The Effects of Polychlorinated Biphenyl Pollution in the Duwamish River on River Otter Reproduction

November 18th, 2012

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Abstract

In this study we propose to examine the effects of the known endocrine-disruptor polychlorinated biphenyl (PCB) on the river otter population in the Duwamish River in Washington State. In doing so, we hope to shed light on the damages that over a century of pollution have brought upon this lotic ecosystem, especially in regards to the reproduction rates of its aquatic inhabitants. To do so, we propose to pick two sites for study—one control where river otter populations are not exposed to PCBs and the site at the Duwamish. At each site we would capture and tag five grown otters and five otter pups with GPS tracking devices. This would allow us to follow their development and reproductive success over the two years of the study. We would intermittently recapture them to run blood tests, study their sex organs, and take samples of their gametes. This would occur every six months. In the interim we would observe their mating habits, including how many times they were having sex compared to how many times they were able to conceive, when they are giving birth, how many live births compared to stillbirths, and the general success of live offspring. We expect that due to the endocrine disruptor properties of polychlorinated biphenyls, the river otter population in the Duwamish will be significantly smaller and less able to successfully reproduce when compared to that of our control site. Because the river otters are at the top of the food chain, we expect that the effects of PCBs will be most noticeable in them due to biomagnification. Even so, they undoubtedly are affecting aquatic populations in ways we cannot yet quantify. The more we know, the closer we will be to the remediation of the Duwamish River.

Introduction

The Lower Duwamish River was declared a Superfund site by the United States Environmental Protection Agency in 2001 (Lower Duwamish Waterway 2012). The site is known to be contaminated with at least 40 chemical pollutants, including heavy metals, arsenic, and PCBs. The contamination has been quite prolonged, with pollutants from industries along the river entering the ecosystem for over 100 years (Lower Duwamish Waterway 2012). As such, toxin concentrations in all trophic levels of the food web have greatly increased—to the point that all aquatic species permanently making their home in the Duwamish River are considered unsafe for human consumption. River otters are perhaps most affected by the pollutants because of their place at the top of the food chain. Biomagnification means the toxins will accumulate in greater concentrations in otters, as they consume organisms already containing high levels of contaminants. We hypothesize that because of biomagnification and because one of the pollutants in highest concentration is polychlorinated biphenyl, a known endocrine disruptor, the river otters of the Duwamish will be less reproductively successful than their counterparts living in waters uncontaminated by PCBs. If we can confirm conclusively that our hypothesis is valid, we would be able to further our understanding of the risks of PCB pollution. This has the potential to lead to the enforcement of stricter regulations and penalties related to industrial aquatic pollution. It also can help push forward remediation efforts by the State of Washington, which would allow for involvement of the surrounding communities with the cleanup and, eventually, increased recreation.

Background:

Wherever there is industry, there will necessarily be some form of pollution or ecological disruption. Aquatic ecosystems are especially vulnerable, as urban and industrial runoff can easily enter into nearby lakes and rivers. This pollution brings with it a host of

problems, which can include loss of biomass and biodiversity, eutrophication, and loss of habitat, to name a few. Even if only one species is affected, the equilibrium of the entire system will be inevitably shifted, as its prey flourishes or predators suffer. Many of the effects of chemical pollution are not readily visible, as an oil spill or waste dumping might be, but they are just as harmful. The Duwamish River in Washington State has seen some of the worst pollution in the nation, placing it on the list of Superfund sites by the United States Environmental Protection Agency (Lower Duwamish Waterway 2012). Among the forty pollutants present in the water is polychlorinated biphenyl—a known endocrine disruptor. Used mainly in electronic equipment, transformers, and motor oil, the commercial production of PCBs has been banned in the United States (Polychlorinated Biphenyls). They take a long time to break down in the environment and are known to accumulate in fish (Polychlorinated Biphenyls). As much as we know about PCBs, their effects on the higher trophic levels of the Duwamish are not well researched. The majority of the studies conducted have been on fish, since they are a more direct possible threat to human health (from eating fish caught in the Duwamish). The most prominent of these studies, entitled "Structural Changes in Gill DNA Reveal the Effects of Contaminants on Puget Sound Fish" was conducted by researchers from the Biochemical Oncology Program of the Pacific Northwest Research Institute in Seattle, Washington (Malins et al.). They found that in comparison to fish caught in a similar, but cleaner, site, those caught in the Duwamish had more abnormalities in their gill DNA (Malins et al.) Although this study was helpful in researching PCB effects, it is representative of the marked dearth of investigation into how biomagnification might play into the contamination of the site and organisms. Thus we propose to pick up where the research has left off and expand further upon the effects the pollution of the Duwamish is having on its aquatic inhabitants.

Study Site Location:

Our project has two study sites. One study site location would be at the lower Duwamish River, which is a five-mile long area in southern Seattle, Washington. Our second study site location is at the Pend Oreille River, a tributary of the Columbia River ("Pend Oreille River Tourism Alliance", 2009).

