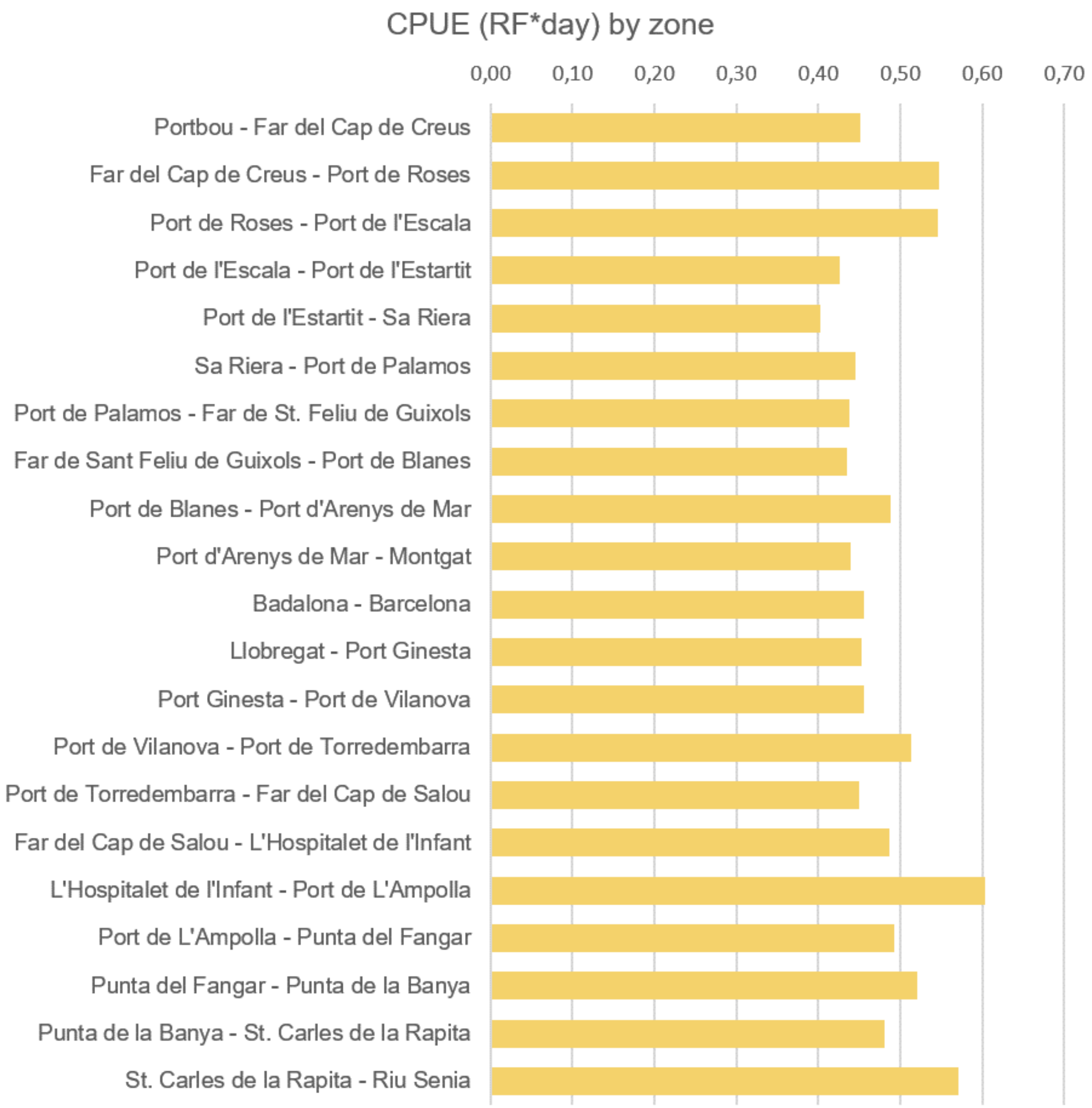


Figure 371. Average CPUE in each of the 21 areas classified for recreational coastal fishing.

The productivity of fishing from boat varied between 0,71 kg * fisherman^{-1} * day^{-1} in Port of L'Escala and 1,53 kg * fisherman^{-1} * day^{-1} in Port of Cambrils. Which allowed to observe an increasing productivity southwards (Figure 372).

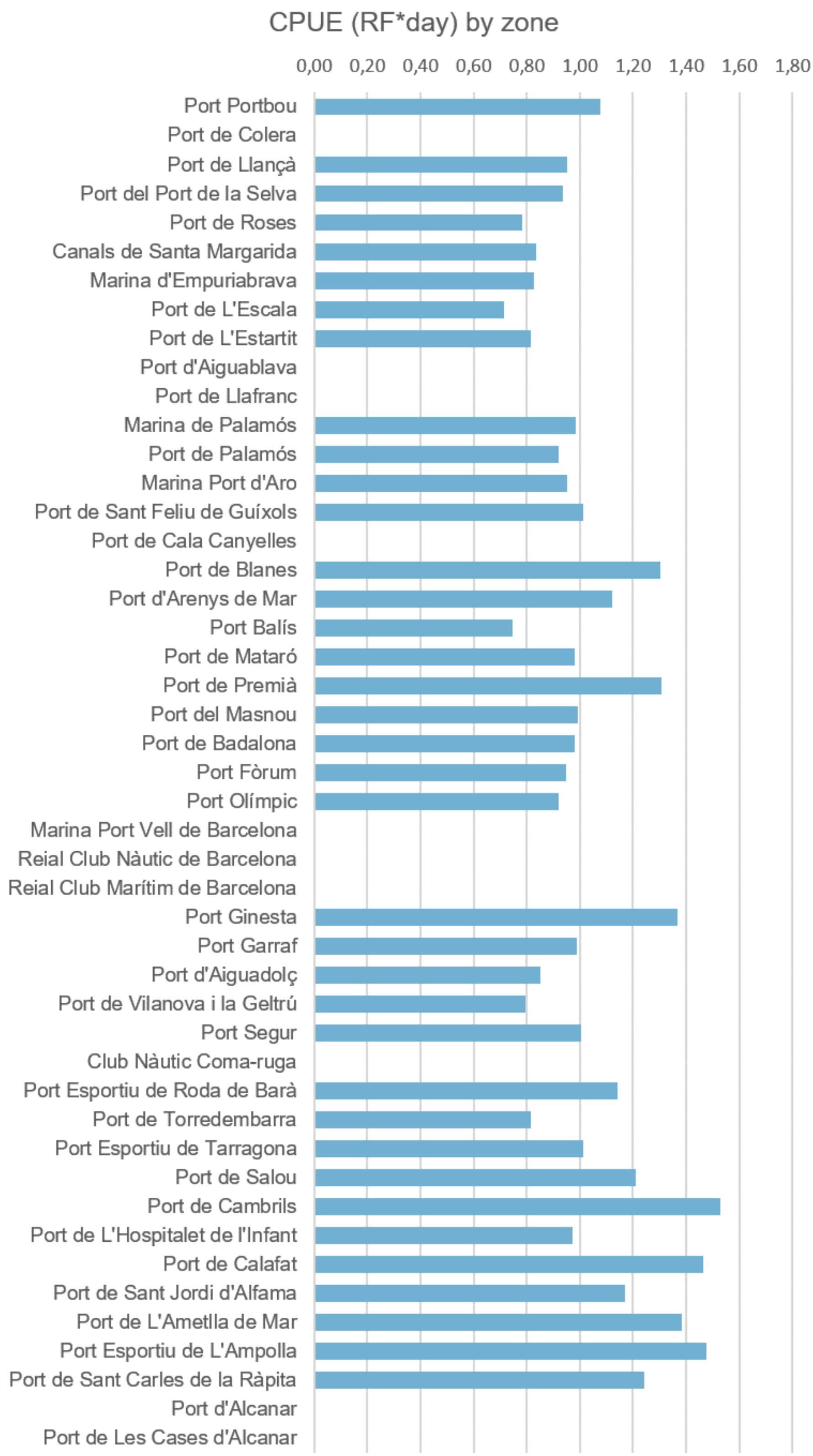


Figure 372. Average CPUE in each of the 21 areas classified for fishing from boat. Ports with less than 10 valid CPUE responses were not considered.CPUE in each of the 21 areas classified for recreational coastal fishing.

The productivity of spearfishing varied between a minimum of 0,58 kg * fisherman^{-1} * day^{-1} at the mouth of the Ter river (coinciding with the minimum productivity of coastal fishing), and a maximum of 1,11 kg * fisherman^{-1} * day^{-1} on the coasts of Barcelonès (from Masnou to Barcelona; Figure 373). An expected relationship between productivity and system eutrophy / oligotrophy was not observed.

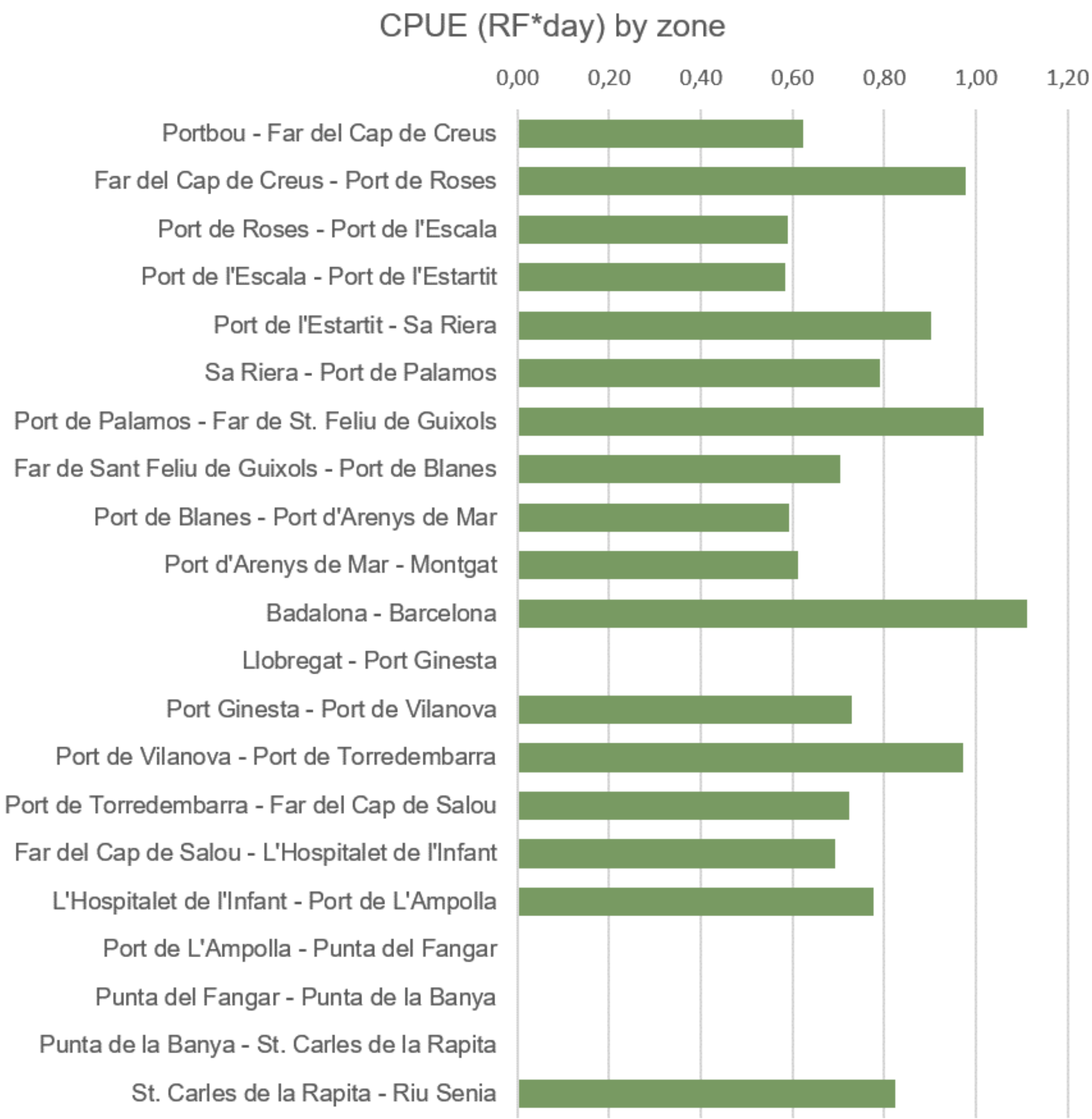


Figure 373. Average CPUE in each of the 21 areas classified for spearfishing. Areas with less than 10 valid CPUE responses were not considered.

4.8 RECREATIONAL FISHING TOTAL CATCH

4.8.1 Total annual catch by modality

The total annual catch had been calculated individually for each recreational fisherman based on their CPUE and effort values. The total annual catch was enormously variable: small proportions of practitioners had very high catches (up to 125 and 150 kg per year depending on the modality), whereas the majority of fishermen's catches were an order of magnitude lower (Figure 374). Half of the fishermen of the three fishing modalities had annual catches three times lower than the average of their modality (Table 67). Extreme values (2,5% lower and higher) were excluded from the total catch analyses. To calculate the total volume of tonnes caught per modality, the average annual total catch in each modality was extrapolated to the total volume of activity. The activity with the greatest impact on fishery resources by weight was fishing from a boat (760 t per year), followed by coastal fishing (508 t) and spearfishing (98 t). Neither the mean values impacted by each of these modalities nor the composition of the catches were the same (Figure 380), so these results should be treated as those of three different fisheries.

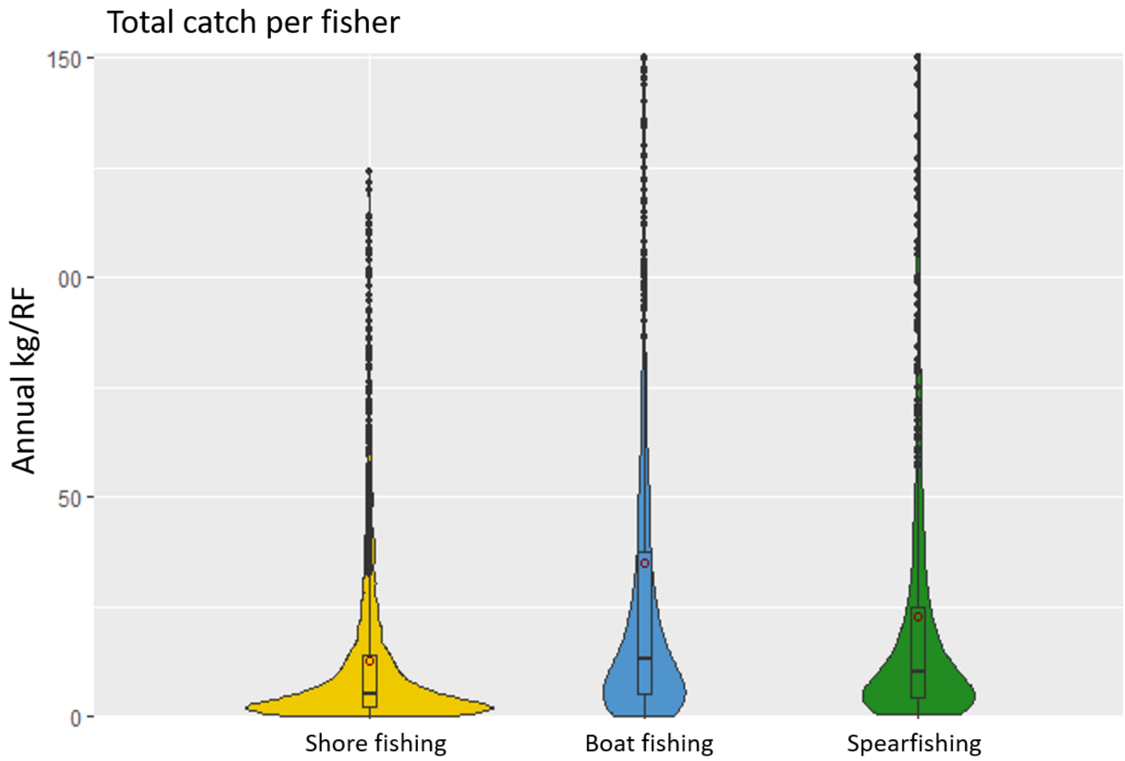


Figure 374. Violin plot with frequency distribution of total annual catch data by recreational fisherman and modality (in kg * year^{-1}) with and overlaped box and whisker plot. The red dot and the black horizontal stripe represent the mean and median, respectively (Table 67). The boundaries of the boxes show the interquartile ranges. Vertical lines represent the 95% confidence interval extension. Black dots represent values that are outside the interval of confidence. Extreme values (2.5% upper and lower) were removed prior to analysis.

Table 67. Median and average of the total annual catch per recreational fisherman, and total tons caught per modality.

	Median (kg/year*RF)	Average (kg/year*RF)	Total catch (t)
Shore fishing	5	15.82	508
Boat fishing	14	41.81	760
Spearfishing	10	27.66	98
Total			1.366

4.8.2 Distribution of total annual catch

The total annual catch was distributed along the Catalan coast according to the fishing effort dedicated to each area, for each modality (Figure 375, Figure 376 and Figure 377).

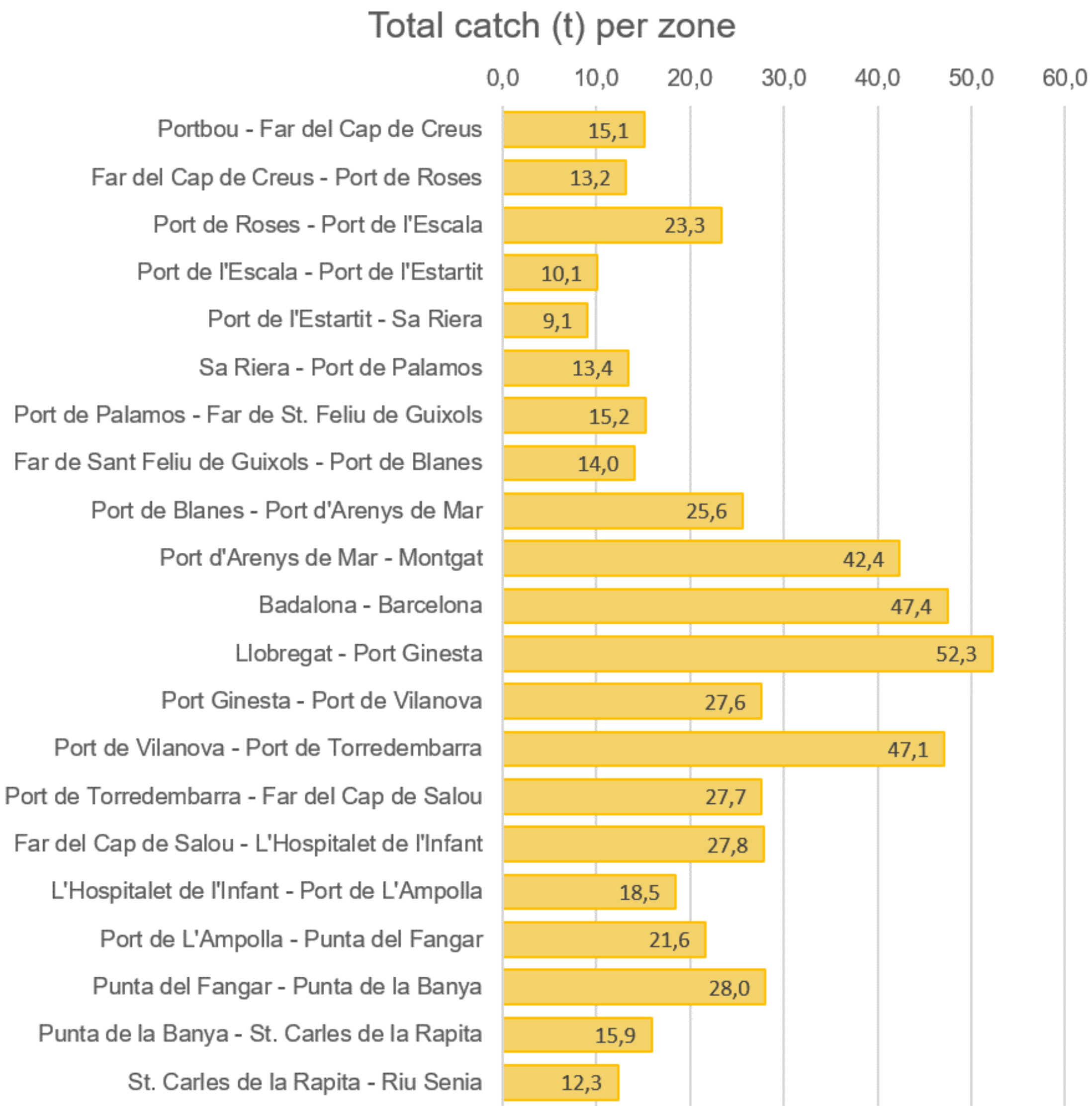


Figure 375. Distribution of total annual catch by area (in tonnes) for coastal fishing.

