



## Mexico Schools' Booklet 2019

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# 1. Terrestrial project overview and research objectives

## Meso-American Biological Corridor

Forest corridors are important for maintaining gene flow between animal populations and for ensuring that animal populations can withstand localized natural disasters such as droughts, forest fires, hurricanes and floods. Forest connectivity also ensures viable populations of animals with large home ranges such as spider monkeys, tapir and jaguar. Mexico's National Strategy on Climate Change (2007) called for establishing biological corridors between protected areas to "improve the adaptive capacities of ecosystems and species." One effort was the incorporation of five ecosystems in southeast Mexico into the Mesoamerican Biological Corridor Project, sponsored by the World Bank's Global Environment Facility. The corridors feature regions of high biodiversity, including dry and moist forests in Tehuantepec and Yucatan, cloud forests in Chiapas, savannas in Tabasco, and wetlands in Quintana Roo. These ecosystems are connected to one another and to the larger Mesoamerican Biological Corridor, spanning Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama. However, even within each ecosystem, forest connectivity is threatened by human population growth and urbanization.

## Calakmul Biosphere Reserve

Forest corridors are important for maintaining Calakmul is a large expanse of tropical forest that is continuous with the Maya Biosphere Reserve in the Petén Province of Northern Guatemala. Calakmul biosphere reserve covers an area of 723,000 hectares, but is attached to two state reserves Balam-kim and Balam-ku which run the entire length of the western side of the biosphere. The total area covered by these connected reserves is 1,200,000 hectares, but these reserves are surrounded by more forest giving rise to over 4 million hectares of forest. This Mexican forest is connected to the even more forest over the border in Guatemala, resulting in approximately 10.6 million hectares of continuous forest. Unlike the majority of forest in the Yucatan, the forest in Calakmul has not been used for timber production nor has it been burned for farming and ranching and as such, it is one of the last remaining stands of virgin forest in Mexico. The northern parts of Calakmul contains tropical deciduous forest, where trees typically have a canopy 8-20m high and lose their leaves in the dry season (December to May), but the majority of the reserve contains tropical semi-deciduous trees (Beletsky, 1999). Tropical semi-deciduous forest has a canopy ranging between 15-40m in height although the majority of trees are from 20-30m. The canopy can be closed or partially open and in the dry season, 20% to 40% of the trees lose their leaves (Beletsky, 1999). The dominant tree species in this forest are ramon (*Brosimum alicastrum*), chicozapote (*Manilkara zapota*), ceiba (*Ceiba pentandra*), zapotillo (*Pouteria reticulata*), chechen (*Metopium brownie*) chaca (*Bursera simaruba*), copal (Protium copal), tzalam (*Lysiloma bahamensis*) and caoba or mahogany (*Swietenia macrophylla*. Ogata et al., 1999). Calakmul also contains numerous temporary lakes known as aguadas, which form during the rainy season and may last well into the dry season. Wildlife in Calakmul includes jaguar, puma, ocelot, jaguarundi, tapir, brocket deer, peccary, howler and spider monkeys, in addition to over 50 species of reptile and amphibian and 350 species of resident birds.

This stretch of forest was also home to the two largest ancient Mayan cities of Tikal in Guatemala and Calakmul in Mexico during the pre-classic and classic period in ancient Mayan history (250BC-900AD). Today the extensive pyramids and ruined cities lie sprawled through the dense jungle, with some of the taller pyramids towering above the canopy at 65m in height. It is these pyramids that gave Calakmul its name. "In Maya, 'ca' means 'two', 'lak' means 'adjacent', and 'mul' signifies any artificial mound, so 'Calakmul'

is the 'City of the Two Adjacent Mounds'. This combination of Ancient Mayan ruins and outstanding diversity of wildlife is why Calakmul is an UNESCO Mixed World Heritage Site of Culture and Nature (UNESCO, 2015).

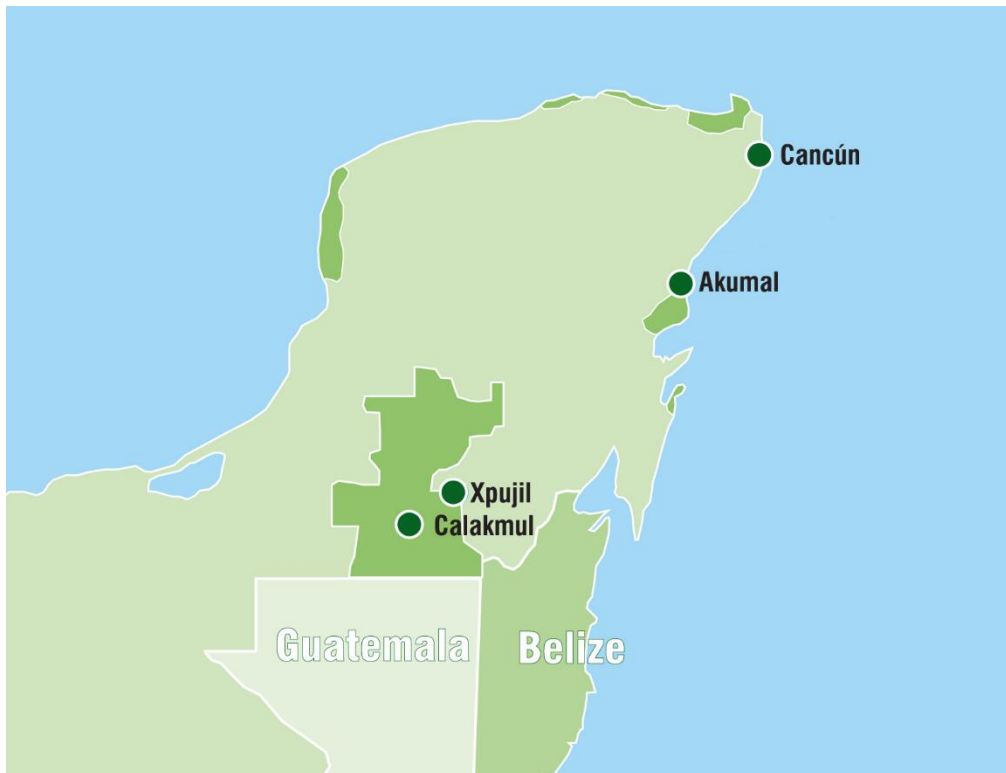


Figure 1. Map of The Yucatan Peninsula showing research locations

Today, over 20,000 people live in and around Calakmul in traditional Mayan villages where the traditional sources of income are slash and burn agriculture. Protecting the forest is therefore not just a case of creating a reserve, but educating and enabling local communities to utilise the forest resources in a sustainable manner. Buffer zone communities continue to grow in size and thus hunting of forest mammals is another major concern for the reserve. Some mammals (fast-producing species that live in high densities) may be hunted sustainably, but it is not possible to calculate sustainable hunting quotas for buffer zone communities until population density of mammals has been determined. The landscape has also been subjected to recent change due a reduction in rainfall and the loss of aguada habitats throughout the reserve.

### Biodiversity Monitoring and Management of Protected Areas

The term “biosphere” was introduced by UNESCO to refer to a protected area larger than 10,000 hectares that contains one or more important biological zones, including significant pristine habitat and or wilderness areas that are untouched by people. The purpose of these reserves is three fold: to conserve biological diversity, to develop and serve as models of sustainable land use, and to provide areas for environmental research, monitoring, training, education and sustainable tourism. In order to determine the effectiveness of these protected areas at conserving biological diversity it is necessary to conduct annual biodiversity monitoring (Sutherland, 2006). Differences in the abundance and diversity of species across areas with varying degrees of human or natural disturbance can define the effect of changes to habitat on

biodiversity and indicate areas in need of improved conservation efforts. For example, an investigation of bird diversity across differing levels of successional forest in the state of Campeche, Mexico found that many endemic bird species were absent from disturbed areas (Smith et al., 2001). Similarly, a study of reptiles in the ejido of Caobas in the state of Quintana Roo, Mexico indicated that both abundance and diversity of reptiles was significantly lower in secondary forest compared to old growth forest (Luja et al., 2008).

Moreover, investigation of the habitat preferences of specific species can identify the most important sections of protected areas for these species and help predict changes to the abundance and distribution of these species over time based on changes to their habitat. For example, a study of two common species of frugivorous bat (*Sturnira lilium* and *Artibeus intermedius*) in the buffer zone of Calakmul Biosphere Reserve in Mexico found that although both species were commonly found in both secondary and primary forest, *Sturnia lilium* would only roost in large trees found in primary forest (Evelyn & Stiles, 2003). Consequently, further destruction of primary forest would have a significant effect on the conservation of this species. A study of the habitat preferences of ungulates in hunted and non-hunted areas of Calakmul indicated that each species preferred different habitats and that the habitat preferences of each species changed when they were in hunted areas compared to non-hunted areas (Reyna & Tanner, 2005). Consequently, all types of forest in hunted and non-hunted areas must be preserved in order to maintain the ungulate population. In addition, a study of habitat preferences of sympatric jaguar and puma in Belize, indicated that in disturbed areas abundance of preferred prey was low, puma remained within the forest whereas jaguar ventured out of the forest into farmlands, presumably in search of livestock (Forster et al., 2010). Thus study explains why reports jaguar attacks on livestock are common place in farmland adjacent to fragmented forest.

