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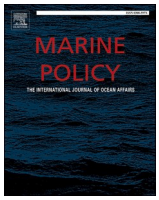

Using crime script analysis to unveil illegal, unreported, and unregulated (IUU) fishing of European eels

Monica Pons-Hernandez [a,*,1], Gohar A. Petrossian [b,2]

[a] Universitat Rovira i Virgili, Av. Catalunya 35, Tarragona 43002, Spain
[b] John Jay College of Criminal Justice, United States

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ABSTRACT

The exploitation of European eels, driven by the global demand for eel meat, is contributing significantly to the declining populations of the species. While the species faces other serious threats, like the loss of habitat, the harvesting of European eels to supply the transnational illegal trade has significantly increased. To better understand the illegal and unreported fishing of European eels, we employed a crime script analysis framework to examine the process by which glass eels are poached in one of the world's major source countries—Spain. Through our analysis, we demonstrate that the IUU fishing of European eels is a specialized activity that requires a specific set of skills and tools. Our findings underscore the need for tailored intervention strategies to address the illegal and unreported fishing of European eels at each phase of the crime script, from preparation to post-activity. By understanding and addressing the intricacies of this criminal activity, we aim to contribute to the conservation efforts necessary to protect this endangered species.

1. Introduction

There has been an exponential growth in scientific literature on illegal, unreported, and unregulated (IUU) fishing over the past decade (e.g., [29,36,37,55]). These studies highlight the undeniable fact that IUU fishing is one of the most serious environmental crimes of this century. This crime is estimated to generate $36 billion in annual losses, decimating the global oceans, disrupting marine ecosystems, and impacting the vulnerable economies of developing countries and communities that rely on fisheries for their livelihoods and sustenance [34]. The impacts of IUU fishing are multifaceted. For example, in many developing countries, 50 % of protein input comes from fisheries [22], and depleting this vital resource puts significant pressure on the basic survival of the communities that depend on fish [13]. IUU fishing also leads to the loss of gross national product, landing fees, and taxes not collected from legitimate fishing activities, directly and indirectly contributing to hunger and poverty, especially in developing countries [28].

Additionally, IUU fishing has placed significant pressure on not only the marine and freshwater ecosystems, but also on commercial fish stocks. IUU fishing vessel owners often employ illegal methods, such as blast fishing—which is prevalent in over 30 countries around the world [10]—along with drift nets, bottom trawling, and muro-ami nets, to carry out their activities. These destructive fishing techniques not only harm essential plankton, coral reefs, and crevices, but also affect other non-target species (collectively referred to as by-catch). Moreover, these methods have detrimental effects on some of the most commercially important species, such as tuna, salmon, billfish, and swordfish [37]. More directly, the overexploitation of these species has placed immense pressure on their stocks, to the extent that if current exploitation rates persist, many of these stocks will collapse entirely within the next several decades. The conservation of these species is crucial, as overexploitation decimates their populations, sometimes pushing them on the brink of irreversible decline [1].

Among the species affected by IUU fishing is the European eel (*Anguilla anguilla*) [2,23,25,51]. For centuries, European eels have been a traditional food source in Europe. However, with the decline of Japanese eel populations, the East Asian market shifted its focus to European eels [44]—and, more recently, to American eels [48]. This shift has placed significant pressure on the survival of these species [44]. While reproduction of European eels in captivity has been achieved [4,50], the commercial viability of the process remains challenging due to their

* Corresponding author.
E-mail addresses: monica.pons@urv.cat (M. Pons-Hernandez), gpetrossian@jjay.cuny.edu (G.A. Petrossian).
[1] ORCID: 0000-0002-6167-8152.
[2] ORCID: 0000-0002-0708-2833.

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complex reproductive biology and the unique early life stage of their larvae [50]. Consequently, the exploitation of European *glass* (baby) eels needs to cover a double demand: (1) consumption—mostly in Spain; and (2) use as "seeds" for aquaculture to be consumed as yellow (juvenile) or silver (maturing) eels. In sum, all eels consumed by humans are still sourced from the wild [4,18], posing a serious threat to the species. According to ICES [25], the European eel's status is critical, with recruitment having drastically declined since 1980.

Due to declining numbers, the European eel has been designated as 'Critically Endangered' by the International Union for Conservation of Nature (IUCN), and listed on the European Red List of Freshwater Fishes [19]. Moreover, the European Union (EU) adopted Council Regulation (EC) No 1100/2007 on 18 September 2007, outlining measures for the recovery of the European eel stock[4] (known as the "Eel Regulation"). The Eel Regulation was implemented to control—among other threats—the unsustainable fishing practices of wild eels at all continental stages (glass, yellow, and silver eels). Also, to control its unsustainable trade, the European eel has been listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Since 2010, the EU has been unable to issue a positive Non-Detrimental Finding—a science-based assessment that determines whether the trade will negatively (or detrimentally) affect the survival of a species [11]. As a result, while internal trade remains, the export and import of this species to and from the EU is prohibited.[5]

Despite these restrictions, demand for European eel meat remains high, and millions of European glass (baby) eels are being trafficked (poached and smuggled) to be farmed and meet the global demand [2,31,40]. As Wyatt [62] explains, wildlife trafficking refers to the entire process, from source to demand. Therefore, the illegal trade in European eels encompasses both IUU fishing and smuggling. Given the distinction between these two crimes (and the actors involved), this research will focus exclusively on the IUU fishing phase, including both purely illegal and under-reported fishing.

