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Public Knowledge and Attitudes on Microplastic Contamination of Aquaculture and Fisheries Products in CAMANAVA

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ABSTRACT

This study determined the relationship between knowledge levels (QK) and attitudes (QA) of microplastic contamination of aquaculture and fisheries products in CAMANAVA with respect to their demographic characteristics (QG). A cross-sectional survey was conducted with 278 respondents quota sampled by municipality at a 95% confidence level with a 6% margin of error. Non-parametric statistics were assumed upon descriptives, Shapiro-Wilk, and Kolmogorov-Smirnov tests, with moderate cumulative scores of QA and QK showing deviations from normality. Correlation results ($\varrho = 0.424$, $p < 0.001$) indicate a moderate positive relationship, but strong significance between QA and QK. SLR of QA with respect to QA results yielded accounting for $R^2 = 0.186$ of variance (QK $\beta_1 = 0.51$). No statistically significant difference across age, gender, education, and municipality was observed in the demographics upon analysis of variance. MLR tested QG as factors; however, only accounting for $R^2 = 0.231$ of variance in attitudes. QK remained the most notable predictor of all factors.

INTRODUCTION

Background of the Study

Plastic debris in the ocean is of increasing concern due to their various effects on marine and human life. Jambeck *et al.* (2015) found that with over 275 million metric tons of plastic waste generated in the year of 2010, plastics have become widely detrimental toward the overall condition of marine environments. They predict that the lack of improvements on waste management and the cumulative quantity of plastic waste are likely to increase by an order of magnitude by 2025. On the other hand, the Philippines contributes 1.88-2.70 million metric tons of plastic waste to the oceans making the country the third largest contributor of plastic waste globally (World Bank Group, 2023).

Large amounts of plastic debris in marine environments can be fragmented into microplastics (MP) - defined as tiny plastic fragments that are <5 mm in diameter with varying sizes and colors as a result of breaking down from various factors such as ultraviolet rays, microbial degradation, extreme currents, oxidation, or heat; with the abundance of these MPs and its consequential effects on the environment and organisms considered as microplastic pollution (Issac & Kandasubramanian, 2021; Rillig *et al.*, 2017).

A study by Guzzetti *et al.* (2018) divulged that microplastics have proven harmful effects to aquatic animals: oxidative stress, damaged immune response, inflammation, change in reproductive activity, cellular toxicity, and cancer. It also states that microplastics are one of the greatest threats for marine biodiversity around the world, crushing both ecosystems and the biological systems of marine life alike. Public attitudes towards its propagation and its potential for harm in human health are risks that remain relevant to the development of food safety, the consumer market, and aquaculture.

Microplastic effects on human health that are currently under consideration are under all three categories of Food Safety classifications for hazards and risk analysis: biological, chemical, and physical. Besides the size of microplastics, its chemical composition and additives contain toxic hazards that pose a health risk to humans (Danopoulos *et al.*, 2020). Human exposure of MPs is suggested to be principally through the process of ingestion and inhalation (Abbasi & Turner, 2021).

Deng *et al.* (2020) states that with microplastics having been found in land, sea, biological media, and human bodies, along with their strong ability to absorb pollutants due to small volume and large surface area, they pose a significant threat toward the stability of the ecosystem. Furthermore, their involvement in the food chain of human beings from the ingestion of aquaculture products may pose an even larger threat toward human and food safety.

There is no effective technical approach to completely eliminate microplastic abundance, thus deeming it is necessary to understand people's perceptions towards the MP phenomena (Che *et al.*, 2014). Although there are several existing studies on the MP phenomena in the perspective of medical and physical science, there is a general perception that MP are a serious threat to both environmental and human health, while studies on the social aspect of this phenomena remain scant.

In Metro Manila, Tanchuling and Osorio (2020) note that MP fragments are likely to have been derived from the degradation of plastic materials which include packaging, bags and containers, household products, and fishing

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tools, with plastic pellets being the most abundant in rivers within Metro Manila. Abundance of these MP fragments are mostly related to population density and urban development within watersheds, showcasing a suggestion that most MPs are locally derived secondary microplastics, derived from larger plastics.

With the Philippines being one of the biggest contributors to world fisheries, and aquaculture being one of the biggest livelihoods of over 2 million fisherfolks, along with the commonality of aquaculture foods and seafoods in Filipino households, the MP phenomena becomes even more relevant a concern for the country.

With household dishes and traditional foods heavily revolved around fisheries, particularly in coastal regions and in Metro Manila, ingestion of microplastics present in marine organisms becomes a likelihood. Among the fishing culture of the Philippines, Navotas, one of the primary locales of interest, is credited for its rich resource of fishes with the following documented through visual ethnography, namely: milkfish, tilapia, sardines, bighead carp, ponyfishes, shrimp, mussel, squid, and tuna. Fisheries are also the primary source of living, thus the derivation of the Fishing Capital of the Philippines. With 70% of the population's livelihood being garnered directly or indirectly from the fishing industry, it is essential to understand the ways in which the aquaculture and fisheries sector is affected by MP pollution.

Garcia-Vazquez and Garcia-Ael (2021) highlights the effect of MP pollution directly on the decline of fish stocks and increased mortality in aquaculture. MPs generate increased levels of stress on aquatic organisms, therefore also increasing the energy requirements to select nutritionally valuable prey or organic matter. Its presence in marine biota is becoming a much larger problem as plastic pollution propagates, most especially in cultures that are both high urbanized, therefore higher plastic concentrations in bodies of water, and are dependent on fisheries, like Navotas and the rest of Caloocan, Malabon, and Valenzuela. Tanchuling and Osorio's (2020) compilation of MP concentrations around Metro Manila shows its abundance, particularly in the highly urbanized areas within the city.

Metro Manila was shown to have a mean abundance of 800 particles/m3 up to 60,000 particles/m3 concentrated on the study areas, in which areas subjected to intense human activities are more likely to have greater microplastic pollution. Among these, Tullahan river, the closest river network extending within the municipalities of Caloocan, Malabon, Navotas, and Valenzuela, was shown to have 50,001-100,000 particles/m3 with particle sizes varying from 0.075 to 5.00mm. Compared to foreign rivers, Deep Bay in Hong Kong has less than 1,000 particles/m3. Likely due to the heavy population density of Metro Manila. To add, the cultural setting of Navotas and Malabon with fishing as a common livelihood further expounds upon the relevance of this study in the local setting (Lumaque *et al.*, 2015).

