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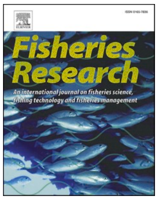

Behavioural patterns, spatial utilisation and landings composition of a small-scale fishery in the eastern Mediterranean

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ABSTRACT

Small-scale fisheries (SSFs) are crucial for global food security and cultural heritage, however, information on their spatial distribution and practices are often lacking, precluding effective management and mitigation of ecological impacts. This is acutely the case in the eastern Mediterranean basin, where, despite concerns being raised regarding the magnitude of marine turtle bycatch in SSFs over two decades ago, a poor understanding of the fishery persists. To address this knowledge gap, we characterised the SSF fleet of Northern Cyprus through a combination of onboard observations, fisher self-reporting and vessel tracking to provide the first comprehensive overview of the fishery. Northern Cyprus had a fleet size, standardised by coastline length, ranked 14th of 23 Mediterranean fleets assessed, with an estimated 49542 and 57198 fishing days in total in 2020 and 2021, respectively. Vessels operated mainly over the continental shelf (< 200 m) and were predominantly active during the night (53.2%, n = 573378 locations). Clear crepuscular peaks in vessel activity and gear deployment raise concerns over spatiotemporal overlap with vulnerable species, even within MPAs previously established to protect them. Fishers (n = 1296 fishing operations) predominantly utilised static and demersal gear types including gill nets (35.0%), trammel nets (27.3%), trammel and gill nets combined (20.3%), demersal longlines (17.0%) and handlines (0.5%). Landings composition was highly diverse with a minimum of 238 different taxa identified, including, but not limited to, 123 species of bony fish, 22 elasmobranch species, 3 marine turtle species and 12 mollusc species of which 18.6% are considered threatened either at a Mediterranean or global scale. However, over 70.0% of total landing mass was comprised of only five species including bogue (*Boops boops*), picarel (*Spicara smaris*), blotched picarel (*Spicara maena*), greater amberjack (*Seriola dumerili*) and Mediterranean parrotfish (*Sparisoma cretense*). As the most up to date and detailed understanding of this fishery's operating behaviours, our research compares the results obtained from onboard observer and self-reporting fisher sampling methodologies and discusses the caveats of each and identifies potential opportunities to adapt existing practices and MPAs to improve long-term sustainability of the fishery, whilst maintaining its socio-economic benefits to the local community.

1. Introduction

Globally, small-scale fisheries (SSFs) play an important role in providing income, employment and food security (Chuenpagdee and Jentoft, 2019; Pauly and Zeller, 2016; Smith and Basurto, 2019) with estimates of more than half a billion livelihoods supported worldwide (Bennett et al., 2018). Previously, SSFs have been considered as more selective and less harmful to marine life than industrial and semi-industrial fisheries (Lucchetti et al., 2020; Maynou et al., 2011; Papaconstantinou and Farrugio, 2000) which are frequently identified as the main contributors to bycatch (Lucchetti and Sala, 2010; Wallace et al., 2010). However, in recent years negative ecological impacts have increasingly been reported for SSFs (Lloret et al., 2019; Shester and Micheli, 2011), with some suggesting the magnitude of their landings

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and bycatch may equal or exceed that of industrialised fisheries (Alfaro-Shigueto et al., 2011; Jacquet and Pauly, 2008; Mangel et al., 2010). Their pervasive impacts on already diminishing fish stocks are now recognised internationally (Coulthard et al., 2011), with the available data suggesting around half of fish stocks targeted by SSFs globally are under threat and overexploited (Costello et al., 2012). Considering that in 2020 the world's motorised fishing fleet was estimated at around 2.5 million vessels with 81% of these being less than 12 m in length (i.e., small-scale vessels) and less than 5% greater than 24 m (FAO, 2022b), the scale of these impacts is hardly surprising.

Reported SSF impacts may be indicative of a deeper global issue given the overwhelming scarcity and inherent difficulty in collecting data to characterise fleets (FAO, 2017; Pascual-Fernández et al., 2020; Pita et al., 2019). The number and diversity of vessels, remote and often inaccessible nature of landing sites, as well as sporadic and decentralised harvest, post-harvest and marketing activities of SSFs make it difficult to collect data on and therefore understand these fisheries (Batista et al., 2014; Salas et al., 2007). This contributes to extremely challenging management and control compared to their industrialised counterparts.

The Mediterranean has a fishing fleet predominantly comprised of SSFs (80.2%) with an estimated 59,608 vessels from more than 20 countries (FAO, 2022a) and is considered one of the most overexploited seas worldwide (Colloca et al., 2013; Fernandes et al., 2017; Panagopoulou et al., 2017). SSFs are fundamental contributors to employment and revenue in the commercial fishery sector of the Mediterranean, providing 60% of total employment, 28% of revenue and the highest contributor to revenue of any fishery type in the eastern Mediterranean sub region (FAO, 2022a). These fleets are generally regarded as multi-gear and multi-species (polyvalent; Lloret et al., 2019; Snape et al., 2013), although there is a general lack of quantitative data on fishing effort and landings. Gear types are known to be adapted according to the target species, market demand, fishing season (Maynou et al., 2011; Tzanatos et al., 2006), local availability and spatial distribution (Roditi and Vafidis, 2019). The combination of these factors is collectively termed métier - however, due to the small size of vessels (<12 m total length) they are often limited in the number of gears they can store onboard and so similarities are often observed between different fleets. Fishing tends to be concentrated in near-shore waters, typically within 12 nautical miles of the coast (Lucchetti and Sala, 2010), although, offshore fishing also occurs (Lloret et al., 2019). Spatially explicit information on the distribution and footprint of SSFs is often lacking, as vessels of less than 12 m in length are typically not required to have vessel tracking systems, largely due to the associated costs of implementation (Glarou et al., 2022). Despite this, proposals to implement compulsory tracking on some small-scale vessels have been suggested (European Commission, 2018). Without these core spatial, behavioural and landings data, policy decision and mitigation efforts designed to modify behaviours, practices and spatiotemporal management of SSFs will likely be ineffective.

In the absence of national initiatives to obtain spatiotemporal and behavioural data from small-scale fishing vessels, sampling methods such as onboard observers and fisher questionnaire surveys have been utilised to collate data on landings (Alfaro-Shigueto et al., 2010; Alonso-Fernández et al., 2019; Pauly et al., 2014; Pere et al., 2019; Ulman et al., 2015a), location of fishing grounds, fishing effort (Grati et al., 2022) and bycatch rates (Alfaro-Shigueto et al., 2010, 2018; Glarou et al., 2022). Despite this, there is a general lack of studies directly comparing the two methods and a paucity of such studies particularly within the Mediterranean, which has resulted in a lack of knowledge surrounding fishing operations and contributed to the underestimation of landings estimates across many countries (Coll et al., 2014; Pauly et al., 2014; Piroddi et al., 2015; Ulman et al., 2015a, 2015b). Relatively low-cost and versatile technologies such as GPS trackers have been increasingly utilised in a variety of industrial and small-scale fisheries monitoring studies globally. Such studies include identifying distinct user groups with vastly differing operating behaviours within fleets (Metcalfe et al., 2017), detecting usage of anchored fish aggregating devices (Widyatmoko et al., 2021) and remote estimation of effort, value and biomass removal (Exeter et al., 2021). Contrary to the lack of onboard observer and fisher surveys in the Mediterranean, vessel monitoring studies have been conducted predominantly utilising VMS data for vessels larger than 15 m for similar purposes (Maina et al., 2021; Russo et al., 2017; Sala-Coromina et al., 2021). Though recently, some pilot studies have emerged estimating overlap of SSFs with cetaceans (Glarou et al., 2022), developing SSF fishery footprints (Snape, 2019) and fishing activity (Burgos et al., 2013). The eastern basin of the Mediterranean is particularly sparse in these types of studies despite ongoing concerns raised over the ecological impact of fisheries in this region, such as bycatch, over two decades ago (Laurent et al., 1998).

One such data scarce fishery is that of Northern Cyprus which is situated in the eastern Mediterranean basin and has a commercial fishing fleet made up exclusively of SSF vessels; trawling and purse seining are banned year-round (Ulman et al., 2015a). The island of Cyprus has been divided into two geopolitical sub regions by the United Nations-monitored buffer zone, the Green Line (Sabri and Sakallı, 2021), since 1974 (Ulman et al., 2015a); the south under the effective control of the Republic of Cyprus authorities and the north by the Northern Cyprus authorities. The Northern Cyprus fishery is the sole fishery in the region which is governed entirely independently of international regulatory bodies as a state which is not recognised by the international community. Turkish Cypriot captains operating in Northern Cyprus are European Union (EU) citizens, and are entitled to export their fish to the Republic of Cyprus administered area through the Green Line Regulation (Council Regulation 866/2004), however, neither the responsible regional fisheries management organisation, General Fisheries Commission for the Mediterranean (GFCM), nor the EU itself undertake any active role in monitoring or management of the Northern Cyprus fleet. The fishery has been monitored for research purposes in recent decades by the local marine conservation NGO, the Society for the Protection of Turtles (SPOT). A basic understanding of the fishery has been gathered with marine turtle bycatch (Haywood et al., 2020; Laurent et al., 1998; Palmer et al., 2021; Snape et al., 2013; Snape, 2019), legal trade in protected elasmobranch species (Snape et al., 2020), interactions with dolphins and overfishing (Snape et al., 2018b) highlighted as causes for concern. Whilst trade of marine turtles is prohibited in Northern Cyprus, elasmobranchs are not afforded the same protections and are often sold for consumption alongside bony fish, crustaceans and molluscs, among others. A network of Marine Protected Areas (MPAs) has been established across Northern Cyprus as part of potential Natura 2000 areas, with the support of the EU, but the management plans of these Special Environment Protection Areas (SEPAs) are yet to be enforced regarding their associated fisheries restrictions. Considering a main concern for this fishery is its spatiotemporal overlap and impacts on vulnerable vertebrate taxa (Casale, 2011; FAO, 2022a; Laurent et al., 1998; Snape et al., 2013, 2018a; b) a detailed characterisation of the fishery is considered a research priority.

To better inform national fisheries management strategies and to provide a baseline understanding of the fishery from which to monitor response to management, we used a multidisciplinary approach to provide the first comprehensive overview of the Northern Cyprus SSF fleet. To achieve this, we used a combination of onboard observations, fisher self-reporting and vessel tracking. Specifically, the aims of this study were to: (1) describe fleet size, distribution and the typology of gears used; (2) quantify landings and landings composition; (3) delineate fisher and vessel operating behaviours; (4) compare onboard observer and self-reporting fisher sampling strategies; and (5) determine spatial patterns of resource use and fishery footprint.

2. Methods and materials

2.1. Study area

The island of Cyprus is situated in the eastern Mediterranean basin and supports two small-scale fisheries regulated by different governing bodies of which those in the northern part of the island are the focus of the current study. This fleet is made up exclusively of SSF vessels which are all less than 12 m in length (Fig. 1A), and utilise a variety of gears including demersal monofilament and multifilament set gill nets (Fig. 1B), trammel nets (Fig. 1C), combined gillnets-trammel nets (a combination of gill and trammel nets tied together laterally), demersal set longlines (Fig. 1E), and handlines (Fig. 1F). The use of any kind of traps is not permitted. The fleet does not contain any trawling vessels, vessels larger than 12 m, purse seiners or pelagic longline vessels, although, as these are polyvalent vessels, a small number of boats occasionally use pelagic longlines. Under the GFCM proposed fleet segments for data reporting, the fleet comprises polyvalent small-scale vessels with engines using passive gear (FAO, 2022a).

Along the coast of Northern Cyprus there are a total of 15 fishing harbours (Fig. 1D), of which 14 are officially recognised and one (harbour 10) is a seasonal landing platform frequently utilised by fishers from nearby harbours when weather permits, and therefore was included in analyses. Similarly, whilst harbour 2 had few registered vessels and was rarely used by fishers during the onboard observer and self-reporting sampling period, its capacity has recently been expanded and has therefore become an important harbour to consider and include in analyses. Harbour 12, whilst an officially recognised harbour, was excluded from analyses due to hosting only one registered vessel and was not utilised by any fisher in our study. The harbours are grouped by the Northern Cyprus Department for Animal Husbandry (DAH) into three broader regions known as Gemikonağı (harbour 1), Girne (harbours 2–5) and Mağusa (harbours 6–15; Fig. 1D; Table S1). The number of registered and active vessels, as well as the number of individual fishers by broader region were obtained from the DAH. Vessel counts were also collected using satellite imagery over concurrent years and compared to the DAH active vessel counts to validate the reliability of the latter. SSF vessels were distinguished from recreational vessels in satellite images by their size, and the presence of square tarpaulin on the vessel used for shade by fishers. Analysis of satellite imagery followed methods in Keramidas et al. (2018); Supplementary Material S3; Fig. S2). To contextualise the Northern Cyprus fleet size and landings per vessel, SSF fleet size of other Mediterranean countries along with that of Northern Cyprus were standardised by their respective country's coastline length (Supplementary Material S2 for details) and compared (Table S2).

Fisheries data collection occurred across all harbours excluding harbour 2 and 12. A total of 31 vessels were sampled collectively between the three sampling strategies (onboard observations: n = 22, self-reporting: n = 9; vessel tracking; n = 12) between 2018 and 2021 (Table S1); six participated in all three sampling strategies (Fig. S1). By region, this equated to 6, 7 and 19 vessels in Gemikonağı (Karavostasi) (13.6%, n = 44), Girne (Kyrenia) (7.0%, n = 99) and Mağusa (Famagusta) (9.0%, n = 212), respectively (Fig. 1D) relative to the mean number of active vessels recorded for those regions between 2018 and 2021 by the DAH (Fig. 2A). Participatory fishers were recruited for this study on a voluntary basis through a number of methods; a long-term contact list was developed through previous fisheries and bycatch interactions research designed and organised by SPOT (Snape et al., 2013; Snape et al., 2018b), this was also supplemented by multiple engagement and training workshops within the main coastal regions, and contacting fishers utilising details provided by the DAH.

Vessels participating in this study were constructed of wood and sealed with fibreglass which ranged in size from 6.6 to 10.7 m in length (mean length: 8.8 ± 1.0 m) with engines between 24.0 and 130.0 hp (mean engine size: 65.3 ± 30.2 hp); vessel metrics obtained from DAH records. All vessels used fish finding equipment, although these were generally used as a navigational tool to locate target setting areas through the depth gauge function, in combination with guidance of landmarks on the coast. Some of these devices had GPS functionality, but GPS was rarely used to locate target setting areas.

