

F. TIRALONGO^{1,2,3}, F. GIOVANNELLI^{3,4}, A. ZAMBETTI³, B. DIMICHINO³, P. BAIATA, P. PIGNALOSA³

¹Department of Biological, Geological and Environmental Sciences, University of Catania, Catania, Italy

²Ente Fauna Marina Mediterranea, Avola, Italy

³Bluechain a.r.l., Torre del Greco, Italy

⁴ DISTAV, University of Genova

corresponding author: francesco.tiralongo@unict.it

TRAP-LINE: AN INNOVATIVE FISHING GEAR FOR MEDITERRANEAN SWORDFISH FISHERIES

TRAP-LINE: UNO STRUMENTO DI PESCA INNOVATIVO PER LA PESCA MEDITERRANEA AL PESCE SPADA

Abstract - During Summer 2024, observer deployed on pelagic longline vessel collected data about an innovative fishing gear known as the "trap-line" increasingly used in the Mediterranean swordfish pelagic longline fishery. Trap-lines consist of concentric monofilament rings combined with artificial bait and differ structurally and functionally from traditional hook-based baits. Despite representing about 30% of deployed fishing units, trap-lines accounted for more than half of the swordfish catch, resulting in a markedly higher catch per unit effort (CPUE) than conventional hooks. Trap-lines also showed improved selectivity, capturing fewer undersized individuals and slightly larger fish. Bycatch was minimal, with only five non-target specimens recorded, all released alive. These preliminary results suggest that trap-lines may provide a more efficient and selective alternative to traditional gears, potentially reducing bycatch and operational costs, although further research is needed to support their sustainable adoption in Mediterranean fisheries.

Keywords: CPUE, size selectivity, bycatch mitigation, artificial bait, longline comparison

Introduction - Over the last years, pelagic longline fisheries targeting swordfish (*Xiphias gladius* Linnaeus, 1758) in the Mediterranean have undergone significant changes, including a shift to deeper waters and various gear modifications. In this context, some fleets have increasingly adopted artificial baits, lights, and, more recently, a new gear type: *trap-lines*. *Trap-lines* exploit the predatory behaviour of swordfish by entangling them in filaments rather than hooking them directly. The origin of this gear is not fully documented (Ochi *et al.*, 2025) but adoption by Mediterranean fleets has been rapid, driven by perceived higher efficiency in swordfish capture and reduced baiting costs. However, the use of these modified baits has encountered regulatory challenges over the years, and their deployment is still considered experimental. As with any modification to fishing gear, the introduction of *trap-lines* can have significant consequences on the impact of longlines on target and non-target species (Tiralongo *et al.*, 2023); at the same time, these innovations may reduce the negative impact of longlines, as observed with the adoption of artificial baits (Ueno *et al.*, 2024), circle hooks (Carbonara *et al.*, 2023), and mesopelagic longlining. Preliminary observations suggest that *trap-lines* may positively influence longline selectivity, not only by increasing target species catch but also by reducing bycatch of other species (Garibaldi *et al.*, 2024; Macias *et al.*, 2025; Coelho *et al.*, 2025). This study contributes to this research field by providing preliminary but encouraging data on the effectiveness of these gears, both in increasing CPUE, LPUE and in reducing bycatch.

Materials and methods - Between April and August 2024, scientific monitoring was conducted onboard a commercial longline vessel operating in the central Mediterranean Sea. Additional observations were carried out at landing points, and structured

interviews with the crew were used to collect technical information on fishing practices. The vessel employed different fishing gears during the season according to target species. During summer, after reaching the bluefin tuna, *Thunnus thynnus* (Linnaeus, 1758) quota, mesopelagic longline operations (150–400 m depth) targeted swordfish (*Xiphias gladius*). In this phase, traditional natural baits and trap-lines were deployed simultaneously, with an average ratio of approximately 3:1, allowing direct comparison under identical environmental and operational conditions. Fig. 1 shows set start and end positions, the two main fishing areas, and the landing ports (Monopoli and Santa Maria di Leuca), divided by sampling periods ("missions").

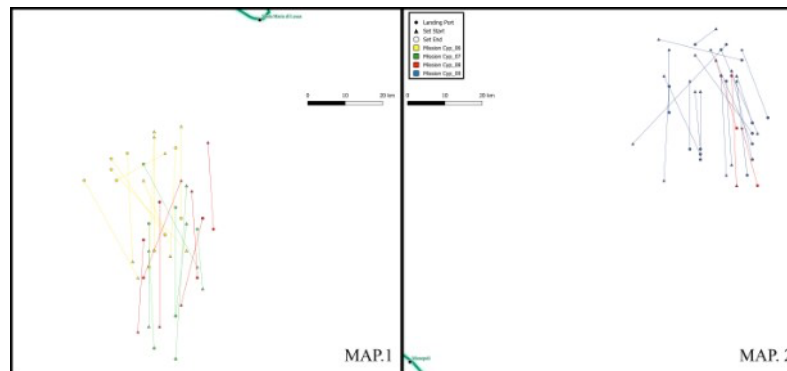


Fig. 1 - Study area. Sets carried out during 4 time periods "missions". (Cyp_06 from 12/06/24 to 20/06/24; Cyp_07 from 23/06/24 to 1/07/24; Cyp_08 from 3/07/24 to 12/07/24; Cyp_09 from 31/07/24 to 21/08/24).