The public's involvement, awareness, and their willingness to reduce MPs are essential towards making improvements and policies towards shifting behaviors that decrease the likelihood and propagation of MPs and plastic pollution as a whole from behavioral or motivational change. For instance, although scientific communities are well-informed of MP pollution, the general public are not guaranteed to have complete awareness nor have any awareness at all of MP pollution due to various socio-economic factors.

Having a complete scope of how the public perceives and understands MPs and MP pollution will provide the necessary insight towards making the necessary changes and pursuits to action by governing bodies and by individuals themselves. Additionally, one of the principal focuses of this study is that the awareness of the phenomena can be disseminated by the survey itself, if the topic of MPs is completely novel to the participant. The sharing of this knowledge will also allow for more people, such as family members, schoolmates, and the community, to understand the consequences and habits of reducing MP propagation.

The lack of studies on the social implications of this phenomena will likely be overshadowed by the various calls for environmental action. Even so, policies on waste segregation within Metro Manila remain trivial with examples like local ordinances on single-use plastics, which are not mandated enough nor assessed. Tanchuling and Osorio (2020) also state that even national policies like R.A. 9003 or The Ecological Solid Waste Management Act have deficient implementations and therefore enforcement as well. The issues presented by waste management have therefore continued due to the lack of infrastructures for waste collection, transportation, and disposal. The researchers acknowledge this gap in the local setting, thus becoming a central interest for assessing public attitudes towards MPs.

This study utilizes a cross-sectional survey on public attitudes and knowledge on MPs, particularly in aquaculture and fisheries products, with respect to the demographic characteristics, with a focus on division by municipality. The gathered data was analyzed using descriptive statistics, correlation analysis, regression analysis, and one-way ANOVA. Participants of this study were gathered through quota sampling, disseminated through various means. Proceeding studies and local government units may utilize the basis of this paper and its data to further reinforce and establish ordinances that will spread awareness on the relevance of waste reduction, particularly plastic pollution. The locale featured in this study will be limited to the municipalities in the 3rd District of the National Capital Region, informally known as CAMANAVA, to remain relevant for the setting of the school and for ease of access on the employment, methodologies, and processes partaken in sampling and in analysis.

Theoretical Framework

This study adapts a theoretical model by Liu *et al.* (2019)

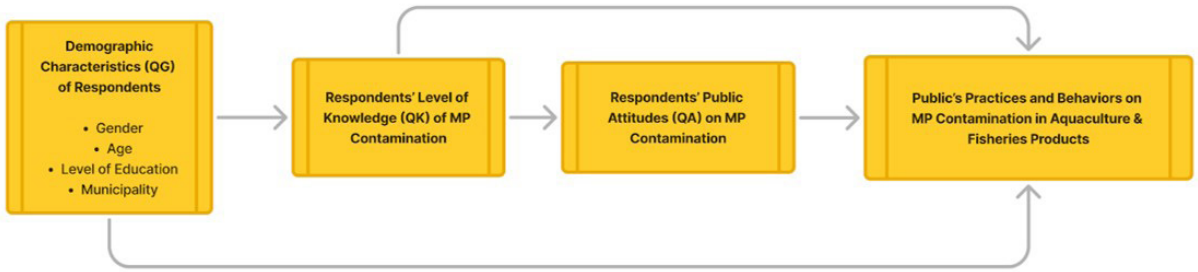

Figure 1: Theoretical Framework of Knowledge, Attitudes, and Practices with regard to MP Contamination of Aquaculture Products

with the variables changed according to what is required in the context of MP contamination of aquaculture and fisheries products. The model, based on the theory of knowledge, attitudes, and practices (KAP), accounts for the formation of the questionnaire, and the overall foundation of the relationship assumptions between QG, QK, and QA. The KAP model in instrumentation is used as a representative survey of target populations, with regard to identifying the knowledge levels and attitudes as to what is known, what is believed, with respect to what is done (Andrade *et al.*, 2020).

The KAP framework allows for the hypothetical relationship of practices and behaviors towards MP pollution, attitudes, and knowledge levels. Attitudes in particular, are also inclusive of eating habits and consumption traits of aquaculture and fisheries products, with the questionnaire identifying the respondents' (1) complacency, (2) fear, (3) ignorance, (4) indifference, and (5) responsibility avoidance towards the phenomena according to the adapted study.

Research Questions

What are the general knowledge levels (QK) and public attitudes (QA) regarding microplastic contamination in the environment, particularly in aquaculture products?

How do public attitudes (QA) toward microplastic contamination in aquaculture products correlate to their level of knowledge (QK)?

Is there a significant difference between demographic characteristics (QG) such as age, gender, education, or municipality in terms of their general knowledge and public attitudes on MP contamination of aquaculture products?

LITERATURE REVIEW

Microplastics in Food

Microplastics are defined as plastic constituents measuring below 5 millimeters in size. They can be obtained from the fragmentation of larger polymer particles, or they can be purchased as tiny pellets. Microplastics also present a very big threat to the environment, especially the aquatic environment, where they congregate and are consumed by aquatic life and other organisms, thus altering ecosystems and the food chain (FAO, Microplastics in Fisheries and Aquaculture, 2019).

These pollutants are evidently present in seas, oceans, rivers, etc.; in fact, even in cold areas such as the Arctic. (Zhou *et al.*, 2021) Microplastic pollution has gradually become a major global concern due to the widespread use of plastics. Microplastics enter the environment and are degraded while also being ingested by organisms, affecting various physiological functions and adversely affecting the health of organisms. Microplastic pollution is currently a wide concern, but data on the impact on organisms is still not sufficient. (Deng *et al.*, 2023)

A study by Jambeck *et al.* (2015) calculated that 275 million metric tons (MT) of plastic waste were generated in 192 coastal countries in 2010, with 4.8 to 12.7 million MT entering the ocean. Population size and the quality of waste management systems largely determine which countries contribute the greatest mass of uncaptured waste available to become plastic marine debris. Without improvements in waste management infrastructure, the amount of plastic waste available to feed the ocean from land sources is expected to rise by an order of magnitude by 2025. In this case, weathering by physical, biological, and chemical factors affects the wear down of this plastic waste to form the microplastic particles. Exposure to sunlight can cause photodegradation, decomposition, and other environmental factors. Marine environments may prevent this, but beaches have high oxygen availability and rapid degradation (Cole *et al.*, 2011).

