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"Risk analysis is a discipline that is best shared by actual experience ...
it is an exercise that is learned by doing..."

Example case study

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Example case study: mangrove crab

Introduction

Example Case Study
Mangrove crab
(Scylla serrata)
to Kosrae State,
Federated States of
Micronesia

This case study is prepared by the International Consultant for the Food and Agriculture Organization of the United Nations (FAO) under Project TCP/MIC/3201: Risk Assessment in Aquaculture Development in FSM, to assist in raising awareness and understanding on the application of risk analysis to aquaculture production. The case study is not a risk analysis, but rather provides a preliminary examination and assessment of the possible pathogen hazards and, to a lesser extent, ecological/pest/invasive species issues that may be involved in the translocation of mangrove crab (*Scylla serrata*) to Kosrae to support aquaculture development (mangrove crab "fattening"). It can thus form a starting point for conducting future pathogen, ecological and/or genetic risk analyses should the FAO or Government of the Federated States of Micronesia (FSM) chose to undertake such studies. It does not consider such issues as impacts on natural stocks by harvesting wild crab to support aquaculture development.

Background

The mangrove or mud crab (*Scylla serrata*) is distributed throughout the Indo-Pacific region from Hawaii, southern Japan, Taiwan POC and the Philippines, to Australia, the Red Sea and East and South Africa; it is thus native to Kosrae State, FSM

The Kosrae State Government has undertaken a feasibility study of mangrove grab farming with the aim of providing enough crabs for local subsistence and for export markets. In Kosrae, traditional extensive culture methods are used to grow-out or "fatten" mangrove crabs by the capture and holding of small numbers of locally caught, wild juveniles in pens constructed in mangrove areas. It is envisaged that using this enclosure grow system can develop the mangrove crab farming sector in Kosrae to meet the growing local and outside demands. The Kosrae State Government has invested some initial capital into this project and has approached the National Government for technical assistance and to solicit potential external assistance (source: FSM Country Report).

The Kosrae Fisheries Department set up a state-funded Mangrove Crab Pilot Project in 2002-2004 that includes construction of a mangrove crab hatchery at the FSM Aquaculture Center in Lelu. (Wortel, 2005; Ponia, 2006). The crab grow-out site comprises two large earthen ponds on a 10 ha site Retaining walls have been built to reduce escapees. The crabs are fed trash tuna provided by transshipment boats in port. Exports of crabs to Guam for the restaurant trade have been taking place (Wortel, 2005).

Problems faced by the project have included competition for food from freshwater eels, the negative impacts on the mangrove forest of excavation and soil build-up around the site, and undetermined mortality rate for crabs within the pond. There has also been difficulty in obtaining small juvenile crabs from the mangrove forests of Kosrae for stocking into the ponds. As a result mangrove crabs of all sizes have been purchased by the state in order to stock the ponds. However, there is concern that this practice is not sustainable and will lead to depletion of local wild stocks (Wortel, 2005).

Species profile

- Taxonomy:
  - Kingdom: Animalia
  - Phylum: Arthropoda
  - Class: Crustacea
  - Order: Decapoda
  - Family: Portunidae
  - Genus: *Scylla*
  - Species: *Scylla serrata*

It is noteworthy that the genus *Scylla* contains four species, *S. serrata, S. tranquebarica, S. olivacea* and *S. paramamosan*. Thus the identity of crabs presently being cultured in FSM, as will as any stock that may be transferred or imported should be verified.

- **Geographic distribution**

  The mangrove or mud crab (*Scylla serrata*) is distributed throughout the Indo-Pacific region from Hawaii, southern Japan, Taiwan POC and the Philippines, to Australia, the Red Sea and East and South Africa.

- **Aquaculture significance**

  The mangrove crab is the most important crab for commercial culture in the Indo-West Pacific region and commands a high price in both the domestic and export markets. It is considered an excellent and sought-after delicacy in Asia and females with mature ovaries are particularly expensive. Mangrove crab is commercially harvested in areas where it has been introduced and populations have become established.

  As interest in this species has grown so has pressure on the wild populations used for stocking, such that hatchery technology for large-scale production of juveniles has now been developed in the Philippines by SEAFDEC-AQD, as well as in Japan and India. However, although techniques for spawning and larval production have been developed (see Jithendran *et al.* 2009), these techniques are not widespread and are also still dependent on the capture of wild crabs for use as broodstock.

- **Status in FSM**
  Mangrove crab occurs throughout FSM and is thus native to Kosrae. Movements of this species, whether from other stocks in FSM or via importation of crabs from abroad would constitute species transfer.

- **Invasiveness**
  There do not appear to be any reports of invasiveness or adverse ecological impacts resulting from translocations of mangrove crabs (e.g. Global Invasive Species Database, http://www.issg.org/database/welcome/). Ecological impact of introductions is unknown, but the species has been described as an active and aggressive[5] As this species is native to Kosrae and has positive economic significance, invasiveness is not considered an issue in this proposed transfer.

- **Genetics**
  The population structure of mangrove crab is not well known. The species is noted to have an extended larval phase, suggesting a high dispersal potential (USGSl. http://nas.er.usgs.gov/queries/FactSheet.aspxPspeciesID=192). A study of genetic differentiation in Indian Ocean populations, however, found reduced gene flow, even between geographically close sites. In contrast, the south-west region of Australia was colonized by large numbers of *S. serrata* from north-west Australia through a planktonic recruitment event enhanced by a strong 1999/2000 Leeuwin Current.

As noted by Uthicke and Purcell (2004), the release or escape of hatchery-produced aquatic species can present the risk of genetic harms to wild stocks via:

(i) Genetic introgression that reduces the genetic differences among stocks. Reduction in frequency of native alleles via introgression of exogenous alleles can result from the use of imported or transferred broodstock of different genetic stock for hatchery production. This introgression may be caused either by interbreeding of animals

[5] (http://nas.er.usgs.gov/queries/FactSheet.aspxPspeciesID=192).

from the two stocks or by the introduced alleles outcompeting native alleles because of higher fitness of individuals carrying these introduced alleles.

