TROPHÉES, FÉCONDITÉ ET LA THÉORIE DU CAPITAL: UNE HISTOIRE ÉCONOMIQUE DE L'EXTINCTION DE *Pristis* spp., ET DES SOLUTIONS POLITIQUES POUR LES POPULATIONS EXISTANTES

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RÉSUMÉ

La voie de l'extinction des animaux marins a posé d'importants problèmes de conservation au cours des 20 dernières années, il existe des preuves que le commerce augmente le risque d'extinction. Cette situation a fait émerger des programmes de protection internationaux, en particulier pour les requins et les raies, parrainés par la CITES, UICN et FAO. Le cas du poisson-scie (*Pristis* spp.), de l'ordre des pristiformes, est particulièrement inquiétant car il est considéré comme le groupe marin le plus menacé au monde. Son cycle de vie pose des problèmes en termes de rétablissement des stocks, la reprise de la population est susceptible de prendre plusieurs décennies, selon la manière dont les poissons-scies sont protégés. D'un point de vue économique, pour éviter le processus d'extinction et favoriser une diversité maximale, la société doit savoir quelles sont les espèces qui ont une haut probabilite d'extinction et investir pour régler ce problème et sur le coût de réduction de la probabilité d'extinction. L'extinction est un problème fondamental de la théorie du capital et cela concernere des êtres vivants avec des taux de croissance inférieurs au coût d'opportunité du capital. En 2016 et 2017, une recherche a exploré le marchés des scies dans les maisons de ventes aux enchères sur internet et 115 scies ont été trouvées. À partir de ces données, une prédiction a été faite pour estimer une régression linéaire simple, et une analyse économique du PIB basée sur les déflecteurs a été réalisée. Les résultats obtenus indiquent que, en plus de la taille des scies, le prix et donc la probabilité de garder l'animal capturé accidentellement augmentent. Un autre résultat surprenant est l'impact neutre du programme CITES. Quelques politiques traitant de ces réalités sont proposées dans le présent document.

Mots-clés: Poisson-scie, théorie du capital, CITES, IUCN, FAO, politiques.

ABSTRACT

The path of extinction of marine animals has posed significant conservation problems over the last 20 years, there is evidence that trade increases the risk of extinction. This has led to the emergence of international protection programs, particularly for sharks and rays, sponsored by CITES, IUCN and FAO. The case of sawfish (Pristis spp.), Of the order of the pristiformes, is particularly worrying as it is considered the most endangered marine group in the world. Its life cycle poses problems in terms of rebuilding stocks, the recovery of the population is likely to take several decades, depending on how sawfishes are protected. From an economic point of view, to avoid the extinction process and promote maximum diversity, society needs to know which species have a high probability of extinction and invest to address this problem and the cost of reducing the probability of extinction. Extinction is a fundamental problem of the theory of capital and it concerns living beings with growth rates lower than the opportunity cost of capital. In 2016 and 2017, a search explored the saw markets in internet auction houses and 115 saws were found. From these data, a prediction was made to estimate a simple linear regression, and an economic analysis of GDP based on the deflectors was performed. The results obtained indicate that, in addition to the size of the saws, the price and therefore the probability of keeping the animal caught accidentally increases. Another surprising result is the neutral impact of the CITES program. Some policies dealing with these realities are proposed in this document.

Key Words: Sawfish, capital theory, CITES, IUCN, FAO, policies.

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CITES	The Convention on International Trade in Endangered Species of Wild Fauna and Flora.
IUCN	International Union for Conservation of Nature.
FAO	Food and Agriculture Organization of the United Nations.
NMFS	National marine fisheries service.
NOAA	National Oceanic and Atmospheric Administration.
PAs	Protected areas.
PES	Payments for ecosystem services.
MPAs	Marine protected areas.
MSY	Maximum sustainable yield
SRY	Short-term yield.
GDP at PPP	GDP per capita at purchasing power parity.
CoPs	Parties to the Convention.
ERM	Environmental resources management.
MoEF	Union ministry of environment and forests
ICTs	Information and communications technology
MVP	Minimum viable population
SRY	Short-run yield

INTRODUCTION GÉNERALE

EXTINCTION ET COMMERCE DES ESPÈCES MARINES

Le processus d'extinction des espèces marines est une préoccupation écologique très importante de nos jours. Ce processus peut se produire pour n'importe quelle ressource naturelle renouvelable, et souvent le problème est que ces types de ressources sont des biens communs non rivaux normalement associées à un « accès ouvert » ou à une « exploitation commune » car personne ne possède ou n'exerce de contrôle sur le ressource (Tietenberg et Lewis, 2010). Les ressources en accès ouvert sont assez rares, mais la gestion est loin d'être durable et efficace La pêche n'est pas une exception; nous voyons que, historiquement, plusieurs pêcheries ont été exploitée à un rythme tel que la rente de rareté se dissipe complètement et que, finalement, les coûts totaux égalent les revenus totaux (Gordon, 1954; Schaefer, 1957; Bjorndal et Conrad, 1987). La dissipation de la rente est due au fait qu'aucun pêcheur n'est prêt à investir dans l'entretien des stocks parce que les avantages attendus vont prendre d'autres formes. Deux inconvénients différents dans les ressources en « libre accès » ont été bien documentés : d'abord lorsque le stock de poisson est gravement appauvri, il en résulte une extinction (Bulte *et al.,* 1995). Par exemple, Spence (1973) a constaté que le stock de rorquals bleus atteignait des niveaux indésirables en raison du caractère ouvert de sa pêche. McKelvey (1983) et Lipton et Strand (1989) ont démontré que la perte de profits et la disparition éventuelle des stocks en «libre accès» entraînent généralement une structure inefficace pour l'industrie de la pêche.

Le processus d'extinction peut être causé par l'augmentation des effets anthropiques, ce qui entraîne une réduction de la biodiversité qui s'accélère en raison de la destruction et la consommation des ressources naturelles (Ehrlich et Wilson, 1991). Les ressources biologiques communes posent un double problème. Premièrement, si la dynamique de la croissance d'une population montre des zones de croissance dépensatoires, en raison d'une croissance lente et d'une faible fécondité, des règles d'utilisation des ressources communes mal définies peuvent conduire à l'extinction, surtout lorsque la valeur de l'animal est élevée ou lorsque le coût d'opportunité du capital est élevé, ou si les coûts marginaux d'extraction sont très bas. Plusieurs pêcheries sont encore exploitées dans un situation en « accès ouvert » où les pêcheurs réagissent à une entrée et à une sortie rentables de la pêcherie, en raison d'une réponse à l'équilibre des revenus et des coûts, y compris les coûts d'opportunité engendrés par d'autres options (Wilen, 1976; Bjorndal et Conrad, 1987; Wilen, 2004). Cela signifie que l'effort de pêche est compris en termes d'équilibre économique, et que, si les pêcheurs abandonnent une pêcherie, c'est parce que les rendements tombent en dessous du seuil de rentabilité (Allison et Ellis, 2001). Un problème important tient au fait que le faible coût d'opportunité des pêcheurs pauvres exprimé par une augmentation de l'effort de pêche et les coûts limités d'entrée dans la pêcherie conduisent à un déséquilibre bioéconomique dans lequel la pêcherie est fortement surexploitée (McManus, 1997). La surpêche peut mène à l'extinction, sous quelques conditions réalistes (Clark, 1973a).

Un monde de commerce libéralisé, que les économistes ont longtemps globalement considéré comme une bonne chose, peut devenir mauvais lorsque le commerce tourne autour de ressources épuisables. Dans un sens, la libéralisation des échanges peut exacerber le problème de la surexploitation des biens communs en élargissant l'éventail des utilisateurs directs et indirects. La diversité des espèces et les stocks d'espèces vivantes sont des exemples classiques de biens communs, don't les problèmes spécifiques sont liés au commerce international. Le commerce international de spécimens d'espèces de faune et de flore sauvages, dont les produits franchissent les frontières, complique les efforts de contrôle de l'utilisation des ressources communes. Les efforts pour réglementer le commerce exigent une coopération internationale pour protéger certaines espèces de la surexploitation. Deux organisations traitent le problème de l'extinction selon différents points de vue. La CITES vise à garantir que le commerce international de spécimens d'animaux et de plantes sauvages ne menace pas leur survie. Les annexes I, II et III de la CITES privilégient une approche commerciale et économique (CITES, 2017) et l'UICN, dont la « Liste Rouge des Espèces Menacées », privilégie une approche écologique (UICN, 2017).

Le marché international de luxe pour les parties de requins et de raies possède deux caractéristiques qui conduisent à un risque extrême d'extinction : la sensibilité intrinsèque des espèces (représentées par la taille) et l'exposition au commerce international (Turner *et al.,* 2003). Plus l'espèce est de grande taille, plus elle a tendance à avoir des taux de croissance démographique trés bas, elle est ainsi moins capable de remplacer les individus tués par la chasse (Reynolds, 2003); et les produits commercialisés non périssables tels que les défenses, les ailerons séchés et les plaques branchiales séchées peuvent être rassemblés et stockés par des réseaux d'acheteurs répartis dans le monde entier (Eriksson et Clarke, 2015). Pour cette raison, il est impossible de connaître l'origine de la pièce et donc de développer une gestion locale efficace (Wasser *et al*., 2004). Il est prévu que si le coût d'exploitation dépasse la valeur du produit, une exploitation réduite permet le rétablissement de la cible de l'espèce (Clark, 1973b). Cependant, en raison de la mondialisation du marché des pièces animales qui peuvent être stockées dans plusieurs populations sources, les informations qui devraient circuler entre les consommateurs-opérateurs sont dissociées, générant une augmentation des prix qui entraîne un épuisement en série à travers un marché diffus des commerçants (Anderson *et al.,* 2011). Des politiques ont été proposées pour protéger et changer le comportement des pêcheurs : (1) contrôle du commerce international, (2) protection nationale et régionale, et (3) réduction de la demande (McClenachan *et al*., 2016). Mais, comme nous le verrons, ces politiques n'ont pas été très efficaces.

LA PÊCHE DES CHONDRICHTHYENS

Les Chondrichtyens (requins, raies et chimères) jouent un rôle important dans la structure des communautés biologiques et jouent un rôle dans la stabilisation des écosystèmes en raison de leur rôle de prédateurs majeurs (Stevens *et al*., 2000; Heithaus *et al*., 2008). Un processus de déclin des populations de chondrichtyens a été signalé à l'échelle mondiale après 1990 (Compagno et Cook, 1995; Zorzi, 1995; Adams et Wilson, 1995; Adams et al., 2006) dans les débarquements des pêcheries d'élasmobranches, ce qui en fait un enjeu central dans les propositions de gestion et de conservation de la pêche dans le monde (Musik *et al*., 2000; Baum *et al*., 2003; Sheperd et Myers, 2005).

Les élasmobranches sont considérés par la communauté scientifique comme des animaux très faciles à capturer et comme une ressource marine importante dans le monde.

L'activité de pêche a amené certaines populations à la limite de l'extinction en raison de la surexploitation de certaines espèces, de leur lente croissance, de leur faible fertilité, et de leur maturité sexuelle tardive. La surexploitation des ressources marines peut également entraîner des déclins écologiques, économiques et sociaux chez les populations humaines qui vivent de cette ressource (Bonfil, 1994; Bonfil, 1997; Baum *et al*., 2003).

Pour ces raisons, il est important de comprendre l'état de la chaîne de production est important pour déterminer la perte environnementale et économique liée à certains membres de Chondrichthyens, comme les poissons-scies, faisant partie des différentes listes d'animaux vulnérables (UICN) et interdits au commerce mondial (CITES). À la fois à la CITES et à l'UICN, les poissons-scies, et certains requins inscrits à l'Annexe I, « comprennent les espèces menacées d'extinction ». « Le commerce de spécimens de ces espèces n'est autorisé que dans des circonstances exceptionnelles » (CITES, 2017); et cela dépend des espèces classées « en voie de disparition, en danger critique d'extinction, vulnérables et déficientes en données » (UICN, 2017).

LE PROBLÈME DU POISSON-SCIE

Le cas des poissons-scies (famille: Pristidae) est inquiétant, car leur cycle de vie est très lent, ils ont une une croissance lente, une maturation sexuelle tardive et une faible fécondité (Simpfendorfer, 2000). En effet, comme de nombreux requins et raies, le poisson-scie est une espèce vivipare, ce qui pose de nombreux problèmes, car ce mode de reproduction implique de nombreux coûts tant énergétiques que comportementaux (Boehlert *et al.,* 1991; Qualls et Shine, 1998). Il a été prouvé que la période de gestation peut réduire la mobilité de la femelle en l'exposant à la prédation et qu'elle peut être capturée par des filets (Fitch, 1970; Thibault et Schultz, 1978; Goodwin *et al*., 2002). La croissance et l'effort reproducteur chez les poissons sont étroitement corrélés. Par conséquent, on a prédit que les vivipares auraient développé l'un ou les deux éléments suivants : (i) augmentation de la taille corporelle des parents et (ii) réduction de la fécondité (Wursms et Lombardi, 1992; Qualls et Shine, 1995).

Ces raies sont considérées comme le groupe marin le plus menacé au monde (UICN, 2013), les principales causes sont le déclin des populations et les pêcheries accidentelles, la destruction ou la modification des habitats et la pollution, la vente de scies et d'ailerons, des blessures causées par les hélices, principalement en raison de taille des poissons (Seitz et Poulakis, 2006). Le rétablissement de la population prendra probablement des décennies ou plus, selon l'efficacité de la protection du poisson-scie (Simpfendorfer, 2000). En fait, les populations du poissons – scie du monde entier sont en danger. Dans de nombreuses régions, le déclin démographique est supérieur à 90 % (UICN, 2017) et l'espèce a été déclarée localement disparue dans la mer des Caraïbes de Colombie (Gómez-Rodríguez *et al*., 2014) eu en risque d'extinction en Amérique du Nord (Dulvy *et al*., 2014).

Les grands animaux tels que les éléphants et les rhinocéros ont occupé une grande partie des projets de conservation au cours des 50 dernières années (Milner-Gulland et Beddington, 1993), dont une grande partie visait à prévenir l'extinction. Au cours des vingt dernières années, la conservation et la gestion des requins ont fait l'objet de beaucoup d'attention et de discussions au sein de la CITES. Au cours de cette période, des recherches et des informations supplémentaires ont été produites sur cette question, les Parties ayant également adopté un certain nombre de recommandations d'action sous la forme de résolutions et de décisions. CITES a fait des propositions d'inscription de diverses espèces de requins (le pèlerin « *Cetorhinus maximus* », le requin-baleine « *Rhincodon typus* », le grand requin blanc « *Carcharodon carcharias* » et les poissons-scies « famille Pristidae » aux annexes de la CITES. Un résumé des processus de la CITES relatifs à la conservation et à la gestion des requins, de 1994 à aujourd'hui, figure aux annexes I et II (Taylor et Crook, 2013). Avec l'augmentation de la recherche et de l'information sur l'environnement marin, nous sommes maintenant en mesure d'identifier l'effet de l'augmentation du commerce sur différentes parties du poisson marin, ce qui exacerbe le processus d'extinction des espèces commercialisées. Par conséquent, de nombreux programmes de conservation ont été créés, en particulier pour les requins et les raies, espèces qui suscitent un commerce important d'ailerons et de branchies (Taylor et Crook, 2013; CITES, 2016).

Objectifs du projet de maitrise

L'objectif général de cette étude est de déterminer si les politiques sur le marché de *Pristis* spp. que ont été prises pour la protection et sur la conservation ont été efficaces.

Objectif i. Analyser les prix historiques des scies, vendues comme trophées et ornements dans les maisons de ventes aux enchères et les pages Web.

Objectif ii. Proposer de meilleures réponses politiques qui ralentiront ou stopperont l'extinction de ces espèces

CHAPITRE 1

TROPHÉES, FÉCONDITÉ ET LA THÉORIE DU CAPITAL: UNE HISTOIRE ÉCONOMIQUE DE L'EXTINCTION DE *Pristis* spp, ET DES SOLUTIONS POLITIQUES POUR LES POPULATIONS EXISTANTES

1.1 RÉSUMÉ EN FRANÇAIS

La voie de l'extinction des animaux marins a posé d'importants problèmes de conservation au cours des 20 dernières années, il existe des preuves que le commerce augmente le risque d'extinction. Cette situation a fait émerger des programmes de protection internationaux, en particulier pour les requins et les raies, parrainés par la CITES, UICN et FAO. Le cas du poisson-scie (*Pristis* spp.), de l'ordre des pristiformes, est particulièrement inquiétant car il est considéré comme le groupe marin le plus menacé au monde. Son cycle de vie pose des problèmes en termes de rétablissement des stocks, la reprise de la population est susceptible de prendre plusieurs décennies, selon la manière dont les poissons-scies sont protégés. D'un point de vue économique, pour éviter le processus d'extinction et favoriser une diversité maximale, la société doit savoir quelles sont les espèces qui ont une haut probabilite d'extinction et investir pour régler ce problème et sur le coût de réduction de la probabilité d'extinction. L'extinction est un problème fondamental de la théorie du capital et cela concernere des êtres vivants avec des taux de croissance inférieurs au coût d'opportunité du capital. En 2016 et 2017, une recherche a exploré le marchés des scies dans les maisons de ventes aux enchères sur internet et 115 scies ont été trouvées. À partir de ces données, une prédiction a été faite pour estimer une régression linéaire simple, et une analyse économique du PIB basée sur les déflecteurs a été réalisée. Les résultats obtenus indiquent que, en plus de la taille des scies, le prix et donc la probabilité de garder l'animal capturé accidentellement augmentent. Un autre résultat surprenant est l'impact neutre du programme CITES. Quelques politiques traitant de ces réalités sont proposées dans le présent document.

Mots-clés: Poisson-scie, théorie du capital, CITES, IUCN, FAO, politiques.

