Wonderful Water

A Watery Environment

Wetland Ecosystems in the Turks and Caicos Islands Part 2:

including:
What is an ecosystem?
Biodiversity
Population Size
Invasive Species

Teachers' Guide

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UNITED KINGDOM OTEP OVERSEAS TERRITORIES ENVIRONMENT PROGRAMME

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Target Age Group - 10 - 12 years

This follows on from Part 1. When to use this material is at teachers' discretion, dependent on pupils' previous experience and knowledge.

This environmental education programme has been produced by the UK Overseas Territories Conservation Forum (UKOTCF) and the Turks and Caicos Department of Education.

It was part-funded by the Overseas Territories Environment Programme (OTEP) of the UK Department for International Development and the Foreign and Commonwealth Office.

The project was developed from an original idea by Mr Edgar Howell, Director of Education, Turks and Caicos Islands, and these materials developed by a team co-ordinated by Ann Pienkowski, Environmental Education Co-ordinator, UKOTCF. It is hoped that through the teaching materials developed for this project, students in TCI will gain a greater understanding of the importance of the water ecosystems in TCI, and the need to conserve these.

As a possible model to assist environmental education in other areas of the Caribbean (especially UK Overseas Territories) these materials will be made available to a wider audience.

Contents

Introduction

In devising these teaching materials, reference was made to the TCI Secondary Science Curriculum Forms 1 - 3. In addition, the English National Curriculum for Science for Grades 7 - 9 (titled Key Stage 3 [KS3]) was consulted, especially regarding expected levels of attainment (competency).

To help teachers review their students' progress, expected levels of achievement for a particular stage in a students' education have been developed into statements of competency. These are summarised below. The objectives given in the student's materials relate to these statements of competency.

Assessment criteria / Statements of Competency

These level statements relate to levels of attainment given in the Science National Curriculum for England, but are compatible with such statements about expected attainment in many other curricula.

This table gives the level an average child is expected to achieve at a particular stage in their schooling. This curriculum has been devised to be as inclusive as possible, hence objectives are given for level 2 up to level 7.

End of grade:	Expected attainment related to curriculum levels (from National Curriculum for England)		
	Slower progress	Most pupils	Faster progress
4	2	3	4/5
5	2/3	3/4	5
6	3	4	5/6
7	3/4	4/5	6
8	4	5 (6)	6/7

At the end of year 8, most pupils should be able to attain level 5, and should be challenged to reach level 6 (although they will not all reach this standard). The highest attaining pupils will be working at level 7. Students with Special Needs could well be working at levels 2-3.

The assessment criteria / statements of competency, which relate to the theme *A Watery Environment - Wetland Ecosystems in the Turks and Caicos Islands Part 2* are:

Ecosystems and Biodiversity

L2: Name some living and non-living parts of an ecosystem using picture prompts.
L3: Know that an ecosystem must have plants and animals.
L4: Know that an ecosystem is a community of living things that sustains itself.
L5: Recognise that a healthy ecosystem supports a wide variety of plants and animals, not just large numbers of individuals (biodiversity).
L6: Recount specific information about biodiversity.
L7: Be able to discuss why biodiversity is important.

Ecosystems and Population Sizes

L2: Know the difference between a predator and a prey.
L3: Know that a healthy ecosystem is balanced (enough food and water for the plants and animals to live and reproduce successfully)
L4: Know that a lack of resources and / or increased predation affects numbers of plants and animals.
L5: Know that an invasive species can seriously affect an ecosystem by excessive predation and / or removal of resources.
L6: Explain that the distribution and abundance of organisms in an ecosystem can be affected by environmental factors and biological factors (introduction of alien invasive species).
L7: Explain why the introduction of alien invasive species can have a devastating effect on biodiversity.

The pupils' text provides key information for pupils.

The teachers' guide contains further information and resources for teachers, suggested activities for pupils and example pupil worksheets. Practical activities and suggestions for places to visit are also included.

The suggested pupil activities and worksheets can be carried out by individuals, pairs or small groups.

These materials are a first draft, and any suggestions for further activities, amendments and improvements are welcome.

