James Taylor

Assignment 1

University of Maryland University College

DATA610-9040 Summer 2019

Dr. Saleeb

james.taylor.ps3@gmail.com

Introduction

The purpose of this assignment was to properly frame an operational decision. I wanted to have a decision scenario where I have experience and can speak with some authority. I settled on deciding if I should take clients on a guided sport-fishing excursion given the numerous factors at the given time, maximizing for the best fishing conditions. I have been involved in some small guiding outfits and am an avid angler. While it is a yes or no question, there are subsidiary decisions and evaluations that build up to a culminating judgement, to bring clients out or reschedule.

To someone unfamiliar with fishing conditions it may seem like an arbitrary decision. There is in fact a plethora of raw data and knowledge that one should engage with to better predict when the rivers' conditions are best. This includes analyzing data from river gages, looking for trends and peak in the height of the river, water temperature fluctuations given recent rainfall, models trained to predict the turbidity of the water by historical data and expertise in how barometric pressure effects feeding activity. Deciding when to take clients fishing during the best conditions requires framing all of these, and more, into a clear process. This would be a judgment that is made anytime a client has an opportunity to go.

Identify Decisions

The main decision is if the guide should reschedule to take a client on a guided fishing trip a later date. In this scenario, the client has requested a guided service from me at a certain date and time. When that day comes, the river conditions may not be conducive for good fishing. If the conditions are bad, I would decide to reschedule. If they are good, I may take them or I may reschedule until conditions are even better. If the guide doesn't reschedule during bad river conditions, people won't be interested in paying for a guided service because many of the

previous clients had a bad experience. It's an important decision my fellow guides and I have to make frequently for the business. Therefore, a structured way of coming to that decision is valuable.

Coming to that decision starts from taking in the raw inputs. The majority of the external information examined is to make two subsidiary decisions to the main one: the general fishing conditions and the current river conditions. These are separate determinations, one is for the likelihood of fish-feeding activity, and the other, on the quality of the river being conducive for fishing. The best opportunities for a guided trip occur when both are favorable.

The general fishing conditions are determined by the broader environmental conditions. For this model these are barometric pressure, lighting conditions and water temperature. All of these influence fish-feeding activity for different reasons, detailed in the appendix. As an example, barometric pressure impact fish's buoyance organ. As fish rush up from the bottom to strike prey, the additional pressure from the barometric pressure adds stress on the buoyance regulation system (ANGLR, n.d.). Warm water temperatures are associated with low oxygen content in the water, making physically strenuous activity less attractive (United States Geological Survey, n.d.). This additional discomfort makes them less likely to chase prey. Someone with fish-feeding experience should compile these three factors. They would interpret the totality of what these are showing and how that maps onto the conditions fish like to hunt in.

The current river conditions determination decision is derived from three data sources and an analytical model. The United States Geological Survey (USGS) studies land and water science in the US and their river gages update every 15 minutes, collecting many different scientific measurements. The majority of gages have only river height, but this can reveal much about the conditions of the river. Looking at two upstream gages gives a picture of what the river

is doing. If the gage height is climbing, that indicates fishing conditions are getting worse because it is becoming more turbulent, making the water murky and bad for fishing. A decreasing river indicates better conditions as less particles are suspended in the water from the uproar. The rate of the decreases also indicates the best conditions are approaching. If the gages are not showing rapid decrease in river height, this indicates the river is near to its equilibrium height, meaning the conditions will likely not improve much more than they are. This is a factor in the analytical model as well.

The analytical model I would create would attempt to predict the current turbidity from the upstream gage height and discharge data from the gages. Turbidity is the scientific measurement for how clear a liquid is (Minnesota Pollution Control Agency, 2008). This model would likely take the form of a multivariate regression or some neural network. I would use the historical data from the USGS gages, the upstream gage heights are the independent variables and the turbidity measurement from a gage that collects it as the dependent. The data is structured and minimal cleaning would be required.

Once the river and fish-feeding conditions are determined, the main decision can be addressed. There are a few additional pieces that are considered. The first is the customers preference for weather. They may not want to fish during overcast or in cool temperatures. We should help deliver the customer the experience they want. The other is the customers' impressions. Different customers will have different standards. Some will have high standards for what constitutes good fishing conditions. Even if our model says the current conditions are good, customers may complain if it doesn't meet their expectations. We should be cognizant of this.

