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Risks and Critical Points of the Oyster Product System

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Abstract
American oyster fisheries are among the most important in Mexico. However, for its economic value, it is located in thirteenth place. At present, there is no constant monitoring of the quality and safety of this fishery resource making it a risk to public health. Epidemiological studies have linked viral illnesses with raw consumption of these bivalves. The application of HACCP quality system to oyster production chain identified four types of risks to health status in the oyster extraction stage that lead to loss of the final product safety, and only one critical control point (CCP) in the production area, since this one is the stage that cannot be controlled in time and space. None of the wild oyster banks located in the lagoon system of Alvarado meet sanitary characteristics necessary to achieve certification, due to the nature and persistence of contaminants in oysters.
Key words: Coastal Lagoons, Ostreiculture, Contamination, HACCP, Food safety

1. Introduction
American oyster fisheries (*Crassostrea virginica*) are among the most important in the Gulf of Mexico. The oyster is positioned in sixth place in Mexico fishery production for its extraction volume. However, for its economic value, it is located in thirteenth place. The average annual production growth over the last 10 years was -0.91 per cent. Meanwhile in exports, it is number 16 among fish species, The United States of America is their main destination (CONAPESCA, 2011).

Veracruz contributed with a total of 245,238 tons to the annual production, which was 58,27 per cent of the national total; in addition to 219,099 tons of the aquaculture production. According to the national fishing charter this fishery is fully exploited in a sustainable manner (CONAPESCA, 2011); however, the oyster product system faces severe limitations caused by pollution, siltation of coastal lagoons, weather disturbances, ecological changes and health problems.

Furthermore, the oyster is vulnerable to diseases that can generate mortality episodes by infectious agents such as viruses, bacteria, fungi, protozoa and metazoa; and particularly adverse environmental conditions. This can cause serious public health problems and even depletion of oyster banks (Cáceres & Vázquez, 2013).

Pollution is one of the main problems of most coastal lagoons of the Gulf of Mexico, there is the possibility that bivalves as filter-feeders organisms are capable of accumulating viruses and bacteria found in the water. The accumulation of these microorganisms will depend on its density, currents temperature, depth of the reservoir and the water chemistry quality, as well as its eating habits, therefore it has also been called bioindicator organism (Marcos, 1987).

The growth of these bivalve molluscs in contaminated or poor quality water, stimulates the presence of microorganisms, such as Salmonella sp, Escherichia coli and Vibrio spp, among others; therefore when ingested cause pathogenic effects to public health (Rowse & Fleet, 1982).

The Oyster Product System is a model which integrates all the links of a production chain, different coordinate actions are performed in order to raise the profitability for the members of each link. At present, there is no constant monitoring of the health and safety of the product quality system oyster, pollution is a problem that is causing impacts on the various links and directly on the safety of the final product, which involves risks to public health . Epidemiological studies have associated viral diseases with the use of these bivalve molluscs. Among these are those that generate gastrointestinal problems such as cholera, which typically occurs in developing countries and tropical climate like Mexico (Suarez, 2012; Negrete & Romero, 2010).

In order to impact the new trends of globalizing markets and to support the needs of Veracruz cooperative, it is required to increase the value added to fishery resources, which are the main source of income for this sector. It is also necessary to extend the marketing of this important fishery resource within the country and abroad by implementing systematic methodologies that comply with national and international regulations for the harvesting and consumption purpose. The system of hazard analysis and critical control points, better known by his acronym HACCP (Hazard Analysis Critical Points Control) includes scientific and systematic basis, which allows to identify critical control points and establish measures to ensure food safety (FAO, 1997). This system involves identifying all potential safety hazards of biological, chemical and physical abuse, which may occur in a natural manner affecting the environment, accidentally or be generated during the production process (Monreal, 2011). Today, every company that engages in pulling out, processing, handling, packaging, marketing and transporting food is required to ascertain the potential risks during the production process, from the extraction or cultivation area to ensure the quality and safety of the raw material to marketing the final product. Thus, in Mexico, the Ministry of Health and Welfare has established the Mexican Official Standards NOM-242-SSA1-2009 for goods and services; which provides an implementation of a system of hazard analysis and critical control points HACCP that responds to the requirements of the FAO (1997).