According to Europol [20], each year, around 100 tonnes of glass eels are illegally removed from European waters to be smuggled to Asia.[6] Due to the scale of the illegal trade in European eels, this crime is receiving increasing scientific attention. For instance, Shiraishi and Crook [47] identified discrepancies between exporter and importer data that may be indicative of illegal trade; Stein et al. [54] provided the first genetic evidence of illegal trade in European eels; and Richards et al. [43] found that European eels are being sold in supermarkets in Hong Kong. Moreover, Alonso and van Uhm [2] examined the synergies between legal and illegal actors in the trafficking of European glass eels; Pons-Hernandez [41] reflected on the harms to the European eels due to their trade and trafficking; Gutierrez and Duffy [23] and Hutchinson et al. [24] explored not only the issues of overfishing and illegal trade but also other threats faced by the European eel; Stein et al. [52] analysed the demand side by evaluating the effectiveness of trade regulations and the use of fraudulent labelling of eel products originating from China; Pons-Hernandez [42] explored the role of Spain within the supply chain of European eel trafficking using the criminogenic asymmetries framework (see [33]); and, lastly, Stein et al. [53] summarised the results of Operation LAKE aimed to disrupt eel trafficking.

However, despite this existing literature, an especially significant gap remains in our knowledge about how European eels are harvested. Acknowledging that "the illegal wildlife trade is a multi-stage crime and smuggling operation" ([62]: 3), this research aims to examine the IUU fishing of European glass eels, providing a detailed account of how this initial stage of the crime unfolds. This research employs the now widely-used method of crime script analysis. Crime script analysis has been used to examine other wildlife crimes, such as illegal ivory markets [30], jaguar poaching and paste production [27], rhino poaching [59], illegal commercial fishing [38], and illegal harvesting of live corals [49]. This analytical approach also allows researchers to examine the roles of the actors involved in illegal harvesting, the methods employed, the targeted locations and times, and the overall operational structure of this activity. Understanding the detailed procedures involved in the IUU fishing of the European eel will enable the development of evidence-based prevention strategies.

2. A brief introduction to crime script analysis

Crime science (also known as environmental criminology) encompasses a family of theories that focus on the crime 'event' and the immediate environment and opportunity structures surrounding that event [61]. Unlike conventional criminological theories, which emphasise the importance of understanding criminal dispositions and how these lead to crime, crime science theories posit that opportunity is at the core of all criminal activity. Thus, understanding the opportunity structures within the built (and natural) environment, and how these opportunities enable crime, will lead to clear and tangible solutions[7] [61].

One of the analytical methods used by crime scientists to understand these opportunity structures and the situations that enable crime is crime script analysis. This analytical method explores the detailed sequential steps involved in carrying out a criminal activity. As a strategy of "procedural analysis" of crime [15], crime scripting provides a foundational framework for crime analysts to adopt a more structured and systematic approach to acquiring an in-depth understanding of the crime 'event'. This method draws from the theoretical underpinnings of the rational choice theory [16] and routine activities theory to propose the analytical steps involved in understanding the decision-making process and the opportunity structures surrounding it that eventually lead to the commission of the crime or the crime 'event'.

A core assumption of this analytical technique is that "all crimes, even the simplest, involve chains of decisions and actions, separable into interdependent stages, involving the attainment of sub-goals that serve to further the overall goals of the crime" ([17]: 47). Thus, understanding the underlying mechanisms and opportunity structures that drive the criminal 'event' requires a detailed understanding of the core components and processes that comprise and lead to that 'event'. Such an understanding will allow for the identification of anchor points for intervention and the development of tailored strategies.

Crime script analysis requires detailed descriptions of the actual acts carried out by offenders, which can be organised into scenes. These scenes involve the offenders, the facilitating conditions,[8] and the settings where these acts take place [8]. This assumption draws from the routine activities theory, which suggests that crime occurs when the paths of a motivated offender and a vulnerable target cross in the absence of a capable guardian [14]. Originally, Cornish [15] proposed seven sequential stages of scripting a crime to understand the underlying choice-structuring conditions required for a criminal activity to take

[4] Council Regulation (EC) No 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel, OJ L 248, 22.09.2007, p. 17–23.

[5] In 2023, the UK government issued a Non-Detrimental Finding (NDF) for the European eel, allowing for controlled trade of the species. Although the UK is no longer part of the European Union (EU), Northern Ireland remains within the EU's Single Market. As a result, European eels exported from England and Wales to Northern Ireland (usually for restoking) can subsequently be legally re-exported to EU member states, such as the Netherlands, bypassing the EU's broader restrictions on trade involving this species [46].

[6] One kilogram of glass (baby) eels accounts for 2800–3000 eels (see [40]). Thus, the illegal trade of 100 tonnes of glass eels means that the lives of 280,000,000 to 300,000,000 European eels are lost to trafficking every year.

[7] Such as through the application of the 25 situational crime prevention techniques that are organized around increasing the risk, increasing the effort, reducing the reward, removing excuses, and reducing provocations [12].

[8] These are pre-conditions that make the commission of the crime easier and less risky, as well as increase the opportunities for that crime to occur.

place. These stages included *preparation* (e.g. obtaining necessary tools), *entry* (e.g. physically entering the location where the crime will be committed), *pre-condition* (i.e. sets of enabling conditions leading to the crime), *initiation* (e.g. selecting the crime target), *actualisation* (various functions), *doing* (the crime), *post-condition* (i.e. conditions that enable the successful completion of the crime), and *exit* (e.g. disposing of the stolen goods) [15]. However, until 2010, the use of this technique was limited primarily due to its complexity and lack of clarity [5]. In 2010, Tompson and Chainey [57] introduced a more simplified and practical method derived from the original steps. This approach focused on the *acts* that led to the key crime 'events' necessary for the overall success of the criminal act. They organised these sequential stages into *preparation*, *pre-activity*, *activity*, and *post-activity*. This study will rely on Tompson and Chainey's [57] simplified scripts to devise the procedural steps involved in the IUU fishing of glass eels.

3. Methods

This research uses the case study of Spain, one of the key suppliers of European glass eels (see [40,42,58]). In Spain, the Eel Regulation (discussed above) led to the drafting of thirteen Management Plans, one for each river basin with an eel population. Each plan restricts the fishing spots, the number of licenses available, the fishing methods allowed, and the months during which eels can be harvested. Accordingly, each river basin has its limits on fishing spots, licenses, methods, and seasons. However, unlike France, Spain does not have a set fishing quota (for a detailed account of how Spain regulates the conservation of the European eel, see [7]), enabling fishers to catch as many eels as possible.