The impact of microplastics is not just limited to marine life; it also affects human health and the environment. Due to their small size and ubiquity in the environment, people's and researchers' concerns regarding the dangers that embrace humans and the entire environment due to micro- and macro plastics have only increased. Because of the small size and large surface area of microplastics, they attract and accumulate pollutants across different environments that are dangerous for an ecosystem. This can be traced to the recent study conducted by Hossain (2024). Marine life also quickly entangles with microplastics, and the body of the aquatic organism is then filled with these materials.

Marine and terrestrial microplastics are an emerging danger to human health and food security. The study indicated that few respondents had prior knowledge about microplastics, with only 22% having any knowledge about microplastics. Some of the considerations considered in this desire were family, occupation, gender,

and knowledge of plastics and microplastics available. It was also found that women prefer compromising to minimize pollution more than men do. Therefore, the study suggests that policy should be reviewed and the law should be enacted to prevent the release of microplastic waste into the aquatic system during the production and recycling process of plastics (Hossain, 2024).

Knowledge Levels, Attitudes, and Practices on Microplastic Pollution

People lack basic understanding of microplastics at the public awareness level. A survey in Shanghai showed that 26% of participants knew about microplastics; however the remaining participants did not have complete comprehension of these materials (Deng *et al.*, 2020). People demonstrated concern for microplastic health risks upon receiving education about its effects.

People show eagerness to discuss the issue when its potential health hazards become understood despite their initial lack of awareness about microplastics. People who demonstrated superior plastic knowledge tend to implement actions that minimize microplastic pollution since women and environmental specialists proved most passionate about the issue.

On the contrary, research examining university students showed they had moderate comprehension along with attitudes toward microplastic pollution according to Azmi *et al.* (2023). The research data showed that none of the student demographics including age distribution and gender composition together with academic Grade Point Average (CGPA) demonstrated meaningful relationships to their awareness of microplastics or their attitudes toward the topic.

Microplastic understanding lacks clarity in every segment of the population so this issue affects groups beyond certain demographics according to research. To overcome this situation educational initiatives that focus specifically on this problem need to be developed according to the researchers. The advancement of understanding about microplastic pollution among young people will lead to better proactive action in reducing these pollutants.

Public opinions hold great importance in this early stage of microplastics environmental removal technology development (Deng *et al.*, 2020). Daily routines and mindsets of individuals hold dual capacities to either worsen or alleviate the situation. Working together education and policy need to provide information to the public to promote action that reduces microplastic emissions.

The Aquaculture and Fisheries Industry in the Philippines

According to the Food and Agriculture Organization, most of aquaculture production in the Philippines comes from the harvesting and raising of seaweed, milkfish, tilapia, shrimp, carp, oyster, and mussel. It contributes significantly to the country's food security, employment, and foreign exchange earnings. The country's global position has fallen steadily from 4th place in 1985 to 11th in the world in 2022 with 826.01 thousand MT or 1.01% share of the total global aquaculture production of 82.10 million MT (FAO, 2020). With that being said, the Philippines is an archipelagic country containing over 7,100 islands.

With a territorial water of 2,200,000 km², it only has 299,735 km² of land area of which 34% is agricultural (Yap, 1999). It is situated in the middle of the coral triangle, which is well known for its marine biodiversity and rich production of seafood. With one of the longest coastlines in the world, much of the Filipino population lives along the coast in order to use the archipelagic country's resources for both nutrition and livelihoods (MSC, 2014). In a study about aquaculture as a food source in the country, "Each, Filipino consumed an average of 34.28 kg per year of fish and fishery products comprising of 23.34 kg of fresh fish, 2.86 kg of dried fish, 3.89 kg of processed fish, 2.88 kg of crustaceans and mollusks, and 1.31 kg of others" (SEAFDEC, 2021).

Food Products in Aquaculture and Fisheries

There are three fisheries sectors in the Philippines consisting of aquaculture, municipal fisheries, and commercial fisheries. In 2018, aquaculture is the leading sector accounting for about 53% of the total production with 2.3 million MT of fish products, where milkfish, seaweeds, shrimps, and tilapia were the major cultured species. It is then followed by Municipal fisheries which includes fishing done in coastal and inland waters with or without the use of boats of three gross tons or less, accounting to 25% of the total production with 968,758.60 MT of marine municipal fish catch with a large bulk production of big-eyed scad, bali sardinella, frigate tuna, round scad, fimbriated sardines, and squid in the marine municipal subsector.

In the inland municipal subsector, it accounts to a total of 156,458.87 MT with the top-produced fish species being tilapia, carp, mudfish, freshwater catfish, and milkfish, totalling to 1.1 Million MT total production of Municipal fisheries. The commercial fisheries sector produced about 931,000 MT of fish consisting of three species with a large bulk production which are skipjack, bali sardinella, and round scad comprising 22% of overall production in the commercial fisheries sector (BFAR, 2019).

Consumer Habits, Cultures of Aquaculture and Fisheries

The capture fish production is insufficient to meet the growing demand of the overpopulated developing countries whereas the culture fish production has emerged as the main solution to fulfill this gap (Mitra *et al.*, 2020; Béné *et al.*, 2015). Despite increasing productivity, many consumers consider culture fish as poorer quality than captured fish that contribute to reduced market demand (Bronnmann & Hoffmann, 2018).

Microplastics in Philippine Coastal Areas

The Philippines has always been reported as one of the countries in the Western Pacific with high plastic (macro- and micro-) load to the marine coastal environment (Jambeck *et al.*, 2015; Lebreton *et al.*, 2017). Comprising more than 7,500 islands, the livelihoods of the Philippines' coastal communities, and the fishing, shipping and tourism industries are especially vulnerable to the impacts of marine debris (World Bank Group, 2021).

In a study conducted by Bucol *et al.* (2019), sampled subtidal marine sediment from Silliman Beach in Dumaguete and sampled fishes from four selected localities in Negros Occidental were found to have microplastics. On a separate study by Esquinas *et. al.* (2020), sampled surface sand from four different areas in Macajalar Bay were also found to have microplastics, higher than the previous study made by another researcher. Papers prove that microplastics are present in every corner of the Philippines' coasts.

Microplastics in Metro Manila Rivers

Due to its geographical location and the prevalence of social issues in the region, Metro Manila has become one of the most polluted areas in the country and in the world. Trash, particularly plastics, are often seen lining up the waters traversing the cities.