2.2. Onboard observations and self-reporting

Over a two-year period (January 2018-December 2019), onboard observations by trained volunteers and self-reported trips conducted by fishers were undertaken simultaneously (Fig. S1). Observers and self-reporting fishers were trained in how to record gear and landings information through onboard training sessions. Recording methods broadly followed “Monitoring the incidental catch of vulnerable species in Mediterranean and Black Sea fisheries: Methodology for data collection” (FAO, 2019). Fishing operations are considered as any single action carried out during a fishing trip, whether or not a catch was made (FAO, 2019). During long soak times, fishers may return to harbour during a fishing trip to rest before retrieving their gears; a fishing trip during onboard observations and self-reported trips was therefore considered as the time vessels left the harbour prior to deploying any gears until their final return to harbour, where all gears that had been deployed after departure had been retrieved. Trips generally begin between noon and dusk and end between dawn and noon the following day. These fishing trip patterns are based on knowledge of fisher behaviour from previous studies (Snape et al., 2013, 2018a; b) and long-term monitoring. Once training had been completed, self-reporting fishers recorded all information without an onboard observer present. Self-reporting fishers were provided with a subsidy per fishing trip for compiling data sheets on their fishing operations.

During both onboard observations and self-reported trips, the following information was recorded: gear type, mesh size (square/bar mesh size; trammel nets: inner panel mesh size) or number of hooks (longlines and hand lines), net height (set nets), filament type (set nets), set length, start and end times of setting and hauling periods, seabed depth at the start and end of sets, target fish species, landings species composition and associated mass. Target fish species were those declared as targets by fishers with non-intended catch including the remaining catch, both commercialised bycatch and discards. Seabed depth of setting locations was recorded using depth sounders present onboard; resolution varied among vessels based on the models and manufacturers used. Onboard observers identified all vertebrate landings to species level and opportunistically (but not exhaustively) identified and quantified invertebrates, while self-reporting fishers identified and quantified the main landings components, but were not expected to record trace amounts of fish captures or invertebrates. Capture events of marine turtles and elasmobranchs were recorded with photographs taken where possible for validation of species identification in close coordination with self-reporting fishers via a phone-based messaging platform. Number of landed marine turtle and elasmobranch individuals are presented throughout as opposed to mass landed due to limitations of equipment and small vessel size that precluded assessment of mass on many occasions. Fish production estimates (landings; tonnes) from the DAH were compared to overall landings sampled through onboard observations and self-reported trips conducted during 2018 and 2019 (Table S7, S8); DAH landing estimates were obtained through interviews with fishers. During onboard observations, set lengths were estimated by fishers but were also recorded during the setting period by observers using a handheld GPS (Garmin eTrex 10); these were statistically compared to verify the accuracy of fishers' estimates (see Supplementary Material S4; Fig. S4). Fisher estimates of set length were collected across both onboard observer and self-reporting sampling strategies, and were therefore used for subsequent analyses conducted using set lengths.

Metrics derived from onboard observations and self-reported fishing operations included: (1) mean soak time; (2) minimum net area; (3)

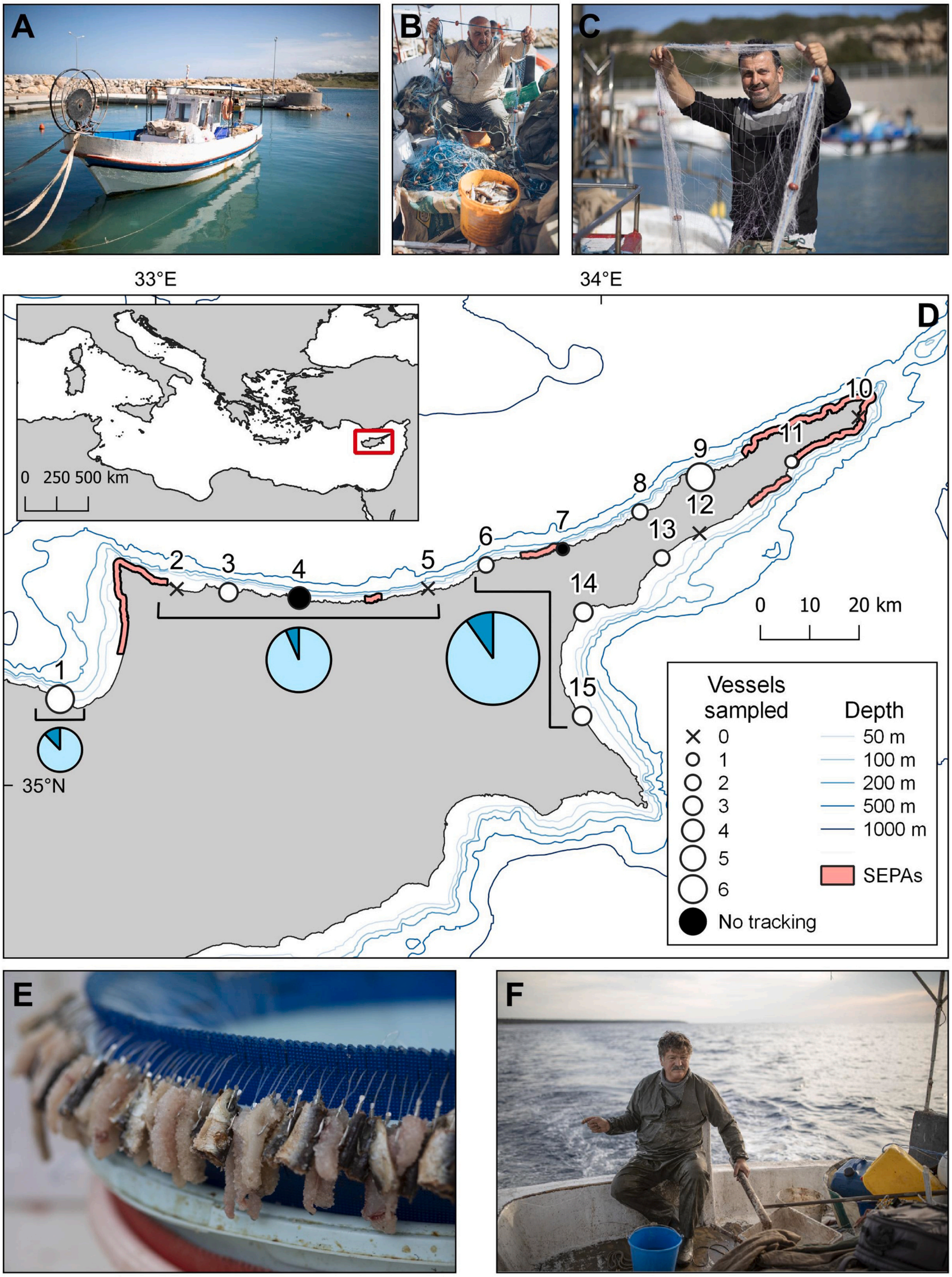

Fig. 1. Typical vessel and gears used in the Northern Cyprus small-scale fleet and study area: (A) archetypal motorised small-scale vessel; (B) monofilament gill net; (C) multifilament trammel net with dolphin depredation damage; (D) location of and sampling effort (n = 31 vessels) by fishing harbour and MPA components of Special Environmental Protection Areas (SEPAs) along the Northern Cyprus coastline; (E) baited demersal longline; and (F) handlining. Pie charts in (D) show the proportion of active vessels by region that were collectively sampled across all sampling strategies and are scaled by the number of active vessels (vessel counts originate from most recent 2021 DAH data). Harbour points are scaled by the number of sampled vessels. Inset map shows the location of Cyprus within the Mediterranean. Photo credits: Olkan Ergüler.

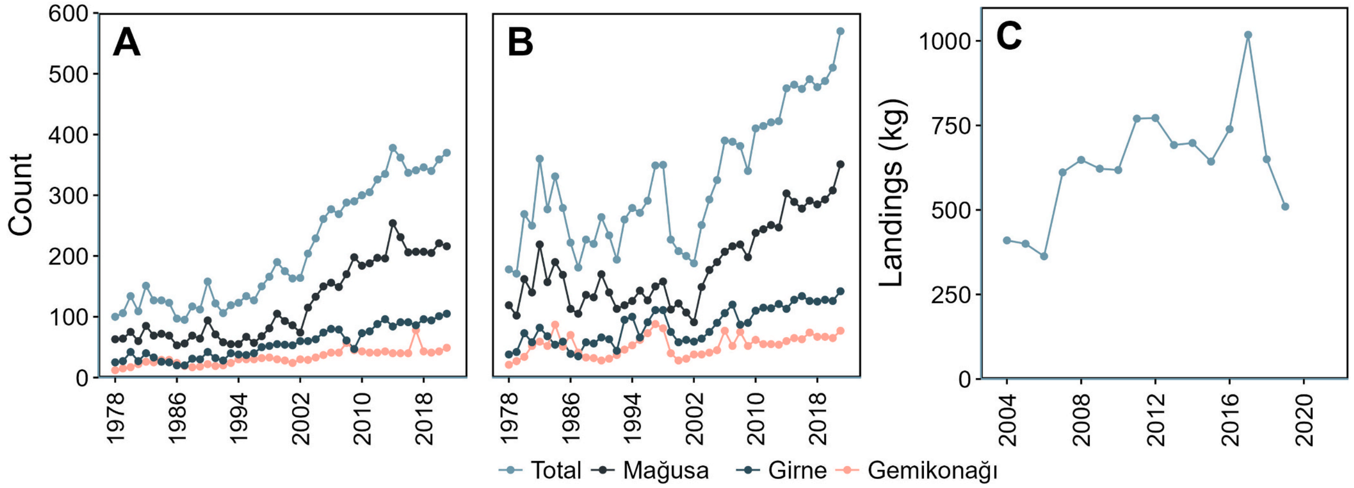

Fig. 2. Yearly counts from the Department of Animal Husbandry of the number of (A) active vessels, (B) fishers and (C) total landings. Note different x axes scales. Totals as well as individual counts by the three main regions of Gemikonağı, Girne and Mağusa are shown in (A) and (B).

mean seabed depth; (4) set length; (5) number of hooks per km; (6) gear specificity; (7); incidental catch of vulnerable species; and (8) top five families by mean landing mass. Two soak times were calculated for each set, one between the start time of setting and start time of hauling and the second between end time of setting and the end time of hauling; these were then subsequently averaged to obtain a mean soak time. Seabed depth was averaged across start and end locations of fishing operations. Gear specificity was calculated per set as the percentage of total landings that were the intended target species. Effects of sampling type and gear type on set net area and average set depth were investigated using GLMs with gamma error distributions.

2.3. Vessel tracking

Intermittent COVID-19 travel and social distancing restrictions in 2020 and 2021 did not prevent fishers from actively fishing, but consistent onboard observations were not always possible and trials for fisher self-reporting ended in 2019. Instead, we used off-the-shelf GPS units (model: I-gotu Gt-600) between 2020 and 2021 to remotely record spatiotemporal data on vessel activity (Cardiec et al., 2020; Glarou et al., 2022; Metcalfe et al., 2017). These were deployed on 22 vessels across 9 harbours resulting in a total of 299 deployments (harbours 1, 3, 6, 8, 9, and 11–14; Fig. 1; Table S1). Date and time of deployment and retrieval was recorded for each unit, programmed to record the location of vessels at 4-minute intervals when vessels were active, and to switch off during periods of inactivity to conserve batteries. As fishing trips are known to span across midnight but not midday and remain within a single 24-hour cycle, fishers do not always return to the same harbour or may anchor in unmarked sheltered bays between trips, and GPS tracked fishers were not required to record trip start and end times, all activity between 13:00:00 and 12:59:59 the following day was considered as a single fishing trip. See Supplementary Material S1 for further detail on fishing trip classification and for relevant data processing and analyses.

3. Results

3.1. Description of the fishery

3.1.1. Fleet size, distribution and gear composition

Active vessels (fishing vessels that are permitted to undertake fishing trips in a given year) and total number of fishers registered with the DAH have steadily increased by 270.0% and 220.2%, respectively, between 1978 and 2021 (Figs. 2A, 2B). The number of registered vessels (all fishing vessels docked in harbours or in dry dock on land) also followed this trend showing a 43.6% increase (Fig. S3). Relative to the 22 Mediterranean national SSF fleets in 2019, the Northern Cyprus fleet ranked 14th (0.85 vessels per km) in terms of density of active vessels relative to coastline length (Table S2). Active vessel counts from the DAH closely matched those detected using satellite imagery, showing a strong positive correlation between the two data sources (Supplementary Material S3; Fig. S2A). Landings recorded by the DAH across the entire fleet showed a general increase peaking at 1018 tonnes in 2017, with a subsequent drastic reduction to 510 tonnes by 2019 (Fig. 2C).

A total of 178 trips with 325 fishing operations were recorded between 2018 and 2019 by onboard observers (OO) and 747 trips with 971 fishing operations through self-reported (SR) trips. Most self-reported trips consisted of only one fishing operation per trip (OO: 43.3%, n = 178 trips; SR: 74.0%, n = 747 trips) whereas most onboard observer trips conducted more than one fishing operation per trip (OO: 56.7%, n = 178 trips; SR: 26.0%, n = 747 trips). Fishers utilised a variety of gears including gill net (35.0%), trammel net (27.3%), combined gillnets-trammel nets (20.3%), demersal longline (16.9%) pelagic longline (0.01%) and handlining (0.5%, n = 1296 fishing operations; Fig. 3). Due to the small sample size of pelagic longlines, all longlines were combined for subsequent analyses. Trammel net fishing operations were more prevalent in onboard observer data (44.3%, n = 325) and gill nets more prevalent in self-reported data (34.2%, n = 971; Fig. 3).

As is common in most SSFs, fishers frequently used multiple gear types within individual trips and fishing operations, combining sections of gill and trammel nets to form one larger deployment (combined gillnets-trammel nets), using multiple filament types, net heights, mesh and hook sizes to select for a variety of target commercial fish species (Table S6). All gear types, excluding the one pelagic longline mentioned already, were demersal and set statically, excluding baited handlines which were towed epipelagically from the stern of the boat. Typically, longlines had a greater number of hooks deployed per kilometre set in self-reported fishing operations (mean±SD=286 ± 320, range: 40–3000) compared to onboard observations (mean±SD=122 ± 110, range: 1–286; Fig. 4D). Baited handline fishing operations were largely opportunistic and generally towed during transit to and from fishing grounds. Longlines used a total of 20 different bait types across both sampling strategies and up to four different bait types in a single fishing operation (SR: 0.9%, n = 202; Table S4); bony fish were the most common group utilised (OO: 68.8% n = 16; SR: 79.7%, n = 202), but at an individual bait type level, cuttlefish (OO: 25.0%, n = 16; SR: 23.3%, n = 202) and octopus (OO: 18.8%, n = 16) were most prevalent (Table S4).