1.2 TROPHIES, FECUNDITY AND CAPITAL THEORY: AN ECONOMIC HISTORY OF *PRISTIS* SPP. EXTINCTION AND SOME POLICY SOLUTIONS FOR EXTANT POPULATIONS

1.2.1 Abstract

The path of extinction of marine animals has posed significant conservation problems over the last 20 years, there is evidence that trade increases the risk of extinction. This has led to the emergence of international protection programs, particularly for sharks and rays, sponsored by CITES, IUCN and FAO. The case of sawfish (Pristis spp.), Of the order of the pristiformes, is particularly worrying as it is considered the most endangered marine group in the world. Its life cycle poses problems in terms of rebuilding stocks, the recovery of the population is likely to take several decades, depending on how sawfishes are protected. From an economic point of view, to avoid the extinction process and promote maximum diversity, society needs to know which species have a high probability of extinction and invest to address this problem and the cost of reducing the probability of extinction. Extinction is a fundamental problem of the theory of capital and it concerns living beings with growth rates lower than the opportunity cost of capital. In 2016 and 2017, a search explored the saw markets in internet auction houses and 115 saws were found. From these data, a prediction was made to estimate a simple linear regression, and an economic analysis of GDP based on the deflectors was performed. The results obtained indicate that, in addition to the size of the saws, the price and therefore the probability of keeping the animal caught accidentally increases. Another surprising result is the neutral impact of the CITES program. Some policies dealing with these realities are proposed in this document.

Key Words: Sawfish, capital theory, CITES, IUCN, FAO, policies.

1.2.2 Introduction

Extinction and trade of marine species

For marine species, a very important ecological concern is the extinction process. This process can occur in any renewable natural resource, but often the problem is that these types of resources are associated with ‘‘open access’’ (no one owns the resource), or “common pool” exploitation (the community, often through governments, exercises control over the resource) (Tietenberg and Lewis, 2010). “Open access’’ resource use is relatively rare. However, many management measures are often still far from sustainable and efficient. As a result, fisheries are often overexploited. However, common pool resource use, where some rules of use exist which are at times sustainable and at other times are not, is quite common. Throughout history, human have exploited fisheries at such a pace that the scarcity rent dissipates completely and that, eventually, total costs equal total revenues (Gordon, 1954; Schaefer, 1957; Bjorndal and Conrad, 1987).

Capital theory deals with durable goods that produce a sustainable flow of services and rent over time. A good example can be a stock of fishes. They provide a flow or annual yield of new fishes that can be sustained year after year. Fisheries management today can have an impact upon the stock abundance in the future. This will have implications for future consumption options. (Clark and Munro, 1975; Constanza and Daly, 1992).

Fisheries are often assumed to be an ‘’open access’’ system where fishers respond to profit signals by entering and exiting the fishery. This is a response to the balance of revenue and costs, including the opportunity costs created by other options (Wilen, 1976; Bjorndal and Conrad, 1987; Wilen, 2004). This means that fishing effort can be understood in terms of economic equilibrium, that implies if fishermen leave a fishery, it is because yields have fallen below the profitable threshold (Clark, 1985; Allison and Ellis, 2001; Beddington *et al*., 2007). The big problem occurs when the low opportunity cost experienced by poor fisherman is expressed as an increase in fishing effort and costs of entering the fishery are low, leading to an equilibrium in which the fishery is heavily overexploited (McManus, 1997). When this occurs, exploitation sometimes leads to extinction (Clark, 1973a).

The opportunity cost in the exploitation of natural resources can vary when there an increase in resource prices, which will impact the reserves in two ways: 1.) there would be an increase in the pressure on resource stocks, causing resource stocks to diminish and 2.) stocks that were not previously exploited may become economically profitable. This is an extention of Hotelling's rule for a mine of known reserve size owned by one person. Thus Hotelling's rule explains how it is possible that there is income in production during all periods of time by considering the market price; the rate of extraction is determined by the opportunity cost of capital, such that all discounted future marginal values of extraction are equal to the marginal value today. However, in the case of an open access resource like fisheries, fishermen prefer extracting an additional unit now rather than leaving it untapped. Indeed, if scarcity income grew at a lower rate than the interest rate, nobody would want to keep an asset that can generate higher returns invested elsewhere, and the natural resource stock would run out quickly. If, on the other hand, such income grew at a faster rate than the interest rate and accrued to one firm (or a small group of firms), then holding stocks of fish would be an ideal way to accumulate wealth, so that fisherman would keep wild stocks sustained and intact. Common pool stocks leads fishermen to exploit those stocks to the limit, since they can not do anything other than fish to maintain a livelihood (Hartwick and Olewiler, 1998). In some countries such as Canada, fisherman are often incentivised *not* to work in the closed seasons (Léonard, 2014), thus decreasing the opportunity cost of labor. In the case of sawfish, the rostrum is the part that has more economic value for artisanal fishermen. These fishermen have been exploiting sawfish as a resource in an accidental way, thus generating a market for animal ornaments or trophys, This is a well-developed market where the buyer of the trophy has many options for acquisition. After a few years he may sell it as an antique and/or animal trophy (McClenachan *et al*., 2016).

Extinction can be accelerated by the addition of anthropogenic effects, which result in a decrease of biodiversity due to destruction and consumption of natural resources by humans (Ehrlich and Wilson, 1991). Anthropogenic influences create a two-fold problem with the common pool living resources.

The first problem occurs when the rules of common use are weakly defined and managed for fish species characterized by slow growth and low fertility, resulting in a depensatory growth of the stock.

The second problem is that it is usually the endangered species that are protected from the exploitation industry, a random change in the resource (caused for example by the El Niño warm winds in the Peruvian anchoveta) disrupts the natural production system. Further, if human and physical capital are fixed, capital in the industry will be used on the fish stock until the total costs of exploitation are equal to the total revenues. For anchovetta, it is unlikely that every last fish will be caught. However, the same cannot be said of *Pristis*. In other words, if the value of an animal is unusually high and / or the opportunity cost of capital (or the interest rate) is high, or if the marginal costs of extraction are very low, there is a higher probability of extinction for the species (Berck, 1979).

Extinction of species and extinction processes may be intertemporally efficient using Hotelling's reasoning, but may not be when taking inter-generational considerations into account. Some economists have suggested "rules" related to conversion to different forms of capital (man-made and natural) that would be made availabe to future generations. Hartwick's rule satisfies the "weak" sustainability criteria that would maintain the total capital stock and keep consumption constant over time (Hartwick, 1977). In other words, when substitution among the different forms of capital is possible both ways (natural to man-made; man-made to natural), investing returns from resource depletion into reproducible capital can lead to constant consumption (Martinet, 2005). However, as discussed in Krutilla (1967), substitutability assumptions are often not valid for many forms of natural capital as it often costs too much to re-convert man-made capital back to natural capital. If natural capital is non-substitutable, then over-exploitations of species and their extinctions are not sustainable. If humankind continues to deplete natural resources at the current rate, future generations will not be able to use and enjoy those resources (Tietenberg and Lewis, 2010).

This will lead to intergenerational inefficiencies, if the preferences of future generations are similar to our own.

The force that drives much of international trade is the notion of comparative advantage. This occurs when a country possesses the ability to produce and sell a good at a lower opportunity cost, allowing the country to sell this good to other countries where the opportunity costs of production are greater (Parkin *et al*., 2011). According to Mehlum and Torvik (2006), natural resources can contribute to growth of countries with good protection of property rights, good environmental policies and little corruption. More natural resources provide private agents with productive investment opportunities, creating positive externalities for other agents. On the other hand, poor protection of property rights and corruption can hinder growth of resources. In these countries, an abundance of natural resources can be considered as *common property*, thus stimulating predation and/or overexploitation. Eventually leading to comparative advantages, while the search for rents and other destructive and/or non-productive activities create negative externalities for the rest of the economy. Considering the above scenarios, it is possible that many countries that export natural resources intensively have weak protection of property rights, corruption, and a lower quality public bureaucracy. Therefore, while slow growth of resources might be blamed on the resources themselves, the real problem may well be the quality of the institutions (Torvik, 2009).

The case of the international market for shark and ray parts possess two features that drive extreme extinction risk: the intrinsic sensitivity of species (represented by body size), and the exposure to international trade (Turner *et al*., 2003). Larger species tend to have low population growth rates and are therefore less able to replace individuals killed by hunting (Reynolds, 2003). Second, international trade of non-perishable traded products such as tusks, dried fins, and dried gill plates can be gathered and stockpiled by globally distributed networks of buyers (Eriksson and Clarke, 2015). With this, it is impossible to know the origin of the part, and thus develop an effective local management strategy (Wasser *et al*., 2004). It is predicted that if the cost of exploitation exceeds the value of the product, reduced exploitation allows the recovery of the target species (Clark, 1973b). McClenachan *et al*.,

(2016) suggested policies for protection of the species that involve changing the behavior of fishers, such as: (1) international trade control, (2) national and regional protection, and (3) demand reduction. Efforts to regulate trade require international cooperation to protect certain species from over-exploitation. There are two different organizations that deal with the problem of extinction from different points of view. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) treaty, aims to ensure that international trade of specimens of wild animals and plants does not threaten their survival. This treaty favors a commercial and economic approach (CITES, 2017), whereas the International Union for Conservation of Nature and Natural Resources (IUCN), with its ‘‘red list of endangered species”, favors an ecological approach (IUCN, 2017).

In the case of artisanal fisheries, demand is an important vaiable, because it plays a significant role in human and socio-economic development. Fisheries are seen as an entry point for poverty reduction through their role in generating revenues, creating employment, and contributing to food security (Heck *et al*., 2007; Béné *et al*., 2007).

According to FAO (2016), fish and fisheries products represent one of the most traded segments of the world food sector. With about 78 percent of seafood products estimated to be exposed to international trade, competition is both significant and an important source of hard-currency earnings and employment. Actual geopolitics have pushed to encourage free trade since World War II, often to help developing countries. This has made it easier to engage in trade that could be harmful to certain species. The situation now is, just as with cars, televisions, and clothes, fish can be produced in one country, processed in a second, and consumed in a third. To put this into context, the world trade in fish and fishery products has grown significantly in value terms, with exports rising from $8 billion USD in 1976 to $148 billion USD in 2014.

The sawfish problem

The case of sawfishes (family: *Pristidae*) is worrisome because their life history makes them easy targets for over-exploitation. Sawfishes typically have a low fecundity, slow growth and late sexual maturation (Simpfendorfer, 2000). As with many sharks and rays, sawfish are a live bearing species. This causes many problems because this reproductive mode implies many costs to the animal both in terms of energetics and behavior (Boehlert *et al*., 1991; Qualls and Shine, 1998). Live bearing may reduce a female's mobility exposing her to predation and capture by fishnets (Fitch, 1970; Thibault and Schultz, 1978; Goodwin *et al.,* 2002). Growth and reproductive effort in fishes are closely correlated with body size; therefore, it is believed that live bearing species have evolved one or both of the following: (i) increased parental body size, and (ii) reduced fecundity (Wourms and Lombardi, 1992; Qualls and Shine, 1995). Sawfishes are considered the most endangered marine group in the world (IUCN, 2013), due to mortality from incidental fisheries, habitat destruction or modification and pollution, bycatch, the sale of the saw and fins, collisions with boats, and wounds from propellers, caused mostly by their size (Seitz and Poulakis, 2006). Recovery of a population is likely to take decades or longer depending on how effectively sawfish can be protected (Simpfendorfer, 2000). Presently, populations around the world are in danger. In many regions, the population decline is greater than 90% (IUCN, 2017), and sawfishes have been declared extinct locally in the Caribbean sea of Colombia (Gómez-Rodríguez *et al.,* 2014) and at risk for extinction in North America (Dulvy *et al.,* 2014).

For these reasons, understanding the state of the production and marketing chain (of the parts) is important to determining the risks of environmental and economic loss of the species group. This is important because they are part of the various lists of animals at risk (IUCN) and world trade ban (CITES). According to both CITES and IUCN, sawfishes are listed in Appendix I, which ''*includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances*'', (CITES, 2017); and ''*endangered, critically endangered, vulnerable and data deficient*'' (IUCN, 2017).

1.2.3 Sawfish life history and distribution

Sawfish (*Pristis* spp.) belong to the group of elasmobranchs in the order Pristiformes, and the family Pristidae, that is composed of two genera and five species; *Pristis pristis*, *P. clavata*, *P. zijsron*, *P. pectinata*, *Anoxypristis cuspidata* (Faria *et al*., 2013). The *Pristis* genus is characterized by a depressed forward body, gill clefts on the ventral surface, an elongated rostrum with large teeth on each side (Figure 1), and two large dorsal fins separated from the posterior region of the trunk and head. The upper part of the body and the pectoral fins are elongated and fused to form a disc. The eyes and nostrils are on the dorsal aspect of the head. The gills and the mouth are ventral, without barbs or grooves, and with numerous teeth forming a band all along the jaw (Fischer *et al*., 1987; Cervigón and Alcalá, 1999) (Figure 2).

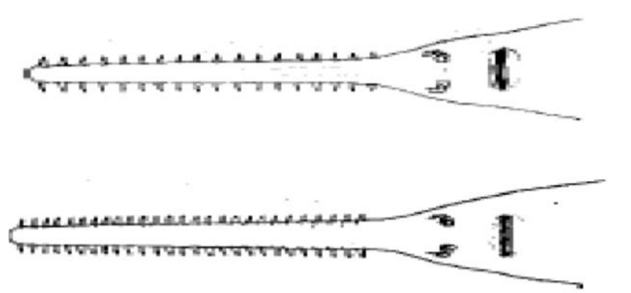

Figure 1. Detail of the saw (Modified from Fischer *et al*., 1987).

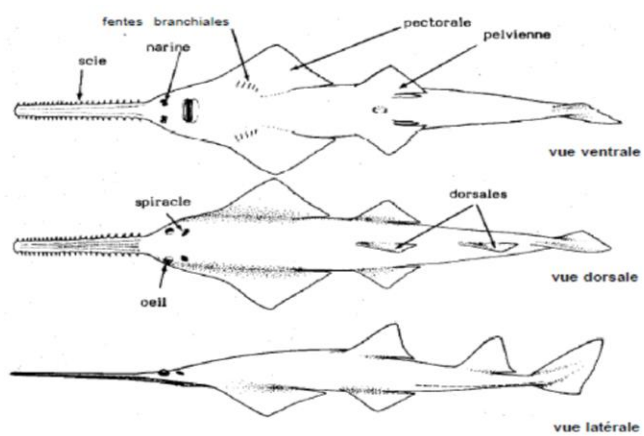

Figure 2.View of *Pristis* spp. (Modified from Fischer *et al*., 1987).

Habitat and world distribution

Members of this family inhabit coastal waters, including those of the great offshore islands, estuaries, mouths of rivers, and fresh waters of tropical and subtropical regions. We have also encountered them in the temperate waters of the Mediterranean basin (Figure 3). Individuals primarily inhabit areas with sandy and muddy bottoms in depths generally less than 10 meters. Sawfish can be found in areas with highly variable salinities. It has been reported that *P. pristis* has a greater physiological tolerance of fresh water than other members of the family (Bigelow and Schroeder, 1953; McEachran and Carvalho, 2002).

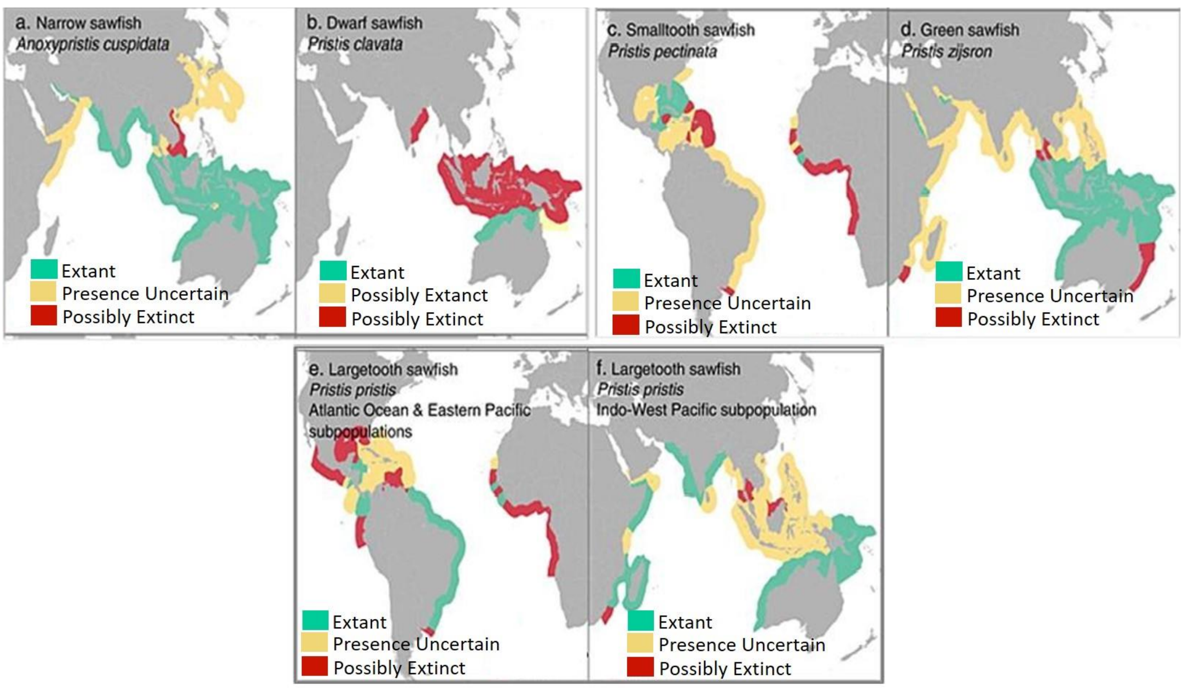

Figure 3. Global Distribution of Sawfish Species (a) *A. cuspidata* (b) *P. clavata* (c) *P. pectinata* (d) *P. zijsron* (e) subpopulations *P. pristis* of the Pacific, East of the subpopulation and sub-population (f) of the Indo-West Pacific of *P. Pristis* (Modified from Dulvy *et al*., 2014). All *Pristis* species on CITES appendix I and endangered in UICN.