To collect data on IUU eel fishing practices in Spain, this research largely draws on primary data gathered using qualitative research methods. The research methods employed to collect data include semi-structured interviews and non-participant observations. Initially, fourteen open-ended semi-structured interviews were conducted between March 2022 and November 2022 with key stakeholders, including eel fishers (5), eel traders and industry representatives (3), law enforcement agents (2), members of the scientific community (2), and non-governmental organisations (NGOs) (2). Participants were selected using a purposive sampling strategy based on their potential contributions in an iterative process. Snowball sampling, as described by Ritchie et al. [45], was then employed to collect additional data. All interviews were recorded, transcribed, and analysed using NVivo 12 software. Data sources (transcripts and notes) were imported to NVivo and organised in folders according to stakeholder groups. Since this research follows a bottom-up approach, initial coding began with an open coding method to identify initial patterns. At this stage, segments of text were coded line-by-line. Thematic coding was then used to group similar codes into broader categories that corresponded to the different stages of the crime. Preliminary findings were discussed with two key stakeholders interviewed (one law enforcement agent and one eel fisher) to validate the accuracy of the information. Throughout the research process, several

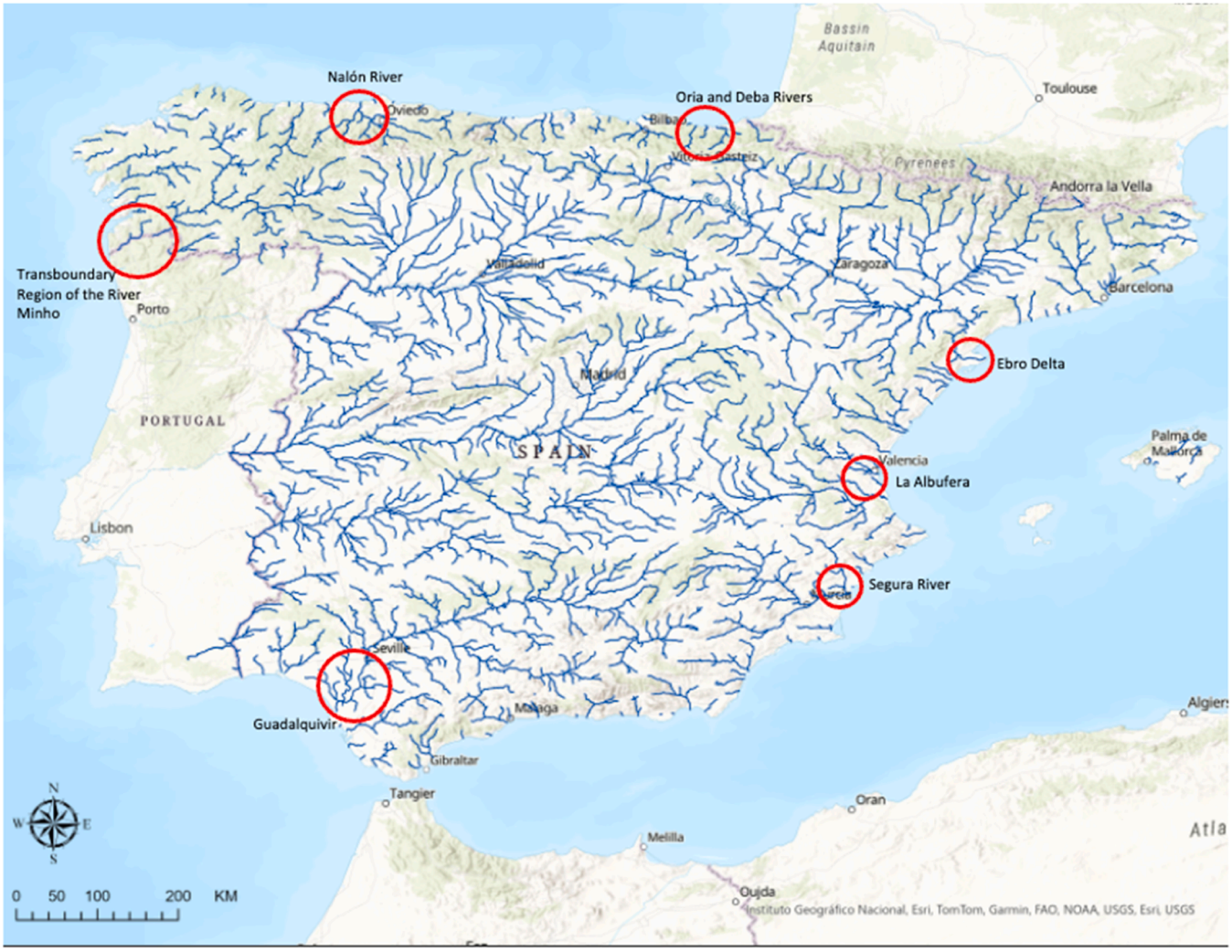

Fig. 1. Map of the most significant Spanish regions for eel fishing.

informal conversations were held with law enforcement agents and eel fishers. It helped to clarify aspects of previous conversations and gain a deeper understanding of the processes involved in the IUU fishing of European eels.

Additionally, given the unfamiliarity with the Spanish regions that have a longstanding tradition of eel fishing (see Fig. 1), non-participant observation was employed to examine the context and landscape in which these crimes occurred. This method helped to gain a deeper understanding of how environmental features are exploited to perpetrate eel-fishing-related crimes and how these practices can be hindered. Non-participant observation took place in Northern Spain (the four regions on the top in Fig. 1). From January 2022 to April 2022, focusing on the Ebro Delta (Catalonia), the Oria and Deba Rivers (Basque Country), and the Nalón River (Asturias), the most significant Spanish regions for eel fishing. In November 2022, observations extended to the Transboundary Region of the River Minho, the natural border between Spain and Portugal. Non-participant observation allowed the researcher to become familiar with the context in which this criminal 'event' occurs. The information was documented through field notes and photographic records. Ethical approval for the research was granted by institution XXX on 29/10/2021 (code XXX-2021-TD-0018). Lastly, the information collected through semi-structured interviews and non-participant observations was triangulated with academic literature, policy documents, and reports.

