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REVIEW OF AI-BASED TECHNIQUES TO DETECT OVERFISHING AND ILLEGAL, UNREPORTED, AND UNREGULATED (IUU) FISHING PRACTICES

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ABSTRACT
Fishing has been an integral part of the human race since the prehistoric age. Approximately more than 80 million tons of seafood is provided annually. Fishing has been shifted as an economic commodity and more than half of today's fishery stocks are in decline or overexploited [1]. Usual fishing activities don't burden the environment when done in moderation but can easily lead to Overfishing when it is done at a rate faster than the fish populations can reproduce. On the other hand, the term Illegal, Unreported, and Unregulated (IUU) is used to describe a fishing activity that violates any regional, national, or international fisheries law. The solution to the above problems lies in sustainable fishing that is catching fish in a way that does not harm the environment or deplete fish populations beyond their ability to recover. AI has the potential to help maintain sustainability in fishing by providing tools and techniques for monitoring and managing fish populations, tracking fishing activities, and reducing bycatch. Through this paper we present a survey of the literature that highlights the techniques and approaches used by researchers to Detect Overfishing and Illegal, Unreported, and Unregulated (IUU) Fishing Practices. The intention of this survey is to explore the potential of Artificial Intelligence (AI) in the context of fish stock assessment. The study's outcomes can contribute to the development of more effective and sustainable fisheries management strategies, as they will provide valuable insights into changes in fish populations.

Keywords: Overfishing, IUU (Illegal, Unreported and Unregulated) Fishing, Sustainable Fishing, Fish Stock Assessment, Fish Traceability, Fish Monitoring

I. Introduction
Overfishing has become one of the major reason of declines in oceanic wildlife populations, with fishing activities leading to a negative impact on the environment and the depletion of fish populations beyond their ability to recover. The solution to this problem lies in maintaining sustainable fishing, which involves catching fish in a way that does not harm the environment or depleting fish populations beyond their ability to recover. Sustainable fishing guarantees there will be populations of ocean and freshwater wildlife for the future. This method requires fishing in a way that allows fish populations to replenish naturally, while minimizing the impact on the ecosystem. However, achieving sustainable fishing is not an easy task, sustainability of marine fisheries has become a global concern because of the rapid increase in fishing pressure which may cause negative consequences for the ecosystem and the society, the situation is worse in particularly in developing countries where it lacks proper management tools [2].
In recent years, Artificial Intelligence (AI) has emerged as a potential solution to help address the issue of sustainable fishing. AI has the potential to provide tools and techniques for monitoring and managing fish populations, tracking fishing activities, and reducing bycatch. The study's outcomes can contribute to the development of more effective and sustainable fisheries management strategies by providing valuable insights into changes in fish populations. An effective management plan that encompasses various management tools can help overcome pervasive illegal fishing. This research thesis will identify the strengths and limitations of using AI for detecting illegal fishing, which can help pave the way for the development of new and innovative methods for sustainable fishing.

In this paper, we will provide an overview of the current state of fishing practices and their impact on the environment by also providing some statistics indicating the increase of Illegal fishing. We will then discuss the concept of sustainable fishing and the challenges associated with achieving it. Finally, we will outline the objectives of this thesis through our observations and discussions and provide an overview of the research methodology used in this study. All the findings of this thesis are backed by a thorough literature survey conducted which includes research papers, reports and articles.

1.1 Overfishing

The overexploitation of the world's fisheries has become a significant concern in recent times. Despite an increase in global production of fish and fishery products, there has been a stagnation in the harvest from capture fisheries in the last ten years. This has resulted in a decline of several fish stocks and species from their peak levels, and even some have collapsed, leading to a pressing need for stricter management and the creation of protected areas [3].

1.2 IUU (Illegal, Unreported and Unregulated) Fishing

1.2.1 Illegal

Illegal fishing refers to the act of national or foreign vessels engaging in activities within the waters under a State's jurisdiction without the necessary permission or in violation of the State's laws and regulations [4]. Data gathered through surveillance, surveys, and sensitive methodologies, as well as expert opinion, have all been utilized to gain insight into illegal fishing. Additionally, researchers have created techniques to merge various datasets and conduct stock assessments [5]. Illegal fishing poses a significant threat not only to financial stability but also to sustainable ocean management, the future of fishing, and global food security. Unfortunately, estimating the full scope of illegal, unreported, and unregulated (IUU) fishing is a challenging task, meaning that the impact of such activities are often overlooked when assessing fish stock conditions. Illegal fishing is more common in areas where the likelihood of prosecution is low due to limited financial resources of coastal states to effectively monitor their territorial waters [6].

1.2.2 Unreported

Unreported fishing is characterized by fishing activities that have been either misreported or not reported at all to the relevant national authority, which violates national laws and regulations [4].

1.2.3 Unregulated

Unregulated fishing occurs in regions where a relevant regional fisheries management organization is in effect, but fishing activities are conducted by vessels without a nationality or by those flying a flag of a non-member state, or by a fishing entity that does not comply with the conservation and management measures of that organization. Additionally, unregulated fishing also takes place in areas where there are no conservation or management measures applicable to the targeted fish stocks [4].

II. Literature

In the financial year 2020, the fish catch volume in India was about 12 million metric tons. Among the various disposition channels, marketing of fresh fish had the highest volume that year.

- The fish catch volume in India has generally been increasing over the years, with some fluctuations. The catch volume has more than doubled from 5.39 million metric tons in FY 2000 to 12.18 million metric tons in FY 2020.
- The year FY 2012 saw an unusual spike in fish catch volume to 14.47 million metric tons, which is more than double the previous year's volume.
- There are some years where the fish catch volume has decreased slightly, such as FY 2014, but the overall trend shows an increase in the catch volume.

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- Overall, the data indicates that the fish catch volume in India has been steadily increasing over the years, with some fluctuations.

Statistics of Illegal Fishing

- The detrimental effects of illegal and unreported fishing activities are evident in the overexploitation of fish stocks and the hindrance to the recovery of fish populations and ecosystems. This study displays the first worldwide analysis of such activities over the past two decades, revealing a noteworthy correlation between governance and the prevalence of illegal fishing. The illegal and unreported fishing industry generates income for lawbreakers while simultaneously taking away profits from legitimate fishermen and management authorities.
- Variations in the amount of illegal and unreported catch, as well as changes in catch trends, were observed across different regions. The Eastern Central Atlantic (Area 34) recorded the highest levels of illegal and unreported fishing, while the Southwest Pacific (Area 81) had the lowest levels, as outlined in Table 1.