Proposed Methods and Known Limitations:

Due to biomagnification, we hypothesize that river otters are being affected by Polychlorinated biphenyls (PCBs) in the water, as they consume fish also containing contaminant sediment. We hope to research and quantify how the lower Duwamish River impacts the river otters in the river, before possible mitigation methods can be proposed. The data we need to collect is manifold. First, we will collect data from Pend Oreille River, which is a comparable study site in Washington, which serves as a model for what a river ecosystem without PCBs would look like. The river serves many important roles, providing a home for wildlife, and has historic, natural, and scenic significance. It is also used for recreational use (Pend Oreille River Tourism Alliance, 2009). This will be our control site.

At this site, we will collect data about the river otters that live there, specifically analyzing reproductive rates and overall health of the river otters. We would analyze the reproductive rates by measuring the blood chemistry of the river otters, as well as the characteristics of their sexual organs. We would also tag each river otter studied with a GPS tracker, allowing us to follow up periodically to take new measurements and reassess the health of the river otters. We estimate we will track 5 adult river otters, and 5 pups, or younger river

otters. This will allow us to also observe how river otters grow and reproduce, without influence of PCBs as a contaminant. We will also count the offspring of the 5 adult river otters that we will track over our period of two years.

We would also take the same measurements at the lower Duwamish River. This again would include tagging 5 adult river otters and 5 pups. We would also collect data about their health over the course of two years, analyzing reproductive rates by testing their blood chemistry and characteristics of sexual organs, and observing the growth of the pups. The lower Duwamish River contains PCBs, so by comparing the two similar sites, we will be able to determine the effect of PCBs on the reproductive health of the river otters, as well as observe how PCBs affect the growth of young river otters.

Known limitations include our budget, which will only allow us to study a limited amount of river otters. Another limitation is that we only have two years to complete the study. River otters usually do not reproduce until they are five to seven years old ("OTTERS - Reproduction", 2012). In order to attain the most accurate data, it would be best to study the river otters over the course of their growth as an organism, and over their reproductive lifetime. Furthermore, we have decided to solely test the river otters, and not other aquatic organisms, because river otters are on the top of the food chain, and will accumulate much more of the contaminants by eating other fish that contain them.

Another major limitation is that the Duwamish River is contains high concentrations of over 40 contaminants, and other than PCBs, the most prominent are arsenic, dioxins, and carcinogenic polycyclic aromatic hydrocarbons ("How will the Duwamish cleanup affect neighbors health?", 2012). It might be that there are other contaminants that are affecting the growth and reproductive health of the river otters. However, because it would be too costly to

test for the effects of over 40 different contaminants, we have decided to focus on one of the most prominent contaminants, PCBs.

Another known limitation is that it is difficult to find a healthy river in Washington to compare the lower Duwamish River to. Most rivers in Washington contain PCBs, as well as other pollutants. We were able to locate three rivers with no PCBs, but two of them contain Mercury, including the Pend Oreille River, our control river, and one contains DDT ("Fish Consumption Advisories", 2012). Thus, we had to choose from the three least polluted rivers, and choose the river that is most comparable in size and wildlife to the Duwamish River. We hope that the mercury found in the Pend Oreille River will not significantly impact the results of our control site. Our study is necessary in order to determine how much of an effect the PCBs have on the river otters, and if the effect is severe enough to justify future mitigation methods.

Anticipated Results:

PCBs have been found to be endocrine disruptors. For instance, PCBs were found to affect the reproductive health of female mice in the study "PCBs are Endocrine Disruptors: Mixture Affects Reproductive Development in Female Mice" (McGovern, 2006). The study found that female mice exposed to PCBs had changes in uterine development, such as less uterine glands, and a changed thickness in the myometrium, which is the uterus's muscular layer. The study also noted that gene variation could allow for some individuals to be more susceptible to the effects of PCB exposure.

We anticipate that our results will reflect that PCBs have a significant impact on the growth and reproductive health of river otters in the lower Duwamish River. We believe it might cause the lack of growth and development of the sexual organs of the river otters. We further

believe this would impact the size of the population of river otters in the lower Duwamish River, and the amount of pups being produced on average. PCBs are known to cause miscarriages, birth defects, and cancers affecting sexual organs ("Endocrine Disruptors", 2012).

If we find that the PCBs are affecting the growth of young river otters, as well as the reproductive health of the river otters, we will be able to propose possible mitigation methods. This would allow for the reproductive health and growth rates of river otters in the lower Duwamish River to be restored.

Broader Impact:

This study will benefit society as a whole by hopefully leading to increased remediation efforts, which would improve the quality of water for the recreational purposes of surrounding communities. The improvement in the water quality would lead to an increase in use not only in communities next to the river but also by other citizens of Washington. This influx of people from surrounding communities will boost the local economy by bringing in new business to a historically low-income area. Scientifically, the study will be beneficial because the pollution in the Duwamish River has been generally studied on organisms of lower trophic levels because they are more likely to be consumed by humans. Because of this, the effects of bioaccumulation have previously not been taken into account. Our study would both highlight the demonstrable increases in toxin concentration at the top of the food chain, as well as the effects of endocrine disrupters on river otters. Because the river otter is the greatest predator in the river, and if in fact the river otter population is affected by the contamination, it will prove to also have a sizable effect on the populations of its prey. Without as many predators it is possible

that there could be a population increase in its smaller prey. The study could also potentially benefit society as a whole because if it inspires remediation efforts then the health of the people surrounded by the Duwamish could improve substantially.