To calculate the distribution of the total catch of fishing from boat, for all those ports from which more than one area can be easily accessed (eg ports delimiting zones), the catch was evenly distributed among the areas.

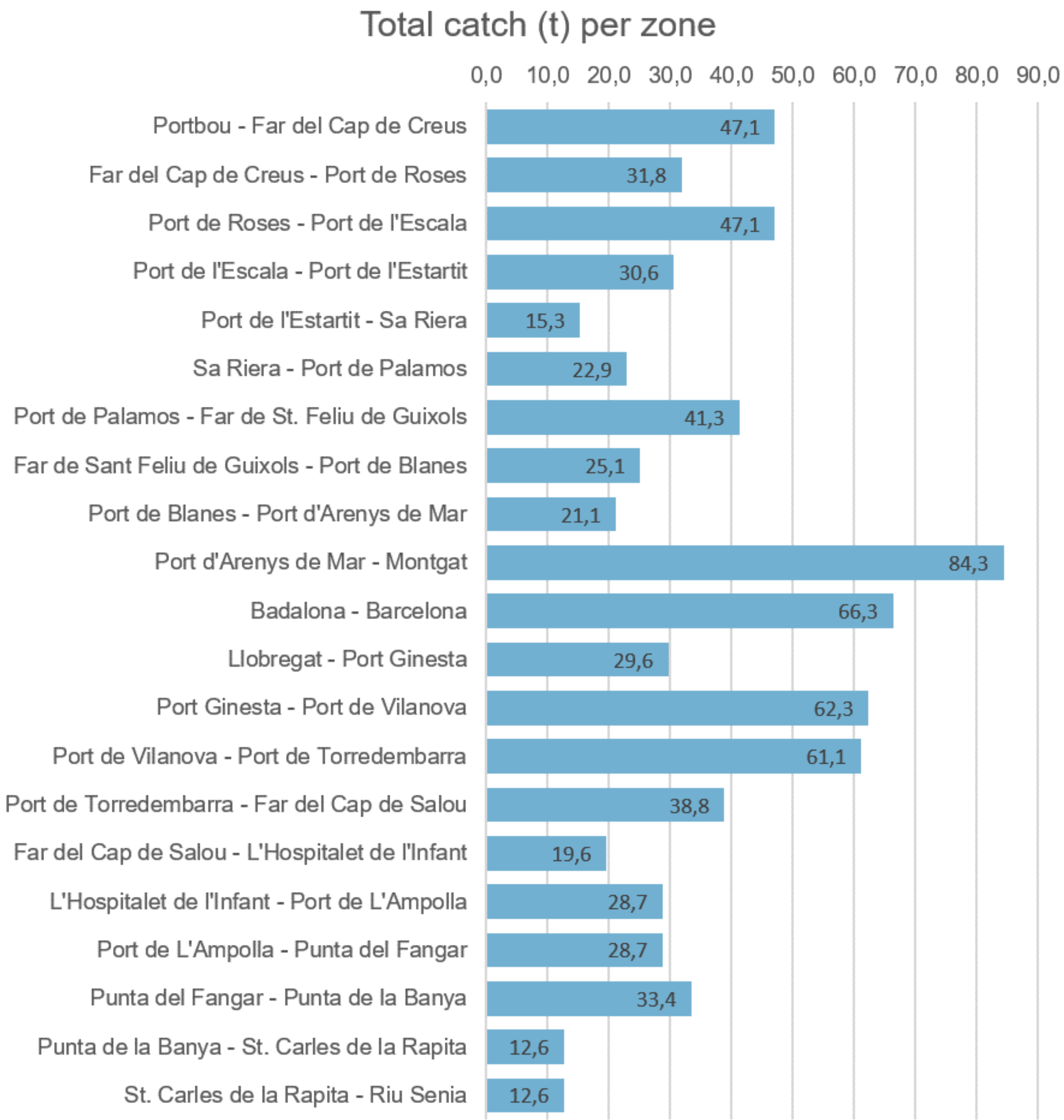


Figure 376. Distribution of total annual catch by area (in tonnes) for boat fishing.

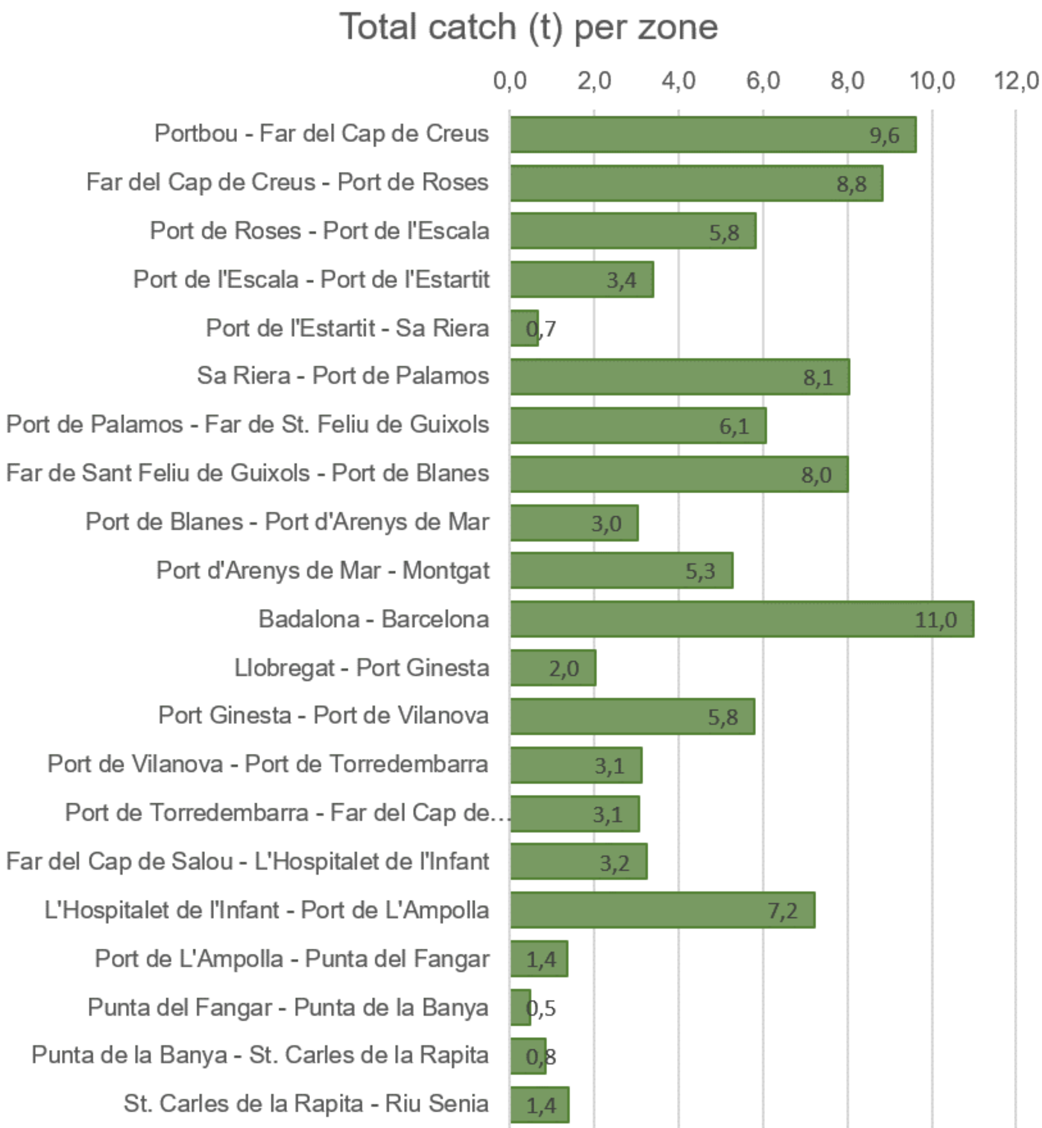


Figure 377. Distribution of total annual catch by area (in tonnes) for spearfishing.

4.8.3 Fishing impact on the territory

The areas into which the Catalan coast was divided, covered extensions with different sizes. The intensity of the fishing impact on the territory must take into account the total catch per area, weighted by the kilometers of coastline in each area. In the case of the fishing impact on coastal resources, the fishing intensity varied between 0,33 kg * year^{-1} per km in Fangar Bay to 2,49 kg * year^{-1} per km in Llobregat Delta (Figure 378). The impact per kilometer of coastal fishing was greater than that of spearfishing throughout the Catalan coast. In the areas dominated by the rocky coast of Cap de Creus, the areas of Costa Brava from

Sa Riera to the port of Palamós and from the port of St. Feliu de Guíxols to the port of Blanes, spearfishing had similar impact values to coastal fishing.

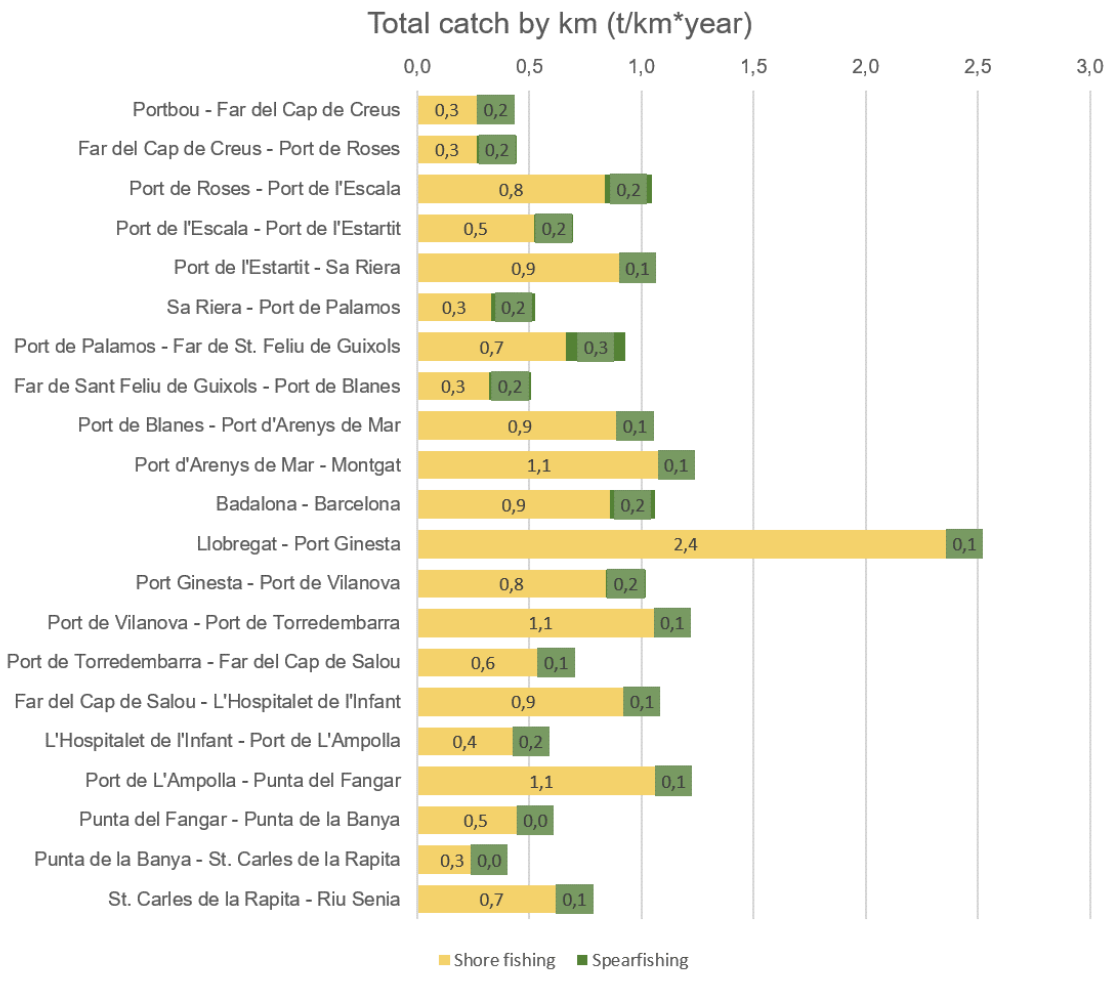


Figure 378. Annual fishing impact per kilometer of coastline from coastal fishing (yellow) and spearfishing (green).

Despite fishing from a boat includes a variety of fishing techniques on the marine bottoms, much of the activity took place on the surface or in the water column furthest from shore (Figure 379). The areas with the highest fishing intensity coincided with those that contained, or were close to, ports and harbors where recreational fishing activity was most relevant (i.e. Roses, L'Escala, L'Estartit, Palamós, Mataró, Badalona, Port Ginesta and Torredembarra).

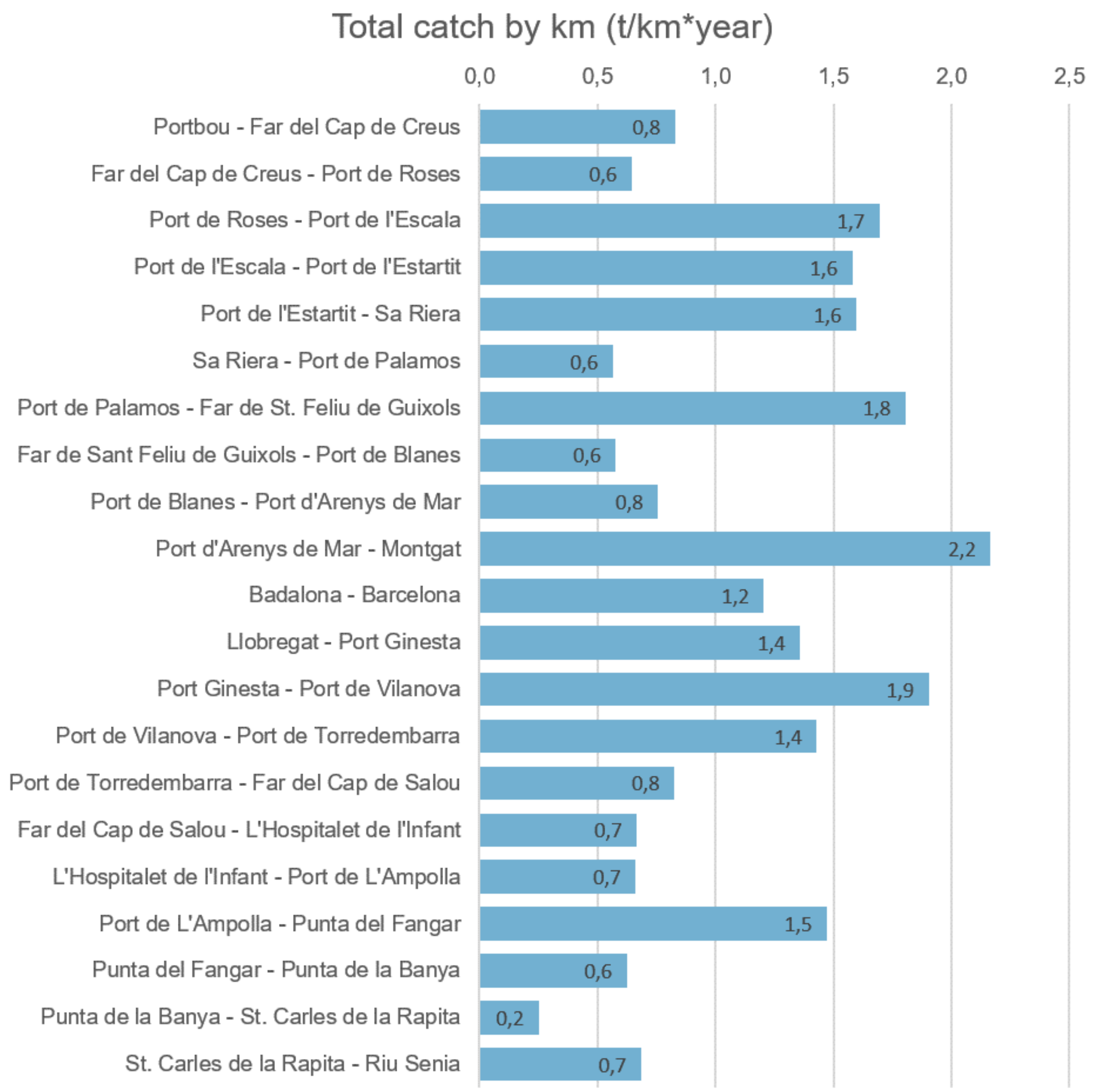


Figure 379. Annual fishing impact per kilometer of coastline from boat fishing.

4.9 CATCH COMPOSITIONS

The species caught by each fishery modality in each region had been estimated from the weight of catches reported during the last fishing trip (Figure 380). The fact that the survey was conducted from June 14 to August 25 means that the answers only represented the catches from late spring to mid-summer. Catches recalled and reported in online surveys were subject to memory and perception biases, tending to over-represent the most attractive catches at a fishing or culinary level. In this sense, it stood out the abundance of sparids (gilthead bream, seabream, salema, saddled seabream, sand steenbras, ...) in the catches of coastal fishing and the absence of serranids and labrids among its main catches. Similarly, the most quoted summer catches (tunas) were abundant in boat fishing wereas no catches of important winter species, such as cuttlefish, were observed. Underwater fishing was dominated by catches of common octopus, a species that can be easily caught in late spring and summer.