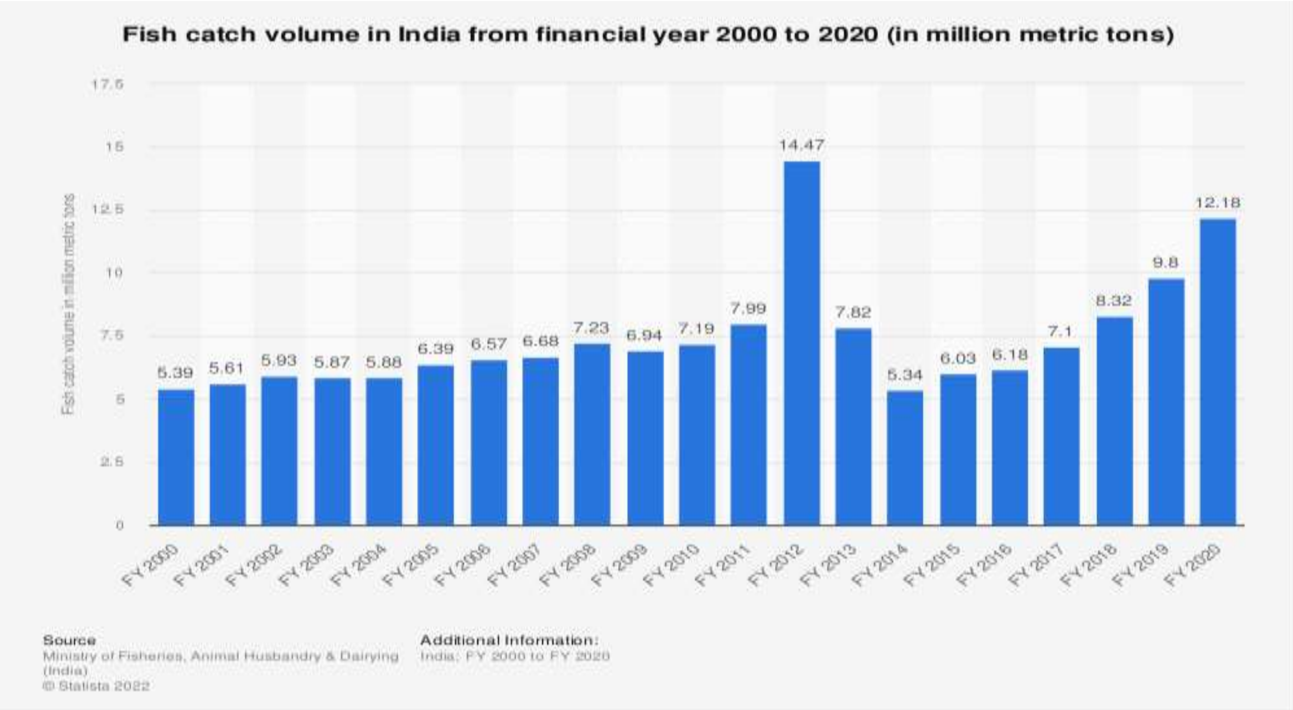

Figure 1. Fish catch volume in India from financial year 2000 to 2020 (in million metric tons) [7]

Expectedly, fish species with high value such as demersal fish, lobsters, and shrimps/prawns have the highest levels of illegal fishing, as depicted in Table 1. However, it may appear surprising that the proportion of illegal catch is relatively low for tunas. This is largely because the majority of tuna

Region	Reported catch of case study species	Catch of case study species as a percentage of total regional catch	Lower estimate of illegal catch (t)	Upper estimate of illegal catch (t)	Lower estimate of value (US$m)	Upper estimate of value (US$m)
Northwest Atlantic	557,147	25%	22,325	82,266	20	74
Northeast Atlantic	6,677,607	60%	364,908	842,467	328	758
Western Central Atlantic	390,942	22%	21,745	58,514	20	53
Eastern Central Atlantic	1,154,586	32%	294,089	562,169	265	506
Southwest Atlantic	1,403,601	65%	227,865	673,712	205	606
Southeast Atlantic	1,351,635	79%	52,972	139,392	48	125
Western Indian	2,165,792	52%	229,285	559,942	206	504
Eastern Indian	2,263,158	44%	467,865	970,589	421	874
Northwest Pacific	7,358,470	32%	1,325,763	3,505,600	1,193	3,155
Northeast Pacific	196,587	7%	2,326	8,449	2	8
Western Central Pacific	3,740,192	36%	785,897	1,729,588	707	1,557
Eastern Central Pacific	1,374,062	73%	129,772	278,450	117	251
Southwest Pacific	451,677	61%	5,227	32,848	5	30
Southeast Pacific	9,799,047	73%	1,197,547	2,567,890	1,078	2,311
Antarctic	136654	100%	9593	9593	9	9
Total	**39,021,155**	**46%**	**5,140,928**	**12,040,052**	**4,627**	**10,836**

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Figure 2. Displays a summary of the estimates for illegal fishing in different regions, which have been averaged over the period of 2000 to 2003.

catches occur within the areas of Regional Fisheries Management Organizations (RFMOs), where the smaller amounts of unreported fishing are typically associated with large volume catches, such as yellowfin and bigeye tuna. Furthermore, in some regions such as the Inter-American Tropical Tuna Commission and the Indian Ocean Tuna Commission, unreported catches of tunas have now become minimal.