Sawfishes live in waters with temperatures ranging from 16-18 ° C. Most catches are recorded in spring and summer, when waters reach ideal temperatures, which gives an index of representativeness of the size the population (Bigelow and Schroeder, 1953).

Pristis spp. evolved in various composite substrates, generally of: 61% clay; 11% sand; 10% pasture; 7% limestone; 4% rocks; 4% coral reef and 2% sponges (Poulakis and Seitz, 2004). Simpfendorfer and Wiley (2004) reported that juveniles prefer shallow water less than 10 m and the roots of mangroves in which the turbidity of the water protects them from potential predators. As for the adults, they can evolve in waters whose depth can reach 70 to 120 m. (Simpfendorfer, 2003).

Reproduction biology

Like most elasmobranchs, *Pristis* spp. utilize internal fertilization and are ovoviviparous. Females have a biennial breeding cycle and a gestation period of about five months. Thorson (1976) stated that a litter can be made up of 13 offspring that are nourished by yolk during development inside the female. At birth, individuals do not have a lower caudal lobe but resemble adults with respect to the position of their fins.

During embryonic development, the rostrum is soft and supple and rostral teeth are wrapped in a protective bag until birth to avoid injuring the females. The teeth of the rostrum are released after birth from their protective bag and begin to grow proportionally to the size of a "saw". Pristis spp. are expressed as low-productivity species due to their slow growth and late sexual maturity, resulting in a low rate of intrinsic population growth (Holden, 1974; Bonfil, 1994) (Table 1).

Age and growth

Individuals are born at a length of 80 cm (Simpfendorfer *et al*., 2008) and reach a size of 300 cm (Bigelow and Schroeder, 1953). Individuals kept in captivity in aquariums can live for more than 26 years (Vieira, *pers com*, 2012). There is no accurate data on the growth of a specimen of wild sawfish. However, estimates have been made using individuals in captivity: in Colombia, Bohorquez (2001) estimated an average growth rate of 19.6 cm per year; Clark *et al*., (2004) in the United States calculated a rate of 13.9 cm per year for individuals from 80 to 412 cm. Thorson (1982) estimated that the age and size at sexual maturity are 10 years and 300 cm, respectively. Preliminary analysis of spinal rings determined that the maximum lifespan is 51 years (Peverell, 2006) (Table 1).

Table 1. Life cycle parameters of sawfish compared to the re-evaluation of the species on the IUCN Red List of Threatened Species. (Modified from Dulvy *et al*., 2014).

Life history parameter	**narrow sawfish *Anoxypristis cuspidata***	**dwarf sawfish *Pristis clavata***	**smalltooth sawfish *Pristis pectinata***	**largetooth sawfish *Pristis pristis***	**green sawfish *Pristis zijsron***
Size at birth (cm TL)	70	60-81	80	72-90	76
Size at maturity (cm TL)	♀:225 ♂: 200	♂: 255-260	♂: 370	♂: 280-300	♂: ?
Maximun size (cm TL)	350	318	550[a]	656	700+
Age at maturity	♀: 3 ♂: 2	♀: ? ♂: 8	♀: 7-12 ♂: 7.5	8-10	♀: 9 ♂: ?
Longevity (years)	9	34	30?[b]	44	>50
Generation leght (years)	4.6	16.4	17	IWP: 14.6 WAT: 17.2	14.6
Three generation lenghts (years)	13.8	49.2	51	IWP: 43.8 WAT: 51.6	43.8
Reproductive periodicity	Presumed annual	?	Presumed biennial	IWP: annual WAT: biennial	?
Litter size (mean)	5-16 (12.4)	?	15-20	1-13 (7.3)	12?[c]
Intrinsic rate of population increase, r (yr^{-1})[d]	0.27	0.10	0.07-0.14	0.12	0.02-0.1

IWP, Indo-West Pacific; TL Total length; WAT, East Atlantic.
a A quantitative source for the largest reported size of 760 cm TL cannot be located.
b Extrapolated from a maximum measured age of 14 years for an individual that was 60% maximum length.
c The origins of this often reported litter size cannot be traced to an original quantitative source and has therefore not been confirmed.
d All estimates from Moreno Iturria (2012), with the largetooth sawfish estimate derived from the entry for *P. microdon*.

1.2.4 Capital theory and the economics of extinction

Capital and capital theory occupies a large part of the bioeconomic literature. As such, a brief discussion of what capital is and capitalist behavior in human beings is necessary. Capital is simply goods that are under a production process that takes time. For example, according to Becker (1994), a human being is a capital good. We accumulate value through education, and discharge or depreciate that value in the production of finished goods over time. A stock of fish is a form of natural capital with its own unique population dynamics. As with human beings, it can be depleted if the rate of transformation to finished goods exceeds the intrinsic rate of growth of the population.

All human beings also exhibit capitalist behavior to one degree or another. This is in part because we are mortal, and must accumulate savings at certain periods and consume in other periods. We also use capital goods to produce other goods, but at the same time the capital we use depreciates; we use that capital up, and must re-invest to cover that depreciation in order to assure sustainability. This raises the issue (to humans) of managing savings and consumption through time. Savings, like investments, are used to store wealth a human has, in exchange for a payment of interest made by other investors that are forming capital now. Most decisions about exploiting natural resources have elements of capital theory and portfolio management. If the *in situ* rates of return for a privately held stock of trees are high enough, the owner of the trees will decide to hold trees in his portfolio. When rates of return on investment of financial capital become higher than this *in situ* rate of return, the owner may be faced with some difficult choices, and if the rates of return rise in one portion of our portfolio, this may incite us to move holdings to the part of the portfolio that gives the highest returns. In the case of humans exploiting common pool goods, this tendancy is exacerbated and can have negative effects (Clark, 1973b). This analysis can be extended in other ways as well. One response by many fishermen would be to put money into a fishing vessel, in the hopes that increasing fishing power will counter-balance the depletion effects. However, and especially in common pool fisheries, the marginal efficiency of the capital investment in the fishery falls, and although this investment behavior will be dissuaded, the high opportunity cost of capital will incite an acceleration of fishing, (Clark, 1973a). This is exacerbated also by the fisher himself, which may have a very low opportunity cost of staying in the fishery.

To avoid extinction of other animals, humans must modify their capitalist behavior to be part of the solution, because we know that part of the problem of extinction is due to anthropogenic disturbances; our economic behavior. It is important to include economic behavior of humans in the calculus of endangered species protection, because not taking these things into account will lead us to an ineffective and in some instances to a counterproductive conservation policy (Shogren *et al*., 1999).

Economics is important because human behavior, and the economic patterns that this behavior sets up, help to determinate the degree of risk to a species, by a determination of the present size, trends and distributions of the populations that are established as an endangered or viable species (Gilpin and Soulé, 1986). But why is understanding economic behavior of humans important for the conservation of species? There are three important reasons: 1. Economic behavior in humans plays an important role in determining whether a species is endangered and whether it must be listed, because it is often human behavior that affects the odds of species survival; 2. In a world of scarce resources, the opportunity cost of species protection in terms of the reduced resources for other causes must be taken into account in decision making; 3. Economic incentives are critical to shaping human behavior and consequently to the recovery of species (Shogren *et al*., 1999).

According to Herfindahl and Kneese (1974), the definition of capital is ‘‘*anything which yields a flow of productive services over time and which is subject to control in production processes… This definition does not restrict capital to man-made durable instruments of production… Thus land is included, since it meets both of the definition's requirements… As the suggested definition of capital stands, labour is a capital good*”, and capital goods are all the things already-produced, durable goods or any non-financial asset that is used in production of goods or services (Varian, 2014). That means that all the renewable and non-renewable natural resources are capital goods as well. Though substitutes for some natural resources may be found through technology, most natural resources are non-substitutable. Natural resources are also called *natural capital* (Tietenberg and Lewis, 2010). Living off the capital rather than the income flowing from it is similar to the depletion of environmental resources in pursuit of economic growth (Pearce and Turner, 1990). An excellent example of this is the fisheries, where because of the common pool nature of the resource fishers deplete the natural capital (the fish stock) rather than managing the resource, meaning that there will not be the same stock of natural capital for the next generation (Tietenberg and Lewis, 2010).

Fish populations therefore can be treated as a capital stock, because as ‘‘conventional’’ capital, it can yield sustainable consumption flows through time. Likewise, for “conventional’’ capital, today’s consumption decision will have an impact on the stocks, which means that it will have implications to future consumption options. The resource management problem thus becomes one of selecting an optimal consumption flow through time, which in turn implies selecting an optimal stock level through time (Clark and Munroe, 1975).

Environmental policies as well as the status quo use of resources all involve costs and benefits. Many of these costs and benefits arise over time. For this reason, basic notions of capital theory and benefit cost analysis are used by analysts to better understand what should be done in the way of environmental protection, and what the net benefits are likely to be over time. Conservation is an investment decision. But we often want to know about the streams of benefits from this investment over time, as well as the costs of the investment, as well as the likely costs of not making sufficient investments in conservation.

A rational cost benefit framework must include wildlife and habitat among the benefits, discovering human use and non-use values, and using these values to protect the existence of those resources. The benefits accrue by the direct use of these natural resources (e.g. hunting, fishing, and nature appreciation like whale-watching) but also through the utility created by their existence, their potential for future use and as values to future generations. Natural resource values held by humans can be revealed or discovered by detecting how much is spent for their use (e.g. recreation expenses or user fees) or by nonmarket surveys designed to find how much consumers are willing to pay for protection against the loss those natural resources. Once wildlife and habitat has been valued one way could be identify ‘’essential fish habitat’’definied as: ‘’those waters and substrate necessary to fish for spawning, breeding, feeding and/or growth to maturity’’, once those areas are identify they are treated as an income flow and become amenable to standard cost benefit comparisons (Sustainable Fisheries Act, 1996; Erickson, 1999).

Cost-benefit approaches applied to exploited species extend to dynamic analyses and capital theory. One of the classical problems in dynamic economic analysis was explored first in the context of Blue Whales using at the time relatively new mathematical concepts called “control theory” (Spence, 1973), expanded upon later by Clark (1973b) and Clark and Munro (1975).

According to Clark (1973b), over-harvesting of certain species that have relatively low intrinsic rates of growth is caused first because of the price of the species, and also because of the high opportunity cost of capital, as well as the low marginal cost of exploitation. This all can lead to a situation where the species will be driven to an ‘‘optimal extinction’’. Clark essentially argued that in economic terms, applying the intertemporal efficiency criterion in capital theory to an exploitable population can result in a situation where the opportunity cost of preservation is too high compared to the opportunity cost of capital. The species in the original Clark example becomes extinct because interest rates of alternative investments are larger than the growth rate of the value of the stock *in situ.* This situation is especially true in situations where the fecundity is low, the growth rate of individuals in a stock is slow, and where the demand for products made from these species is high. The property rights institutions under which fishers exploit the populations also play a role. Clark and Munro (1975) show that the open access bioeconomic condition cited by Gordon (1954) is essentially the point where the opportunity cost of capital, or the discount rate, approaches infinity, whereas the sole owner solution assumes that the discount rate approaches zero.

It is important to understand how the interaction of the intertemporal preferences of society can affect biological growth of resources, to determine the possibility of extinction and conservation for a most favorable managed resource. Normally, economists have related overexploitation to market failures and ill-defined property rights. Nevertheless, those failures can be corrected, and society can ‘‘manage”, their resources better. Eventual extinction events can be slowed or stopped by policies that strike a better balance between current and future welfare that a society is willing to make. That is why it is important to relate the depletion of resources to economic incentives that affect harvesting (Mitra and Roy, 2006). Common property resources are the frequent focus of extinction models and policy in developing countries. The various economic models of extinction are used to identify the difficulties of predicting extinction, given the historical case of common property access (Farrow, 1995).

In fisheries, as with most extractive industries based upon renewable resources, the most commonly encountered proposal for managing a biological resource has historically been to maximize the sustained physical yield of the capital stock. However, certainly since the early 50’s, economists have generally suggested adopting the maximization of economic rent as a management policy. Economic rent refers to the regular income derived form a sustainable resource (Clark, 1973a). This assumes that the discount rate, or the opportunity cost of capital, could force a collective of rational producers to exploit the resource at somewhere below Maximum Sustainable Yield, yielding at the same time maximum economic rent.

According to Gordon (1954), ‘‘*in sea fisheries the natural resource is not private property; hence the rent it may yield is not capable of being appropriated by anyone. The individual fisherman is more or less free to fish wherever he pleases. The result is a pattern of competition among fishermen which culminates in the dissipation of the rent*”. To summarize the argument, the fishery may actually operate at near rent-maximizing levels. So, new fishermen will be attracted to the industry because the incumbents are making profit. But meanwhile, the fish population decreases as fishing intensity increases, as will the total rent. This process will continue, if any rents remain, and the fishery keeps expanding until the population reaches the level of zero economic rent (Clark, 1973a). This has been called the open access equilibrium (Figure 4), in this case the zero-rent population X_0 equals zero, and rent dissipation will lead to extinction.

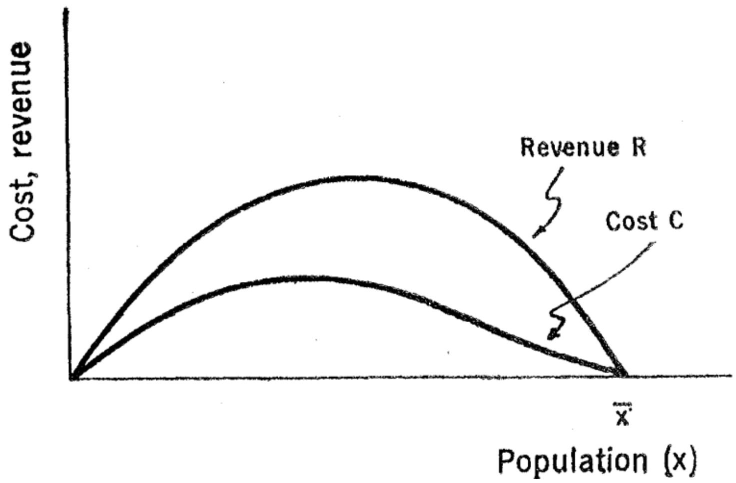

Figure 4. Cost-revenue curves (extinction feasible). (Modified from Clark, 1973a).

Fisheries based on a rent maximization concept, meansthe maximization have annual revenues (Scott, 1955). It has been noted that, if the harvesting costs rise with the decrease of the population levels, a rent maximization policy will automatically lead to biological conservation, with an equilibrium population in excess of the population corresponding to maximum sustained yield (Clark, 1973a).

In the context of intergenerational equity considerations, making decisions that are equitable involve thinking about what resources future generations would really want. Biodiversity is one of those environmental goods that we suspect that future generations would value (Erickson, 2000).

There are two social conditions that can reduce productivity for populations such as elasmobranches, which possess low reproductive capacities and slow growth: common-property and private-property maximization of profits. According to Clark (1973b), if the opportunity cost of capital is high enough, compared to the intrinsic rate of growth of a stock, even private property and profit maximization can lead to the extinction of a resource. Further, that extinction would satisfy the conditions of intertemporal efficiency; it would be "optimal" extinction. Both conditions will lead to the extirpation of some members of this group such as sawfishes, like it happened in Colombia and some areas of the United States (Gómez-Rodríguez *et al.,* 2014; Dulvy *et al.,* 2014).

More recent literature on bioeconomics has discussed the value of biodiversity. This is a difficult concept to measure and to understand how rational decisions could be made about how best to preserve it (Weitzman, 1993). Knowing that it is impossible to preserve everything, due to our limited resources, the preservation of diversity only can be addressed rationally by comparing it to the real opportunity cost of conservation policies. This opportunity cost is usually measured in terms of real income that consumers are willing to sacrifice in other aspects of their lives for that maintained biodiversity, including the costs of diversity loss in other groups of species (Weitzman, 1992).

Currently, the process of extinction is a major subject of analysis for marine species, especially for these resources considered ‘‘open access" (Berck, 1979). Economically, the extinction process can occur when the growth rate of the value of the resource stock is lower than the opportunity cost of capital, or the interest rate. When this happens the confluence of the biology of the species and the demand expressed for these specialized goods on a market come into play (for example the fins and shark gills). Parts of sharks in particular may qualify as "luxury goods[1]" in many countries. For example, Sotheby's and other auctions houses sell animal parts at very high prices. These are considered in many countries as a luxury. However, the rising international demand for these goods, which have led to the collapse of

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[1] A luxury good, paradoxically is one that has many substitutes but the purchase of which is sensitive to rising incomes. At low income levels, more goods become luxury goods. It could be that fish parts are becoming "normal" or goods of first necessity, and if human behavior towards these species is not modified, this will lead to mass extinctions as real incomes rise.

many shark fisheries, is being driven by rising real incomes, which makes these goods less "luxurious". Unfortunately, this largely exceeds the reference point where the stock could have had a biological recovery. China, one of the largest economies in the world, experienced rising real incomes beginning roughly in the 1980's. If preferences do not change in China, rising real incomes will make the consumption of animal parts and possession as "goods of first necessity", no longer luxury goods at all. This could have devastating effects for many species. (Caddy and Mahon, 1995). On the other hand iconic resources such as elephants, rhinos, and sawfish, among others, have lasting value as trophies or amenities that can accelerate the process of extinction (Kremer and Morcom, 2000; McClenachan *et al*., 2016).

To avoid the extinction process and obtain the maximum diversity out of the limited conservation resources, policy-makers must have a sense of the magnitude of the appropriate species distance or dissimilarity, extinction probability, and extinction probability reduction costs, which society might be willing to spend on the problem (Weitzman, 1992).