Gears were set and hauled around crepuscular periods, with more

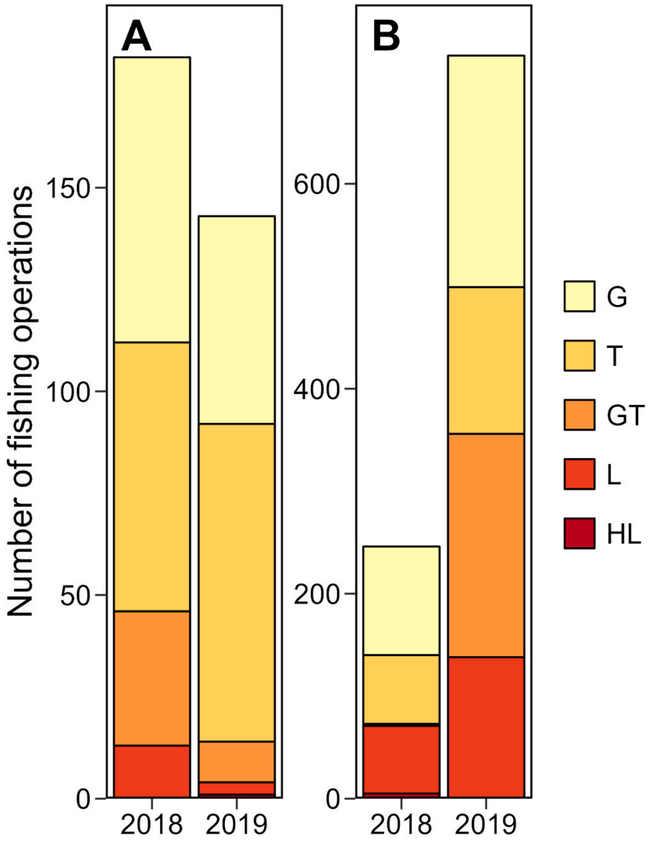

Fig. 3. Number of fishing operations by gear type (G: gill nets; T: trammel nets; GT: combined gillnets-trammel nets; L: longlines; HL: handlines) and year for **(A)** onboard observations (n = 325) and **(B)** self-reported fishing operations (n = 971). Note different y axis scales.

fishing operations deployed and retrieved around sunrise than sunset (Fig. S5). Time of day setting and hauling occurred were similar across gear types, with longlines generally set and hauled earlier both at dawn and dusk (Fig. S5), but varied more markedly at individual target species level (Fig. S6). Mean soak times (average of soak times between start time of setting and start time of hauling and soak time between end time of setting and end time of hauling; see Supplementary Material S1 for details) of set nets ranged from 0.3 to 28.7 h (Fig. 4A; mean±SD=6.2 ± 5.7 h, n = 1070) whereas longline soak times ranged between 1.0 and 29.1 h (mean±SD=3.8 ± 3.3 h). Most mean soak times were less than 12 h in length (set nets: 75.2%, n = 1070; longlines: 93.2%, n = 220; Fig. 4). Some fishing operations exceeded a 24-hour soak time (0.8%, n = 1296 fishing operations; Table S6).

Overall, set length averaged 2.30 km for set nets (SD: 1.50 km; range: 0.03–8.50 km) and 3.00 km for longlines (SD: 1.71 km; range: 0.20–8.50 km). Of the total 325 onboard observer sets, 281 had both fisher and GPS estimates recorded; set lengths estimated by fishers averaged 1.48 ± 0.96 km (mean±SD, range: 0.03–6.00 km) and GPS estimates at 1.56 ± 1.04 km (mean±SD, range: 0.19–6.21 km; Fig. S4A). Pairwise comparison of fisher and GPS set length estimation suggested fishers' estimates were on average 68.5 m lower (95% CI: 8.7–128.5 m; t_{279} =−2.30, n = 281, p = 0.03; Fig. S4B) resulting in an average percentage difference of −3.0 ± 29.6% (mean±SD, range:−133.3 to 94.4%) between the two estimation methods; given these relatively minor discrepancies and that fishers' estimates were available for both sampling strategies, fishers' estimates were utilised for all analyses involving set lengths and area. Set net area was influenced by an interaction between sampling type and gear type; set nets deployed in self-reported fishing operations were larger in area on average than those of onboard observations with trammel nets largest in onboard observations and combined gillnets-trammel nets largest in self-reported fishing operations (GLM, F_{2890} =3.46, p = 0.03; Fig. 4B; Table S3).

Fishing effort was concentrated around shallow coastal waters (mean ±SD=38.0 ± 25.8 m; Fig. 4C), with longlines, followed closely by gill nets, set deeper on average (LM, $F_{3,1056}$ =18.16, p < 0.001; Fig. 4C).

3.1.2. *Target species and landings*

Of the total 325 onboard observations and 971 self-reported fishing operations, landings data were available for 314 and 790 fishing operations, respectively; four self-reported fishing operations reported zero landings. Overall, 23,744.4 kg of fish, excluding marine turtles and elasmobranchs, were landed during the sampling period (OO: 5116.7 kg; SR: 18,627.7 kg) and a minimum of 238 taxa were recorded (211 in onboard observations and 87 in self-reported), comprising 144 bony fishes, 3 marine turtles, 29 elasmobranchs, 25 crustaceans, 14 echinoderms, 18 molluscs, 4 cnidarians and a polychaete worm species (Table S7, S8). Of those identified to species level, 30 are classified by IUCN as threatened either at a Mediterranean or global scale (12 bony fishes, 9.8%, n = 123; 15 elasmobranchs, 75.0%, n = 23; 2 marine turtles, 66.7%, n = 3; and 1 mollusc, 8.3%, n = 12) and 13 as Data Deficient (7 bony fishes, 5.7%, n = 123; 3 elasmobranchs, 13.0%, n = 23; and 2 molluscs, 16.7%, n = 12). Of the 238 taxa recorded, 14 are considered invasive including, but not limited to, common lionfish (*Pterois miles*), yellowspotted puffer (*Torquigener flavimaculosus*), silver-cheeked pufferfish (*Lagocephalus sceleratus*), marbled and dusky spinefoot, bluespotted cornetfish (*Fistularia commersonii*) and Red Sea goatfish (*Parupeneus forsskali*).

Fishing operations targeted 33 unique combinations of species including those where a pool of species was collectively specified by the fisher (e.g., seabreams, groupers etc.) as well as individually named species. Where a pool of target species was specified by the fisher, the total number of species targeted for that set included any species recorded within the landings data that are taxonomically classified within the specified group (see Table S5 for target species group classifications). More than one gear type was used for 28 of the 33 unique target groups (81.3%) resulting in 83 different gear-target combinations. Most fishing operations targeted only one (OO: 65.2%, n = 325; SR: 49.6%, n = 971) or two species (OO: 21.2%, n = 325; SR: 30.2%, n = 971) but fishing operations targeting up to 21 different species (OO: 0.3%, n = 325) were also observed as well as those that had no specific target (OO: 2.8%, n = 325; SR: 1.0%, n = 971). The most commonly targeted species identified were similar between sampling strategies, where onboard observer fishing operations most frequently targeted striped red mullet (21.8%), bogue (19.1%) and spinefoot species (15.1%; n = 325) and self-reported targeted bogue (36.4%), dusky grouper (*Epinephelus marginatus*; 16.8%) and striped red mullet (14.4%; n = 971; Table S7). Landings were generally higher during summer months, though there was some variation by target species, gear type and sampling strategy (Fig. S7, S8).

Number of species landed within a fishing operation varied between sampling strategies; on average 11.9 species were caught in fishing operations recorded by onboard observers (SD=6.7, range: 1.0–31.0 species) and 2.8 in self-reported (SD=2.1, range: 1.0–12.0 species). At a family level, excluding elasmobranchs and marine turtles, similar families were observed across sampling strategies which contributed the most to landed mass across all gear types (mean landed mass per fishing operation). The top five families across all gear types in decreasing order were Sparidae, Siganidae, Mullidae, Holocentridae and Scaridae for onboard observations, and Sparidae, Serranidae, Carangidae, Mullidae and Scaridae for self-reported (Fig. 5). Regarding landings by species across all gear types and both sampling strategies by mass, over 70.0% of total landings were comprised of only five species namely bogue, picarel, blotched picarel (*Spicara maena*), greater amberjack and Mediterranean parrotfish (*Sparisoma cretense*). These were also similar when considered at the individual sampling strategy level, with bogue (OO:

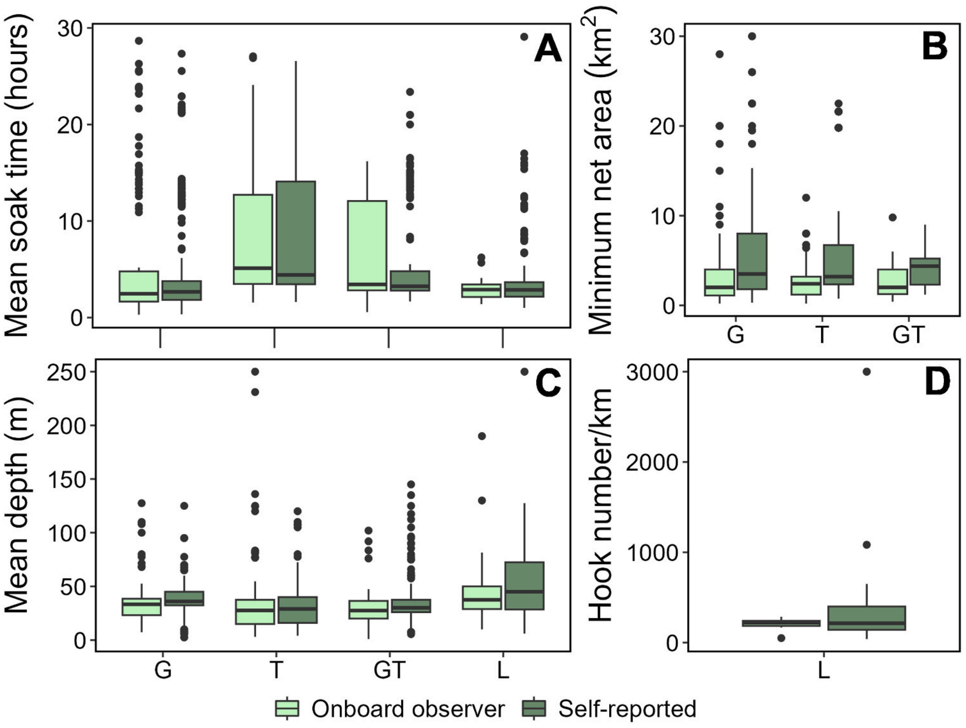

Fig. 4. Operating metrics by gear type (G: gill nets; T: trammel nets; GT: combined gillnets-trammel nets; L: longlines) derived from onboard observer (n = 325) and self-reported fishing operations (n = 971), including: **(A)** mean soak time (hours); **(B)** minimum net area (km^2); **(C)** mean depth (m); and **(D)** number of hooks per km. HL not shown due to small sample size (n = 6). Bold black line shows the median, boxes represent the interquartile range (IQR) whiskers show minimum and maximum values within 1.5 times the IQR, and values outside of this by dots (see Table S3 for exact values).

747.6 kg, 15.0%; SR: 7511.5 kg, 40.3%) and picarel (OO: 1221.7 kg, 24.5%; SR: 3718.5 kg, 20.0%) in the top three species for both, greater amberjack for self-reported only (1234.3 kg, 6.6%) and blotched picarel for onboard observations only (863.5 kg, 17.3%). The most frequently landed species were Mediterranean parrotfish (49.7%), redcoat (*Sargocentron rubrum*; 48.1%) and painted comber (*Serranus scriba*; 44.9%) for onboard observations, and bogue (33.7%), striped red mullet (25.2%) and dusky grouper (20.3%) for self-reported fishing operations (Table S7, S8).

Despite mainly targeting a single species, landings recorded during onboard observations and self-reported fishing operations were often comprised of, and in some cases dominated by, many non-target species. Specificity (defined as the percentage of landings attributable to the stated target species) varied by gear type and sampling strategy and on average was generally higher in self-reported fishing operations across all gear types. Handlines (mean±SE=100.0 ± 0.0%, n = 5) and gill nets (mean±SE=82.0 ± 2.4%, n = 332) in self-reported fishing operations had on average the highest specificity, whereas longline (mean ±SE=14.0 ± 7.5%, n = 16), trammel nets (mean±SE=21.5 ± 2.2%, n = 144) and combined gillnets-trammel nets (mean±SE=21.5 ± 4.7%, n = 43) in onboard observer fishing operations were the gear types with lowest specificity overall (see Table S6 for individual gear-target species specificity values).

A total of 308 fishing operations with available landings data recorded incidental catch events of elasmobranchs or marine turtles; 84 onboard observations (26.8%, n = 314) and 224 self-reported fishing operations (28.4%, n = 790). Within these, 886 individuals of marine turtles and elasmobranchs from 25 species across 15 families were identified (Fig. 6). The most frequently caught taxa were common stingrays (*Dasyatis pastinaca;* OO: 13.4%, n = 314; SR: 13.0%, n = 790), unidentified batoid species (Batoidea spp.; OO: 0.0%, n = 314; SR: 4.6%, n = 790), green turtles (*Chelonia mydas*; OO: 4.5%, n = 314; SR: 2.3%, n = 790), torpedo rays (*Torpedo* spp.; OO: 0.6%, n = 314; SR: 3.7%, n = 790) and marbled torpedo rays (*Torpedo marmorata*; OO: 3.2%, n = 314; SR: 1.1%, n = 790; Table S8). Within a single fishing operation, a maximum of 160 individuals were bycaught (OO: mean ±SD=1.2 ± 9.3, range: 0.0–160.0; SR: mean±SD=0.6 ± 2.6, range: 0.0–62.0) which were predominantly small juvenile and pregnant adult longnose spurdogs (*Squalus blainville*), suggesting a possible spawning/nursery habitat. However, only a maximum of five different species were present in any given fishing operation (OO: mean±SD=0.4 ± 0.8, range: 0.0–5.0; SR: mean±SD=0.4 ± 0.6, range: 0.0–4.0).