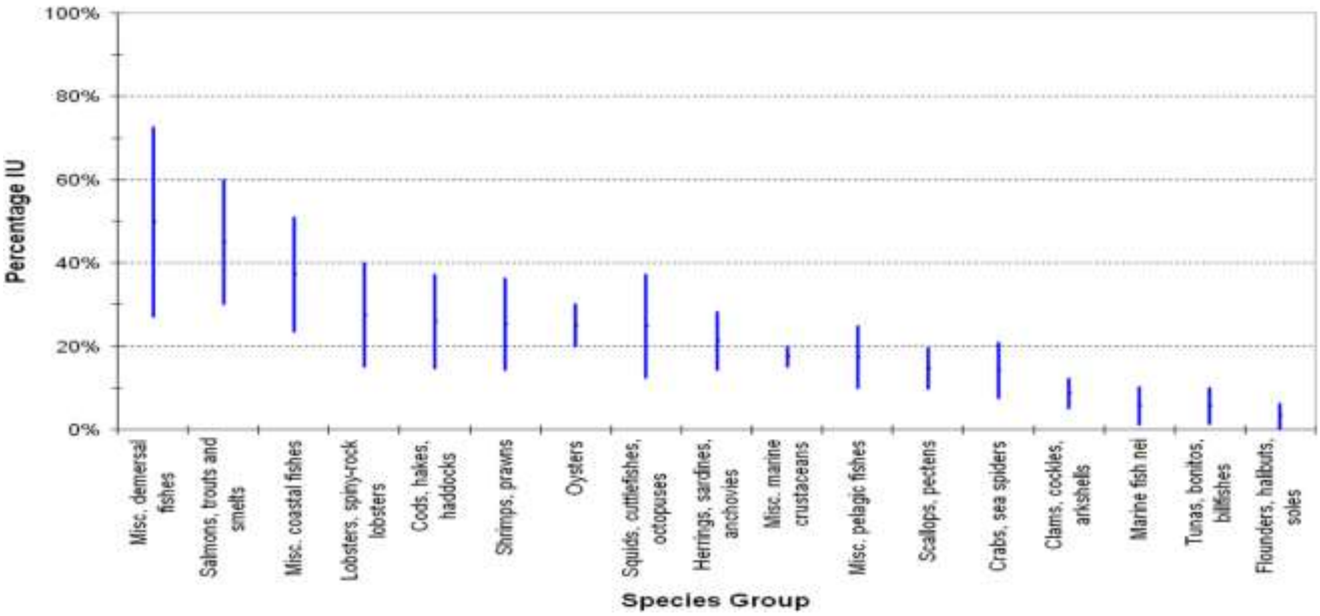

Fig 3. Illegal and Unreported catch, expressed as a percentage of reported catch, by species group 2000-2003 [8]

The chart presented in Figure 2 shows the percentage of illegal and unreported catch as compared to reported catch by species group, covering the period from 2000 to 2003. The upper and lower estimates are provided [8].

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To support our research, we have presented a comprehensive literature review on various research papers that have utilized AI-based techniques, which are grouped, based on their respective methods. The review papers encompass a diverse range of AI-based techniques such as Fish Traceability, Monitoring, Stock Assessment, Identification and others.

2.1 Fish Traceability

Nga Mai et al. (2010) [9] proposed in the case-based study have used methodologies like surveys, case studies of the selected actors, methods of CBA and data analysis to produce Qualitatively perceived benefits of traceability and also added cost-benefit analyses (CBAs) of adopting new traceability systems are conducted for two firms, operating at different steps of the seafood supply chains and on how cost and benefits are distributed among the actors. JoséOliveiraa et al. (2021) [10] discusses seafood traceability using food supply chain traceability, this research process is structured according to the Design Science Research (DSR) methodology, which is aimed at research problems with unstable requirements and complex interactions. The study shows the development of an application by starting with modeling the value chain, then we design the platform architecture, next the platform is fed with traceability information, then to retrieve traceability information we will make use of ValorMar platform, lastly the traceability platform deployment and validation is conducted thus the research concludes that it is mandatory to stare information in a value chain to maintain quality when it comes to food products, also middleware platform have been utilized during the architecture design phase to have the ease of extensibility of the knowledge base. Labonnah Farzana Rahman et al. (2021) [11] takes the approach of RFID based traceability systems in safe fisheries supply chain management, radio frequency identification (RFID) are being used to trace and assess the safety of fresh and processed food in the supply chain process. RFID is particularly popular due to its mobility, inventory accuracy, increased security and traceability, and real-time information through unique electronic product codes. Further on how different technologies of traceability are used in different applications their advantages and references have been discussed in an organized manner. Pratyush Kuman Patro et al. (2022) [12] focuses on efficient traceability management for managing products in the fishery supply chain to prevent food fraud that could harm consumer health. This paper proposes a private Ethereum blockchain-based solution for managing the fishery supply chain in a decentralized, transparent, traceable, secure, private, and trustworthy manner. The solution architecture includes five smart contracts to automate processes in the fishery supply chain, and ten algorithms with full implementation, testing, and validation details. The proposed solution is secure and trustworthy, and is compared to existing blockchain and non-blockchain-based solutions to demonstrate its effectiveness and novelty.

2.2 Fish Monitoring

Agnew, D. J et al. (2004) [13] report contains building a framework around the economic aspects of IUU fishing, the report addresses the economic and social issues of IUU/FOC fishing operations, the term Flag of Convenience(FOC) refers to a state that is willing to have a vessel on its national register without undertaking fully its obligations to exert Flag State jurisdiction and control lastly they review the economic and social impacts of IUU fishing, and how they might be monitored. J. David Allan et al. (2005) [3] research paper provides information with Overfishing as a major problem in both marine and inland waters, causing the decline of many fish stocks and species. It is driven by factors such as increasing demand for fish, improved fishing technology, and inadequate fisheries management. Inland fisheries, which capture wild stocks of freshwater fish, provide livelihoods and contribute to the global food supply, particularly in developing countries. To address overfishing in inland waters, it is necessary to improve fisheries management and establish protected areas. Techniques used to address overfishing include implementing catch limits, establishing marine protected areas, and regulating fishing gear and methods. Nicolas Longepe et al. (2018) [14] the research paper talks about identification of illegal fishing activities in Indonesia and detection of it with the help of Automatic Identification System (AIS). G.J. Edgar et al. (2007) [15] research paper shows the procedure of Marine protected areas (MPAs) of the ocean that are designated for the

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protection and conservation of marine biodiversity. They are often established in response to threats such as overfishing and other human activities that can negatively impact marine ecosystems. MPAs can have a variety of goals, including the protection of threatened species, the conservation of biodiversity, and the recovery of depleted species. It is important to clearly define the goals of an MPA when it is established in order to determine its effectiveness. MPAs can also have unintended effects, such as the indirect impact on species through interactions at different trophic levels. It is important to carefully monitor and study MPAs to understand their impact and to adapt management strategies as needed. MPAs can be an effective tool in marine conservation, but they must be used in conjunction with other approaches.