In a study conducted by Tanchuling & Osorio (2020), sampled sites in the rivers of Cañas, Pasig, Sapang Baho, Tullahan, and Tunasan were found to have solid wastes floating on rivers and creeks, as well as along the riverbanks. Microplastics in the surface waters were detected in all study areas with a mean abundance ranging from about 800 particles/m3 up to 60,000 particles/m3. Among the different bodies of water that are studied, the highest concentration of microplastics in surface waters was found to be in the Meycauayan River, followed by the Tullahan River, while the lowest concentration was identified in the Makati Creeks.

In the same study, it was concluded that the microplastics detected in the surface waters of Paranaque, Meycauayan, Tullahan, and Tunasan were relatively higher compared to other studies involving the surface waters of other countries.

Existing Policies on MP and General Plastic Pollution

The Philippine government has made small but significant steps towards a cleaner and healthier environment through its laws. On January 26, 2001, Republic Act No. 9003 was enacted in response to the critical condition of the solid waste management problem and the threat it poses to the environment and public health. It declares the intention of the state to adopt a systematic, comprehensive, and ecological solid waste management program that will ensure the protection of the environment and public health.

The National Solid Waste Management Commission (NSWMC) was then formed under the Office of the President, in which its main duty is to prescribe policies to achieve the goals of the Law and to oversee the implementation of the solid waste management programs in every local government unit. The local government units (LGUs), particularly cities and municipalities, are the primary responsible units in the implementation of RA 9003. There are also local ordinances related to various aspects of waste management, such as those regulating the use of single-use plastics. As of 2019, 489 cities and municipalities (30% of all cities and municipalities in the country) have some form of policy to regulate the use of plastics, particularly single-carrier plastic bags and plastic straws. Additionally, Republic Act No. 8749 or the Philippine Clean Air Act of 1999, prohibits the use of incineration and open burning for the disposal of waste according to Section 20.

Currently, the government is exploring the use and operation of waste-to-energy (WtE) technologies using the guidelines provided by the NSWMC Resolution No. 669, Series of 2016.

Furthermore, the DENR also issued Department Administrative Order (DAO) 2019-21 on the Guidelines Governing Waste to Energy Facilities for the Integrated Management of Municipal Solid Waste. There are also pending Senate bills filed in the 18th Congress institutionalizing WtE systems, which aim to establish environmentally sound waste management systems including the facilities that cover reduction, segregation, recycling, re-use, disposal, and conversion of waste into useful resources (Tanchuling & Osorio, 2020).

Existing Aquaculture and Fisheries Culture in CAMANAVA

The CAMANAVA region, comprising Caloocan, Malabon, Navotas, and Valenzuela, is a hub of aquaculture and fisheries culture, with Navotas leading as the "Fishing Capital of the Philippines." In Navotas, the traditional practices of fishing continue to thrive despite modernization (Lumaque *et al.*, 2015). Fishermen often sell their catch to fish processing industries or in local markets, with species such as milkfish, tilapia, and sardines playing a major role in the region's aquaculture. However, they also cite that poor sanitation and not wearing gloves of fishermen may contribute to the perpetuation of plastic pollution.

Malabon and Valenzuela also contribute to the region's fish culture through extensive aquaculture operations, focusing on farming species such as milkfish and shrimp. The interplay between traditional fishing techniques and aquaculture in CAMANAVA supports local economies, while governmental initiatives aim to improve fisheries infrastructure and ensure sustainable practices.

Marilao-Meycauayan-Obando River System (MMORS) on Aquaculture and Fisheries

The Marilao-Meycauayan-Obando River System (MMORS) plays an important role in the aquaculture and fisheries sector within the CAMANAVA Region. The river system provides essential resources for fish

and shellfish farming, which is crucial for the food and nutrition security of coastal communities in Caloocan, Malabon, Navotas, and Valenzuela. Fishes and shellfish from MMORS are predominantly cultivated in earth-diked ponds and harvested directly from the river. Due to a lack of post-harvest processing facilities, these products are sold fresh in local markets or distributed to nearby towns, impacting their market value and availability (Amparo *et al.*, 2017).

Fish Consumption in CAMANAVA

Fish consumption in the CAMANAVA region has increased due to the growth of local aquaculture and fisheries. This increase is particularly evident in Navotas, where the Philippine Fisheries Development Authority (PFDA) reported a 27.22% growth in fish volume unloaded at the Navotas Fish Port Complex (PFDA, 2021). Fresh fish that are harvested are sold directly to the market. The direct sale of fresh harvests to the market without additional processing has resulted in lower prices for consumers. This lack of value addition has made fish more affordable and accessible to local residents (Amparo *et al.*, 2017).

Food Safety and Implication for Human Health

Microplastic Contamination in aquaculture products poses a growing threat towards food security, economic inequality worsens between wealthy and poor populations which reduces the purchasing capacity of the poor individuals to afford essential requirements such as food. The lack of resources directly causes poverty because it ensures people cannot attain basic needs while earning insufficient wages. Addressing this issue requires both humanitarian aid and long term strategies such as sustainable agricultural support, food waste reduction, and managing the main foundation of the problem to build a clean and lasting food system. The presence of microplastics in food provides evidence that people are mistreating the environment through pollution. Contaminated by pollution affects fish populations and marine life, which makes it more challenging to eliminate global hunger among all people. (Mohamed, 2025)

MATERIALS AND METHODS

Research Design

The study design utilized a quantitative approach on knowledge, attitude, and practices (KAP) theory, in which its data was analyzed through descriptive statistics, KAP scoring, and non-parametric tests as per the pilot testing. A cross-sectional survey approach was utilized for this study. In particular, the KAP framework became the basis for both analysis and the questionnaire design, but excluding practices. Questionnaires were pre-tested upon validation, to be used for Cronbach's Alpha, prior to the actual dissemination of the questionnaire to the sample population. In calculating the QK and QA scores, cumulative scores were simply computed. Total populations were divided into strata based on municipality and questionnaires were deployed using a quota sampling method to gather responses. Among the strata, the City of Caloocan showcased the largest population thus requiring a larger sample size for generalizability. Following municipalities would be the City of Malabon, City of Navotas, and then the City of Valenzuela. Exclusion criteria included respondents who did not consume aquaculture and fisheries products within the locale of the study.