The mistake this process will mainly prevent is making wrong assumptions. A clear sky is generally correlated with high barometric, but a front may be dropping because a weather front is moving into the area. Thinking the lack of rain in the area means conditions should be ok is flawed because that does not reveal anything about the rain that may have occurred a hundred miles up river, which would affect your stretch of water days later. Warm weather does not guarantee warm water temperature. By operating off of information, not assumptions, it would protect the business from embarrassing client testimonies and help to maximize the likelihood of utilizing good fishing conditions.

Insights Gained

This approach to deciding when to reschedule is standardizing one of the most important decision the small-time business makes. Failure to get clients on the water during good conditions dooms our prospects as an outfit. Primarily it will force all the guides and myself to check our assumptions and sufficiently inform ourselves of the real conditions. It will also allow the different guides to align their thought process. Currently guides make their determination on when to bring clients out. We would get a numerical understanding of what good conditions look like for each guide. We would also if guides value some variables over others. For instance, if the past month's data reveals poor water temperature but guides took lots of clients out, that's evidence that water temperature may not have a large influence in deciding. The structured decision making would be helpful in enforcing a policy on when to take clients out. The incentive to take as many clients out as possible is strong, but this has a cost on customer satisfaction.

A foreseeable resistance is that taking in the information is an arduous process. It doesn't all exist in one place and sometimes on weekends there are multiple clients a day, meaning

retrieving all the information multiple times. There is likely a quick technical solution with Python and web-scrapping capabilities.

The most promising aspect of this structure is the ability to validate our model for good fishing conditions. As the decision model is used, we will have a dataset with all the conditions, if clients were taken out and how the fishing was when they went. We will be able validate and tune our model to fit what the data shows correlates with good fishing. We could test the sensitivity of the model to see if we are extracting useful information from the data or if it's really a guessing game. As far as I've looked this has not been done before. This is where the key performance indicators lie. If we can improve the amount of fish we catch currently by implementing this decision structure and refine the decision model by the data we collect using it, it could take the human element out of the decision and be completely automated.

Fishing appears to some like a simple pleasure mainly to pass time or get outside. Research has estimated 38 million people participated in freshwater fishing in 2017 (RBFF & Outdoor Foundation, 2017). Guiding outfits depend on this industry for their livelihood. Bring a scientific approach with decision models and analytical insights could extract information even the acclaimed experts and successful guides don't have. With the amount of pertinent data out there to help us understand fishing, we should leverage it as much as possible.

References

ANGLR Labs, Inc. (n.d.). Science of fishing: fishing barometer and barometric pressure. Retrieved from https://anglr.com/fishing-blog/anglr/science-of-fishing-barometric-pressure/

Recreational Boating & Fishing Foundation, & Outdoor Foundation. (2017). 2017 special report on fishing. Retrieved from https://outdoorindustry.org/wp-content/uploads/2017/05/2017-Special-Report-on-Fishing_final.pdf

United States Geological Survey. (n.d.). Dissolved oxygen and water. Retrieved from https://www.usgs.gov/special-topic/water-science-school/science/dissolved-oxygen-and-water?qt-science_center_objects=0#qt-science_center_objects

Minnesota Pollution Control Agency. (2008). Turbidity: description, impact on water quality, sources, measures. Retrieved from https://www.pca.state.mn.us/sites/default/files/wq-iw3-21.pdf

United States Geological Survey. (2019). USGS 01646500 POTOMAC RIVER NEAR WASH, DC LITTLE FALLS PUMP STA. Retrieved from https://waterdata.usgs.gov/md/nwis/uv?site_no=01646500