3.2. *Vessel GPS tracking*

Vessels were active and left port on an average of 40.0% (SD: 14.0%) of total tracked days per sampled vessel across 2020 and 2021 (range: 1.0–75.0%, n = 22 vessels). This resulted in an average of 138 ± 47.7 (mean±SD, range: 2.0–220.0 days) and 154.6 ± 53.2 (mean±SD, range: 76.0–274.0 days) active fishing days per vessel, per year in 2020 and 2021, respectively. Scaled to the total estimated active fleet size, this suggests a total of 49,542 estimated active fishing days in 2020 and 57,198 in 2021, of which 3.9% and 2.8% were covered by GPS tracking. Daily fishing effort (proportion of tracked vessels that were active and left port on any given day) peaked during the summer months (Fig. 7A: days 122–274; Fig. 7B: days 121–273), generally coinciding with peak mean daily temperatures (Fig. S9 C, D), where daily fishing effort showed little variation among regions (Gemikonağı: mean±SD=0.3 ± 0.2, range: 0.0–1.0; Girne: mean±SD=0.2 ± 0.3, range: 0.0–1.0; Mağusa: mean±SD=0.3 ± 0.2, range: 0.0–0.9). Wind speed was consistently lower along the north coast (Girne: mean±SD=7.6 ± 6.0 km/h, range: 0.0–40.8 km/h), but in all regions remained fairly consistent throughout the year (Gemikonağı: mean±SD=12.4 ± 4.5 km/h, range: 3.4–40.8 km/h; Mağusa: mean±SD=12.7 ± 5.0 km/h, range: 3.2–42.2 km/h; Fig. S9 E, F). Daily fishing effort was significantly negatively affected by wind (GLM, F_{1710} =31.83, $p < 0.001$; Fig. S9A), and positively affected by temperature (GLM, F_{1710} =97.19, $p < 0.001$; Fig. S9B). Daily fishing effort was lower in 2021

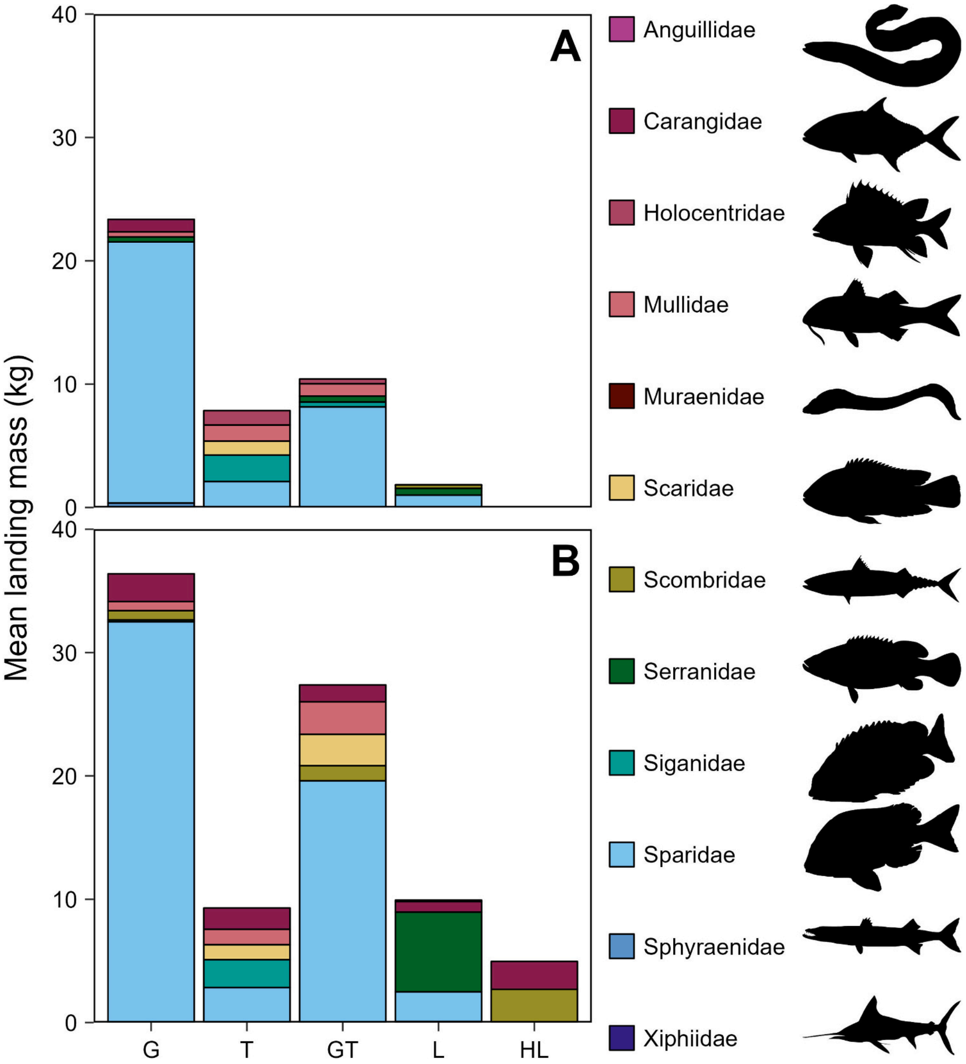

Fig. 5. Mean landing mass of top five taxonomic families landed, excluding non-target marine turtle and elasmobranch species, by gear type (G: gill nets; T: trammel nets; GT: combined gillnets-trammel nets; L: longlines; HL: handlines) derived from **(A)** onboard observations (n = 314) and **(B)** self-reported fishing operations (n = 790), averaged across fishing operations**.** Elasmobranch and marine turtles excluded due to lack of mass data available. Where family level identification wasn't possible, the lowest taxonomic group is given instead. Species illustrations represent the family group and not always Mediterranean-specific species. Illustrations from www.phylopic.org; see acknowledgements for individual artists.

than 2020 (GLM, F_{1710} =7.65, p = 0.006; Fig. S9 A, B).

3.2.1. *Diel activity patterns*

Fishing trips showed clear crepuscular tendencies with most trips beginning before or after mean sunrise or sunset times (65.9%, n = 3793 trips; Fig. 8A). Trips that began in the afternoon usually spanned overnight, ending after sunrise the following day (94.6%, n = 2268 trips; Fig. 8B). This is also reflected in overall activity of vessels, which showed peaks in activity around dawn and dusk and consistently higher nocturnal activity (53.2%, n = 573,378 locations; Fig. 8C). During the day, mornings had more locations and therefore greater activity than the afternoons (95.4%, n = 268,597 locations; Fig. 8C).

3.2.2. *Operating behaviour*

Overall, GPS tracked trip durations were between 0.8 and 23.9 h (median: 8.9 h, IQR: 10.5 h), travelled 0.7–96.0 km (median: 17.7 km, IQR: 17.5 km) at a median speed of 2.4 km/h (IQR: 2.2 km/h, range: 0.0–14.1 km/h) over seabed depths of 2.0–680.0 m (median: 82.0 m, IQR: 114.0 m). Vessels reached maximum offshore distances of up to 14.5 km (median: 1.6 km, IQR: 1.6 km) with median displacement distances of 5.3 km (IQR: 6.6 km, range: 0.2–43.8 km). Trends in operating behaviours were generally consistent across regions (Fig. 9), sites (Fig. S10), seasons (Fig. S11) and years. However, there was a significant effect on all operating metrics, excluding total distance (Fig. 9B), of an interaction between region and year (Table S9). All operating behaviours tended to be greater in 2021 compared to 2020 (Table S10; Fig. S10; Fig. S11). Trips by vessels from Gemikonağı tended to be faster, and in deeper waters further offshore, whereas trips by vessels from harbours in Mağusa were longer in duration (Table S10; Fig. 9).

3.2.3. *Spatial patterns of resource use*

Sampled vessels occupied an area of 1281 km^2 equivalent to 15.9% of the territorial waters (i.e., 12 nautical mile limit from Northern Cyprus coast). Vessel activity was observed along most of the Northern Cyprus coastline excluding an area between harbours 4 and 5 where no vessels were sampled (Fig. 10). Whilst deeper waters, or those further offshore, were used by some vessels in the Gemikonağı region or off the tip of the Karpaz peninsula, respectively, the vast majority of trips operated within shallow coastal waters (<200 m deep; 84.4%, n = 3793 trips), with recorded fishing pressure being more intense near shore in the southernmost part of the bay in Gemikonağı (Güzelyurt Bay), the north coast of the Karpaz peninsula and the northern side of Mağusa

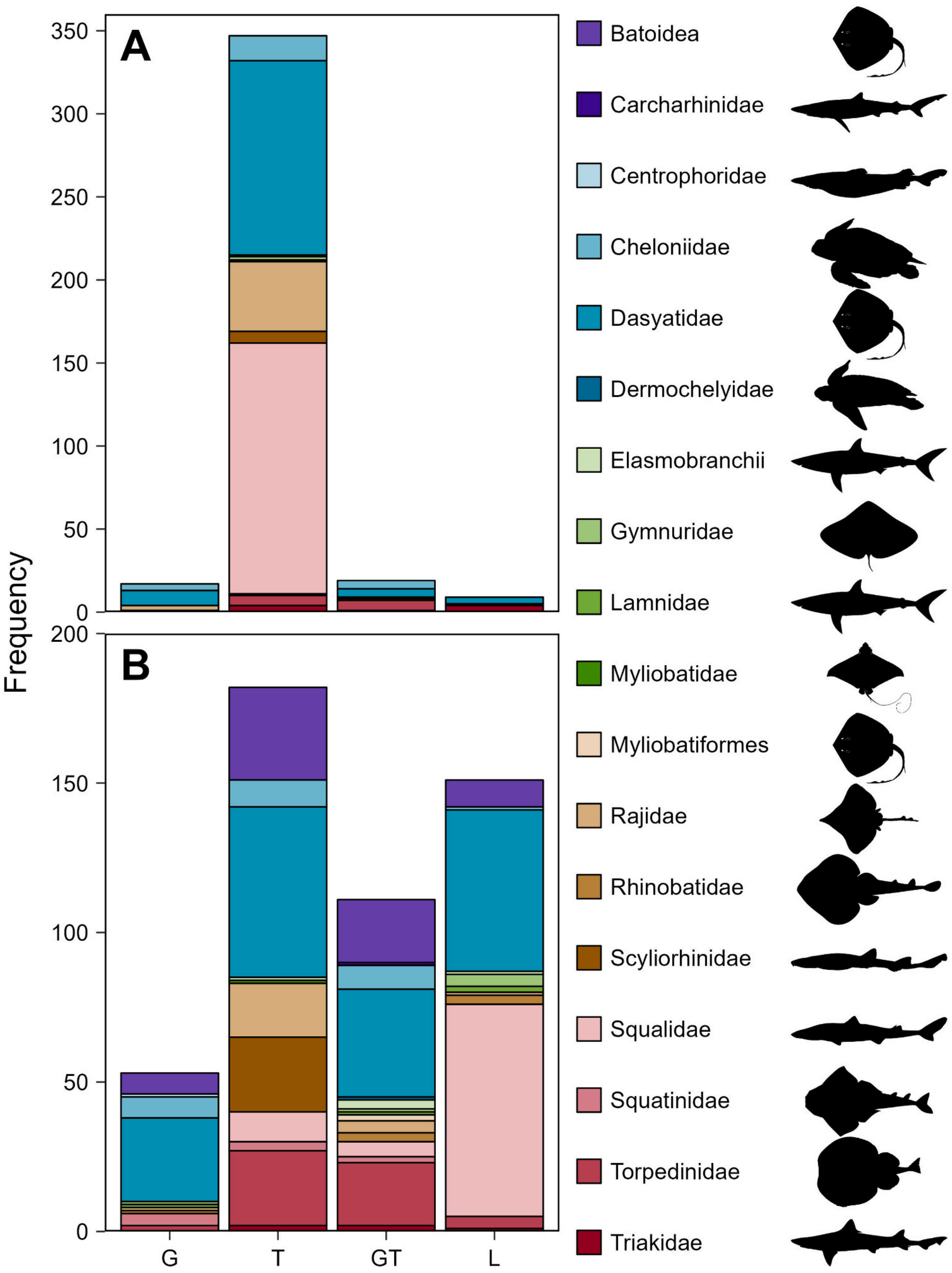

Fig. 6. Total number of elasmobranchs and marine turtles caught by taxonomic family and gear type (G: gill nets; T: trammel nets; GT: combined gillnets-trammel nets; L: longlines) derived from (A) onboard observations (n = 314) and (B) self-reported fishing operations (n = 790). Where family level identification wasn't possible, the lowest taxonomic group is provided instead. Species illustrations represent the family group and not always Mediterranean-specific species. Illustrations from www.phylopic.org; see acknowledgements for individual artists.

Bay.

4. Discussion

This study used a novel approach, through combining detailed onboard observations, engaging fishers in self-reporting and GPS tracking, to address the knowledge gap on SSFs in the eastern Mediterranean over a four-year period, resulting in holistic information for a discrete fishing fleet. We have demonstrated that the active fleet of approximately 370 vessels predominantly operates in nearshore waters overlying the continental shelf (< 200 m) with a clear preference to fish around dawn and dusk. Landings were highly diverse, recording at least 238 different taxa including 22 elasmobranchs and 3 marine turtle species. We also compared two onboard survey methods for gathering data on landings and fishing métier utilisation, which provided contrasting results in some aspects, consideration of which may be helpful in developing future monitoring plans for SSFs.

Records of registered and active fleet size, managed by the Northern Cyprus Department for Animal Husbandry (DAH), were shown to be increasing over the last two decades, a trend that was mirrored in estimates obtained through analysis of satellite images. Across the Mediterranean many fleets have recently been undergoing reductions in size, activity or capacity (FAO, 2022a; Guillen and Maynou, 2016; Maynou, 2020; Quetglas et al., 2016; Sabatella et al., 2017; Lloret et al., 2018; Tzanatos et al., 2020) with the Republic of Cyprus experiencing declines of more than 30% (Lloret et al., 2018). This has been attributed to a variety of reasons including low economic efficiency (Maynou, 2020; Sabatella et al., 2017), low biological productivity of overexploited

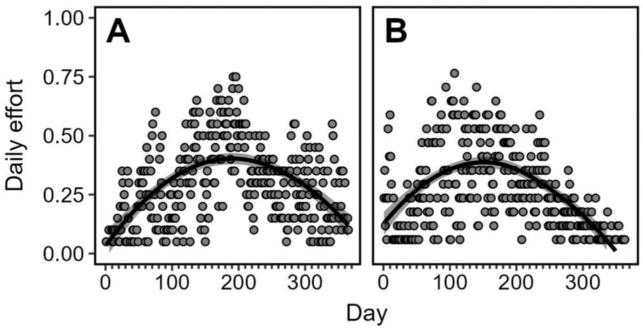

Fig. 7. Annual variation in daily fishing effort derived from GPS tracked vessels (n = 22) along the coast of Northern Cyprus in 2020 (A) and 2021 (B). Solid lines indicate fitted smoothed estimates (derived using LOESS) and shaded regions represent ± 1SE.