## Calakmul Research Aims and Objectives

Operation Wallacea is a UK based NGO that specializes in biodiversity assessment and monitoring of protected areas using the expertise of university academics and students. Although the Calakmul Biosphere Reserve is very well managed, the forest surrounding the reserve that connects Calakmul to the Mesoamerican Biological Corridor is disappearing at an alarming rate. The cause of the problem is increased population size combined with an unpredictable climate causing agriculture to fail. In conjunction with the reserve management team and our project partners Pronatura Peninsula de Yucatan we have developed ecotourism and sustainable agriculture projects with local Mayan communities in the buffer zone of the reserve. The data collected by students is being used to monitor the efficacy of these community projects in protecting the forest and its wildlife. The other major threat to the reserve is climate change and associated reduction in rainfall and loss of water sources, known locally as aguadas.

The aim of this project is therefore to assess the abundance, diversity and distribution of flora and fauna in the Calakmul Biosphere Reserve and monitor changes to this diversity over time in relation to changing water distribution and an increase in agriculture. The data produced from this project may then be used to assist with management decisions for the reserve, such as whether to intervene and mitigate aguada habitats.

These broad project aims can be broken down into a series of specific objectives as follows:

1. To investigate the abundance, diversity and geographical distribution of flora and fauna in Calakmul reserve, specifically that of trees, birds, bats, herpetofauna (reptiles and amphibians), and large mammals

2. To utilize survey data to understand the habitat preferences and ranging patterns of flagship species for the Selva Maya biological corridor such as jaguar, Baird's tapir and spider monkeys.
3. To utilize survey data to understand the relationship between forest disturbance and the abundance and diversity of herpetofauna
4. To utilize survey data to identify the most important forest characteristics for maintaining diversity of resident bird species
5. To utilize survey data to identify the relationship between forest disturbance and bat abundance and diversity
6. To investigate the relationship between forest structure and butterfly community assemblage
7. To utilize monitoring data to assess the impact of human disturbance (forest encroachment from agriculture and hunting) on the abundance and distribution of species in the reserve
8. To utilize monitoring data to assess the efficacy of sustainable development projects with buffer zone communities in maintaining forest coverage and diversity
9. To utilize monitoring data to assess the impact of the loss of aguada habitats on the abundance and ranging of fauna in the reserve
10. To create and manage a biodiversity database for Calakmul that may be used by all relevant parties to assist with management of the reserve

Calakmul can be divided into two separate sections, the original reserve under federal management (green area on Figure 2) and the new state reserves (brown area on Figure 2) that were added to avoid the bottle neck between the northern and southern sections of the original reserve. Data collection will be carried out in 6 different locations with the Calakmul Biosphere Reserve (Figure 2). These camp locations have been chosen due to their accessibility during the wet season and because they cover the full geographical and vegetation range of the reserve. Each camp will contain four 2km long transect lines for data collection. Each transect line will be mapped using a GPS unit. Five sample sites will be located along each transect line at 400m intervals, giving rise to 120 sample sites across the 5 research camps in the reserve. Each sample site will consist of a 20m x 20m area adjacent to the transect line. These sample sites will be marked and the GPS location recorded.

School groups will be based at one of two camps: KM20 or Hormiguero. Hormiguero is adjacent to a small ruins site of the same name and the camp is located next to a lake surrounded by forest. Transects are located in the forest close to the lake and within the ruins site. KM20 is located next to the natural history and archaeology museum that is similarly surrounded by forest. Transects are located in the forest radiating out from camp, with additional transects located in the Zona Nucleo Sur that are accessed via pickup trucks from the KM20 camp. All data collection, lectures and jungle skills training sessions will take place in these camps. However, students will travel to the archaeological zone (following a guided tour of the museum) to complete the introduction to the Ancient Maya course where students will learn about the Ancient Mayan culture, social structure, architectural styles, gods, rituals and sacrifices and the specific uses of the different structures in the ruined city of Calakmul. This tour will provide amazing photo opportunities and some very entertaining viewing of the resident primates within the ruins site.

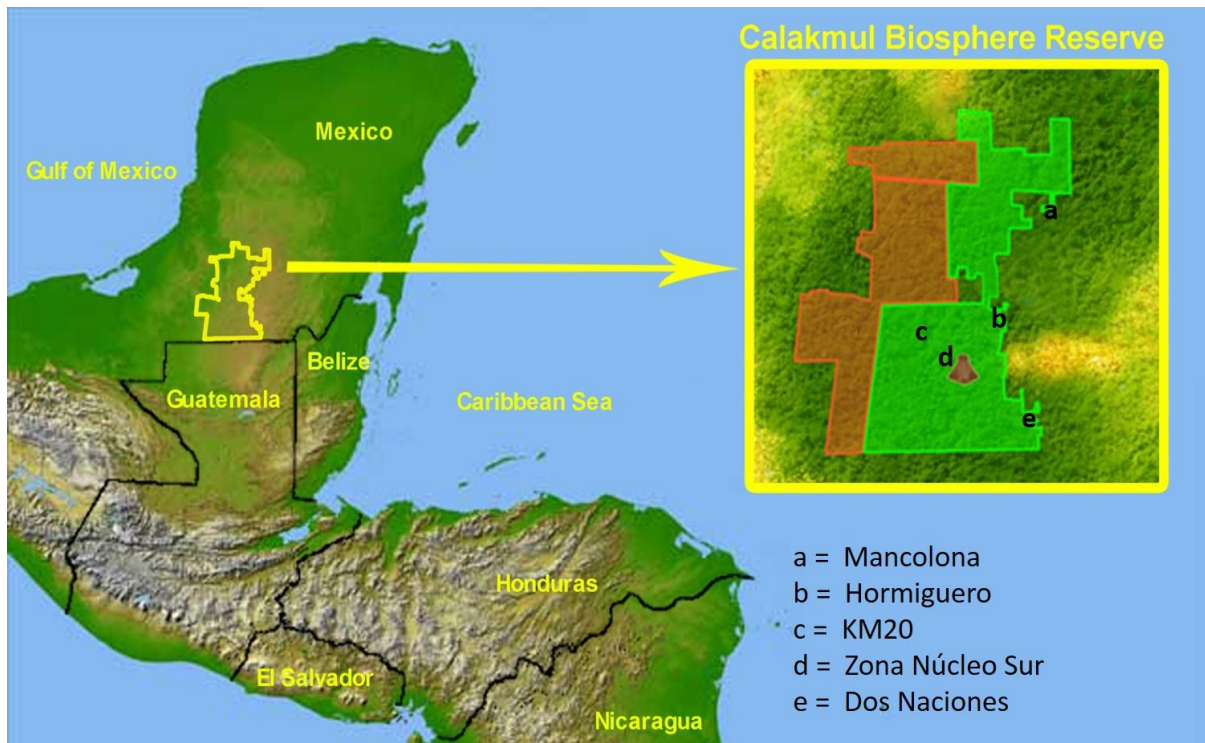


Figure 2: Study sites within the Calakmul Biosphere Reserve.

## 2. Week 1 Itinerary

The students on site will complete six days of training and research. These are divided into morning, afternoon and evening sessions. Students will arrive in the forest on Monday lunchtime and will attend a welcome lecture and briefings on health and safety, camp orientation and the schedule for the week for each group. The rest of the afternoon will be spent settling into camp and then students may join the nocturnal surveys after dinner. Student will then spend 4 days and nights receiving lectures, jungle training skills and assisting with data collection. Mid-way through the week, one full day will be spent at the museum and in the archaeological zone for the introduction to the Ancient Maya course, and primate monitoring. As the primates return to their sleep trees within the ruins site at dusk, they are best monitored in the late afternoon. Thus, students will remain at the ruin site until late afternoon and then transfer back to base camp for dinner. The project runs during rainy season so we expect all students to be flexible and understand why plans may need to be modified in the event of heavy rain. Accommodation at all these camps will be large tents.

During the briefings on the first day, students will be divided into small groups of 4-8 students. Students will stay in these small group when participating in biodiversity surveys (you see more animals if you enter the forest in small groups), but groups may join together again for lectures and meal times. An example weekly timetable is set out below (Table 1). Different groups of students will join different biodiversity surveys each day to ensure that all students get the chance to work with each of the different teams. The normal schedule will be a dawn start for the groups working with birds or mammals, around 8am for those working with herpetofauna or habitat and around 10am for those setting butterfly traps. These teams will then be back at camp mid to late morning with a bit of rest time before lunch. Straight after lunch there will be a lecture followed by afternoon data collection (birds, butterflies, mammals and habitat) or camp skills training that starts at around 4pm. The teams return to camp for dinner and after dinner some students

(those who are not scheduled to start early the next day) will be scheduled to participate in nocturnal surveys for herpetofauna or bats. This schedule has been designed to avoid data collection in the heat of the day because physical activity at this time of day can be exhausting and because animal activity is extremely low at this time.