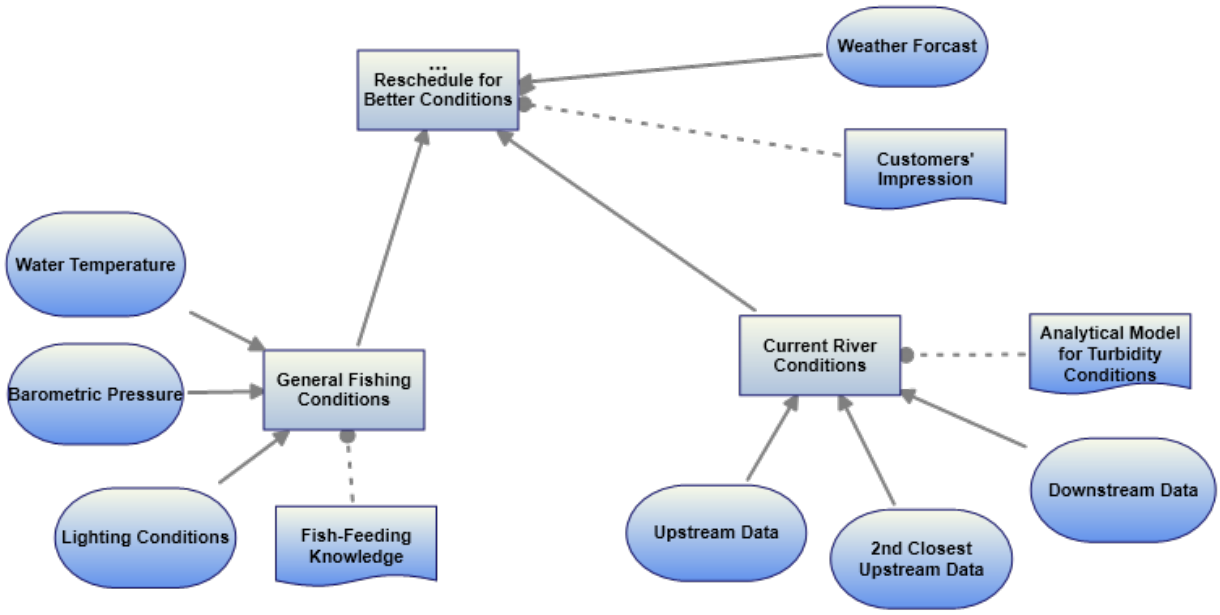
Decision Management Solutions. (n.d.). DecisionsFirst Modeler. Retrieved from http://decisionsfirst.com/

Appendix A

This is the Analytics Requirement Document from the DecisionsFirst Software (Decision Management Solution, n.d.).

Should we take clients fishing?

Decision Requirements Diagram



Nodes		Description
Decision	General Fishing Conditions	Conditions will lie on a spectrum. Some generalizations will have to be made. The expert with Fish-Feeding Knowledge should be making this decision.
Decision	Current River Conditions	The decision here is to make a determination on the current river conditions. It takes in raw data from river gages that have height, discharge and other information, and an analytical model that would help predict the clarity of the water. Again, this should be generalized. The raw data will have numerical values and the point of this decision is to convert them to a descriptive understanding (e.g good, bad, poor, etc.).

Nodes		Description
Decision	Reschedule for Better Conditions	This is the final decision. It is to decide whether to reschedule when to take a client, or take them out fishing. It takes in River Conditions, General Fishing Conditions, Weather Forecast and Customers' Impression Knowledge. These are two subsidiary decisions, one knowledge and one input. The two decisions lay on a spectrum from great to poor and obviously better the conditions means better fishing. The weather forecast is an unstructured, customer preference. If the weather forecast doesn't jive with their expectations it should be rescheduled. The Customers' Impression is like a marketing strategy component. We should not be providing anything less than our best effort in delivering the client a exciting experience. It is essentially begging the question, "even if the conditions are good now, should we wait until they are even better?" Of course, if we have unattainable standards then we won't bring any clients out, so there needs to be some discretion.

Data Source	Upstream Data	The data source is from a gage run by the United States Geological Survey, a government organization that studies natural resources in the US. In most cases, these gages only have the river height. Some have other information like water temperature and discharge (amount of water flowing per second). In any case, the closest upstream gage should be monitored to see what the conditions will be when you arrive there. The real purpose is to see the conditions/clarity of the river. The higher the more water that is in and flowing correlates to bad sport fishing. It is murky and turbulent. If the river is very high, it may become too dangerous to go out in a boat. In scenarios with low water, it may be impossible to navigate a boat in a river that is too shallow. If its low some spots may become impassable, preventing a boat from getting to prime fishing areas. For example, if there is a sudden increase in the river height upstream, this probably indicates that it rained in the river basin upstream and fishing conditions are likely going to be poor soon. If a river is decreasing in gage height, it indicates the river conditions are improving, but the rate of the decrease indicates how