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Time:

Initially, we will find the ten river otters that we are going to be testing throughout the experiment and we place trackers on them. Then every week we choose one river otter to observe and test its mating habits. At the end of 6 months we collect samples from all ten otters. Every 6 months we will spend two weeks observing each river otter individually. This process will continue until we reach the two year mark. At the end of the two years each river otter will have been observed for 8 weeks and tested 5 times.

Week 1: Initial testing of all 10 otters

Week 2-22: Rotating observation of otters

Week 23: Second round of testing

Week 24-26: Lab testing and data recording/analysis

Week 27-47: Rotating observation

Week 48: Third round of testing

Week 49-51: Lab testing and data recording/analysis

Week 52: Break

Week 53-73: Rotating observation

Week 74: Fourth round of testing

Week 75-77: Lab testing and data recording/analysis

Week 78-98: Rotating observation

Week 99: Final tests of otters

Week 100-104: Finalization of results and report

Budget:

10 GPS-GPRS device, materials assembling labor: $10,000

A boat: $10,000

Unpaid College Interns: Earn College Credit

Researchers: $4,000

Box of Latex Gloves: $10

3 Lab coats: $60

6 pairs of Safety Goggles: $90

Gas for the boat: $1,500

Gas for the car: $1,500

10 Leg hold traps: $80

Telazol for anesthesia (9 mg/kg): $250

Blow gun for administering anesthesia: $5

Holding box: $30

10 PIT (Passive integrated transponder) tags: $30

Examination dental development to determine age: $0 ← How is this done?

Microscope: $400

ANOVA and posthoc Scheffe test used to determine influences of region, age, class and season on mean litter size: $0 ← explain the test

Testing of significance between the number of embryos and the number of following cubs per mother calculated by statistical Mann-Whitney U-test: $0 ← explain

Small sample of fat taken to analyze for chlorinated hydrocarbons by gas chromatography: $1,500

✓ Examination of each otter by a veterinarian for signs of preexisting health problems or injuries: $800

Hematology machine for analyzing blood samples: $20,000

Hormone metabolites extracted from fecal samples of otters: $100

Total Spent: $50,255

Will you need more GPS devices for the offspring or do they stay near the other parents during their first two years?

How will you know of their being a rescourge for instance?

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Great title!

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Abstract

In this study we propose to examine the effects of a known endocrine-disruptor, polychlorinated biphenyl (PCB's), on the river otter population in the Duwamish River in Washington State. In doing so, we hope to shed light on the damages that over a century of pollution have brought upon this lotic? ecosystem, especially in regards to the reproduction rates of its aquatic inhabitants. To do so, we propose to pick two sites for study—one control where river otter populations are not exposed to PCBs and the site at the Duwamish. At each site we would capture and tag five grown otters and five otter pups with GPS tracking devices. This would allow us to follow their development and reproductive success over the two years of the study. We would intermittently recapture them to run blood tests, study their sex organs, and take samples of their gametes. This would occur every six months. In the interim we would observe their mating habits, including how many times they were having sex compared to how many times they were able to conceive, when they are giving birth, how many live births compared to stillbirths, and the general success of live offspring. We expect that due to the endocrine disruptor properties of polychlorinated biphenyls, the river otter population in the Duwamish will be significantly smaller and less able to successfully reproduce when compared to that of our control site. Because the river otters are at the top of the food chain, we expect that the effects of PCBs will be most noticeable in them due to biomagnification. Even so, they undoubtedly are affecting aquatic populations in ways we cannot yet quantify. The more we know, the closer we will be to the remediation of the Duwamish River.

single space Abstract

do the two sites both have the same species of river otters?

is this possible?

how will you observe this? do mating habits vary on time of day

how are the populations currently?

Introduction

The Lower Duwamish River was declared a Superfund site by the United States Environmental Protection Agency in 2001 (Lower Duwamish Waterway 2012). The site is known to be contaminated with at least 40 chemical pollutants, including heavy metals, arsenic, and PCBs. The contamination has been quite prolonged, with pollutants from industries along the river entering the ecosystem for over 100 years (Lower Duwamish Waterway 2012). As such, toxin concentrations in all trophic levels of the food web have greatly increased—to the point that all aquatic species permanently making their home in the Duwamish River are considered unsafe for human consumption! River otters are perhaps most affected by the pollutants because of their place at the top of the food chain. Biomagnification means the toxins will accumulate in greater concentrations in otters, as they consume organisms already containing high levels of contaminants. We hypothesize that because of biomagnification and because one of the pollutants in highest concentration is polychlorinated biphenyl, a known endocrine disruptor, the river otters of the Duwamish will be less reproductively successful than their counterparts living in waters uncontaminated by PCBs. If we can confirm conclusively that our hypothesis is valid, we would be able to further our understanding of the risks of PCB pollution. This has the potential to lead to the enforcement of stricter regulations and penalties related to industrial aquatic pollution. It also can help push forward remediation efforts by the State of Washington, which would allow for involvement of the surrounding communities with the cleanup and, eventually, increased recreation.??

citation

citation - what concentration?

how will you control for the other contaminants? is this possible?

significance may relate more to the extinction of the otters and less about increasing recreation.