Any comments / suggestions should be sent to the UKOTCF Environmental Education Co-ordinator, Ann Pienkowski. Email apienkowski@ukotcf.org

Background Information on Ecosystems

Explaining what an ecosystem is

The word **ecosystem** is short for ecological systems. Eco comes from a Greek word (oikos) meaning house or surroundings. Ecology can be defined as the branch of science that studies the interrelationship between organisms and their environment. This includes the physical parts of the environment, as well as the living parts. So ecology encompasses aspects of biology and environmental geography.

Because ecology is about interrelationships it can be a vast and confusing topic, and students may find it hard to understand the basic concept of how ecosystems work. The materials prepared on ecosystems for the primary phase can be used as an introduction to this topic, or for revision, if appropriate.

Texts and materials about ecology and ecosystems can include a number of technical terms, which can also add to students' confusion. Explanations of these terms will be provided, and a glossary of such terms included in these materials.

Ecosystems vary in size and the elements that are included in them, but an ecosystem will be a functioning unit. Everything that lives in an ecosystem is dependent on other species and elements that are also part of that ecological community. If one part of an ecosystem is damaged or disappears, it can an impact on everything else.

The **biosphere** is made up of the living organisms of the earth, and their environments, so can be considered the largest ecosystem. However, a small pool or puddle can also be considered an ecosystem. A large ecosystem will consist of several smaller ecosystems interacting with each other. These interconnections are one reason why the idea of an ecosystem can be quite difficult to grasp.

Components of an Ecosystem

Sometimes the parts of an ecosystem are described as the **biotic** (living) and **abiotic** (non living) parts. (The "a" in abiotic means "not".) There can be confusion even in considering these terms, as some explanations define biotic as those things that were once living. This is not a very clear definition, for example coral sand was once living, so would it be classed as a biotic or abiotic component of an ecosystem? This sort of question can actually be a very good discussion point with students.

Perhaps the clearest way of defining the biotic and abiotic components of an ecosystem is:

<u>Biotic components</u>:

Producers - green plants which convert simple inorganic matter such as carbon dioxide (CO^2), water and minerals into organic compounds (sugars and starches).

Consumers - the different types of animals that eat producers and / or other animals. These include the primary consumers (**herbivores**) that feed on plants; secondary, tertiary and quarternary consumers (**carnivores**) that eat other animals; **omnivores** that eat plants and animals, and **detrivores** - animals which feed on fragments of dead and decaying plant and animal material.

Decomposers - like bacteria and fungi. They recycle nutrients by breaking down dead organisms into organic compounds again for absorption by green plants.

The difference between detrivores and decomposers can be confusing. They both get nutrition from dead organic matter. The difference is that detritivores actually eat the organic matter (like earthworms eating their way through the soil) and decomposers secrete enzymes to digest the organic matter and then absorb the resulting molecules (like bacteria or fungi do).

These feeding relationships will be dealt with more fully in Unit X of the **Watery Environment** theme.

Abiotic components:

Inorganic nutrients, for example water, carbon, gases and minerals.

In describing the structure of ecosystems, further technical terms are utilised, with which students should be familiar.

Niche - the role of an organism in its ecosystem (or, more strictly, the opportunity in the ecosystem which the organism uses.
Community - all the populations that live in an ecosystem.

If the role of an organism (its niche) is affected, then the changes that occur for that organism will often have a considerable effect on other components of the ecosystem.

Inputs and Outputs

All ecosystems have inputs (what is going into the ecosystem) and outputs (what is leaving the ecosystem). A healthy ecosystem will be balanced. Scientists describe this state as being sustainable.

The inputs to and outputs from any ecosystem represent a link with other parts of the environment, other ecosystems. For example some of the outputs from one area become inputs into another area.

Typically, inputs will be: solar radiation (energy supply), water, gases, nutrients, animals migrating into the ecosystem, plants and seeds introduced into the ecosystem.

Examples of outputs are: water (eg loss through evaporation or drainage), migration of animals out of the ecosystem, harvesting of plants, gases and heat escaping back to the atmosphere.

These complex relationships will be dealt with more fully in other units.

Activity suggestions to support pupil learning about Wetland Ecosystems in TCI

The activities can be carried out by individuals, pairs, or small groups.