*Table 1. shows an example timetable school groups during week 1. Note there may be changes to this schedule depending on size of groups, fitness of students, weather conditions or operational problems.*

Day	Activities
Monday afternoon	Welcome lecture Health and safety briefings Camp orientation and allocation to small groups for survey work
Monday evening	Optional opportunistic surveys for herpetofauna or mist net surveys for bats
Tuesday morning	Large mammal transect surveys, bird mist surveys, habitat surveys, butterfly surveys or herpetofauna trapping and transect surveys
Tuesday afternoon	Lecture 1: Conservation, Opwall and Calakmul Camera trap surveys, bird mist net surveys, butterfly surveys, habitat surveys or camp skills training
Tuesday evening	Herpetofauna transect or aguada surveys or bat mist net surveys (unless scheduled for early morning activities the next day)
Wednesday morning	Large mammal transect surveys, bird mist surveys, habitat surveys, butterfly surveys or herpetofauna trapping and transect surveys
Wednesday afternoon	Lecture 2: Biodiversity: definitions, gradients and monitoring Camera trap surveys, bird mist net surveys, butterfly surveys or habitat surveys
Wednesday evening	Herpetofauna transect or aguada surveys or bat mist net surveys (unless scheduled for early morning activities the next day)
Thursday morning	Lecture 3 : Endemism, hotspots and Calakmul reserve Introduction to Ancient Maya part 1: Guided tour of museum Transfer to archaeological zone
Thursday afternoon	Packed lunch at the ruins Introduction to Ancient Maya part 2: Guided tour of ruins Primate monitoring at the ruins
Thursday evening	Transfer back to camp Active searching for herpetofauna or bat surveys (for those that are not too exhausted!)
Friday morning	Large mammal transect surveys, bird mist surveys, habitat surveys, butterfly surveys or herpetofauna trapping and transect surveys
Friday afternoon	Lecture 4: Neotropical birds Camera trap surveys, bird mist net surveys, butterfly surveys, habitat surveys or camp skills training
Friday evening	Herpetofauna transect or aguada surveys or bat mist net surveys (unless scheduled for early morning activities the next day)
Friday morning	Large mammal surveys, bird point counts, bird mist netting, habitat surveys, butterfly surveys or herpetofauna pitfall surveys
Saturday morning	Large mammal transect surveys, bird mist surveys, habitat surveys, butterfly surveys or herpetofauna trapping and transect surveys
Saturday afternoon	Lecture 5: Herpetofauna, butterflies and adaptation



	Camera trap surveys, bird mist net surveys, butterfly surveys, habitat surveys or camp skills training
Saturday evening	Herpetofauna transect or aguada surveys or bat mist net surveys (unless scheduled for early morning activities the next day)
Sunday morning	Large mammal transect surveys, bird mist surveys, habitat surveys, butterfly surveys or herpetofauna trapping and transect surveys
Sunday afternoon	Lecture 6: Neotropical mammals Camera trap surveys, bird mist net surveys, butterfly surveys, habitat surveys or camp skills training
Sunday evening	Social evening
Monday morning	Travel to marine site

### 3. Jungle skills

There will be briefings on camp orientation, how to identify and ameliorate risks throughout the Calakmul sites, jungle health and disease issues on your arrival day at Calakmul. In addition, there will be two full afternoon sessions on jungle skills that will be led by your camp manager. The first session will teach you how to select a safe camp site (e.g. what characteristics of the forest to look for when selecting the camp location, where to locate toilets and washing facilities etc), how to make a camp fire, field cooking, water sterilisation, how to set up hammocks, mosquito nets and bashers etc. The second session will focus more on jungle survival skills such as basic first aid, how to deal with snake bites, navigation and where to find food and safe drinking water in the forest.

Learning outcomes:

- Awareness of dangerous plants and animals - from the briefings and demonstrations in the field
- Awareness of disease and health issues working in a tropical rainforest - from the medical briefings and additional information given by the accompanying medic
- Safe working practices in remote locations - this is to do with trekking procedures, keeping rehydrated and avoiding heatstroke, organising communication etc using information from the health and safety briefings and practical sessions
- Establishing a temporary field camp – students will learn what factors to consider when determining the location of a field camp, how to build the accommodation (e.g. slinging a hammock) and how to prepare food (building camp fires, cooking etc)
- Basic jungle survival – students will learn how to deal with emergency situations in the jungle and the application of skills such as basic first aid, navigation and finding food

### 4. Forest Structure Measurements

Assessment of habitat type and level of habitat degradation provides the backbone to biodiversity monitoring programmes and assessment of ecosystem health. Assessment of a range of habitat variables and monitoring of habitat changes over time can be used to interpret variation in space and time of faunal diversity and abundance. Modelling of habitat quality and animal distribution patterns can then be used to

predict changes to the ecosystem caused by a range of management plans as a means of choosing the most effective method of land management for a given area.

Habitat surveys will be conducted in each of 20m x 20m survey sites to investigate tree diversity and forest structure. On each transect the first plot will be located at 200m, the second at 600, the third at 1000m, the fourth at 1400m and the fifth at 1800m along the transect line. The number of saplings (trees with circumference <15cm and a minimum height of 3 metres) will be counted for each plot. For each tree in the plot with a circumference >15cm, the circumference at breast height (which will be converted to DBH), whether the tree is alive or dead, and the tree species, will be recorded on datasheets. Where species cannot be identified in the field, photographs of leaves, fruit (if available leaves and bark will be taken for later identification from textbooks. If identification is not possible from photographs, then samples may be taken from the tree at a later date for full examination. CBH will be measured using 50m tape measures. The number of fallen trees and cut stumps in the plot will also be recorded.

Forest structure measurements include understorey vegetation, canopy cover and leaf litter depth. To measure understorey vegetation, the plot will be bisected to produce the four quadrants. A 3m pole marked in 0.5m segments will be used to record the number of vegetation touches on the pole in each 0.5m segment up to a maximum of 10 touches, every 1m along these bisecting tapes. If one of the positions coincides with a tree then each of the 0.5m segments will be recorded and having vegetation touches. The openness of the canopy will be measured by taking a reading with a canopy scope facing the largest opening in the canopy from the centre of each of the four quadrants and one from the centre of the overall 20m X 20m square. If any of these points is closer than 1m to a tree trunk, then the observation point should be moved slightly so that it is at least 1m from the nearest tree trunk. The perspex square has 25 dots engraved on the square. The observer should look upwards holding the square 20cm from the eye count the number of dots that coincide with gaps in the canopy to give a score out of 25. Leaf litter depth should also be recorded in each of the 4 quadrants and in the centre of the plot using a ruler to give 5 separate leaf litter measurements (mm) per plot.

## 5. Biodiversity Monitoring

### Amphibians and Reptiles

Herpetofauna data will be collected using active searching along the forest transect lines between 9.30am-1pm (to monitor diurnal species) and between 7.30pm-11.30pm (to monitor nocturnal species). Searches will be conducted along the transect line and up to 2m either side of the transect line. The duration of the survey and total distance travelled will be recorded for each survey in order to calculate relative abundance of species that incorporates survey effort. For each animal observed the species will be identified using field guides (Lee, 2000; Kholer, 2008; Mandujano et al., 2010; Cedeño-Vásquez et al., 2010), the GPS location and distance travelled along the transect will be recorded along with the time, weather conditions and habitat type. Wherever possible, the animal will be captured in order to mark for recapture (scale clipping of reptiles only) and to record additional information before releasing the animal in the same location as capture. For each animal captured the sex, age (adult or juvenile), weight (g), the length of the animal (SVL), length of the head, and length of tail (were relevant) and colouration (camouflage or aposematic) will be recorded. In addition, the animal will be photographed in situ (back, head and side).

Data collected in and around aguadas will involve various capture methods. Pitfall and funnel traps will be arranged at various locations around the perimeter of the aguada and baited traps for turtles will be placed at the water's edge. Morelet's crocodiles will be captured with nooses while wading into the aguadas. Pitfall

and funnel traps will be arranged in a Y shape consisting of 3 buckets buried flush with the ground surface, a fence of mosquito netting to connect the buckets and a funnel trap at the end of each fence (3 funnel traps in total). The traps will be left in-situ each night and will be checked for captures each morning. For each capture, the sex, age (adult or juvenile), weight (g), the length of the animal (SVL), length of the head, and length of tail (where relevant) and colouration (camouflage or aposematic) will be recorded. In addition, the animal will be photographed in situ (back, head and side).

## Birds

Bird data will be collected using point counts and mist netting. The point count surveys will be completed between 05:00am and 09:00am. If it is raining heavily or there are strong winds the survey should be cancelled. On all surveys the weather conditions at the time of the point count should be recorded. Point counts of birds (by sight or call) will be conducted at 10 different points along the transect at 200m intervals. No settling down period should be allowed with counts starting immediately. Then over the next 10 minutes for each species the following details should be recorded: species, number of individuals, whether the bird(s) was seen or heard, and the approximate distance of the bird from the observer (recorded at 5m intervals). A minimum of 4 repetitions of each transect in each camp is required to ensure that data collected is representative of the population.

The abundance and diversity of understory birds will also be assessed using mist nets. Mist nets are unable to sample canopy and mid-canopy species adequately, but does allow for quantitatively reliable data to be produced for tropical understory birds, allows for the identification of birds that are shy or seldom vocal, minimises observer bias, and produces results that are easily repeatable.