4. Results

This scripting focuses exclusively on the "extraction stage" of the supply chain led by licensed fishers and poachers (see [2]). Thus, throughout the scripting of the IUU fishing of European glass eels in Spain, the terms 'poacher' and 'fisher' will be used to refer to those who fish illegally—without a fishing licence or outside the fishing season, and those who fish legally—but do not report some of the catches to sell them in the illegal market—, respectively. Therefore, because the scope of the paper includes both under-reported fishing *and* illegal fishing (or poaching), both activities will be presented separately (see Table 1 and Table 2).

4.1. A crime script on the process of under-reporting glass eel catches (Table 1)

4.1.1. Stage 1: preparation

Under-reporting fishing catches requires the licensed fisher to take preparatory steps before concealing part of the catches. First, the member of the local community (familiar with the river and the territory and who has the required materials and transport) must apply for one of the few licenses available. As explained by a member of a fishers' guild (*cofradía*) in Spain, only guild members are eligible to apply for these licenses. However, applying does not secure obtaining a license to fish. The fishing licenses available for each fishing season will be auctioned among interested applicants. Due to fluctuating demand, a fisher may be licensed one season and resort to poaching the next despite remaining a guild member. One participant noted that while fewer people apply for licenses than in past years, there are also fewer licenses issued each year to comply with the Eel Regulation.

If the fisher obtains a licence, he must pay the self-employed tax (around 300 euros/month). Our interviews found that this requirement has led many fishers to stop applying for glass eel fishing licenses due to the reduced profit margins. If a licence is obtained, the fisher will receive:

1) An accreditation that certifies that he is a legal fisher and is allowed to fish glass eels in a specific fishing spot (Fig. 2);
2) A *guia*—a document where he is required to record the daily catches; and
3) A tag to identify the fishing trap.

Table 1
A crime script on the process of under-reporting glass eel catches.

STAGE	Steps and options	Spatial	Temporal	People/Actors
Preparation	• Gain relevant knowledge about how to build a glass eel trap and obtain the materials or buy one. • Obtain appropriate clothing (waterproof boots, jacket, and trousers). • Have an appropriate car to be able to go to the fishing spot with all the materials needed. • Familiarize oneself with the region and learn the landscape (is a vast, wild, unpopulated area, with a lot of small tracks. Easy to "get lost"). • Learn how to "read the river", and when is a good day to fish. • Join a fisher's guild and apply for one of the fishing licenses that will go to auction. • Win one of the fishing licenses. • If winning a fishing license: pay the freelance worker tax; wait to get the identification tag for the glass eel trap and the accreditation document attesting to the legality of the status as a fisher.	Under-reporting glass eel catches takes place in rural areas in Spain with glass eel populations (towns near river basins where salt and continental water meet (estuaries) and upper in the river if it is not cut by dams).	In late summer or early autumn.	A male member of the local fisher's guild applies for a fishing license and if he gets one, gets a glass eel trap.
Pre-Activity	• Put the tag in the trap and carry the fishing license. • Take the trap, empty buckets, the *guia,* and a scale to weigh the catches and put those in the car. • Go to your assigned fishing spot.	The pre-activity takes place at home and in the roads leading to the assigned fishing spot.	*Time of year*: during autumn/winter when the fishing season takes place. *Time of day*: between 5–6 p.m.	The male fisher takes all the materials he needs and drives to the fishing spot he got assigned. Submerges his legal eel trap making sure that it is not so deep that water and glass eels can go over the

(*continued on next page*)

Table 1 (*continued*)

STAGE	Steps and options	Spatial	Temporal	People/Actors
	• Submerge the trap in the fishing spot and chain it. • Leave the *trap* in the water overnight (go home and sleep/stay there in a shelter to guard it/ask another fisher to keep an eye on the *bussó*). • Take the trap out of the water in the morning, strain the eels and discard the bycatch. • Weigh the eels without water.		and 6–8 a.m.	trap. The fisher guards his trap overnight and when it is time (before 8 a.m.), he takes the trap out of the water.
Activity	• Grab the *guia* and annotate less weight—under-report catches.[11] • Hide the under-reported eels in your car and keep the legally reported ones in a visible place in case you are stopped by the authorities.	The activity takes place in the assigned fishing spots.	*Time of year:* during autumn/winter. *Time of day*: around 6–8 am.	The fisher lies about the real weight putting less grams/kilograms than the ones caught so he can keep part of the catches for himself (for his own consumption, or as a gift to local authorities, or to sell them in the illegal market—in a fish shop, in an upper scale restaurant, or to a collector—who will start the smuggling).
Post-Activity	• Leave (check WhatsApp or your phone to see if someone alerted about the presence of police, if so, avoid this road and take another one). • Hide the under-reported eels at home/your property. • Go to the fish market and sell the reported eels.	The post-activity takes place in the road leading to the fishing market, residential areas, and private premises.	*Time of year*: during autumn/winter. Time of day: between 8 and 11 a.m. Fishers must go to the market before 11 a.m.	The fisher leaves the scene with the under-reported eels hidden in his vehicle. Leaves the under-reported eels in his house or premises and heads to the fishing market to sell the eels reported in the *guia*. The fisher sells the under-reported eels in the illegal market (restaurant, collector, individual) or keeps them for personal consumption or for a friend.

Table 2
A crime script on the process of glass eel poaching.