(ii) Outbreeding depression resulting from interbreeding of an introduced stock with a native stock, which can disturb potentially complex adaptations to the local environment that have evolved over time. Such hybridizations tend to have long-lasting effects that are disadvantageous to native stocks rather than beneficial through added genetic variation.

Therefore, unless the genetic structures of stocks at release and source sites are known, juveniles should be released only at native sites to preserve the genetic diversity of stocks.

- **Pathogens**

  In general, the pathogens and parasites of mangrove crabs are poorly known. A wide range of "fouling organisms" and commensals (filamentous bacteria, algae, stalked protozoans, barnacles etc.) are common on crabs reared under suboptimal conditions. These are not considered further in this preliminary analysis; however, the Government should note their likely presence as "fellow travelers" on imported mangrove crabs. There are few studies on the diseases of larval stages and in hatchery production.

It is important to emphasize that there have been no studies of the diseases, pathogens or commensals of native mangrove crab stocks in FSM. Thus a precautionary approach would be to assume that local populations are free from infection until it is shown otherwise.

Summary of issues

The following appear to be the main issues surrounding the transfer of mangrove crab to Kosrae State for aquaculture development:

- *Genetic risks:* Possible loss of genetic integrity of local crab populations due to breeding of escapees with native populations.

- *Ecological risks*: Possible ecological risks due to the unintended translocation of "fellow travelers" (e.g. commensals and epiphytic organisms) with mangrove crab.

- *Pathogen risks*: Possible risk of introducing new diseases, parasites and pathogens due to unknown health status of transferred crabs, the unknown health status of local Kosrae stocks, the lack of SPF stocks, the generally poor state of knowledge of mangrove crab diseases and parasites, and the absence of diagnostics tests for some diseases.

Preliminary consideration of pathogen risks

Commodity description

1. Commodity description

TABLE 3
Commodity description: Mangrove crab

Species to be translocated:	*Scylla serrata*
Proposed date of importation:	not determined
Life cycle stage to be imported:	juvenile/adult
Importer:	Kosrae Fisheries Department
Exporter:	not determined
Source:	not determined (wild caught)
Proposed number of shipments:	not determined
Volume:	not determined
Proposed destination:	Kosrae. Stocking in project net pens and/or use as hatchery broodstock (not determined)

2 . Scoping considerations

Risk analysis should focus on *Scylla serrata;* however, the possibility that other species of *Scylla* will be included in domestic or international movements of crabs should be considered, as well as the possibility that new species or strains of pathogens may negatively impact other native *Scylla* spp. should be considered.

The risk analyses should include pathogen, genetic and ecological "fellow traveler" concerns.

Because of the absence of any pathogen data on local stocks of mangrove crabs and that source has not been determined, a generic approach should be taken that includes consideration of all diseases and pathogens of juvenile and adult *Scylla serrata* and other relevant *Scylla* spp. reported from any part of the world.

3. Hazard identification

- **Criteria for initial listing**
  - pathogen or parasite or a disease or syndrome likely to be caused by a biological agent; and
  - reported from mangrove crab from any locality (global)

- **Consideration as a Potential Hazard:**
  - pathogen is reported or likely to infect juvenile or adult mangrove crab
  - pathogen is present or potentially present in the exporting country (if international source) or region (island) or State of FSM (if a domestic source is used). Due to the absence of contradictory data, all pathogens reported from mangrove crab are assumed to be potentially present in the source population.
  - pathogen is absent from the importing country (if international movement) or state or local population (if a domestic movement), or, if present, it should be an OIE-listed disease or a disease subject to a program of eradication or control. Due to the absence of contradictory data, all pathogens are assumed to be absent from the aquatic fauna of Kosrae.
  - pathogen causes significant disease in mangrove crab or in other species found in Kosrae.

A preliminary listing of pathogens and parasites reported globally from mangrove crab are summarized below in Table 1. Pathogens are separated into two broad categories (i) those listed by the World Organisation for Animal Health (OIE) and (ii) other, non-OIE listed pathogens. For each pathogen, the following information is presented: name, occurrence of reports from juvenile or adult crabs, importance as a pathogen, whether a pathogen that requires avoidance by Kosrae, references, and comments on geographic distribution, life cycle, pathogenicity, etc.

Based on this information, the following six pathogens/diseases (two virus, one protozoan, two rhizocephalan barnacles, and one disease of unknown cause) are considered to be of primary concern to Kosrae:

- OIE-listed pathogens
  - o Whitespot syndrome virus (WSSV)

- Other serious pathogens
  - o Mud crab reovirus (MCRV)
  - o Hematodinium sp.
  - o Loxothylacus ihlei
  - o Sacculina granifera
  - o "Orange crab disease"

4. Preliminary recommendations

(1) Only locally collected mangrove crabs should be used for aquaculture development

There appears to be only one real option for reducing the risk of introducing exotic pathogens, and that is to prohibit all importations of mangrove crabs and require that aquaculturists use only domestically (i.e. Kosrae) collected crabs. This is suggested due to the absence of any source of SPF stock or stock of known disease history that could be imported, and the high probability that imported crabs will be carrying serious diseases. Of these, WSSV is most problematic. Although the virus does not cause losses in crabs, they can act as carriers, posing a serious potential threat to the development of penaeid shrimp culture in Kosrae and to native shrimp populations. It should be noted that there are no effective treatments for WSSV. In the Philippines, where WSSV is common, it is recommended that crabs not be cultured in the vicinity of shrimp ponds due to the high risk of contamination (C.R. Lavilla-Pitogo, pers. comm.) The occurrence of at lease five other diseases in crabs that are of potential concern also suggests that a highly conservative approach should be taken.

(2) Undertake baseline diagnostics studies on cultured and native Scylla* spp. *of Kosrae

A survey of the diseases of mangrove crabs in Kosrae could be undertaken to provide a basis for more in-depth risk analysis and to support aquaculture development. Such a study need not be overly expensive, basic diagnostics can be done in FSM, with support for viral and bacterial analyses could be arranged with regional (e.g. SEAFDEC-AQD, Philippines, AAHRI, Bangkok) or international laboratories.