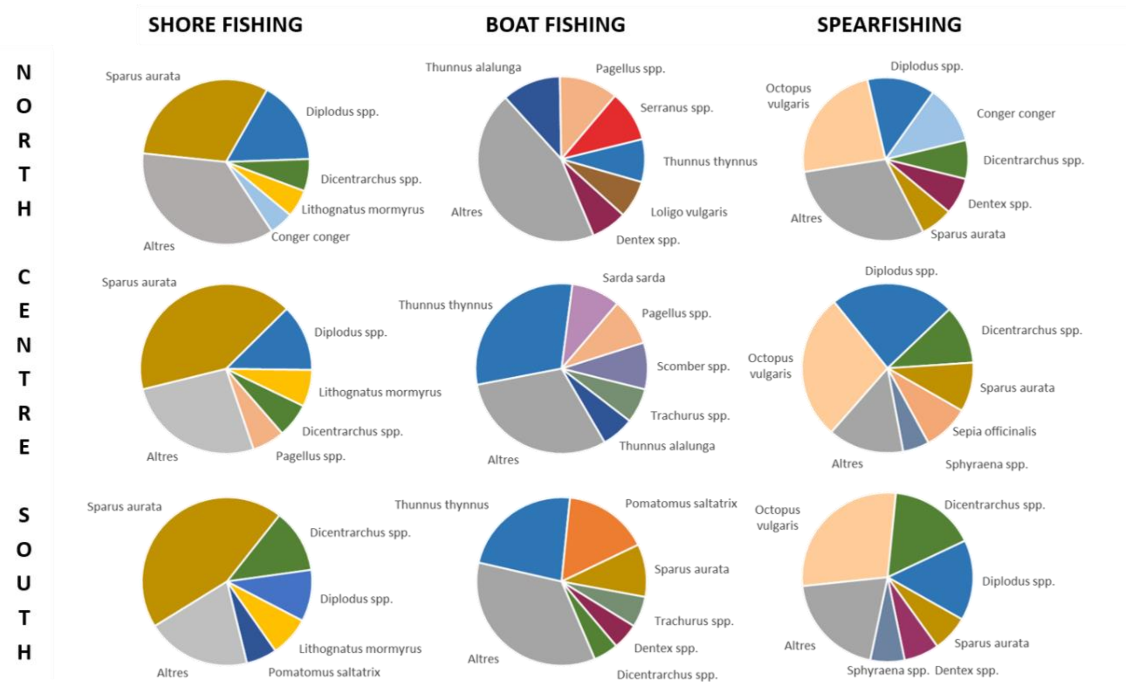


Figure 380. Composition of catches as weight percentage of the main species caught by region and modality.

4.10 RECREATIONAL FISHING ECONÒMIC IMPACT

The analysis of the economic impact of recreational fishing was estimated based on fishing suplies expenses, travel, food, insurance, and subscriptions associated with the activity. The costs of the activity varied considerably when it was on a boat, so coastal fishing and boat fishing were analyzed separately. In the case of expenses associated with boats, the fuel costs of the boat on fishing days, the boat maintenance costs, and those of ports and moorings were considered. The extreme values (2,5% upper and lower) of each response were removed from the analyses.

4.10.1 Expenses of Recreational Fishing Initiated From Land

The average daily expenditure on fishing materials for coastal recreational fishing (bait, threads, weights, floats, etc.) was € 13,67. Considering the costs of spearfishing initiated from land, this value was € 3,55. Other average daily expenses related to the activity (transport, parking and meals) of the two modalities were similar (average of € 12,27 and € 1,23, respectively).

Individual daily costs were multiplied by each respondent's annual effort values to obtain an individual annual spending value. The average annual expenses accumulated on fishing equipment purchased on a daily basis was € 342,96 for inshore fishing and € 105,65 for spearfishing. Other daily expenses added to the annual value were € 645,23 and € 483,22 for coastal fishing and diving, respectively (Figure 381; Table 68).

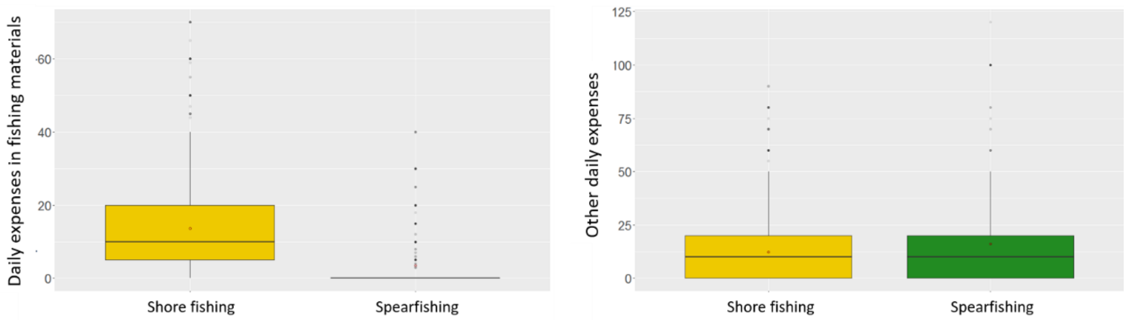


Figure 381. Box and whisker plot of daily expenses (in €) on fishing supplies and other costs related to coastal and diving fishing activities initiated from the coast. The red dot represents the mean, the black horizontal bar is the median. The boundaries of the boxes represent the interquartile ranges. Vertical lines are the 95% confidence interval extension. Black dots represent values that are outside the interval of confidence.

Table 68. Average daily and annual expense on materials for daily use (bait, thread, weights, floats, etc.…), and other expenses related to coastal and dibing fishing activites initiated from the coast (transport, parking, meals, etc…).

	Shore fishing		Spearfishing	
Expenses	**Daily average**	**Annual average**	**Daily average**	**Annual average**
Materials	13.67 €	342.96 €	3.55 €	105.65 €
Other expenses	12.27 €	302.27 €	16.23 €	377.57 €
Total	**25.94 €**	**645.23 €**	**19.78 €**	**483.22 €**

Annual expenses for land-based activities included fishing materials (such as fishing rods, spearguns, clothing, etc.), fishing-motivated trips (including travel, transportation, and lodging), and other expenses related to the activity (i.e. insurance, medical certificates, subscriptions, maps, and mobile apps). While expenses on coastal and underwater fishing equipment was similar (average of € 161,26 and € 170,92 per year, respectively), expenses on travelling (€ 117,86 and € 305,31) and other related activity costs (€ 18,63 and € 60,51 respectively) differed significantly (Figure 382 and Table 69).

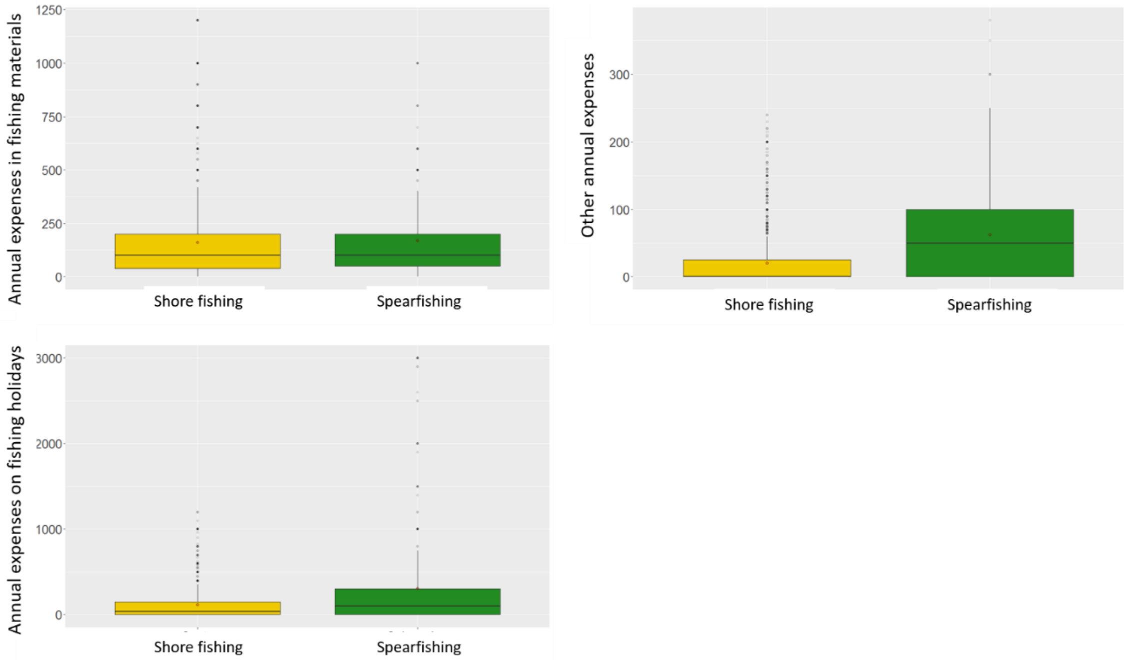


Figure 382. Box and whisker plot of annual expenses (in €) on occasional purchase fishing supplies (upper left), fishing-motivated trips (upper right) and other activity-related costs (lower left) for fishing from the coast and spearfishing initiated from land. The red dot represents the mean, the black horizontal bar is the median. The boundaries of the boxes are the interquartile ranges. Vertical lines represent the 95% confidence interval extension. Black dots represent values that are outside the interval of confidence.

Table 69. Average annual expenses on occasional purchasing materials (fishing rods, spearguns, clothing, etc.…), fishing-motivated travel (including accommodation, transportation, and meals), and other expenses related to the activity (subscriptions to magazines, license, apps, insurance, etc.…) of fishing and spearfishing initiated from the coast.

Average annual expenses	Shore fishing	Spearfishing
Long-lived materials	161.26 €	170.92 €
Fishing holidays	117.86 €	305.31 €
Other expenses	18.63 €	60.51 €
Total	**297.75 €**	**536.74 €**

4.10.2 Expenses of Recreational Fishing Initiated From a Boat

Regarding recreational fishing (both boat and diving) initiated from a boat, daily expenses included materials for the daily practice of the activity (bait, threads, weights, floats, etc.), fuel, and other expenses related to develop the activity (such as transportation, parking, and meals). The values of the daily averages (Figure 383) were multiplied by the individual annual effort of each fisherman to obtain individual annual values (Table 70).

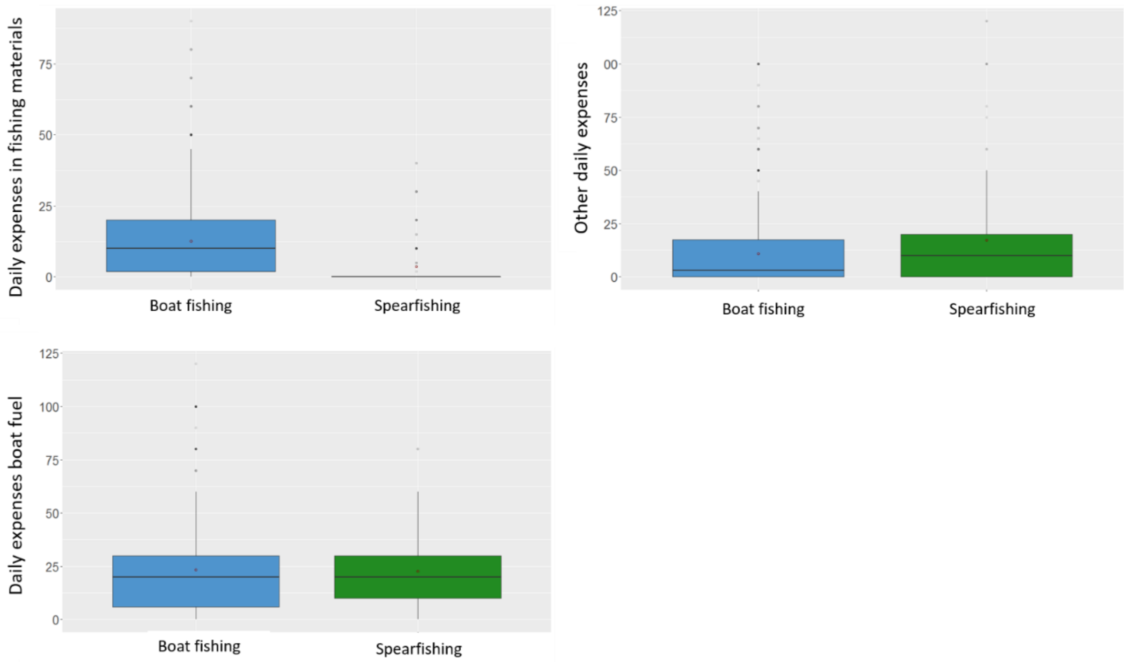


Figure 383. Box and whisker plot of daily expenses (in €) on fishing equipment (upper left), boat fuel (upper right) and other activity-related costs (lower left) for boat fishing and spearfishing initiated from a boat. The red dot represents the mean, the black horizontal bar is the median. The boundaries of the boxes represent the interquartile ranges. Vertical lines represent the 95% confidence interval extension. Black dots represent values that are outside the interval of confidence.

Table 70. Average daily and annual expenses on fishing materials (bait, wires, weights, floats, etc.…), boat fuel and other expenses (transport, parking, meals, etc.…) related to the fishing activity of boat and spearfishing initiated from boat.

	Boat fishing		Spearfishing	
	Daily average	**Annual average**	**Daily average**	**Annual average**
Materials	12.61 €	447.96 €	3.57 €	98.19 €
Boat fuel	23.44 €	812.62 €	22.72 €	831.94 €
Other expenses	10.92 €	372.75 €	17.26 €	592.00 €
Total	**46.97 €**	**1,633.33 €**	**43.55 €**	**1,522.13 €**

The annual expenses of recreational fishing using a vessel () included expenses on occasionally purchased fishing supplies (fishing rods, reels, spearguns, clothing, etc.), port and mooring costs, boat maintenance, fishing-motivated trips (including travel, meals and lodging) and other activity-related expenses (such as insurance, medical certificates, subscriptions, maps, and mobile apps). Expenses related to boats (ports and moorings along with boat maintenance) were weighted by the individual percentage of boat use intended for recreational fishing. In cases where this value was not declared, the average use of the vessel was applied (62,5% for vessel fishing and 74,3% for spearfishing).

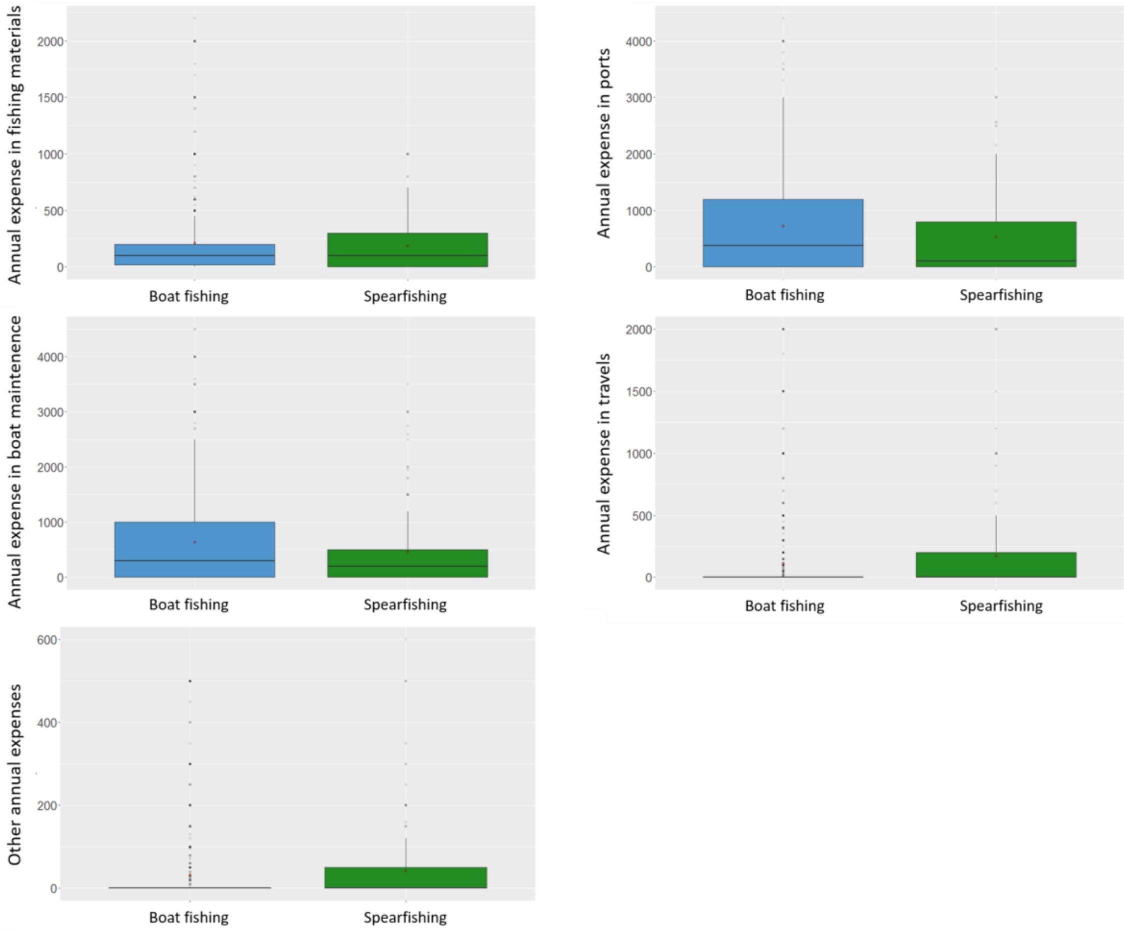


Figure 384. Box and whisker plot of annual expenses on occasional purchase fishing supplies (upper left), ports and moorings (upper right), boat maintenance (center left), travel (center right), and other expenses related to fishing (lower left) for fishing activities initiated from a boat including spearfishing. The boundaries of the boxes represent the interquartile ranges. Vertical lines represent the 95% confidence interval extension. Black dots represent values that are outside the interval of confidence.

Table 71. Average annual expenses on occasional purchase fishing supplies, port and mooring costs, boat maintenance, fishing-motivated trips and other expenses related to fishing and spearfishing initiated from boat.

Average annual expenses	Boat fishing	Spearfishing
Long-lived materials	211.04 €	189.94 €
Port expenses	487.57 €	398.06 €
Boat maintenence	419.75 €	347.11 €
Fishing holidays	111.40 €	176.07 €
Other expenses	31.80 €	42.65 €
Total	**1,261.56 €**	**1,153.83 €**

For those who begun their fishing activity onboard, 4,5% of recreational boaters and 1,8% of diving fishermen, did so from a rented boat. In addition, 1,4% of recreational boaters occasionally used charter services. Boat rental users spent an annual average of € 604,9 and € 894,3 respectively, on rentals (Figure 385 Table 72). Weighted by the total number of users of each modality, Figure 385 plots € 27,2 and € 12,5 per year for boat fishing and spearfishing, respectively. The average annual charter costs for its users was € 861,2 (Figure 385; Table 72); weighted by the total number of boat fishing practitioners, with an average expense per practitioner of € 15,5 on charters. Extreme values (2,5% upper and lower) were removed from the analysis.

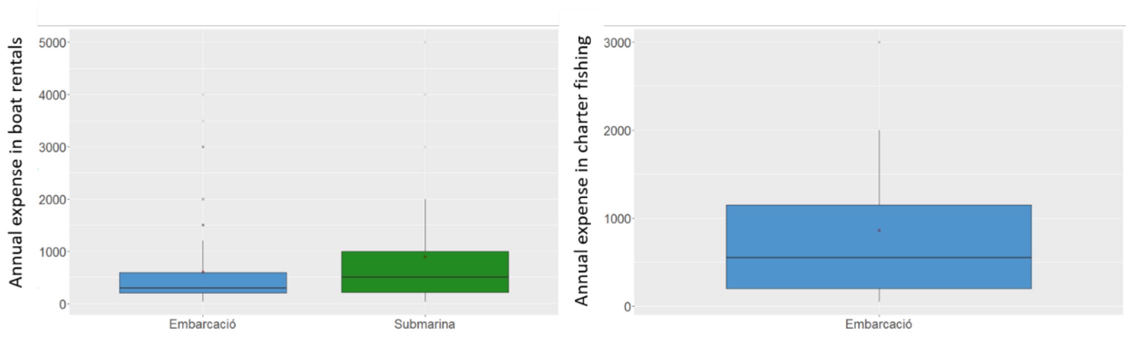


Figure 385. Box and whisker plot of annual boat rental costs (left) and charter services (right). The boundaries of the boxes represent the interquartile ranges. Vertical lines represent the 95% confidence interval extension. Black dots represent values that are outside the interval of confidence.

Table 72. Average annual and daily expenses on boat rentals and charter services for users, and for recreational fishermen and sperafishing initiated from a boat.

Expense	Boat fishing		Spearfishing	
	Annual average (users)	Annual average (total)	Annual average (users)	Annual average (total)
Boat rentals	604.9 €	27.2 €	894.3 €	12.5 €
Charter fishing	861.2 €	15.5 €		

4.10.3 Total annual expenses by modality

The average annual cost of each type of expenses was extrapolated to the group of recreational fishermen in each modality, considering whether the activity starts from land or from a boat in the case of spearfishing.