This project aimed to implement HACCP to identify hazards and critical control points of the oyster product system since its extraction from the lagoon system of Alvarado, Veracruz; to marketing, in order to design procedures to ensure the health quality and safety of this fishery resource.

2. Methods

2.1 Study Area

The Alvarado lagoon system (Fig. 1) is located on the coast of the Gulf of Mexico to the southern part of the coast of Veracruz between 18° 43' and 18° 52' north latitude and 95° 42' and 95° 57' west longitude. The municipality is irrigated by the Papaloapan and Blanco rivers; both tributaries of the Alvarado Lagoon. Around this lagoon there are other smaller lagoons, such as La Camaronera, Tlalixcoyan and Tequiapan. The Alvarado Lagoon covers 6,200 ha, La Camaronera 3,900 ha and Tlalixcoyan 1,700 ha. The climate is warm sub-humid with a summer rainfall rate of AW2, the annual average temperature is 25,5 °C, January is the coldest month and May the hottest (Garcia, 1973). The average annual rainfall is 1914.1 mm^3 (Luna *et al.*, 2002).

Figure 1. Oyster bank located in the lagoon system of Alvarado, Veracruz.

2.2 Selection of oyster beds

The selection of oyster beds was performed according to extraction volumes reported by members of the oyster fishery cooperatives in the area of Alvarado. Two oyster beds that provide the largest share of production were identified. These are located in the channel connecting the lagoons of La Camaronera with Buen País.

2.3 Implementation of HACCP

The design methodology for the implementation of HACCP was conducted in accordance with the requirements of the FAO (1997); which provides for the application of seven principles and stages of development of risk analysis, identification and control of critical points for food handling in each of the stages of the oyster product system.

2.3.1 Diagnosis of the Oyster Product System

The diagnosis of the oyster production chain in the Alvarado lagoon system was performed according to the description of health conditions: (i) Extraction area, (ii) Collection of the resource, (iii) Means of transportation and transfer, and (iv) Receipt of the product. This information was obtained by applying a survey to cooperative and oyster farmers on management, marketing, hygiene practices and oyster manufacturing resource. The health, microbiological and physicochemical characteristics of the extraction areas were obtained from data published in scientific journals.

2.3.2 Design of the HACCP for the oyster product system

The description of the desired product was made. It was also defined the objective, health and safety characteristics of the collected product, as well as goals, and alternatives of consumption of the finished product.

2.3.3 Identification, analysis and evaluation of the oyster product risks (Crassostrea virginica) in the Alvarado lagoon system

Each of the biological, chemical and physical hazards occurred, or is likely to occur at each stage of production and resource management was identified; from the production area to the reception of the product. It was also analyzed and its significance was observed by evaluating the severity and occurrence probability.

2.3.4 Identification of critical control points

The determination of critical control points (CCP) was made based on the application of the HACCP decision tree (HACCP, 1999). This was applied to only those steps representing a significant hazard.

2.3.5 Selection of critical control limits of the lagoon system of Alvarado

At this point the critical limits for each CCP is established, and these levels or prescribed tolerances should not be exceeded to ensure the CCP is effectively controlled. Also, preventive measures associated with critical limits were established. In some cases, it was necessary to establish a critical limit for each point in the process.

2.3.6 HACCP system for monitoring and verification at health level of the oyster product system

The proposal for the monitoring and verification of health status and product safety system was performed according to the documentation of all above, plus the appropriate HACCP procedures records, its implementation and smooth performance.

2.4 Establishment of regulatory framework

To apply the HACCP system is necessary to consider a regulatory framework in which health and safety conditions are set to determine the quality of the resource. The Federal Fisheries Law and its regulations regulate use of aquatic resources in Mexico. The exploitation of bivalve molluscs is established in the Mexican Health Program of Shellfish

(1989), the same program that is responsible for establishing and monitoring compliance with health technical standards for the successful development and commercialization of the oyster resource in the country. Applying for these purposes, the Regulations of the General Health Law Concerning the Sanitary Control (Title VI, Chap. I and II), the Sanitary Control of Products and Services (Title Seven Ch. I & II), and the provisions for Secretary of Health and Welfare (SSA) in NOM-242-SSA1-2009 for products and services; fishery products, fresh, chilled, frozen and processed. Sanitary specifications and test methods.