(3) Consider ecological, pathogen and genetic risk analyses

More comprehensive risk analyses could be completed to support the position that only locally collected mangrove crabs should be used for aquaculture development. However, it can be concluded that such studies would only support a decision not to allow importation of mangrove crabs from neighbouring countries or from other States within FSM.

(4) Support development of hatchery technology for breeding of mangrove crab

Given concerns about overharvesting of local mangrove crab stocks for aquaculture development and the recommendation that the use of imported crabs be prohibited, the only option to significantly expand Kosrae's crab culture production would appear to be the development of hatchery production, including the long-range goal of domesticated stocks.

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TABLE 4
Pathogens and parasites of mangrove crab (Scylla serrata). (Y=Yes, N=No, P=Plausible, P=Uncertain)

Pathogen	Infects juvenile or adult	Causes significant disease	Further consideration required	References	Comments
Diseases Listed by the Office International des Épizooties (OIE)					
Viruses					
White spot syndrome virus (WSSV)	Y	Y	Y	OIE database; Lavilla-Pitogo & de la Peña 2004; Jithendran et al. 2009	All stages of mangrove crab can carry this important pathogen of penaeid shrimp without signs of disease; global distribution; wide host range.
Other pathogens					
Viruses					
Mud crab reovirus (MCRV)	Y	Y	Y	Weng et al., 2007	Caused large losses of cultured mangrove crabs in southern China and "sleeping disease". The virus infects connective tissue cells of the hepatopancreas, gills and intestine, developing in the cytoplasm. 100% mortality observed in mud crab experimentally infected by intramuscular injection, bath inoculation and oral inoculation, while cohabitation infection caused 80% mortality. An RT-PCR detection method has been developed.
Muscle necrosis virus	Y	P	P	Song et al., 2003-04	Reported to cause a "sleeping disease" characterized by muscle necrosis in China.

Pathogen	Infects juvenile or adult	Causes significant disease	Further consideration required	References	Comments
Scylla baculovirus (SBV)	Y	N	N	Anderson & Prior 1992	No clinical disease noted; focal infections in hypertrophied hepatopancreatic epithelial cells; Australia.
Bacteria					
Vibrio harveyi	Y	Y	N	Lavilla-Pitogo & de la Peña 2004	Causes luminescent vibriosis, a devastating disease in crab larvae; mortalities can reach 100%;common in in-shore sea water; worldwide distribution.
V. vulnificus V. parahemolyticus V. splendidus V. orientalis Aeromonas spp. Pseudomonas spp.	Y	Y	N	Lavilla-Pitogo & de la Peña 2004; Jithendran et al. 2009	Opportunistic bacteria causing shell disease and/ or systemic infections in mangrove crabs. Shell disease can affect 100% of tank-held crabs, but is seldom seen in wild populations.
Parasites					
Hematodinium sp.	Y	P	Y	Hudson & Lester 1994; Jithendran et al. 2009	Protozoan infecting the blood of mangrove crabs; Australia. Infections by members of this genus are highly pathogenic to other genera of crabs. Also in China and India.

Pathogen	Infects juvenile or adult	Causes significant disease	Further consideration required	References	Comments
Epistylis, Vorticella, Zoothamnium	Y	P	N	Jithendran et al. 2009	Listed as infecting mangrove crabs in India. Ubiquitous free-living sessiline ciliates that are fouling organisms on crustaceans. Includes fouling organisms (peritrich and suctorian cilates, and internal infections (microsproridians, gregarines) not noted to cause disease.
Amyloodinium sp.	Y	P	N	Jithendran et al. 2009	Flagellated protozoan listed as infecting mangrove crabs in India. Genus includes common parasite of the gills of fishes with pathogenic significance in aquaria.
Nematopsis sp.	Y	N	N	Jithendran et al. 2009	Gregarine protozoan listed as infecting mangrove crabs in India. Genus is common in other crustaceans; unlikely to be pathogenic.
Acineta, Ephelota	Y	N	N	Jithendran et al. 2009	Suctorian cilates listed as infecting mangrove crabs in India. Ubiquitous genera, fouling organisms.
Polypocephalus sp. metacestode	Y	P	N	Hudson & Lester 1994	Larval cestode
Digenea metacercaria	Y	P	N	Jithendran et al. 2009	Unidentified metacercariae listed as occurring in crabs in India. Unlikely to cause significant pathology but may have zoonotic significance.

Table 4

Pathogen	Infects juvenile or adult	Causes significant disease	Further consideration required	References	Comments
Nematodes	Y	P	N	Jithendran et al. 2009	Unidentified nematodes listed as occurring in crabs in India. Probably larval stages.
Crustacea					
Loxothylacus illei	Y	Y	Y	Knuckley et al. 2005	Rhizocephalan barnacle; causes parasitic castration; infected crabs noted to be smaller than uninfected; recorded distribution includes Australia and Indonesia.
Sacculina granifera	Y	Y	Y	Lavilla-Pitogo & de la Peña 2004	Parasitic barnacle causing sterility and altered meat flavour; distribution includes Australia.
Fungi					
Atkinsiella hamanaensis Lagenidium spp. Sirolpidium spp. Halocrusticida spp. Haliphthoros spp. Fusarium sp.	Y	N	N	Bian and Egusa 1980; Lavilla-Pitogo & de la Peña 2004; Jithendran et al. 2009	Ubiquitous; can destroy eggs and larvae.
Thelohania. sp.	Y	NP	N	Jithendran et al. 2009	Microsporean listed as infecting mangrove crabs in India. Genus includes species pathogenic to other crustaceans.
Diseases of unknown etiology					

Pathogen	Infects juvenile or adult	Causes significant disease	Further consideration required	References	Comments
“Orange crab disease”	Y	Y	Y	Lavilla-Pitogo & de la Peña 2004	Septicemic disease of unknown etiology causing losses of crabs held in floating cages in Singapore.