Description of Respondents, Locale, & Demographics

The following data on municipalities is from the only available Philippine Statistics Authority population census in the public domain, from the year 2020. The Third District of Metro Manila, namely Caloocan, Malabon, Navotas, and Valenzuela were chosen as geographic points of interest particularly due to the cultural and economic significance of aquaculture and fisheries products. Preceding studies on the proportionality of urbanization and microplastics and the aquaculture and fisheries cultures in the given cities were the basis for the locale, as well as a convenience factor for the researchers.

Caloocan City, with an estimated population of 1,661,584, is a 1st class high urbanized city, the fourth-most populous and urbanized city within the country.

Malabon City, with an estimated population of 380,522, is a 1st class highly urbanized city known for various culinary delicacies and atlantic ambience, with connected fishponds along the coast of Barangay Dampalit across Obando, Bulacan from Tullahan River.

Navotas City, with an estimated population of 247,543, is a 1st class highly urbanized city primarily known for its extensive network as a commercial fishing hub and widely known as the fishing capital of the Philippines.

Valenzuela City, with an estimated population of 714,978, is a 1st class highly urbanized city and sixth-most populous city in the country. Like Malabon City, it also has various aquaculture ponds linked to Tullahan River with the most known as Tagalag Fishing Village.

The general public of CAMANAVA are of direct significance regarding the social effects of MP pollution due to the cultural and economic significance of aquaculture and fisheries. The role of the public attitudes, and knowledge on given issues are essential factors towards guiding policies to be developed for the innovation of research-focused solutions to environmental problems. The following demographic characteristics (QG) are to be

Table 1: Stratification of Population

City	Population	Sample Size
Caloocan City	1,661,584	154
Malabon City	380,522	35
Navotas City	247,543	23
Valenzuela City	714,978	66

Note. The following citizen population data was extracted from the Philippine Standard Geographic Code (PSGC) under the Philippine Statistics Authority, census 2020

recorded and are as follows: Gender (Male, Female), Level of Education (Basic Education, Vocational Education, Bachelor's Degree, Post-Graduate), Age Group (15<, 15-25, 25-35, >35 years) and most notably, municipality (Caloocan, Malabon, Navotas, Valenzuela). After totaling the population of each municipality, the researchers utilize Slovin's formula in calculating the sample size.

The strata were accomplished via quota sampling. Demographic characteristics, particularly the respondent's municipality, were of significance to have a suitable comparison of knowledge and attitude variables per stratum.

Questionnaire and Instrumentation

A digital questionnaire via Google Forms was adapted and modeled after preliminary studies on attitudes conducted by Azmi *et al.* (2023), Omoyajowo *et al.* (2022), and Dowarah *et al.* (2022) and modified to include a focus on aquaculture & fisheries. Prior to the prepared survey questions, a confidentiality agreement was given to ensure anonymity and data protection for the respondents. Provided questions were answered by respondents via a five-point Likert Scale providing further elaboration compared to the three-point used by Azmi *et al.* (2023). The same were to be observed for public attitudes (QA), in which questions were derived and modified from Omoyajowo *et al.* (2022). Modifications were based on the focus on aquaculture and fisheries products, while maintaining the same number of questions to ensure the questionnaire's ease of use.

Likewise with Azmi *et al.* (2023), the questionnaire, consisting of a total of 20 questions, was split into four modules to include QG, QK, and QA, in the following order: (1) Demographic Characteristics (QG), (2) General Knowledge Levels (QK), and (3) Public Attitudes (QA) on MPs in aquaculture and fisheries products. QG is given four subsections of characteristics on gender, level of education, age, and municipality. QA is subgrouped into five to narrow the construct of attitudes according to complacency, fear, ignorance, indifference, and responsibility avoidance. A five-point Likert Scale was used for each question, which were then randomized in order to maintain reliability of responses. Reliability scores and confirmatory factor analysis were estimated initially through pilot testing. Upon employing Cronbach's alpha, an overall reliability score of = 0.786 was calculated. After data collection, another reliability test was done to ensure consistency.

Table 2: Final Reliability Scores

Variable	Question Code	Cronbach's α
Attitudes	QA	0.806
Knowledge Levels	QK	0.926

Note. Ideally, a > 0.7 would posit a reliable consistency between survey questions

Data Gathering Procedure

The study made use of a combination of sampling methods, such as convenience, snowballing, and voluntary responses (to minimize bias, a raffle cash prize was employed). Data collection was facilitated through an online survey, developed via Google Forms, and disseminated through multiple channels to maximize reach and ensure stratified representation across municipalities. Stratified random sampling was initially considered as the most ideal way to minimize bias, however, due to limited responses and time constraints due to scheduling, the approach shifted to snowball sampling, offering a ₱500 prize pool as an incentive.

The distribution methods included: (1) Outreach: The survey link was directly sent to potential respondents on online platforms. (2) Facebook Advertisement: The survey was posted as an advertisement taking advantage of the platform's broad reach and algorithm to reach a wider audience within the target area. (3) Field-Based Recruitment via QR Code: The researchers visited schools and malls in the CAMANAVA area, providing a QR code and link for scanning. (4) Snowball Sampling: To further broaden the reach, the survey was initially disseminated to individuals residing or studying in CAMANAVA, who were then encouraged to recirculate the survey within their personal and academic contacts.

Data Analysis

Completing data collection; descriptive statistics, calculating percentage composition, mean, median, and mode was done prior to a final reliability test for each cumulative variable. Non-parametric tests were done after verifying ideal statistical assumptions, such as Shapiro-Wilk and Kolmogorov-Smirnov for normality. Non-parametric ANOVA (Kruskal-Wallis) was conducted to calculate statistical difference of subgroups in QG with QA and QK. Preliminary computations involved were done through LibreOffice Calc and JAMOVI for all statistical treatments involved. Visualizations and plots were done through Python packages: Matplotlib, Pandas, Seaborn, Statsmodels, SciPy.