The opportunistic exploitation concept was originally coined as ''opportunistic depletion'' by Purcell *et al.,* (2013). It occurs when a scarce but desirable species is captured, while the target is another species that is less desirable but more common. The capture of the rare species is only profitable because of the presence of the less desirable species (Branch *et al*., 2013). This concept allows to continue the exploitation at densities below the bioeconomic equilibrium (Gordon, 1954). This is the problem encountered in the case of the *Pristis* species group.

1.2.5 Institutions: CITES, FAO and IUCN

Pristis spp. that is captured opportunistically does not necessarily enter local markets. There are several markets for parts that are world-wide in nature. Most international trade then falls under international agreements. And an important question is whether these agreements have in fact helped in the conservation effort, and if not, then why not. An overview of these international institutions is therefore necessary.

CITES

CITES is an international voluntary agreement between governments. This convention was created in 1963 after an adopted resolution at a meeting of members of IUCN (The International Union for the Conservation of Nature), but it was not until 1975 that CITES entered in force. CITES is the largest multilateral agreement on species conservation and regulates the trade in more than 30,000 species of animals and plants, through a system of certificates that allows the trade of the species under certain circumstances. The structure is composed by the Conference of the Parties, meeting every two to three years, where they review the implementation of the Convention. These meetings last for about two weeks and are usually hosted by one of the Parties to the Convention. The meetings are often referred to as ‘‘CoPs’’ (Figure 5). CITES is financed from the CITES Trust Fund. This Trust Fund is replenished by contributions from the Parties to the Convention based on the United Nations scale of assessment, adjusted to take account of the fact that not all members of the United Nations are Parties to the Convention (CITES, 2017).

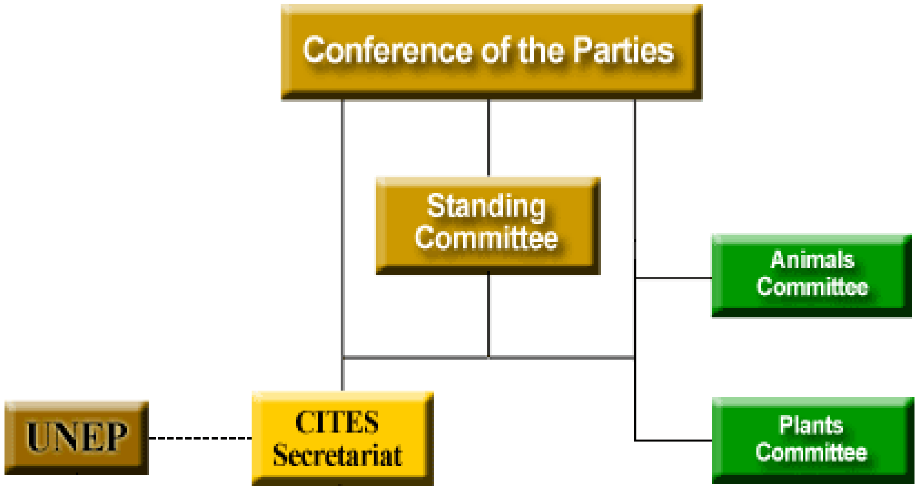

Figure 5. Structure of CITES (Modified from CITES, 2017)

CITES tries to achieve this goal from the commitments made by each of the members (called a party) during regular meetings, who then ratify the agreement within their country. In 2016, CITES was ratified by 183 countries, each of which must designate an Administrative Authority in charge of the administration of that licensing system, and a Scientific Authority to give advice on the effects of trade on the status of the species. To avoid trade in endangered species, The CITES treaty has Appendix I, II and III of endangered species, ranging from threatened by extinction (Appendix I) to Species needing joint protection by members (Appendix III). According to the level of protection required and the vulnerability of the species, this will determine where the species will be included in one of the 3 appendices. Each appendix has different levels of commercial controls aimed at controlling overexploitation (Table 2) (CITES, 2017).

Table 2. CITES Appendices (Modified from CITES, 2017)

Appendix	Content
I	Species that are threatened with extinction and CITES prohibits international trade except when the purpose of the import is not commercial (e.g. most hunting trophies, parts and derivatives such as carved products as tourist souvenirs). In these exceptional cases, international trade may take place on the basis of permits.
II	Species that are not necessarily now threatened with extinction but that may become so unless international trade is closely controlled. Trade permits are only granted if certain conditions are met, above all that trade is not detrimental to the survival of the species in the wild (Article IV of the Convention, and Article 4 of the EU Wildlife Trade Regulation No. 338/97).
III	Species that are included at the request of a Party that already regulates trade in the species and that needs the cooperation of other countries to prevent unsustainable or illegal exploitation.

In a search for agreement among Parties, CITES uses a combination of “carrots” and “sticks” (Reeve, 2002). This includes providing Parties with training, species identification manuals, and technical assistance. Conversely, the threat and establishment of trade sanctions for listed species are used where Parties are non-compliant (e.g., failure to enact implementing legislation; Reeve, 2002). However, non-compliance remains a problem, and 31 Parties are currently subject to recommendations to suspend trade (Velázquez-Gomar and Stringer, 2011). CITES is supposed to help in regulating the trade of species among the Parties. However, many countries cannot implement CITES listings for marine fishes, because they continue to have serious problems with their own public management of their fisheries. CITES does not have any police means to enforce the implementation of the convention (Vincent *et al*., 2014).

Since creation of the agreement, CITES has dealt with highly emotive issues and the use of animals for what some would regard as disturbing purposes such as the exploitation of nature for profit, the trafficking in the illegal goods, and the killing or capture of wild animals (Huxley, 2000).

One of the problem of CITES is that in more than 26 years they have not added any more marine animals; and only the coelacanth (both species), totoaba, seahorses (all), sharks (three species), hump head wrasse and sawfishes (all) are regulated and forbidden for international trade. Some of the most depleted fish species are listed in CITES Appendices I, despite clear evidence that some global fish species have become severely depleted by exploitation (Worm *et al*., 2009; Costello *et al*., 2010; Veitch *et al*., 2012). CITES, an organization which is supposed to control international trade, and whose mandate includes all living organisms, seems to have consistently focused on terrestrial rather than marine species (Vincent *et al*., 2014).

According to 't Sas-Rolfes (1997), the listing of all rhino species in Appendix I, failed to stop trade or poaching. It was the decisions of the governments of South Africa and Zimbabwe to allow a controlled legal trade in rhino horn and auctioned black rhinos that ultimately led to some control. In 1990, the Natal Parks Board started auctioning black rhinos. Increasing demand and rising prices for live rhinos have ensured that private landowners had a stronger incentive to conserve and sustainably manage the rhino populations. This is considered by many as the only conservation success story, in part because it dealt with economic incentives of those directly involved. However, in the case of marine species such as *Pristis*, such incentive-based measures are even less in evidence.

FAO

The Food and Agriculture Organization of the United Nations (FAO), was created in 1943. One of their objectives is "*Make agriculture, forestry and fisheries more productive and sustainable*". The departments of FAO Fisheries and Aquaculture Department ''*promotes policies and strategies aiming at sustainable and responsible development of fisheries and aquaculture in inland and marine waters. For this purpose, the Department provides discussion fora, information, legal and policy frameworks, codes and guidelines, options for strategies, scientific advice, training material, etc.*" (FAO, 2017a).

In 1974, FAO indicated that 10% of all fisheries was overexploited, depleted or recovering from depletion, in 1989, that value increases to 26% and in 2012 it was 58% and required effective management to avoid decline (FAO, 2017a). Over 80% of global catches, are derived from fisheries lacking formal assessment and small unassessed fisheries are in substantially worse condition than assessed fisheries (Costello *et al*., 2012). That is the reason why the populations of marine fishes could be extirpated or become globally threatened (Hutchings, 2001).

The management of international trade in marine species is even less successful, possibly because approximately 36% of all fish products were exported (FAO, 2016). The economic value of many species draws greatly from their international trade, which has been facilitated by new improvements in storage and transport capabilities. It has also been motivated by the increasing use of fish in expanding cash economies and for foreign exchange earnings (Béné *et al*., 2007; Asche and Smith, 2009).

There are two other important factors that causes the overexploitation and depletion of fisheries: (a) more than 820 million people depend directly on fishing for their livelihoods; (b) 3 billion people use fishing as a form of food security (FAO, 2017a). These 2 factors, coupled with spiraling prices attained by some species (Collette *et al.,* 2011), led to seafood being one of the most traded commodities (Figure 6).

Figure 6. Net exports of selected agricultural commodities by developing countries. (Modified from FAO, 2017a).

In 2014, fishery exports from developing countries were valued at US$80 billion, and their fishery net-export revenues (exports minus imports) reached US$42 billion, higher than all other major agricultural commodities (such as meat, tobacco, rice and sugar) combined (FAO, 2017a). FAO has made substantial contributions to tracking the evolution of fisheries world-wide and making important information available, but the nature of the organization precludes it from being an effective management institution.

IUCN

The International Union for Conservation of Nature (IUCN) which was created in 1948, is an international organization composed of both government and civil society organizations and provides public, private and non-governmental organizations with the knowledge and tools that enable human progress, economic development and nature conservation to take place together. Their mission is to "*Influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable*". This is achieved by working with many partners and supporters. IUCN implements a portfolio of conservation projects worldwide. Combining the latest science with the traditional knowledge of local communities, these projects work to reverse habitat loss, restore ecosystems and improve people's well-being, according to their reports (IUCN, 2017).

In 1994 the IUCN, created the Red List, to determine the risk of extinction that is applicable to all species. The red list is underpinned by the information management tools which facilitate the collection, management and processing of species data from their workshops to their publication on the IUCN Red List. The Red List has nine different categories, which measure the level of extinction risk, ranging from Not Evaluated to Extinct (Figure 7) (IUCNRedList, 2017).

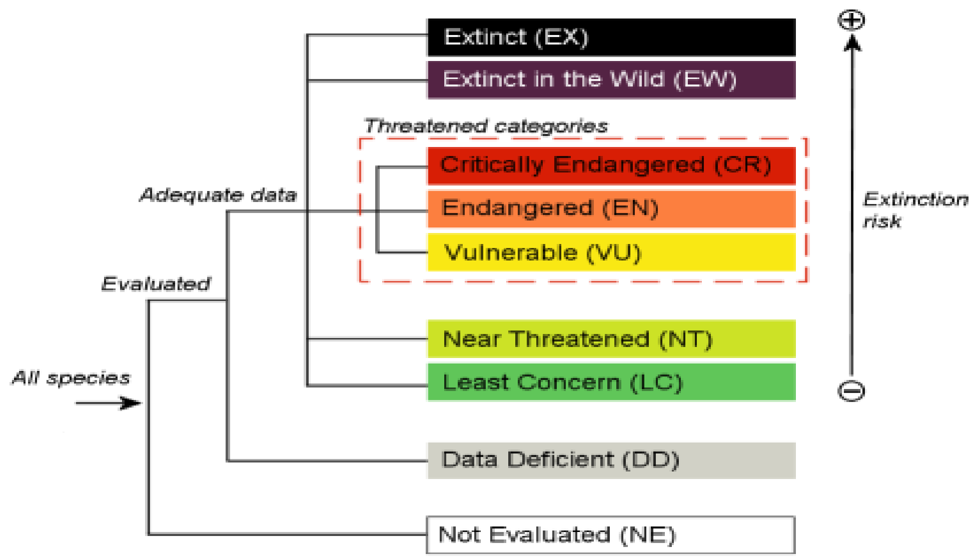

Figure 7. Red List categories. (Modified from IUCNRedList, 2017).

Although each of these institutions are interested in species conservation, the entire effort is likely to be a gross underinvestment, for reasons that Tietenberg and Lewis (2010) described. Biodiversity is a public good, but because it is a public good, no investor will provide sufficient amounts of investment to make a difference, because it is so difficult for an investor to capture the income streams arising from that investment. In addition to that, the international organizations aimed at conservation, while they may do an excellent job of bringing conservation issues to the attention of world governments, cannot make these governments manage their own resources better. That requires investments on their part, and unfortunately, many countries, are neither equipped nor willing to have tighter regulation for various reasons, according to Costello *et al.*, (2012). Liberalized trade makes management for conservation even more difficult. This has importance for species such as *Pristis* spp., because markets of certain parts of the animal are already well-developed. One of the most surprising international markets for sawfish is the market for the rostrum, or the saw part of the animal. The data thus collected gives us some insight into two things; the role of economic growth on the market for rostrums, and an indirect test of the efficiency of the CITES program. This case study is presented in the following chapter.

1.2.6 Understanding the trophy market for sawfish: methodology

Searching the data

During 2016 and 2017 an exhaustive search of rostrums for sale on the internet was performed. The parameters of the search, was a simple Google search, typing ''sawfish rostrums or sawfish parts, sawfish bill, marine animal parts + sale'' in different languages. The search lead us to a different auction houses, and those auction houses may have suggested other pages or auction houses. Also, publicity made by our historic search on Google was important to find some rostrums. Another important way to find some prices and rostrums was the communication with others researches, especially Dr Matthew McDavitt, who kindly shared his database, which had information to complement our database. Most of the rostrums found belong to private collections and were offered in different auction houses and in sale pages such as E-bay, Gumtree,Etsy, and Mossgreen, among others. Apparently, most of the saws have the CITES certification that allows trade before the sawfish entered in the Appendices; or the owners claim that the saw comes from the 19th century, and thus outside the time periods of CITES ban. A total of 174 observations were collected, but because of incomplete entries as length, price, origin, year etc, only 115 could be used for analysis.

An attempt was made to search the dark web, but could not be done because after downloading the software and entering in the dark web, a warning from the Canadian government was posted to us that the search could be illegal. Being from the university network and not knowing how to change an IP address, that search was left aside. This however raises an important issue about the malleability of markets, and the role that CITES might have played to push these markets underground.

A classification of the data was made that includes: Item (if it's a saw or a tooth); Species; Price (in local nominal currency); real US prices at the time of sale[2]; Size (in millimeters); Country (country where the item is offered for sale) and Year (time at which the item was sold) and a binary variable indicating whether or not Auction Houses were used in the sale. This binary variable is important because we know a priori that auction houses use techniques aimed at getting the highest price possible from a group of buyers. After the classification, incomplete data were eliminated for the analysis. Later, it was found that for purposes of consistency over time, it was necessary to render the prices in real USD at purchasing power parity. We also looked at gross welfare indicators such as the real GDP per person in the selling country.

Analysis of data

We wanted to understand better, with the little amount of data that we had, the main explainers of price of rostrums. Obviously, the size of the rostrum was one important variable determining real price. We used multiple regression, including data from both the original internet search and the additional variables, which includes dummy variables, which takes on a value of 1 for that data point and zero otherwise (Salkever, 1976). For the regressions we tried a number of different specifications that could explain prices (Table 3). Apart from the size of the rostrum, we thought that the real GDP (at purchasing power parity) might play a role. We were concerned about untangling the effects of CITES represented in our dummy variable with the other effects related to time. So, for subsequent specifications we added a trend (untested for singularity) and for some specifications a variable TREND*CITES07. This was intended to respond to the question: what effect might CITES have had on the trend in prices as represented by the slope of the trend variable? Doing this sacrifices estimator

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[2] Real price is the price of a good that has been adjusted for the rate of inflation. This may include the use of GDP deflators or price indexes. The aim is to be able to compare prices and their effects accurately over time periods where the price levels may be fluctuating.

efficiency (variance inflation), since we do introduce multicollinearity with such an estimation.

We use the dummy variable CITES 07 (2007 was the year that all species of Pristidae entered Appendix I, so pre-CITES observations take on a value of 0, and from 2007 on, it takes a value of 1), Country, Size and a dummy variable to identify sales made through auction houses (Auction Houses). This variable was added for economic reasons. Price formation using auction houses would yield prices which are higher than in a disaggregated market, because the auction house uses bidding protocols aimed at revealing maximum willingness to pay. We use a deflator provided by The World Bank (2017), to find the real price at purchasing power parity, to make a better prediction. Also, we tested for collinearity and for heteroscedasticity in this first model (Criddle, 2007). We found no evidence of either.

1.2.7 *Pristis* spp. as study case: results and analysis

We present these 3 models to show the possible scenarios on the saws market, a market that is part of the objectives of CITES. The first model we present is significant (F=16.45; p= 1.36E-10; n=115), but incomplete (adjusted R^2 = 0.35). A log-log specification with the variables SIZE (length of the rostrum in millimeters); CITES DUM 07 (a binary variable that relates date of sale to the date that the CITES treaty came into force); AUCTION HOUSES (a binary variable signifying if the sale was made by an auction house), and finally, real per capita GDP at purchasing power parity (PPP) standardization at 2007 in the country selling the trophy. The test for multicollinearity was made to proved if the exploratory variables had a related effects on the dependent variable (Criddle, 2007). It shows that there is not multicollienearity between LNSIZE vs CITES DUM; Real GDP v LNSIZE.

The F-test of the Golfeld-Quandt test associated with the estimation shows that there is no heteroskedasticity between the samples. Unsurprisingly, we found a positive and significant correlation between size of rostrum and real price paid for the article. However, and surprisingly, we also found that the addition of *Pristis* spp. on Appendix I of the CITES agreement may have led to higher prices for the rostrums.

Finally, there is a relation between the higher prices and the type of market, as we expected. If the sale was recorded from an auction house the price is higher than the items that sell in pages like E-bay (Table 3).

Table 3. Coefficients of the regression for the 1st model.