Example of Powerpoint presentation

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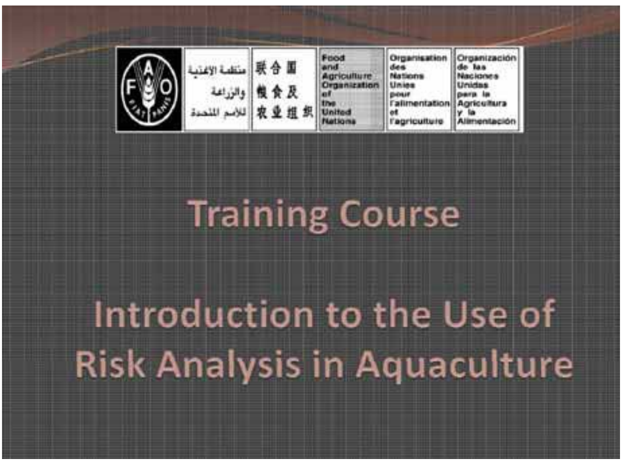
Part 1

Part 1 – Course introduction: Information on course resource personnel, course goals and limitations, course overview and course outline. **(14 Slides)**

Slide 1



Examples of PowerPoint presentation

Part 2

Part 2 – Overview of trade in aquatic animal commodities: Why trade is "risky", the global growth of aquaculture and trade in aquatic products and the driving forces, and the nature of the trade **(20 Slides)**.

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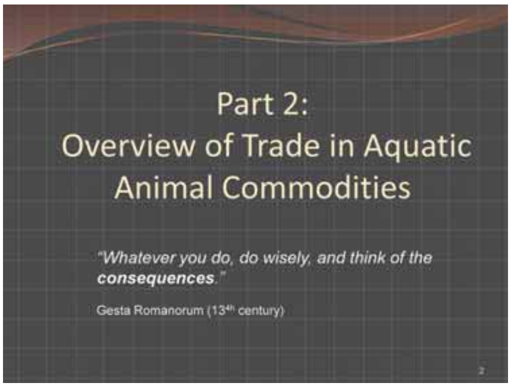

Slide 9

Examples of PowerPoint presentation

Part 2

Slide 12

Slide 15

Examples of PowerPoint presentation

Part 3

Part 3 – Overview of risks in aquaculture: The nature of risk and the types of risk inherent in aquaculture development, the seven risk sectors, the invasive species problem, overview of genetic risks, balancing the risks and benefits of aquaculture **(37 Slides)**.

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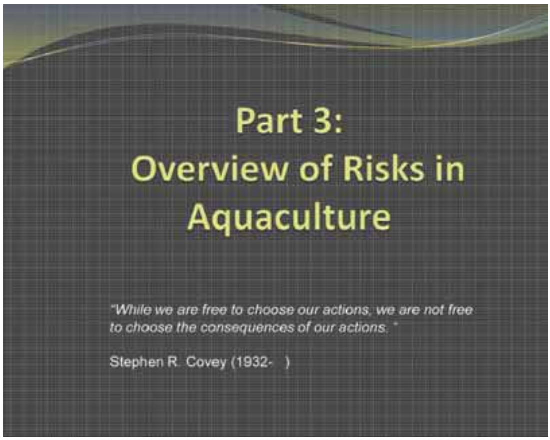

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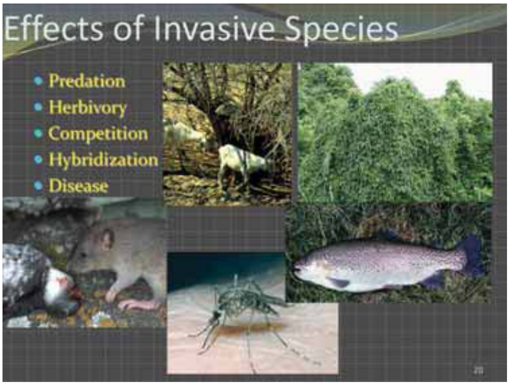

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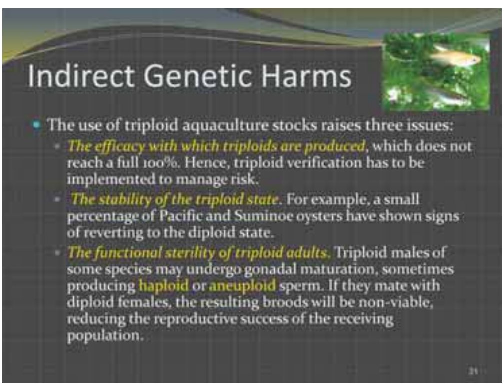

Examples of PowerPoint presentation

Part 4

Part 4 – Overview of risk analysis: What is risk?, important terms, protection vs. free trade; What is risk analysis?; Who uses risk analysis?; Relation of risk analysis and national biosecurity; National biosecurity actions; Why do countries need to be able to conduct risk analysis?; Two sides of the coin – risks to and from aquaculture; The four risk analysis questions; Approaches to risk analysis; Simplified risk analysis process; The World Organisation for Animal Health (OIE) framework (risk communication, hazard identification and the concept of hazard, risk assessment, risk management); Examples of risk analysis frameworks for various risk sectors; Simplified process for pathogen risk analysis **(60 Slides).**

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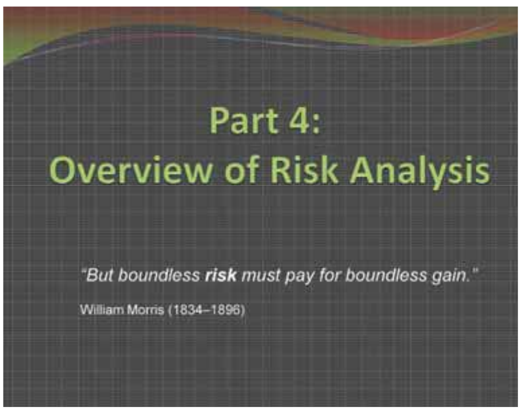