In order to gain a wider panorama in diagnosis of the oyster product system, a benchmarking exercise was carried out between the results of the literature search concerning the sanitary quality of the extraction area, critical limits established in international standards FAO, WHO, EU, US and in MX with respect to the Program of Health Shellfish (PSMB) so that the critical control points are identified through the application of the HACCP quality system to the oyster product system.

3. Results and Discussion

3.1 Diagnosis of the oyster product system

3.1.1 Extraction area

Different studies in the lagoon system of Alvarado said the main categories of contaminants in major oyster beds are four: heavy metals (Table 1), organochlorine pesticides (Table 2), petroleum hydrocarbons (Table 3) and pathogens (Table 4) (Botello *et al*., 2002). These results were compared with the limits set in Mexico (MX) in the European Union (EU) and in The United States of America (USA). This was done to compare the type of items that are being legislated and the variability in the maximum allowed concentrations in the different countries.

Table 1. Heavy metals reported in the Alvarado lagoon, Ver., and permissible limits.

Study Area	Metal	Concentration reported in various types of displays (mg/kg)			Permissible limits (mg/kg) PSMB		
		Water	Oyster	Sediment	MX[b]	UE	EU
Blanco river	Pb	-	-	30.5[3]	1.0	1.5	1.7
Papaloapan river		-	-	39.5[12]			
Alvarado		1.209[1a] 4.105[1]	11.58[4] 20.15[2]	21.44[4]			
	Cd	-	7.28[4]	1.91[4]	0.5	1.0	4.0
	Hg	-	-	-	1.0	0.5	-
	Cr	-	-	109.83[2]	n.r.	n.r.	13.0
	Ni	-	-	47.77[2]	n.r.	n.r.	80.0
	As	-	-	-	n.r.	n.r.	86.0
	Co	-	-	36.26[2]	No regulations		
	Cu	-	214.5[4]	15.55[2] 17.18[4]			
	Zn	-	987.9[4]	80.72[2] 65.04[4]			
	Fe	-	-	39.29[2]			
	Mn	-	-	757.58[2]			
	Al	-	927.9[4]	26,020[4]			

- No records; n.r: no regulations. [a]Maximum allowable limit inshore 0.2 mg / l (NOM-001-SEMANART-1996; [b]NOM-242-SSA1-1996; [1]Luna et al., 2002; [2]Rosales et al, 1986b; [3]Marcos, 1987; [4]Maximum concentrations (dry weight) cited in Lango et al, 2010).

Table 2. Organochlorine pesticides reported in the Alvarado lagoon, Ver., and permissible limits.

Pollutant	Reported concentration (ng / g dry weight)		Permissible limits PSMB		
	Sediments	Oyster	MX[3]	UE*	EU
Aldrin	2.11[1]	6.61[1]	Absence	< IDA	Not covered for bivalve molluscs
Endrin	7.82[1]	7.95[1]			
Dieldrin	2.05[1]	s.d.			
Heptachlor	3.91[1]	2.91[1]			
Kapone	n.d.	n.d.			
Alpha HCH	0.47[1]	2.61[1]	No Regulations	No Regulations	
Hepoxido heptachlor	0.86[1]	2.17[1]			
Endosulfan I	1.22[1]	1.22[1]			
p,p'-DDE	1.78[1]	0.42[1]			
Beta HCH	1.86[1]	2.08[1]			
Gama HCH	0.85[1]	2.73[1]			
p,p'-DDD	0.89[1]	n.d.			
Endosulfan II	0.67[1]	17.65[1]			
p,p'-DDT	2.24[1]	1.64[1]			
Endrin aldehyde	1.77[1]	1.92[1]			
Endosulfan sulfate	1.40[1]	n.d.			

<IDA: less than the acceptable daily intake. nd: no data * Harmful toxic compounds occurring naturally or added to the environment ([1]Botello et al., 2002; [3]Marcos, 1987).