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0,430	2,798	0,154	0,878	-5,115	5,976
LNSIZE (mm)	1,026	0,178	5,762	0,000	0,673	1,379
CITES DUM 07	0,554	0,212	2,610	0,010	0,133	0,975
AUCTION HOUSES	0,387	0,195	1,985	0,050	0,001	0,774
LN GDP	-0,209	0,229	-0,915	0,362	-0,663	0,244

The antilog for the 1st model estimated can be expressed as:

$$\boldsymbol{price} = \boldsymbol{e}^{\mathbf{0{,}430}} * \boldsymbol{size}^{\mathbf{1{,}026}} * \boldsymbol{e}^{\mathbf{0{,}554}*\boldsymbol{CITESDUM07}} * \boldsymbol{e}^{\mathbf{0{,}387}*\boldsymbol{AUCTIONHOUSES}}\boldsymbol{GDP}^{-\mathbf{0{,}209}} \quad (1)$$

It is important to point out that for the continuous variables (size and GDP) the estimated values are expressed as elasticities, or, the percentage change in price for a percentage change in the value of the regressors. So, for example, the value of (positive) 1.026, would say that for a 1% change in the size, there would be a 1.02% change in price; an elastic response. On the other hand, the elasticity of -0.209 for per capita GDP suggests that as real incomes rise in the country selling the item, the real price rise is negative; poorer selling countries receive proportionately higher prices than sellers from richer countries. This is important, because it is also evidence of the effects of post CITES in higher prices. The price of a trophy, *ceteris paribus*, increased by a factor of 0.554 after the enactment of CITES; the use of auction houses increases trophy prices by a factor of 0.387. And a 1% rise in real GDP at PPP, the market price transacted declines by 0.209 %. This suggests that transactions occurring in countries having higher real revenue sell for lower prices. However the statistical significance of this variable is low (Figure 8).

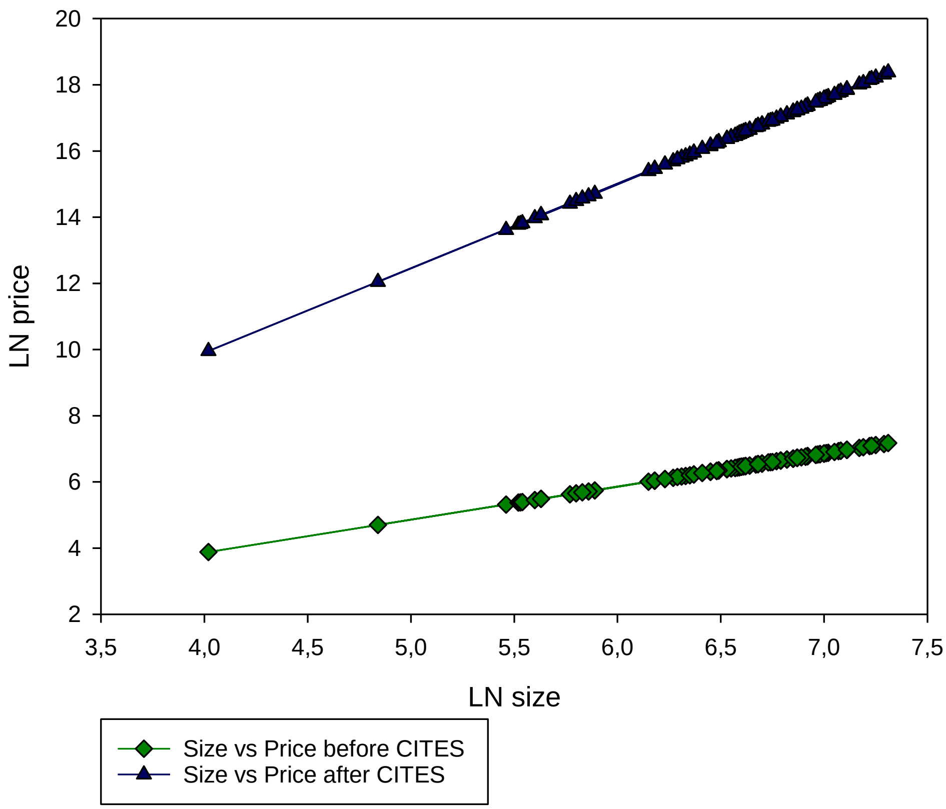

Figure 8. The effect of the CITES binary variable on the real price of rostrums, by size.

A negative coefficient for GDP, indicates that rises in real income leads to a comparative decline in prices, suggesting that these artifacts are inferior goods in developed countries.

It is important to point out here that the dependent variable is real prices at purchasing power parity. This means that the effects of inflation at the world level have been taken account of. So inflationary trends cannot be confounded with pre-CITES/post CITES analysis in this regression. There may be pressures on prices due to, for example, rising real incomes in Asia. However, the binary variable in this regression does suggest at least a coincidence between CITES and price rises.

This is a partial structural model explaining prices in a world market for one part of *Pristis*. It could be that there are secular trends in this market that make the binary variable for CITES difficult to interpret directly. One possible secular trend is rising real incomes in certain Asian economies, that would be collinear with the binary variable. The second model presented tries to untangle the effects of time and the punctual effect of CITES. The model is significant (F= 18.05; p= 1.3E-10; n= 115), and also incomplete (adjusted R^2= 0.33). The same log-log specifications were made, but in this case, we used LNSIZE and we tried to untangle the trend effect from the CITES effect. To do this, a variable called TREND was created starting from 1 in 2002 to 15 in 2017. Then another binary variable LNTREND was created. Then DUMCITES07*LNTREND was formed. LNTREND was replaced with DUMCITES07*LNTREND. The combination of these two variables tries to measure the change in the slope of the trend before and after CITES. This regression shows that this instrumental variable appears to be positive as well, suggesting that the effects of the trend is accentuated after CITES. The trend slope is NEGATIVE before CITES (-0.019) and nearly flat (-0.571 + 0.552 = 0.019) after CITES (Table 4).

Table 4. Coefficients of the regression for 2nd model.

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-1,499	1,322	-1,134	0,259	-4,118	1,120
LNSIZE (mm)	1,094	0,182	6,014	0,000	0,734	1,455
LNTREND	-0,571	0,481	-1,187	0,238	-1,524	0,382
DUMCITES07*LNTREND	0,552	0,307	1,798	0,075	-0,057	1,161

The antilog of the 2nd model estimated can be expressed as:

$$Price = e^{-1.499} * size^{1.094} * LNTREND^{-0.571} * DUMCITES07 * LNTREND^{0.552} \quad (2)$$

The implication of this estimation is that BEFORE CITES, there is weak evidence that the trend in logged prices was falling. Before CITES, our categorical model does not have the term DUMCITES07*LNTREND (it is 0, which makes the antilog of it as 1). But after CITES, the two last terms are added to get the post CITES effect.

The 3rd model proposed is weaker than the other ones (F= 13.603; *p*= 4.83E-9; n= 115) and also incomplete (adjusted R^2= 0.31), in the sense that we know that other information would be necessary for a full structural model. One thing we do know is that whether or not a rostrum was sold in an auction house should have a positive impact on price. This is because auction methods tend to maximize the extraction of consumer surplus by using different protocols that encourage bidding. For these reason, we included the binary variable AUCTION HOUSES. Even the variables AUCTION HOUSES, become insignificant, and it is remarkable that the trend slope is NEGATIVE before CITES (-0.020) and also nearly flat (-0.548 + 0.527). suggesting the same as in the 2nd model. These results suggest that prices had been steadily falling with time. But after CITES these decline slowed. This may mean that CITES has likely helped the price rises over time, or that the agreement has possibly counteracted trends that were already occurring (Table 5).

Table 5. Coefficients of the regression for 3rd model.

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-1,429	1,329	-1,076	0,284	-4,062	1,203
LNSIZE (mm)	1,091	0,182	5,982	0,000	0,730	1,453
DUMCITES07*LNTREND	0,527	0,310	1,702	0,092	-0,087	1,142
AUCTION HOUSES?	-0,131	0,188	-0,698	0,486	-0,505	0,242
LNTREND	-0,548	0,483	-1,134	0,259	-1,506	0,410

The antilog of the 3rd model estimated can be expressed as:

$$Price = e^{-1.429} * size^{1.091} * DUMCITES07 * LNTREND^{0.527} * e^{0.131} * LNTREND^{-0.548} \quad (3)$$

These models suggest that even eliminating the weakest variables (GNLPD and AUCTIONS) and removing the effect of the market trend after the inclusion of sawfish in Annex I of CITES, the response to the market of the saws and the deterioration of the populations of sawfish has increased. Authors such as 't Sas-Rolfes (2010), Dickson (2003), and ERM (1996), criticize CITES actions, pointing out that declines in protected populations are more common than recoveries of species included in CITES. In the case of sawfish and our analysis, this seems to be corroborated by the continuing low populations worldwide and even with declarations that the species has been extirpated from the Colombian and

Venezuelan Caribbean (Simpfendorfer and Wiley, 2004; Gómez-Rodríguez *et al.,* 2014), and. This usually occurs when trade bans are used; populations fail to recover once trade and fishing have been banned (Leader-Williams, 2003; Jachmann, 2003). Further to these criticisms, in implementing trade bans, CITES policy makers do not consider complex demand and supply dynamics (Hall *et al*., 2008; Rosen and Smith, 2010; Challender *et al*., 2015).

These observations are also bourne out in the trade theory literature. According to Krugman *et al* (2015), countries sometimes favor the production and exportation of goods that use public goods. These can generate significant negative externalities , although production and trade can contribute to country economic growth for a while. When social costs like pollution and overexploitation become acute, a country's politicians may decide to correct these externalities by imposing trade sanctions and tarifs, similar to CITES, citing the positive effects of mitigating the externality. However, Krugman *et al* (2015) in particular has argued persuasively that trade policy in the name of correcting externalities is a second best solution that often causes more problems than it solves. This is because trade policies often do not consider unintended consequences of the policy due to changing incentives. It is better policy for a country to deal with the externality through internal taxes, education, and specific rules.

In the case of species at risk of extinction like *Pristis* spp., CITES does not have a high capacity for persuasion to combat damage caused to exploited populations due to the lack of information and infrastructure necessary to encourage local policies to reduce demand. In order to solve the problem of trade in endangered species, it is again not recommended to tackle the problem withtrade policy.. This has also been observed in rhinos, where the trade ban increased poaching by creating more profitable opportunities for crime syndicates and increasing the incentives for poachers. Similar outcomes have been seen in attempts to ban or control alcohol, illicit drugs, and other wildlife products (Biggs *et al*., 2013). This is important from a management standpoint. It is possible that the CITES agreement and the placement of the *Pristis* spp on Annex I led to scarcity in this market, resulting in rising prices. If this is the case, countries with little or no management may accelerate the rate of extinction rather than slow it.

Not surprisingly, prices of the sawfish trophies increase with the size of the rostrum. In the market, a saw can reach prices of $1,000 and $13,200 USD, depending on the tooth count (Harrison and Dulvy, 2014; Hoover, 2008). The saws are displayed as trophies in living rooms, restaurants, museums, hotel, private collections and other places where such luxuries signify status (Hoover, 2008). These displays create a market for taxidermists who may ornament the saws. For example, Sotheby's sold a rostrum in 2014 for $40,625 USD (Figure 9). Other auction houses and e-commerce web pages offered rostrums for an average of $690 US, mounted or without ornament. According to all the auction houses, the rostrums were collected before *Pristis* spp. was added to the CITES agreement in 2007, and each rostrum is delivered with a certificate that allows the sale of the rostrum.

Figure 9. A rostrum with an unknown skin from Sotheby's sold in 40,625 USD in 2014. This case was removed from the analysis, because the price only reflected the total value and not the value of each of the parts that made up the item

Based upon this analysis, the inclusion of *Pristis* spp. in Appendix I of CITES can be disadvantageous for the species, because as we see in the results, the prices appear to have increased after 2007, and may well lead to the emergence of a black market for parts, especially the saws (Pires and Moreto, 2016). This black market may be even more problematic for the conservation of the species, because in driving it underground, it becomes even harder to control the accidental capture, and to do market analysis. Fishermen, when catching a sawfish, usually have an incentive to sell the animal in parts to be able to pay for the repair of fishing gear (gillnets) (*com. pers* fishermen of Don Jaca, Santa Marta, Colombia, 2014). An additional tax-free income can be tempting as well. This type of black market is similar to the illegal market of narcotics, which generates large incomes for smugglers (Davidson *et al.,* 2007).

Nowadays the black market of animal parts has found a new niche from which it has been able to make a profit: the internet. Pages such as e-bay and Amazon among others have removed animal parts from their inventory. In the case of sawfish, since 2007 it is very difficult find these products on legitimate internet markets. However in the deep web, anything can be found, (Milliken, 2014; Jardine, 2015; Pires and Moreto, 2016). Thanks to the deep web, and the geographical location, lax laws and number of ports of entry available, several countries are considered ideal transit for deep web smugglers (Jardine, 2015), for example, the illegal trade in ivory horn and rhinoceros across Africa (Milliken, 2014; Pires and Moreto, 2016).

Society, as well as the supply and demand components of markets, are constantly changing for different wildlife products. However, there is a steady flow of both legal and illegal wildlife objects from developing countries to developed countries (Reeve, 2002; Roe *et al.,* 2002; Duffy, 2010; Rosen and Smith, 2010; Lawson and Vines, 2014). Countries in Latin America and Africa tend to have open-air illicit markets, as these countries have the greatest bio-diversity. Most of the narratives of the black market are remarkably similar, and include usually impoverished people that have intentionally or accidentally captured an animal. They then turn to a legal or an illicit market to make extra income, which is often also used to repair or replace damaged equipment. Such activities in the developing world are almost expected and normal (Pires and Moreto, 2016). Commercial bans may lead to an increase in the black-market prices of threatened or endangered species, causing poaching to increase (Hall *et al*., 2008; Pires and Moreto, 2016). This appears to be what we have found in our case study on the prices of rostrums. Those who developed CITES provisions hoped that it would limit the international trade in endangered species. However, these policies and others aimed at conservation are often made without a clear knowledge of the economic incentives humans have, and the unintended consequences that occur when these incentives are not understood. Despite the CITES ban in 2007, sawfish rostrums continue to have a high value. This provides considerable incentive for fishers to retain sawfishes; it is also common for buyers to approach fishers and offer money for certain parts (CITES, 2007; McDavitt, 2014). Recent CITES listings of marine species are promising. However, the high individual price of sawfish, reported by McClenachan *et al*., (2016) (Figure 10) and in our findings, could incentivize a black-market trade (Rivalan *et al*., 2007).

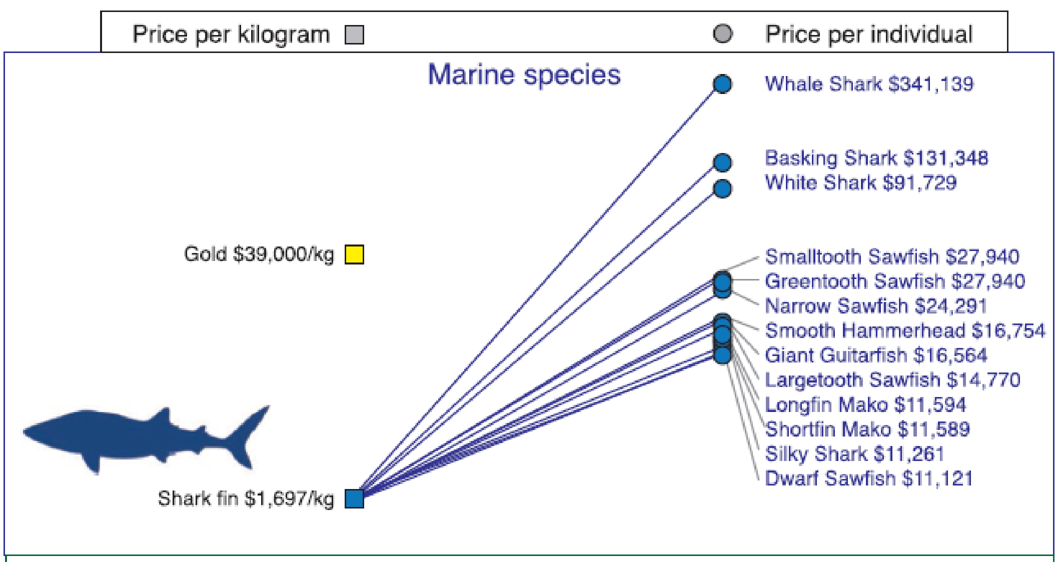

Figure 10. The species that are worth their weight in gold. (Modified from McClenachan *et al*., 2016)

The data collected for this thesis, and the difficulties in obtaining data to test hypotheses in a counter-factual way, limits our ability to offer a complete assessment of CITES policies. What evidence we have suggests that CITES may even contribute to this problem, because the estimation of threatened populations are not available for many species found in the Appendix I, and detailed data are not available on their own website. In the case of marine animals, CITES depends almost entirely on data taken by FAO, which depends in turn on local governments, and are usually incomplete or poorly taken (Watson and Pauly, 2001; Abensperg-Traun *et al*., 2009). Another important point is that CITES is affected because it is designed to control illegal international trade in wildlife and not local trade. However, it is the nature of markets and the process of price formation that make these two markets inextricably intertwined. In recent years research has shown that domestic illegal wildlife trade is important and may even be larger than international trade for some species (Pires and Moreto, 2016; Pires 2012). Finally, it is sometimes impossible to imagine incentives to villagers to protect wildlife, especially if trade in the wildlife is illegal. It is here that the "private resource" plays an important role, because the resource can be valued, and local people can therefore benefit from its use. (Martin, 2000; Dickson, 2003; Leader-Williams, 2003).

The IUCN Red List is a method to identify endangered or threatened species. This means that species protection policies are made either by protecting the species or by creating protected areas (PAs) and payments for ecosystem services (PES) (Miteva *et al*., 2012). These areas impose legal restrictions on access and human use within their limits and impose penalties on offenders. The PES approach is more recent and more often used in Latin America and China. The main difference between PES and PAs is that PES seeks to promote biodiversity conservation and the provision of ecosystem services through incentives in the form of payments to landowners, whereas PAs do not. In exchange for these payments, landowners cannot convert parts of their property into arable land. Rather they must conserve it as high conservation value land. On the other hand, PAs use punishment to induce a change in human behavior (Pattanayak *et al*., 2010). Many of the PAs in the intertropical zones are natural habitats for the sawfish, even though in these areas, artisanal and subsistence fishing continues to be the great threat to this species.