2.3 Fish Identification

Buncha Chuaysi et al. (2020) [16] exhibits in their study, a new technique proposed for identifying the behavior of fishing vessels using data from the Automatic Identification System (AIS) and vessel monitoring system (VMS). The technique involves extracting local features of time series data and transforming the trajectory patterns into global features for use in deep learning. The proposed method is applied to AIS and VMS data from Thai fishing vessels, and behaviors are classified as fishing, non-fishing, and transshipment. The method is shown to have an average accuracy of 97.50%. It is suggested that this concept could be used to address the problem of illegal, unreported, and unregulated fishing (IUU fishing) and enable traceability in the seafood supply chain. The technique involves extracting points of interest (POI) from the trajectory data and calculating the turning angles at these points. The POI and turning angles are then used to create a global feature representation of the trajectory, which is used to classify the vessel behavior. Bejawada Chanikya Naidu et al. (2022) [17] has written the following research paper on how AI can be utilized for fish identification in machine learning as it can be used for virtually unlimited amounts of training data for a given problem. They have mentioned different applications of AI in different domains of the fishery sector in an organized manner and have showcased examples of whale and coral reef identification. Shilavadra Bhattacharjee (2022) [18] showcased that Automatic Identification System (AIS) a tracking system that displays other nearby vessels on a ship's screen and shows the ship on the screens of other nearby vessels. It operates using a VHF transponder system and is required to be on at all times, unless the ship's master determines that it should be turned off for security reasons. There are two types of AIS: Class A, which is required for all SOLAS vessels, and Class B, which has limited functionality and is primarily used for non-SOLAS vessels such as pleasure crafts. The data transmitted by AIS includes the vessel's identification, position, course, and speed, as well as information about the vessel's dimensions, type, and cargo. AIS can be used as a surveillance tool and as an aid in collision avoidance and also useful in detecting illegal activity.

2.4 Fish Stock Assessment

Andre Punt et al. (1997) [19] the research paper provides an overview of the Bayesian approach to fisheries stock assessment and decision analysis. It discusses the importance of conducting stock assessments to evaluate the consequences of alternative management actions, and how the Bayesian approach can incorporate expert judgment and data from other species or stocks to assign probabilities to alternative hypotheses in a general and complete manner. The file also covers the advantages and disadvantages of using this approach, as well as future data collection and analysis requirements for making Bayesian assessments more useful. Finally, it provides suggestions based on experience applying the techniques discussed. Per Sparre et al. (1998) [20] follows the approach in the manual with a review of stock assessment in detail along with calculations with special emphasis placed on methods based on the analysis of length-frequencies, it introduces statistics and covers the estimation of growth parameters and mortality rates and also includes virtual population methods including age based, length based, gear selectivity, sampling prediction models analysis. Emygdio L. Cadima (2003) [21] book starts with an introduction to the mathematical models applied in Fish stock assessment and some considerations on the importance of fisheries. The basic assumptions about a model and the concepts of different variation rates of a characteristic in relation to time are presented, with regard to fishing resources the discussion is focused on the biological reference points. D.D. Hoggarth et al. (2006) [22] research paper showcases the process of Fishery management systems aim to ensure sustainable and responsible use of marine resources through a variety of activities such as governance, management procedures, scientific advice, compliance measures, and monitoring. The process of stock assessment has been explained in detail whether is it qualitative or quantitative, does it allow uncertainty or is the assessment based on age or length. (2012) [23] mentions Fish Stock Assessment 101 series, by presenting the three primary types of data used in fish stock assessments—catch, abundance, and biology data. These three types of data feed into mathematical models that represent the factors causing changes in harvested fish stocks. The models produce estimates of the fishery management factors needed for managers to make informed decisions about how to best regulate a fishery. When possible, stock assessment models include information on ecosystem and environmental effects to improve the interpretation of historical information and the precision of forecasts. E. Vivekanandan (2017) [24] research paper is about the Summer School on Advanced Methods for Fish Stock Assessment and Fisheries Management. It discusses the concept and objectives of stock assessment, which is important in managing fisheries resources. The file also mentions the complexities in assessing tropical fish stocks and provides suggested reading materials for further information. However, it does not provide a summary of all the topics covered in the Summer School program or its location and duration. Colm J. Fitzgerald et al. (2018) [25] discusses the contrast between data-rich fish stocks in temperate zones and data-poor stocks in tropical waters, and the economic constraints on data collection that contribute to this divergence. The paper also highlights accessible data-poor assessment approaches that may be applicable in diverse inland systems, with a case study application using archived length, catch and catch-per-unit-effort data to characterize the ecological status of an important recreational brown trout stock in an Irish lake. The broader purpose of the paper is to provide a crossover between marine and inland fisheries science, and to highlight the importance of inland fisheries to numerous rural communities. Arnaud Helias (2019) [26] proposes how assessing the state of fish stocks requires the determination of descriptors. They correspond to the absolute and relative (to the carrying capacity of the habitat) fish biomasses in the ecosystem, and the absolute and relative (to the intrinsic growth rate of the population) fishing mortality resulting from catches. This allows, among other things, to compare the catch with the maximum sustainable yield. Some fish stocks are well described and monitored, but for many data-limited stocks, catch time series are remaining the only source of data. Recently, an algorithm (CMSY) has been proposed, allowing an estimation of stock assessment variables from catch and resilience. Qingpeng Han et al. (2021) [27] the article is about data-limited stock assessment for fish species devoid of catch statistics, using case studies for Pampus argenteus and Setipinna taty in the Bohai and Yellow Seas. The authors developed a Bayesian hierarchical model to estimate the population parameters of these two species, using data from fishery-independent surveys. They found that the model provided reliable estimates of the population parameters, despite the lack of catch data. The results suggest that this approach could be useful for managing and conserving other data-limited fish stocks in the region. Daniel Ovando et al. (2021) [28] proposal provides an overview of the importance of catch data in managing fisheries, particularly in cases where formal stock assessments are lacking due to insufficient data. The Food and Agriculture Organization (FAO) maintains a global database of fisheries landings that includes over 20,000 individual catch histories by FAO statistical region, country and taxon. The file also discusses various "catch-only" models that estimate aspects of stock status based primarily on characteristics of a fishery's catch history. Additionally, the RAM Legacy Stock Assessment Database (RLSADB) is introduced as a resource for conducting stock assessments. Ubair Nisar et al. (2021) [29] discusses a study that assesses the sustainability of five major exploited tuna species in India's Eastern and Western Indian Ocean using the Monte Carlo Method and the Bayesian Schaefer Model. The study reveals that all tuna stocks in both regions are overfished, with longtail tuna fishery being strongly overfished in the Western Indian Ocean Region.