The highest cost of coastal fishermen accounted for the materials purchased prior to fishing trips (€ 342,96 per year) and the expenses related to trip logistics (€ 302,27 per year; Table 73). The average total annual costs per person was € 942,98, which, extrapolated to the total number of users of the activity, added up to an annual economic impact of € 30M. The Teble shows all the expenses indirectly related to the activity (travel, meals, subscriptions ...). The annual total costs just considering the essential materials needed to carry out the activity was € 16,2M (Table 77).

Table 73. Average annual expenses per person and total annual expenses of all recreational fishermen who fish from the coast.

Shore fishing	Average expenditure by RF	Total annual expenditure
Materials of daily use	342.96 €	11,004.24 €
Other daily expenses	302.27 €	9,698.66 €
Long-lived materials	161.26 €	5,174.20 €
Fishing holidays	117.86 €	3,781.67 €
Other annual expenses	18.63 €	597.76 €
Total	**942.98 €**	**30,256.54 €**

When fishing from boat, the most significant cost was the vessel's fuel (averaging € 812,62 per year), followed by port and mooring costs (€ 487,57 per year) and expenses on purchased materials prior to fishing trips (€ 447,96 per year; Table 11). The total annual costs on fishing materials was € 12M per year, and the total annual expenses, including indirect costs, were € 53,4M (Table 77).

Table 74. Average annual expenses per person and total annual expenses of all recreational fishermen who fish from a boat.

Boat fishing	Average expenditure by RF	Total annual expenditure
Materials of daily use	447.96 €	8,146.78 €
Boat fuel	812.62 €	14,778.63 €
Other daily expenses	372.75 €	6,778.98 €
Long-lived materials	211.04 €	3,838.06 €
Port expenses	487.57 €	8,867.12 €
Boat maintenance	419.75 €	7,633.74 €
Fishing holidays	111.40 €	2,025.96 €
Other annual expenses	31.80 €	578.33 €
Boat rentals	27.15 €	493.81 €
Charter fishing	15.46 €	281.21 €
Total anual	**2,937.50 €**	**53,422.60 €**

The most important expenses of spearfishing initiated from land accounted for travelling, parking and meals (average of € 377,57 per year) and in trips motivated by fishing (€ 305,31 per year; Table 75). The total annual expense related to the activity was € 2,5M (Table 77).

Table 75. Average annual expenses per person and total annual expenses of the group of recreational fishermen who practice spearfishing initiated from land.

Spearfishing from land	Average expenditure by RF	Total annual expenditure
Materials of daily use	105.65 €	260.68 €
Other daily expenses	377.57 €	931.61 €
Long-lived materials	170.92 €	421.72 €
Fishing holidays	305.31 €	753.32 €
Other annual expenses	60.51 €	149.30 €
Total	**1,019.96 €**	**2,516.63 €**

In spearfishing initiated from boat, the highest expense accounted for the boat's fuel (averaging € 831,94 per year), followed by costs related to the logistics of the departure (€ 592; Table 76). The total annual expense related to the activity was € 2,9M.

Table 76. Average annual expenditure per person and total annual expenses of the group of recreational fishermen who practice spearfishing initiated from a boat.

Spearfishing from boat	Average expenditure by RF	Total annual expenditure
Materials of daily use	98.19 €	106.12 €
Boat fuel	831.94 €	899.13 €
Other daily expenses	592.00 €	639.81 €
Long-lived materials	189.94 €	205.28 €
Port expenses	398.06 €	430.21 €
Boat maintenance	347.11 €	375.14 €
Fishing holidays	176.07 €	190.29 €
Other annual expenses	42.65 €	46.10 €
Boat rentals	12.54 €	13.55 €
Total anual	**2,688.50 €**	**2,905,630.00 €**

The total annual expense on spearfishing was € 5,4M. Of this, € 1M accounted for fishing equipment (Table 77).

The total annual expense of recreational fishing on fishing materials was € 29,2M, and the total annual costs related to the activity was € 89,1M (Table 77).

Table 77. Total annual expenses on fishing materials and total annual expenses related to the activity for each modality.

	Expenditure in fishing materials	Total activity expenditure
Shore fishing	16,178,446 €	30,256,536 €
Boat fishing	11,984,832 €	53,422,600 €
Spearfishing	993,803.00 €	5,422,256 €
Total	**29,157,080 €**	**89,101,392 €**

4.10.4 Economic impact distribution

The total annual costs related to the activity of each modality was distributed by studied areas in proportion to the fishing effort in each area (Figure 386). The areas had different lengths and therefore the economic impact per area is not directly comparable between them.

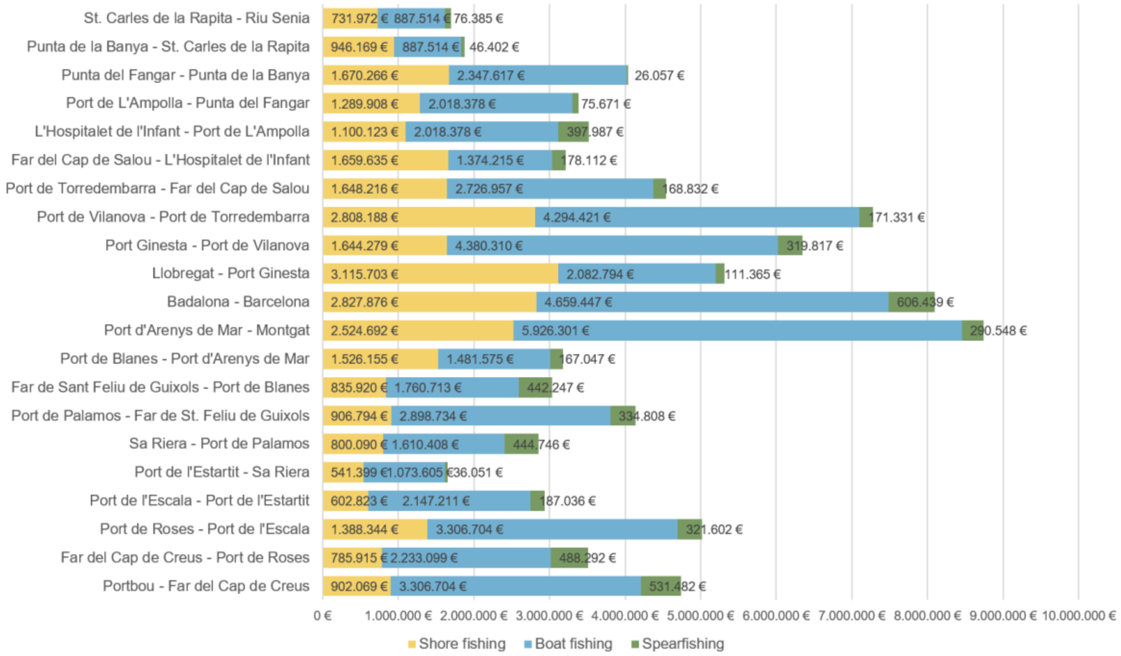


Figure 386. Total annual expenses related to the activity for each type of fishing in each studied area.

To be able to stablish comparisons, the economic impact per kilometer represents the total annual costs related to the activity on each kilometer of each area of the Catalan coast (Figure 387). In this case, the comparison of costs among areas is valid and allows us to estimate the relative importance of each modality in the economy of coastal municipalities. This data should be used with caution, as it includes all expenses indirectly related to the activity, such as expenses in the logistics of departure (travel, parking, meals), travel motivated by the activity, and the cost of port and moorings in addition to the maintenance of the boat whenever the activity required the use of a boat.

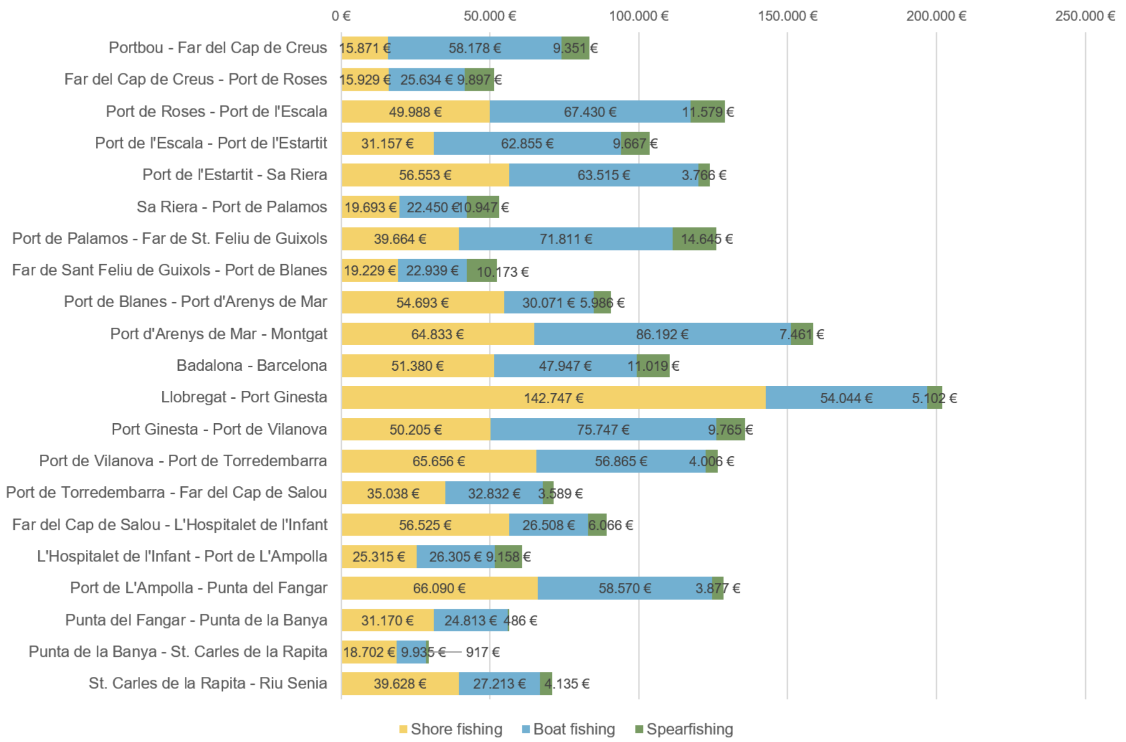


Figure 387. Total annual expenses related to the activity for each type of fishing per area and km of coastline.

The amount of expenses on fishing materials could only be related to the practice of the activity, and can be used as an indicator of the quantity of sales of fishing materials by the sector (Figure 388). Spending on fishing supplies per kilometer of coastline allowed us to estimate the impact of the activity on coastal municipalities and stablish comparisons between municipalities.

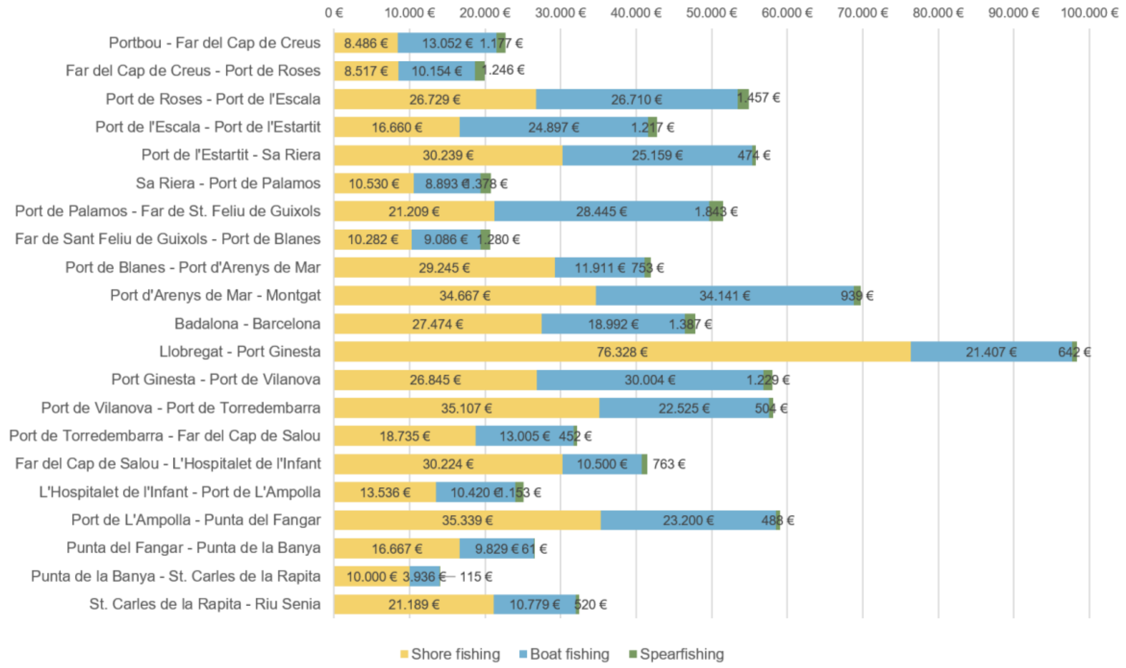


Figure 388. Expeses on annual fishing materials related to the activity for each type of fishing per area and km of coastline.

5. INFORMATION SYSTEMS

The main goal of the project was to perform a data collection of fishing samplings in order to support fisheries' management.

Conceptually, the information systems of the fishing assessment service must allow the following (Figure 389):

- Data collection of fishing samplings (including fishing cruises and biological dissection).
- Data analysis from this data collection, several parameter calculations and integration of external sources of data.
- Fisheries evaluation from the data analysis.
- Visualization of the collected data, their analysis and evaluation.

These information systems are essential for the following reasons:

- Data volume.
- Complexity of the calculations.
- The relationship between different data sources.
- The need to perform data quality control and maintain quality assurance.
- Instant availability.
- Accessibility through different platforms.

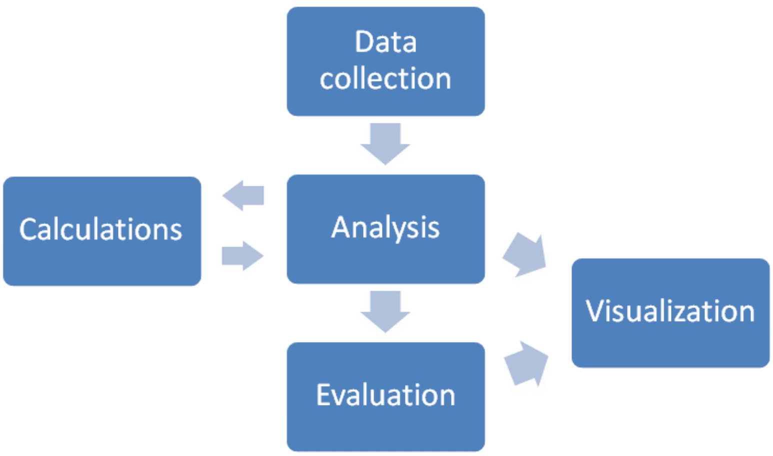


Figure 389. Conceptual structure of the Information Systems.

The architecture of the Information Systems (Figure 390) has been defined as:

- PostgreSQL database (DB): Open-source relational DataBase Management System (RDBMS).
- PostGIS: Open-source software program that adds support for geographic objects to the PostgreSQL database.
- Currently, the DB is accessed through:

  - ✓ PgAdmin: Open-source RDBMS for PostgreSQL DBs.
  - ✓ QGIS for creating Geographic Information Systems (GIS).
  - ✓ Programming languages as Python, R, and Javascript to access from a Website, script or server.

- The Websites are divided in two major concepts:

  - ✓ Data introduction: allowing the introduction and validation of the collected data to be stored in the DB in a structured way. It has been developed using Django, an open-source framework based on Python, with continuous improvements as the project moves forward. Django follows the architectural pattern Model-Template-View (MTV) and its main objective is to simplify complex Website creation. The principles for Django are reusing, facilitating the use of plugins, quick development and no repeatability.
  - ✓ Data viewer: It allows retrieving the DB data and visualizing maps and charts dynamically.

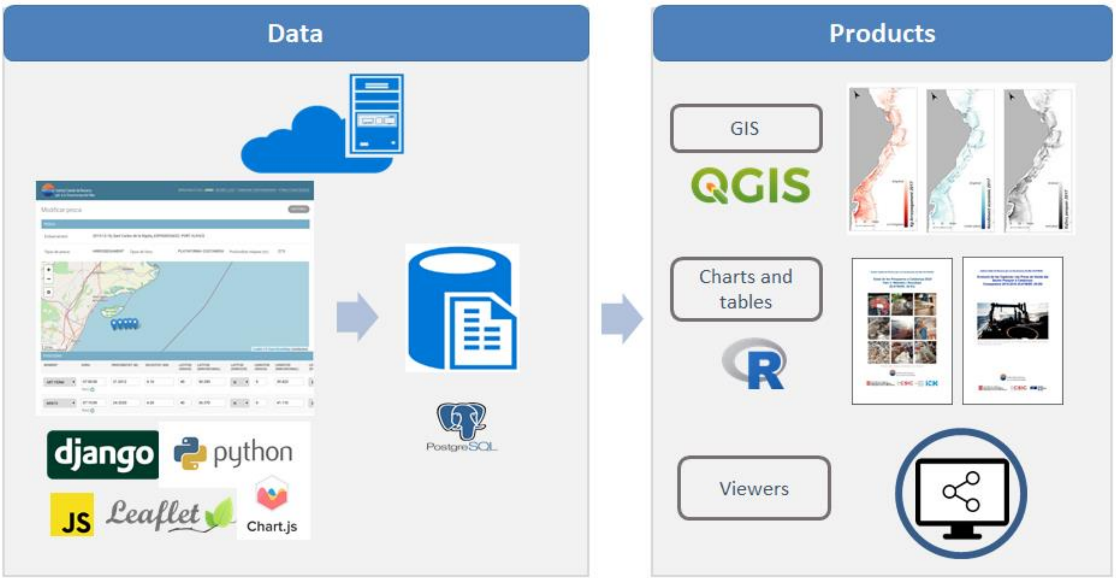


Figure 390. Information Systems' architecture.

All the system is stored in several virtual machines provided by the department of scientific computing of the Institut de Ciències del Mar (ICM). The main advantages of the virtual machines are availability, cloneability, easy recovery, backups, scalability, etc.

Three environments are used for each development phase:

- Local: Initial development + Unit testing
- Test: Virtual machine working as testing environment. It is a clone of the production environment, where the most stable versions are uploaded to perform a more extensive testing before transitioning to the production environment.
- Production: Virtual machine working as production environment where the production DB and the final version of the system are stored.

The source code of the Website is stored in CSIC's Git, a development collaborative platform that uses a version control system.

The workflow for data introduction is the following, represented in Figure 391:

- All sampled data from both, the fishing cruises and the dissection laboratory, was recorded in the corresponding sampling forms as defined in the protocols.
- A GPS device was used to obtain the track of each fishing sampling.
- All data from the sampling forms was introduced to the database through the data introduction Website. This process allows having more data control, error prevention and validation, data availability, and system reliability.