As an introduction / revision, some of the activities suggested in *A Watery Environment - Wetland Ecosystems in the Turks and Caicos Islands Part 1*

Details are not repeated here, but in summary are:

1. Assess initial knowledge.

2. Power point presentation of TCI Wetland sites, with follow-up discussion.

3. Match pictures of animals and plants to wetland habitat.

4. Field Trip to a wetland ecosystem.

5. Create an Ecosystem in a bottle or jar.

6. Investigate the importance of freshwater.

7. Consolidation of knowledge and understanding with different kinds of writing, artwork, etc.

Some suggestions for activities specific to *A Watery Environment - Wetland Ecosystems in the Turks and Caicos Islands Part 2* .

1. Identify Biotic and Abiotic components of a wetland ecosystem

This activity can usefully be carried out on a field trip, but can also be done using pictures of wetland ecosystems.

Ask the students to list the Biotic and Abiotic components which they can see in the ecosystem / picture of ecosystem. The listing can be accompanied by drawings, sketches, etc.

This activity can be extended by asking pupils to spot interactions between biotic and abiotic components (eg animal drinking water; plant leaves in the sunshine) and between two biotic components (eg heron eating fish).

2. What if ....? / Consequences activity - discussion

This activity can usefully be carried out on a field trip, but can also be done using pictures of wetland ecosystems. Pose a question, eg:

What if all the plants died?

What if there were no animals living in the water?

What if all the water dried up?

Ask the students to discuss the possible consequences of such an event.

3. Invite a scientist to give a talk.

Students can write the letter of invitation.

Notes

Biodiversity

Biodiversity is actually a shortening of the phrase "Biological Diversity" - the variety of living things on Earth. So far, more than 1.7 million species have been described, including:

- 950,000 species of insects
- 270,000 species of plants
- 19,000 species of fish
- 10,500 species of reptiles and amphibians
- 9,000 species of birds
- 4,000 species of mammals.

The rest includes molluscs, worms, spiders, fungi, algae and micro-organisms.

But scientists think that millions more species, mostly micro-organisms and invertebrates, such as insects and worms, are yet to be discovered. Even new species of mammals are still being discovered. The World Wide Fund for Nature (WWF, known in some countries by its earlier name, World Wildlife Fund) has reported that, during the decade 1999-2009, 39 new mammals were found in the Amazon, including seven monkeys, a pink river dolphin, two porcupines, eight mice, nine bats, six opossums, five rats and a guinea pig.

Very little work has been carried out on the invertebrates found in the Turks and Caicos Islands, so it is likely that there are new species waiting to be found here. In the 1990s a new species of copepod (*Erebonectes macrochaetus*), which lives in caves, was found in caves in Middle Caicos.

And some species which were thought to be extinct have been re-discovered. These re-discoveries include plants and animals. The Ascension Island Parsley Fern, last seen in 1958 and declared extinct in 2003, was re-discovered in 2010. Ascension Island is another UK Overseas Territory, and sits near the equator in the middle of the Atlantic Ocean. And in TCI, the endemic Caicos Barking Gecko, thought to be extinct for many years, was re-discovered in the early 2000s by a project organised by UK Overseas Territories Conservation Forum.

Genetic Diversity

The huge variety of species on earth, from microscopic bacteria to huge whales, is very impressive, but biodiversity is not limited to the numbers and kinds of organisms. It also includes genetic diversity, which refers to the variety of genes within a species. This is very important, as the genetic diversity within a species allow the species to evolve to cope with changing conditions, and keep the population healthy. When a species is reduced to a small number of individuals, then the genetic diversity will be reduced, and the chances of the species survival is also reduced. This is especially important for **endemic species.** Endemic species are found nowhere else in the world, so if the population dies out, then it becomes extinct. In the Turks and Caicos Islands, the rock iguana, some other lizards, and the greater Antillean Bullfinch are endemic species or sub-species.

Ecosystem Biodiversity

In warm climates like the Caribbean, most healthy ecosystems are rich in species biodiversity and genetic biodiversity. It is worth mentioning that there is a third important aspect, the diversity between different ecosystems. In some parts of the world, such as cold areas on the tops of mountains, or in the arctic or antarctic regions, important ecosystems will not have many species due to the limiting factor of low temperature. These ecosystems are as important as more species rich ecosystems. However, ecosystems which should be species rich, and genetically diverse, which become impoverished, are ones we should be concerned about.