Spearman Rank Correlation analysis was used for cumulative scores of QA and QG. Along with calculating for the correlation coefficient, a simple and multilinear regression was conducted to examine the predictability of QA depending on QK. To account for differences in scale, normalization through min-max was necessary to calculate for the appropriate coefficients. The following equation as used to represent the predictive model:

$$QA = \beta_0 + \beta_1 (QK) + \epsilon \quad ....(1)$$

Wherein:

QA = Attitudes summation for individual (DV)

QK = Knowledge summation for individual (DV)

β_0 = Constant/Intercept

β_1 = Coefficient for QK

ϵi = Error term

Following simple linear regression, the multilinear regression model was conducted to determine how demographic factors (QG) contributed to QK and QA scores in terms of their correlation. The following equation as used to represent the predictive model(s) for each QG:

$QA_i = \beta_0 + \beta_1 QK_i + \sum^{m}_{(j=1)} \beta_2 QG_{ij} + \epsilon$ ....(2)

Where:

QA_i = Attitudes summation for individual i (DV)

QK_i = Knowledge summation for individual i (DV)

β_0 = Constant/Intercept

β_1 = Coefficient for QK

D_{ij} = Variable for subgroup j in QG

β_{2j} = Coefficient for each subgroup j in demographic factor QG

ϵ_i = Error term

RESULTS AND DISCUSSION

General Knowledge (QK) & Public Attitudes (QA) on MP Contamination of Aquaculture & Fisheries Products

Table 3: Descriptives

	Mean	Median	Mode	SD	Variance	S-W W	S-W p
Knowledge Levels (QK)	28.2	29.0	35.0	6.24	38.9	0.881	<0.001
Public Attitudes (QA)	48.4	48.0	53.0	7.44	55.3	0.974	<0.001

Note. Maximum value for QK = 35, QA = 65

The participants' QK scores had a mean of 28.2 (SD = 6.24). Similarly, QA scores had a mean of 48.4 (SD = 7.44). To test normality of cumulative scores, Shapiro-Wilk and Kolmogorov-Smirnov tests were done. Results show that QK scores significantly deviated from normality ($W = 0.881$, $p < 0.001$; $D = 0.140$, $p < 0.001$). QA scores shown through Shapiro-Wilk ($W = 0.974$, $p < 0.001$) suggested a deviation from normality as well, contrasting Kolmogorov-Smirnov ($D = 0.062$, $p = 0.219$) indicating normal distribution. Thus, along with inconsistencies in QA, normality assumptions were not used for both variables.

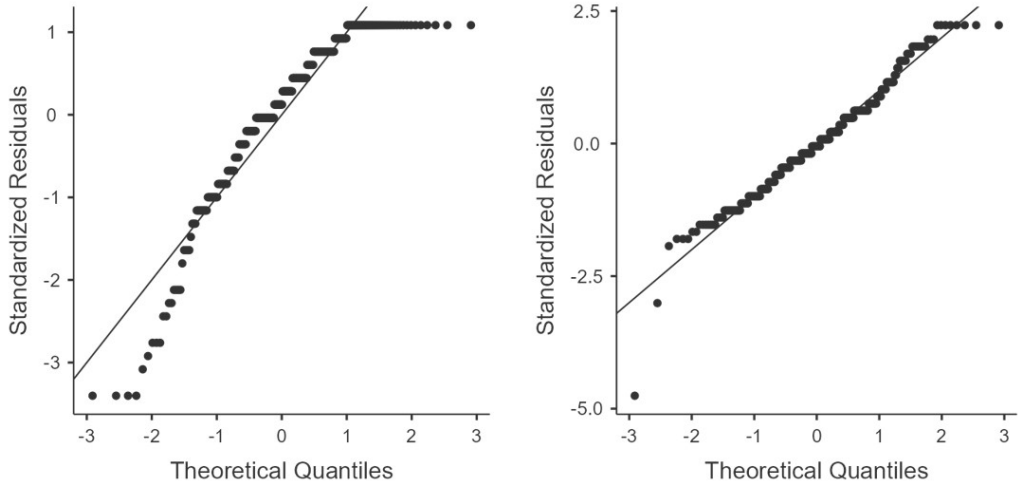

Figure 2: Q-Q plot of normality of knowledge levels (left) and attitudes (right)

Shapiro-Wilk and Kolmogorov-Smirnov treatments indicate that QK significantly deviates from normality, meaning knowledge distribution may be skewed, potentially showing clusters of highly informed and less informed groups, although ANOVA results of chosen demographics did not show any significant difference in the QG factors that were measured.

In addition, cumulative scores of QA and QK were generally high, thus it can be inferred that efforts have been made to disseminate information of MP contamination in the last five years with reference to the work of Deng *et al.* (2020) who found that public awareness was low. This is consistent with the work of Azmi *et al.* (2023) and Dowarah *et al.* (2022), with results indicating moderate scores of public awareness and attitudes.

In conclusion, statistical results indicate that knowledge scores were not normally distributed, suggesting clusters of individuals who are either highly informed or have limited knowledge regarding microplastic contamination. Furthermore, the results suggest that public knowledge may not have reached all population groups equally which creates inconsistencies between highly knowledgeable individuals and those with minimal awareness.

Correlation Analysis of Knowledge Levels (QK) on Public Attitudes (QA)

Results show that Spearman's rho value is 0.424, Showing a moderate positive correlation between cumulative scores of QA and QK. This means that as Attitudes (QA) increases, their Knowledge level (QK) tends to increase as well, a positive relationship.

Simple linear regression results further support this, showing that QA significantly predicted attitudes, aligning with the prior correlation analysis. After a min-max adjustment due to the difference of scale, coefficient calculated was $\beta_1 = 0.283$—meaning that for each minimum to maximum unit increase in QK, QA increases by β_1%. The model accounted for only 18.6%