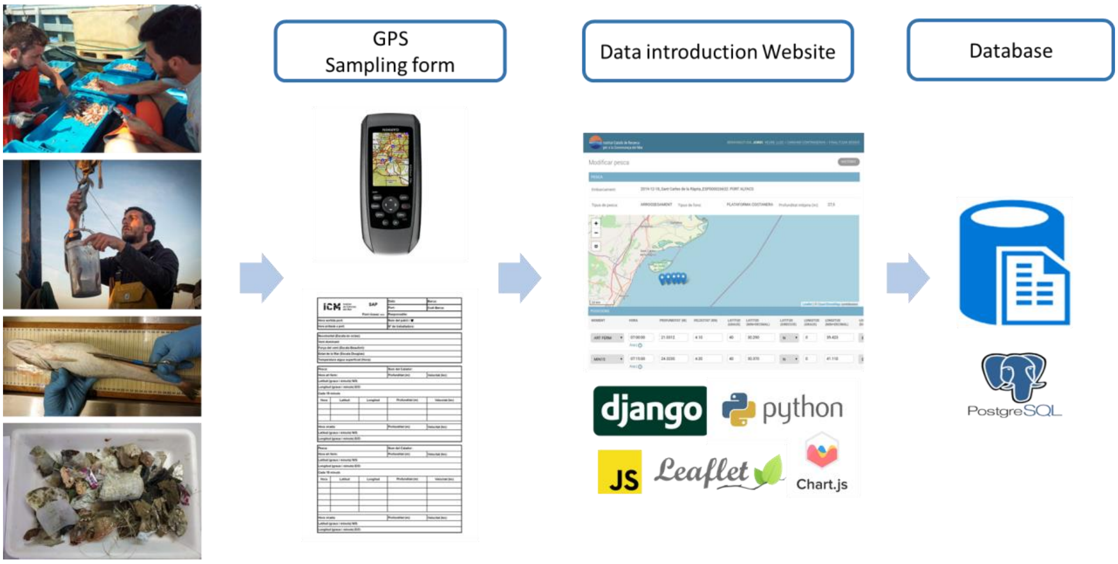


Figure 391. Sampling data introduction workflow.

The relational database was created in PostgreSQL with PostGIS. The database was designed as an object-relational database, combining a relational database with an object-oriented model, facilitate object-oriented programming. The model of the database was designed by grouping the related fields in tables regarding each data concept. Then, each table was related with the others through its corresponding cardinality and seeking the reduction of data redundancy (Figure 392).

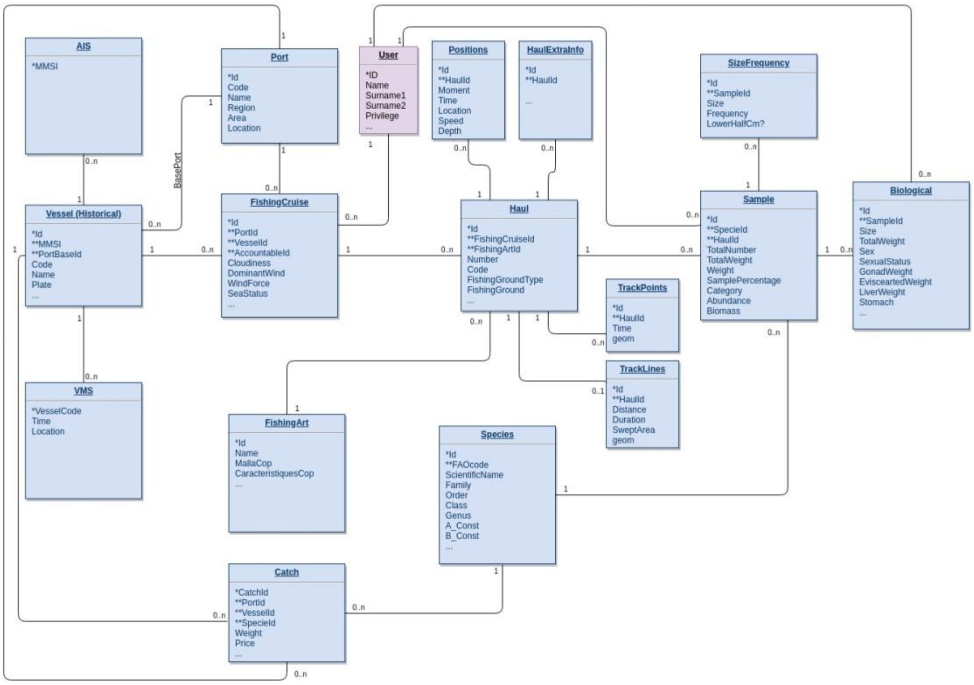


Figure 392. Database model.

5.1 CURRENT STATUS OF THE INFORMATION SYSTEMS

The database to store data from fishing samplings is working since November 2018 and contains data for all the fishing samplings performed until December 2020 despite the database keeps growing as samplings continue. All the stored data was exported to make the analysis in this report.

Besides the sampling data of the project, this database contains the following external datasets to complement the data analysis (Figure 393):

- Historical data of the Spanish fishing fleet extracted from the EU Fleet Register. This dataset contains all the changes on the census of the Spanish fishing fleet since 2000.
- Vessel Monitoring System (VMS) data from 2004 to 2020. VMS is a satellite surveillance system primarily used to monitor the location and movement of commercial fishing vessels over 12 m in length.
- Daily landings from all the fishing fleet registered in the Catalan auction markets.

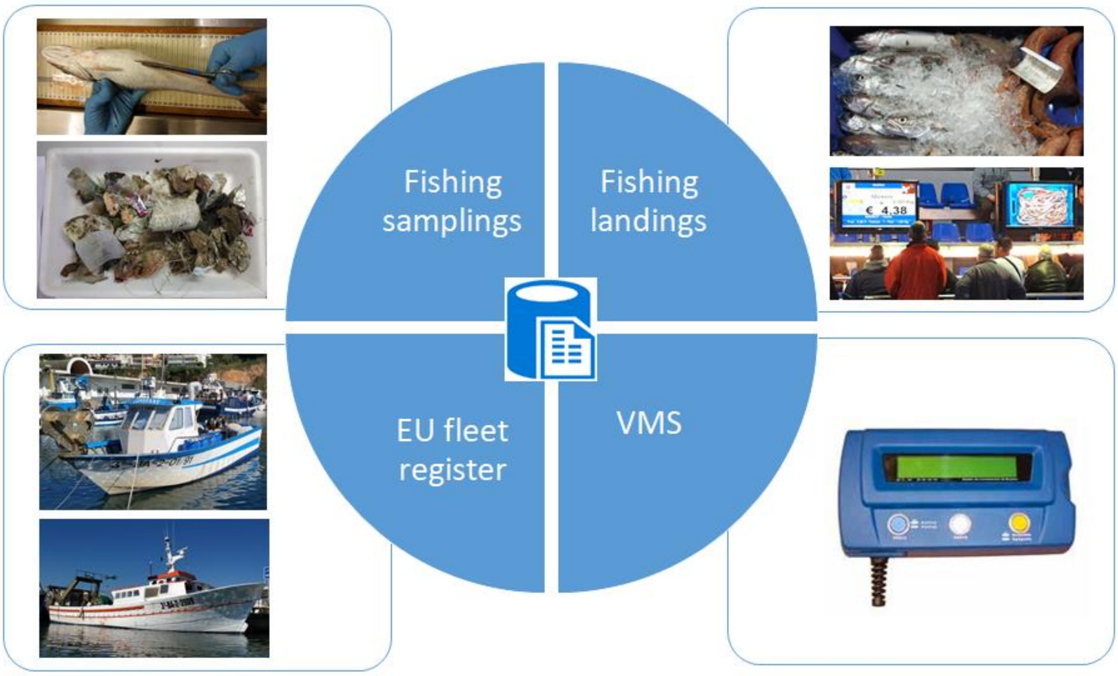


Figure 393. Main datasets stored in the database.

Historical data from other samplings was also integrated in the database to facilitate temporal evolution analysis. The first dataset recently integrated and imported in the database was the historical data of the sand eel fishery in Catalonia from 2012 to 2019 from the sampling questionnaires answered by the fishermen (almost 10000 fishing cruises).

All the defined requirements to develop the data introduction Website were implemented. The Website was developed, validated and it is completely functional. From August 2019, all sampled data is introduced directly in the database through the Website.

The data introduction Website has been evolving in a continuous improvement process since its launching. These improvements are focused on usability, data quality control and assurance.

5.2 DATABASE (DB)

Figure 394 plots the amount of records that have been stored in the DB from October 2018 to December 2020. In summary, 650 fishing hauls have been sampled, taking 1900 positions, measuring 140000 individuals and dissecting more than 33000 of them.

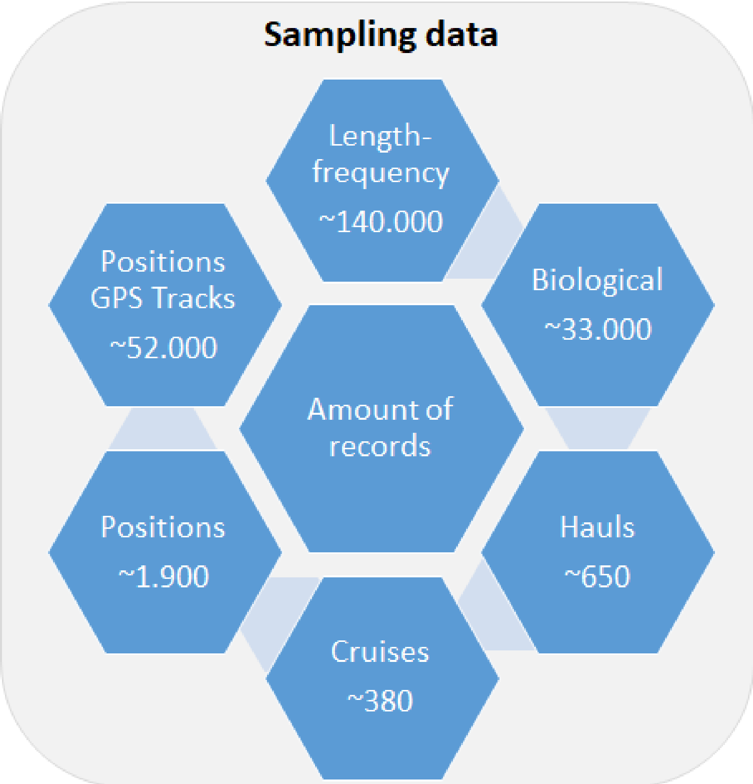


Figure 394. Number of records of the project sampling data in the DB.

Figure 395 and Figure 396 are two screenshots of the RDBMS pgAdmin querying alphanumeric and georeferenced data.

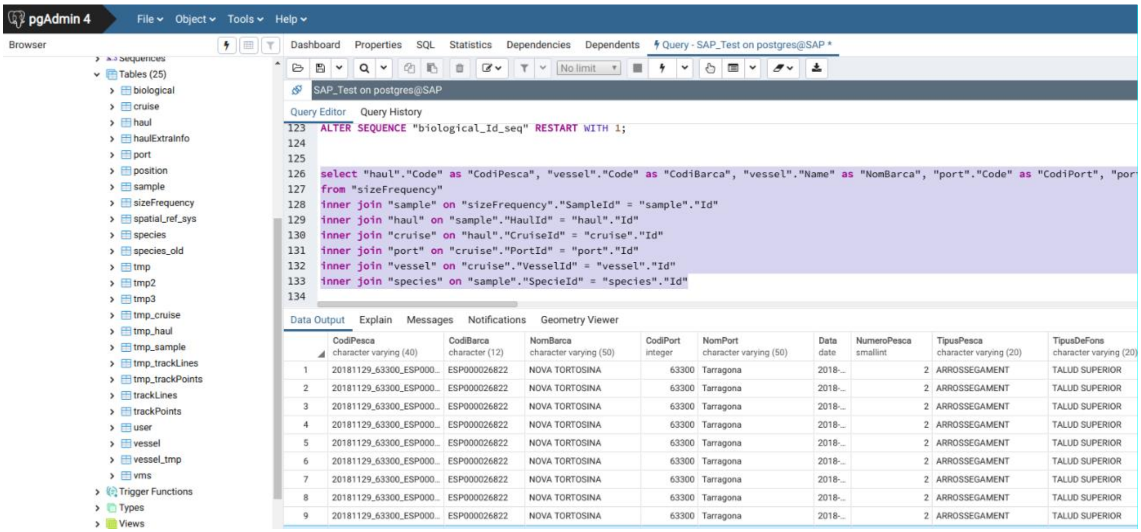


Figure 395. DB alphanumeric query.

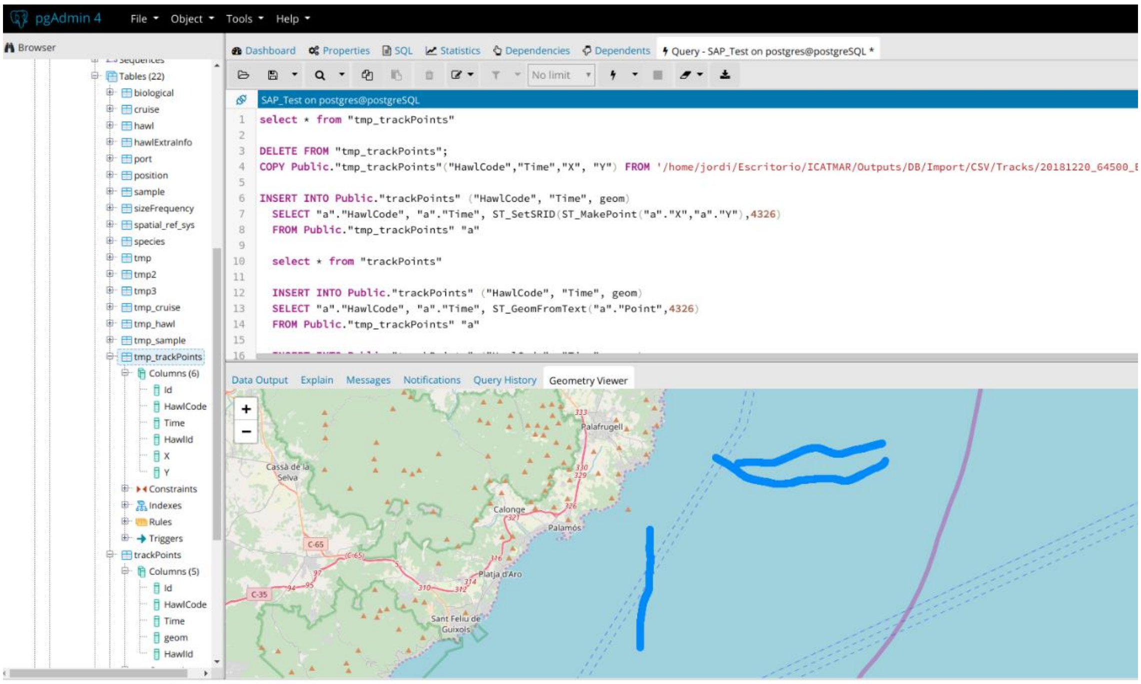


Figure 396. DB georeferenced query.

Besides Project own data, external datasets are currently integrated in the DB or could be integrated in the future on the same structure (Figure 397). These datasets are directly related with the project and facilitate the overall analysis and evaluation.

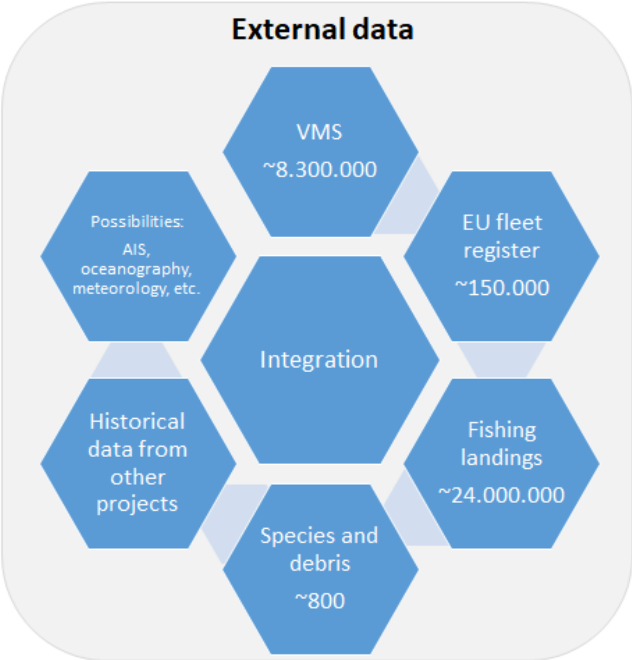


Figure 397. Number of records of external data in the DB.

Besides the fishing sampling data, there are other Information Systems in ICATMAR that are taken into account to integrate them in the current system in the future (Figure 398). Among them, Marine GIS will be a Marine Geographic Information System to store marine and oceanographic data available in real time. The goal is to provide information for the uses and activities taken place in the marine environment and become a useful tool for the different stakeholders (government, fishing sector, nautical sector, tourism, etc.).

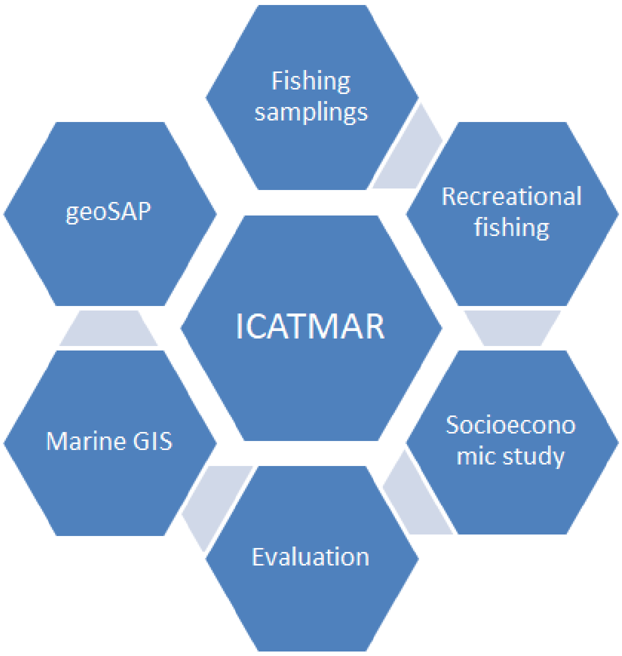


Figure 398. Other ICATMAR Information Systems.

GeoSAP DB contains georeferenced information not generated by the project (Figure 399). Figure 400 and Figure 401 are examples of queries to geoSAP standalone and in combination with the other DB from pgAdmin and QGIS.

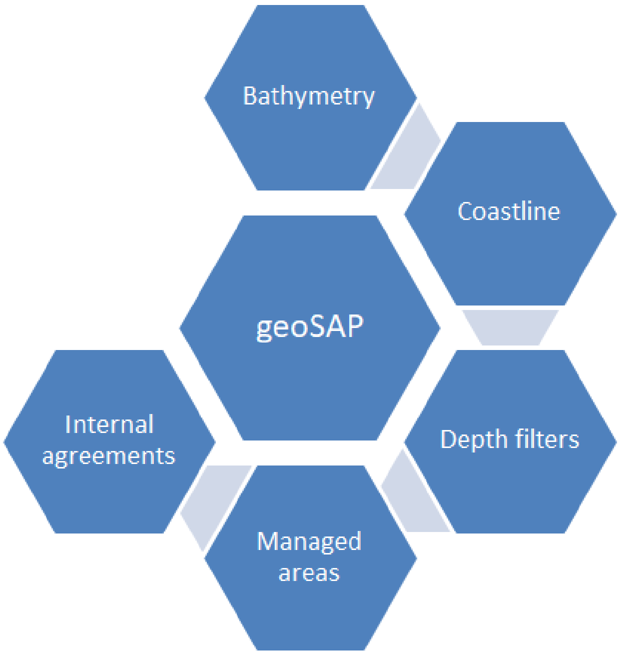


Figure 399. GeoSAP content.