The study aims to provide a sustainable approach to managing tuna fisheries in the region. (2022) [30] talks about NOAA Fisheries completed 177 stock assessments in fiscal year 2022, including 73 assessments of FSSI (federal statutory species of importance) stocks and 104 assessments of non-FSSI stocks. The West Coast and Alaska regions typically complete the most assessments each year due to the high number of salmon and groundfish stocks in those regions. Stock assessments evaluate various aspects of fish biology that affect a stock's current and future condition, including abundance, reproduction and growth, and mortality. NOAA Fisheries uses several different models to conduct stock assessments, including data-limited, index-based, aggregate biomass dynamics, virtual population dynamics, statistical catch-at-length, and statistical catch-at-age methods. The type of model used depends on the data available and the level of complexity needed for the assessment. Stock assessment results are used to inform management decisions and set catch limits to ensure the long-term sustainability of fish stocks.

2.5 Machine Vision

Graham G. Monkman et al. (2019) [31] in this research used machine vision and regional convolutional neural networks (R-CNNs) to estimate the total length of European sea bass from images. The R-CNNs were trained on public images and tested on images captured with non-specialist cameras. The method was able to accurately predict the location of the fish and estimate its length, with a mean bias error of 2.2%. The method was robust to horizontal flipping and downsampling of the images, but became less accurate at higher levels of image rotation.

2.6 Deep Convolutional Neural Network

Joseph S Iwin Thanakumar et al. (2019) [32] the research paper describes the use of deep convolutional neural networks (CNNs) for automatic detection of ships in satellite images. The authors compare the performance of the deep learning algorithm to a state-of-the-art method and find that the CNNs provide excellent accuracy in classifying ships in satellite images, even in complex background environments. The authors suggest that deep learning algorithms, which do not require manual feature extraction, could be an effective tool for classifying objects in satellite images. The research was published in a conference in 2018 and added to IEEE Xplore in 2019.

2.7 Precision Fisheries

Philip Christani et al. (2019) [33] showcases the use of advanced analytics, including the collection and interpretation of big data, may provide a solution to the issue of declining fish populations and overfishing in the fishing industry. Advanced analytics, including precision fishing techniques, can decrease operating costs and improve the management of ocean resources, potentially increasing industry profits and fish biomass. The adoption of these technologies is being aided by increased awareness and understanding of their benefits, as well as a sense of urgency due to diminishing fish stocks. The article discusses various use cases for advanced analytics in the fishing industry and provides a guide for next steps for stakeholders.

III. Observations

The following observations are made based on the extensive survey done on papers published.

3.1 Types of method used

Figure 4 displays an infographic based on different methods used by researchers to address the issue of illegal and unsustainable fishing. The surveyed papers have been grouped together based on different AI process and techniques that are Traceability, Monitoring, Identification, Stock assessment and Machine vision, Deep convolutional neural network, Precision fisheries. Figure 5 displays the frequency of different methods surveyed.

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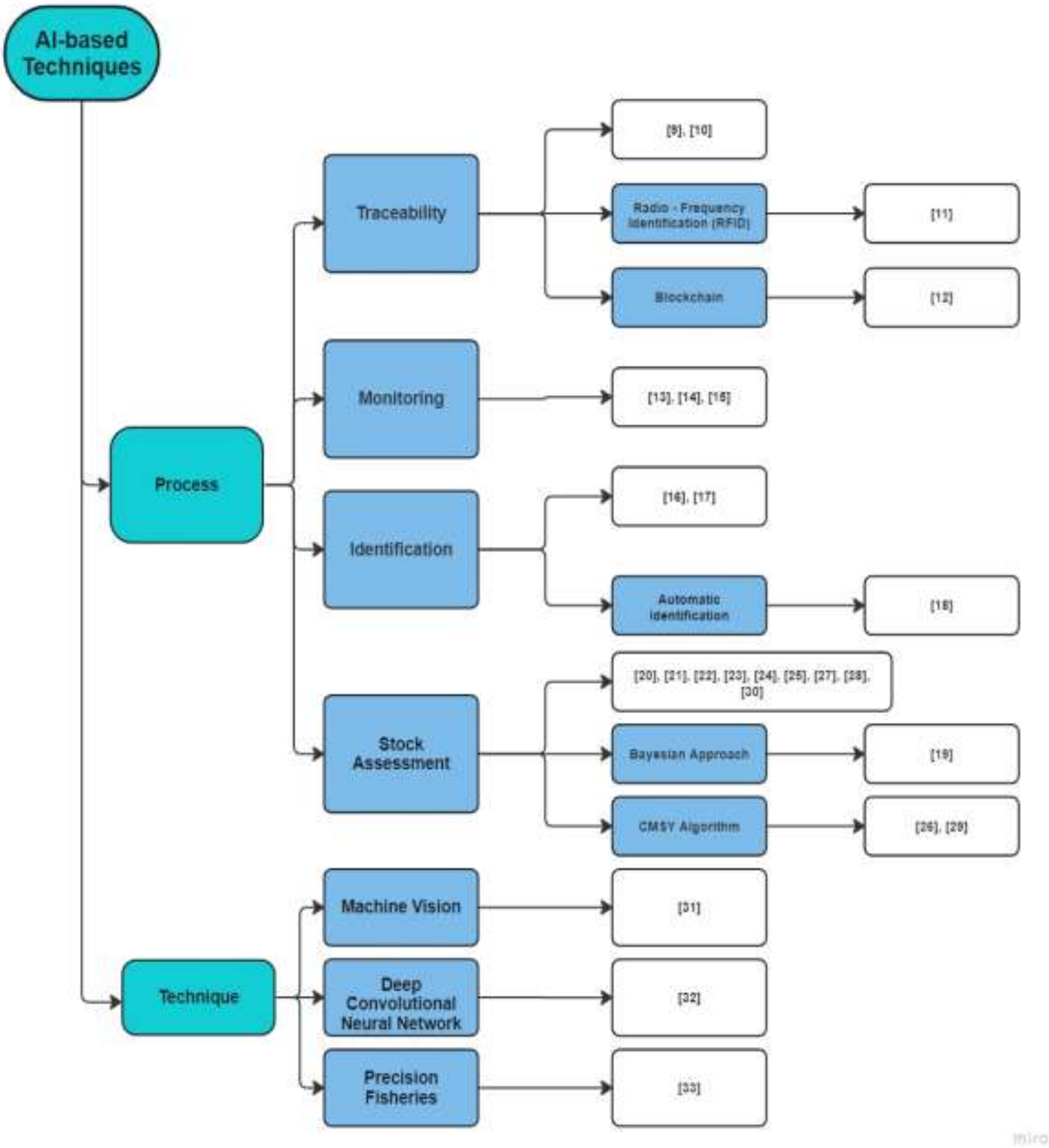