Table 3. Petroleum hydrocarbons in sediments of the Alvarado Veracruz lagoon.

Study area	Level	Permissible limits		
		PSMB		
		MX[1]	UE	EU
Alvarado lagoon	18.0 ppm[2]	N.R.	N.R.	N.R.
Allowable limit for unpolluted areas [19]	70.0 µg/g			

N.R.: No Regulations; [1]NOM-242-SSA1-2009, [2]Botello et al., 2002.

Table 4. Microorganisms present in the Alvarado Lagoon System, Ver., and permissible limits.

Microorganisms	Reported Concentration		Permissible limits		
			PSMB		
	Water	Oyster	MX*	UE	EU
Total Coliforms (NMP/100 ml.)	Unnumbered[1, 2]	-	230	-	230
Fecal (NMP/100 ml.)	Unnumbered[1] >230[2]	-	43	< 300	43
Salmonella (25 g.)	Present[2]	Present[1]	Absence	Absence	Absence
Shigella	-	Present[1]	N. R.	N. R.	N. R.
Vibrio cholerae	Present[1]	Present[1]	Absence		
Vibrio cholerae no O1	Present[2]	Present[2]			
Vibrio cholerae O1 INABA	Present[2]	Present[2]			
Vibrio parahaemolyticus	-	Present[1]	N. R.		
Vibrio alginolyticus	Present[2]	Present[1]			

No records; N. R.: No Regulations, * NOM-242-SSA1-2009, [1]Botello, 1990; [2]Lango et al., 2010.

3.1.2 Methods of extraction

Snorkeling and/or diving mask: two methods of extraction, which are used interchangeably. Free diving is practiced in areas with depths of less than 2m. This fishing gear, the diving mask, is used when the depth is greater and also during winter season. They are made with two rakes attached in the middle portion of the handle and it is operated as a clamp. Once removed the "oyster's pineapple" the shell removal begins, the larger sizes over 7 cm are selected and average or smaller sizes are returned to the sea. The oysters are brushed and placed inside the boat, without any conservation measure, outdoors, and prone to any type of physical damage, biological or chemical contamination; also at risk of contaminating the product on board for direct contact with the engine fuel tank.

3.1.3 Transfer

The oyster transfer to the facilities of the oyster fishing cooperatives in the Alvarado lagoon system is carried out in small boats made of wood or fiberglass, with a length of 2.5 to 10 m with outboard engines 8-40 HP depending on the distance and depth that fishermen work. This activity is performed without any control of health and safety. Sometimes the oyster is placed in plastic sacks of 31-35 kg for delivery. In general, the conditions of the vessels used for this activity does not cover the necessary safety features in terms of disease control, provided in the regulations of the General Law of Health in Mexico, (Title VI, Chapter II), and it is not uncommon to find traces of fish offal, garbage, gas and oil, in addition to visible physical damage to the surface of the vessels which affects the safety of oysters.

3.1.4 Receipt of oysters

When the cooperative is more than 100 m away from the coast, the product is transported without temperature control on polyethylene fibers bags. The carriage is performed in vehicles, trucks, bicycles and tricycles, to the premises of the fishing cooperative. At the reception site this product is checked, wheighed and the extraction volume is recorded in a log. Then it is stored for 12 to 24 hours at room temperature for immediate sale. After the oyster's shell is removed, it gets packed by the thousands in polyethylene bags. The water in it, is potable water containing no record of quality and is used as a liquid medium. The packaged product is kept refrigerated, although there is not a log that shows the temperature control during storage.

3.2 Implementation of HACCP

3.2.1 Risk Identification

As part of the HACCP methodology, the implementation of the decision tree identified three critical points which are responsible for the loss of oyster safety. These critical control points are: the area of production, transfer and receipt of the product in the cooperative (Fig. 2).