Mist nets surveys will run 6 days per week at each research camp using a suitable existing clearing along one of the sample routes with enough space to erect five 12m long mist nets 2.5 meter high. The location of this mist net site will be marked and the GPS location recorded. All mist netting will be conducted at the same site per transect. Mist netting will occur in the mornings between 6:00am and 10:00am (or slightly later if bird activity is still high) and in the afternoons between 4.30pm and 6:00pm. The opening and closing time of the nets will be recorded each session and nets will be checked every 20 minutes for the duration of the survey. When birds are found in the net, the time of capture will be noted.

The birds will be taken out of the net, placed in a cotton bag for holding whilst other birds are being processed. Wing clippings or ringing will be used to control for recaptures. This is done by nipping a small triangle out of the same feather on every bird caught. The birds will be weighed (to the nearest gm) and standard morphological measurements taken. The birds will be released close to the net site but far enough away to avoid them being immediately re-trapped. The abundance and community composition will be compared between habitats and all the species will be categorised into breeding, habitat and feeding guilds.

## Bats

Bat mist nets surveys will run 6 nights per week at each research camp using a suitable existing clearing along the transects with enough space to erect five 6m long mist nets 2.5 meter high. Additional mist netting sites outside of the transects (e.g. adjacent to aguadas) may also be used. The location of each mist net site will be marked and the GPS location recorded. Mist netting will be conducted between 7:30pm and 1am, but as data collection may be affected by rain, the exact opening and closing time of the nets will be recorded each session. The nets will be checked every 15 to 20 minutes during the first 3 hours

of sampling and every 30 minutes for the last three. All the bats will be extracted from the nets following standardized protocols so as to minimize the stress and will be kept in a capture bags for 30mins, maximum. This time will vary depending on the size of the bat and the sex; pregnant females will be measured and released. Bats will be weighed, sexed, and species, reproductive status, the length of the forearm, feet and leg will be measured.

Each bat captured must be marked to control for recaptures (i.e. capture-mark-recapture sampling). The marking of captures only needs to last for the duration of the study and as data collection will only be conducted over the summer so the same method of painting rings around the feet with different coloured nail polish can be used (where rings painted on the right foot depict mist net location and rings on the left foot indicate the number of times captured).

## **Butterflies**

The relationship between forest structure and tree species composition with butterfly community structure will be investigated by placing a series of conical traps in different forest locations. Traps will be made from mosquito netting rolled into a large cylinder. Mosquito netting will also be used to enclose the top of the cylinder and a plastic plate will be hung from the bottom of the cylinder using wire. The plastic plate will be baited with rotten bananas and other fruit each morning at 10-11am and then checked in the afternoon between 3-4pm. Traps will be hung from suitable trees in different areas of the forest and a 20m x 20m habitat plot (using the previously described methods) will be conducted around each trap in order to record forest structure variables and tree species composition. A total of 10 traps (5 understorey and 5 canopy) will be used in each of the research camps. Each butterfly caught in the trap will be identified to species level and will then be released.

## **Primates and Large Terrestrial Mammals**

Primates and large terrestrial mammals will be surveyed along line transects that were placed without any pre-determined knowledge of the distribution of the animals. Primates will be surveyed using distance sampling as they are conspicuous and the particular species present in the reserve do not shy away from observers. These data will be collected by walking the entire length of the transect line in small groups of 4-5 observers walking quietly and slowly (500-1,000 m/hr) starting at 6.30am, when the primates are most active and are easiest to detect. Each time a primate is encountered, the species, whether the animals was seen or heard, number of individuals (visual sightings only), perpendicular distance from the individual to the transect line, habitat, time, distance travelled along the transect line and weather conditions will be recorded.

The distance sampling method is only suitable when animals are relatively easy to detect and is therefore unsuitable for monitoring elusive species or species that naturally live at low densities such as jaguar. Thus, an additional method will be used to monitor these species known as patch occupancy sampling. Patch occupancy sampling involves detecting animals based on tracks and faeces rather than visual or vocal sightings of the animals (Figure 3). These data will be collected at the same time as the primate surveys. For each track encountered the following data will be recorded: species, length and width of track, approximate age of track (days) and leaf litter depth.

In addition to transect surveys, large mammals are monitored using camera traps arranged in a trapping grid located in the core zone of the reserve away from the transect lines to avoid human disturbance. The cameras are left in situ from January through to the end of September each year (avoiding the peak of rainy

season where excessive rain can destroy the cameras) and students will assist with the organization and analyses of photos using Time Lapse software loaded onto laptops in camp and changing of SD cards and camera batteries where necessary.



Figure 3: Jaguar and jaguar tracks seen during surveys at Calakmul

## 6. Biodiversity Lectures

### Lecture 1: Conservation, Operation Wallacea and Calakmul

- Opwall Conservation Model
- Pressure-State-Response monitoring of Calakmul Biosphere Reserve
- Calakmul baseline data
- Sustainable hunting of forest ungulates
- REDD+ scheme

Discussion/Activity – Discussion of the use of REDD+ in Calakmul

### Lecture 2: Biodiversity and Evolution

- Definitions of biodiversity
- Biodiversity gradients, Darwin and Wallace
- Biodiversity monitoring, sampling strategies and replication
- Mark-recapture surveys
- Line transect surveys
- DISTANCE and PRESENCE to model species abundance
- How data is used for long-term monitoring

Discussion/Activity – Discussion on pros and cons of different survey techniques

### Lecture 3: Endemism, hotspots and the Calakmul forest

- Endemism
- Biodiversity hotspots
- Formation of and habitat characteristics of Central America
- Great Faunal Interchange
- Forest structure and tropical semi-deciduous forest

- Endemism in the Yucatan Peninsula
- Trees of Calakmul
- Impact of Ancient Mayan agro-forestry on forest around ruin sites

Discussion/Activity – How have the Ancient Mayans modified the habitat in Calakmul?

#### **Lecture 4: Neotropical birds**

- Bird diversity and evolution
- Bird anatomy and adaptation
- Bird Identification
- Courtship and mating
- Flight and migration
- Birds of Calakmul

Discussion/Activity – Bird Sampling Challenge

#### **Lecture 5: Herpetofauna, Butterflies and Adaptations**

- Classification of herpetofauna
- Amphibians
- Snakes and Lizards
- Crocodiles and caiman
- Snake teeth and venom
- Butterflies as forest indicators
- Cryptic and warning colouration
- Batesian mimicry and Mullerian mimicry

Discussion/Activity – Adaptation quiz

#### **Lecture 6: Neotropical mammals**

- Bats – roost site preferences in Calakmul and survey methods
- Primates – spider monkey social behaviour, survey methods
- Large rodents - agouti, paca
- Forest ungulates – feeding ecology, seed dispersal and predation
- Felids – jaguar population monitoring in Calakmul, survey methods

Discussion/Activity – Check the latest camera trap photos

## **7. Learning Outcomes from Week 1**

The students should achieve the following learning outcomes from the fieldwork, practicals, lectures and discussions/activities:

- Be able to define a rainforest and tropical semi-deciduous forest
- Be able to describe the key flora and fauna found in tropical Mexican forests
- Describe the Ancient Mayan Civilization of Calakmul
- Give examples of cryptic, warning colourations, Batesian and Mullerian mimic species

- Be able to identify 5 species of herpetofauna in Calakmul.
- Describe how snakes are classified according to their teeth and venom
- Describe different bird survey techniques
- Be able to identify 10 species of resident birds in Calakmul
- Describe survey techniques used to monitor mammal populations.
- Be able to identify 10 species of forest mammals in Calakmul
- Give examples of species that can be hunted sustainably and explain why
- Be able to describe the pros and cons of the UN REDD+ scheme

## 8. Marine Project Overview

### Sea Turtle Health and Tourism

All sea turtles in the Caribbean are listed by the IUCN (2012) as endangered or critically endangered. The diet and behaviour of green turtles are reported to change from the juvenile to adult life stages, with juveniles and sub-adults feeding exclusively on sea grasses, with large numbers of turtles aggregating around the same feeding ground (Arthur et al., 2008). These concentrations of turtles in shallow water close to shore are very accessible for swim and snorkel based tourism. Sea turtles are increasingly popular as a form of wildlife tourism, but little is known about the effect of tourism on turtle behaviour (Tisdell & Wilson, 2002). Data from other wild species suggests that if tourism is not correctly managed, interactions with tourists can lead to behavioural changes and increased anxiety in the target animals (Constantine, 2001; Stensland & Bergren, 2007).

Fibropapillomatosis (FP) is a debilitating disease that is characterized by the presence of epithelial fibropapillomas (cutaneous tumours) and internal fibromas (benign tumours that are composed of fibrous or connective tissue). Sea turtles appear most susceptible to FP following recruitment to seagrass ecosystems close to shore. Seagrass habitats tend to have relatively shallow water resulting in warmer temperatures and in developed tourist destinations, close proximity to shore often results in environmental pollutants, biotoxins and bacteria, all of which are reported to contribute to advancement of FP (Van Houtan et al., 2010). In addition, physiological factors such as stress are reported to be associated with FP. Studies of glucocorticoid stress hormones in wild *Chelonia mydas* in Hawaii have indicated FP infected turtles were immunosuppressed and chronically stressed (Work et al., 2001). The FP herpesvirus has been found in turtles free from tumours and this suggest that the FP progression is multifactorial and involves a tumour-promoting phase triggered by a range of factors. Thus, it appears that turtles living in polluted coastal environments with high nitrogen-footprints are more susceptible to FP and the virus develops at a faster rate if the turtles are also subjected to chronic stress resulting in immunosuppression.