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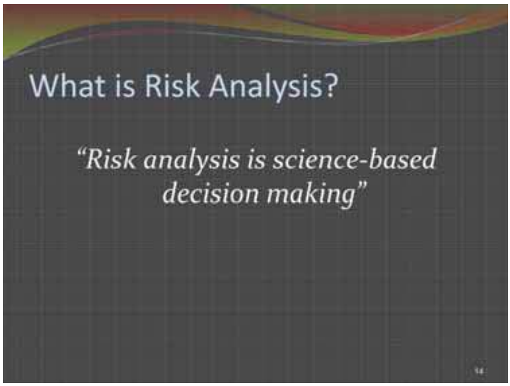

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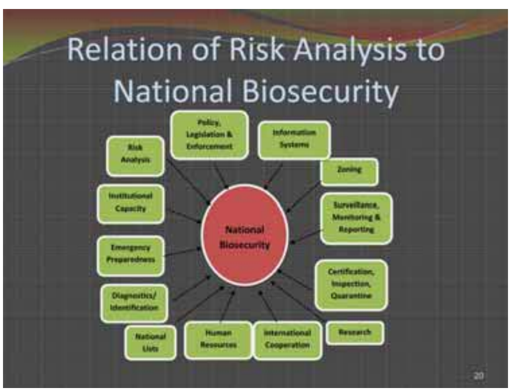

Part 5 – Relevant international treaties, agreements and guidance: Key treaties and agreements; World Trade Organization Sanitary and Phytosanitary (WTO SPS) Agreement main regulatory instruments; Key guidance (voluntary guidelines, guidance manuals, completed pathogen risk analyses, global and farm-level guidelines); Online resources. **(21 Slides)**

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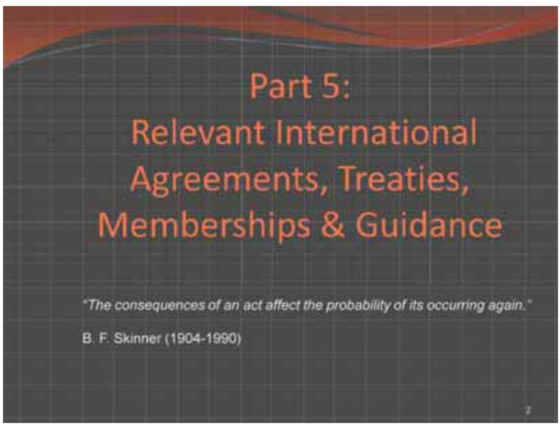

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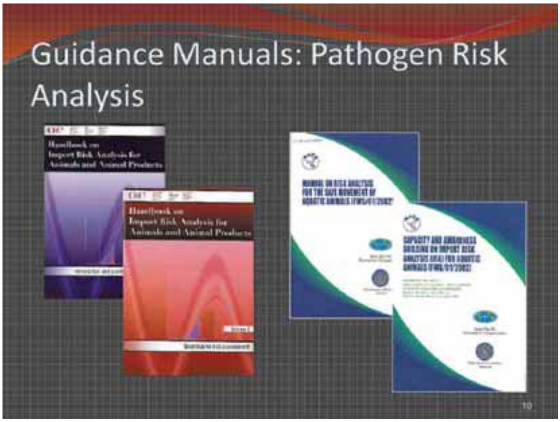

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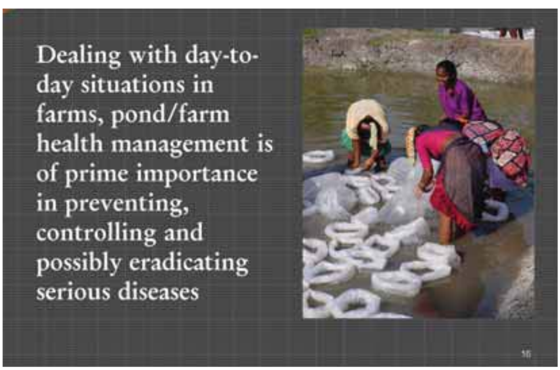

Part 6 – Pathogen risk analysis – Transboundary aquatic animal diseases (TAADs), introduction and preliminaries: Examples of TAADs: koi herpesvirus, white spot syndrome virus, epizootic ulcerative syndrome; Estimates of losses due to disease; What is pathogen risk analysis?; What is import risk analysis?; Historical aspects; Summary of completed formal risk analyses; Major risk factors; The risk analysis process; The risk analysis team and its duties; How risk analyses are initiated; The proposal to import; The risk analysis working group; Scoping a risk analysis (including an example from an actual risk analysis); Special issues and problems **(59 Slides).**

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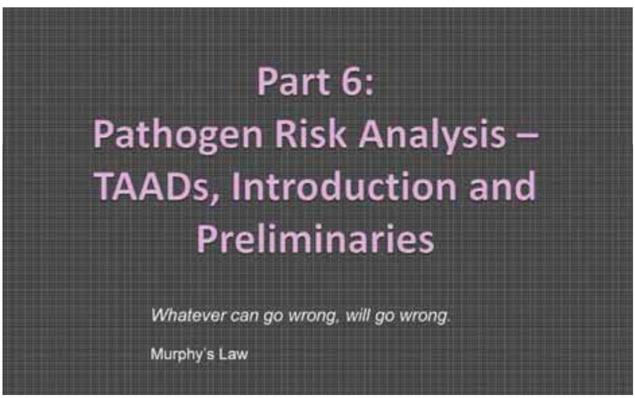

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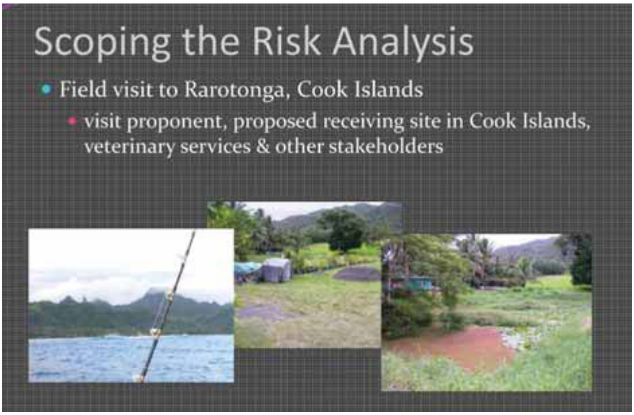