Nodes		Description
		long ago the river peaked. The peak is considered the worst conditions.
Data Source	2nd Closest Upstream Data	The next closest upstream gage should be monitored for the same purposes the other upstream gages are. It is an attempt to understand the conditions of the river and what the conditions are going to be.
Data Source	Barometric Pressure	Barometric Pressure, or atmospheric pressure, has been shown to influence the feeding activity of fish. Since fish have to regulate their buoyancy in the water, changes in pressure are felt more acutely than land-mammals. The analogy here is pressure changes to fish are similar to migraine headaches. The discomfort pushes fish to deeper water and loss of appetite, which spells bad for fishermen. Many sportfish that fisherman target hunt for food by rushing up from the bottom and striking their food near the surface. The quick change in pressure from this activity puts strain on their buoyancy organ. If buoyancy is already giving a fish discomfort, it is less likely for them to strike, creating even more discomfort for themselves.

Nodes		Description
Data Source	Downstream Data	Downstream data from USGS river gages is used to gather more context on the conditions. It shows what the conditions where in the targeted area you want to fish. From looking at the conditions above and the conditions below, one can infer what the conditions between are. This is where the analytical model helps us.
Data Source	Lighting Conditions	The Bass species tend to feed in less-intense light conditions. This would include dawn, dusk and cloudy weather. Bright light pushes fish to deeper water, creating more difficulty to catch them.
Data Source	Weather Forecast	This is the weather forecast for the time we would potentially have clients on the water. Some clients may be willing to put up with drizzling rain while others may want sunny weather. It's up to the customer. This is separate from river conditions because we would see changing river conditions in the upstream river gages.

Nodes		Description
Data Source	Water Temperature	Water temperature effects the activity level of fish. Since they are cold blooded, it is easier for fish to be active when water temperatures are higher. If the temperature is too high though, their feeding activity drops. Warm water temperatures are correlated to low oxygen levels in the water, which fish need for activity like humans.

Nodes		Description
Know How	Fish-Feeding Knowledge	This knowledge is connecting the water temperature, barometric pressure and lighting conditions data, and understanding of fish-feeding activity based on these exterior markers. In other words, being able to understand if the information correlates to good fishing. As an example, imagine if two input-data nodes are considered satisfactory, but the third is considered poor for fishing. Just how poor does it have to be to negate the other satisfactory input-data nodes? Expertise would be able to decide on these controversial cases. An expert would also know the ranges that are considered acceptable for each input-data node. For example, barometric may be able to stray 15% in either direction from its mean and be satisfactory, but temperature has a different acceptable range. Also, deviation from the mean in one direction may be worse than deviation in the other. For example, 5% below the median temperature may be worse than 5% above the median value. An expert would understand the interactions between the input data and how it all relates to determining the General Fishing Conditions decision.

Nodes		Description
Know How	Analytical Model for Turbidity Conditions	This model is meant to predict the clarity of the water at the area where you want to fish. The inputs to the model are the upstream and downstream data, and the outputs would be clarity of the water. To train this model, I would use a dataset where gage height and discharge are the independent features, and the dependent variable would be a turbidity value from a downstream gage. The turbidity value is a scientific measurement of how clear a liquid is, or how well someone can see through it. The higher the turbidity value, the less clear the liquid is. Particles floating in the water would make the water murky, raising the turbidity. When it rains, sediment is pulled into the river as water runs off the land. These particles remain suspended in the water if the river is flowing well.

Nodes		Description
Know How	Customers' Impression	This knowledge node is to determine what impression does the business want to leave on the clients. We may want to guarantee a particular customer perfect conditions. They may be well connected, and we hope to have them speak favorably of our services. They may live locally and we hope to have them book a guide with us again. This is part of marketing as well. To start a guide business and gain traction as a reputable guide, we probably want our first few clients to have great conditions so your reputation starts off in good standing.

General Fishing Conditions

Operational Decision

Conditions will lie on a spectrum. Some generalizations will have to be made. The expert with Fish-Feeding Knowledge should be making this decision.

Question: What are the general fishing conditions?