STAGE	Steps and options	Spatial	Temporal	People/Actors
Preparation	SCENE 1 • Gain relevant knowledge about how to build a glass eel trap and obtain the materials or buy one. • Obtain appropriate clothing (waterproof boots, jacket, and trousers). • Have an appropriate car to be able to go to river margin with all the materials needed. • Familiarize oneself with the region and learn the landscape (is a vast, wild, unpopulated area, with a lot of small tracks. Easy to "get lost"). • Learn how to "read the river", and when is a good day to have catches. SCENE 2: • Acquire a bolt cutter. • Have an *appropriate* vehicle to be able to go to river margin. • Identify the fishing spots of licensed fishers along the river.	Poaching takes place in rural areas with glass eel populations (towns near river basins where salt and continental water meet (estuaries) and upper in the river if it is not cut by dams).	All year, but most predominantly in late summer or early autumn.	A male member of a local community without a license to fish glass eels gets a glass eel trap (bussó in Catalonia) or a bolt cutter. The poacher makes sure to have all he needs (clothing, tools, car).
Pre-Activity	SCENE 1 • Grab the eel trap, illegal ones tend to be smaller. • Take the car with all the materials and go to a fishing area that is unguarded (especially to a location that is far from a residential area).	The pre-activity takes place at home and in the roads leading to the river margins.	SCENE 1 *Time of year:* Occurs all year round but most predominantly during autumn/winter. *Time of day:* when most convenient. SCENE 2 *Time of year:* Occurs exclusively in autumn/winter (when legal fishing is allowed).	The male poacher member of a local community takes all the materials he needs and drives to the river margin.

(*continued on next page*)

Table 2 (*continued*)

STAGE	Steps and options	Spatial	Temporal	People/ Actors
	• Go to a good fishing area in observance of the time of the year and the weather conditions. SCENE 2: • Grab the bolt cutter and keep it in your car. • Identify an unguarded trap of a licensed eel fisher.		*Time of day:* during the night (when legal fishing is allowed).	
Activity	SCENE 1 • Submerge the trap into the water. SCENE 2 • Identify an unguarded glass eel trap. • Walk into the fishing spot, break the chain if it is chained, take it out of the water and empty it.	SCENE 1 Takes place in the bushes of the river margins —this can be done near a fishing spot for licensed fishers. SCENE 2 Takes place in the fishing spots for licensed fishers.	SCENE 1 *Time of year:* Occurs all year round but most predominantly during autumn/ winter. *Time of day:* when most convenient. SCENE 2 *Time of year:* Occurs exclusively in autumn/winter (when legal fishing is allowed). *Time of day:* during the night (when legal fishing is allowed).	SCENE 1 The male poacher goes to a quiet place, hides in the bushes, and submerges the eel trap in the river margin or near a fishing spot. The male poacher leaves the trap in the water and leaves the scene to avoid detection. After a few hours, he returns to the place to remove his illegal trap and puts the eels in a bucket. SCENE 2 A male poacher identifies an unguarded glass eel trap and, if it is chained, uses the bolt cutter to break the chain and empties its content.
Post-Activity	SCENE 1 & 2 • Strain the eels and put them in a bucket (without much water). • Hide the eels in the vehicle. • Leave (check WhatsApp or	The post-activity takes place in the bushes, in the roads leading back to residential areas, and at home or the premises	SCENE 1 *Time of year:* Occurs all year round but most predominantly during autumn/ winter. *Time of day:* when most convenient. SCENE 2	The male poacher leaves the scene in his vehicle with the poached eels and hides them to sell them in the illegal market, usually a

Table 2 (*continued*)

STAGE	Steps and options	Spatial	Temporal	People/ Actors
	your phone to see if someone alerted about the presence of police, if so, avoid this road and take another one). • Hide the poached eels at home/ your property. • Identify a buyer (consumer or collector).	where the eels will be hidden.	*Time of year:* Occurs exclusively in autumn/winter (when legal fishing is allowed). *Time of day:* during the night (when legal fishing is allowed).	collector [2].

Fig. 2. Glass eel fishing spot in the Ebro Delta region.
Source: Photograph taken by the researcher 01/20/2024.

At each fishing spot, a licensed fisher is allowed to use only one trap (*bussó*). They are provided with a tag that includes a serial number (e.g., PAS794) specific to their trap and fishing location. In other words, each trap is tied to a particular licensed fisher and spot. Before heading out, the fisher must attach the current season's tag to their *bussó* and remove the previous year's tag. One research participant mentioned that being caught with an outdated tag results in a fine. To help law enforcement quickly identify legal traps, the tag colour changes each year (e.g., red, yellow, white).

4.1.2. *Stage 2: pre-activity*

Unlike poaching, under-reporting involves legal fishing activities before any concealment occurs. In the pre-activity stage, fishers will ensure that the previous year's tag has been removed and the current one is in place. They will gather the necessary equipment: the *bussó* (trap), a light and batteries, a wing (*ala*, if used, which helps funnel glass eels into the trap), a bucket for transporting the eels to the fish market[9]

[9] Fish markets in this context refer to markets where fresh fish is sold, often through auctions. These markets are common in coastal areas in Spain, where fishers bring in their daily catch, and buyers bid on the fish in bulk to then distribute to retailers, restaurants, or directly to consumers. In the case of eels, only traders can buy glass eels at the fish market.

(*lonja*), a scale to weigh the catch, the license, the *guia* (to record the daily catch), and a pen to log the catches in grams. Once prepared, the fisher loads everything into the car and, around 5 p.m., drives to the fishing spot.

Between 5 p.m. and 7 p.m., the fisher will submerge the trap into the water, secure it with a chain to prevent theft, and leave it overnight. During the night, he may return to the fishing spot several times to check that the trap is still in place. As explained to the researcher, a fisher is likely to stay at the fishing site if they expect favourable conditions, or a "good moon". If the fisher has a secondary job (which fishers mostly have), he may leave the trap in the water until around 5 a.m. or 6 a.m., allowing time to weigh and sell the eels at the fish market before starting their shift at 7 a.m. Thus, between 5 a.m. and 6 a.m. (or by 8 a.m. at the latest), the fisher returns to the fishing spot, retrieves the trap, discards the bycatch (Fig. 3), and transfers the eels—without water—into a bucket to weigh them.

4.1.3. Stage 3: activity

In the case of under-reporting catches, the crime occurs when not all the glass eels caught are recorded in the *guia*. Before leaving the fishing spot, the fisher engaged in under-reporting will fill out the *guia* indicating a lower weight (along with the time of the catch, their license number, and the car's plate number), while concealing the unreported eels in their vehicle. As one fisher explained, he once forgot to complete the *guia* and was stopped by the Nature Protection Service (SEPRONA). As a result, he was fined 300 euros.