Area di studio. Set di campionamento adottato durante i 4 periodi di attività. (Cyp_06 from 12/06/24 to 20/06/24; Cyp_07 from 23/06/24 to 1/07/24; Cyp_08 from 3/07/24 to 12/07/24; Cyp_09 from 31/07/24 to 21/08/24).

For each set and haul, gear type and number, catch composition, bycatch condition (alive/dead), and biometric data (curved fork length and weight) were recorded. Trap-lines consisted of 7–8 concentric monofilament nylon rings (30–70 cm in diameter) attached to a rubber sheath and mounted at the end of the branch line, clipped to a traditional hook. An artificial lure (plastic squid, 30–35 cm) with an internal weight (20–40 g) was suspended at the center to stabilize movement. Hooks were retained only for structural support and handling, as trap-lines operate by entanglement rather than hooking; swordfish become entangled when striking the lure with the rostrum. Due to the controversial and non-standardized nature of this gear, fishers typically manufactured trap-lines themselves, often modifying them onboard to adapt the gear to specific operational conditions. Catch-per-unit-effort (CPUE) and landings-per-unit-effort (LPUE) were calculated as the number and landed weight (kg) of swordfish (*Xiphias gladius*) per unit of effort, respectively. Effort was standardised to 360 hooks per basket, based on observed deployment (340–380 hooks). Trap-line effort was estimated from hook-to-trap-line ratios recorded for each set. CPUE and LPUE were calculated separately for trap-lines and conventional baited hooks using gear-specific effort units. Size selectivity was evaluated using fork length frequency distributions (5 cm classes), and differences in bycatch composition and survival at haulback were assessed. Due to non-normal data distributions, comparisons were performed using Wilcoxon rank-sum tests. All analyses were conducted in R software.

Results - Data were collected from 44 longline sets and 43 haulbacks, corresponding to an estimated 46,373–50,690 deployed J-hooks. Approximately 30% of the fishing

units (15,272–16,700) were equipped with trap-lines, while the remaining hooks were baited with natural baits. A total of 426 marketable swordfish (*Xiphias gladius*) were caught, together with 31 non-commercial individuals (17 specimens severely damaged by predation and 14 individuals below the minimum legal size). Five swordfish were excluded from analyses due to severe predation damage or uncertainty in gear attribution. A further 50 swordfish showed partial damage caused by squid or other scavenging organisms; these individuals were retained in the dataset, and damage condition was accounted for during data analysis. Trap-lines accounted for 213 swordfish ($\approx 51\%$ of the marketable catch), while conventional hooks captured 207 individuals. When standardised by effort, mean CPUE was significantly higher for trap-lines (13.6 individuals per 1,000 trap-lines) than for hooks (6.9 individuals per 1,000 hooks). Similarly, LPUE was higher for trap-lines (444.8 kg per unit of effort) compared to hooks (181.5 kg). Differences in CPUE and LPUE were statistically significant (Wilcoxon rank-sum test, $p < 0.001$). Swordfish caught with trap-lines were also slightly larger than those caught with hooks. Median curved fork length was 145 cm (IQR 133–159 cm) for trap-lines and 137 cm (IQR 122–150 cm) for hooks, with undersized individuals predominantly captured by hooks (11 of 14). Size-related differences were significant ($p < 0.01$; Fig. 2). A total of 119 non-swordfish specimens were recorded as bycatch. Most bycatch (95.8%) was associated with standard hooks, whereas only five individuals (4.2%) were captured by trap-lines, all released alive. No interactions with marine mammals, seabirds, or sea turtles were observed. The relative contribution of bycatch species is shown in Fig. 3.