Figure 5. An infographic categorizing surveyed papers on different AI techniques used in detection of Illegal fishing

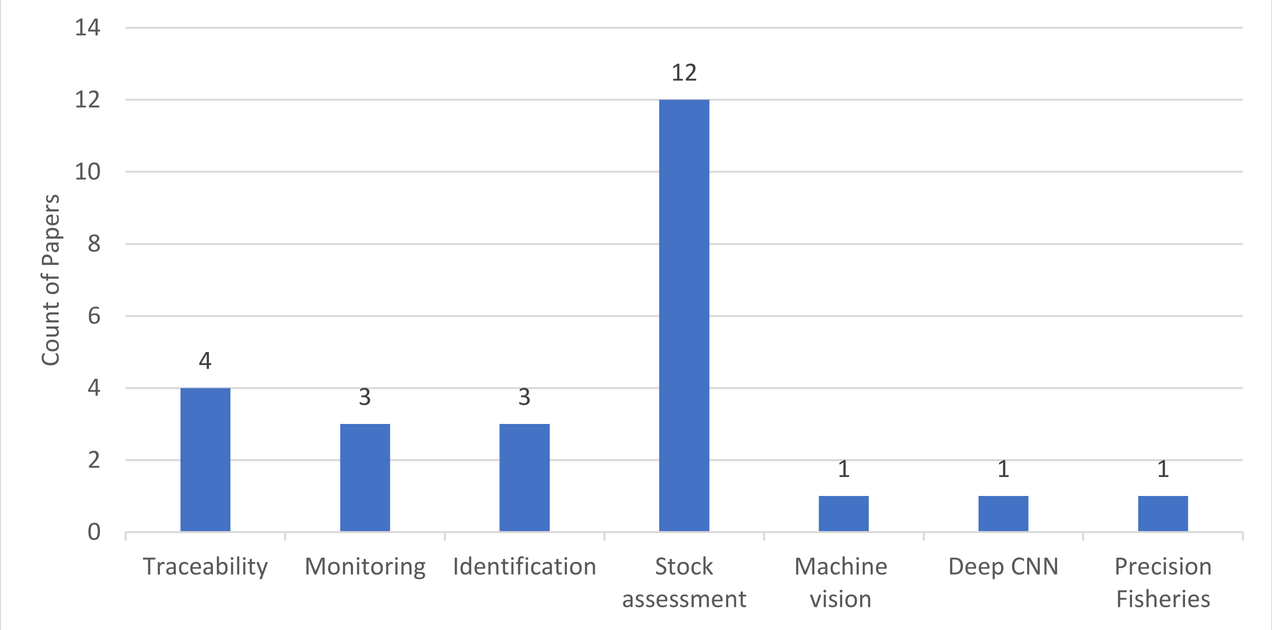

Figure 4. Frequency of different categories of papers published

3.2 Stock Assessment Process

The following Stock assessment framework includes the following steps: data collection, stock identification, stock modeling, reference point establishment, stock status determination, management option development, and monitoring, after conducting a comprehensive review of the literature.

3.2.1 Stock Assessment Models

Stock assessment models are used to analyze crucial elements of fish biology that affect the current and future status of a fish stock. These models consider three primary factors:

a) Abundance: This refers to the total number of fish in a given stock over a period.
b) Reproduction and Growth: This factor involves evaluating the amount of fish and biomass that is added to a stock each year.
c) Mortality: This factor considers the number of fish that die each year due to various causes, including both natural and man-made factors such as fishing [30].

3.3 Datasets

The following Table 4 shows how different datasets are used in different algorithms to detect illegal fishing using AI techniques. There are several sources of data available for Overfishing detection, one of the popular sources is the United Nations Food and Agriculture (FAO), which maintains a database of fishery statistics that includes information on fish catches, fishing effort, length-frequency and other dynamics.

3.4 Fisheries Management

Fisheries management is a crucial element of sustainable fishing practices, and stock assessment plays a vital role in this context that helps with application of Fisheries Management Science Program (FMSP) and other stock assessment tools, by using a fishery management system we can work with a wide range of parameters that affect the interaction between the fishery and its stakeholders. The effectiveness of fishery management systems depends on three primary components: fishery policy, management context, and management process. The fishery policy