According to Garcia *et al.,* (2008) and Simpfendorfer and Keyne (2009), deep water chondrichthyans, due to their slow growth and lower productivity, are intrinsically more sensitive to overfishing than their shallow-water relatives, but for a given body size they are less threatened - largely because they are inaccessible to most fisheries. The intrinsic rate of increase (r) for *P. perotteti*, (synonymy of *P. pristis*) 0.05 to 0.07 yr^{-1}; and for *P. pectinata* was 0.08 to 0.13 yr^{-1} (Simpfendorfer, 2000). Dulvy *et al*., (2014) report values of r for five species of Pristidae. *A. cuspidata* $r = 0.27\ yr^{-1}$; *P. clavata* $r = 0.10\ yr^{-1}$; *P. pectinata* $r = 0.07 – 0.14\ yr^{-1}$; *P. pristis* $r = 0.12\ yr^{-1}$ and *P. zijsron* $r = 0.02 – 0.1\ yr^{-1}$. *Carcharhinus plumbeus* (sandbar shark) have an $r = -0.124\ year^{-1}$ indicating an over exploitation (Musick and Bonfil, 2004). *Thunnus albacares* $r = 0.45\ year^{-1}$ (Moore, 1951); *Xiphias gladius* $r = 0.09–0.19\ year^{-1}$ (Berkeley and Houde 1983) and *Orcinus orca* $r = 0.024\ year^{-1}$ (Brault and Caswell, 1993). As we can see, all the species named above, have a low r, meaning they are considered species particularly vulnerable to population decline in a context of exploitation (Musick *et al*., 2000). Sawfish females are slightly larger than males (Table 1) and use shallower water when delivering young. So, we can assume that encounters with fishermen and retention of captures are more frequent with females, in part because coastal and continental shelf and pelagic species greater than 1 m total length have a more than 50% chance of being threatened, compared to ~12% risk for a similar-sized deep water species (Dulvy *et al*., 2014), and for rebuilding a stock, females are highly important.

There is presently no evidence to support that more females are fished than males, but it is known that they are the ones closest to the coasts, mangroves and other shallow areas to give birth to the offspring (NMFS and NOAA, 2010). Sawfish distribution closely overlaps coastal areas which are in fact highly developed for the most part, but lying in developing country areas. For these reasons, they probably run into a lot of artisanal fishermen and sport fishermen, not only in developing areas, but also in richer nations like the U.S. and Australia. Also, larger specimens are probably not returned to the water, mainly for the economic reasons mentioned before. Looking at the world map and in describing the range of the species group, it becomes immediately apparent that the problem of over-exploitation and extinction is one closely associated with small-scale commercial fisheries and recreational fishing in developing areas of the world.

We have seen evidence of this after the 1960s in the global increase of the catches of sawfish, as well as now with the decline of their populations (FAO, 2017a) (Figure 11). Apparently the populations of sawfish reached levels below or close to the minimum viable population (MVP), due to the levels of effort above short-run yield (SRY), where the populations can not regenerate and the effects of overfishing are irreversible. These levels are reached when, the yield-effort relationship there is an MVP zone (from 0 to MPV), if the effort increases from the equilibrium point SRY_{f1}, the curve moves to SRY_{fmsy} and as the effort increases (SRY_{f*}) generate an uncertainty in this relationship (Cunningham *et al.*, 1988) (Figure 12). But, according to Harrison and Dulvy (2014), populations such as *Pristis* spp., who have a complicated life history, the number of individuals may still increase due to conservation programs and their populations could be restored. The same problem had been seen with blue whales, where they reached lower levels of MVP and were on the edge of extinction, after conservation programs imposed in the 1960's, the whales managed to increase their population to sustainable levels. (Spence, 1973; Cunningham *et al.*, 1988).

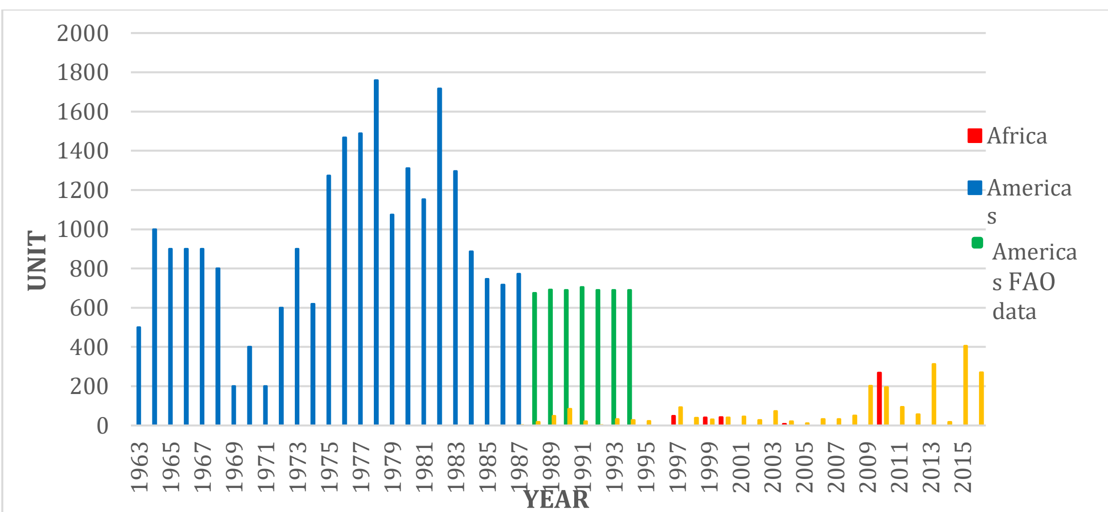

Figure 11. *Pristis* spp. catch from 1963 to 2016. (Modified from FAO, 2017b).

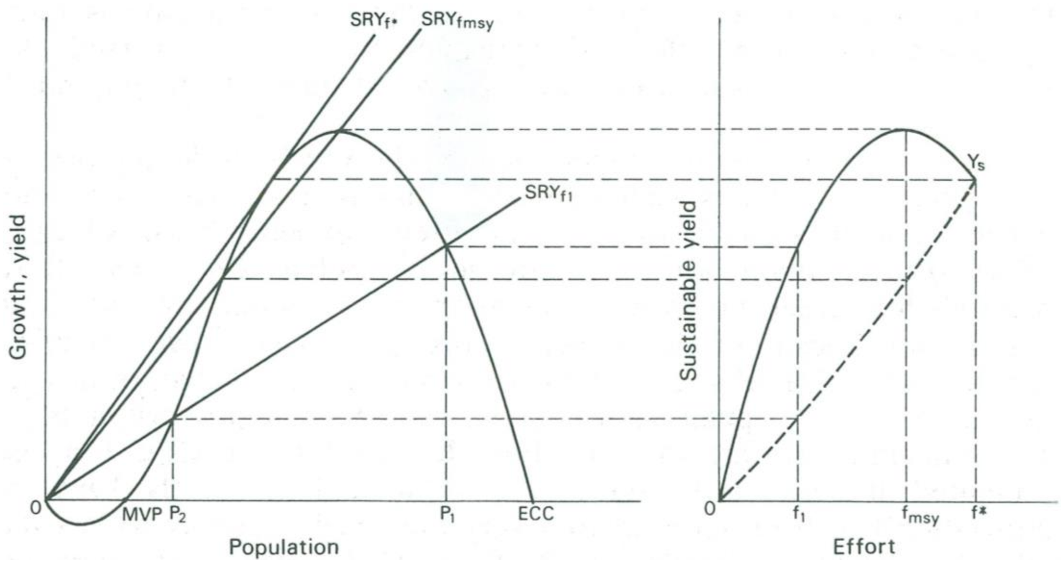

Figure 12. Sustainable yield with a MVP zone. Long-run extinction occurs if SRY_{fmsy} increases (Took from Cunningham *et al*., 1988).

Although representatives of this species show declining numbers, mainly due to a bycatch (Fowler *et al.,* 2005), this is worrisome not just at a biological level but an economic level, because the bycatch itself is considered as a underpriced negative externality, which is an unintended adverse impact on fisheries (Lent, 2015). The ‘‘cost” of bycatch in terms of impact in marine ecosystem is not taken into account into the cost of fishing (Lent and Squires, 2017). In the case of sawfish, the big income for bycatch is for the saw, fins and meat, although other parts like liver oil, leather, teeth can be sold as a traditional medicine or as curios in Asia, Africa, Brazil and Peru (Harrison and Dulvy., 2014).

The United States and Australia have the strongest programs for the conservation and protection of sawfishes (Harrison and Dulvy, 2014) (Figure 13). In both countries it is forbidden to capture and retain a sawfish. In the ‘’ENDANGERED SPECIES ACT PENALTY SCHEDULE’’, the fines go from $500 to $13,500 USD. In cases where a species is in the CITES annex I the punishment goes from $500 to $10,500 USD (Table 6). In Australia the penalties from breaches of the “ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION Act 1999” goes from $110,000 AUD and up to 10 years in prison for an individual, and up to $550,000 AUD for a corporation (CITES, 2017). Poaching fines are a step in the positive direction, but our results suggest that they may be currently too low and policies are not well implemented, especially in developing countries, where the market value of the animal does little to disincentivize illegal hunting. At any rate, the level of the fine may be less important than the probability of being caught and convicted. Also, ultimately, policies need to address the incentives for keeping the animals in the first place.

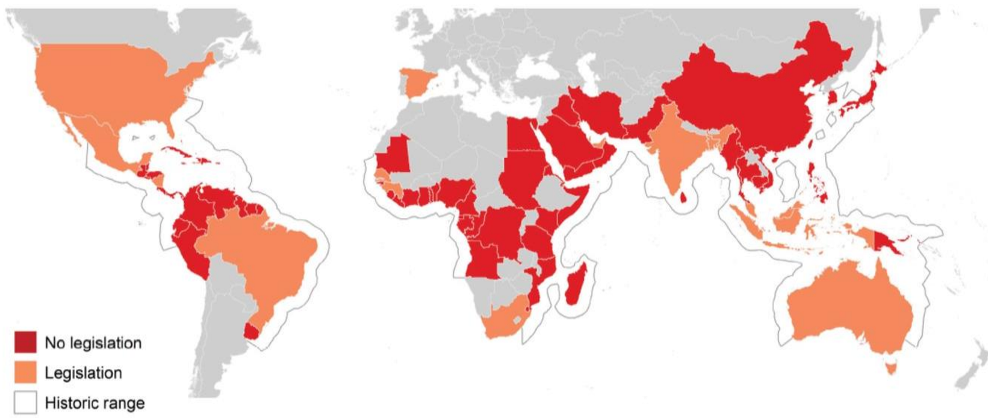

Figure 13. Map indicating location of sawfish-specific country-based conservation policies (Modified from Harrison and Dulvy, 2014).

Table 6. Endangered species act penaltyin (USD) schedule (Modified from NOAA, 2017)

VIOLATION	FIRST	SECOND	THIRD
Import/Export	$500 - $4,000	$2,000 -$15,000	$7,500 - Statutory Maximum
Possess, deliver, carry, transport, sell or ship illegally taken threatened or endangered species in interstate or foreign commerce	$3,500 - Statutory Maximum	$7,500 - Statutory Maximum	$13,000 - Statutory Maximum
Deliver, receive, carry, transport, sell or ship threatened or endangered species in interstate or foreign commerce	$500 - $3,000	$1,500 - $10,500	$5,500 - Statutory Maximum
Other Violations			
Trade in violation of CITES	$500 - $2,500	$1,500 - $10,500	$5,500 - Statutory Maximum
Violate certificate of exemption regulations	$500 - $2,500	$1,500 - $10,500	$5,500 - Statutory Maximum
Violate the conditions of a permit issued for research or propagation	$100 - $1,500	$500-$2,500 and/or permit revocation	$2,000-$4,000 and/or permit revocation

1.2.7 Some policy recommendations

The analysis of the available data we have of this species group suggests that the conservation policies in place, mainly aimed at limiting international trade, has not slowed real price increases, and mayhave possibly increased them. At best, using trade policy to address resource over-exploitation seems to have had no effect at damping price increases. This observation is consistent with other empirical work on the effects of trade bans for other goods, and the effects of trade restrictions in general. Paul Krugman, a Nobel Prize winner in economics for his work in trade theory, has argued that dealing with social cost issues (such as over-exploitation of natural resources and environmental degradation) using trade restrictions is like using a blunt instrument to solve a problem that is better solved through more focused resource and environmental management policy (Krugman *et al* 2015). For example, banning the trade of carpets to control the problem of child labor might be more efficient if consumers of carpets had reliable information on the countries that had lax child labor laws, and that these countries were exposed for their unfair labor practices (Krugman, 1997). China is now attepting to ban their own importation of certain animal parts along with publicity campaigns for their own consumers against the use of certain medicines based upon animal parts. However, CITES has none of these mechanisms, relying entirely on trade bans. CITES as a management structure does not have enough teeth to encourage the development of conservation policy of member countries. However, the lessons from Australia and the U.S. and our own analysis suggests other approaches which might be more compatible with the economic incentives faced by fishers who come in first contact with the animals.

The likelihood of the species being kept after accidental capture increases with size. Since larger animals of this species class are more fecund, and bear their young alive, we predict that these price signals of larger animals will be one of the factors that will accelerate extinction pathways, and become stronger as more and different parts are traded. To protect the species, it is necessary to develop policies aimed at both conservation and education. It is also necessary to have enforceable “no take’’ laws.

CITES designations may accelerate extinction pathways by further driving prices of parts up, and driving markets underground. For this reason, it may be necessary for CITES to focus on public reporting on management progress by country. In this way, analysts can see which countries have made the most progress on conservation, and which countries have not. More pressure on poor performing countries other than trade bans could lead to greater compliance.

Policies aimed at improving release survival rates should be explored, including publicity and education on how to release fish unharmed. For instance, the development of workshops for fishermen that teach them what to do in case they catch a sawfish, and what techniques scientists recommend for avoiding permanent injury to animals is an important first step. “Spreading the word’’, not just where fishermen gather, but in the media explaining the life cycle of sawfish and reasons for protecting them are also important steps. Spreading such publicity in stores that sell fishing equipment and on docks used by commercial and recreational fishers is being currently used to insure compliance with regulations. Other policies aimed at protecting habitat, like restricting construction near or in mangroves areas, because these are the habitats of sawfish and other important marine species, would also be important to explore and put in place, as NMFS and NOAA (2010) has done in some of their management plans.

Scientists could and should work with fishers for identifying nursery and other areas that are sensitive to *Pristis* spp. and create avoidance measures like: closed seasons to those areas during critical times in the life cycles of species; interdictions on takeing any part of the ecosystem that can disturb the normal development of the species, especially during critical times in life cycles. Rules formed for Marine Protected Areas or MPAs, can be made more stringent in certain times that could help to improve the rate of survival. MPAs are a powerful tool for the artisanal fishery, according to Dichmont *et al*., (2013), the management of a small-scale fishery with MPAs is easier than for a large -scale fishery, because artisanal fisheries are close to the resource and the coast. It is demonstrated that in the MPAs there is an increase in the target and non-target fish populations and in conjuction with traditional management, can help build sustainable fisheries (Autl *et al*., 2006).

In recent years FAO has been involved in the design, development and implementations of innovative tools including information and communications technologies (ICTs) in support to the fisheries statistics supply chain. As a global organization their objective is to collect national statistics (FAO, 2015; Laurent and Bealey, 2017). In addition to FAO's efforts, countries such as Costa Rica, Mexico India among others, have implemented ICTs in their small-scale fisheries. Allowing fishermen to be informed about the weather, which species are being sold and/or landed, also to letting them know the market chain of the species caught (Chhachhar and Omar, 2012; Anariba, 2017; Nembhard, 2017; Sfeir, 2017). Those ICTs platforms can be exploited by many fishermen and sportsmen who now own cellular technology that allows them to take pictures that are dated, timed and positioned. This technology might be used in conjunction with both educational programs for catch and release including species in Appendix I of CITES, with the promise of a bounty for the released animal. Bounties for verified catch/release activities among artisanal and sport fisheries, and the development of technological alternatives for recording important life cycle information on animals could improve the quality of regulation, making them eventually less onerous on fishers. These rewards could function like a drivers license; every time the fisher gives evidence of having accidentally caught an endangered species and release alive, they receive a point in their fishers license. When they have a required number of points they may be eligible for government programs to improve their boats, their houses, scholarships or low interest rates on mortgages. This alternative can be through the application for intelligent devices that can be subsidized by local governments. Scientists can take advantage of this technological platform and develop tagging programs with fishers, that allows both fishers and scientific identify the potentials areas of nursery and feed which would allow a better understanding of the life history of the animal.

In a conversation with a CITES agent, the answer to the question of interest in knowing the black-market prices of *Pristis* saws, the agent replied that "*CITES does not regulate or* *have records on domestic trade, nor do we generally have information about market prices, be it legal or black market*". From a social perspective, this is clearly a serious blind spot in the agreement and for the policy. For this reason, CITES should focus on all markets, including black markets in order to become more effective.It should provide more complete databases that deal more directly with markets and market behavior. The knowledge of the markets, be they legal or illegal, is a fundamental tool necessary in order to carry out control policies and awareness campaigns..

The relatively undeveloped trade networks and concentration of demand in a few luxury markets provides strong opportunity for meaningful intervention in a few Southeast Asian countries to change human behavior and perceptions of certain types of products. For this reason, it is necessary to strengthen campaigns to reduce demand for shark fins and other so-called luxury products, especially in countries where the real incomes of citizens are rising rapidly. For example, campaigns that provide factual information that could change human perceptions on the so-called "aphrodisiac powers''of elasmobranch products like fins and oil might cause dramatic demand responses, especially in cases where it were to go "viral" in a population. Other factual information about potential health problems such as bio-accumulation in elasmobranches and how it could affect humans can cause the consumers of shark meat not to buy it, thus allowing the demand for this product to decline, helping natural populations not to reach critical levels of overexploitation.