Wetland Biodiversity

The biodiversity of all ecosystems is incredibly important, but in the context of the Wonderful Water curriculum it is worth noting particularly that wetlands have very high levels of biodiversity. For example, a single coral reef can support more than 3000 species of fish and invertebrates. Acre for acre, there can be more life in a healthy wetland than in almost any kind of habitat.

Why Biodiversity is important

If a dozen biologists were asked to explain why a high level of biodiversity is important, you would probably get a dozen different explanations. But one message would be clear - the quality of our lives depends on it.

Just consider plants, without which no ecosystem can exist. They produce oxygen, necessary for all animal life; they remove carbon dioxide (the main greenhouse gas) from the atmosphere; they convert radiant solar energy to sugars and starches thus providing food for all animals; and they are the source of almost all of the medicines we rely on. Many people in TCI know the value of "Bush Medicine". There are undoubtedly many plant derived medicines still waiting to be discovered.

A huge number of products derived from wild species not only help keep us healthy, but also boost all levels of the economy.

For example, sales of prescription drugs that contain ingredients extracted or derived from wild plants total billions of dollars. Millions of people visit national parks and wildlife areas for recreation, generating jobs and income. This is especially important for places like the Turks and Caicos Islands, where a major part of the economy is based on tourism. Certain bacteria fix nitrogen in the soil, reducing the need for artificial fertilizer and consequent pollution. Bees, butterflies, birds, bats and other animals pollinate 75 % of the world's staple crops and 90% of all flowering plants. The dollar value of all the services provided by ecosystems throughout the world is estimated to be over $33 trillion per year, about double the value of all human-produced goods and services.

There is also the strongly held belief of many people that biodiversity should be preserved not just because it is valuable economically, but because it exists, and the natural world should be respected and protected.

Activity suggestions to support pupil learning about Biodiversity

1. How many different kinds of .....?

Ask students to count and record how many **different** kinds of plants or animals they can see, either on a field trip or from pictures / photographs.

Digital photographs, taken during a field trip, or to show to students in class, will be a valuable resource for this activity.

It is not necessary that students know the names of all the plants and animals, as long as they can spot differences, although some simple identification books or cards would be useful.

Discussion could focus on whether the students consider the ecosystem to be healthy or otherwise, based on their observations of the number of different kinds of plants and animals they could see.

2. Hold a debate

eg Is a fish farm a healthy ecosystem?

Questions for debate need to be considered carefully, and set in context.

Although a fish farm is not a healthy, self-sustaining ecosystem (eg one type of animal, even though there are lots of them, so low biodiversity, and lots of input needed from humans re feeding and cleaning, etc) a fish farm could be a good thing, if properly managed, since it could prevent overfishing of the natural resource.

3. Organise a campaign to make everybody aware what biodiversity is, and why it is important.

Students can create:
Articles
Posters
Leaflets
Reports
Presentations - (including Power Point if feasible)
3D models or diorama

These can be displayed in the school. Or perhaps a local business, supermarket or other public place would be prepared to display the students' work.

4. Consolidate knowledge and understanding with comprehension exercises, word puzzles, quizzes, etc.

FURTHER ACTIVITY SUGGESTIONS WELCOME

Ecosystems and Population Sizes

The population of a plant or animal species is constantly fluctuating for a number of reasons. More animals may enter the habitat. Humans may alter the habitat. Natural disasters such as hurricanes may occur.

Though populations may increase or decrease over time, there is a "comfortable" number of animals that a given habitat can support over time. This is called the **carrying capacity**. Sometimes the population is a little above the carrying capacity, and sometimes it's a little below. A healthy ecosystem sustains itself in a balanced way, and the factors which maintain that balance are commonly called **limiting factors.** Limiting factors refer to anything that can restrict the size of a population, where population means a group of the same type of organisms living in the same place at the same time. Limiting factors can include living and non-living components, such as **predators** or drought. There may also be seasonal effects, where an increase in food or water seasonally means that more animals can be supported.

It is clear that the complex nature of ecosystems, and the way the relationships of the living and non-living things are connected, makes it quite difficult to determine what are the limiting factors in the system.

Some of the most obvious factors are those caused by predation, limited resources and competition for resources.

Predation is when one species (the predator) feeds on another (the prey), for example pelican (predator) eating fish (prey).