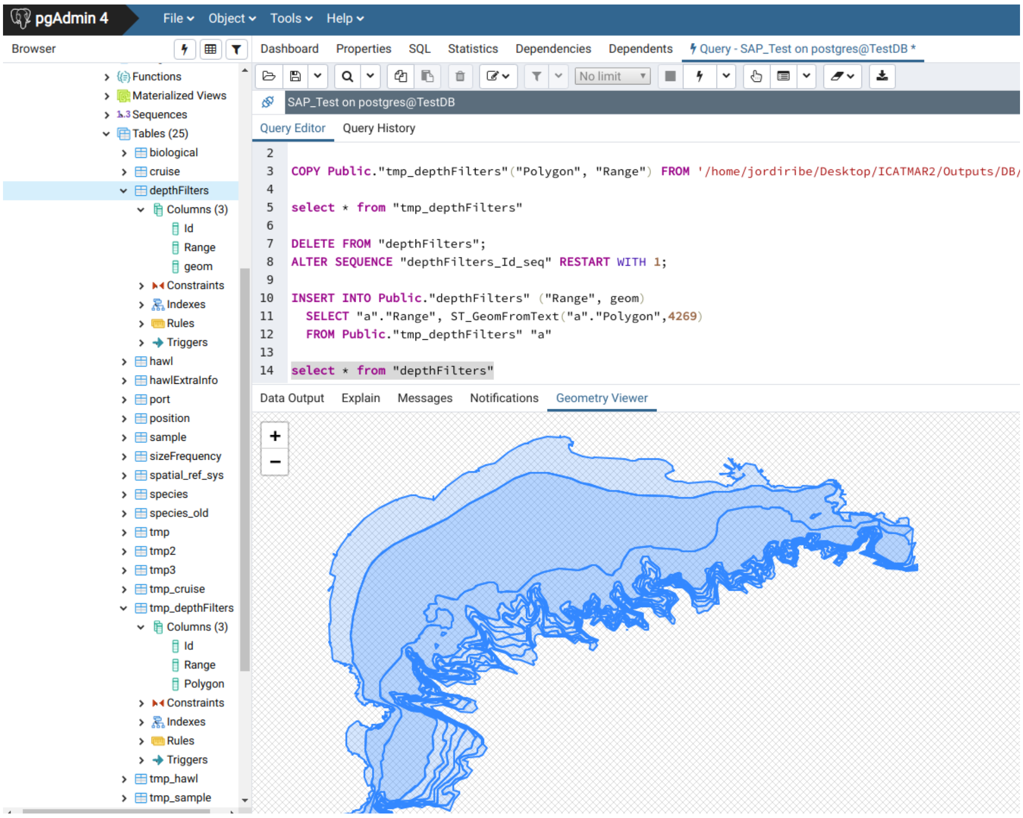


Figure 400. GeoSAP query form pgAdmin.

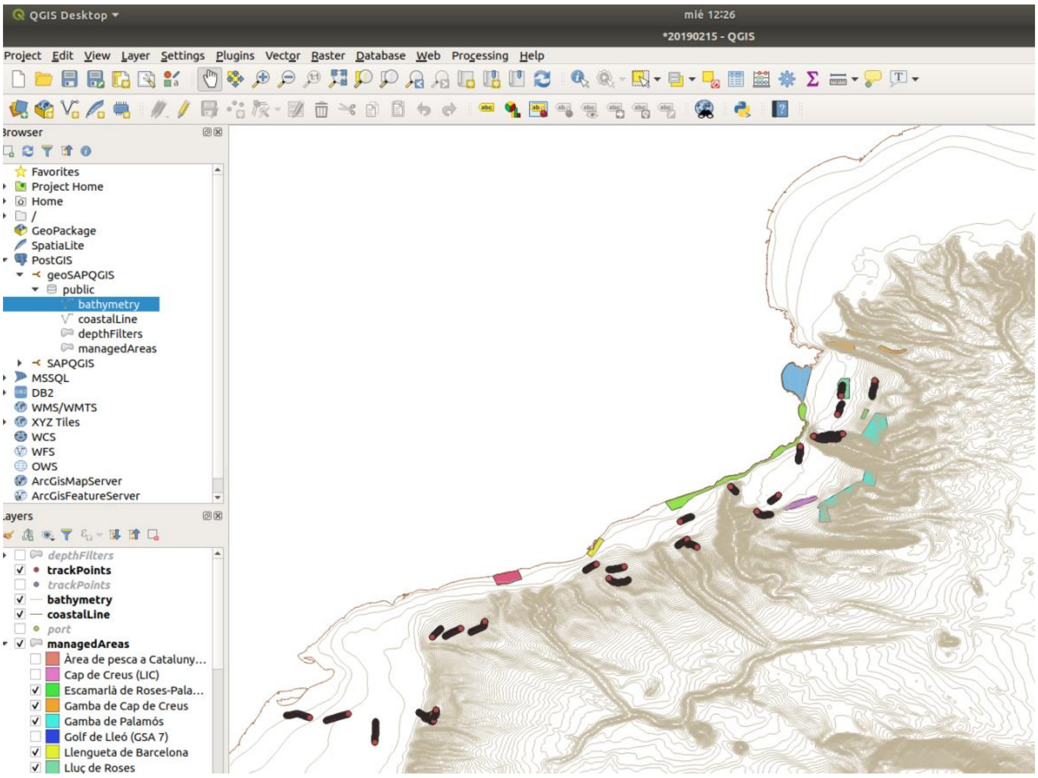


Figure 401. GeoSAP query form QGIS.

5.3 DATA INTRODUCTION WEBSITE

The data introduction Website is fully working. It allows to store in a DB all samplings, either the data taken during the fishing cruises or during dissection. The user manual of the data introduction Website contains all the possible use cases and all the user functionality.

5.3.1 Data Quality Control and Assurance

A fundamental part of data collection is ensuring that the data has the maximum possible quality. On data Quality Control, the cost of fixing an issue increases exponentially as time passes by. Therefore, the objective is preventing issues or fixing them as soon as possible.

In order to prevent any problem and maximize data quality, different improvements were developed in the data introduction Website:

- Positions:
    - ✓ An error is shown when an introduced position is out of the fishing range of the Catalan fishing fleet.
    - ✓ The introduced positions are visualized on a map to detect erroneous positions (Figure 402). The information of each position allows the user to visually validate that the time and moment of the position is correct.

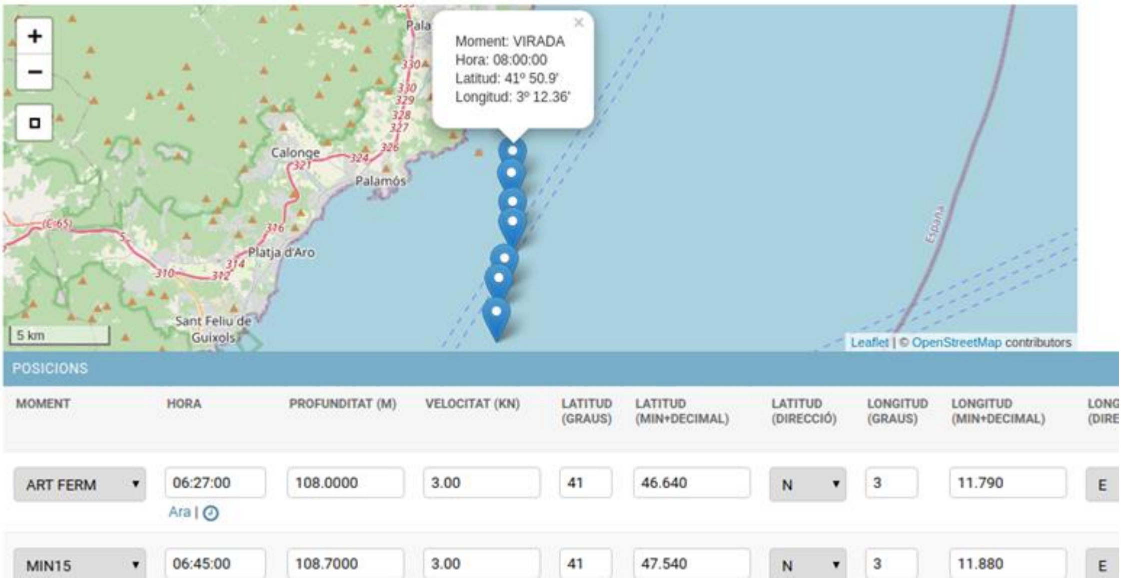


Figure 402. Visualization of the positions on a map for their validation.

- Length-frequency:

  - ✓ Minimum and maximum length validation: A length range was defined for almost 250 species in the database. This data was extracted from the samplings or related bibliography. A warning is shown when an introduced length is out of the range defined for the corresponding species.
  - ✓ To detect outliers, the length-length and the length-frequency relation are visualized when the data is stored. Moreover, the length range for the current species is shown on the length-frequency chart (Figure 403).

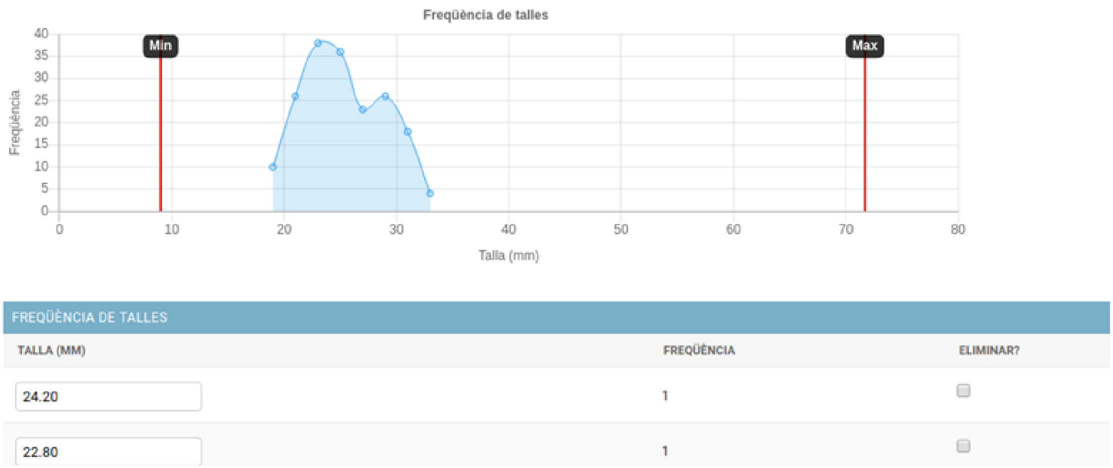
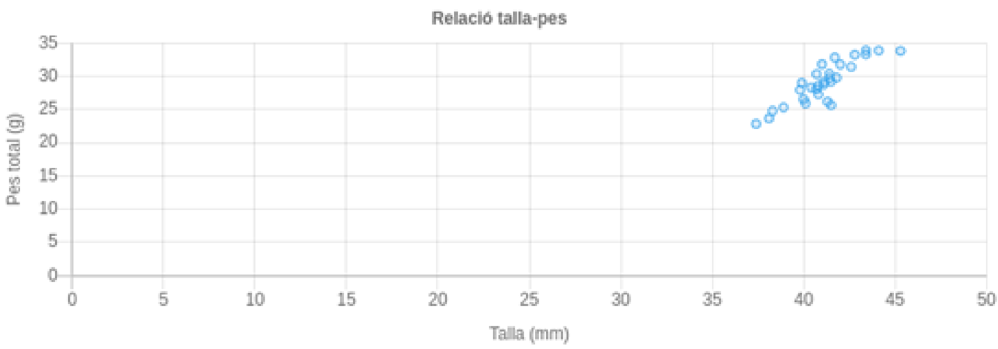


Figure 403. The length-frequency of the introduced data is visualized with the minimum and maximum range for the current species.

- Biological:

  ✓ To detect outliers, the weight-weight and the length-weight relation are visualized when the data is stored (Figure 404). The weight-weight visualization is useful for the species in which, typically, only weight is measured, not length, e.g. common octopus.



BIOLÒGIC

NÚMERO	TALLA (MM)	PES TOTAL (G)	SEXE (M,F,I)	ESTAT SEXUAL	PES GÒNADA (G)	ESPERMATÒFOR (S,N)
1	38.90	25.33	F	2	0.211	N
2	37.40	22.87	F	2	0.117	N
3	40.80	27.31	F	2	0.229	N

Figure 404. The length-weight of the introduced data is visualized.

Once all the data from a fishing trip is introduced through the Website, a second validation is performed in couples to double check that all data of the Website matches the data in the sampling forms.

Finally, a person validates the data all together focusing on its analysis. As an example, if an error is detected in a sampling form, the incorrect value is corrected and modified on the Website but indicating that the value differs from its original sampling form (Figure 405).

LATITUD (MIN+DECIMAL)	LATITUD (DIRECCIÓ)	LONGITUD (GRAUS)	LONGITUD (MIN+DECIMAL)	LONGITUD (DIRECCIÓ)	DIFEREIX DE L'ESTADILL
9.998	N	2	9.861	E	☐
9.312	N	2	9.312	E	☑
8.605	N	2	8.605	E	☐

Figure 405. This option allows tagging a value that differs from its original sampling form.

5.4 AUTOMATIC GENERATION OF CHARTS AND TABLES

Most of the charts and tables presented in this report must be presented annually to show the evolution of the different studied parameters. Therefore, an extra effort was undertaken to develop scripts with the programming language R to automate the chart and table generation (Figure 406). Some scripts were developed to automatically connect from R to the DB and execute the needed queries to perform the analysis.

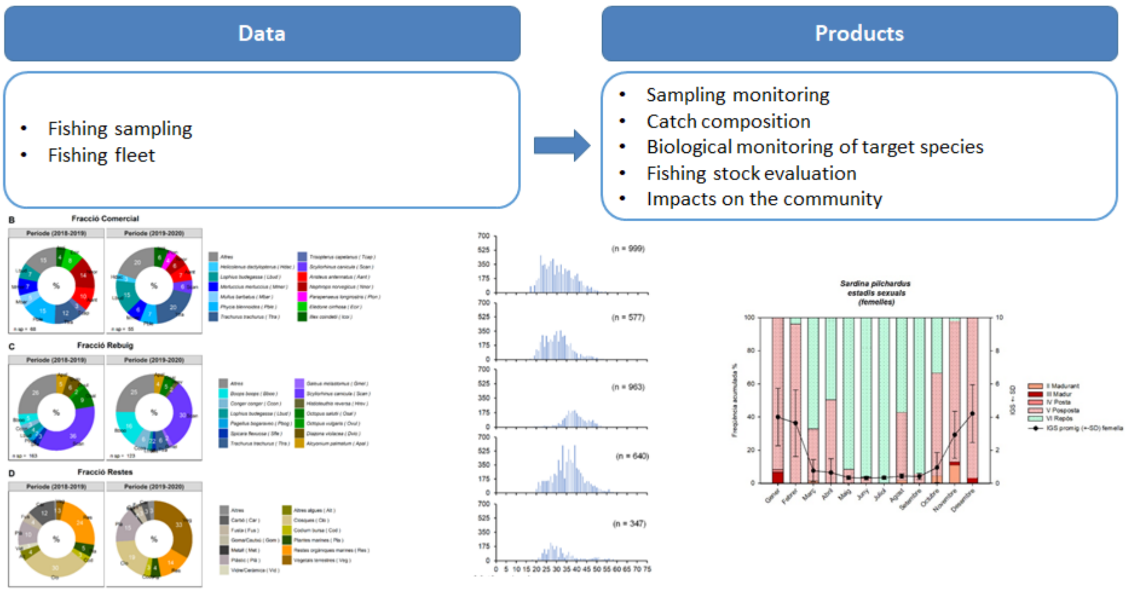


Figure 406. Examples of the charts generated automatically through R scripts.

5.5 DATA VIEWER

Up to now, the publication of the performed analysis has been through reports. However, the aim is also to have a tool to understand the status of the fisheries in Catalonia and facilitate their management. This tool aims to achieve the following goals (Figure 407):

- Having a dynamic and accessible visualization of the collected and analysed data.
- Transferring scientific knowledge to the stakeholders: government, fishing sector, scientific community, and public in general.

- Maximize the possibilities for data analysis.

Therefore, a Web Viewer is being developed to fullfil these requirements.

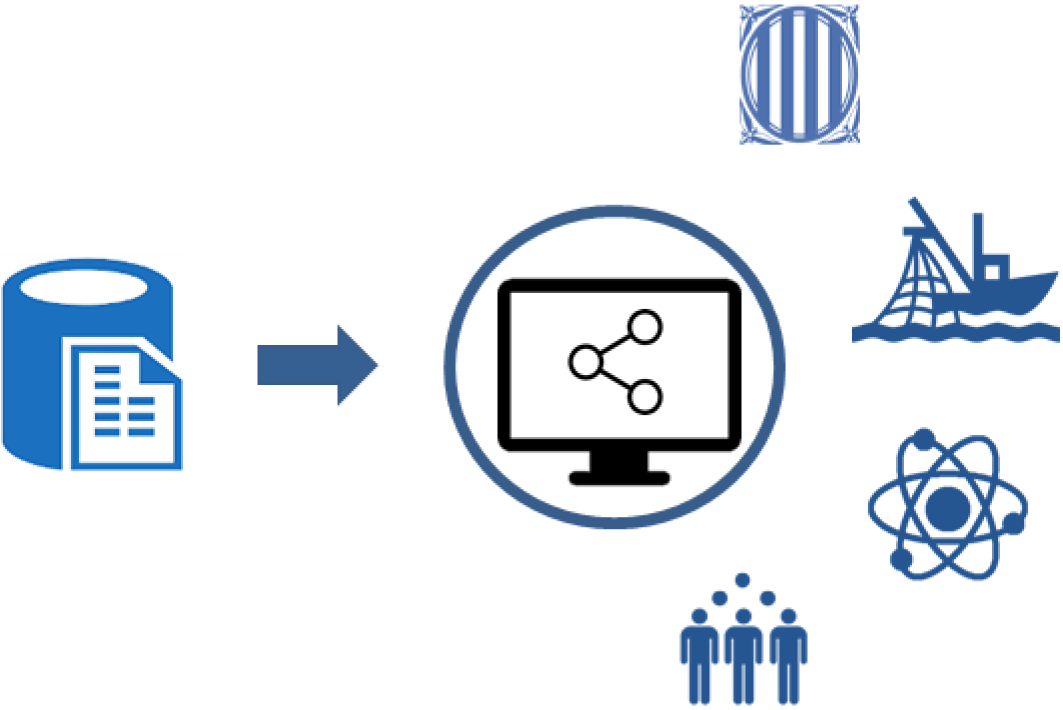


Figure 407. Conceptual representation of the data viewer.

6. FISHERIES SPATIAL DATA ANALYSIS

Fisheries spatial characterization is a key aspect for fisheries management and understanding (Lorenzen et al., 2010). A sustainability driven fisheries policy require an accurate mapping of fishing activity so its impacts on fished stocks can be better understood and linked to other marine activities. This is an especially important aspect considering the recent Multiannual Plan for demersal fisheries in the Mediterranean (EU, 2019), where the establishment of fisheries restricted zones is a management measure that must be adopted in the Western Mediterranean.

The need of an accurate and efficient scientific advice on fisheries spatial activities urges the optimization of spatial data storage, treatment, and visualization. Therefore, the main working areas for this section are:

- Spatial data collection and storage in a structure that allowed an efficient query and product generation.
- Spatial data analysis for fisheries parameters calculation according to management needs.
- Visualization of data products in a clear and comprehensive manner in order to reach all fisheries management stakeholders.

6.1 SPATIAL DATA COLLECTION AND STRUCTURE

6.1.1 VMS

The main fisheries spatial data source is the Vessel Monitoring System (VMS) dataset. VMS is a vessel positioning system mandatory for > 15 m length vessels since 2005 and for > 12 m length vessel since 2012. The system was originally designed for fisheries' surveillance and each EU member state is in charge of its monitoring and data validation. This is the reason why VMS data is highly reliable in terms of data quality and temporal coverage compared to other non-mandatory positioning system such as AIS. However, VMS offers a low minimum ping frequency of 2h. This low ping is a consequence of the high costs of data monitoring and validation in addition to using an Atlantic fleet as a baseline for all other fleets. The system registers vessels' position, speed and course.