4.1.4. Stage 4: post-activity

In the post-activity stage, the fisher will leave the fishing area. He might check his WhatsApp groups to see if any of his colleagues found the police on one of the exit roads. He will hide the under-reported eels at home or on his premises before heading to the fish market. At the fish market, the eels will be weighted, and the weight will match the one indicated in the *guia*. The fisher will be paid according to the market price, which usually ranges from 250 to 500 euros per kilogram, depending on the time of year. Prices typically drop after Christmas. The unreported eels will be stored in a safe place (e.g. at their home) until sold on the illegal market.

Thus, both illegally fished glass eels and those that are under-reported remain in the fisher's/poacher's possession until they are sold on the illegal market. These eels will be gathered by a collector or intermediary (see [2]) and smuggled outside the EU. A thorough discussion of how the illegally fished and under-reported eels reach Asia is out of the scope of this analysis. On very limited occasions, the eels may be kept for personal consumption, used as bribes for local authorities, or given to friends and family (usually during the Christmas season).

4.2. A crime script on the process of glass eel poaching (Table 2)

4.2.1. Stage 1: preparation

4.2.1.1. Scene 1. Glass eel poaching necessitates several preparatory steps before poachers can reach the river margins, estuaries, water channels, or lagoons where they are typically harvested. Poachers may operate either opportunistically or in organised groups, with the latter being more common in Portugal and France. By contrast, poaching in Spain is predominantly opportunistic, often involving local community members engaging in IUU eel fishing [2]. As [2] point out, "poachers are generally locals, young, jobless, or employed in seasonal work". Both this and previous studies have found no evidence of organised poaching of glass eels in Spain. Consequently, this crime script will focus exclusively on the activities of opportunistic poachers.

Poachers must first acquire relevant knowledge regarding the river and the migratory patterns of glass eels (which primarily occur in the winter). While glass eels can be found throughout the year in small quantities, the majority of catches take place during the colder months—from November to the end of February. Moon phases and weather conditions are key factors in determining the optimal time for fishing glass eels. According to research participants, most catches take place on stormy nights with no moonlight, when the water appears red and the river's current flows upward. Consequently, poaching activities tend to increase during these specific days and months.

The poacher will also need to obtain all the necessary equipment before going to a fishing area where glass eels can be harvested. To fish glass eels, the poacher will need to build a fishing trap (*bussó*) or buy one (Fig. 4). Also, he will need to acquire adequate clothing, have a driver's license (or know how to drive a car), and have an appropriate car. In other words, a car that is large enough to carry all the equipment and is capable of navigating various types of roads. As one interviewee, a local fisher, stated, opportunistic poachers are typically locals because they

Fig. 3. Bussó showing captured glass eels and other fish species.
Source: Image sent by a participant. Permission to use granted on 01/20/2024.

Fig. 4. Bussó, the traditional glass eel trap in Catalonia, Spain.
Source: Photograph taken by the researcher 03/02/2022.

know the territory. As the fisher said,

> *"They [poachers] are local people because an outsider doesn't know and the territory is complicated, you have to know it because you enter a road, and I know there is an exit, but you won't know it. The territory is not exactly easy. Those who fish are from here, are from the area." [own translation].*

4.2.1.2. Scene 2. Instead of fishing illegally, the poacher might choose to steal someone else's glass eel trap. In this scenario, while the poacher still needs an appropriate vehicle, he will require a bold cutter instead of a fishing trap. Due to the rise in trap theft, licensed fishers have begun chaining their traps to their designated fishing spot. As a result, the poacher not only needs to acquire a bolt cutter but must also identify the fishing spots of licensed fishers that are most suitable (e.g., those far from residential areas).

4.2.2. Stage 2: pre-activity

4.2.2.1. Scene 1. Poachers, relying on their knowledge of the territory, will determine the best locations for catching glass eels based on the time of year. For example, in the Ebro Delta, it is more effective to fish in the wetlands, or "*basses*", at the start of the season. This is because water pumps mix freshwater with seawater, attracting glass eels earlier than in the river. Once the poacher identifies a suitable spot, he packs all the equipment in his car, but conceals it to avoid detection. If he is stopped by a law enforcement agent,[10] he could face fines for using an unregistered trap (discussed below). Once he identifies a quiet location (might be next to a legal fishing spot), he will take all the equipment with him and get ready to submerge the illegal fishing trap into the water.

4.2.2.2. Scene 2. Otherwise, if a poacher identifies an unguarded trap, he will park the car as close to the licensed fishing spot as possible and grab the chain cutter to cut the chain.

4.2.3. Stage 3: activity

4.2.3.1. Scene 1. The poacher will immerse an illegal trap in the water and leave it behind, returning to retrieve it and empty it only when it is safe.

4.2.3.2. Scene 2. The poacher will cut the chain of a licensed fisher's trap and steal the eels caught inside. He will transfer the eels to a bucket and hide it filled with eels in his vehicle before leaving the scene.

4.2.4. Stage 4: post-activity

4.2.4.1. Scene 1. As explained above, the poacher will collect his illegal fishing trap at the time of the day that he finds most convenient to not get caught. Once he takes it out of the water, he will discard the bycatch, put the eels in a bucket and leave the illegal eel trap behind (Fig. 5) to avoid suspicion if he is stopped by the police. He will hide the eels in his car and leave as soon as possible. The poacher will hide the eels until he can sell them in the illegal market.

4.2.4.2. Scene 2. If the poacher is stealing the eels from an unguarded legal trap, he will break the chain, empty the trap, and repeat the same procedure.

[10] In the Ebro Delta (Catalonia), three police forces are policing the glass eel fishing during the fishing season.

Fig. 5. Abandoned illegal eel trap.
Source: Image sent by a participant. Permission to use granted on 01/20/2024.