Table 1. Information of Dataset used in the surveyed papers

Dataset Used	**Paper Title**	**Author**
New Zealand's western stock of hoki (Macruronus novaezelandiae, Merlucciidae) and	Fisheries stock assessment and decision analysis:	Andre Punt et al. (1997) [19]

the Bering–Chukchi–Beaufort Seas stock of bowhead whales (Balaena mysticetus, Balaenidae)	the Bayesian approach	
IUCN Red List, Conservation status of the world's largest freshwater fish species. Fisheries landings from inland waters, 1950–2002 from the Food and Agriculture Organization of the United Nations (FAO 2004). 2003. Food Balance Sheet. FAOSTAT database. Rome: FAO. (20 October 2005; http://faostat.fao.org/)	Overfishing of Inland Waters	J. David Allan et al. (2005) [3]
Survey results from the 24 seafood companies	Benefits of traceability in fish supply chain – case studies	Nga Mai et al. (2010) [9]
Seabass detection data (Images of Shore and Charter)	Using machine vision to estimate fish length from images using regional convolutional neural networks	Graham G. Monkman et al. (2019) [31]
government publications, articles, organizational reports, interviews with fishermen and government officials	Impacts of Illegal, Unreported and Unregulated (IUU) Fishing on Developing Countries: The Case of Somalia	Abdimalik Jama Omar et al. (2019) [4]
Data for stock assessment obtained from the CMSY algorithm for all global FAO datasets	Data for Fish Stock Assessment Obtained from the CMSY Algorithm for all Global FAO Datasets	Arnaud Helias (2019) [26]
Sampling carried out at 12 Fish landings sites from Jan 2017 to Dec 2018, Length frequency data of 6132 individuals(both sex) of Hilsa, Bangladesh	Fish Stock Assessment for Data-Poor Fisheries, with a Case Study of Tropical Hilsa Shad (Tenualosa ilisha) in the Water of Bangladesh	Mohammed Shahidul Alam et al. (2021) [2]
RAM Legacy Stock Assessment Database, global landings dataset by Food and Agricultural Organization of the United Nations (FAO)	A history and evaluation of catch-only stock assessment models	Daniel Ovando et al. (2021) [28]
FAO statistical database and Indian Ocean Tuna Commission (IOTC)	Assessing five major exploited tuna species in India (eastern and western indian ocean) using the monte carlo method (CMSY) and Bayesian Schaefer Model (BSM), Sustainability	Ubair Nisar et al. (2021) [29]

outlines the goals and objectives of the management system, while the management context includes a range of factors that are critical to the way the fishery is managed. Finally, the management process involves decision-making processes and specific measures used to control the fishery.

The stock assessment and research provide the scientific and technical basis for the management framework as shown in the below diagram [22].

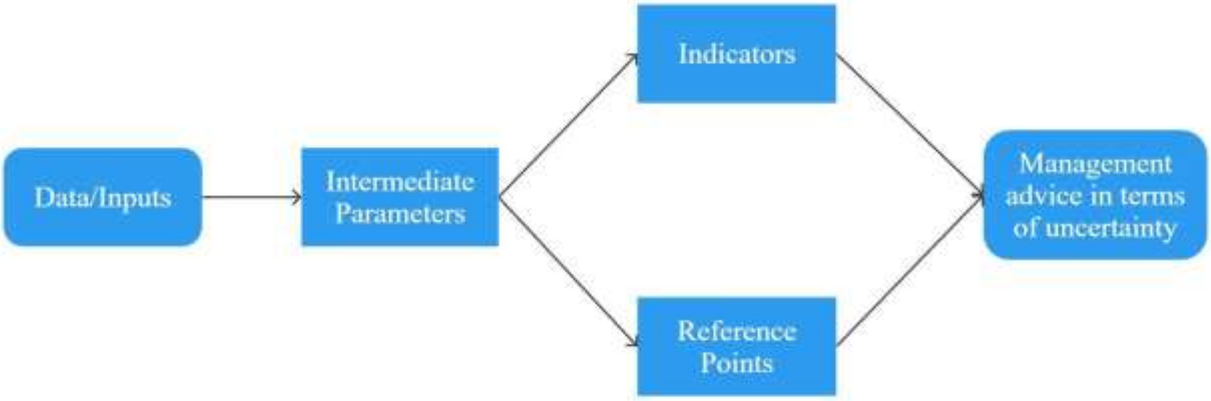

Figure 7. Stock Assessment Process for Management

3.5 Publication Statistics

The following section presents the bifurcation of surveyed papers according to the publisher and year of publication and are presented in Figure 8 and Figure 9. While Figure 10 shows the year when individual papers were published.