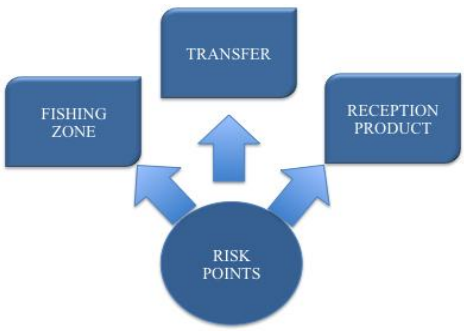

Figure 2. Risk points of the oyster product system that lead to safety loss.

3.2.2 Design and implementation of HACCP for the extraction of the American oyster

An important factor in the success and smooth functioning of a HACCP system, whatever the field of application is, it lies in the hierarchy of the obligations of the company through the development of a general organization chart. This should ensure the proper implementation, monitoring and verification of HACCP as a plan for quality assurance (Fig. 3). This, through the knowledge of each of the responsibilities of each hierarchical level process (Steven & Garrido, 1995), thus the good organization of the staff will enable them to meet their expectations and goals, which are aimed to achieve a national and international competitive product. The design is performed as stipulated in Table 5.

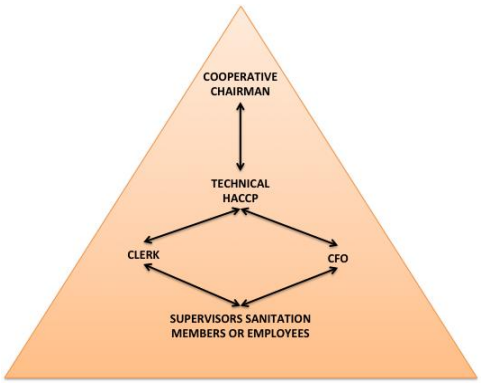

Figure 3. General organization for quality assurance of the oyster activity.

Table 5. HACCP design for the oyster extraction in the Alvarado lagoon system.

HACCP DESIGN	
Objective:	To obtain a safe product for the consumer.
Goals:	Evaluate extraction areas, evaluate the extraction process, and establish a monitoring program and health check.
Product definition:	American oyster (*C. virginica*), of commercial size (9.0 ± 2.0 cm), packed in shell, in 50 x 84 cm white polypropylene sacks.
Consumption alternatives of the ultimate product:	The American oysters can be enjoyed in the following ways: Fresh oysters.- The procedures that are performed for processing are removing the shell and packing in plastic lithographed caliber 0.22, nontoxic variable weight. Preserved oysters.- Including cooked, smoked and pickled oysters; this variety requires more elaborated procedures than the previous one, for example, cooked oysters, besides the cooking procedure, they need hermetical packaging. Purified oysters.- The treatment process may be performed using ultraviolet rays, chlorine or ozone, or a combination of some of these. Time and purifying features depend on the capacity and what is used as purifier.

3.2.3 Identification, analysis and evaluation of risks to health status of the oyster business in the Alvarado lagoon system.

3.2.3.1 Extraction Area

The prevailing conditions of the system are governed by climatic changes (seasons: winter, drought and rainfall), the anthropogenic influence of settlements near to oyster beds, and because of sediment transport and pollutants from the river mouths. The potential dangers that the oysters are exposed in the extraction area, plus the preventive measures and regulations that protect them are detailed in Table 6.

Table 6. Potential hazards and preventive measures for the removal of oysters in the collecting area.

POTENTIAL HAZARDS			
BIOLOGICAL	**PHYSICAL**	**CHEMICAL**	**ECOLOGICAL**
* Microbial Contamination: Bacteria, total coliforms, fecals coliforms, *Vibrio spp.*, *Salmonella*, *Shigella*, biotoxins.	Removing specimens of size < 7cm.	* Presence of heavy metals, pesticides, petroleum hydrocarbons.	Negative interactions.
PREVENTIVE MEASURES			
* Identify emission sources * Establish monitoring programs to detect contamination.	Monitoring	* Establish monitoring programs to detect pollution.	Monitoring
REGULATIONS			
Permissible limits: NOM-242-SSA1-2009 PSMB CSPS	Federal Fishery Law	Permissible limits: NOM-ECOL-001-1996 NOM-242-SSA1-2009 RLGS-CS[1], PSMB	PSMB

PSMB: Shellfish Health Plan; CSPC: Sanitary Control of Products and Services (Seventh Title, Chapters I and II); RLGS-CS: Regulation of the General Health Law concerning the Sanitary Control, [1] Seventh Title, Chapters II and I.