In the Catalan fleet, good coverage is achieved for trawling vessels, with 97% of the fleet having a VMS system in 2017, similar to the coverage of the purse seiners (98% of the fleet in 2017). However, artisanal fishery vessels are not well covered by the VMS system because of their lower length overall.

The data used in this study was transferred to the ICM-CSIC via the Fisheries Activity Control Center in the Agriculture, Fisheries and Food Ministry, from the Spanish Government. Data transfers were done every three months. We gathered registers from 2005 to 2020 for purse seine and bottom trawlers from the Catalan fleet.

6.1.2 AIS

The Automatic Identification System (AIS) is a positioning system originally designed for maritime traffic security. It is not a mandatory system for any of the Catalan fishing vessels as only vessels with GTs higher than 300-500 must be equipped with the AIS system. Nevertheless, a lot of non-obliged vessels use this system but it does not imply having a complete register of their positions because the vessel skipper is able to turn it off anytime. AIS system registers the same variables than VMS.

The advantage of AIS data with respect to VMS is that it has a substantially higher ping frequency, reaching a ping every minute. Nevertheless, the fact that this system can be powered off voluntarily by the fishers leads to important data gaps in fishing activity registers. That is the reason why we don't consider AIS data a good approximation to calculate global fleet fisheries' parameters such as fishing effort. We used AIS data complementarily to VMS mainly when a high ping resolution is needed, for example, when new fishing operations must be understood.

We accessed AIS data via Shiplocus application, managed by the Spanish Transport, Mobility, and Urban Agenda Ministry.

6.1.3 Sampling data

When performing on board samplings, hauls position was registered with GPS devices. Posteriorly, this data was used to visualize sampling sites but also to calculate important variables for fisheries' management such as swept area for trawling hauls.

6.1.4 General spatial data

Besides fishing vessel data, other basic spatial information was needed for fisheries analysis. Therefore, data was also collected on bathymetries, coastal lines, ports information, and fisheries related areas such as Marine Protected Areas (MPAs).

6.2 VMS ANALYSIS

6.2.1 General methodology

Positioning data do not indicate per se whether a vessel is involved in fishing activities or other uses of the sea. Therefore VMS data must be processed in order to calculate final interest variables such as fishing effort or thegeographic distribution of landings.

The first step to discriminate between fishing and non-fishing activities was to study the speed of the vessel (see 6.2.2). Afterwards, each fishing trip (day and vessel) fishing time was calculated. In parallel, landings by species and fishing trip were also calculated. Finally, fishing time and landings were assigned to all fishing points by trip homogeneously (see 6.3 for specific data structuring). Once the collected data was linked, we could aggregate variables (fishing time, general landings or by species) in grid cells for a general distribution or in specific areas when, for example, evaluating an MPA performance (e.g. Sala-Coromina et al., 2021).

6.2.2 Fishing activity fleet specific filtering

6.2.2.1 Trawling fleet

Based on previous studies (Campbell et al., 2014; Gerritsen & Lordan, 2011; Lee et al., 2010), fishing activity was mainly identified from other vessel's operations using speed variable. In the Catalan fleet, a good discrimination of fishing points can be done with speed as Figure 408 shows. There were two speed modes (Figure 408), one in 3.5 and another in 11 kn, corresponding to fishing and navigation operations, respectively. Based on this results, a speed filter between 1 and 4.5 kn was applied to retain trawling fleet fishing positions. We also applied a spatial filter retaining points between 50 and 1000 m depth (where trawling operations occur) in order to exclude port points and possible positional errors.

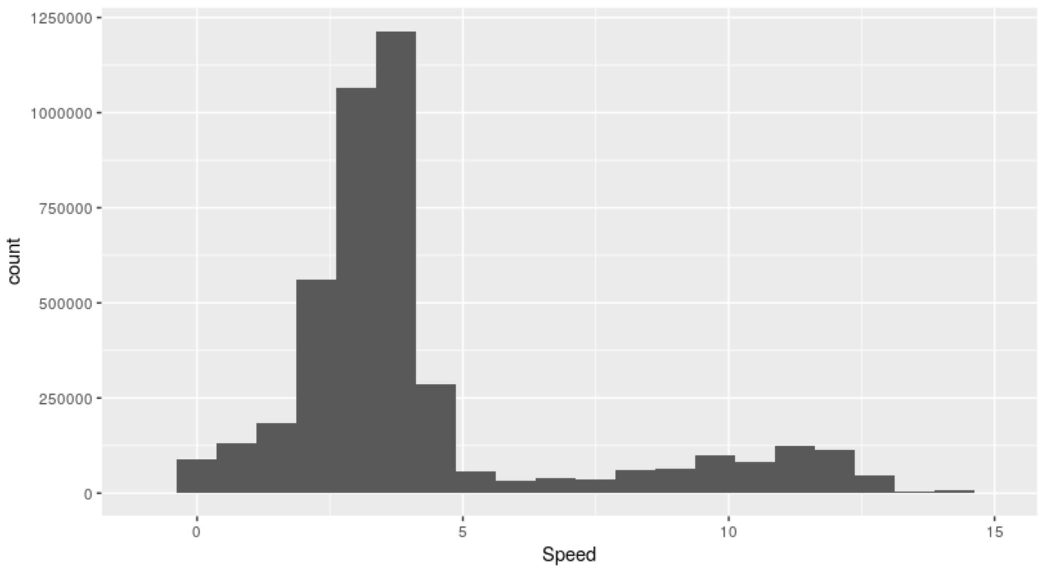


Figure 408.Speed distribution histogram for Catalan trawlers fleet. VMS data from 2008 to 2017. Inner port vessel's data is deleted.

6.2.2.2 Purse seine fleet

In a spatial dimension, the analysis of the purse seine fleet presented some challenges compared to the trawling activity. Trawlers' effort (fishing time) corresponded to fishing positions where landings were caught. This correspondence was not the same for purse seiners as their fishing trips consists of long phases of school search and short fish operations where actual landings were caught (see Figure 409).

Purse seiners targeting small pelagic fish operations are not well studied in the Mediterranean even if, at least in the Catalan coast, they are responsible for most of the fish biomass landings. Trying to put some light on this issue, we studied the Catalan purse seine fleet in detail with the objective to establish a preliminary methodology for its spatial fishing effort and landings distribution estimation. We carried out on board observations that allowed a detailed description of fleet fishing operations. Considering the information gathered, a fishing effort and landings distribution analysis methodology was carried out and is presented in this report. Finally the results for fishing effort, sardine (*S.* pilchardus) and anchovy (*E. encrasicolus*) landings distribution are shown.

Complete report "Catalan Research Institute for Sea Governance (ICATMAR). Fishing effort and landings geographic distribution of Catalan purse seine fleet. (ICATMAR 20-12) 25pp, Barcelona" can be found in Annex XIII.

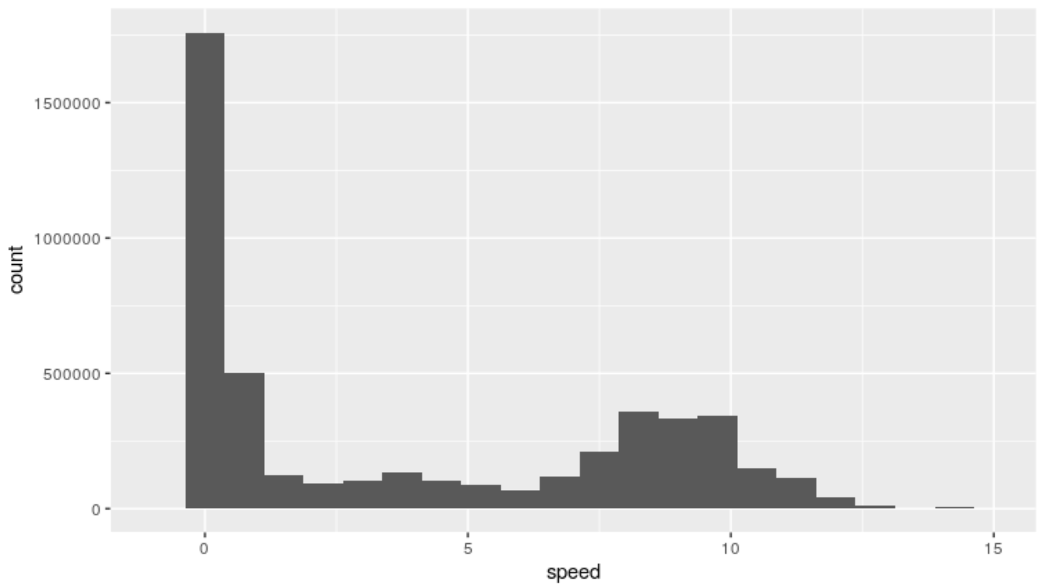


Figure 409. Speed distribution histogram for Catalan purse seine fleet. VMS data from 2008 to 2017. Inner port vessel's data is deleted.

6.2.3 Data interpolation

As explained in section 6.1.1. the VMS dataset main weakness is ping frequency, with its minimum set in 2h. This frequency is too low to retain typical purse seine hauls (1 hour long) and may lead to fishing time underestimations for the trawling fleet. The increase of ping frequency via point interpolation presents a good option to reach higher precision on spatial fishing variables calculation. At the moment, we are exploring methodologies that can be integrated in our information systems based on Russo (2011).

6.3 SPATIAL DATA STRUCTURE IN SAP INFORMATION SYSTEMS (IS)

Spatial fisheries data analysis can be complex and computing resources demanding. Therefore, it is crucial to structure the information in a system that makes its processing and consulting as effective as possible. The structure should also allow an easy importation of new registers and a good integration with other service data such as fleet landings.

All spatial data is integrated in ICATMAR's IS PostgreSQL databases with a PostGIS extension. General spatial data is continuosly stored in tables without a direct relationship with other data. VMS, AIS and sampling GPS data are integrated with other database tables.

GPS sampling dataset is linked with sampling haul registers that samplers introduce via data introduction website. GPS data should be validated and some variables calculated (i.e. swept area) before integration to DB. Until the moment this process has been done via QGIS with posterior DB integration. We are working on the optimization of the process and its integration to SAP data introduction website for samplers to introduce GPS data to service DB directly from GPS sampling devices.

VMS data is key information that must be accurately structured to be easily used. We currently have 8.461.239 registers of row VMS points that must be crossed with fleet landings data (23.805.447) to calculate fisheries variables such as fishing effort or catches spatial distribution. We process both VMS and landings tables so fisheries information can be extracted faster than if all filtering and crossing processes should be done for each data query. The intermediate tables we create in the database are (Figure 410):

- vmsf (6.155.950 r): points filtered by fishing activity. Each fleet data is retained depending on different criteria explained in 6.2. A "state" variable is included so effort and actual fishing points can be distinguished specially for purse seine fleet.
- vmsfTrack (1.045.034 r): fishing/effort points are aggregated by fishing trip (day and vessel) using a variable "trackCode" (VesselCode_Date). Fishing time is calculated for each track code. A geometry corresponding to fishing track line is also calculated so it can be also used in mapping fisheries activity.
- vcpeTrack (2.511.462 r): species landings aggregated by track codes (fishing trip).

- vmsfFtCa (6.155.950 r): fishing VMS points linked with fishing time (from vmsfTrack) and with species landings (from vcpeTrack). “TrackCode” variable is used to link tables and to assign each fishing point its corresponding fishing time and landings. This static table is the one queried when elaborating most fisheries spatial products. Python package “psycopg2” is used when iterating data products.
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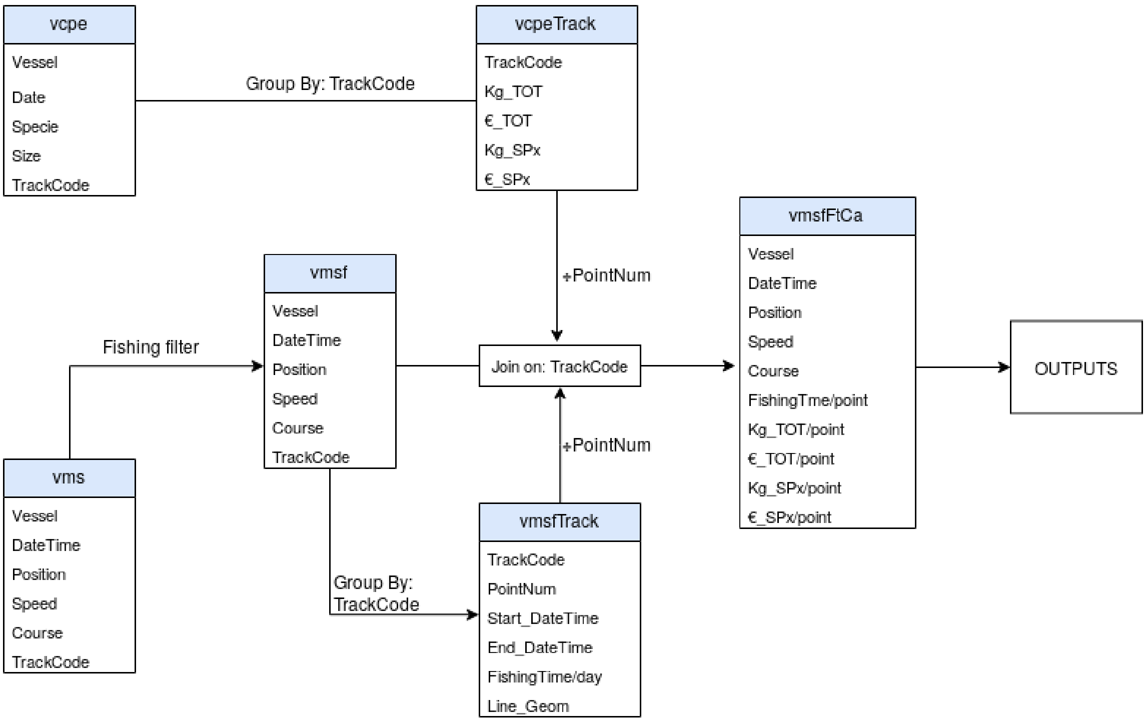

Figure 410. VMS and landings pre-processed tables in SAP database system. Columns containing each table are specified.

6.4 FRAs FOR FISHING EFFORT REDUCTION AND HABITAT PROTECTION IN GSA6, A THEORICAL ANALYSIS

The recently approved Multiannual Plan for the fisheries exploiting demersal stocks in the western Mediterranean (EU, 2019) include important spatial management measures (Article 11), for example, a 3 months ban for trawling activity within six nautical miles from the coast, except areas deeper than 100 m.

The ban can be substituted by spatial closures achieving a reduction of 20% of hake juveniles catches in each geographical subarea.

In this context, the importance of a strong and efficient fisheries spatial information system is evident. Data structure and analysis is needed in the planning of spatial measures but also in the evaluation of its effectiveness.

In the GSA6, bottom trawling fishery has a strong spatial structure determined by fleets' base ports. Vessels are obligated to land its catches at their base port and have a limit of 12 hours of fishing time a day (Real Decreto 144 / 1999). These measures imply that the trawling fleet spatial footprint in each port has a low overlap with neighbouring ports (Figure 411). This distribution and the characteristic social organization of fishers in port associations (named Confraries) contribute to a strong pertinence feeling of fishers with their base port and exploited fishing grounds. This fact must be taken into account when applying fisheries measures, especially when reductions of fishing effort or catches need to be applied. Fishing reductions should be designed under both, a biological and a social point of view. The collaboration of the fishing sector in management measures can be a key aspect in its effectiveness (Di Franco et al., 2016).

With this idea in mind, a theoretical study was done with the goal to explore the possibility to reduce the fishing effort along the GSA6 via closure areas (MPAs). One of the main criteria to develop the study was to balance this reduction among the fleet from each port. MPAs effectiveness in fisheries management lays in the expected spillover effect of objective species. In this direction, designing MPAs covering all habitats impacted by trawling activity was another criteria incorporated in this study. Considering this framework, three scenarios where studied:

- **Scenario 1:** two miles width areas in the border zones overlapping two consecutive trawling zones (Figure 411).
- **Scenario 2:** two miles width areas in front of each individual port (Figure 412).

- **Scenario 3:** optimized areas containing 10% of each port fleet fishing effort (Figure 413).

In every scenario considered, each port effort inside MPAs were calculated as well as the protected area extension relative to global trawling fleet activity. Fishing effort was calculated from VMS data and queried from vmsfFtCa table (see 6.3). Data from years 2015 to 2019 was incorporated in the analyses and calculated yearly mean values by area and port fleet.

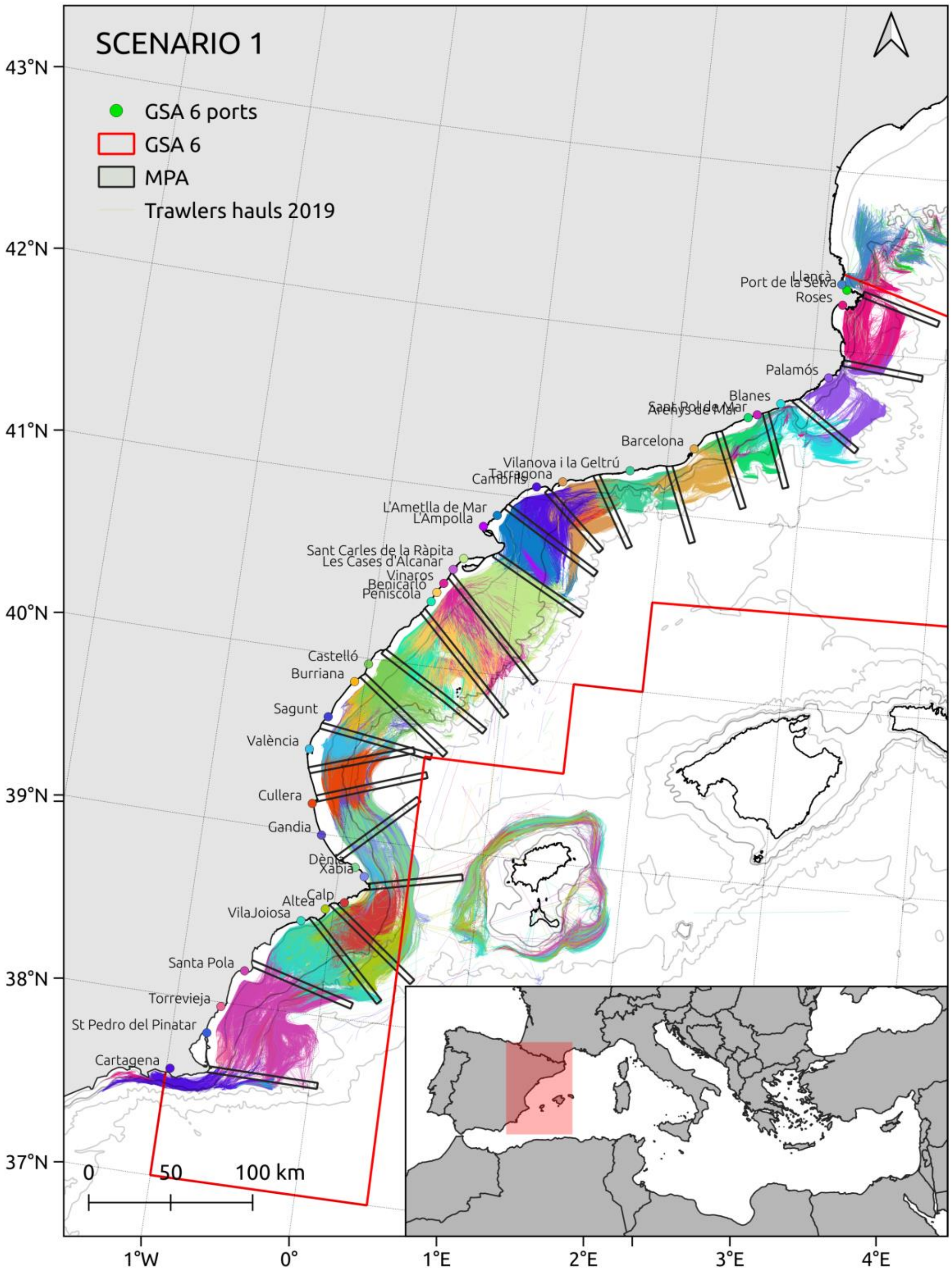

Figure 411. Scenario 1 designed MPAs. GSA6 trawling straight line interpolation tracks from 2019 coloured by fleet base port.