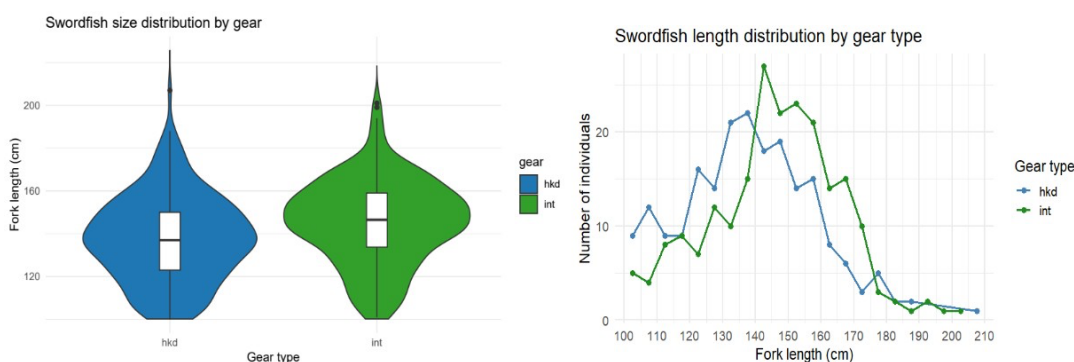


Fig. 2 - Swordfish size distribution (violin plots) by gear (left panel) and Length/frequency distribution of swordfish (related to each gear type) in the right panel. hkd = hooks; int = trap-line.

Distribuzione delle dimensioni del pesce spada (grafici a violino) per attrezzo (pannello a sinistra) e distribuzione lunghezza/frequenza del pesce spada (in relazione a ciascun tipo di attrezzo) nel pannello a destra; hkd = ami; int = lenza.

Discussion - These early findings highlight the potential of trap-lines to increase fishing efficiency, improve size selectivity, and significantly reduce bycatch, supporting their use as a more environmentally responsible fishing strategy. With a CPUE nearly twice that of conventional hooks, trap-lines showed a higher capacity to capture both a greater number and larger swordfish, optimizing yield per unit of effort and reducing dependence on natural bait. Moreover, the reduced bycatch associated with trap-lines, particularly the limited interactions with elasmobranchs, addresses key conservation concerns in pelagic longline fisheries (Lima *et al.*, 2023). Overall, these results are consistent with observations from other swordfish fisheries in the Ligurian Sea (Garibaldi *et al.*, 2024) and the Atlantic Ocean (Coelho *et al.*, 2025), and provide additional evidence relevant to the ongoing evaluation of trap-lines within the ICCAT regulatory framework.

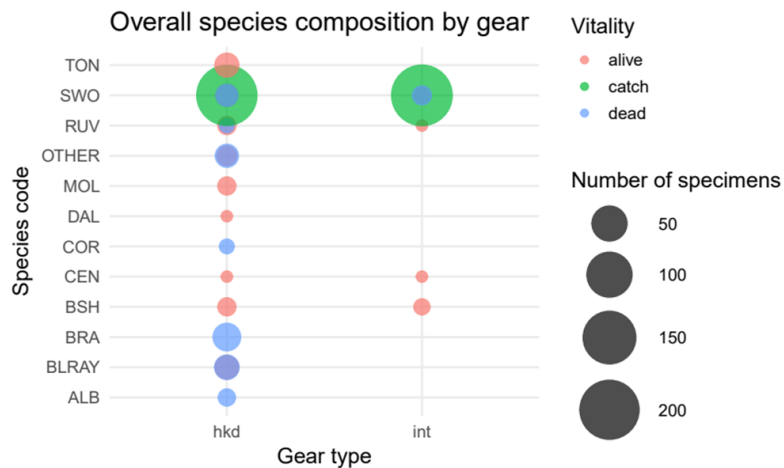


Fig. 3 - Species composition by gear. The graph shows both the number and the vitality of each species caught. Code of species: TON (*Thunnus thynnus* (Linnaeus, 1758)); SWO (*Xiphias gladius* Linnaeus, 1758); RUV (*Ruvettus pretiosus* Cocco, 1833); MOL (*Mola mola* (Linnaeus, 1758)); DAL (*Dalatias licha* (Bonnaterre, 1788)); COR (*Coryphaena hippurus* Linnaeus, 1758); CEN (*Centrolophus niger* Gmelin, 1789); BSH (*Prionace glauca* (Linnaeus, 1758)); BRA (*Brama brama* (Bonnaterre, 1788)); BLRAY (*Pteroplatytrygon violacea* (Bonaparte, 1832)); ALB (*Thunnus alalunga* (Bonnaterre, 1788)).

Composizione delle specie per attrezzo. Il grafico mostra sia il numero che la vitalità di ciascuna specie catturata. Codice della specie: TON (*Thunnus thynnus* (Linnaeus, 1758)); SWO (*Xiphias gladius* Linnaeus, 1758); RUV (*Ruvettus pretiosus* Cocco, 1833); MOL (*Mola mola* (Linnaeus, 1758)); DAL (*Dalatias licha* (Bonnaterre, 1788)); COR (*Coryphaena hippurus* Linnaeus, 1758); CEN (*Centrolophus niger* Gmelin, 1789); BSH (*Prionace glauca* (Linnaeus, 1758)); BRA (*Brama brama* (Bonnaterre, 1788)); BLRAY (*Pteroplatytrygon violacea* (Bonaparte, 1832)); ALB (*Thunnus alalunga* (Bonnaterre, 1788)).

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