3.2.3.2 Extraction and Transfer

The process of extraction or collection of oysters is done manually by free diving to different depths. The organisms obtained are selected by size and brushed; they are then stacked in the boat with no conservation measures. The boats commonly used are the canoe and boats with outboard engine. Conveying the product is carried out in a variable time, which ranges from one to three hours, depending on the vessel. Potential hazards, preventive measures and relevant regulations are detailed in Table 7.

Table 7. Potential risks and preventive measures for the oyster during collection and transfer.

POTENTIAL HAZARDS			
BIOLOGICAL	**PHYSICAL**	**CHEMICAL**	**ECOLOGICAL**
* Decomposition of the product and contact and unusual matter * Cross contamination	Break valves in the process of epibionts elimination.	Product contamination by gasoline and other hydrocarbons on board.	Removing juvenile
PREVENTIVE MEASURES			
* Preservation measures in cold and storage. *Fishermen health certificate.	*Implementation of good hygiene practices and product manufacturing.	*Implementation of good hygiene practices and product manufacturing.	Brushing *in situ*.
REGULATIONS			
RLGS-CS[3] Good hygiene practices and manufacturing	RLGS-CS[2] PSMB	RLGS-CS[2] PSMB	Federal Fisheries Act

PSMB: Shellfish Health Plan RLGS-CS: Regulation of the General Health Law Concerning the Sanitary Control, [2]Sixth Title, Chapter II, Art. 541.[3]Sixth Title, Chapter II, Art. 540 and 535.

3.2.3.3 Receipt of Product

The reception takes place directly in the cooperative, or upon reaching the edge of the lagoon. In the first case, the reception is done manually by placing the product on the desks to remove the shell and then washed with water in plastic containers, after that it is bagged with well or potable water in quantities of 100, 200 and 500 bodies. If the product has not had the shell removed, it gets packed in sacks of 31-35 kg. Both presentations are available immediately. In high season they are stored in horizontal refrigerators or freezers with crushed ice for a maximum of 24 hours. When the product is received at the edge of the lagoon, the same process of landing is performed and then the product is moved manually to the cooperative, in wheelbarrows, or in motor vehicles. It was noted that some cooperative fishermen hand the product by following some rules of hygiene and health, such as the use of boots and gloves. However, most of them are not familiar with health standards for hygienic food handling. The potential dangers when receiving the product, preventive measures and regulations are detailed in Table 8.

Table 8. Potential risks and preventive measures for oysters at the reception of the product.

POTENTIAL HAZARDS			
BIOLOGICAL	PHYSICAL	CHEMICAL	ECOLOGICAL
* Product contamination by improper conditions in the reception site. * Risk by presence for pets in the workplace. *Inadequate container conditions. *Use of non-potable water. *Poor ice quality.	Rupture of valves in the download process.	Presence of contaminants in the water that is used as a liquid medium in the shell-removed product.	None
PREVENTIVE MEASURES			
* Implementation of good hygiene practices and product manufacturing. * Use of potable or disinfected water. * Use of refrigerators.	*Staff Awareness *Implementation of good hygiene and manufacturing of the product.	* Using purified water as liquid medium.	None
REGULATIONS			
RLGS-CS[4] PSMB	RLGS-CS[2] PSMB	RLGS-CS[4]	None

PSMB: Health Plan Shellfish. RLGS-CS: Regulation of the General Law on Health Matters for Disease. [2]Sixth title, Chapter II, Art. 541. [4]Sixth title, Chapter III.

3.2.3.4 Identification of critical control points

This is based on the identification of risks that lead to loss of product safety in the oyster extraction stages (Fig. 4). After the application of the decision tree for each of risk, it was identified just one Critical Control Point (CCP), in the collection area. It is relevant to mention, that controlling the events in time and space is not possible, especially when there is dumping of chemicals, which implies the presence of heavy metals, pesticides and hydrocarbons in the lake systems and extraction areas. Contrasting, the risk in the extraction area is controlled in the next stages by using cleaning

systems, against pathogenic bacteria, and the application of good hygiene practices and manufacturing of the product; in addition of monitoring and verifying the implementation of the rules of hygiene and sanitation (Table 9).