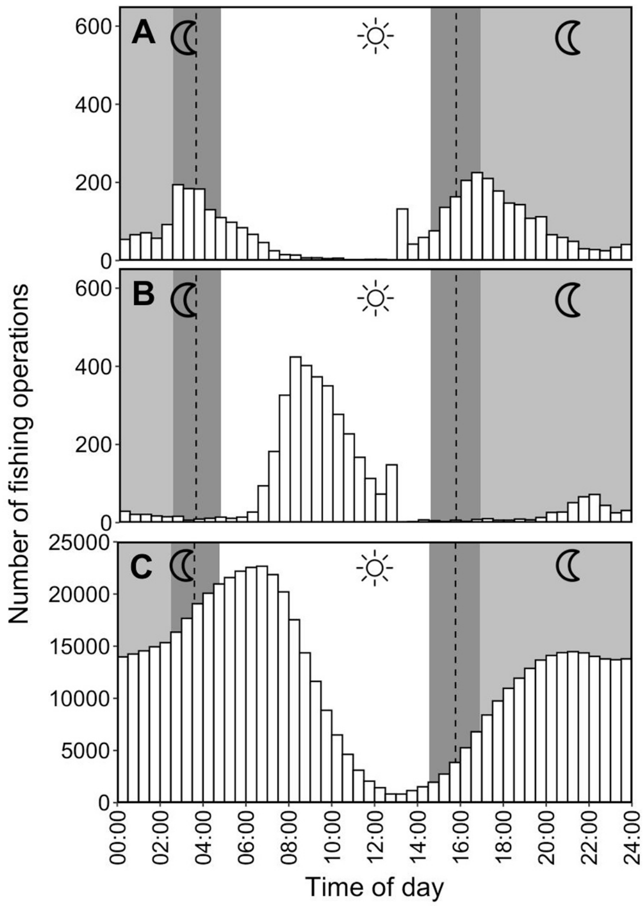

Fig. 8. Vessel diel activity patterns derived from vessel tracking trips (n = 3793) including time of day that trips began (A), ended (B) and the number of individual locations by time demonstrating overall daily activity **(C)**. Areas shaded grey show daily periods without daylight and dark grey indicates the range of sunrise and sunset times throughout the study period based on daily sunrise and sunset times during 2020–2021. Mean sunrise and sunset times are shown by dashed lines. Illustrations from https://www.vecteezy.com/.

stocks (Guillen and Maynou, 2016), EU effort reduction measures (Quetglas et al., 2016) and increases in the amount of decommission aid offered by local fisheries management administrations (Maynou, 2020). However, the observed increase in SSF fleet capacity in Northern Cyprus does not necessarily indicate a corresponding increase in landings; in Mallorca, reductions in fleet size of over 50%, implemented as effort reduction measures, saw landings remained constant despite this decrease (Quetglas et al., 2016). Similarly, data from the DAH in Northern Cyprus suggest as of 2019, landings have decreased below levels recorded over ten years earlier in 2007 despite increasing fleet size. A lack of investment and incentives for the development of the fishery has previously been highlighted by stakeholders across Northern Cyprus (Ciftcioglu, 2021). However, the Green Line regulation on trade has likely offered a major lifeline to the fishery. Due to continued embargos to trade between Northern Cyprus and the global community, the state became economically dependent on Turkey, which has seen exceptional rates of inflation. Northern Cyprus also uses the Turkish Lira, the value of which has continued to depreciate. In supporting sale of fresh fish as one of the very limited products that can be traded for Euro to the ROC controlled area, the Green Line Regulation likely supported fishing as a relatively lucrative trade. In the first full year of the implementation of the Green Line Regulation, fish traded to the ROC controlled area was valued at €760,000, rising to €961,255 in 2019, when it was the second most traded product in terms of value (European Commission, 2023). Fishers wishing to engage in this trade must register, and comply with hygiene measures which are checked by EU officials. However, the EU does not collect data on the fleet itself nor work with the Northern Cyprus authorities on issues such as research and sustainability.

Small scale fishers in Northern Cyprus were found to target a total of 32 different fish species, some of which have been previously shown to be targeted seasonally (Snape et al., 2013), with most targeted by more than one gear type. As fishing métiers vary widely across the Mediterranean and can be extremely localised (Silva et al., 2002), there are clear ramifications for potential management methods which would need to carefully consider the suspected heterogeneity within the fleet to ensure any common governance policies at a broader scale do not unintentionally result in any socio-ecological inequalities (Calò et al., 2022). Informal discussions with fishers during the study period indicated that many have additional sources of income and suggests a detailed socio-economic study is required to evaluate the reliance on the fishery and perceived changes over time. This would additionally provide the relevant social factors derived from interviews and focus groups necessary to undertake a comprehensive métier analysis that explores spatial and temporal changes in the deployment of métiers relative to a variety of target species (Schadeberg et al., 2021).

Despite stocks in the eastern Mediterranean considered as having high or intermediate biomass levels overall (FAO, 2022a), to date there are no formal stock assessments published specific to those exploited by the Northern Cyprus fleet, or indeed other nearby fleets such as those in Greece (Tzanatos et al., 2020). However, the Turkish Cypriot Chamber of Commerce and EU do monitor catches traded across the Green Line. Views of fishers from this fleet were also gathered during the study period through a community voice-based process (Cumming and Norwood, 2012) and reflected in a short film (available here: https://youtu.be/wHBMTBS5knk) which indicated a general consensus that fish stocks are decreasing with a concurrent reduction in the size of fish landed. This standpoint is echoed by other Mediterranean fisheries, including Turkey's SSF where fishers reported that CPUE was 40 times larger in the 1950 s compared to 2013 (Ulman and Pauly, 2016). Data reported by the DAH do suggest a recent decline in overall landings since 2017, but these were not corroborated by estimates obtained from onboard observer and self-reported trips; these estimates suggested landings increased up until 2019. Landings are not required to be recorded by fishers or reported to the DAH annually, and so their estimates are derived from interviews with fishers. Previously reconstructed island-wide estimates of landings suggest actual landings may be much higher (Ulman et al., 2015a) and therefore the fishing effort in Northern Cyprus may be more pervasive than estimated by the DAH. Conservative scaled estimates from the current study suggest the magnitude of landings may be between two to four-fold higher than those reported by the DAH at around 1110 and 2250 tonnes for self-reported fishing

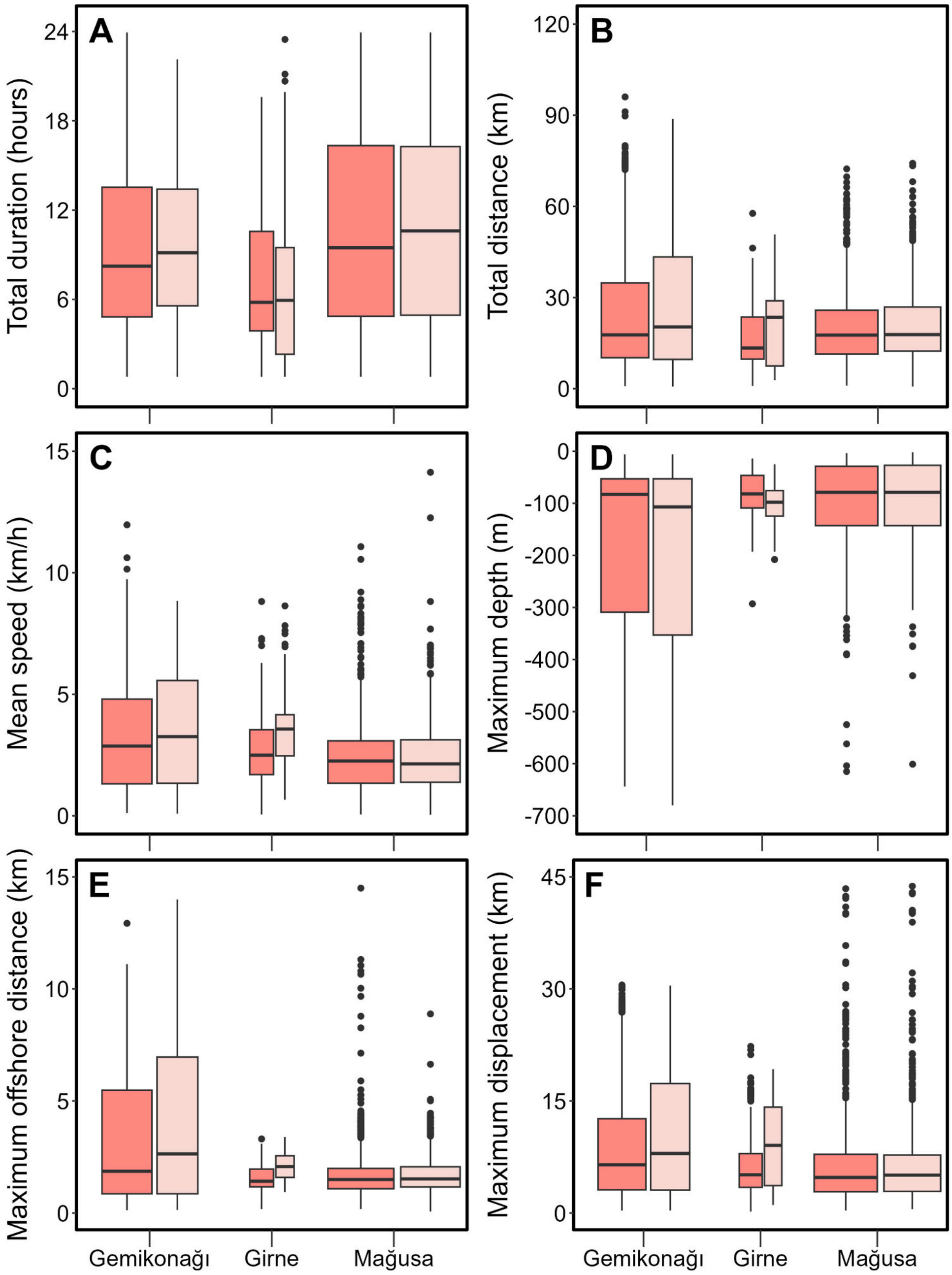

Fig. 9. Operating behaviours of fishers on GPS tracked vessels (n = 22) by region and year (2020: dark pink, n = 2175 trips; 2021: light pink, n = 1618 trips) along the coast of Northern Cyprus, including: (A) total duration (hours); (B) total distance (km); (C) average speed (km/h); (D) maximum depth (m); (E) maximum offshore distance (km); and (F) maximum displacement (km). Bold black line shows the median, boxes the interquartile range (IQR), whiskers 1.5 x IQR and black dots represent values outside this (see Table S10 for exact values). Width of boxes is proportional to sample size.

operations and onboard observations, respectively (mean landings vessel^{-1} year^{-1} multiplied by mean proportion of active fishing days and number of active vessels in the fleet in each sampling year, averaged across sampling years), 1.4–2.8 times the average landings reported to the GFCM for the island of Cyprus during the years 2016–2018 (813 tonnes; FAO, 2019) and within or slightly exceeding the upper range estimated by Snape et al. (759–1923 tonnes; 2018b).

It is speculated that greater quantities of gears are being deployed either to maintain minimum economically viable landings where fish stocks are low (Ulman et al., 2015b; Snape et al., 2018b), or capitalise on profitable returns. Indeed, the minimum net area and set length of demersal longlines observed during fishing operations indicated consistently larger and longer fishing operations being deployed in 2019 compared to 2018. Similar trends were observed in vessels sampled by GPS tracking, demonstrating trips in 2021 were longer, deeper, faster and further offshore than those in 2020. Previously, observations made between 2010 and 2013 in this fishery found set net lengths of 2.0 km (SE: 148.0 km, range: 781.0–4150.0 km; n = 27 fishing operations; Snape et al., 2018b) which is lower than those observed in the current study (mean±SD=2.30 ± 1.50 km; range: 0.03–8.50 km). Fishers in Turkey similarly expressed a need to increase length of set nets to obtain the same quantities of fish with concurrent declines in revenue and catch (Ünal and Ulman, 2020). However, in addition to the relatively low sample size in Snape et al. (2018b), effects of COVID-19 restriction measures could have impacted this due to reduced demand for seafood and resultant impacts on income as observed in the ROC administered area of the island (Giannakis et al., 2020), where much of the catch of this fleet is consumed.

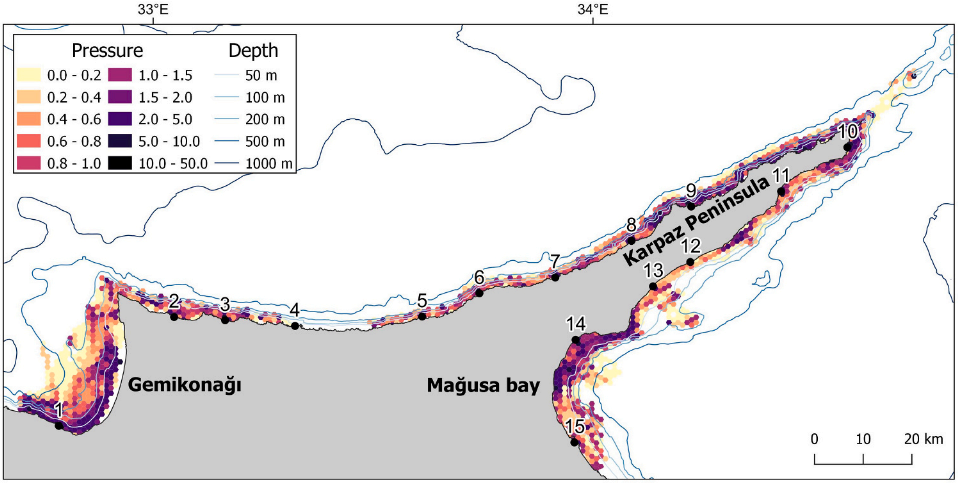

Fig. 10. Spatial distribution of Northern Cyprus small-scale vessels sampled through GPS tracking highlighting relative vessel pressure (number of sampled vessels multiplied by mean number of hours per trip per cell) per km^2, derived from GPS units deployed across 21 vessels and 9 harbours.

Mean size of fish caught has also fallen in some other areas of the Mediterranean (Vasilakopoulos et al., 2014). This can be particularly problematic for sequential hermaphrodites (e.g., Sparidae spp. – one of the top five families contributing to landings identified in the current study) which experience bias in sex ratios if they do not reach the required age or size to switch to the opposite sex (Erzini et al., 2006). Species within this family, such as bogue and picarel, were major contributors to landings in the current study. These are two of nine species that are recognised by the FAO as important to SSFs in the eastern Mediterranean in terms of either landings and/or economic value, but which are not regularly assessed (FAO, 2020); all nine of these species were recorded in the current study including Lessepsian invasive rabbitfishes. These contributed the most to landed biomass in onboard observations in the present study and are the most important Mediterranean recreational fishery species in the ROC administered area of the island (Michailidis et al., 2020). Siganids are considered some of the most detrimental invasive species in the Mediterranean due to the impacts of overgrazing on phytobenthic communities (Katsanevakis et al., 2014). They have become a popular species to consume within the community, and along with some other Lessepsian species, such as the common lionfish, are actively advocated by conservation groups across the region as species whose consumption should be promoted, as a means of controlling their expansion. However, whilst an encouraged potential management method for controlling these populations (Giakoumi et al., 2019), recommendations to target such species should be carefully considered alongside alterations to fishing tactics that minimise potential ecological impacts, such as bycatch. In Northern Cyprus, the métiers used to target rabbitfish are suspected to heavily contribute to locally observed bycatch of green turtles (present study; Snape et al., 2013).

Time of day and depth of the gear deployed by fisheries varies widely and are usually reflective of the activity profiles of their target catch species (Abbott et al., 2015; Gilman et al., 2017; Young et al., 2010). Although setting and hauling patterns were broadly similar across gear types in this fleet, when evaluated on an individual target species level there were marked departures in time of day gears were deployed and retrieved. GPS tracked vessels also demonstrated clear diel activity patterns, where the majority of vessel locations were recorded at night with peaks around dawn and dusk. Trip start and end times were similarly concentrated around these peaks in activity which may be suggestive of setting and hauling periods. This was further evidenced from onboard observations and fisher self-reporting where gears were set and retrieved during crepuscular periods. Whilst this mirroring of activity patterns generally improves catch rates of target species, interspecies variability in vertical habitat preferences and diel activity patterns inevitably results in unintended cross-taxa conflicts (Gilman et al., 2019). Changes to time of day and gear deployment depth are often employed to reduce bycatch of some taxa, but thereby also have the potential to unintentionally intensify bycatch rates of other species of conservation concern (Gilman et al., 2017; Melvin et al., 2001; Musyl et al., 2011). For instance, in the central Pacific Ocean, setting pelagic longline hooks deeper than 100 m during the day resulted in higher catch of target species, whilst avoiding epipelagic shark species, however, catch rate of mesopelagic species such as threatened bigeye thresher sharks (*Alopias superciliosus*) increased (Musyl et al., 2011). Likewise, satellite telemetry data from the Indo-Pacific suggests green turtles display distinct diel behaviour both in relation to range shifts and activity profiles with peaks in foraging adult green turtle activity between 6 and 8 am and 4–6 pm (Christiansen et al., 2016). Should similar crepuscular peaks in activity and vertical habitat use be observed for marine turtles in Northern Cyprus, this could result in direct spatio-temporal overlap with the demersal gears deployed by the fishery. Detailed evaluation of habitat utilisation of vulnerable species are therefore paramount in this region to assess their horizontal and vertical fishery threats.