5. Discussion

The overexploitation of glass eels is one of the primary causes of the decline of the species in the wild [21]. While the species population is, at best, at 10 % of its historical numbers [32], their illegal harvesting remains rampant. This is also true in Spain, one of the primary suppliers of European glass eels to the European and East Asian markets. Therefore, in an attempt to better understand the characteristics of the actors, their modus operandi, and the steps required for them to engage in and successfully complete illegal glass eel harvesting and the under-reporting of catches in Spain, this research applied the crime script analysis technique. This approach breaks the steps involved in both crimes into four distinct phases to untangle the relevant preparation, pre-activities, activities, and steps required to successfully complete the extraction of the species from the wild, as well as their concealment [3,38,39,49]. Taking a product-based crime script approach allowed us to identify the dynamic activities and decision processes fishers and poachers engage in. Such an understanding allows us to outline potential policy interventions focused on opportunity reduction and the 25 techniques of situational crime prevention [12].[12]

In Spain, current intervention points for preventing IUU eel fishing primarily involve patrolling river margins and roads to intercept illegal fishers and, in the case of legal fishers, the use of the *guia* to improve traceability. However, the effectiveness of these measures is limited due to the vastness of the territory, as noted during non-participant observations, and the scarcity of material and personnel resources. Interestingly, one participant highlighted that, in local communities where the IUU fishers are also locals, lawbreaking is permissive: even when caught, fishers are rarely sanctioned, possibly because eels are sometimes given as gifts to authorities or because law enforcement agents are also members of the community and, thus, are the friends and neighbours of fishers and poachers. Additionally, law enforcement units might only be present in fishing regions during specific times of the year, aligned with the seasonal nature of fishing activities. Accordingly, this section

[12] This is a set of 25 techniques that are grouped under five headings to include "increase the risk", "increase the effort", "reduce reward", "reduce provocations", and "remove excuses". These techniques, originally proposed by Ronald Clarke [12] have been empirically tested in over 250 studies and proven to be among the most significant and effective crime prevention techniques.

provides recommendations for more effective interventions that can help reduce the opportunities for this crime.

5.1. Interventions addressed to disrupt under-reporting and poaching

5.1.1. Preparation and pre-activity stages

When examining eel poaching and under-reporting activities, it became evident that the activity is carried out by locals from the communities where they live. This research also untangled distinct temporal patterns: IUU fishing (as happens with legal fishing) is most prevalent during cold months (from November through February) and under such specific weather conditions as storms, during high river currents, on days without moonlight, and when the water looks red. Drawing from situational crime prevention techniques [12], several distinct interventions are proposed to stop under-reported fishing and poaching. First, we suggest that to *remove the excuses*[13] for illegal eel harvesting and under-reporting, preventive efforts should focus on *alerting conscience.* This can be accomplished by implementing education campaigns that specifically focus on both the environmental and social harms caused by this activity. Most local fishers are vested in their communities and will not likely be willing to harm the members of their community if they are aware of the consequences of their actions.

Second, to *reduce provocations,* intervention strategies should focus on *discouraging imitation* by other community members—either fishers or poachers. This can be achieved by posting different signs and signatures[14] around the estuaries, water channels, and lagoons where these activities take place. Moreover, these awareness-raising efforts, if done in collaboration with local authorities, will also, in essence, have a diffusion of benefits effect on those authorities who are more likely to accept eels as bribes.

Also, considering there are distinct temporal concentrations of these activities, to *increase the risk* by making the crime commission process more difficult, engaging in focused patrol efforts and inspections as a way of *strengthening formal surveillance* during these distinct times will yield more effective prevention outcomes. This recommendation aligns with those made by Petrossian [36], who argued that strengthening formal surveillance would be one of the most effective ways of tackling IUU fishing in the exclusive economic zones of coastal countries.

Lastly, glass eels are captured using distinct tools, gear, and materials, such as fishing traps (*bussó*). This process also requires special clothing to safeguard the fisher from winds, water, and cold temperatures. To *increase the effort* of engaging in IUU eel fishing, *controlling tools* can be done by monitoring the places where these tools are obtained. It is unlikely that the fishers and poachers will travel far from their communities to obtain these tools,[15] therefore, working with local shops to post signs about the penalties for illegal eel harvesting and under-reporting may prove useful. Thus, concentrating enforcement efforts at places, routes, key fishing sites, and most likely fishing hours and days will likely lead to more effective and efficient removal of illegally harvested glass eel contributing to the decimation of the species population in the wild.

5.1.2. Activity and post-activity stages

As discussed above, some of the poached and under-reported glass eels are destined for local consumption. Bearing this in mind, working with the demand side at the local level is key. Steps can be taken to place more efforts in educating consumers about the critical state of the European eel. Local authorities can also *set rules* and *assist compliance* by working together with restaurants to inform them about the conservation implications of having glass eels on their menus. Additionally, *removing excuses* by *alerting the conscience* of the general public about the illegality of eel fishing and the impacts it may have on the species populations, as well as *extending guardianship* of the species by engaging community members in the prevention efforts, can be of significant help to the law enforcement.

5.2. Interventions addressed to disrupt under-reporting

5.2.1. Preparation and pre-activity stages

At the preparation and pre-activity stages, to *reduce provocations,* intervention strategies should focus on *discouraging imitation*. Along with what was discussed above addressed to both fishers *and* poachers, awareness-raising campaigns in fishers' guilds should be addressed to those potentially engaging in under-reporting. For example, during the months before the start of the fishing season and sometime during the fishing season, fisher guilds could organise talks for their members to discuss the critical state of the species and the consequences of over-exploiting them. They can engage researchers in these discussions where they will also have the opportunity to learn about the current state of knowledge about the harms caused by the under-reported harvesting of the species. This could increase awareness and *alert conscience* among eel fishers and potentially prevent them from engaging in these activities.

One other vital 'tool' that a fisher must obtain is the license that can only be provided by a fishers' guild, or *cofradia*, in Spain. Therefore, to *reduce the rewards*, the government can partner with the fishers' guild to *deny benefits* to licensed fishers known to have under-reported their catches by not allowing them to participate in the auction of fishing license distribution. This will send a clear message about the consequences of such activities that are harmful not only to the community, but also to the fisher and his family.