Background:

Wherever there is industry, there will necessarily be some form of pollution or ecological disruption. Aquatic ecosystems are especially vulnerable, as urban and industrial runoff can easily enter into nearby lakes and rivers. This pollution brings with it a host of

problems, which can include loss of biomass and biodiversity, eutrophication, and loss of habitat, to name a few. Even if only one species is affected, the equilibrium of the entire system will be inevitably shifted, as its prey flourishes or predators suffer. Many of the effects of chemical pollution are not readily visible, as an oil spill or waste dumping might be, but they are just as harmful. The Duwamish River in Washington State has seen some of the worst pollution in the nation, placing it on the list of Superfund sites by the United States Environmental Protection Agency (Lower Duwamish Waterway 2012). Among the forty pollutants present in the water is polychlorinated biphenyl—a known endocrine disruptor. Used mainly in electronic equipment, transformers, and motor oil, the commercial production of PCBs has been banned in the United States (Polychlorinated Biphenyls). They take a long time to break down in the environment and are known to accumulate in fish (Polychlorinated Biphenyls). As much as we know about PCBs, their effects on the higher trophic levels of the Duwamish are not well researched. The majority of the studies conducted have been on fish, since they are a more direct possible threat to human health (from eating fish caught in the Duwamish). The most prominent of these studies, entitled "Structural Changes in Gill DNA Reveal the Effects of Contaminants on Puget Sound Fish" was conducted by researchers from the Biochemical Oncology Program of the Pacific Northwest Research Institute in Seattle, Washington (Malins et al.). They found that in comparison to fish caught in a similar, but cleaner, site, those caught in the Duwamish had more abnormalities in their gill DNA (Malins et al.) Although this study was helpful in researching PCB effects, it is representative of the marked dearth of investigation into how biomagnification might play into the contamination of the site and organisms. Thus we propose to pick up where the research has left off and expand further upon the effects the pollution of the Duwamish is having on its aquatic inhabitants.

This is very similar to the introduction - differentiate and try not to repeat facts in the sections. Avoid redundancy.

Great info - discuss how this relates to the others

Study Site Location: Focus on similarity between locations except for the differing levels of PCB's. Try to find data concerning levels of both in proposed areas.

Our project has two study sites. One study site location would be at the lower Duwamish River, which is a five-mile long area in southern Seattle, Washington. Our second study site location is at the Pend Oreille River, a tributary of the Columbia River ("Pend Oreille River Tourism Alliance", 2009).

Proposed Methods and Known Limitations: Include the testing that will be done to each otter as described in budget!

Due to biomagnification, we hypothesize that river otters are being affected by Polychlorinated biphenyls (PCBs) in the water, as they consume fish also containing contaminant sediment. We hope to research and quantify how the lower Duwamish River impacts the river otters in the river, before possible mitigation methods can be proposed. The data we need to collect is manifold. First, we will collect data from Pend Oreille River, which is a comparable study site in Washington, which serves as a model for what a river ecosystem without PCBs would look like. The river serves many important roles, providing a home for wildlife, and has historic, natural, and scenic significance. It is also used for recreational use (Pend Oreille River Tourism Alliance, 2009). This will be our control site.

At this site, we will collect data about the river otters that live there, specifically analyzing reproductive rates and overall health of the river otters. We would analyze the reproductive rates by measuring the blood chemistry of the river otters, as well as the characteristics of their sexual organs. We would also tag each river otter studied with a GPS tracker, allowing us to follow up periodically to take new measurements and reassess the health of the river otters. We estimate we will track 5 adult river otters, and 5 pups, or younger river

Are you focusing on alterations of sexual organs or number of offspring produced? Maybe try to narrow it down and be more specific. Choose 1 or two areas and test those!

- some repetition in structure, can clean this up a bit!
- Choose constant tense

otters. This will allow us to also observe how river otters grow and reproduce, without influence of PCBs as a contaminant. We will also count the offspring of the 5 adult river otters that we will track over our period of two years.

We would also take the same measurements at the lower Duwamish River. This again would include tagging 5 adult river otters and 5 pups. We would also collect data about their health over the course of two years, analyzing reproductive rates by testing their blood chemistry and characteristics of sexual organs, and observing the growth of the pups. The lower Duwamish River contains PCBs, so by comparing the two similar sites, we will be able to determine the effect of PCBs on the reproductive health of the river otters, as well as observe how PCBs affect the growth of young river otters.

will?

will?

in addition to sexual organs?