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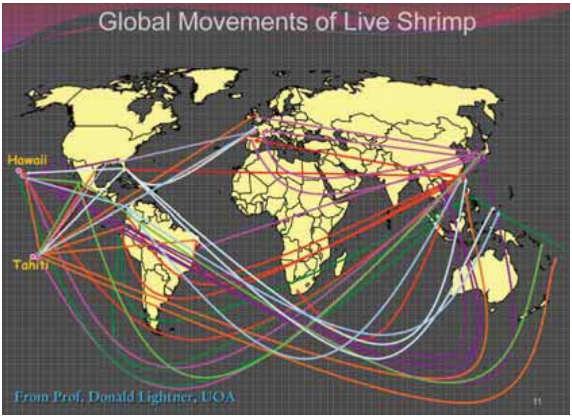

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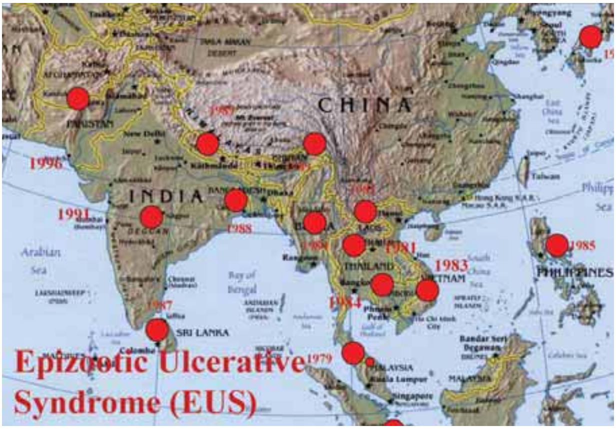

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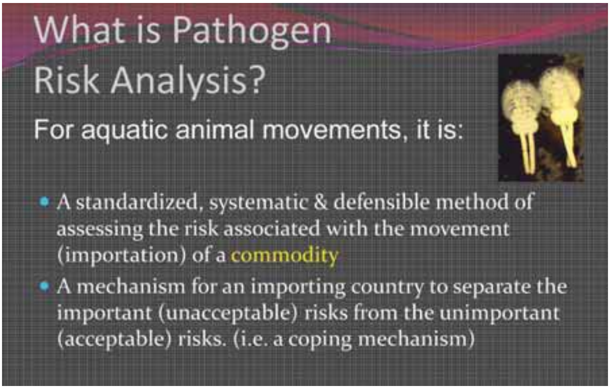

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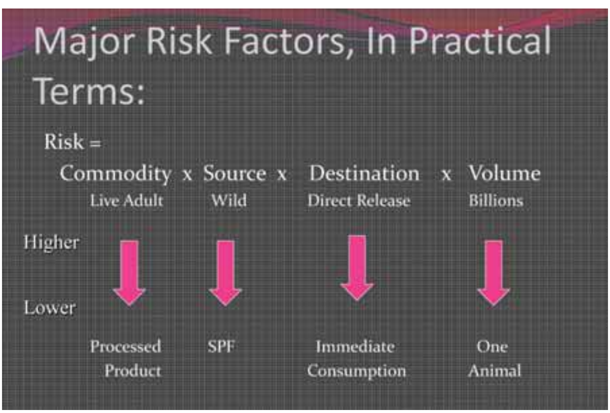

Part 7 – Pathogen risk analysis – Hazard identification: Screening criteria; Summary of procedure; Summary of hazards identified from completed risk analyses, giant river prawn as an example **(18 Slides)**.

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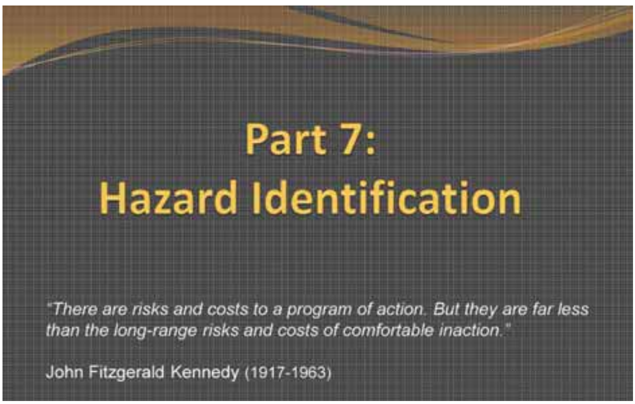

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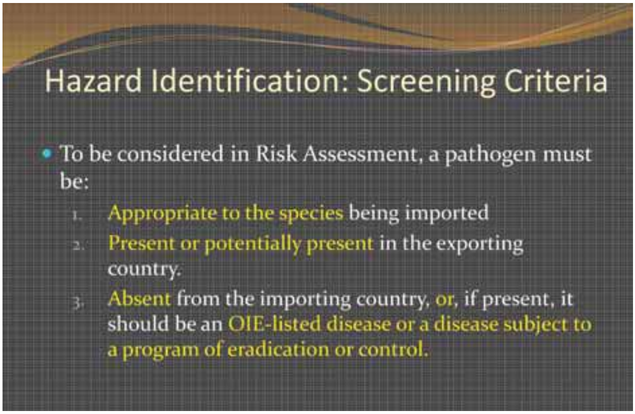

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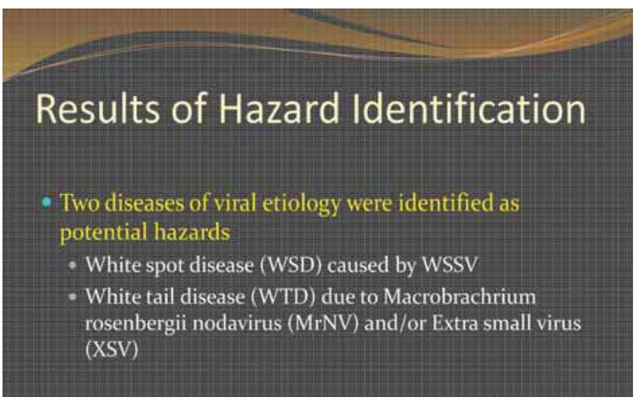