Answer Type Value from explicit list
Answers Poor, Below Average, OK, Good, Great
Default Answer:
Supporting Information:

Requirements Network

Requires		Description
Input Data	Barometric Pressure	Barometric Pressure, or atmospheric pressure, has been shown to influence the feeding activity of fish. Since fish have to regulate their buoyancy in the water, changes in pressure are felt more acutely than land-mammals. The analogy here is pressure changes to fish are similar to migraine headaches. The discomfort pushes fish to deeper water and loss of appetite, which spells bad for fishermen. Many sportfish that fisherman target hunt for food by rushing up from the bottom and striking their food near the surface. The quick change in pressure from this activity puts strain on their buoyancy organ. If buoyancy is already giving a fish discomfort, it is less likely for them to strike, creating even more discomfort for themselves.

Requires		Description
Input Data	Lighting Conditions	One is that fish are cold-blooded animals. The colder the water, the more difficult it is for them to make quick movements and strike prey. They want to conserve energy. Warm water also means there are low oxygen levels in the water. Fish need oxygen for activity just like humans, so the less there is the more strenuous it for them to exert themselves to chase prey. There is a preferable range where fishing is best.

Requires		Description
Knowledge Source	Fish-Feeding Knowledge	This knowledge is connecting the water temperature, barometric pressure and lighting conditions data, and understanding of fish-feeding activity based on these exterior markers. In other words, being able to understand if the information correlates to good fishing. As an example, imagine if two input-data nodes are considered satisfactory, but the third is considered poor for fishing. Just how poor does it have to be to negate the other satisfactory input-data nodes? Expertise would be able to decide on these controversial cases. An expert would also know the ranges that are considered acceptable for each input-data node. For example, barometric may be able to stray 15% in either direction from its mean and be satisfactory, but temperature has a different acceptable range. Also, deviation from the mean in one direction may be worse than deviation in the other. For example, 5% below the median temperature may be worse than 5% above the median value. An expert would understand the interactions between the input data and how it all relates to determining the General Fishing Conditions decision.

Requires		Description
Input Data	Water Temperature	Water temperature effects the activity level of fish. Since they are cold blooded, it is easier for fish to be active when water temperatures are higher. If the temperature is too high though, their feeding activity drops. Warm water temperatures are correlated to low oxygen levels in the water, which fish need for activity like humans.

Required by		Description
Decision	Reschedule for Better Conditions	This is to decide whether to reschedule when to take a client. It takes in River Conditions, General Fishing Conditions, Weather Forecast and the Customers' Impression Knowledge node.

Properties

Name	Value	Description
Volume	Medium	
Repeatability	Medium	
Complexity	Medium	
Variability	High	
Measurability	Low	
Time to outcome	Short	
Decision Value Decay		

Current River Conditions

Operational Decision

The decision here is to make a determination on the current river conditions. It takes in raw data from river gages that have height, discharge and other information, and an analytical model that would help predict the clarity of the water. Again, this should be generalized. The raw data will have numerical values and the point of this decision is to convert them to a descriptive understanding (e.g good, bad, poor, etc.).

Question: What are the current river conditions?

Answer Type Value from explicit list

Answers Poor, Below Average, OK, Good, Great

Default Answer:

Supporting Information:

Requires		Description
Input Data	Upstream Data	The data source is from a gage run by the United States Geological Survey, a government organization that studies natural resources in the US. In most cases, these gages only have the river height. Some have other information like water temperature and discharge (amount of water flowing per second). In any case, the closest upstream gage should be monitored to see what the conditions will be when you arrive there. The real purpose is to see the conditions/clarity of the river. The higher the more water that

		is in and flowing correlates to bad sport fishing. It is murky and turbulent. If the river is very high, it may become too dangerous to go out in a boat. In scenarios with low water, it may be impossible to navigate a boat in a river that is too shallow. If its low some spots may become impassable, preventing a boat from getting to prime fishing areas. For example, if there is a sudden increase in the river height upstream, this probably indicates that it rained in the river basin upstream and fishing conditions are likely going to be poor soon. If a river is decreasing in gage height, it indicates the river conditions are improving, but the rate of the decrease indicates how long ago the river peaked. The peak is considered the worst conditions.
Input Data	2nd Closest Upstream Data	The next closest upstream gage should be monitored for the same purposes the other upstream gages are. It is an attempt to understand the conditions of the river and what the conditions are going to be.
Input Data	Downstream Data	Downstream data from USGS river gages is used to gather more context on the conditions. It show what the conditions where in the targeted area you want to fish. From looking at the conditions above and the conditions