4. Conclusions

The application of HACCP allowed identifying four health risks in the oyster extraction process that lead to loss of product safety. Among those, only one Critical Control Point in the production area, since this one is the stage process that cannot be controlled in time and space. None of the wild oyster banks located in the lagoon system of Alvarado meet sanitary and safety features to ensure their accreditation due to the nature of the contaminants and their persistence in organisms. The Mexican Shellfish Health Plan has methodological deficiencies in extraction techniques, handling and transportation of the product, thus it is harder to ensure the sanitary quality of oysters when there is no official document that sets out the steps to perform this fishery.

Because higher concentrations of heavy metals have been found in sediments, it is recommended to implement surface cultures in order to avoid exceeding the permissible limits established in different national and international normativities.

Table 9. Table 9. HACCP application form of the production area of oyster *Crassostrea virginica.*

Control Critical Point (PCC)	**Significant Health Risk**	**Critical Limits**			**Monitoring**				**Corrective actions**	**Records**	**Verification**
		MX	**CEE**	**EU**	**What**	**How**	**Frequency**	**Who**			
1) Collection Area	Heavy metals	The established in the relevant regulations for each metal of public health importance.			Concentration in oyster	Laboratory analysis	Each season	Cooperative and HSV*	Reject batch	Location of bed and collecting season.	Semiannual review of monitoring and preventive measures.
	Pesticides	The established by the relevant regulations for each compound of public health importance.			Concentration in oyster	Laboratory analysis	Each season	Cooperative and HSV*	Reject batch	Location of bed and collecting season.	Semiannual review of monitoring and preventive measures.
	Hydrocarbons	None mentioned in normativities.			Concentration in oyster	Laboratory analysis	Each season	Cooperative and HSV*	Reject batch	Location of bed and collecting season.	Semiannual review of monitoring and preventive measures.
	Microorganisms	The established by the relevant regulations for each bacteria of public health importance.			Presence and concentration in oyster	Laboratory analysis	Each season	Cooperative and HSV*	Transplant or debugging	Location of bed and collecting season.	Semiannual review of monitoring and preventive measures and corrective actions.

* Health Services of Veracruz

5. References

Consejo Nacional de Acuacultura y Pesca (CONAPESCA). (2011). *Anuario Estadístico de Pesca*. En línea. Retrieved from http://www.gbcbiotech.com/genomicaypesca/documentos/industria/SAGARPA%20Anuario%20Estadístico%20de%20Acuacultura%20y%20Pesca%202011.pdf. Accesed 20 May 2014.

Cáceres, M; & Vásquez R. (2013). Enfermedades, parásitos y episodios de mortalidad de ostiones de importancia comercial en México y sus implicaciones para la producción. *Ciencia Pesquera*. 21(Numero especial), pp. 5-48.

Marcos, V. M. (1987). Correlación de algunos parámetros fisicoquímicos con la presencia de entero bacterias en el ostión (*Crassostrea virginica*) en la laguna de Tampamachoco, Ver. Tesis de licenciatura. Facultad de Biología. UV. Tuxpan, Ver. pp, 1-6.

Rowse, J. A., & Fleet, H. G. (1982). Viability and release of *Salmonella* charity and *Escherichia coli* from Oyster Feces. *Applied and Environmental Microbiology*. 44(3),pp 544-548.

Suarez, V. (2012). Estimación del riesgo a la salud por consumo de ostión americano (*Crassostrea virginica*) depurado mediante tecnologías avanzadas de oxidación (mezclas UV/Ozono). Tesis de Maestría. Facultad de medicina y veterinaria y zootecnia (2012). Veracruz, Ver. pp, 6-7.

Negrete, R. P; & Romero, J. J. (2010). Carga bacteriana en ostión (*Crassostrea virginica*) desde su recolecta hasta su consumo. *Sociedades rurales, producción y medio ambiente*. 10(20), pp. Accesed 15 January 2015.