According to FAO, the probability of a sea turtle getting entangled into a gillnet increases in the night, and the gillnet is the gear most used for artisanal fisheries catch sawfish. Local governments should possibly encourage reduced soak times or increase the number of checks of gear to increase survival rates and to minimize discards. This reduces the risk of capturing non-target species and thus prevents the discarding of dead or unserviceable animals. NMFS and NOAA (2010), recommends "*limit soak times to 24 hours when using sink gillnet gear and vessels using drift gillnet gear will need to conduct net checks at least once every 2 hours to look for and remove any sea turtles, marine mammals, or smalltooth sawfish*''.

The economic data present in this work suggests that trade bans, the most important tool that CITES has in its arsenal to combat the illicit trade in wildlife, may be too simplistic a response to a very complex problem.

The alarming decline of fisheries worldwide demands a change in the way resources are managed and in the way managers deal with human behavior. Often, the obvious fixes (more regulation that is unenforceable) makes things worse. Governments, scientists, NGOs and international agreements are in constant battle against this problem, and it is necessary to break the old paradigm and generate new approaches in fisheries that can overcome the gaps in the management of captured species. These should focus on policies which deal with economic incentives of humans and increase the funding of research projects, so as not to simply focus on reporting the alarming declines in populations. Resource management policies that are focused on human behavior as well as life history if the animal in question stand a greater chance of achieving sustainability. Parties to the CITES Convention, must commit to increasing funds for protection and research of endangered species, as well as strengthening MPAs. This strengthening can be managed by the fishing community under the supervision of the local fishing agency, and this as well will generate incentives and responsibilities for both the communities and the authorities.

CONCLUSION GÉNÉRALE

Les données économiques présentées dans ce travail suggèrent que l'outil le plus important de la CITES dans son arsenal pour lutter contre le commerce illicite des espèces sauvages est peut-être trop simpliste pour répondre à un problème très complexe.

Les acteurs institutionnels de la CITES ont essayé de mettre en place des mesures qui aident à éviter le commerce des animaux en voie de disparition. Cependant, une grande partie de cette politique ne tient pas compte du comportement économique des acteurs à l’échelle local. Cela entraîne des conséquences inattendues compte tenu des marchés des parties des animaux capturés. Essayer d'interdire ou de contrôler le commerce peut conduire ces marchés à la clandestinité et même à augmenter les prix.

Le déclin alarmant de la pêche dans le monde exige de changer la façon dont les ressources sont gérées et la façon dont les gestionnaires traitent le comportement humain. Souvent, les correctifs évidents (plus de réglementation qui est inapplicable) aggravent les choses. Les gouvernements, les scientifiques, les ONG et les accords internationaux luttent constamment contre ce problème, et il est nécessaire de rompre avec le vieux paradigme et de créer de nouvelles approches dans les pêcheries capables de combler les lacunes dans la gestion des espèces capturées. Tous devraient se concentrer sur les politiques qui traitent des incitations économiques des êtres humains, plutôt que de se concentrer simplement sur le caractére alarmant du déclin .

La façon dont le comportement humain peut changer dépend de l'éducation. Pour générer des incitations appropriées pour les pêcheurs sur la base de meilleurs droits de récolte individuels et collectifs, il est nécessaire d'enseigner aux pêcheurs comment améliorer les droits de récolte individuels et collectifs et comment ils peuvent augmenter leurs revenus s'ils améliorent l'utilisation des ressources. Les incitations à développer ou à adopter de nouvelles façons de protéger la ressource favoriseront une utilisation économique et écologique durable de cette ressource.

En raison de l'utilisation excessive des interdictions commerciales en l'absence de politiques de conservation viables sur le terrain, les espèces menacées pourraient ne pas se remettre de leurs faibles quantités. Le tigre du Bengale est un exemple, les efforts du projet Tiger, financé par le gouvernement de l'Inde en 1973, “Project Tiger” ont confronté à un nouvel ensemble de problèmes. Il a sauvé le tigre du Bengale de l'extinction, mais plus de 20 ans après, il est clair que l'expansion des populations humaines, un nouveau mode de vie basé sur un mélange de différents modèles et l'effet sur les ressources naturelles ont créé de nouveaux problèmes pour le tigre. L'activisme et le braconnage ne font qu'ajouter au problème. C'est un moment critique et sérieux dans l'histoire de la conservation du tigre (MoEF, 1993) et des pangolins, la demande pour la médecine traditionnelle et les mets fins dans la culture asiatique sont énormes, d'où le prix élevé du marché noir, beaucoup de chasseurs et de commerçants. Plus de 30 000 pangolins ont été saisis depuis 2000, et les populations sont en déclin. Même avec l'interdiction sur le commerce (Pantel et Chin 2009).

En général, les interdictions commerciales peuvent sembler être un outil utile à court terme. Cependant, comme nous le voyons, cela peut aussi mener au braconnage à long terme et à la promotion du commerce de la faune sur le marché noir. D'autres stratégies, que nous avons soigneusement élaborées dans la section politique du mémoire, doivent être considérées. Enfin, les règlements ne peuvent pas être utilisés exclusivement à titre de punition, même dans des pays développés comme les États-Unis et l'Australie. Ces règlements doivent être complétés par une éducation et des moyens plus innovants pour inciter à les pêcheurs eux-mêmes dans la tâche difficile de prévenir l'extinction causée par la capture opportuniste.

ANNEXE

Annexe 1. Total data found.

	Price	Currency	Size (cm)	Size (mm)	COUNTRY	YEAR
1	4444,54	CAD	89,00	890,00	USA	2016
2	3637,85	CAD	66,00	660,00	USA	Unsold 2017
3	600,00	EUROS	121,00	1210,00	IRELAND	Unsold 2017
4	326,18	US	68,58	685,80	UK	2016
5	427,66	US	72,65	726,50	UK	2016
6	475,00	US	48,26	482,60	USA	2016
7	750,00	CAD	112,00	1120,00	UK	2016
8	1875,00	US	106,00	1060,00	UK	Unsold 2017
9	230,00	US	58,42	584,20	USA	2016
10	500,00	US	60,96	609,60	USA	Unsold 2017
11	675,00	US	43,18	431,80	USA	No info
12	600,00	US	60,96	609,60	USA	No info
13	550,00	US	63,50	635,00	USA	No info
14	2200,00	US	91,44	914,40	USA	No info
15	380,00	US	35,56	355,60	USA	No info
16	1700,00	US	83,83	838,30	USA	No info
17	1400,00	US	78,74	787,40	USA	No info
18	1500,00	US	60,96	609,60	USA	No info
19	400,00	US	48,26	482,60	USA	No info
20	1500,00	US	60,96	609,60	USA	No info
21	1200,00	US	68,58	685,80	USA	No info
22	1400,00	US	83,82	838,20	USA	No info
23	1300,00	US	78,74	787,40	USA	No info
24	388,00	US	45,72	457,20	USA	No info
25	382,00	US	45,72	457,20	USA	No info
26	475,00	US	48,26	482,60	USA	No info
27	475,00	US	50,80	508,00	USA	No info
28	400,00	US	35,56	355,60	USA	No info
29	39,00	US	7,62	76,20	USA	No info
30	38,66	CAD	5,58	55,80	USA	2016
31	1200,00	US	95,25	952,50	USA	Unsold
32	100,00	GBP	72,00	720,00	UK	2014
33	1342,00	US	73,60	736,00	USA	2011
34	1200,00	US	141,00	1410,00	AU	Unsold
35	396,90	US	61,00	610,00	AU	2015
36	198,00	US	105,00	1050,00	THAILAND	2015
37	1800,00	US	137,16	1371,60	USA	Unsold
38	2750,00	US	60,96	609,60	USA	Unsold
39	200,00	GBP	123,00	1230,00	UK	2015
40	800,00	GBP	129,54	1295,40	UK	No info
41	145,00	GBP	78,74	787,40	UK	2015
42	80,00	GBP	63,00	630,00	UK	2012
43	350,00	US	66,40	664,00	USA	Unsold 2008
44	194,47	US	50,80	508,00	UK	2016
45	80,00	GBP	58,00	580,00	UK	Unsold 2014
46	1800,00	US	105,00	1050,00	USA	Unsold 2015

	Price	Currency	Size (cm)	Size (mm)	COUNTRY	YEAR
47	320,00	GBP	125,00	1250,00	UK	Unsold 2015
48	741,00	EUROS	80,00	800,00	UK	2015
49	350,00	US	56,51	565,10	USA	Unsold 2016
50	177,50	US	81,28	812,80	USA	2014
51	180,38	US	63,50	635,00	USA	2016
52	875,00	US	93,98	939,80	USA	2016
53	298,95	US	52,70	527,00	USA	2016
54	247,50	US	73,66	736,60	USA	2016
55	444,55	US	74,30	743,00	USA	Unsold 2016
56	472,00	US	93,98	939,80	USA	2015
57	349,85	US	68,58	685,80	USA	2015
58	225,00	US	71,12	711,20	USA	2015
59	349,99	US	76,20	762,00	USA	2016
60	100,00	US	101,60	1016,00	USA	Unsold 2016
61	387,00	US	121,92	1219,20	USA	2015
62	3999,99	US	104,14	1041,40	USA	Unsold 2016
63	290,09	US	84,45	844,50	USA	2015
64	379,00	US	87,00	870,00	USA	2013
65	250,00	EUROS	95,00	950,00	BELGIUM	Unsold 2016
66	749,00	EUROS	100,00	1000,00	ITALY	2015
67	750,00	US	88,90	889,00	USA	No info
68	167,50	US	55,88	558,80	USA	2015
69	195,00	US	48,26	482,60	USA	2015
70	160,00	US	73,66	736,60	USA	2015
71	81,00	US	81,28	812,80	USA	2015
72	305,00	US	101,60	1016,00	USA	2015
73	2500,00	US	140,97	1409,70	USA	2015
74	327,00	US	12,70	127,00	USA	2015
75	687,00	US	121,92	1219,20	USA	2015
76	366,99	US	73,00	730,00	BELGIUM	2015
77	1000,00	US	80,01	800,10	USA	2015
78	295,00	US	119,38	1193,80	USA	2016
79	325,37	US	68,58	685,80	UK	2015
80	235,00	EUROS	81,28	812,80	UK	Unsold 2016
81	571,21	US	106,68	1066,80	UK	2016
82	150,00	EUROS	55,00	550,00	UK	2013
83	550,00	US	78,74	787,40	UK	Unsold 2014
84	199,00	US	41,91	419,10	BELGIUM	Unsold 2014
85	65,00	GBP	65,00	650,00	UK	2011
86	275,00	US	79,37	793,70	AU	2013
87	600,00	GBP	137,00	1370,00	UK	2011
88	1320,00	US	109,85	1098,50	PHILLIPINES	2007
89	420,00	GBP	32,00	320,00	UK	2010
90	2160,00	US	109,22	1092,20	BANGLADESH	2008
91	2800,00	CAD	86,36	863,60	ITALY	Unsold 2017
92	80,00	GBP	118,00	1180,00	UK	2012
93	70,00	GBP	101,00	1010,00	UK	2014
94	150,00	GBP	108,00	1080,00	UK	2016
95	12,00	GBP	47,00	470,00	UK	2013
96	500,00	US	109,22	1092,20	USA	2010
97	501,00	US	107,00	1070,00	USA	2015

	Price	Currency	Size (cm)	Size (mm)	COUNTRY	YEAR
98	850,00	US	96,52	965,20	USA	2006
99	250,00	US	26,67	266,70	USA	Unsold 2016
100	385,00	GBP	73,00	730,00	UK	2015
101	660,00	EUROS	111,00	1110,00	DEUTCHLAND	2015
102	200,00	EUROS	73,00	730,00	DEUTCHLAND	2012
103	1200,00	EUROS	119,00	1190,00	DEUTCHLAND	2005
104	100,00	EUROS	36,00	360,00	DEUTCHLAND	2005
105	189,00	EUROS	54,00	540,00	DEUTCHLAND	2014
106	56,00	EUROS	65,00	650,00	DEUTCHLAND	2015
107	1050,00	EUROS	110,00	1100,00	DEUTCHLAND	2008
108	800,00	EUROS	94,50	945,00	DEUTCHLAND	2008
109	500,00	EUROS	130,00	1300,00	DEUTCHLAND	2008
110	500,00	EUROS	76,50	765,00	DEUTCHLAND	2008
111	125,00	EUROS	115,00	1150,00	DEUTCHLAND	2016
112	215,00	EUROS	100,00	1000,00	DEUTCHLAND	2014
113	1100,00	EUROS	96,00	960,00	DEUTCHLAND	2013
114	366,57	US	91,44	914,40	UK	2017
115	456,07	US	105,41	1054,10	UK	2017
116	118,70	US	48,26	482,60	UK	2017
117	263,93	US	81,28	812,80	UK	2017
118	168,68	US	50,80	508,00	UK	2017
119	258,35	CAD	56,00	560,00	UK	Unsold 2017
120	2583,53	CAD	115,00	1150,00	UK	Unsold 2017
121	1050,00	EUROS	105,50	1055,00	DEUTCHLAND	2008
122	122,51	EUROS	57,00	570,00	DEUTCHLAND	2004
123	350,00	US	146,00	1460,00	AU	2003
124	105,00	US	71,00	710,00	AU	2003
125	120,00	US	74,50	745,00	AU	2003
126	120,00	US	74,50	745,00	AU	2003
127	100,00	US	70,00	700,00	AU	2003
128	1650,00	US	122,50	1225,00	USA	2006
129	2027,11	CAD	88,00	880,00	AU	Unsold 2017
130	200,00	US	132,08	1320,80	USA	2017
131	350,00	US	74,93	749,30	USA	2014
132	2,00	GBP	73,66	736,60	UK	Unsold 2002
133	2,00	GBP	71,12	711,20	UK	Unsold 2002
134	2,00	GBP	55,88	558,80	UK	Unsold 2002
135	20,00	GBP	58,42	584,20	UK	2017
136	2749,00	US	66,04	660,40	USA	Unsold 2017
137	400,00	EUROS	105,00	1050,00	DEUTCHLAND	No info
138	260,00	GBP	66,00	660,00	UK	2003
139	260,00	GBP	66,00	660,00	UK	2003
140	828,00	US	137,00	1370,00	UK	No info
141	800,00	US	12,70	127,00	UK	No info
142	1625,00	US	68,50	685,00	USA	2015
143	104,50	US	91,40	914,00	USA	2003
144	201,00	US	66,00	660,00	USA	2003
145	117,50	US	96,50	965,00	USA	2003
146	56,00	US	27,90	279,00	USA	2003
147	71,07	US	73,60	736,00	USA	2004
148	171,26	US	88,90	889,00	USA	2004

	Price	Currency	Size (cm)	Size (mm)	COUNTRY	YEAR
149	46,64	US	88,90	889,00	UK	2004
150	178,50	US	83,80	838,00	USA	2004
151	27,00	US	33,00	330,00	USA	2004
152	99,00	US	97,79	977,90	USA	2004
153	20,25	US	23,50	234,95	USA	2004
154	20,25	US	24,99	249,93	USA	2004
155	20,25	US	25,16	251,56	USA	2004
156	20,25	US	25,40	254,00	USA	2004
157	27,00	US	26,99	269,88	USA	2004
158	41,00	US	34,93	349,25	USA	2004
159	99,99	US	93,98	939,80	USA	2004
160	26,00	US	96,20	962,00	USA	2004
161	1295,00	US	149,86	1498,60	USA	2016
162	91,94	GBP	65,00	650,00	UK	2005
163	156,00	US	75,00	750,00	UK	2004
164	85,00	US	85,00	850,00	UK	2004
165	46,00	US	28,00	280,00	UK	2004
166	40,63	US	75,20	752,00	USA	2014
167	3750,00	EUROS	75,20	752,00	HOL	2007
168	7450,00	EUROS	44,00	440,00	HOL	2007
169	1875,00	EUROS	75,20	752,00	HOL	2007
170	2280,00	US	116,80	1168,00	USA	2003
171	308,00	EUROS	59,00	590,00	HOL	2003
172	308,00	EUROS	36,00	360,00	HOL	2003
173	308,00	EUROS	34,00	340,00	HOL	2003
174	235,00	GBP	1385,00	13850,00	UK	2002