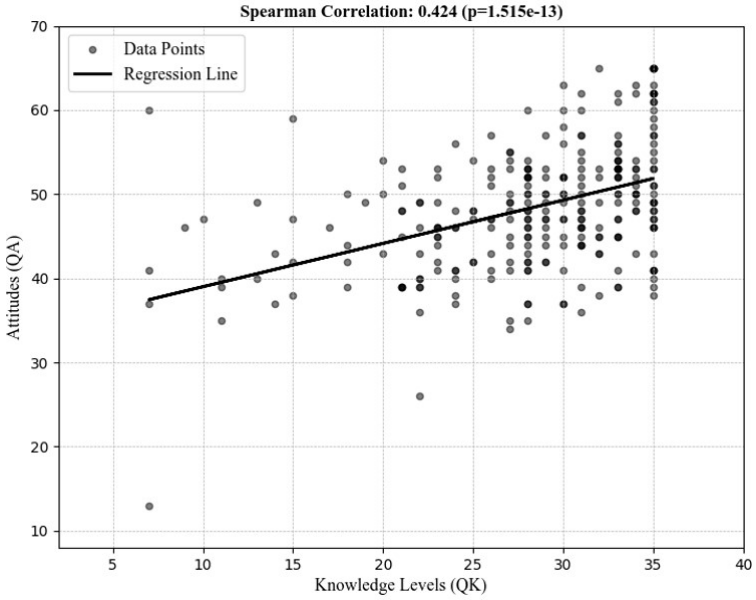

Figure 3: Spearman correlation of QA to QK

of the variance in attitudes at $R^2 = 0.186$. Public attitudes (QA) do relate to knowledge levels (QK), but only to a moderate extent. The correlation is statistically significant. The overall positive correlation indicates that individuals of higher QK scores also exhibit stronger attitudes toward mitigation efforts. The strong statistical significance shows that compared to the findings of Deng *et al.* (2020), who emphasized that awareness alone does not completely translate to behavioral changes, knowledge remains a significant predictor of attitudes.

Demographic Characteristics (QG) to General Knowledge (QK) and Public Attitudes (QA) on MP Contamination of Aquaculture Products

Table 4: Non-Parametric ANOVA (Kruskal-Wallis) of Demographic Characteristics QG

Demographic Characteristics (QG)	Attitudes (QA) p-value	Knowledge Levels (QK) p-value
Municipality	0.403	0.361
Gender	0.294	0.695
Education Level	0.308	0.506
Age Group	0.182	0.214

Note. The acceptable value for identifying significant differences is $p < 0.05$

The assessment of the Demographic Characteristics (QG), regarding its significance in assessing public attitudes (QA) and knowledge level (QK) on microplastic contamination was done through a non-parametric ANOVA using Kruskal-Wallis test. The test results indicated that none of the demographic characteristics had a significant effect as all p-values are greater than 0.05 as indicated in Table 4.

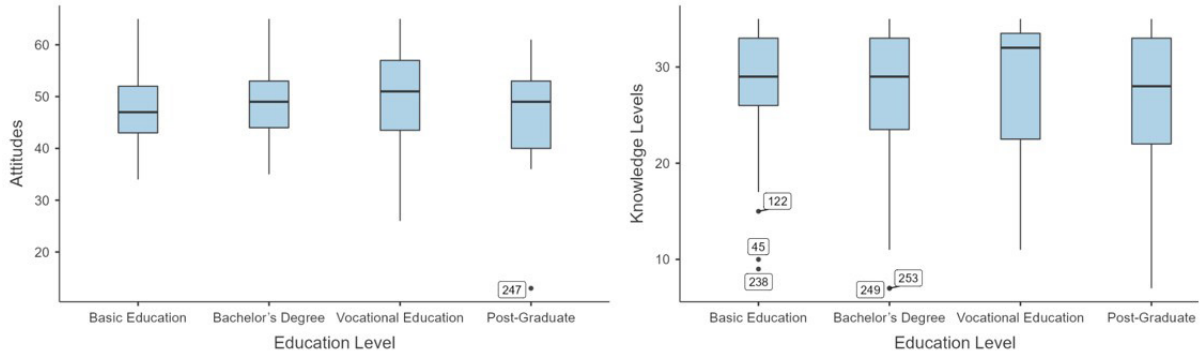

Figure 4: Box plots of descriptives of QA and QK by education level

Municipality and gender show no significant difference in public attitudes or knowledge levels, indicating that both men and women generally share similar levels of understanding about MP contamination of aquaculture

and fisheries products across CAMANAVA, regardless of proximity to fish ports and aquaculture farms. Education level and age group might be expected to influence attitude and knowledge levels, however, results show that knowledge levels and attitudes of microplastic contamination is not significantly different across different educational backgrounds and ages. Another interesting fact derived from the study is that the mean of respondents in vocational education (Mean = 27.5) was higher than post-graduate (Mean = 25.0).

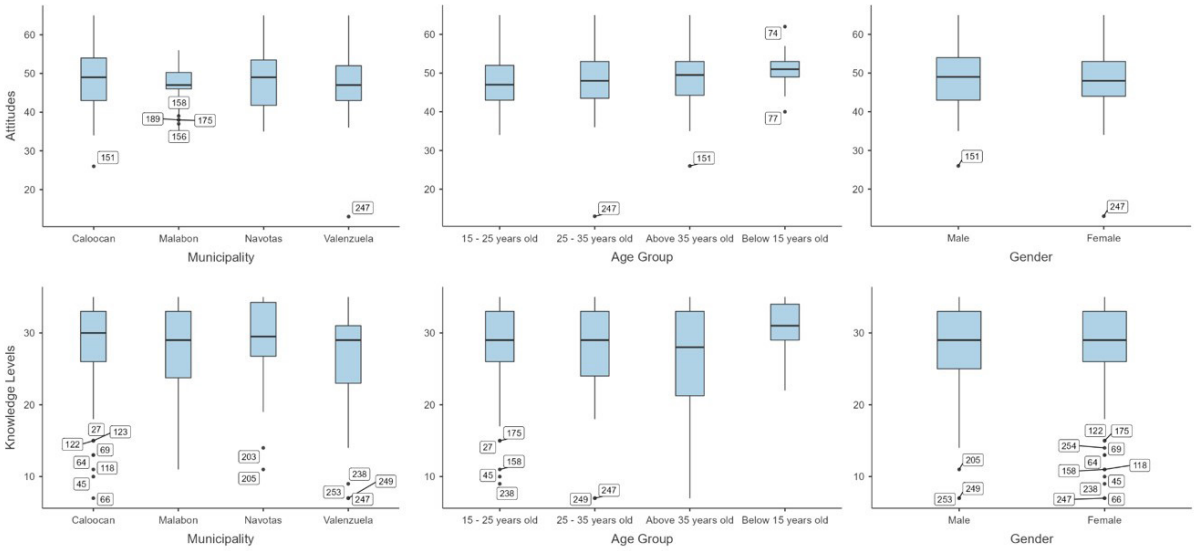

Figure 5: Box plots of descriptives of QA and QK by Municipality, Age, and Gender

The results implies a uniformity that the lack of knowledge and minimal attitudes toward microplastic contamination has become a broadly recognized issue across society, rather than being confined to specific demographic characteristics.