Examples of PowerPoint presentation
Part 8

Part 8 – Pathogen risk analysis – Risk assessment: Overview; Qualitative versus. quantitative methods; Use of scenario trees and pathways analysis; Release assessment; Exposure assessment; Consequence assessment; Risk estimation; Practical example using giant river prawn **(36 Slides).**

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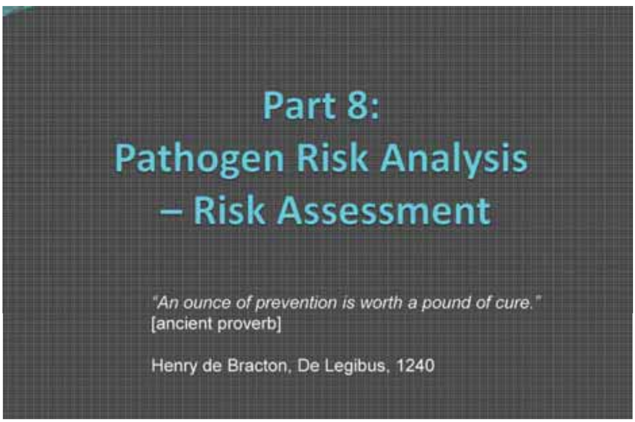

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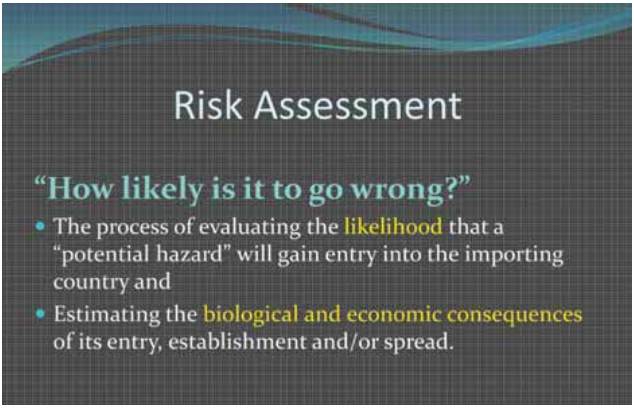

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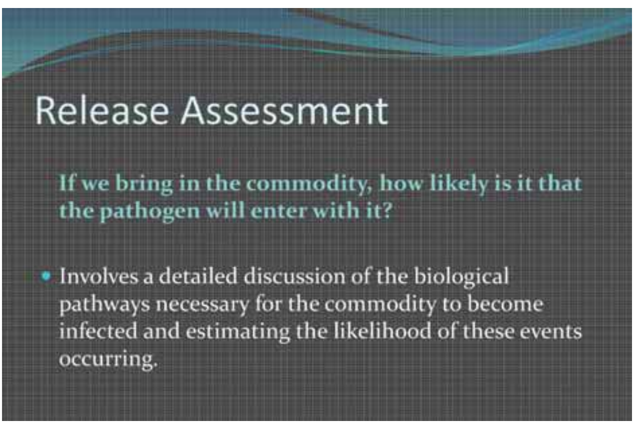

Examples of PowerPoint presentation

Part 9

Part 9 – Pathogen risk analysis – Risk management: Overview; Risk evaluation; ALOP/ALOR; Practical example using giant river prawn; Possible outcomes of risk evaluation; Summary of results from completed risk analyses; Options evaluation; Summary of risk management measures from completed risk analyses; The precautionary principle and its application to pathogen risk analysis; Practical example using giant river prawn; Implementation; Monitoring and review; Reporting and report preparation **(44 Slides)**

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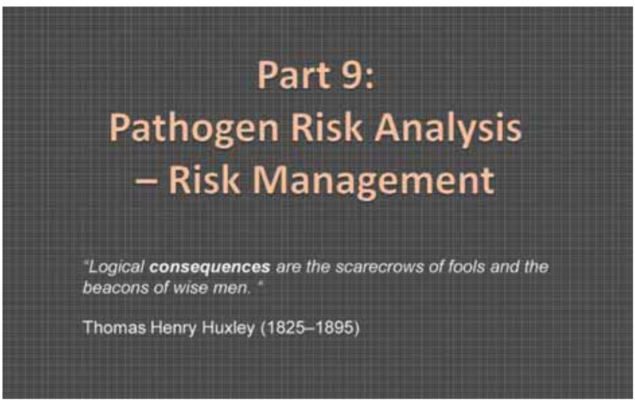

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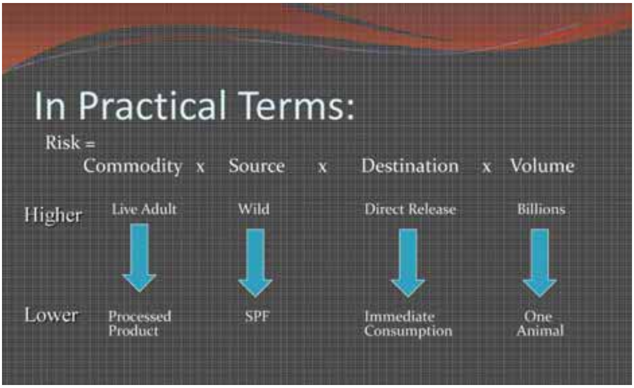

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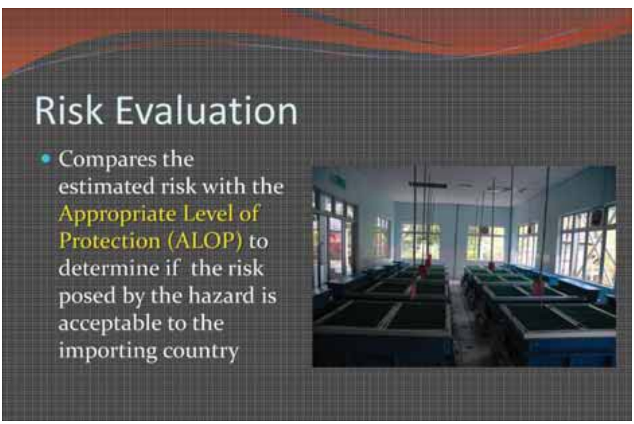