Known limitations include our budget, which will only allow us to study a limited amount of river otters. Another limitation is that we only have two years to complete the study. River otters usually do not reproduce until they are five to seven years old ("OTTERS - Reproduction", 2012). In order to attain the most accurate data, it would be best to study the river otters over the course of their growth as an organism, and over their reproductive lifetime. Furthermore, we have decided to solely test the river otters, and not other aquatic organisms, because river otters are on the top of the food chain, and will accumulate much more of the contaminants by eating other fish that contain them.

will otters chosen be all male or female? pups won't reproduce, yeah?

Another major limitation is that the Duwamish River is contains high concentrations of over 40 contaminants, and other than PCBs, the most prominent are arsenic, dioxins, and carcinogenic polycyclic aromatic hydrocarbons ("How will the Duwamish cleanup affect neighbors health?", 2012). It might be that there are other contaminants that are affecting the growth and reproductive health of the river otters. However, because it would be too costly to

Is there anyway to control for this? as to have a definitive claim at conclusion of study.

test for the effects of over 40 different contaminants, we have decided to focus on one of the most prominent contaminants, PCBs.

Another known limitation is that it is difficult to find a healthy river in Washington to compare the lower Duwamish River to. Most rivers in Washington contain PCBs, as well as other pollutants. We were able to locate three rivers with no PCBs, but two of them contain Mercury, including the Pend Oreille River, our control river, and one contains DDT ("Fish Consumption Advisories", 2012). Thus, we had to choose from the three least polluted rivers, and choose the river that is most comparable in size and wildlife to the Duwamish River. We hope that the mercury found in the Pend Oreille River will not significantly impact the results of our control site. Our study is necessary in order to determine how much of an effect the PCBs have on the river otters, and if the effect is severe enough to justify future mitigation methods.

Third variable problem - any way to solve for this?

Anticipated Results:

PCBs have been found to be endocrine disruptors. For instance, PCBs were found to affect the reproductive health of female mice in the study "PCBs are Endocrine Disruptors: Mixture Affects Reproductive Development in Female Mice" (McGovern, 2006). The study found that female mice exposed to PCBs had changes in uterine development, such as less uterine glands, and a changed thickness in the myometrium, which is the uterus's muscular layer. The study also noted that gene variation could allow for some individuals to be more susceptible to the effects of PCB exposure.

Good source! Focus on clarity - it is repetitive as is

We anticipate that our results will reflect that PCBs have a significant impact on the growth and reproductive health of river otters in the lower Duwamish River. We believe it might cause the lack of growth and development of the sexual organs of the river otters. We further

believe this would impact the size of the population of river otters in the lower Duwamish River, and the amount of pups being produced on average. PCBs are known to cause miscarriages, birth defects, and cancers affecting sexual organs ("Endocrine Disruptors", 2012).

If we find that the PCBs are affecting the growth of young river otters, as well as the reproductive health of the river otters, we will be able to propose possible mitigation methods. This would allow for the reproductive health and growth rates of river otters in the lower Duwamish River to be restored.

Broader Impact:

This study will benefit society as a whole by hopefully leading to increased remediation efforts, which would improve the quality of water for the recreational purposes of surrounding communities. The improvement in the water quality would lead to an increase in use not only in communities next to the river but also by other citizens of Washington. This influx of people from surrounding communities will boost the local economy by bringing in new business to a historically low-income area. Scientifically, the study will be beneficial because the pollution in the Duwamish River has been generally studied on organisms of lower trophic levels because they are more likely to be consumed by humans. Because of this, the effects of bioaccumulation have previously not been taken into account. Our study would both highlight the demonstrable increases in toxin concentration at the top of the food chain, as well as the effects of endocrine disrupters on river otters. Because the river otter is the greatest predator in the river, and if in fact the river otter population is affected by the contamination, it will prove to also have a sizable effect on the populations of its prey. Without as many predators it is possible

?? probably not implication of study

Fauna on otters health and possible threat of there extinction caused by PCB and loss on local economy.

that there could be a population increase in its smaller prey. The study could also potentially benefit society as a whole because if it inspires remediation efforts then the health of the people surrounded by the Duwamish could improve substantially.

References: Site academic sources only! Probably don't need the sources about budgetary costs - just include in the budget!

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was this in paper?

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Time:

Initially, we will find the ten river otters that we are going to be testing throughout the experiment and we place trackers on them. Then every week we choose one river otter to observe and test its mating habits. At the end of 6 months we collect samples from all ten otters. Every 6 months we will spend two weeks observing each river otter individually. This process will continue until we reach the two year mark. At the end of the two years each river otter will have been observed for 8 weeks and tested 5 times.