In addition to elucidating potential ecological interactions on a diel basis, vessel tracking can also highlight longer term trends in fleet movements (Russo et al., 2019), patterns in operating behaviours and resource use (Metcalfe et al., 2017) and the extent of spatial overlap with protected habitats or species distributions (Casale et al., 2017; Lucchetti et al., 2016; Soriano-Redondo et al., 2016). Such studies on vessel movements and behaviours of small-scale vessels have only recently started to emerge, with those in the Mediterranean thus far either deployed on a small scale to trial new technologies (Tassetti et al., 2022), or through participatory mapping with fishers (Grati et al., 2022). The current study is one of the first in the Mediterranean to deploy trackers on an annual long-term basis across a representative sample of the Northern Cyprus fleet, contributing to the knowledge on SSFs in this data poor region of the Mediterranean. Vessel tracking highlighted relatively short trips of up to around 13 h conducted by sampled vessels from this fishery which are similar to those reported in other SSFs in the Mediterranean (Gürlek and Atay, 2021; Maynou et al., 2011).

Most Mediterranean small-scale coastal fisheries operate predominantly along the continental shelf (i.e., < 200 m in depth; Duarte et al., 2009; Maynou et al., 2011; Tzanatos et al., 2006). For the most part, this is also reflected in the sampled vessels of the Northern Cyprus fleet, with the exception of trips conducted along the west coast in the region of

Gemikonağı, where GPS tracked vessel movements are recorded over seabed depths in excess of 650 m. As a result, there was a high degree of overlap between vessel activity and SEPAs currently in place in Northern Cyprus. This highlights that within these protected areas, current restrictions that preclude fishing by nets or trawling and anchoring by all boat users within the coastal area up to a depth of 30 m and to a distance of 1.5 km from the shore are not being effectively enforced, or that there is a general lack of awareness on their location and boundaries. These measures need to be revisited and their efficacy evaluated in light of more detailed information regarding the spatiotemporal overlap and interactions between the SSF and threatened species becoming available (present study; Beton et al., 2021; Bradshaw, et al., 2018; Snape et al., 2022).

Onboard observer programmes are often viewed as more accurate and reliable than fisher-led reporting but are usually at the trade-off of restricted fleet coverage due to high costs, space limitations and large fleet sizes. Fisher-led reporting is often opted for where costs of reaching representative sample sizes preclude onboard observations, but concerns remain over the motivation and training of fishers (Mangi et al., 2015) as well as potential bias from misreporting (Hoare et al., 2011; Kraan et al., 2013). However, studies are increasingly reporting results from fisher-led reporting that show a comparable level of accuracy to onboard observer programmes such as in estimating spatiotemporal patterns of effort and discards (Hoare et al., 2011; Mendo et al., 2022), disruptions to small scale fisheries operations due to COVID-19 (Campbell et al., 2021; Das et al., 2022) and assessing compliance with fishing area closures (Meyer et al., 2022). Comparisons of observer and self-reported data from the current study highlighted that at a broad level, the percentage of fishing operations with bycatch events were comparable between the two data sources, with bycatch of marine turtle and elasmobranch species reported in 26.8% of OOs and 28.4% of SR fishing operations. This suggests a high degree of reliability of the self-reporting fishers' data collection. Additionally, self-reported trips also recorded a wider range of elasmobranch species and number of individuals, overall and by individual gear type than trips with onboard observers. Temporal coverage of onboard observations was limited in certain months (Fig. S1), whereas, self-reporting fishing operations were much more consistent throughout the year and particularly across summer months where landings were also higher across both sampling strategies (Fig. S7; Fig. S8). The combination of this overall higher fishing effort during summer, greater tonnage of landings, more representative coverage by self-reporting fishers, and temporally restricted seasons for different target species (Fig. S7; Fig. S8; Snape et al., 2013) may have interplayed to produce the variation in catch and bycatch composition and tonnage/number of individuals between sampling strategies. Indeed, the difference in scaled estimates of landings between sampling strategies, which perhaps counterintuitively resulted in higher estimates for onboard observations which recorded fewer landings overall, highlights the need for caution when selecting the most appropriate method when considering monitoring methods for other fisheries.

Other discrepancies were also observed between sampling strategies, including the number of species recorded per fishing operation, landings composition and number of fishing operations per trip. Self-reporting fishers were incentivised per fishing trip rather than per fishing operation. Other differences, such as the greater number of hooks reported per kilometre in self-reported longlines, and differences in overall number of fishing operations per gear type are more likely due to the more representative coverage of individual fisher behaviours and of these fishing operations, with 13 times the number of longline fishing operations recorded in self-reported trips than onboard observations. This is likely due to lack of observer coverage in winter when fishers tend to switch to longlines, and three times as many fishing operations being covered by this method. Additionally, there was a greater percentage of fishing operations with landings data available from observers compared to self-reported, and observers typically recorded a higher diversity of species both collectively and per fishing operation. Self-reporting fishers were not expected to identify and record invertebrates or trace amounts of fish and additionally had a low level of taxonomic knowledge compared to onboard observers, who were asked to identify all vertebrates landed. It is unlikely that fishers engaged with self-reporting were deliberately omitting data for fear of its use as evidence for enforcing restrictions (Kraan et al., 2013), as evidenced by the similar representation of threatened species among their landings. Fisher participation is voluntary and there are currently no negative legal implications for reporting such data in Northern Cyprus.

With the aim to reduce missing data and ensure data quality remains high, methods such as remote electronic monitoring (REM) could provide complimentary information on landings (Kindt-Larsen et al., 2011), discards (Mortensen et al., 2017) and bycatch events (Glemarec et al., 2020). This would also verify whether the number of fishing operations recorded by self-reporting fishers is truly representative. Further, specific anomalies in video footage or missing data could be followed up and fisher data collection training regularly reviewed through other means such as fisheries officers that could directly liaise with self-reporting fishers. This would also allow physical sampling required for stock assessments that REM cannot provide (James et al., 2019) to be carried out. Over time, these approaches could provide a viable lower cost alternative to onboard observer programmes (Kindt-Larsen et al., 2012) whilst maintaining the benefits of more comprehensive fleet coverage in Northern Cyprus.

This study has revealed that the SSF in Northern Cyprus is a highly dynamic fishery primarily operating over the continental shelf with vessel activity strongly influenced by environmental conditions such as temperature and wind as well as fishing practices that reflect preferences of target species. Despite this baseline understanding of how the fishery operates, further in-depth studies are needed to quantitatively assess its resultant ecological issues including, but not limited to, specificity of local métiers, regional stock assessments, and the vertical and horizontal spatiotemporal overlap with species and habitats of conservation concern. This will provide a more comprehensive assessment of how this key ocean user group interacts with the marine environment, which can be used for the implementation of a management strategy reflective of the complexity of this fishery.

CRediT authorship contribution statement

Josie L. Palmer: Writing - original draft, Software, Validation, Formal analysis, Investigation, Data curation, Writing – review & editing, Visualisation. **Carina Armstrong:** Formal analysis, Investigation, Data curation, Writing – review & editing. **Hasan D. Akbora:** Investigation, Data curation, Writing – review & editing. **Damla Beton:** Resources, Data curation, Writing – review & editing, Supervision, Project administration. **Çiğdem Çağlar:** Investigation, Resources, Data curation, Writing – review & editing. **Brendan J. Godley:** Conceptualisation, Writing – review & editing, Supervision, Project administration, Funding acquisition. **Kristian Metcalfe:** Writing – review & editing, Supervision. **Meryem Özkan:** Investigation, resources, Data curation, Writing – review & editing. **Robin T. E. Snape:** Conceptualisation, Investigation, Resources, Data curation, Writing – review & editing, Supervision, Project administration, Funding acquisition. **Annette C. Broderick:** Conceptualisation, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.fishres.2023.106861.

References

Abbott, J., Haynie, A., Reimer, M., 2015. Hidden flexibility: institutions, incentives, and the margins of selectivity in fishing. Land Econ. 91, 169–195. https://doi.org/10.3368/le.91.1.169.

Alfaro-Shigueto, J., Mangel, J.C., Pajuelo, M., Dutton, P.H., Seminoff, J.A., Godley, B.J., 2010. Where small can have a large impact: structure and characterization of small-scale fisheries in Peru. Fish. Res. 106 (1), 8–17. https://doi.org/10.1016/j.fishres.2010.06.004.

Alfaro-Shigueto, J., Mangel, J.C., Bernedo, F., Dutton, P.H., Seminoff, J.A., Godley, B.J., 2011. Small-scale fisheries of Peru: a major sink for marine turtles in the Pacific. J. Appl. Ecol. 48 (6), 1432–1440. https://doi.org/10.1111/j.1365-2664.2011.02040.x.

Alfaro-Shigueto, J., Mangel, J.C., Darquea, J., Donoso, M., Baquero, A., Doherty, P.D., Godley, B.J., 2018. Untangling the impacts of nets in the southeastern Pacific: rapid assessment of marine turtle bycatch to set conservation priorities in small-scale fisheries. Fish. Res. 206, 185–192. https://doi.org/10.1016/j.fishres.2018.04.013.

Alonso-Fernández, A., Otero, J., Bañón, R., Campelos, J.M., Quintero, F., Ribó, J., Filgueira, F., Juncal, L., Lamas, F., Gancedo, A., Molares, J., 2019. Inferring abundance trends of key species from a highly developed small-scale fishery off NE Atlantic. Fish. Res. 209, 101–116. https://doi.org/10.1016/j.fishres.2018.09.011.

Batista, V.S., Fabré, N.N., Malhado, A.C.M., Ladle, R.J., 2014. Tropical artisanal coastal fisheries: challenges and future directions. Rev. Fish. Sci. Aquac. 22 (1), 1–15. https://doi.org/10.1080/10641262.2013.822463.

Bennett, A., Patil, P., Kleisner, K., Rader, D., Virdin, J., Basurto, X., 2018. Contrib. Fish. Food Nutr. Secur. 46.

Beton, D., Broderick, A.C., Godley, B.J., Kolaç, E., Ok, M., Snape, R.T.E., 2021. New monitoring confirms regular breeding of the Mediterranean monk seal in Northern Cyprus. Oryx 55 (4), 522–525. https://doi.org/10.1017/S0030605320000848.

Burgos, C., Gil, J., del Olmo, L.A., 2013. The Spanish blackspot seabream (Pagellus bogaraveo) fishery in the Strait of Gibraltar: spatial distribution and fishing effort derived from a small-scale GPRS/GSM based fisheries vessel monitoring system. Aquat. Living Resour. 26 (4), 399–407. https://doi.org/10.1051/alr/2013068.

Calò, A., Di Franco, A., Quattrocchi, F., Dimitriadis, C., Ventura, P., Milazzo, M., Guidetti, P., 2022. Multi-specific small-scale fisheries rely on few, locally essential, species: evidence from a multi-area study in the Mediterranean. Fish Fish 23 (6), 1299–1312. https://doi.org/10.1111/faf.12689.

Campbell, S.J., Jakub, R., Valdivia, A., Setiawan, H., Setiawan, A., Cox, C., Kiyo, A., Darman, Djafar, L.F., Rosa, E. de la, Suherfian, W., Yuliani, A., Kushardanto, H., Muawanah, U., Rukma, A., Alimi, T., Box, S., 2021. Immediate impact of COVID-19 across tropical small-scale fishing communities. Ocean Coast. Manag. 200, 105485 https://doi.org/10.1016/j.ocecoaman.2020.105485.

Cardiec, F., Bertrand, S., Witt, M.J., Metcalfe, K., Godley, B.J., McClellan, C., Vilela, R., Parnell, R.J., Loc'h, F. le, 2020. "Too Big To Ignore": A feasibility analysis of detecting fishing events in Gabonese small-scale fisheries. PLOS ONE 15 (6), e0234091. https://doi.org/10.1371/journal.pone.0234091.

Casale, P., 2011. Sea turtle by-catch in the Mediterranean. Fish Fish 12 (3), 299–316. https://doi.org/10.1111/j.1467-2979.2010.00394.x.

Casale, P., Abitsi, G., Aboro, M.P., Agamboue, P.D., Agbode, L., Allela, N.L., Angueko, D., Bibang Bi Nguema, J.N., Boussamba, F., Cardiec, F., Chartrain, E., Ciofi, C., Emane, Y.A., Fay, J.M., Godley, B.J., Kouerey Oliwiwina, C.K., de Dieu Lewembe, J., Leyoko, D., Mba Asseko, G., …, Formia, A., 2017. A first estimate of sea turtle bycatch in the industrial trawling fishery of Gabon. Biodivers. Conserv. 26 (10), 2421–2433. https://doi.org/10.1007/s10531-017-1367-z.

Christiansen, F., Esteban, N., Mortimer, J.A., Dujon, A.M., Hays, G.C., 2016. Diel and seasonal patterns in activity and home range size of green turtles on their foraging grounds revealed by extended Fastloc-GPS tracking. Mar. Biol. 164 (1), 10 https://doi.org/10.1007/s00227-016-3048-y.

Chuenpagdee, R., Jentoft, S., 2019. Transdisciplinarity for Small-Scale Fisheries Governance: Analysis and Practice, Vol. 21. Springer International Publishing. https://doi.org/10.1007/978-3-319-94938-3.

Ciftcioglu, G.C., 2021. Participatory and deliberative assessment of the landscape and natural resource social values of marine and coastal ecosystem services: the case of Kyrenia (Girne) Region from Northern Cyprus. Envir*onmental Sci. Pollut. Res.* 28 (22), 27742–27756. https://doi.org/10.1007/s11356-021-12600-x.

Coll, M., Carreras, M., Cornax, M.J., Massutí, E., Morote, E., Pastor, X., Quetglas, A., Sáez, R., Silva, L., Sobrino, I., Torres, M.A., Tudela, S., Harper, S., Zeller, D., Pauly, D., 2014. Closer to reality: reconstructing total removals in mixed fisheries from Southern Europe. Fish. Res. 154, 179–194. https://doi.org/10.1016/j.fishres.2014.01.013.

Colloca, F., Cardinale, M., Maynou, F., Giannoulaki, M., Scarcella, G., Jenko, K., Bellido, J.M., Fiorentino, F., 2013. Rebuilding Mediterranean fisheries: a new paradigm for ecological sustainability. Fish Fish 14, 89–109. https://doi.org/10.1111/j.1467-2979.2011.00453.x.