### Akumal research objectives

The second week will be run from the marine research sites run by Operation Wallacea in the Akumal area (Figure 4). Akumal (meaning “home of the turtles” in Mayan) is a small coastal town located south of Cancun. Akumal earned this name due to the numerous turtle nesting sites along the beaches, and the permanent presence of juvenile turtles in the seagrasses just off shore. Over the last 10 years, snorkel tours with the sea turtles in Akumal Bay have increased exponentially and as Akumal was a public beach, these tours were not regulated resulting in serious physical damage to the seagrasses, water contamination from sunblock, insect repellent and other sources, and a decline in the health of the turtles. Since 2013 Operation Wallacea have been monitoring the impact of snorkel tours on stress related behaviour in the green turtles

living in the seagrasses in Akumal Bay. Our data indicated that each turtle was being grabbed by tourists on average 4 times hour and we have repeatedly reported indicators of chronic stress in the turtles caused by harassment from tourists. In 2016, Operation Wallacea monitoring data were presented to the Mexican government and by 2017, Akumal was established as a marine protected area. Since then, snorkel tours with turtles have been reduced by more than 50% and are only conducted in designated areas, under the control of licensed tour guides.

The aim of the Operation Wallacea project in Akumal is to collect all the necessary data to find a balanced level of tourism that will continue to bring sustainable income to local people without an associated negative impact on the wildlife and ecosystem. Now that Akumal is a protected area, our monitoring programme is now focussed on assessing the recovery of the ecosystem and calculating tourism carrying capacity. The new protected area also provides the opportunity for recovery of the coral reefs, but as natural coral recovery rates are so slow, we are assisting the process by attaching coral fragments to artificial reefs composed of different substrates of varying structural complexity in order to assess the best methods for coral reef restoration in the region. In addition, our teams are assisting with ground breaking research to collect coral gametes during spawning to provide assisted fertilization and subsequent reintroduction of juvenile corals back onto the reefs. Combined with mapping and monitoring of the existing reefs we are able to determine the positive impact of the new protected area on the coral reef ecosystem. Another aim of the Akumal project is to monitor the impact of mangrove degradation on the adjacent reefs and to investigate the ecology of the unique mangroves surrounding sink holes (cenotes) connected to the underground river system that runs throughout the Yucatan Peninsula.

There are 4 bays in Akumal (aventuras bay, akumal bay, jade bay and half moon bay) and a lagoon called Yal Ku to the north of half moon bay (Figure 4). Our accommodation is located in a wooded lot on the other side of the 307 highway just a short 10-minute drive to the various beaches and lagoons used as survey sites.

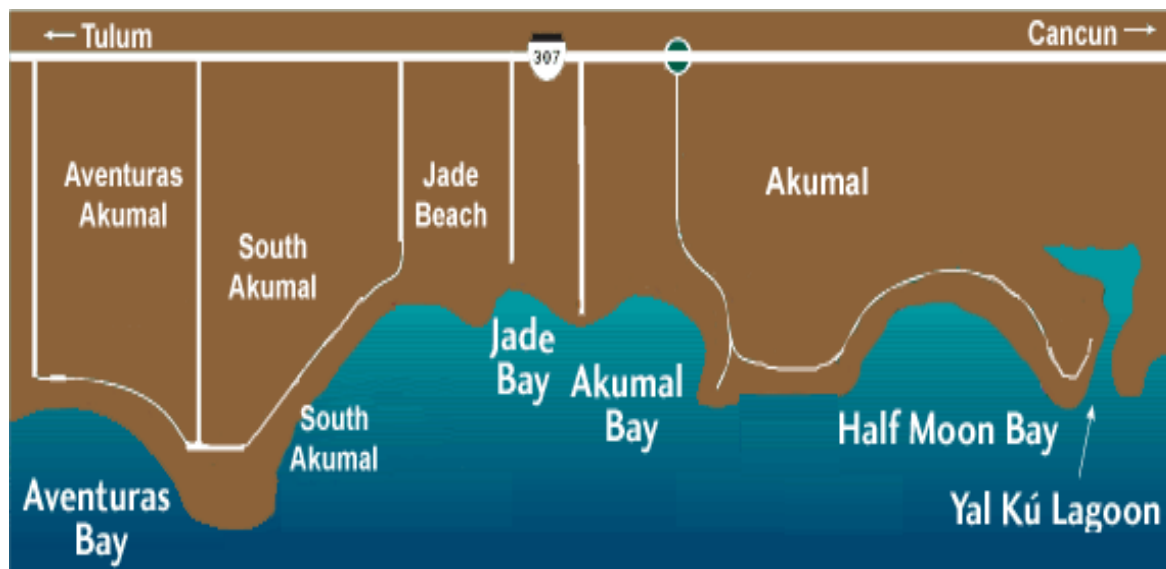


Figure 4: Map of Akumal showing location of the bays included in the Operation Wallacea monitoring programme



## 9. Week 2 Itinerary

The students will complete six days of training in marine science. Students will arrive at Akumal on the Monday afternoon and go directly to the research and accommodation facilities located in a beautiful wooded lot just a short 10-minute drive from the survey sites. Accommodation is in dorm rooms with fans and shared bathrooms. There are central dining and lectures areas on each floor of the three story building. Students will eat breakfast at the accommodation site and then travel in minibuses to the designated bay for their diving and research activities. Students will spend the day at the survey sites and will eat lunch at these sites or back at the accommodation. While at the beaches there is a small selection of local restaurants and gift shops, supermarkets and ATM machines.

If students are already dive trained or don't want to learn to dive, then they can do the Caribbean Reef Ecology Course (with the practical's done either by diving or snorkelling – see section 9). Alternatively, they can learn to dive to PADI Open Water level (see section 10). A third alternative is to complete their theory and confined water practical's before coming out and then just do their 4 open water dives to achieve the PADI Open Water qualification (see section 11) and then move onto the reef ecology course. Students will be occupied in the evenings through a series of science talks, documentary viewings and discussions/activities relative to the Coral Reef Ecology course.

In addition to dive training and reef ecology course, all students will have the chance to assist with day time turtle and sea grass monitoring between scheduled course activities.

## 10. Green Turtle Health Monitoring

Due to the abundant sea grasses in Akumal, there is a large population of juvenile and sub-adult green turtles in Akumal Bay. Although there is restricted access to the majority of the turtle feeding ground, students are likely to encounter turtles during practical sessions as part of the reef ecology course or while dive as part of their PADI training. When this happens, photographs should be taken to assist with the updating of our turtle photo ID library and to help monitoring the status of the FP virus in the turtle population. Students can use underwater cameras to take close-up photographs of the head, back, fins and tag number if relevant (see figure 5). Any evidence of tumours should also be photographed



Figure 5: Photos of the resident green turtles in Akumal Bay for ID library and health monitoring

## 11. Coral Reef Ecology Course

Table 2 below shows an example timetable of the activities that students undertaking the Caribbean Coral Reef Ecology Course will complete over the week. The contents of the timetable are comprehensive but the timing of the sessions will vary for each group. The practical element of the reef ecology course can be completed by either diving or snorkelling. If students are already qualified divers by the time they arrive on site, they will be required to complete a compulsory check dive with a PADI Professional at the start of the course. The Indo-Pacific Coral Reef Ecology course is designed specifically for 6th Form students in mind. It covers a range of topics suitable to support A-Level biology and geography students over a range of different syllabuses. Lectures will be supported by in-water practicals. In addition to the lectures, a discussion/activity element will be sure to engage the students into the science and get them thinking themselves of the importance of the study topic.

*Table 2 shows Indicative timetable for students completing the Caribbean Coral Reef Ecology Course. Note there may be changes to this itinerary depending on fitness of students, weather conditions or operational issues on site.*

Day	Schedule for reef ecology students
Monday pm	Welcome lecture Allocation to groups for diving and practical sessions
Monday evening	Dive documentation
Tuesday am	Check dive/skin diver course (snorkellers)
Tuesday pm	Dive/snorkel practical 1 – Reef structure and topography
Tuesday evening	Lecture 1 – Introduction to coral reef ecology
Wednesday am	Dive/snorkel practical 1 – Reef structure and topography Lecture 2 – Identification of coral and algal Species
Wednesday pm	Dive/snorkel practical 2 – coral and algal identification skills
Wednesday evening	Lecture 3 – The importance of mangrove and seagrass habitats
Thursday am	Snorkel practical 3 – Seagrass snorkel with green turtles in Akumal bay Lecture 4 – Identification of ecologically important invertebrate species
Thursday pm	Snorkel practical 4 – snorkel seagrass beds / invertebrate identification skills
Thursday evening	Lecture 5 – Identification of coral reef fish
Friday am	Dive/snorkel practical 5 – fish identification skills (to be conducted in Yal Ku lagoon. Water quality data will also be collected during this practical) Lecture 6 – How to survey a coral reef
Friday pm	Dive/snorkel practical 6 – quadrat and transect survey
Friday evening	Lecture 7 – Global threats to coral reefs Documentary
Saturday am	Dive/snorkel practical 7 Lecture 8 – Methods to protect the world's coral reefs
Saturday pm	Dive/snorkel practical 8 – fun dive!
Saturday evening	Reef Ecology Quiz
Sunday am	Late wake up/packing
Sunday pm	Depart Akumal at noon

### **Lecture 1: The Blue Planet**

- Quick fire facts to excite students about the marine world
- Who would win in a fight between a great white shark and a killer whale?
- Why is the sea blue?
- Why is the sea salty?
- Why are whales so important?
- Where did life originate?