Examples of PowerPoint presentation

Part 10

Part 10 – Risk communication: Overview; Purpose; Strategies; Identifying stakeholders; Risk communication methods; The risk analysis report **(15 slides)**

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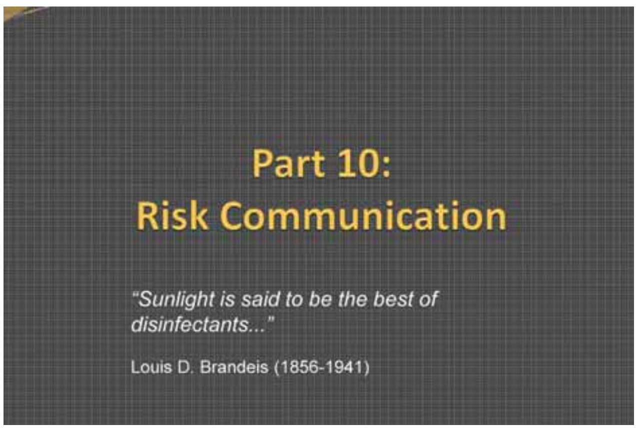

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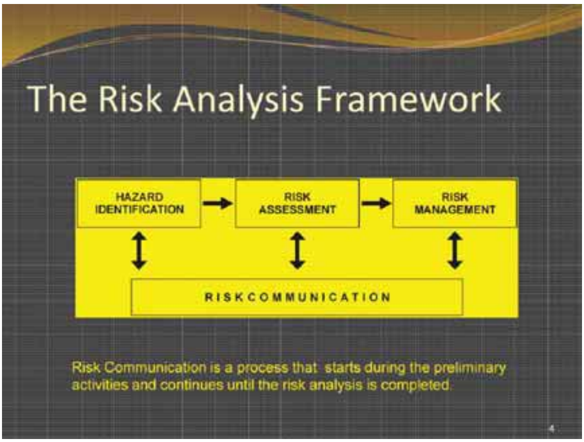
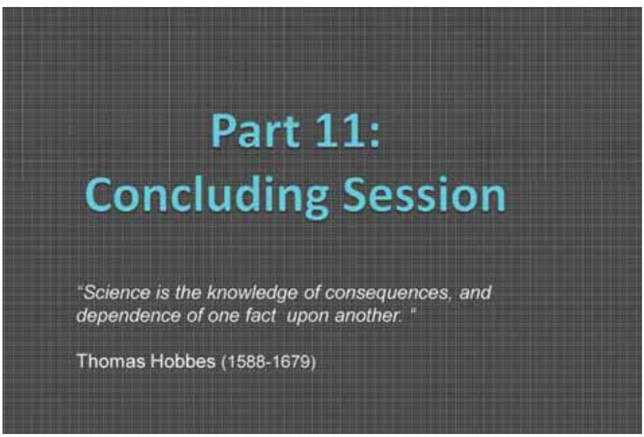


Slide 15

Part 11 – Concluding session: Some universal principles of risk analysis; What is needed to implement risk analysis?; Risk analysis and developing countries; Characteristics of risk analysis that support good governance; Regional approaches; Constraints; Evaluating your country's current situation **(26 Slides)**.

Slide 1



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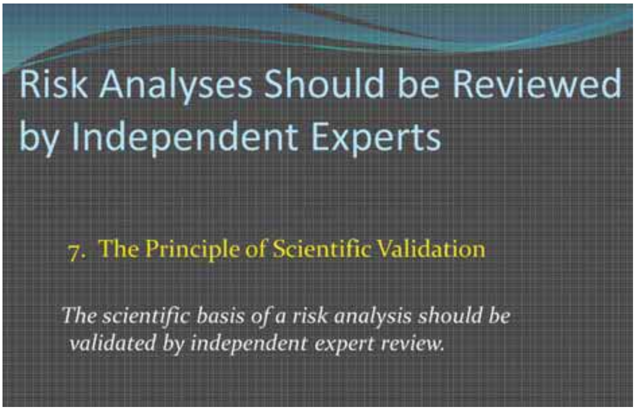

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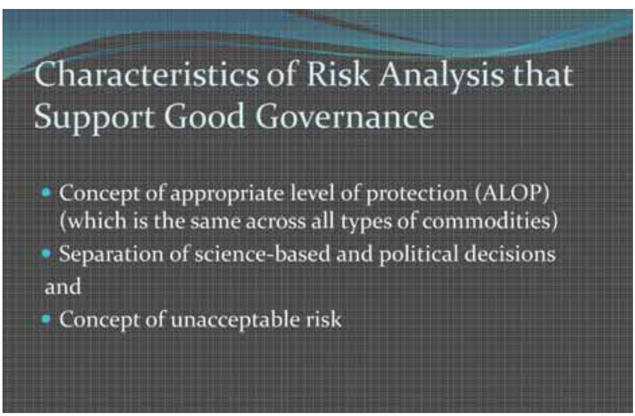

Risk analysis is complex subject that is best learned by actual experience. This manual was created to assist national competent authorities and others involved in the assessment and management of risks associated with the international or domestic moment of live aquatic animals in training professional staff and raising awareness and understanding among other stakeholders of the principles and methodology of risk analysis. Using the training course manual and the recommended supplementary materials, responsible managers will be able to train staff in the planning and supervision of risk analyses. The training course will also assist specialists in the fields of disease, genetics or ecology of aquatic animals to successfully conduct risk analyses in a manner that incorporates best scientific knowledge, is transparent and includes adequate stakeholder consultation.

Using a structured step-wise process, the training course guides trainees through the risk analysis process as applied in the analysis of ecological, genetic and pathogen risks. Through the use of case studies and group exercises tailored to local situations, the course provides an in-depth look at risk analysis as currently applied for evaluation of risks due to pathogens (import risk analysis), taking trainees from the initial process of establishing a commodity description and scoping a risk analysis through to conducting the four risk analysis components of hazard identification, risk assessment, risk management and risk communication.

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