A good example of limited resources affecting population size was seen on the hummingbird (Bahama Woodstar) population following Hurricane Ike in September 2008. The hummingbirds, which could be seen quite frequently, feed on the nectar of flowers. After Hurricane Ike, there were no flowers for the hummingbirds to feed on, and their numbers crashed. Very few hummingbirds were seen over the next 2 years, and it was only in 2010 that they started being obvious again.

Within an ecosystem there are many examples of **competition**. Plants compete amongst themselves for water, nutrients, sunlight and space, whilst animals compete over food, water, mating and territory. If you observe the birds feeding on the salinas, you will often see them chasing other birds to keep them away from favoured feeding spots. In a dry climate, such as TCI, fresh water is clearly a limiting factor for both plants and animals. The number of feral donkeys, horses and cattle on the salt islands are limited by their access to water and the amount of vegetation available for food. Plants and animals, of course, adapt to the conditions in their ecosystem. Adaptations will be covered in Unit X.

It is clear, that if predation is taking place, and if there is competition for a limited resource, then the population sizes within an ecosystem will be affected. If a pelican eats most of the fish in a salina, the pelican will move elsewhere. The fish population might then increase again.

Activity suggestions to support learning about Ecosystems and Population Size.

On a field trip, or by looking at an ecosystem picture, ask students to look for examples of predation, possibly limiting resources, and competition for resources.

The **What if ....? Consequences** activity described previously will encourage students to start thinking about these aspects.

Invasive species

Introduced, alien invasive species are non-native species of animals, plants or micro-organisms that disrupt the balance in an ecosystem, causing native species to decline in numbers, or even to disappear from their natural environment. Invasive species are the cause of some of the most severe threats to ecosystems and biodiversity. Invasive species are introduced either accidentally or intentionally by human beings or their activities.

One of the most invasive species affecting the coral reefs in the Caribbean, including the Turks and Caicos Islands, is the Lionfish.

Native to the tropical Indo-Pacific region, red lionfish have been introduced to the Atlantic Ocean within the past few years. They spreading rapidly throughout the Caribbean. There is concern among fishery scientists that the red lionfish, having no natural enemies, may adversely impact natural fish populations. In addition, this fish has venomous spines that pose a danger to divers and anglers.

It has been recognised as a great threat to the TCI coral reefs. DECR have reported that the lionfish population is multiplying in record numbers in local waters. If they are not controlled, then there is a real risk that the coral reef could die. Lionfish hunts have been organised, fishermen are encouraged to catch them for food. Once the poisonous spines are removed, they are good to eat. There are plans for a lionfish cookbook.

More information will be included about invasive species affecting wetlands in the Turks and Caicos Islands, as this becomes available.

Activity suggestions to support pupil learning about Invasive Species

The lionfish fact sheet can be followed up by several different activities:

Ask a scientist (possibly from DECR) to give a talk about the threat from lionfish.
Create materials for a public awareness campaign: posters, leaflets, reports, news articles, board games, oral presentations
Quizzes
Comprehension exercises
etc.

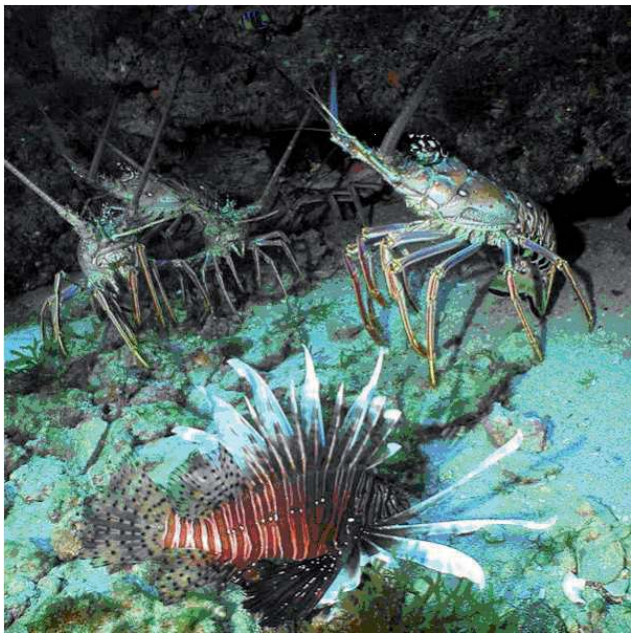
FURTHER SUGGESTIONS WELCOME

Lionfish Fact Sheet

The Lionfish (scientific name *Pterois volitans*) is also known as the turkey fish, dragon fish, scorpion fish and firefish.