Annexe 2. Analyzed data with DUMs and deflator

	Original Price	Currency	Real price (USD)	LN real price	Size (mm)	LNSIZE (mm)	CITES DUM 07	AUCTION HOUSES?	LN GDP	GDP (ppp per capita)	COUNTRY	YEAR	Real deflator	TREND	LN TREND	DUMCITES07 *LNTREND
1	4444,54	CAD	3114,405	8,044	890,00	6,791	1	1	10,996	59609,000	USA	2016	1,101	14	2,639	2,639
2	326,18	US	297,067	5,694	685,80	6,531	1	1	10,692	44001,000	UK	2016	1,098	14	2,639	2,639
3	427,66	US	389,490	5,965	726,50	6,588	1	1	10,692	44001,000	UK	2016	1,098	14	2,639	2,639
4	475,00	US	431,426	6,067	482,60	6,179	1	1	10,996	59609,000	USA	2016	1,101	14	2,639	2,639
5	750,00	CAD	526,976	6,267	1120,00	7,021	1	1	10,692	44001,000	UK	2016	1,098	14	2,639	2,639
6	230,00	US	208,901	5,342	584,20	6,370	1	0	10,996	59609,000	USA	2016	1,101	14	2,639	2,639
7	38,66	CAD	27,357	3,309	55,80	4,022	1	0	10,996	59609,000	USA	2016	1,101	14	2,639	2,639
8	100,00	GBP	134,688	4,903	720,00	6,579	1	1	10,615	40745,187	UK	2014	1,073	12	2,485	2,485
9	1342,00	US	1315,686	7,182	736,00	6,601	1	1	10,815	49781,801	USA	2011	1,020	9	2,197	2,197
10	198,00	US	137,596	4,924	1050,00	6,957	1	0	9,701	16340,029	THAILAND	2015	1,439	13	2,565	2,565
11	200,00	GBP	281,650	5,641	1230,00	7,115	1	1	10,641	41801,049	UK	2015	1,079	13	2,565	2,565
12	145,00	GBP	196,339	5,280	787,40	6,669	1	1	10,641	41801,049	UK	2015	1,079	13	2,565	2,565
13	80,00	GBP	112,819	4,726	630,00	6,446	1	1	10,532	37477,802	UK	2012	1,036	10	2,303	2,303
14	194,47	US	177,113	5,177	508,00	6,230	1	1	10,692	44001,000	UK	2016	1,098	14	2,639	2,639
15	741,00	EUROS	770,130	6,647	800,00	6,685	1	1	10,641	41801,049	UK	2015	1,079	13	2,565	2,565
16	177,50	US	165,116	5,107	812,80	6,700	1	0	10,907	54539,666	USA	2014	1,075	12	2,485	2,485
17	180,38	US	163,833	5,099	635,00	6,454	1	0	10,996	59609,000	USA	2016	1,101	14	2,639	2,639
18	875,00	US	794,732	6,678	939,80	6,846	1	0	10,996	59609,000	USA	2016	1,101	14	2,639	2,639
19	298,95	US	271,526	5,604	527,00	6,267	1	0	10,996	59609,000	USA	2016	1,101	14	2,639	2,639
20	247,50	US	224,796	5,415	736,60	6,602	1	0	10,996	59609,000	USA	2016	1,101	14	2,639	2,639
21	472,00	US	434,223	6,074	939,80	6,846	1	0	10,935	56115,718	USA	2015	1,087	13	2,565	2,565
22	349,85	US	321,849	5,774	685,80	6,531	1	0	10,935	56115,718	USA	2015	1,087	13	2,565	2,565
23	225,00	US	206,992	5,333	711,20	6,567	1	0	10,935	56115,718	USA	2015	1,087	13	2,565	2,565
24	349,99	US	317,884	5,762	762,00	6,636	1	0	10,996	59609,000	USA	2016	1,101	14	2,639	2,639
25	387,00	US	356,026	5,875	1219,20	7,106	1	0	10,935	56115,718	USA	2015	1,087	13	2,565	2,565
26	290,09	US	266,872	5,587	844,50	6,739	1	0	10,935	56115,718	USA	2015	1,087	13	2,565	2,565
27	379,00	US	358,902	5,883	870,00	6,768	1	0	10,848	51433,047	USA	2013	1,056	11	2,398	2,398
28	749,00	EUROS	763,602	6,638	1000,00	6,908	1	0	10,525	37217,384	ITALY	2015	1,066	13	2,565	2,565
29	167,50	US	154,094	5,038	558,80	6,326	1	0	10,935	56115,718	USA	2015	1,087	13	2,565	2,565
30	195,00	US	179,393	5,190	482,60	6,179	1	0	10,935	56115,718	USA	2015	1,087	13	2,565	2,565
31	160,00	US	147,194	4,992	736,60	6,602	1	0	10,935	56115,718	USA	2015	1,087	13	2,565	2,565
32	81,00	US	74,517	4,311	812,80	6,700	1	0	10,935	56115,718	USA	2015	1,087	13	2,565	2,565
33	305,00	US	280,589	5,637	1016,00	6,924	1	0	10,935	56115,718	USA	2015	1,087	13	2,565	2,565
34	2500,00	US	2299,908	7,741	1409,70	7,251	1	0	10,935	56115,718	USA	2015	1,087	13	2,565	2,565
35	327,00	US	300,828	5,707	127,00	4,844	1	0	10,935	56115,718	USA	2015	1,087	13	2,565	2,565
36	687,00	US	632,015	6,449	1219,20	7,106	1	0	10,935	56115,718	USA	2015	1,087	13	2,565	2,565
37	366,99	US	343,302	5,839	730,00	6,593	1	0	10,731	45757,458	BELGIUM	2015	1,069	13	2,565	2,565
38	1000,00	US	919,963	6,824	800,10	6,685	1	0	10,935	56115,718	USA	2015	1,087	13	2,565	2,565
39	295,00	US	267,938	5,591	1193,80	7,085	1	0	10,996	59609,000	USA	2016	1,101	14	2,639	2,639
40	325,37	US	301,548	5,709	685,80	6,531	1	0	10,641	41801,049	UK	2015	1,079	13	2,565	2,565
41	571,21	US	520,228	6,254	1066,80	6,972	1	1	10,692	44001,000	UK	2016	1,098	14	2,639	2,639
42	150,00	EUROS	197,727	5,287	550,00	6,310	1	1	10,573	39052,033	UK	2013	1,056	11	2,398	2,398
43	65,00	GBP	92,098	4,523	650,00	6,477	1	1	10,504	36456,002	UK	2011	1,020	9	2,197	2,197
44	600,00	GBP	850,167	6,745	1370,00	7,223	1	1	10,504	36456,002	UK	2011	1,020	9	2,197	2,197
45	1320,00	US	962,801	6,870	1098,50	7,002	1	1	8,497	4899,392	PHILIPPINES	2007	1,371	6	1,792	1,792
46	420,00	GBP	660,940	6,494	320,00	5,768	1	1	10,484	35740,737	UK	2010	1,000	8	2,079	2,079
47	2160,00	US	1881,533	7,540	1092,20	6,996	1	1	7,683	2171,630	BANGLADESH	2008	1,148	7	1,946	1,946
48	80,00	GBP	123,736	4,818	1180,00	7,073	1	1	10,532	37477,802	UK	2012	1,036	10	2,303	2,303
49	70,00	GBP	103,169	4,636	1010,00	6,918	1	1	10,615	40745,187	UK	2014	1,073	12	2,485	2,485
50	150,00	GBP	169,667	5,134	1080,00	6,985	1	1	10,692	44001,000	UK	2016	1,098	14	2,639	2,639
51	12,00	GBP	17,841	2,881	470,00	6,153	1	1	10,573	39052,033	UK	2013	1,056	11	2,398	2,398
52	292,80	US	292,800	5,679	1092,20	6,996	1	1	10,787	48374,087	USA	2010	1,000	8	2,079	2,079
53	501,00	US	460,902	6,133	1070,00	6,975	1	1	10,935	56115,718	USA	2015	1,087	13	2,565	2,565
54	850,00	US	907,150	6,810	965,20	6,872	0	1	10,746	46437,067	USA	2006	0,937	5	1,609	0,000
55	385,00	GBP	546,358	6,303	730,00	6,593	1	0	10,641	41801,049	UK	2015	1,079	13	2,565	2,565
56	660,00	EUROS	654,383	6,484	1110,00	7,012	1	0	10,780	48041,701	GERMANY	2015	1,086	13	2,565	2,565
57	200,00	EUROS	247,788	5,513	730,00	6,593	1	1	10,682	43564,148	GERMANY	2012	1,026	10	2,303	2,303
58	1200,00	EUROS	1641,392	7,403	1190,00	7,082	0	1	10,373	31968,467	GERMANY	2005	0,948	4	1,386	0,000
59	100,00	EUROS	136,783	4,918	360,00	5,886	0	1	10,373	31968,467	GERMANY	2005	0,948	4	1,386	0,000

	Original Price	Currency	Real price (USD)	LN real price	Size (mm)	LNSIZE (mm)	CITES DUM 07	AUCTION HOUSES?	LN GDP	GDP (ppp per capita)	COUNTRY	YEAR	Real deflator	TREND	LN TREND	DUMCITES07 *LNTREND
60	189,00	EUROS	240,789	5,484	540,00	6,292	1	0	10,760	47099,718	GERMANY	2014	1,065	12	2,485	2,485
61	56,00	EUROS	57,762	4,056	650,00	6,477	1	0	10,780	48041,701	GERMANY	2015	1,086	13	2,565	2,565
62	1050,00	EUROS	1709,621	7,444	1100,00	7,003	1	1	10,546	38028,772	GERMANY	2008	0,975	7	1,946	1,946
63	800,00	EUROS	1290,010	7,162	945,00	6,851	1	1	10,546	38028,772	GERMANY	2008	0,975	7	1,946	1,946
64	500,00	EUROS	806,256	6,692	1300,00	7,170	1	1	10,546	38028,772	GERMANY	2008	0,975	7	1,946	1,946
65	500,00	EUROS	806,256	6,692	765,00	6,640	1	1	10,546	38028,772	GERMANY	2008	0,975	7	1,946	1,946
66	125,00	EUROS	128,721	4,858	1150,00	7,048	1	0	10,816	49815,000	GERMANY	2016	1,102	14	2,639	2,639
67	215,00	EUROS	270,235	5,599	1000,00	6,908	1	0	10,760	47099,718	GERMANY	2014	1,065	12	2,485	2,485
68	1100,00	EUROS	1406,338	7,249	960,00	6,867	1	0	10,720	45273,101	GERMANY	2013	1,046	11	2,398	2,398
69	366,57	US	333,852	5,811	914,40	6,818	1	1	10,756	46906,392	UK	2017	1,098	15	2,708	2,708
70	456,07	US	415,364	6,029	1054,10	6,960	1	1	10,756	46906,392	UK	2017	1,098	15	2,708	2,708
71	118,70	US	108,106	4,683	482,60	6,179	1	1	10,756	46906,392	UK	2017	1,098	15	2,708	2,708
72	263,93	US	240,373	5,482	812,80	6,700	1	1	10,756	46906,392	UK	2017	1,098	15	2,708	2,708
73	168,68	US	153,625	5,035	508,00	6,230	1	1	10,756	46906,392	UK	2017	1,098	15	2,708	2,708
74	122,51	EUROS	172,887	5,153	570,00	6,346	0	0	10,356	31439,583	GERMANY	2004	0,942	3	1,099	0,000
75	350,00	US	499,287	6,213	1460,00	7,286	0	0	10,299	29691,535	AU	2003	0,701	2	0,693	0,000
76	105,00	US	149,786	5,009	710,00	6,565	0	0	10,299	29691,535	AU	2003	0,701	2	0,693	0,000
77	120,00	US	171,184	5,143	745,00	6,613	0	0	10,299	29691,535	AU	2003	0,701	2	0,693	0,000
78	120,00	US	171,184	5,143	745,00	6,613	0	0	10,299	29691,535	AU	2003	0,701	2	0,693	0,000
79	100,00	US	142,653	4,960	700,00	6,551	0	0	10,299	29691,535	AU	2003	0,701	2	0,693	0,000
80	1650,00	US	1760,939	7,474	1225,00	7,111	0	0	10,746	46437,067	USA	2006	0,937	5	1,609	0,000
81	200,00	US	181,653	5,202	1320,80	7,186	1	1	11,278	79026,214	USA	2017	1,101	15	2,708	2,708
82	350,00	US	325,581	5,786	749,30	6,619	1	0	10,907	54539,666	USA	2014	1,075	12	2,485	2,485
83	20,00	GBP	23,570	3,160	584,20	6,370	1	1	10,756	46906,392	UK	2017	1,098	15	2,708	2,708
84	260,00	GBP	519,565	6,253	660,00	6,492	0	1	10,306	29898,236	UK	2003	0,850	2	0,693	0,000
85	260,00	GBP	519,565	6,253	660,00	6,492	0	1	10,306	29898,236	UK	2003	0,850	2	0,693	0,000
86	1625,00	US	1494,940	7,310	685,00	6,529	1	1	10,935	56115,718	USA	2015	1,087	13	2,565	2,565
87	104,50	US	122,079	4,805	914,00	6,818	0	0	10,589	39677,198	USA	2003	0,856	2	0,693	0,000
88	201,00	US	234,813	5,459	660,00	6,492	0	0	10,589	39677,198	USA	2003	0,856	2	0,693	0,000
89	117,50	US	137,266	4,922	965,00	6,872	0	0	10,589	39677,198	USA	2003	0,856	2	0,693	0,000
90	56,00	US	65,421	4,181	279,00	5,631	0	0	10,589	39677,198	USA	2003	0,856	2	0,693	0,000
91	71,07	US	80,761	4,391	736,00	6,601	0	0	10,644	41921,810	USA	2004	0,880	3	1,099	0,000
92	171,26	US	194,614	5,271	889,00	6,790	0	0	10,644	41921,810	USA	2004	0,880	3	1,099	0,000
93	46,64	US	53,606	3,982	889,00	6,790	0	0	10,361	31617,612	UK	2004	0,870	3	1,099	0,000
94	178,50	US	202,841	5,312	838,00	6,731	0	0	10,644	41921,810	USA	2004	0,880	3	1,099	0,000
95	27,00	US	30,682	3,424	330,00	5,799	0	0	10,644	41921,810	USA	2004	0,880	3	1,099	0,000
96	99,00	US	112,500	4,723	977,90	6,885	0	0	10,644	41921,810	USA	2004	0,880	3	1,099	0,000
97	20,25	US	23,011	3,136	234,95	5,459	0	0	10,644	41921,810	USA	2004	0,880	3	1,099	0,000
98	20,25	US	23,011	3,136	249,93	5,521	0	0	10,644	41921,810	USA	2004	0,880	3	1,099	0,000
99	20,25	US	23,011	3,136	251,56	5,528	0	0	10,644	41921,810	USA	2004	0,880	3	1,099	0,000
100	20,25	US	23,011	3,136	254,00	5,537	0	0	10,644	41921,810	USA	2004	0,880	3	1,099	0,000
101	27,00	US	30,682	3,424	269,88	5,598	0	0	10,644	41921,810	USA	2004	0,880	3	1,099	0,000
102	41,00	US	46,591	3,841	349,25	5,856	0	0	10,644	41921,810	USA	2004	0,880	3	1,099	0,000
103	99,99	US	113,625	4,733	939,80	6,846	0	0	10,644	41921,810	USA	2004	0,880	3	1,099	0,000
104	26,00	US	29,545	3,386	962,00	6,869	0	0	10,644	41921,810	USA	2004	0,880	3	1,099	0,000
105	1295,00	US	1176,203	7,070	1498,60	7,312	1	0	10,996	59609,000	USA	2016	1,101	14	2,639	2,639
106	91,94	GBP	194,597	5,271	650,00	6,477	0	0	10,382	32274,765	UK	2005	0,894	4	1,386	0,000
107	156,00	US	179,310	5,189	750,00	6,620	0	0	10,361	31617,612	UK	2004	0,870	3	1,099	0,000
108	85,00	US	97,701	4,582	850,00	6,745	0	0	10,361	31617,612	UK	2004	0,870	3	1,099	0,000
109	46,00	US	52,874	3,968	280,00	5,635	0	0	10,361	31617,612	UK	2004	0,870	3	1,099	0,000
110	40,63	US	37,791	3,632	752,00	6,623	1	0	10,907	54539,666	USA	2014	1,075	12	2,485	2,485
111	3750,00	EUROS	5604,756	8,631	752,00	6,623	1	1	10,680	43462,049	NETHERLANDS	2007	0,963	6	1,792	1,792
112	308,00	EUROS	413,041	6,024	340,00	5,829	0	1	10,425	33701,440	NETHERLANDS	2003	0,809	2	0,693	0,000
113	235,00	GBP	414,060	6,026	1385,00	7,233	0	1	10,262	28630,368	UK	2002	0,830	1	0,000	0,000
114	396,90	US	396,900	5,984	610,00	6,413	1	0	10,742	46270,799	AU	2015	1,000	13	2,565	2,565
115	275,00	US	276,939	5,624	793,70	6,677	1	1	10,727	45574,633	AU	2013	0,993	11	2,398	2,398

Annexe 3. Results for the F-test of the Goldfeld-Quandt for Regression 1

		Regression Statistic				
Multiple R	0,649					
R Square	0,421					
Adjusted R Square	0,341					
Standard Error	0,574					
Observations	34					
		ANOVA				
	df	***SS***	***MS***	***F***	***Significance F***	
Regression	4	6,953	1,738	5,277	0,003	
Residual	29	9,554	0,329			
Total	33	16,507				
	Coefficient	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***
Intercept	0,804	1,335	0,603	0,551	-1,926	3,535
LNSIZE	0,607	0,165	3,679	0,001	0,270	0,944
CITES DUM	0,155	0,281	0,550	0,586	-0,420	0,730
Real GDP	0,000	0,000	-0,916	0,367	0,000	0,000
Auction houses DUM	0,031	0,287	0,109	0,914	-0,556	0,618
		Regression Statistics				
Multiple R	0,368					
R Square	0,135					
Adjusted R Square	0,058					
Standard Error	0,690					
Observations	50					
		ANOVA				
	df	***SS***	***MS***	***F***	***Significance F***	
Regression	4	3,344	0,836	1,757	0,154	
Residual	45	21,404	0,476			
Total	49	24,748				
	Coefficients	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***
Intercept	3,307	1,690	1,957	0,057	-0,097	6,711
LNSIZE	0,480	0,233	2,061	0,045	0,011	0,948
CITES DUM	-0,033	0,296	-0,111	0,912	-0,630	0,564
Real GDP	0,000	0,000	-0,414	0,681	0,000	0,000
Auction houses DUM	0,265	0,217	1,217	0,230	-0,173	0,703
		TEST= 1.494; F= 1.74				

Annexe 4. Results of multicollinearity T- test.

	LN real price	LNSIZE	CITES DUM	Real GDP	Auction houses DUM
LN real price					
LNSIZE	6,731				
CITES DUM	4,119	2,300			
Real GDP	0,311	-0,415	5,489		
Auction houses DUM	3,521	1,770	3,330	-2,301	

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