Land-based activity: presentation briefing

In-water activity: check dive/snorkel

### **Lecture 2: An Introduction to Coral Reefs**

- Coral biology; growth, development, feeding and reproduction
- Importance of the symbiotic relationship between corals and photosynthetic microalgae
- What are coral reefs and where are they found?
- Introduction to the Caribbean

Land-based activity: assessing the complexity of a coral reef

In-water activity: coral ID dive

### **Lecture 3: Conservation of Coral Reefs**

- The value of coral reefs
- An introduction to macroalgae
- Competition between macroalgae and hard coral; phase-shifts
- Local threats to coral reefs that stimulate phase-shifts; i. Destructive fishing, ii. Coral mining, iii. Overfishing, iv. Water pollution, v. Coastal development, vi. Disease, vii. Lionfish invasion
- Potential management solutions

Land-based activity: quadrat building

In-water activity: assessing levels of coral bleaching using PADI's 'Coral Watch' guideline

### **Lecture 4: The Diversity of Coral Reefs I**

- An introduction to taxonomy
- Classifying a green alga
- Classifying a sea cucumber
- Classifying the stoplight parrotfish

Land-based activity: talk preparation

In-water activity: fish ID dive

### **Lecture 5: The Diversity of Coral Reefs II**

- Coral reef food webs
- Fish herbivory

- Invertebrate herbivory
- Filter feeding
- Predation

Land-based activity: video analysis

In-water activity: urchin collection

### **Lecture 6: The Diversity of Coral Reefs III**

- An introduction to behaviour
- Parasitism
- Commensalism
- Symbiosis
- Camouflage
- Fish sensory systems

Land-based activity: urchin practical

In-water activity: invertebrate ID dive

### **Lecture 7: Mangroves and Seagrass**

- Mangrove adaptations
- Seagrass adaptations
- Ecosystem services and functions
- Importance of habitat connectivity
- Threats to mangroves and seagrasses

Land-based activity: lionfish practical

In-water activity: seagrass practical

### **Lecture 8: The Future of Coral Reefs**

- Rising sea surface temperature
- Ocean acidification
- The structure of a reef in 2100
- Conservation management

Land-based activity: bntalk preparation

In-water activity Rapid Reef Assessment

## **12. PADI Open Water Diver Course**

This course consists of three different elements of learning; dive theory (knowledge development), confined water dives and open water dives. Each component plays its own role in the students' development to meet the performance requirements and objectives they need to become a qualified diver.

Please be aware that as a part of the PADI Open Water Course, all students will be required to complete some basic stamina tests on site. Student divers will need to demonstrate that they can comfortably maintain themselves in water too deep in which to stand by completing a 10-minute swim/float without using any swimming aids. Students will also have students complete a 200m continuous surface swim or a 300 m swim with mask, fins and snorkel.

*Table 3 shows indicative timetable for students completing the PADI Open Water Course. Note there may be changes to this itinerary depending on progression through the course, fitness of students, weather conditions or operational issues on site.*

Day	Activity
Monday pm	Arrive and settle in
Monday evening	Dive Documentation
Tuesday am	Dive theory
Tuesday pm	Evening science talk
Tuesday evening	Dive theory
Wednesday am	Confined water
Wednesday pm	Confined water
Wednesday evening	Dive theory
Thursday am	Confined water
Thursday pm	Open Water 1
Thursday evening	Dive theory
Friday am	Open water 2
Friday pm	Open water 3
Friday evening	Dive theory exam
Saturday am	Open water 4 & Dive certification
Saturday pm	Dive/snorkel practical 8 – fun dive! Revision Session
Saturday evening	Social evening
Sunday am	Packing
Sunday pm	Depart Akumal

### 13. PADI Open Water Referral Course

For those students who have completed both the dive theory and confined water sessions prior to expedition they can complete their PADI Open Water Referral Course on site. The students will first complete a check dive with their instructor to demonstrate that they still remember and can confidently perform the necessary skills to progress on to complete their open water dives.

Once referral students have successfully completed the final stages of their PADI Open Water course, they will be able to progress on to the Coral Reef Ecology course. Although there will not be enough time to run the full course, referral students will be able to join at a stage where they can get the chance to learn about the application of survey techniques in the marine environment and how that supports the management of coral reefs.

### 14. Links to A levels and UCAS points

The following two tables highlight how your Opwall expedition relates to the AS and A-level syllabuses across all exam boards. The red blocks indicate that the keywords listed are covered on our expedition (through lectures, practical's or in discussion topics) and that these keywords are also within AS or A-level topics as shown.



Topic	Keywords	AQA –Human Biology		EdExcel Human Biology		OCR Human Biology		WJEC Human Biology		AQA Geography		EdExcel Geography		OCR Geography		WJEC Geography		
		AS	A2	AS	A2	AS	A2	AS	A2	AS	A2	AS	A2	AS	A2	AS	A2	
<b>Evolution, Classification and DNA</b>	Evolution; Speciation; Species; Endemism; Gene pool; Allopatric; Sympatric; Isolation; Variation; Adaptation; Wallace; Darwin																	
	Classification; Taxonomy; Binomial system; Dichotomous Keys																	
<b>Ecology and Ecosystems</b>	Ecology; Habitat; Niche; Abiotic; Biotic																	
	Biome; Ecosystems; Rainforests Coral reefs; Mangroves; Marine; Coasts; Woodland; Tropics; Tropical																	
	Populations; Competition; Interspecific; Intraspecific; Predator Prey;																	
	Succession; Climax community																	
	Biodiversity																	
	Practical work; Field techniques; Ecological sampling; Random sampling; Transects; Capture, mark, release and recapture; Biodiversity indexes; Data handling and; presentation; Quadrats; Statistical testing; Measuring; GIS; Research tools																	
	Written reports; Research project; Report; Case studies																	
<b>Agriculture, Human activities, Conservation and Sustainability</b>	Sustainability																	
	Forestry; Timber; Deforestation; Fisheries; Over fishing; Deforestation; Human management; Human effects; Human activities																	
	Fair-Trade; Coffee; Rain Forest Alliance; Ecotourism; Tourism; Carbon trading; Greenhouse gas emission control (REDD)																	
	Indicator species;																	
	International conservation; Endangered species; Invasive species;																	
	National Parks; Wildlife reserves																	
<b>Behaviour</b>	Animal behaviour; Primate Social behaviour;																	

## 15. Reading and research questions

The following research questions and accompanying reading lists are provided to give everyone a chance to think about the scientific work and research areas that they might encounter in Mexico. The list is a starting point for those doing CoPE and other extended project work and you may wish to alter the question or go in a slightly different direction but do consult your tutor/Opwall before deciding in your final topic: make sure it is practical and you are really interested in it.

The reading lists are only 'starters' and NOT meant to be a definitive list for your research. You will get many leads from these and we have chosen a good range of sources from academic papers to video clips. We have checked all of the internet links but these constantly change with time so expect some not to work (cut and paste into your web browser address bar if you have an electronic version of this booklet). We have tried to direct you to the summary abstracts of many of the papers cited as they are not easily available unless you have access to a University library or a journal 'on-line'. Try [www.mendeley.com/](http://www.mendeley.com/) which is a new 'free open source' website to locate scientific papers.

If you do use a reference ALWAYS quote as much detail as you can and if possible, the original citation.