Even its name reveals the fiery character of the Indo-Pacific red lionfish. With bold maroon and white zebra stripes, and a plume of feathery spines, the lionfish is a stunning specimen, elegant, graceful, but deadly to its prey. Pretty much everything about the venomous lionfish, from its colouration, long, showy pectoral fins, and generally cantankerous demeanor, says, "Don't touch!"

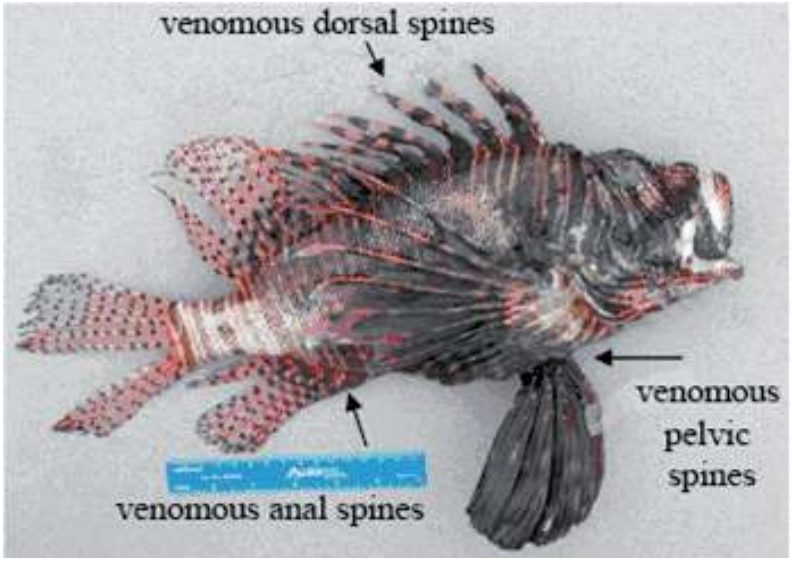
The lionfish's native habitat is the rocky crevices and coral reefs in Indo-Pacific waters, although now, via human activity, they have invaded the eastern coast of America, and the Caribbean, where they are increasing rapidly, and causing much damage to coral reefs. It is not clear how they got to the Atlantic from the Pacific, but they are popular aquarium fish, and some people think that perhaps some individuals were released from aquariums.



Without any natural predators in Caribbean waters, the lionfish are thriving – putting native marine species at risk, as well as recreational and commercial divers and anglers who come in contact with the fish.

The largest of lionfish can grow to about 15 inches (0.4 meters) in length, but the average is closer to 1 foot (0.3 meters).

The red lionfish's profuse dorsal, anal and pelvic spines deliver a venomous sting that is fatal to potential predators. A sting from a lionfish is extremely painful to humans and can cause nausea and breathing difficulties, but is rarely fatal.



Treatment of Lionfish Stings

Stings from lionfish can be serious, and should not be taken lightly. Any broken spines should be removed, if possible, and the affected area soaked in non-scalding hot water (100-110 degrees F. or 38-43 degrees C.) for 15-20 minutes. Lionfish venom contains proteins that are denatured by heat, thus, preventing them from spreading in the bloodstream. If hot water is not available, aspirin, or aspirin with codeine can be taken. (Do not use hot water and aspirin together.) Because possible adverse reactions or secondary infections can occur from lionfish stings, a medical professional should be seen as soon as possible. (This medical advice was approved by the Florida Poison Information Center – Miami)

More information about the Lionfish (including video) is available from the following web sites:

https://oceanservice.noaa.gov/education/stories/lionfish/welcome.html

https://www.nationalgeographic.com/search?q=lionfish

Great efforts are being made in TCI to control the lionfish by hunting. Hunting techniques include spear fishing, live bait on hook, and clear glass with bait fish inside to lure lionfish to one area then scoop them up in clear bags. Hunting and eating lionfish will not solve the problem, but it will help.

Lionfish have been a food source for hundreds of years in the South Pacific. DECR are collecting recipes for a cookbook. Further information and some recipes are available from this web site:

https://www.cbsnews.com/news/lionfish-recipes/