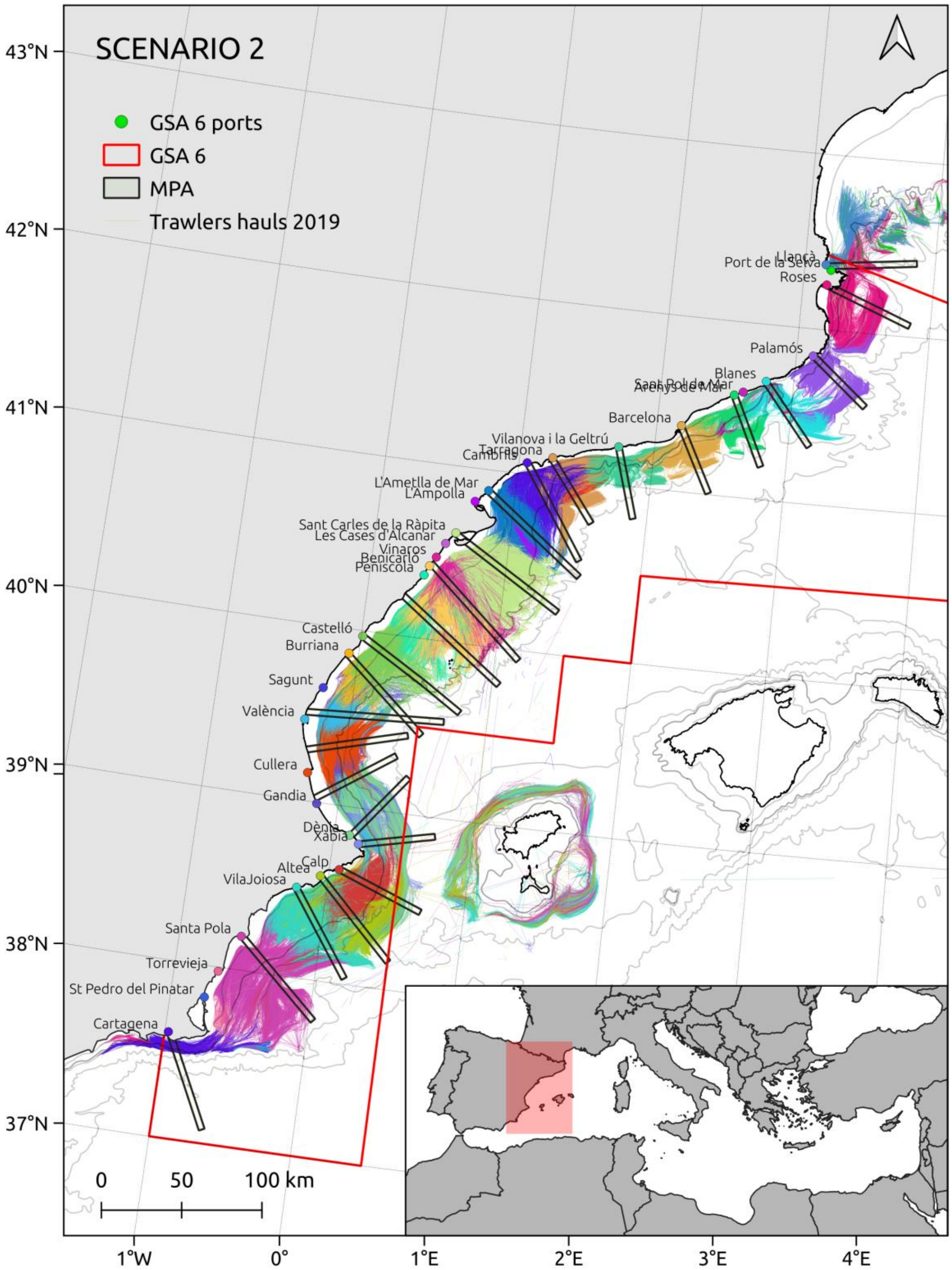

Figure 412. Scenario 2 designed MPAs. GSA6 trawling straight line interpolation tracks from 2019 coloured by fleet base port.

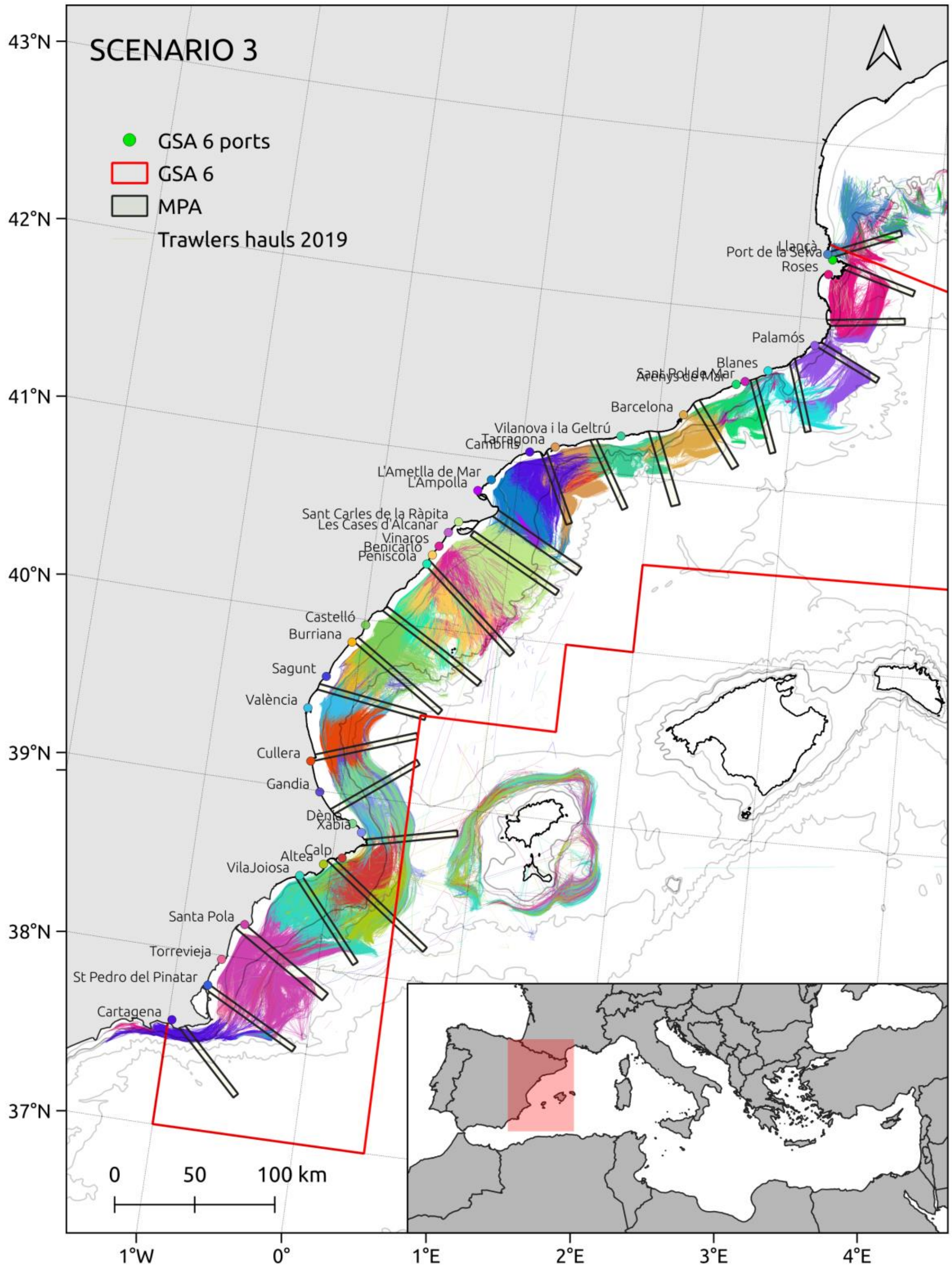

Figure 413. Scenario 3 designed MPAs. GSA6 trawling straight line interpolation tracks from 2019 coloured by fleet base port.

Results showed how, for the same MPA of legal bottom trawling fishing grounds (12 - 13% in all scenarios considered), it would be possible to establish protected areas that equally affect all port fleets in the studied zones (Figure 416). Scenarios that did not take into account port balancing criteria (scenario 1, Figure 414, and scenario 2, Figure 415) led to an unbalanced effort reduction between port fleets. Even if these scenarios could have a biological meaning, the disparity in effort reduction between ports is high. This hypothetical management measures could leed to important conflicts between port fleets and a probable weak implication of fishers with the management measures. In contrast, scenario 3 is protecting the same surface as the others (concretely 12.37 % of legal trawling grounds), protection is still well distributed along the coast and moreover effort reduction is balanced between port fleets. Potentially, this scenario would be more easily accepted by fishers as all ports would contribute in a same scale to the resource management.

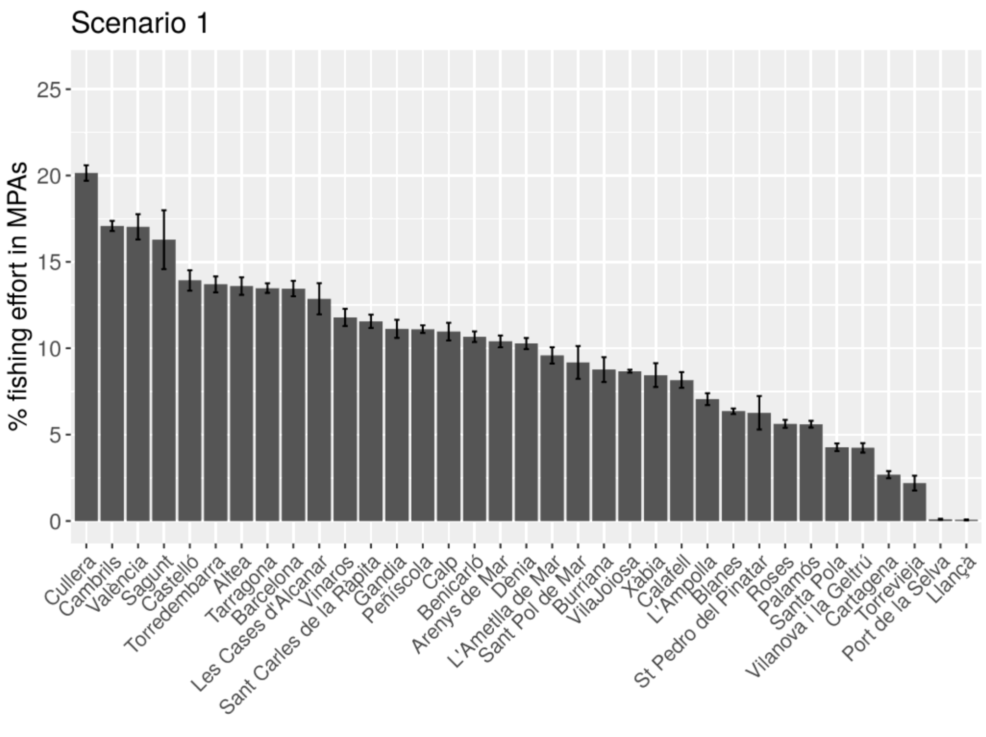

Figure 414. Mean five years (2015-2019) values for the port relative fishing effort inside MPAs designed under scenario 1 criteria. Standard errors for the yearly mean are shown.

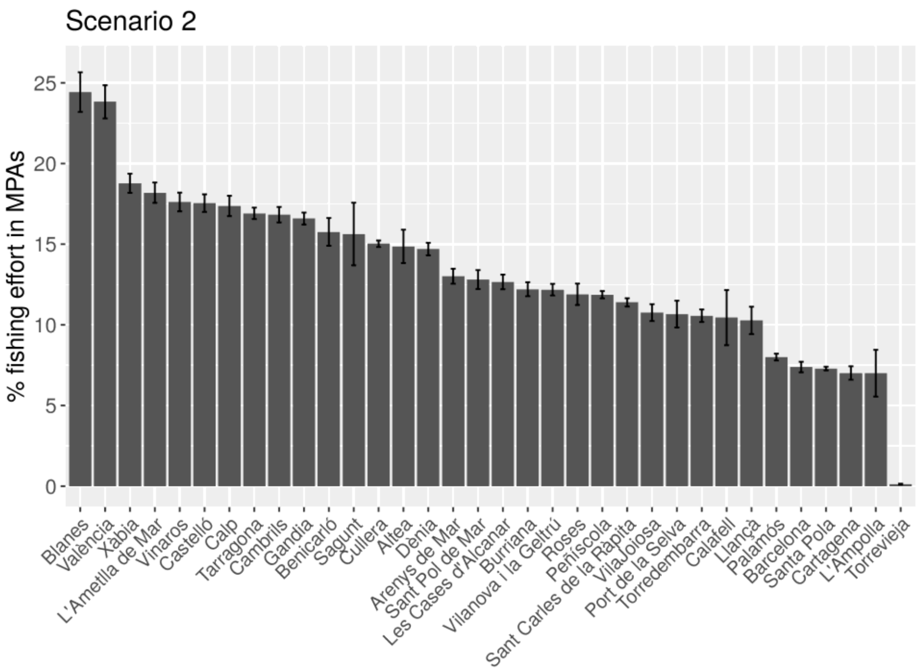

Figure 415. Mean five years (2015-2019) values for the port relative fishing effort inside MPAs designed under scenario 2 criteria. Standard errors for the yearly mean are shown.

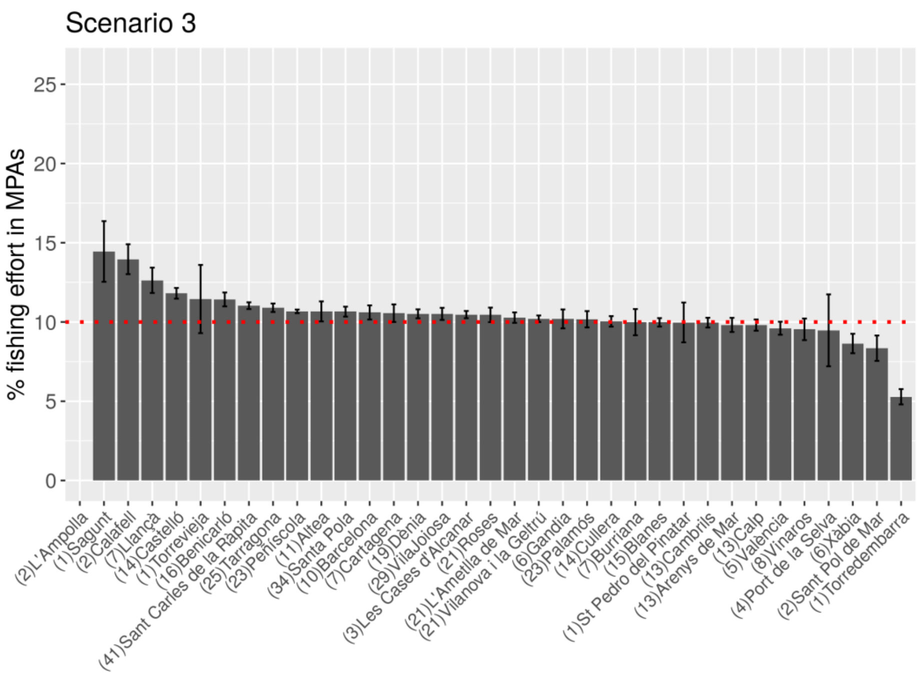

Figure 416. Mean five years (2015-2019) values for the port relative fishing effort inside MPAs designed under scenario 3 criteria. Standard errors for the yearly mean are shown. Number of vessels in each base port is indicated in each port name, therefore number of vessels affected by each reduction can be also taken into account.

7. CONCLUSIONS (CONCLUSIONS)

Aquest informe de treball i de resultats correspon als dos any i escaig (25 mesos) des de l'inici i posta en marxa del del sistema de seguiment de les pesqueres a Catalunya. Ha estat un periode de posta a punt de les diverses metodologies per fer un seguiment que fins a la data no es tenia protocolitzat. L'equip tècnic d'ICATMAR, amb l'assessororament científic de diversos investigadors de l'Institut de Ciències del Mar del Consejo Superior de Investigaciones Científicas (ICM-CSIC), ha hagut de preparar i testar tot el sistema de monitoreig així com el sistema d'amagatzamatge i tractament de dades. Per aquest motiu, aquest informe té un carácter molt metodològic i descriptiu. Es preten que els propers informes anuals de l'estat de les pesqueres a Catalunya tingui un caràcter més analític i amb recomanancions concretes per la millora de la gestió pesquera de Catalunya.

Les conclusions d'aquest Informe Final d'Activitats i Resultats són en base a les dades i resultats del seguiment biològic des d'octubre de 2018 fins a desembre de 2020. En aquest informe disposa de 2 cicles anuals complerts de dades biològiques i pesqueres que són un punt de partida per poder iniciar les tasques d'avaluació dels estocs, que s'espera poder abordar durant el segon semestre de l'any 2022, on es disposaran de 3 cicles anuals complerts de dades biològiques. Cal mencionar que els organismes internacionals de gestió i avaluació dels estocs pesquers demanen com a mínim 5 anys de dades per poder emetre els seus informes de recomanacions.

Així, les conclusions d'aquest Informe Final de l'estat de les pesqueres a Catalunya per periode octubre de 2018 a desembre de 2020 són les següents:

1. Com s'ha mencionat, les dades i resultats que conformen aquest informe no ens permeten elaborar recomanacions globals de gestió dels estocs del marge català. Però les dades i resultats presentats si que mostren la tendència global de sobreexplotació generalitzada dels estocs pesquers de les nostres costes. Tots els indicadors biològics de les espècies principals d'interès pesquer així com els indicadors de quilos capturats i

desembarcaments de peix a les llotges són negatius. Cal però fer una anàlisi més detallada d'aquests paràmetres.

2. Els resultats obtinguts amb l'anàlisi de métiers de les diferents confraries catalanes seran la base per poder classificar i caracteritzar les diferents pesqueres dels ports en base a les diferents estratègies dels pescadors .
3. És important destacar els resultats que s'han obtingut de la distribució espacial de l'esforç pesquer mitjançant dades de caixes blaves (VMS) de l'art d'arrossegament i de les captures de les espècies comercials i no comercials i del rendiment econòmic de les comercials, que ens permetran dins d'un entorn geoespacial (GIS) abordar el rendiment pesquer tant en captures com en euros dels diferents ports i confraries de la costa catalana.
4. A la fi s'han creat les bases per poder aplicar models DataPoor, fer anàlisis de productivitat i susceptibilitat de la comunitat d'espècies explotades (PSA), anàlisis de pseudocohorts (VIT) i finalment fer una avaluació amb els estàndards europeus (VPA, models de producció) en la mesura del possible, quan es tingui un mínim de 5 anys de dades de les diferents espècies objectiu.
5. S'han recollit dades biològiques de les principals espècies d'interès comercial (cicle reproductiu, talla de primera maduresa i relació talla-pes), i es pretén recalcular aquests valors per ser comparats amb dades pròpies de fa 20 anys. Aquests valors actualitzats ajudaran sens dubte a poder ajustar millor els models actuals d'avaluació pesquera.

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