Costello, C., Ovando, D., Hilborn, R., Gaines, S.D., Deschenes, O., Lester, S.E., 2012. Status and Solutions for the World's Unassessed Fisheries. Science 338 (6106), 517–520. https://doi.org/10.1126/science.1223389.

Coulthard, S., Johnson, D., McGregor, J.A., 2011. Poverty, sustainability and human wellbeing: a social wellbeing approach to the global fisheries crisis. Glob. Environ. Change 21 (2), 453–463. https://doi.org/10.1016/j.gloenvcha.2011.01.003.

Cumming, G., Norwood, C., 2012. The community voice method: using participatory research and filmmaking to foster dialog about changing landscapes. Landsc. Urban Plan. 105 (4), 434–444. https://doi.org/10.1016/j.landurbplan.2012.01.018.

Das, B.K., Roy, A., Som, S., Chandra, G., Kumari, S., Sarkar, U.K., Bhattacharjya, B.K., Das, A.K., Pandit, A., 2022. Impact of COVID-19 lockdown on small-scale fishers (SSF) engaged in floodplain wetland fisheries: evidences from three states in India. Environ. Sci. Pollut. Res. 29 (6), 8452–8463. https://doi.org/10.1007/s11356-021-16074-9.

Duarte, R., Azevedo, M., Afonso-Dias, M., 2009. Segmentation and fishery characteristics of the mixed-species multi-gear Portuguese fleet. ICES J. Mar. Sci. 66 (3), 594–606. https://doi.org/10.1093/icesjms/fsp019.

Erzini, K., Salgado, M., Castro, M., 2006. Dynamics of black spot sea bream (Pagellus bogaraveo) mean length: evaluating the influence of life history parameters, recruitment, size selectivity and exploitation rates. J. Appl. Ichthyol. 22 (3), 183–188. https://doi.org/10.1111/j.1439-0426.2006.00702.x.

European Commission. (2018). Proposal for a Regulation of the European Parliament and of the Council; European Commission: Brussels, Belgium, 1 June 2018 COM (2018) 392 Final 2018/0216 (COD); https://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=COM%3A2018%3A392%3AFIN.

European Commission. (2023). Annual report 2022: Implementation of the green line regulation; European Commission: Brussels, Belgium, 29 June 2023 COM(2023) 354 final; https://commission.europa.eu/publications/annual-reports-implementation-green-line-regulation_en.

Exeter, O.M., Htut, T., Kerry, C.R., Kyi, M.M., Mizrahi, M., Turner, R.A., Witt, M.J., Bicknell, A.W.J., 2021. Shining Light on Data-Poor Coastal Fisheries. Front. Mar. Sci. 7 https://www.frontiersin.org/articles/10.3389/fmars.2020.625766.

FAO. (2022a). The State of Mediterranean and Black Sea Fisheries 2022. General Fisheries Commission for the Mediterranean. Rome. https://doi.org/10.4060/cc3370en.

FAO. (2022b). The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome, FAO. https://doi.org/10.4060/cc0461en.

FAO. (2017). Workshop on improving our knowledge on small-scale fisheries: data needs and methodologies. Workshop proceedings, 27–29 June 2017, Rome, Italy. FAO Fisheries and Aquaculture Proceedings No. 55. Rome, Italy.

FAO. (2019). Monitoring the incidental catch of vulnerable species in Mediterranean and Black Sea fisheries: Methodology for data collection. FAO Fisheries and Aquaculture Technical Paper No. 640. Rome, FAO.

FAO. (2020). The State of Mediterranean and Black Sea Fisheries 2020. General Fisheries Commission for the Mediterranean. Rome. https://doi.org/10.4060/cb2429en.

Fernandes, P.G., Ralph, G.M., Nieto, A., García Criado, M., Vasilakopoulos, P., Maravelias, C.D., Cook, R.M., Pollom, R.A., Kovačić, M., Pollard, D., Farrell, E.D., Florin, A.-B., Polidoro, B.A., Lawson, J.M., Lorance, P., Uiblein, F., Craig, M., Allen, D.J., Fowler, S.L., …, Carpenter, K.E., 2017. Coherent assessments of Europe's marine fishes show regional divergence and megafauna loss. Article 7 Nat. Ecol. Evol. 1 (7). https://doi.org/10.1038/s41559-017-0170.

Giakoumi, S., Katsanevakis, S., Albano, P.G., Azzurro, E., Cardoso, A.C., Cebrian, E., Deidun, A., Edelist, D., Francour, P., Jimenez, C., Mačić, V., Occhipinti-Ambrogi, A., Rilov, G., Sghaier, Y.R., 2019. Management priorities for marine invasive species. Sci. Total Environ. 688, 976–982. https://doi.org/10.1016/j.scitotenv.2019.06.282.

Giannakis, E., Hadjioannou, L., Jimenez, C., Papageorgiou, M., Karonias, A., Petrou, A., 2020. Economic consequences of coronavirus disease (COVID-19) on Fisheries in the Eastern Mediterranean (Cyprus). Article 22 Sustainability 12 (22). https://doi.org/10.3390/su12229406.

Gilman, E., Musyl, M., Itano, D., Heberer, C., Zimring, M., & Williams, P. (2017). Effects of pelagic longline time-of-day and gear soak depth on species- and size-selectivity. The Nature Conservancy, San Francisco. https://tinyurl.com/PLL-time-depth.

Gilman, E., Chaloupka, M., Dagorn, L., Hall, M., Hobday, A., Musyl, M., Pitcher, T., Poisson, F., Restrepo, V., Suuronen, P., 2019. Robbing Peter to pay Paul: replacing unintended cross-taxa conflicts with intentional tradeoffs by moving from piecemeal to integrated fisheries bycatch management. Rev. Fish. Biol. Fish. 29 (1), 93–123. https://doi.org/10.1007/s11160-019-09547-1.

Glarou, M., Kerametsidis, G., Akkaya, A., Beqiri, K., Nikpaljevic, N., Awbery, T., Bakiu, R., Geijer, C.K.A., 2022. Using off-the-shelf GPS loggers to assess co-occurrence between marine mammals and small-scale fisheries: a pilot study from the Mediterranean Sea. J. Mar. Biol. Assoc. U. Kingd. 1–11. https://doi.org/10.1017/S0025315422000522.

Glemarec, G., Kindt-Larsen, L., Lundgaard, L.S., Larsen, F., 2020. Assessing seabird bycatch in gillnet fisheries using electronic monitoring. Biol. Conserv. 243, 108461 https://doi.org/10.1016/j.biocon.2020.108461.

Grati, F., Azzurro, E., Scanu, M., Tassetti, A.N., Bolognini, L., Guicciardi, S., Vitale, S., Scannella, D., Carbonara, P., Dragičević, B., Ikica, Z., Palluqi, A., Marčeta, B., Ghmati, H., Turki, A., Cherif, M., Bdioui, M., Jarboui, O., Benhadjhamida, N., …, Arneri, E., 2022. Mapping small-scale fisheries through a coordinated participatory strategy. Fish Fish 23 (4), 773–785. https://doi.org/10.1111/faf.12644.

Guillen, J., Maynou, F., 2016. Increasing fuel prices, decreasing fish prices and low productivity lead to poor economic performance and capacity reduction in the fishing sector: evidence from the Spanish Mediterranean. Turk. J. Fish. Aquat. Sci. 16 (3), 659–668. https://www.trjfas.org/abstract.php?lang=en&id=922.

Gürlek, M., Atay, B., 2021. Socio-economic status of small-scale fishery of the Hatay Region in Northeastern Mediterranean Coast of Turkey. Nat. Eng. Sci. 6 (2), 112–126. https://doi.org/10.28978/nesciences.970550.

Haywood, J.C., Casale, P., Freggi, D., Fuller, W.J., Godley, B.J., Lazar, B., Margaritoulis, D., Rees, Al, F., Shutler, J.D., Snape, R.T., Swain-Diaz, N.R., Widdicombe, S., Broderick, A.C., 2020. Foraging ecology of Mediterranean juvenile loggerhead turtles: insights from C and N stable isotope ratios. Mar. Biol. 167 (3), 28 https://doi.org/10.1007/s00227-020-3647-5.

Hoare, D., Graham, N., Schön, P.-J., 2011. The Irish Sea data-enhancement project: comparison of self-sampling and national data-collection programmes - Results and experiences. ICES J. Mar. Sci. 68, 1778–1784. https://doi.org/10.1093/icesjms/fsr100.

Jacquet, J., Pauly, D., 2008. Funding Priorities: Big Barriers to Small-Scale Fisheries: *Funding for Fisheries*. Conserv. Biol. 22 (4), 832–835. https://doi.org/10.1111/j.1523-1739.2008.00978.x.

James, K.M., Campell, N., Viðarsson, J.R., Vilas, C., Pérez-Martín, R.I., Antelo, L.T., Plet-Hansen, K.S., Ulrich, C., Borges, L., González, Ó., Pérez-Bouzada, J., van Helmond, A.T.M., 2019. Tools and technologies for the monitoring, control and surveillance of unwanted catches. In: Uhlmann, S.S., Ulrich, C., Kennelly, S.J. (Eds.), The European landing obligation: reducing discards in complex, multi-species and multi-jurisdictional fisheries. Springer, Cham, pp. 363–382. https://doi.org/10.1007/978-3-030-03308-8.

Katsanevakis, S., Wallentinus, I., Zenetos, A., Leppäkoski, E., Çinar, M.E., Oztürk, B., Grabowski, M., Golani, D., Cardoso, A.C., 2014. Impacts of invasive alien marine species on ecosystem services and biodiversity: a pan-European review. Aquat. Invasions 9 (4), 391–423. https://doi.org/10.3391/ai.2014.9.4.01.

Keramidas, I., Dimarchopoulou, D., Pardalou, A., Tsikliras, A.C., 2018. Estimating recreational fishing fleet using satellite data in the Aegean and Ionian Seas (Mediterranean Sea). Fish. Res. 208, 1–6. https://doi.org/10.1016/j.fishres.2018.07.001.

Kindt-Larsen, L., Kirkegaard, E., Dalskov, J., 2011. Fully documented fishery: a tool to support a catch quota management system. ICES J. Mar. Sci. 68 (8), 1606–1610. https://doi.org/10.1093/icesjms/fsr065.

Kindt-Larsen, L., Dalskov, J., Stage, B., Larsen, F., 2012. Observing incidental harbour porpoise Phocoena phocoena bycatch by remote electronic monitoring. Endanger. Species Res. 19 (1), 75–83. https://doi.org/10.3354/esr00455.

Kraan, M., Uhlmann, S., Steenbergen, J., Van Helmond, A.T.M., Van Hoof, L., 2013. The optimal process of self-sampling in fisheries: lessons learned in the Netherlandsa. J. Fish. Biol. 83 (4), 963–973. https://doi.org/10.1111/jfb.12192.

Laurent, L., Casale, P., Bradai, M.N., Godley, B.J., Broderick, G.G., A, C., Schroth, W., Schierwater, B., Levy, A.M., Freggi, D., Abd El-Mawla, E.M., Hadoud, D.A., Gomati, H.E., Domingo, M., Hadjichristophorou, M., Kornaraky, L., Demirayak, F., Gautier, Ch, 1998. Molecular resolution of marine turtle stock composition in fishery bycatch: a case study in the Mediterranean. Mol. Ecol. 7 (11), 1529–1542. https://doi.org/10.1046/j.1365-294x.1998.00471.x.

Lloret, J., Cowx, I.G., Cabral, H., Castro, M., Font, T., Gonçalves, J.M.S., Gordoa, A., Hoefnagel, E., Matić-Skoko, S., Mikkelsen, E., Morales-Nin, B., Moutopoulos, D.K., Muñoz, M., Neves dos Santos, M., Pintassilgo, P., Pita, C., Stergiou, K.I., Ünal, V., Veiga, P., Erzini, K., 2018. Small-scale coastal fisheries in European Seas are not what they were: ecological, social and economic changes. Mar. Policy 176–186. https://doi.org/10.1016/j.marpol.2016.11.007.

Lloret, J., Biton-Porsmoguer, S., Carreño, A., Di Franco, A., Sahyoun, R., Melià, P., Claudet, J., Sève, C., Ligas, A., Belharet, M., Calò, A., Carbonara, P., Coll, M., Corrales, X., Lembo, G., Sartor, P., Bitetto, I., Vilas, D., Piroddi, C., …, Font, T., 2019. Recreational and small-scale fisheries may pose a threat to vulnerable species in coastal and offshore waters of the western Mediterranean. ICES J. Mar. Sci. 77 (6), 2255–2264. https://doi.org/10.1093/icesjms/fsz071.

Lucchetti, A., Sala, A., 2010. An overview of loggerhead sea turtle (Caretta caretta) bycatch and technical mitigation measures in the Mediterranean Sea. Rev. Fish. Biol. Fish. 20 (2), 141–161. https://doi.org/10.1007/s11160-009-9126-1.

Lucchetti, A., Pulcinella, J., Angelini, V., Pari, S., Russo, T., Cataudella, S., 2016. An interaction index to predict turtle bycatch in a Mediterranean bottom trawl fishery. Ecol. Indic. 60, 557–564. https://doi.org/10.1016/j.ecolind.2015.07.007.

Lucchetti, A., Virgili, M., Petetta, A., Sartor, P., 2020. An overview of gill net and trammel net size selectivity in the Mediterranean Sea. Fish. Res. 230, 105677 https://doi.org/10.1016/j.fishres.2020.105677.

Maina, I., Kavadas, S., Vassilopoulou, V., Bastardie, F., 2021. Fishery spatial plans and effort displacement in the eastern Ionian Sea: a bioeconomic modelling. Ocean Coast. Manag. 203, 105456 https://doi.org/10.1016/j.ocecoaman.2020.105456.

Mangel, J.C., Alfaro-Shigueto, J., Van Waerebeek, K., Cáceres, C., Bearhop, S., Witt, M.J., Godley, B.J., 2010. Small cetacean captures in Peruvian artisanal fisheries: high despite protective legislation. Biol. Conserv. 143 (1), 136–143. https://doi.org/10.1016/j.biocon.2009.09.017.

Mangi, S.C., Dolder, P.J., Catchpole, T.L., Rodmell, D., de Rozarieux, N., 2015. Approaches to fully documented fisheries: practical issues and stakeholder perceptions. Fish Fish 16 (3), 426–452. https://doi.org/10.1111/faf.12065.

Maynou, F., 2020. Evolution of fishing capacity in a Mediterranean fishery in the first two decades of the 21st c. Ocean Coast. Manag. 192, 105190 https://doi.org/10.1016/j.ocecoaman.2020.105190.

Maynou, F., Recasens, L., Lombarte, A., 2011. Fishing tactics dynamics of a Mediterranean small-scale coastal fishery. Aquat. Living Resour. 24 (2), 149–159. https://doi.org/10.1051/alr/2011131.