5.2.2. Activity and post-activity

Licensed fishers fish during the night and complete the activity between the morning hours of 5 a.m. and 6 a.m. This allows them to reach the markets and sell the proportion of the eels caught legally that night before going to their (day) jobs—if they have one—and hide the under-reported eels at home. The illegal component of their activity at this stage involves either manipulating the weight of the eels (under-reporting the catches) or not selling the eels through the legal channel (the fish market or *lonja*). Considering much of the exchange of the eels at the fish markets happens during the early morning hours, formal surveillance efforts can be increased along the routes leading to these markets. These efforts should also extend to near these markets where fishers can be asked to show their logs, fishing gear and tools, and weights of the eels caught, and to the locations where their cars can be examined to see if there are concealed eels. This *increased formal surveillance* along such important routes and engagement points will *increase the risk* of getting caught exchanging/selling under-reported glass eels and/or engaging in fraudulent representation of their weight. Law enforcement and fisheries management authorities can also work closely with the owners and operators of these core markets to *reduce the rewards* of engaging in under-reporting. They can *disrupt these markets*, *remove targets*, and *deny the benefits* of selling under-reported eels.

Another way of *reducing the rewards* by *denying the benefits* at the post-activity phase is by fisheries management authorities to work with fishers' guilds and fish markets to introduce a catch certification system. For example, this can be done by introducing a fishing quota monitored through a 'swipe card' system similar to the one implemented by Maine's Department of Marine Resources in the United States. This system allows for electronic monitoring of eel catches, which would be accomplished by linking the swipe card that is encoded with personal and licensing data to the fisher, thus effectively removing the

[13] Italics are added to highlight the actual technique within the 25 techniques of situational crime prevention, or the broader SCP heading. For example, "remove the excuses" is a heading, while "alert conscience" is one of the 25 techniques that falls under this heading.

[14] This approach aligns with the arguments made by Thompson and Magrath [56] who studied the utility of signatures used to prevent illegal logging.

[15] This assumption is derived from the extensive 'journey to crime' criminological literature. See, for example, Brantingham et al. [6].

opportunity to sell underreported fish. Should the fisher exceed the catch quota, the Department could immediately shut down their license, preventing the fisher from being able to catch and sell eels illegally [60]. To prevent both illegal and under-reported eel harvesting, the Japan Fisheries Agency is introducing a glass eel certification system that will go into effect in December 2025 [26]. This measure aims to increase transparency and traceability of the source from which the glass eels originate, which is a means to *control tools* that are used to catch the species. Therefore, a similar measure can be adopted in Spain.

5.3. Interventions addressed to disrupt poaching

To disrupt illegal harvesting, *extending guardianship* to *increase the risk* of being caught poaching can be achieved by working closely with legal fishers. This will entail encouraging them to serve as informal guardians of the locations where illegal harvesting of glass eels is rampant. Legal fishers' depth of knowledge, familiarity with the territory, and their experience, can be gauged to help law enforcement in capturing individuals who unfairly compete for the same resources [9, 35]. For these fishers to help law enforcement in capturing poachers, it would also prove beneficial to create an anonymized report form that can be used to give tips to pertinent authorities about illegal fishers in the area. A unique nuance that should be considered is that legal fishers might become discouraged from reporting someone's illegal activity due to the fear of their identity being revealed. Ultimately, if they are all members of the same community, this concern can deter them from reporting altogether. Therefore, any intervention incorporating this approach should be sensitive to these nuances.

6. Conclusion

In the past, a significant number of studies that used crime script analysis to understand illegal wildlife crimes relied heavily on secondary data, literature reviews, reports, and policy papers to describe and analyse a given wildlife crime problem. This research, in turn, is one of the few that heavily relied on fieldwork notes, semi-structured interviews, and observations to understand the stages involved in the illegal harvesting of European glass eels. It is also one of the fewest empirical studies on this topic, thus making an important and significant contribution to our understanding of the problem, especially within the context of Spain. Lastly, it is the first study to apply crime script analysis to understand the processes involved in both illegal and unreported glass eel harvesting.

Engaging with the stakeholders who have the most in-depth knowledge about the intricacies of glass eel harvesting in Spain, we were able to uncover the activities involved in the illegal aspect of these activities. Such knowledge allowed us to recommend evidence-based interventions that flow from these findings and derive from the 25 techniques of situational crime prevention. Illegal fishers are persistent, driven, and resilient, and through their harmful activities, they are capable of imposing irreversible damage to the ecosystem and the species within. It is most urgent that evidence base continues to be generated through empirical research, such as the one attempted in this study, so that persistent, effective, and resilient crime prevention strategies can be designed and implemented to reverse this tide.

In sum, our research is distinctive in its application of crime script analysis to environmental crime, offering a structured approach to dissecting the intricate stages of this illicit activity—from preparation to post-activity. This methodological innovation not only enhances our theoretical grasp of wildlife crime, but it also provides practical insights for conservation and policy interventions. By delineating the specific skills, tools, and stages involved in IUU fishing, our findings contribute substantively to conservation efforts, highlighting the urgent need for targeted strategies addressed to fishers, poachers and consumers to protect the endangered European eel.

CRediT authorship contribution statement

Gohar A. Petrossian: Writing – review & editing, Writing – original draft, Supervision, Conceptualization. **Monica Pons-Hernandez:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization.

Declarations of interest

None.

Data availability

The data that has been used is confidential.

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Monica Pons-Hernandez, Member of the Universitat Rovira i Virgili Tarragona Center for Environmental Law Studies (CEDAT), the University Research Institute in Sustainability, Climate Change and Energy Transition (IU-RESCAT), and the research group of the Universitat Rovira i Virgili Territory, Citizenship and Sustainability, recognized as a consolidated research group and supported by the Department of Research and Universities of the Generalitat of Catalonia (2021 SGR 00162).