Week 1: Initial testing of all 10 otters

Week 2-22: Rotating observation of otters

Week 23: Second round of testing

Week 24-26: Lab testing and data recording/analysis

Week 27-47: Rotating observation

Week 48: Third round of testing

Week 49-51: Lab testing and data recording/analysis

Week 52: Break

Week 53-73: Rotating observation

Week 74: Fourth round of testing

Week 75-77: Lab testing and data recording/analysis

Week 78-98: Rotating observation

Week 99: Final tests of otters

Week 100-104: Finalization of results and report

Budget:

10 GPS-GPRS device, materials assembling labor: $10,000

A boat: $10,000

Unpaid College Interns: Earn College Credit

Researchers: $4,000

Box of Latex Gloves: $10

3 Lab coats: $60

6 pairs of Safety Goggles: $90

Gas for the boat: $1,500

Gas for the car: $1,500

10 Leg hold traps: $80

Telazol for anesthesia (9 mg/kg): $250

Blow gun for administering anesthesia: $5

Holding box: $30

10 PIT (Passive integrated transponder) tags: $30

Examination dental development to determine age: $0] Talk about this in procedures. Probably doesn't need to be included in budget because it is $0

Microscope: $400 (citation)

ANOVA and posthoc Scheffe test used to determine influences of region, age, class and season on mean litter size: $0

Testing of significance between the number of embryos and the number of following cubs per mother calculated by statistical Mann-Whitney U-test: $0

Small sample of fat taken to analyze for chlorinated hydrocarbons by gas chromatography: $1,500

Examination of each otter by a veterinarian for signs of preexisting health problems or injuries: $800

Hematology machine for analyzing blood samples: $20,000

Hormone metabolites extracted from fecal samples of otters: $100

These are all great ideas - they should be more adequately addressed in procedures!

Total Spent: $50,255

May be a good idea to set up budget like this:

Unit	Purpose	Cost
GPS/GPRS device	Track the 10 otters	$1,000 x 10 = $10,000
...	...	...
...	...	...
...	...	...
...	...	...
...	...	...
		Total = $50,255

The Effects of Polychlorinated Biphenyl Pollution in the Duwamish River on River Otter Reproduction

November 18th, 2012

7

The Effects of Polychlorinated Biphenyl Pollution in the Duwamish River on River Otter Reproduction

Abstract

In this study we propose to examine the effects of the known endocrine-disruptor polychlorinated biphenyl on the river otter population in the Duwamish River in Washington State. In doing so, we hope to shed light on the damages that over a century of pollution have brought upon this lotic ecosystem, especially in regards to the reproduction rates of its aquatic inhabitants. To do so, we propose to pick two sites for study—one control where river otter populations are not exposed to PCBs and the site at the Duwamish. At each site we would capture and tag five grown otters and five otter pups with GPS tracking devices. This would allow us to follow their development and reproductive success over the two years of the study. We would intermittently recapture them to run blood tests, study their sex organs, and take samples of their gametes. This would occur every six months. In the interim we would observe their mating habits, including how many times they were having sex compared to how many times they were able to conceive, when they are giving birth, how many live births compared to stillbirths, and the general success of live offspring. We expect that due to the endocrine disruptor properties of polychlorinated biphenyls, the river otter population in the Duwamish will be significantly smaller and less able to successfully reproduce when compared to that of our control site. Because the river otters are at the top of the food chain, we expect that the effects of PCBs will be most noticeable in them due to biomagnification. Even so, they undoubtedly are affecting aquatic populations in ways we cannot yet quantify. The more we know, the closer we will be to the remediation of the Duwamish River.

Introduction

The Lower Duwamish River was declared a Superfund site by the United States Environmental Protection Agency in 2001 (Lower Duwamish Waterway 2012). The site is known to be contaminated with at least 40 chemical pollutants, including heavy metals, arsenic, and PCBs. The contamination has been quite prolonged, with pollutants from industries along the river entering the ecosystem for over 100 years (Lower Duwamish Waterway 2012). As such, toxin concentrations in all trophic levels of the food web have greatly increased—to the point that all aquatic species permanently making their home in the Duwamish River are considered unsafe for human consumption. River otters are perhaps most affected by the pollutants because of their place at the top of the food chain. Biomagnification means the toxins will accumulate in greater concentrations in otters, as they consume organisms already containing high levels of contaminants. We hypothesize that because of biomagnification and because one of the pollutants in highest concentration is polychlorinated biphenyl, a known endocrine disruptor, the river otters of the Duwamish will be less reproductively successful than their counterparts living in waters uncontaminated by PCBs. If we can confirm conclusively that our hypothesis is valid, we would be able to further our understanding of the risks of PCB pollution. This has the potential to lead to the enforcement of stricter regulations and penalties related to industrial aquatic pollution. It also can help push forward remediation efforts by the State of Washington, which would allow for involvement of the surrounding communities with the cleanup and, eventually, increased recreation.