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## Electronic media

Documentary BBC Planet Earth, Episode 8: Jungles

Documentary BBC Planet Earth, Episode 9: Freshwater

Documentary BBC Life of Mammals, Episode 8: Tree Dwellers

## Research questions

A level keyword link	Research area	Research questions	Suggested reading list
Ecotourism; national park; conservation	Biodiversity and Man's impact on wildlife	Can ecotourism provide a viable alternative income for the Calakmul Bioshere Reserve?	<b>Academic paper:</b> Sound the stressor: how Hoatzins (Opisthocomus hoazin) react to ecotourist conversation - Daniel S. Karp and Terry L. Root - <i>Biodiversity and Conservation</i> , 2009, Volume 18, Number 14, Pages 3733-3742 <a href="http://www.springerlink.com/content/hu8g74217981p481/fulltext.html">http://www.springerlink.com/content/hu8g74217981p481/fulltext.html</a> <b>Article</b> - Eco-tourism: A sustainable trade? James Mair - DEC 2006 - <a href="http://news.bbc.co.uk/1/hi/sci/tech/6179901.stm">http://news.bbc.co.uk/1/hi/sci/tech/6179901.stm</a> <b>Paper</b> - Andrews, Joann. 1994. Evaluation of ecotourism potential, in the areas in and around the Calakmul Biosphere Reserve. PPY.
human impact; rainforest; deforestation	Biodiversity and Man's impact on wildlife	Has deforestation in Central America	<b>Other</b> - Statistics - <a href="http://www.biodiversityhotspots.org/xp/hotspots/mesoamerica/Pages/biodiversity.aspx">http://www.biodiversityhotspots.org/xp/hotspots/mesoamerica/Pages/biodiversity.aspx</a> <b>Other (website)</b> - World deforestation rates and forest

		slowed?	<p>cover statistics, 2000-2005 Rhett A. Butler, mongabay.com November 16, 2005  <a href="http://news.mongabay.com/2005/1115-forests.html">http://news.mongabay.com/2005/1115-forests.html</a></p> <p><b>Article</b> - Deforestation in Central America 2006 :  <a href="http://www.biodiversityhotspots.org/xp/hotspots/mesoamerica/Pages/biodiversity.aspx">http://www.biodiversityhotspots.org/xp/hotspots/mesoamerica/Pages/biodiversity.aspx</a></p> <p><b>Academic paper</b> - De Fries R, Hansen A &amp; Turner BL (2007) Land use change around protected areas: Management to balance human needs and ecological function. Ecological Applications 17: 1031-1038</p> <p><b>Book</b> - P. W. Richards, University of Wales, Bangor - The Tropical Rain Forest An Ecological Study 2nd Edition - 1996 ISBN: 9780521421942</p>
Biodiversity; mesoamerica	Biodiversity and Mans impact on wildlife	Why are there so many species in Central American forests?	<p><b>Report</b> - Biodiversity hotspots  <a href="http://www.biodiversityhotspots.org/xp/hotspots/mesoamerica/Pages/default.aspx">http://www.biodiversityhotspots.org/xp/hotspots/mesoamerica/Pages/default.aspx</a></p> <p><b>Article</b> - Habitat Loss and Extinction in the Hotspots of Biodiversity - Brooks, TM; Mittermeier, RA; Mittermeier, CG, et al, CONSERVATION BIOLOGY Volume: 16 Issue: 4 Pages: 909-923 Published: AUG 2002 - abstract can be found on -  <a href="http://onlinelibrary.wiley.com/doi/10.1046/j.1523-1739.2002.00530.x/abstract">http://onlinelibrary.wiley.com/doi/10.1046/j.1523-1739.2002.00530.x/abstract</a></p> <p><b>Article</b> - Biodiversity hotspots for conservation priorities - Norman Myers, Russell A. Mittermeier, Cristina G. Mittermeier, Gustavo A. B. da Fonseca &amp; Jennifer Kent - Nature - Volume: 403 Pages 853- 858 Published FEB 2000 - available at  <a href="http://biolambiental.posgrado.unam.mx/pdf/Myers2000.pdf">http://biolambiental.posgrado.unam.mx/pdf/Myers2000.pdf</a></p>
classification rainforest population	Forest mammals	Describe the large mammal communities of the Calakmul Reserve.	<p><b>Book</b> - Krebs C (2006) Mammals. In WJ Sutherland (Ed.) Ecological Census Techniques: A Handbook Cambridge: Cambridge University Press pp 351 369</p> <p><b>Book</b> - Fiona Reid (1998). A Field Guide to the Mammals of Central America and Southeast Mexico.</p> <p><b>Academic paper</b> - Myton B. 1974. Utilization of space by Peromyscus leucopus and other small mammals. Ecology 55: 277 290. <a href="http://www.jstor.org/pss/1935216">http://www.jstor.org/pss/1935216</a></p>
population ;sampling ecology	Forest mammals	How do you estimate animal populations in the Calakmul Reserve?	<p><b>Paper</b> – The use of camera traps for estimating jaguar Panthera onca abundance and density using capture/recapture analysis Oryx (2004), 38: 148-154  <a href="http://journals.cambridge.org/action/displayAbstract?jsessionid=DF9F1C3656DEC4752B6730BD7FA4498A.tomcat1?fromPage=online&amp;aid=220195">http://journals.cambridge.org/action/displayAbstract?jsessionid=DF9F1C3656DEC4752B6730BD7FA4498A.tomcat1?fromPage=online&amp;aid=220195</a></p> <p><b>Book</b> – Timber, Tourists and Temples: Conservation and Development in the Maya Primack, RB – Chapter 6 Calakmul -</p>

			<a href="http://books.google.co.uk/books?hl=en&amp;lr=&amp;id=VVEsm95ArYC&amp;oi=fnd&amp;pg=PA81&amp;dq=estimating+animal+populations+in+rainforest+calakmul+reserve&amp;ots=xeYypQgchi&amp;sig=VDh2Oy-8SmiSWUfquemyqZeQixY#v=onepage&amp;q&amp;f=false">http://books.google.co.uk/books?hl=en&amp;lr=&amp;id=VVEsm95ArYC&amp;oi=fnd&amp;pg=PA81&amp;dq=estimating+animal+populations+in+rainforest+calakmul+reserve&amp;ots=xeYypQgchi&amp;sig=VDh2Oy-8SmiSWUfquemyqZeQixY#v=onepage&amp;q&amp;f=false</a>
Classification ; rainforest; population ; primate behaviour	Forest mammals	Describe the social structure of spider monkeys – e.g. <i>Ateles geoffroyi</i>	<p><b>Article</b> – Spider Monkeys – reference list at the bottom of the Wikipedia article - <a href="http://en.wikipedia.org/wiki/Geoffroy's_spider_monkey">http://en.wikipedia.org/wiki/Geoffroy's_spider_monkey</a></p> <p><b>Article</b> – BBC website <a href="http://www.bbc.co.uk/nature/wildfacts/factfiles/310.shtml">http://www.bbc.co.uk/nature/wildfacts/factfiles/310.shtml</a></p> <p><b>Article</b> – The Primata website - Black-handed spider monkey - <a href="http://www.theprimata.com/ateles_geoffroyi.html">http://www.theprimata.com/ateles_geoffroyi.html</a></p>
conservation ; sampling; biodiversity	Birds and sampling	Does mist netting adequately describe the bird fauna of the reserve?	<p><b>Book</b> - Gibbons DW &amp; Gregory RD (2006) Birds. In WJ Sutherland (Ed.) Ecological Census Techniques: A Handbook Cambridge: Cambridge University Press pp 308 350</p> <p><b>Other</b> - Definition <a href="http://en.wikipedia.org/wiki/Mist_net">http://en.wikipedia.org/wiki/Mist_net</a></p> <p><b>Article</b> - Using two survey methods to determine a suburban bird population by C Hansrote and M Hansrote <a href="http://elibrary.unm.edu/sora/NABB/v016n04/p0114p0118.p">http://elibrary.unm.edu/sora/NABB/v016n04/p0114p0118.p</a></p> <p><b>Academic paper</b> - Derlindati, J., Enrique and Caziani, M., Sandra. 2005. Using canopy and understory mist nets and point counts to study bird assemblages in Chaco forests. The Wilson Bulletin 117(1): 92 99. Abstract found at <a href="http://www.bioone.org/doi/abs/10.1676/03063?cookieSet=1&amp;journalCode=wils.1">http://www.bioone.org/doi/abs/10.1676/03063?cookieSet=1&amp;journalCode=wils.1</a></p> <p><b>Academic paper</b> - Whitman, A. A., Hagan, J. M. and Brokaw, N. V. L. 1997. A comparison of two bird survey techniques used in a subtropical forest. The Condor Vol. 99(4): p955 965. Abstract found at <a href="http://cat.inist.fr/?aModele=afficheN&amp;cpsidt=2062566">http://cat.inist.fr/?aModele=afficheN&amp;cpsidt=2062566</a></p>
conservation sampling; biodiversity; transect	Birds and sampling	The advantages and disadvantages of point and transect counting to describe bird communities?	<p><b>Book</b> - Gibbons DW &amp; Gregory RD (2006) Birds. In WJ Sutherland (Ed.) Ecological Census Techniques: A Handbook Cambridge: Cambridge University Press pp 308 350</p> <p><b>Book</b> - Bibby CJ, Burgess ND, Hill DA, Mustoe, SH. (2002) Bird Census Techniques (Second edition). Academic press: London</p> <p><b>Article</b> - Avian ecology field methods <a href="http://en.wikipedia.org/wiki/Avian_ecology_field_methods">http://en.wikipedia.org/wiki/Avian_ecology_field_methods</a></p> <p><b>Book</b> - Howell SNG, Webb S. (2005) A Guide to the</p>