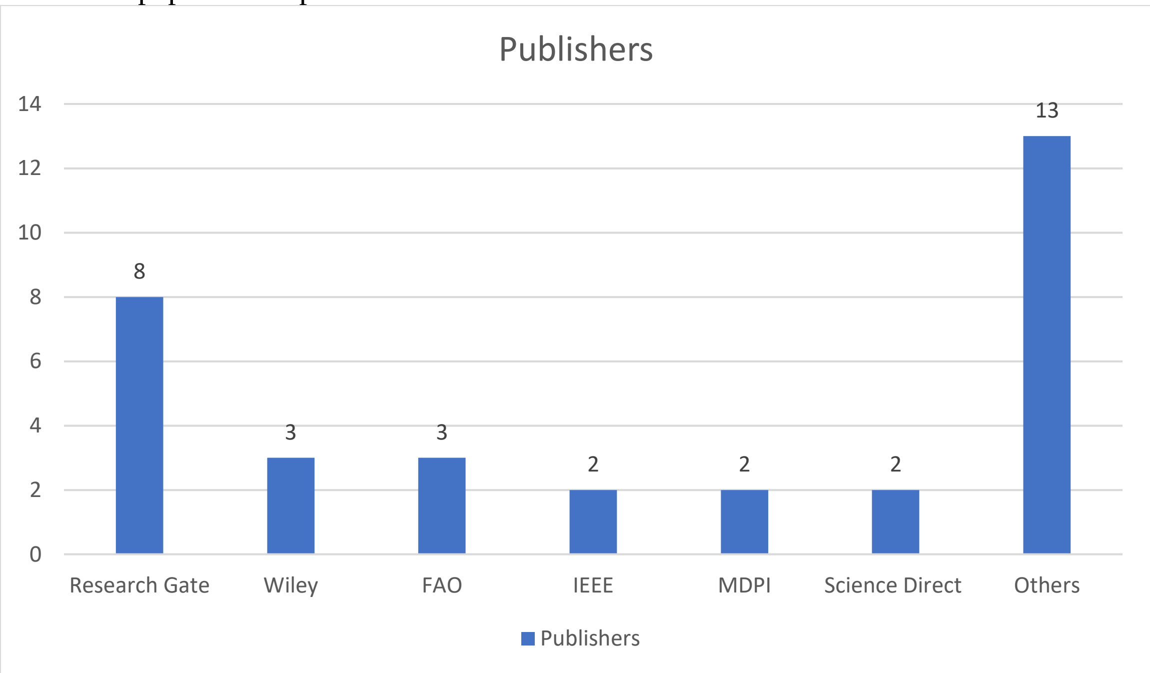

Figure 8. Publisher wise Publication bifurcation of surveyed papers

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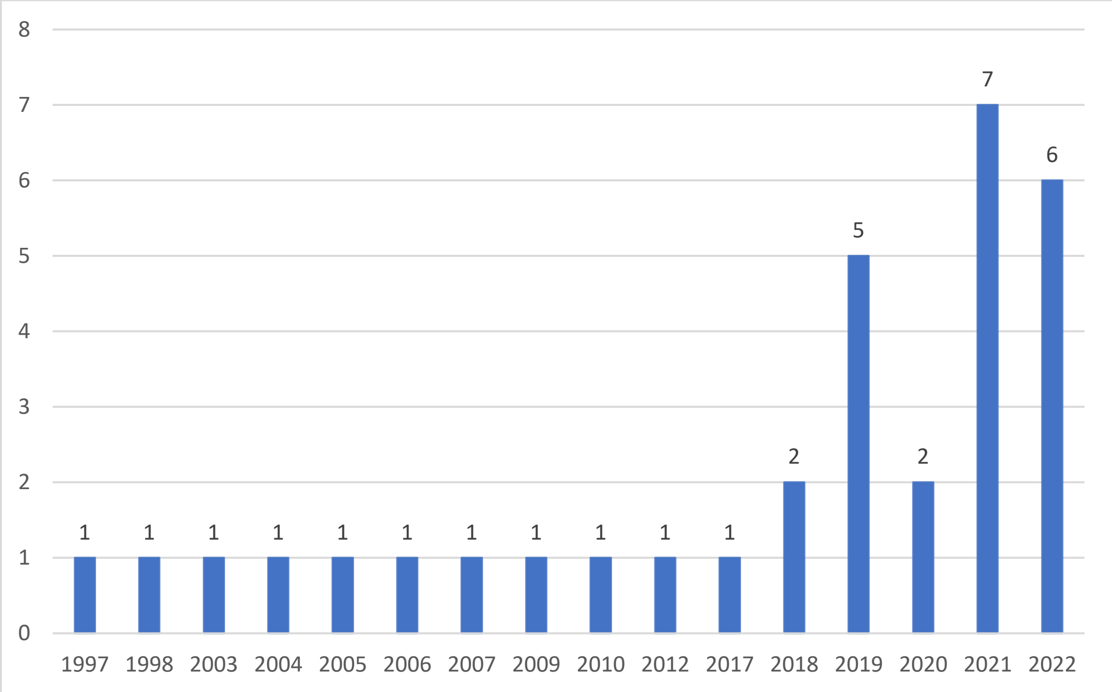

Figure 9. Papers published year wise

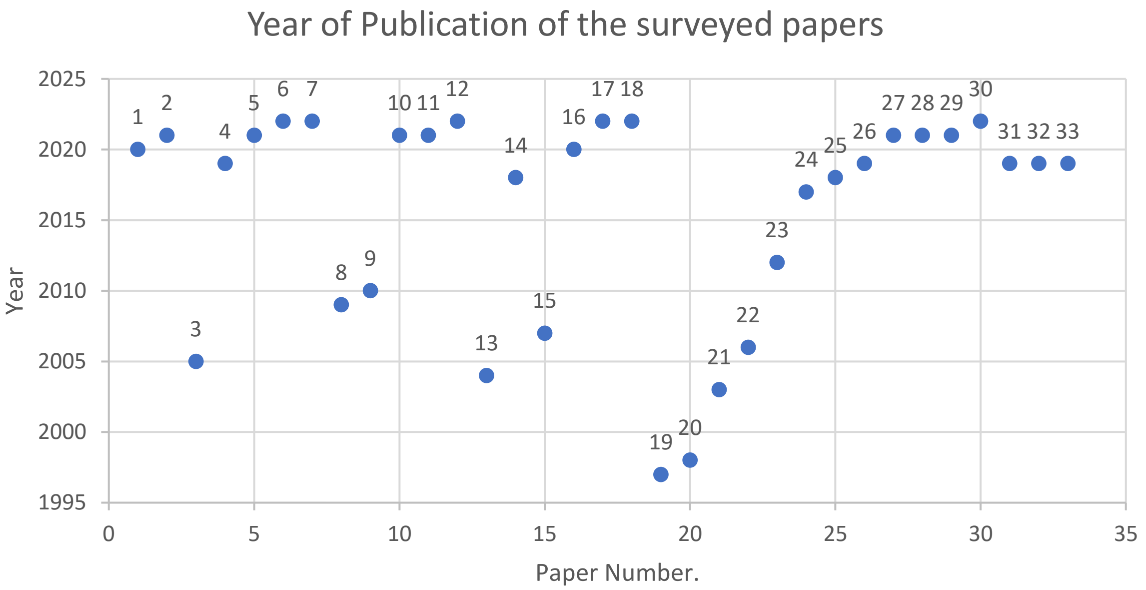

Figure 10. Histogram of the Year Distribution based on the different surveyed papers for AI – based techniques

IV. Conclusion

This paper outlines the potential to detect and stop IUU fishing and overfishing using AI-based techniques. The survey indicates use of AI to examine vast amounts of data on fish landings, fishing operations and environmental conditions, pinpoint areas where overfishing is occurring, and alert authorities of potential IUU fishing activity and thereby help in the management of processes in fisheries management making it sustainable. This work can further contribute to develop sustainable fishing practices by providing real-time data on fish stocks and helping fishermen make informed decisions about when and where to fish.

While the potential benefits of AI for fishing businesses are clear, there are still issues & challenges that need to be addressed. The lack of information on fish stocks in many parts of the world is a severe problem. Without sufficient data on fish stocks, it is difficult to develop effective management policies that promote sustainable fishing. There are also security and privacy concerns when exchanging sensitive information with outside companies

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