Background:

Wherever there is industry, there will necessarily be some form of pollution or ecological disruption. Aquatic ecosystems are especially vulnerable, as urban and industrial runoff can easily enter into nearby lakes and rivers. This pollution brings with it a host of

problems, which can include loss of biomass and biodiversity, eutrophication, and loss of habitat, to name a few. Even if only one species is affected, the equilibrium of the entire system will be inevitably shifted, as its prey flourishes or predators suffer. Many of the effects of chemical pollution are not readily visible, as an oil spill or waste dumping might be, but they are just as harmful. The Duwamish River in Washington State has seen some of the worst pollution in the nation, placing it on the list of Superfund sites by the United States Environmental Protection Agency (Lower Duwamish Waterway 2012). Among the forty pollutants present in the water is polychlorinated biphenyl—a known endocrine disruptor. Used mainly in electronic equipment, transformers, and motor oil, the commercial production of PCBs has been banned in the United States (Polychlorinated Biphenyls). They take a long time to break down in the environment and are known to accumulate in fish (Polychlorinated Biphenyls). As much as we know about PCBs, their effects on the higher trophic levels of the Duwamish are not well researched. The majority of the studies conducted have been on fish, since they are a more direct possible threat to human health (from eating fish caught in the Duwamish). The most prominent of these studies, entitled "Structural Changes in Gill DNA Reveal the Effects of Contaminants on Puget Sound Fish" was conducted by researchers from the Biochemical Oncology Program of the Pacific Northwest Research Institute in Seattle, Washington (Malins et al). They found that in comparison to fish caught in a similar, but cleaner, site, those caught in the Duwamish had more abnormalities in their gill DNA (Malins et al). Although this study was helpful in researching PCB effects, it is representative of the marked dearth of investigation into how biomagnification might play into the contamination of the site and organisms. Thus we propose to pick up where the research has left off and expand further upon the effects the pollution of the Duwamish is having on its aquatic inhabitants.

how?

cite some studies that show these effects

again, cite a study that shows this

such as?

cite

cite these (some of) studies here!

cannot mention facts of studies without citing them

don't cite titles like this! author and year such as "A study by Smith (2012) found..."

always cite year!!

year

Study Site Location:

Our project has two study sites. One study site location would be at the lower Duwamish River, which is a five-mile long area in southern Seattle, Washington. Our second study site location is at the Pend Oreille River, a tributary of the Columbia River ("Pend Oreille River Tourism Alliance", 2009). ↑ mention this in abstract too

Proposed Methods and Known Limitations:

Due to biomagnification, we hypothesize that river otters are being affected by Polychlorinated biphenyls (PCBs) in the water, as they consume fish also containing contaminant sediment. We hope to research and quantify how the lower Duwamish River impacts the river otters in the river, before possible mitigation methods can be proposed. The data we need to collect is manifold. First, we will collect data from Pend Oreille River, which is a comparable study site in Washington, which serves as a model for what a river ecosystem without PCBs would look like. The river serves many important roles, providing a home for wildlife, and has historic, natural, and scenic significance. It is also used for recreational use (Pend Oreille River Tourism Alliance, 2009). This will be our control site.

hypothesis should be declarative statement, such as "PCBs cause ____ and ____ problems in otters"

contaminated

repetetive

like what?

At this site, we will collect data about the river otters that live there, specifically analyzing reproductive rates and overall health of the river otters. We would analyze the reproductive rates by measuring the blood chemistry of the river otters, as well as the characteristics of their sexual organs. We would also tag each river otter studied with a GPS tracker, allowing us to follow up periodically to take new measurements and reassess the health of the river otters. We estimate we will track 5 adult river otters, and 5 pups, or younger river

how does this tell you reproductive rates? describe, cite.

is it possible to tag otters? has this been done before? cite a study

otters. This will allow us to also observe how river otters grow and reproduce, without influence of PCBs as a contaminant. We will also count the offspring of the 5 adult river otters that we will track over our period of two years. ← how often would you check up on the otters? more detail!

We would also take the same measurements at the lower Duwamish River. This again would include tagging 5 adult river otters and 5 pups. We would also collect data about their health over the course of two years, analyzing reproductive rates by testing their blood chemistry and characteristics of sexual organs, and observing the growth of the pups. The lower Duwamish River contains PCBs, so by comparing the two similar sites, we will be able to determine the effect of PCBs on the reproductive health of the river otters, as well as observe how PCBs affect the growth of young river otters.

but also other contaminants → how do you know observed effects are caused only by PCBs?

Known limitations include our budget, which will only allow us to study a limited amount of river otters. Another limitation is that we only have two years to complete the study. River otters usually do not reproduce until they are five to seven years old ("OTTERS - Reproduction", 2012). In order to attain the most accurate data, it would be best to study the river otters over the course of their growth as an organism, and over their reproductive lifetime. ← MAJOR limitation! Furthermore, we have decided to solely test the river otters, and not other aquatic organisms, because river otters are on the top of the food chain, and will accumulate much more of the contaminants by eating other fish that contain them.

Another major limitation is that the Duwamish River is contains high concentrations of over 40 contaminants, and other than PCBs, the most prominent are arsenic, dioxins, and carcinogenic polycyclic aromatic hydrocarbons ("How will the Duwamish cleanup affect neighbors health?", 2012). It might be that there are other contaminants that are affecting the growth and reproductive health of the river otters. However, because it would be too costly to

author + year

yes! also MAJOR limitation

test for the effects of over 40 different contaminants, we have decided to focus on one of the most prominent contaminants, PCBs.

but how can you possibly conclude the effects you see are due to PCBs only, or at all?