			Birds of Mexico and Northern Central America, Oxford: Oxford University Press
Classification ; biodiversity	Reptile and amphibian communities	What are the main species groupings of amphibians and reptiles in Calakmul Reserve?	<p><b>Article</b> – Central American Herpetofauna  <a href="http://pubget.com/paper/pgtmp_jstor1441404?title=The%20Origins%20and%20History%20of%20the%20Central%20American%20Herpetofauna">http://pubget.com/paper/pgtmp_jstor1441404?title=The%20Origins%20and%20History%20of%20the%20Central%20American%20Herpetofauna</a></p> <p><b>Other</b> – Yucatan Wildlife -  <a href="http://www.yucatanwildlife.com/places/calakmul.htm">http://www.yucatanwildlife.com/places/calakmul.htm</a></p> <p>Article – List of Reptiles of Yucatan Peninsula -  <a href="http://www.yucatanwildlife.com/species/reptiles.htm">http://www.yucatanwildlife.com/species/reptiles.htm</a></p>
Alien/invasive/ species ; conservation population ; biodiversity	Reptile and amphibian communities	What are the impacts of Chytrid fungus on amphibian populations in Central America?	<p><b>Article</b> – Holland J (2009) Vanishing amphibians. National Geographic April 2009, available online at <a href="http://ngm.nationalgeographic.com/2009/04/amphibian/holland">http://ngm.nationalgeographic.com/2009/04/amphibian/holland</a> text</p> <p><b>Academic paper</b> – Puschendorf, R., Castaneda, F. and McCranie, J. R. 2006. Chytridiomycosis in Wild Frogs from Pico Bonito National Park, Honduras. Ecohealth Vol.3 (3): 178 181.  <a href="http://www.springerlink.com/content/2470032p58368067/">http://www.springerlink.com/content/2470032p58368067/</a></p> <p><b>Electronic media</b> – Definition and sampling video  <a href="http://www.amphibianark.org/chytrid.htm">http://www.amphibianark.org/chytrid.htm</a></p>
Population; biodiversity	Reptile and amphibian communities	How can you estimate the diversity and population levels of reptiles and amphibians?	<p><b>Book</b> – Blomberg S &amp; Shine R (2006) Reptiles. In WJ Sutherland (Ed.) Ecological Census Techniques: A Handbook Cambridge: Cambridge University Press pp 297 307</p> <p><b>Book</b> – Halliday T (2006) Amphibians. In WJ Sutherland (Ed.) Ecological Census Techniques: A Handbook Cambridge: Cambridge University Press pp 278 296</p> <p><b>Book</b> – Gent T and Gibson S (2003). Herpetofauna Workers Manual. JNCC, Peterborough.</p> <p><b>Book</b> – Bennett D (1999). Expedition Field Techniques: Reptiles and Amphibians. Expedition Advisory Centre, Royal Geographical Society, London. -  <a href="http://www.rgs.org/NR/rdonlyres/9E3CF152-C817-470C-AC0C-C8FE82A8CBAD/0/Reptilesupdated.pdf">http://www.rgs.org/NR/rdonlyres/9E3CF152-C817-470C-AC0C-C8FE82A8CBAD/0/Reptilesupdated.pdf</a></p> <p><b>Academic paper</b> – Which Methods Are Most Effective for Surveying Rain Forest Herpetofauna?  <a href="http://www.jstor.org/pss/1565833">http://www.jstor.org/pss/1565833</a></p>
Climate change; REDD;	Forest conservation	How is total carbon locked up in a forest calculated?	<p><b>Other - website</b> - <a href="http://www.un-redd.org/">http://www.un-redd.org/</a></p> <p><b>Articles</b> – Mongabay news articles on Carbon credits -  <a href="http://news.mongabay.com/news-index/carbon%20credits1.html">http://news.mongabay.com/news-index/carbon%20credits1.html</a></p> <p>Article – Forest carbon stores may be massively overestimated New Scientist September 2010  <a href="http://www.newscientist.com/article/dn19408-forest-carbon-stores-may-be-massively-overestimated.html">http://www.newscientist.com/article/dn19408-forest-carbon-stores-may-be-massively-overestimated.html</a></p>

ecology niche; trophic level	Forest Conservation	Why are fig trees so important for the forest fauna?	<p><b>Book</b> - P. W. Richards, University of Wales, Bangor - The Tropical Rain Forest An Ecological Study 2nd Edition 1996 ISBN: 9780521421942</p> <p><b>Other - definition</b> - Ficus - <a href="http://en.wikipedia.org/wiki/Ficus">http://en.wikipedia.org/wiki/Ficus</a></p> <p><b>Other - website</b> - Figweb - <a href="http://www.figweb.org/Ficus/index.htm">http://www.figweb.org/Ficus/index.htm</a></p> <p><b>Book</b> - Burrows, J and S - Figs of Southern &amp; South-Central Africa - <a href="http://www.figweb.org/Ficus/Fig_book/Figs_of_Africa.htm">http://www.figweb.org/Ficus/Fig_book/Figs_of_Africa.htm</a></p>
Conservation; human impact	Forest Conservation	What are the main threats to the Calakmul Biosphere Reserve?	<p><b>Report</b> - Parks Watch – Calakmul Biosphere Reserve – Threats - <a href="http://www.parkswatch.org/parkprofile.php?l=eng&amp;country=mex&amp;park=ckbr&amp;page=thr">http://www.parkswatch.org/parkprofile.php?l=eng&amp;country=mex&amp;park=ckbr&amp;page=thr</a></p> <p><b>Article</b> – Calakmul Biosphere Reserve – Heart of the Maya Forest Rich with natural and Cultural Wonders - <a href="http://www.parksinperil.org/files/page_2_calakmul_biosphere_reserve.pdf">http://www.parksinperil.org/files/page_2_calakmul_biosphere_reserve.pdf</a></p> <p><b>Article</b> – Calakmul Biosphere Reserve – The Nature Conservancy – Parks in Peril - <a href="http://www.parksinperil.org/wherework/mexico/protectedarea/calakmul.html">http://www.parksinperil.org/wherework/mexico/protectedarea/calakmul.html</a></p>
Evolution	Rainforests	Why do more species live in Rainforests than in other ecosystems?	<p><b>Other</b> – Save the Rainforest - <a href="http://www.savetherainforest.org/savetherainforest_005.htm">http://www.savetherainforest.org/savetherainforest_005.htm</a></p> <p><b>Paper</b> - Novotny, V., Drozd, P., Miller, S. E., Kulfan, M., Janda, M., Basset, Y., &amp; Weiblen, G. D. (2006). Why are there so many species of herbivorous insects in tropical rainforests? <i>Science</i>, 313(5790), 1115-8. American Association for the Advancement of Science. Retrieved from <a href="http://www.ncbi.nlm.nih.gov/pubmed/16840659">http://www.ncbi.nlm.nih.gov/pubmed/16840659</a> <a href="http://www.mendeley.com/research/why-are-there-so-many-species-of-herbivorous-insects-in-tropical-rainforests/">http://www.mendeley.com/research/why-are-there-so-many-species-of-herbivorous-insects-in-tropical-rainforests/</a> also see related research articles.</p>
Conservation; biodiversity	Conservation	What would be achieved by implementing the Meso – American wildlife corridor?	<p><b>Article</b> - The Mesoamerican Biological Corridor – What is it, why is it significant? <a href="http://www.ecoreserve.org/2010/07/08/the-mesoamerican-biological-corridor-what-is-it-why-is-it-significant/">http://www.ecoreserve.org/2010/07/08/the-mesoamerican-biological-corridor-what-is-it-why-is-it-significant/</a></p> <p><b>Report</b> – Mesoamerican Biological Corridor Project - <a href="http://www.cakex.org/case-studies/1586">http://www.cakex.org/case-studies/1586</a></p> <p><b>Other – website</b> – Mesoamerican Biological Corridor - <a href="http://www.biodiversidad.gob.mx/v_ingles/corridor/mesoamericanCor.html">http://www.biodiversidad.gob.mx/v_ingles/corridor/mesoamericanCor.html</a></p>

Evolution, colonisation	Conservation	How has the formation of the central American land bridge influenced current wildlife communities in Calakmul?	<p><b>Paper</b> - Marshall, L. G. (July–August 1988). "Land Mammals and the Great American Interchange". <i>American Scientist</i> (Sigma Xi) <b>76</b> (4): 380–388. Retrieved 2009-06-06.  <a href="http://eebweb.arizona.edu/Courses/Ecol485_585/Readings/Marshal_1988.pdf">http://eebweb.arizona.edu/Courses/Ecol485_585/Readings/Marshal_1988.pdf</a></p> <p><b>Article</b> - The Great American Interchange – good references  <a href="http://en.wikipedia.org/wiki/Great_American_Interchange">http://en.wikipedia.org/wiki/Great_American_Interchange</a></p>
Conservation	Archaeology	Describe Calakmul at the height of the Mayan empire	<p><b>Article</b> – Exploring the Calakmul Biosphere Reserve - <a href="http://www.planeta.com/ecotravel/mexico/yucatan/calakmul.html">http://www.planeta.com/ecotravel/mexico/yucatan/calakmul.html</a></p> <p><b>Article</b> – The Lowland Maya site of Calakmul <a href="http://anth507.tripod.com/">http://anth507.tripod.com/</a></p> <p><b>Article</b> – Lots of useful references at the bottom of the article - <a href="http://en.wikipedia.org/wiki/Calakmul#History">http://en.wikipedia.org/wiki/Calakmul#History</a></p>