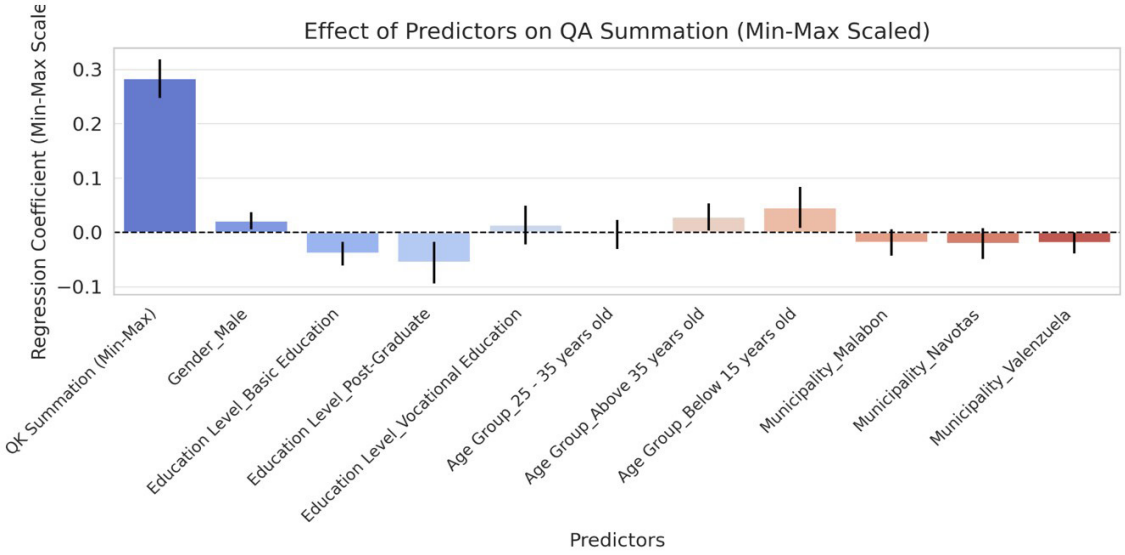

Figure 6: Effect of Predictors on Regression Coefficient in MLS

Upon multilinear regression, QK remained a significant predictor (β_1 = 0.283), with QG_{j1} municipality, QG_{j2} age group, QG_{j3} gender, and QG_{j4} education level (See figure 6). The model explained 23.1% of variance in QA with R^2 = 0.231. A min-max transformation was required for accurately interpreting the effects of the coefficients. Residents of Navotas exhibited the lowest QA scores followed by Valenzuela and Malabon with reference to Caloocan (Malabon: β = -0.019, Navotas: β = -0.021, Valenzuela: β = -0.020). In terms of age, participants under 15 years old were shown to have significantly higher attitudes with reference to adults aged 15-25 (<15 year olds β = +0.046, 25–35 year olds β =-0.004, 35+ year olds β = +0.029). With respect to the biologically female group, biological males tended to show slightly higher attitudes (β = +0.021). Participants with post-graduate or basic education reported to have lower QA scores with respect to college graduates (Basic Education β = -0.039, Vocational Education β = +0.014, Post Graduate β = -0.056).

In the bigger picture, QG factors such as age, gender, education, and municipality unanimously show limited to no significant relation to attitudes with respect to knowledge. Instead, attitude scores are still largely dependent on knowledge regardless of their demographics. Educational level having little to no significant relationship, in particular, signifies a need for education on MP contamination and food safety to be instilled. Likewise to what was shown in figure 4, post graduate respondents showed lower cumulative scores of QK and QA, as shown in regression by education level in figure 4. However, the relatively minute difference still does not make it completely representative of the subgroup. The results of the following also align with the work of Azmi *et al.* (2023), who found that even with different QG factors in their study, there is still no significant difference between such grouping variables.

CONCLUSION

Although differing in setting and in scope, the results of this study remain consistent with the global situation of public perception on MPs as a whole. Comparative to prior studies, public information on MPs may have seen improvements, particularly based on the increase of both knowledge and attitude scores in the results.

Moderate levels of knowledge and attitudes were observed based on the results of this study. In comparison, prior studies observed that in practice, communities in Navotas continue to engage in traditional fishing and aquaculture practices with minimal consideration of health hazards and safety protocols, citing poor sanitation and maintenance of the fish port.

Despite CAMANAVA's proximity and ties to the major fisheries industry, the absence of strong consumer demand for sustainable practices—combined with the normalization of plastic dependency in daily life—may further explain why attitudes are not as significantly influenced by their age, gender, municipality, or even education level for that matter. Most importantly, educational institutions should instate the inclusion of such an issue for students, given similar scores were observed even for those in higher education, with vocational education students having the highest mean score for knowledge.

Public perception overall may be seeing improvements to dissemination and communication, thus positing the relatively higher knowledge and attitude scores. However, descriptives also reveal that there is still an existing disparity between scores, which may be an outcome of bias or the demographic factors were simply not indicative to account for the variance observed. In the Filipino context, addressing microplastic contamination must consider deeply ingrained cultural practices related to plastic use and seafood consumption.

It may be implied that practices regarding MP pollution may actually be improving based on knowledge and attitudes scores. However, based on the still-perpetuating and growing issue of MP contamination and pollution, it may also mean that practices in mitigating MP contamination of such products in particular, is not strongly affected by attitudes and knowledge, as opposed to the KAP framework. However, practices are not deliberately measured in this study, thus presenting a limitation that may be built upon by future studies.

Future studies may build upon the findings of this study by (1) adding onto attitudes with more complexity, such as subgroups: (1) complacency, (2) fear, (3) ignorance, (4) indifference, and (5) responsibility avoidance towards the phenomena according to the adapted study. Another important factor is (2) to expand across more parts of the Philippines. While various studies on MP concentrations have been done so far, it is important to also understand how public perception could greatly shape policy and practices on mitigating MP pollution. (3) Practices should also be another measured construct, and developing instrumentations to measure such variables would be essential to completing the overall framework. (4) Additional demographic factors may also be key ways to understand the origin of the variance, in which initial regressions done in this study did not even account for more than 40%. (5) Improvements on sampling techniques, such as stratified random sampling methods would yield better results and representability for each subgroup involved in district studies.

While knowledge levels and attitudes have improved, persistent disparities indicate a necessity for targeted education and developments on policy. The public's involvement in mitigating such an issue is necessary for alleviating threats on food safety, marine life, and public health.

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