Melvin, E.F., Parrish, J.K., Dietrich, K.S., & Hamel, O.S. (2001). *SOLUTIONS TO SEABIRD BYCATCH IN ALASKA'S DEMERSAL LONGLINE FISHERIES*.

Mendo, T., Mendo, J., Ransijn, J.M., Gomez, I., Gil-Kodaka, P., Fernández, J., Delgado, R., Travezaño, A., Arroyo, R., Loza, K., McCann, P., Crowe, S., Jones, E.L., James, M.A., 2022. Assessing discards in an illegal small-scale fishery using fisher-led reporting. Rev. Fish. Biol. Fish. 32 (3), 963–974. https://doi.org/10.1007/s11160-022-09708-9.

Metcalfe, K., Collins, T., Abernethy, K.E., Boumba, R., Dengui, J.-C., Miyalou, R., Parnell, R.J., Plummer, K.E., Russell, D.J.F., Safou, G.K., Tilley, D., Turner, R.A., VanLeeuwe, H., Witt, M.J., Godley, B.J., 2017. Addressing Uncertainty in Marine Resource Management; Combining Community Engagement and Tracking Technology to Characterize Human Behavior. Conserv. Lett. 10 (4), 460–469. https://doi.org/10.1111/conl.12293.

Meyer, S., Krumme, U., Stepputtis, D., Zimmermann, C., 2022. Use of a smartphone application for self-reporting in small-scale fisheries: lessons learned during a fishing closure in the western Baltic Sea. Ocean Coast. Manag. 224, 106186 https://doi.org/10.1016/j.ocecoaman.2022.106186.

Michailidis, N., Katsanevakis, S., Chartosia, N., 2020. Recreational fisheries can be of the same magnitude as commercial fisheries: the case of Cyprus. Fish. Res. 231, 105711 https://doi.org/10.1016/j.fishres.2020.105711.

Mortensen, L.O., Ulrich, C., Olesen, H.J., Bergsson, H., Berg, C.W., Tzamouranis, N., Dalskov, J., 2017. Effectiveness of fully documented fisheries to estimate discards in a participatory research scheme. Fish. Res. 187, 150–157. https://doi.org/10.1016/j.fishres.2016.11.010.

Musyl, M.K., Brill, R., Curran, D., Fragoso, N.M., McNaughton, L., Nielsen, A., Kikkawa, B., Moyes, C.D., 2011. Postrelease survival, vertical and horizontal movements, and thermal habitats of five species of pelagic sharks In The Central Pacific Ocean. Fish. Bull. 109 (4), 341–368 https://scholarworks.wm.edu/vimsarticles/549.

Palmer, J.L., Beton, D., Çiçek, B.A., Davey, S., Duncan, E.M., Fuller, W.J., Godley, B.J., Haywood, J.C., Hüseyinoğlu, M.F., Omeyer, L.C.M., Schneider, M.J., Snape, R.T.E., Broderick, A.C., 2021. Dietary analysis of two sympatric marine turtle species in the eastern Mediterranean. Mar. Biol. 168 (6), 94 https://doi.org/10.1007/s00227-021-03895-y.

Panagopoulou, A., Meletis, Z.A., Margaritoulis, D., Spotila, J.R., 2017. Caught in the same net? Small-scale fishermen's perceptions of fisheries interactions with sea turtles and other protected species. Front. Mar. Sci. 4 https://www.frontiersin.org/articles/10.3389/fmars.2017.00180.

Papaconstantinou, C., Farrugio, H., 2000. Fisheries in the mediterranean. Mediterr. Mar. Sci. 1 (1), 5. https://doi.org/10.12681/mms.2.

Pascual-Fernández, J.J., Florido-del-Corral, D., De la Cruz-Modino, R., Villasante, S., 2020. Small-Scale Fisheries in Spain: Diversity and Challenges. In: Pascual-Fernández, J.J., Pita, C., Bavinck, M. (Eds.), Small-Scale Fisheries in Europe: Status, Resilience and Governance. Springer International Publishing, pp. 253–281. https://doi.org/10.1007/978-3-030-37371-9_13.

Pauly, D., Zeller, D., 2016. Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining. Nat. Commun. 7, 10244 https://doi.org/10.1038/ncomms10244.

Pauly, D., Ulman, A., Piroddi, C., Bultel, E., Coll, M., 2014. Reported' versus 'likely' fisheries catches of four Mediterranean countries. Sci. Mar. 78 (S1), 11–17. https://doi.org/10.3989/scimar.04020.17A.

Pere, A., Marengo, M., Lejeune, P., Durieux, E., 2019. Evaluation of Homarus gammarus (Crustacea: Decapoda: Nephropidae) catches and potential in a Mediterranean small-scale fishery, 0–000 Sci. Mar. 83. https://doi.org/10.3989/scimar.04862.22B.

Piroddi, C., Gristina, M., Zylich, K., Greer, K., Ulman, A., Zeller, D., Pauly, D., 2015. Reconstruction of Italy's marine fisheries removals and fishing capacity, 1950–2010. Fish. Res. 172, 137–147. https://doi.org/10.1016/j.fishres.2015.06.028.

Pita, C., Villasante, S., Pascual-Fernández, J.J., 2019. Managing small-scale fisheries under data poor scenarios: lessons from around the world. Mar. Policy 101, 154–157. https://doi.org/10.1016/j.marpol.2019.02.008.

Quetglas, A., Merino, G., Ordines, F., Guijarro, B., Garau, A., Grau, A.M., Oliver, P., Massutí, E., 2016. Assessment and management of western Mediterranean small-scale fisheries. Ocean Coast. Manag. 133, 95–104. https://doi.org/10.1016/j.ocecoaman.2016.09.013.

Roditi, K., Vafidis, D., 2019. Net fisheries' métiers in the eastern mediterranean: insights for small-scale fishery management on Kalymnos Island. Article 7 Water 11 (7). https://doi.org/10.3390/w11071509.

Russo, T., Bitetto, I., Carbonara, P., Carlucci, R., D'Andrea, L., Facchini, M.T., Lembo, G., Maiorano, P., Sion, L., Spedicato, M.T., Tursi, A., Cataudella, S., 2017. A holistic approach to fishery management: evidence and insights from a central mediterranean case study (Western Ionian Sea). Front. Mar. Sci. 4 https://www.frontiersin.org/articles/10.3389/fmars.2017.00193.

Russo, T., Carpentieri, P., D'Andrea, L., De Angelis, P., Fiorentino, F., Franceschini, S., Garofalo, G., Labanchi, L., Parisi, A., Scardi, M., Cataudella, S., 2019. Trends in effort and yield of trawl fisheries: a case study from the mediterranean sea. Front. Mar. Sci. 6 https://www.frontiersin.org/articles/10.3389/fmars.2019.00153.

Sabatella, E.C., Colloca, F., Coppola, G., Fiorentino, F., Gambino, M., Malvarosa, L., Sabatella, R., 2017. Key economic characteristics of italian trawl fisheries and management challenges. Front. Mar. Sci. 4 https://www.frontiersin.org/articles/10.3389/fmars.2017.00371.

Sabri, R., Sakallı, B., 2021. Full article: the politics and ethical dilemmas of architectural conservation in an unrecognised state: Insights from northern Cyprus. Int. J. Herit. Stud. 27 (12), 1245–1263. https://doi.org/10.1080/13527258.2021.1950031.

Sala-Coromina, J., García, J.A., Martín, P., Fernandez-Arcaya, U., Recasens, L., 2021. European hake (Merluccius merluccius, Linnaeus 1758) spillover analysis using VMS and landings data in a no-take zone in the northern Catalan coast (NW Mediterranean). Fish. Res. 237, 105870 https://doi.org/10.1016/j.fishres.2020.105870.

Salas, S., Chuenpagdee, R., Seijo, J.C., Charles, A., 2007. Challenges in the assessment and management of small-scale fisheries in Latin America and the Caribbean. Fish. Res. 87 (1), 5–16. https://doi.org/10.1016/j.fishres.2007.06.015.

Schadeberg, A., Kraan, M., Hamon, K.G., 2021. Beyond métiers: social factors influence fisher behaviour. ICES J. Mar. Sci. 78 (4), 1530–1541. https://doi.org/10.1093/icesjms/fsab050.

Shester, G.G., Micheli, F., 2011. Conservation challenges for small-scale fisheries: bycatch and habitat impacts of traps and gillnets. Biol. Conserv. 144 (5), 1673–1681. https://doi.org/10.1016/j.biocon.2011.02.023.

Silva, L., Gil, J., Sobrino, I., 2002. Definition of fleet components in the Spanish artisanal fishery of the Gulf of Cádiz (SW Spain ICES division IXa). Fish. Res. 59 (1), 117–128. https://doi.org/10.1016/S0165-7836(01)00420-9.

Smith, H., Basurto, X., 2019. Defining small-scale fisheries and examining the role of science in shaping perceptions of who and what counts: a systematic review. Front. Mar. Sci. 6 https://www.frontiersin.org/articles/10.3389/fmars.2019.00236.

Snape, R., Bengil, E., Beton, D., Çağlar, Ç., Palmer, J., & Broderick, A. (2020). Cyprus Bycatch Project "Understanding multi-taxa 'bycatch' of vulnerable species and testing mitigation a collaborative approach in Cyprus". Technical Report: Results of Phase 1 (2018–2019) of the bycatch monitoring programme in Northern Cyprus (pp. 45). Society for Protection of Turtles (SPOT). Nicosia. ⟨https://www.togetherforthemed.org/img/uploads/2021/04/TECHNICAL_REPORT_NORTHERN_CYPRUS_WEB_DOUBLE_PAGE.pdf.

Snape, R.T.E. (2019). Investigating conflict between threatened marine megavertebrates and Mediterranean small-scale fisheries [Doctoral dissertation, University of Exeter]. Open Research Exeter. http://hdl.handle.net/10871/36636.

Snape, R.T.E., Beton, D., Broderick, A.C., Çiçek, B.A., Fuller, W.J., Özden, Ö., Godley, B. J., 2013. Strand Monitoring and Anthropological Surveys Provide Insight into Marine Turtle Bycatch in Small-Scale Fisheries of the Eastern Mediterranean. Chelonian Conserv. Biol. 12 (1), 44–55. https://doi.org/10.2744/CCB-1008.1.

Snape, R.T.E., Bradshaw, P.J., Broderick, A.C., Fuller, W.J., Stokes, K.L., Godley, B.J., 2018a. Off-the-shelf GPS technology to inform marine protected areas for marine turtles. Biol. Conserv. 227, 301–309. https://doi.org/10.1016/j.biocon.2018.09.029.

Snape, R.T.E., Broderick, A.C., Çiçek, B.A., Fuller, W.J., Tregenza, N., Witt, M.J., Godley, B.J., 2018b. Conflict between dolphins and a data-scarce fishery of the European Union. Hum. Ecol. 46 (3), 423–433. https://doi.org/10.1007/s10745-018-9989-7.

Snape, R.T.E., Beton, D., Davey, S., Godley, B.J., Haywood, J., Omeyer, L.C.M., Ozkan, M., Broderick, A.C., 2022. Mediterranean green turtle population recovery increasingly depends on Lake Bardawil, Egypt. Glob. Ecol. Conserv. 40, e02336 https://doi.org/10.1016/j.gecco.2022.e02336.

Soriano-Redondo, A., Cortés, V., Reyes-González, J.M., Guallar, S., Bécares, J., Rodríguez, B., Arcos, J.M., González-Solís, J., 2016. Relative abundance and distribution of fisheries influence risk of seabird bycatch. Article 1 Sci. Rep. 6 (1). https://doi.org/10.1038/srep37373.

Tassetti, A.N., Galdelli, A., Pulcinella, J., Mancini, A., Bolognini, L., 2022. Addressing gaps in small-scale fisheries: a low-cost tracking system. Article 3 Sensors 22 (3). https://doi.org/10.3390/s22030839.

Tzanatos, E., Somarakis, S., Tserpes, G., Koutsikopoulos, C., 2006. Identifying and classifying small-scale fisheries métiers in the Mediterranean: a case study in the Patraikos Gulf, Greece. Fish. Res. 81 (2), 158–168. https://doi.org/10.1016/j.fishres.2006.07.007.

Tzanatos, E., Georgiadis, M., Peristeraki, P., 2020. Small-scale fisheries in Greece: status, problems, and management. In: Pascual-Fernández, J.J., Pita, C., Bavinck, M. (Eds.), Small-Scale Fisheries in Europe: Status, Resilience and Governance, 23. MARE Publication Series, pp. 125–150. https://doi.org/10.1007/978-3-030-37371-9.

Ulman, A., Pauly, D., 2016. Making history count: The shifting baseline of Turkish fisheries. Fish. Res. 183, 74–79. https://doi.org/10.1016/j.fishres.2016.05.013.

Ulman, A., Saad, A., Zylich, K., Pauly, D., & Zeller, D. (2015b). Reconstruction of Syria's Fisheries C Atches from 1950–2010: Signs of Overexploitation. *Acta Ichthyologica et Piscatoria*, *45*(3), 259–272. https://www.proquest.com/docview/1728665564/abstract/852147180DEA4E93PQ/1.

Ulman, A., Çiçek, B.A., Salihoglu, I., Petrou, A., Patsalidou, M., Pauly, D., Zeller, D., 2015a. Unifying the catch data of a divided island: Cyprus's marine fisheries catches, 1950–2010. Environ., Dev. Sustain. 17 (4), 801–821. https://doi.org/10.1007/s10668-014-9576-z.

Ünal, V., Ulman, A., 2020. The Current Status and Challenges Facing the Small-Scale Fisheries of Turkey. In: Pascual-Fernández, J.J., Pita, C., Bavinck, M. (Eds.), Small-Scale Fisheries in Europe: Status, Resilience and Governance, 23. MARE Publication Series, pp. 83–103. https://doi.org/10.1007/978-3-030-37371-9.

Vasilakopoulos, P., Maravelias, C.D., Tserpes, G., 2014. The alarming decline of mediterranean fish stocks. Curr. Biol. 24 (14), 1643–1648. https://doi.org/10.1016/j.cub.2014.05.070.

Wallace, B.P., Lewison, R.L., McDonald, S.L., McDonald, R.K., Kot, C.Y., Kelez, S., Bjorkland, R.K., Finkbeiner, E.M., Helmbrecht, S., Crowder, L.B., 2010. Global patterns of marine turtle bycatch. Conserv. Lett. 3 (3), 131–142. https://doi.org/10.1111/j.1755-263X.2010.00105.x.

Widyatmoko, A.C., Hardesty, B.D., Wilcox, C., 2021. Detecting anchored fish aggregating devices (AFADs) and estimating use patterns from vessel tracking data in small-scale fisheries. Article 1 Sci. Rep. 11 (1). https://doi.org/10.1038/s41598-021-97227-1.

Young, J.W., Lansdell, M.J., Campbell, R.A., Cooper, S.P., Juanes, F., Guest, M.A., 2010. Feeding ecology and niche segregation in oceanic top predators off eastern Australia. Mar. Biol. 157 (11), 2347–2368. https://doi.org/10.1007/s00227-010-1500-y.