FAO. (1997). *Legislación y regulaciones*. Dirección de la pesca marítima y acuacultura. Retrieved from http://www.fao.org/docrep/005/y1579s/y1579s03.htm Accesed 15 January 2015.

Monreal, R. (2011). HACCP sinónimo de seguridad. A BNP media publication USA. *Revista industria alimentaria*, 22(4), pp.

Garcia, E. (1973). Modificaciones del sistema de clasificación climática de Copen (para adaptarlas a la República Mexicana); Instituto de Geografía, Univ. Nal. Autom. México. p. 33

Luna, J. M., Jaime R. V., & Alpuche, G. L. (2002). Presencia de plomo en agua y ostión en las lagunas de Alvarado y La Mancha. In: La Pesca en Veracruz y sus Perspectivas de Desarrollo. Editores Inst. Nacional de Pesca y Universidad Veracruzana. Xalapa, Ver. pp, 145-155.

HACCP, (1999). *Un enfoque sistemático a la seguridad de los alimentos*. Manual para el desarrollo e implementación de un plan de análisis de peligros y puntos críticos de control. National Food processors Association. The Food Processors Institute. Washington, D.C. 20005-3305. pp, 5-60.

Botello, A. V., Barrera, G., Díaz, G., Ponce G. V., Villanueva, F. S., & Wong Ch., I. (2002). Contaminación Marina y Costera. In: *La Pesca en Veracruz y sus Perspectivas de Desarrollo*. Inst. Nacional de Pesca y Universidad Veracruzana (Eds). Xalapa, Ver. pp, 97-111.

NOM-001-SEMARNAT-1996. Norma Oficial Mexicana Límites máximos permisibles de contaminantes de las descargas de aguas residuales en aguas y bienes nacionales. Retrieved from http://www.profepa.gob.mx/innovaportal/file/3290/1/NOM-001-SEMARNAT-1996.pdf Accesed September 23 2014.

NOM-242-SSA1-2009. Norma Oficial Mexicana Productos y servicios. Productos de la pesca frescos, refrigerados, congelados y procesados. Especificaciones sanitarias y métodos de prueba. Retrieved from http://dof.gob.mx/nota_detalle.php?codigo=5177531&fecha=10/02/2011 Accesed September 23 2014.

Luna, J. M., Jaime R. V., & Alpuche, G. L. (2002). Presencia de plomo en agua y ostión en las lagunas de Alvarado y La Mancha. In: La Pesca en Veracruz y sus Perspectivas de Desarrollo. Inst. Nacional de Pesca y Universidad Veracruzana (Eds.). Xalapa, Ver. pp, 145-154.

Rosales, L., A, Carranza, & Álvarez, U. (1986b). Sedimentological and chemical studies in sediments from Papaloapan river México. *An. Inst. Ciencias del Mar y Limn*-UNAM. 13(3), pp. 263-272.

Álvarez, U., L. Rosales & Carranza, A. (1986). Heavy metals in Blanco river sediments in México. *An. Inst. Ciencias del Mar y Limnología*-UNAM. 13(2), pp. 1-10.

Lango, R. F., Landeros S. C., & Castañeda C. M. (2010). Bioacumulación de cadmio (Cd), plomo (Pb) y arsénico (As) en *Crassostrea virginica* del sistema lagunar Tamiahua, Veracruz, México. *Revista internacional de contaminación ambiental*, 26(3), pp. 201-210. ISSN: 0188-4999

UNESCO (1976). Guide to operational procedures for de IGOSS pilot project on Marine Pollution (petroleum) Monitoring Manual and Guides No. 7.

Botello, A. V. (1990). Impacto ambiental de los hidrocarburos organoclorados y de microorganismo patógenos específicos en lagunas costeras del Golfo de México. Informe final Proyecto OEA/CONACYT/UNAM, México. p, 69.

Steven, O., & Garrido, M. V. (1995). Total Quality Assurance (TQA) and Hazard Analysis Critical Control Point (HACCP). Manual for Clam production and processing. Sea Grant Florida-University of Florida. pp, 1-8.