Another known limitation is that it is difficult to find a healthy river in Washington to compare the lower Duwamish River to. Most rivers in Washington contain PCBs, as well as other pollutants. We were able to locate three rivers with no PCBs, but two of them contain Mercury, including the Pend Oreille River, our control river, and one contains DDT ("Fish Consumption Advisories", 2012). Thus, we had to choose from the three least polluted rivers, and choose the river that is most comparable in size and wildlife to the Duwamish River. We hope that the mercury found in the Pend Oreille River will not significantly impact the results of our control site. Our study is necessary in order to determine how much of an effect the PCBs have on the river otters, and if the effect is severe enough to justify future mitigation methods.

cite

- would almost be better to find river that contain similar levels of all other pollutants PCBs, then could say results most likely due to PCBs

Except

Anticipated Results:

cite this!

PCBs have been found to be endocrine disruptors. For instance, PCBs were found to affect the reproductive health of female mice in the study "PCBs are Endocrine Disruptors: Mixture Affects Reproductive Development in Female Mice" (McGovern, 2006). The study found that female mice exposed to PCBs had changes in uterine development, such as less uterine glands, and a changed thickness in the myometrium, which is the uterus's muscular layer. The study also noted that gene variation could allow for some individuals to be more susceptible to the effects of PCB exposure.

don't cite titles! "in a study by McGovern (2006).

We anticipate that our results will reflect that PCBs have a significant impact on the growth and reproductive health of river otters in the lower Duwamish River. We believe it might cause the lack of growth and development of the sexual organs of the river otters. We further

don't use such unsure language. Plain statements best

believe this would impact the size of the population of river otters in the lower Duwamish River, and the amount of pups being produced on average. PCBs are known to cause miscarriages, birth defects, and cancers affecting sexual organs ("Endocrine Disruptors", 2012).

If we find that the PCBs are affecting the growth of young river otters, as well as the reproductive health of the river otters, we will be able to propose possible mitigation methods. This would allow for the reproductive health and growth rates of river otters in the lower Duwamish River to be restored.

Broader Impact:

This study will benefit society as a whole by hopefully leading to increased remediation efforts, which would improve the quality of water for the recreational purposes of surrounding communities. The improvement in the water quality would lead to an increase in use not only in communities next to the river but also by other citizens of Washington. This influx of people from surrounding communities will boost the local economy by bringing in new business to a historically low-income area. Scientifically, the study will be beneficial because the pollution in the Duwamish River has been generally studied on organisms of lower trophic levels because they are more likely to be consumed by humans. Because of this, the effects of bioaccumulation have previously not been taken into account. Our study would both highlight the demonstrable increases in toxin concentration at the top of the food chain, as well as the effects of endocrine disrupters on river otters. Because the river otter is the greatest predator in the river, and if in fact the river otter population is affected by the contamination, it will prove to also have a sizable effect on the populations of its prey. Without as many predators it is possible

what about ecological benefits of remediation?

many fish aren't in low trophic levels... can be in high trophic levels too.

they probably have, just not extensively, you can't really claim this.

how will it "prove" this?

that there could be a population increase in its smaller prey. The study could also potentially benefit society as a whole because if it inspires remediation efforts then the health of the people surrounded by the Duwamish could improve substantially.

References:

*make sure ALL are cited within body of the paper!

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Is this equipment you will be using? ⇒ don't need to cite it

no links in references lists

cite journal, not JSTOR! JSTOR did not publish it.

↑ publishing date? author?

↑ date retrived. Possible author?

↑ year here

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author! also make sure this is a legitimate source

legitimate source? author?

author, date accessed

This is a perfect citation

year published, author?

don't cite equipment!

from http://www.porta-us.com/pages/activities/watertrails.asp

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Week 49-51: Lab testing and data recording/analysis

Week 52: Break → why?

Week 53-73: Rotating observation

Week 74: Fourth round of testing

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Week 78-98: Rotating observation

Week 99: Final tests of otters

Week 100-104: Finalization of results and report

Budget:

10 GPS-GPRS device, materials assembling labor: $10,000

A boat: $10,000 ← what type?

Unpaid College Interns: Earn College Credit ← undergrads?

Researchers: $4,000 ← for what? $4,000 total? grad students? that's very little!

Box of Latex Gloves: $10

3 Lab coats: $60

6 pairs of Safety Goggles: $90

Gas for the boat: $1,500

Gas for the car: $1,500

10 Leg hold traps: $80

Telazol for anesthesia (9 mg/kg): $250

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Holding box: $30

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Microscope: $400

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don't need to cite in budget if it doesn't cost $

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Examination of each otter by a veterinarian for signs of preexisting health problems or injuries: $800

Hematology machine for analyzing blood samples: $20,000

Hormone metabolites extracted from fecal samples of otters: $100

Total ~~Spent~~: $50,255
budget