		below, one can infer what the conditions between are. This is where the analytical model helps us.
Knowledge Source	Analytical Model for Turbidity Conditions	This model is meant to predict the clarity of the water at the area where you want to fish. The inputs to the model are the upstream and downstream data, and the outputs would be clarity of the water. To train this model, I would use a dataset where gage height and discharge are the independent features, and the dependent variable would be a turbidity value from a downstream gage. The turbidity value is a scientific measurement of how clear a liquid is, or how well someone can see through it. The higher the turbidity value, the less clear the liquid is. Particles floating in the water would make the water murky, raising the turbidity. When it rains, sediment is pulled into the river as water runs off the land. These particles remain suspended in the water if the river is flowing well.

Requirements Network

Required by		Description
Decision	Reschedule for Better Conditions	This is to decide whether to reschedule when to take a client. It takes in River Conditions, General Fishing Conditions, Weather Forecast and the Customers' Impression Knowledge node.

Properties

Name	Value	Description
Variability	High	
Volume	Medium	
Complexity	Medium	
Repeatability	Medium	
Measurability	High	
Time to outcome	Short	
Decision Value Decay		

Reschedule for Better Conditions

Operational Decision

This is the final decision. It is to decide whether to reschedule when to take a client, or take them out fishing. It takes in River Conditions, General Fishing Conditions, Weather Forecast and Customers' Impression Knowledge. These are two subsidiary decisions, one knowledge and one input. The two decisions lay on a spectrum from great to poor and obviously better the conditions means better fishing. The weather forecast is an unstructured, customer preference. If the weather forecast doesn't jive with their expectations it should be rescheduled. The Customers' Impression is like a marketing strategy component. We should not be providing anything less than our best effort in delivering the client a exciting experience. It is essentially begging the question, "even if the conditions are good now, should we wait until they are even better?" Of course if we have unattainable standards then we won't bring any clients out, so there needs to be some discretion.

Question: Should we reschedule or take the clients out?

Answer Type Yes/No
Answers
Default Answer: No
Supporting Information:

Requirements Network

Requires		Description
Decision	General Fishing Conditions	Conditions will lie on a spectrum. Some generalizations will have to be made. The expert with Fish-Feeding Knowledge should be making this decision.
Decision	Current River Conditions	The decision here is to make a determination on the current river conditions. It takes in raw data from river gages that have height, discharge and other information, and an analytical model that would help predict the clarity of the water. Again, this should be generalized. The raw data will have numerical values and the point of this decision is to convert them to a descriptive understanding (e.g good, bad, poor, etc.).
Knowledge Source	Customers' Impression	This knowledge node is to determine what impression does the business want to leave on the clients. We may want to guarantee a particular customer perfect conditions. They may be well connected, and we hope to have them speak favorably of our services. They may live locally and we hope to have them book a guide with us again. This is part of marketing as well. To start a guide business and gain traction as a reputable guide, we probably want our first few clients to have great conditions so your reputation starts off in good standing.

Requires		Description
Input Data	Weather Forecast	This is the weather forcast for the time we would potentially have clients on the water. Some clients may be willing to put up with drizzling rain while others may want sunny weather. It's up to the customer. This is separate from river conditions because we would see changing river conditions in the upstream river gages.

Required by		Description
Decision	Take clients to the river? - Y/N	

Properties

Name	Value	Description
Complexity	High	
Volume	High	
Variability	High	
Repeatability	Medium	
Measurability	Low	
Time to outcome	Short	
Decision Value Decay		

Objectives

Influences Objectives	Impact	Notes
KPI for taking clients out on guided trips		

Upstream Data

External, Structured Input Data

The data source is from a gage run by the United States Geological Survey, a government organization that studies natural resources in the US. In most cases, these gages only have the river height. Some have other information like water temperature and discharge (amount of water flowing per second). In any case, the closest upstream gage should be monitored to see what the conditions will be when you arrive there. The real purpose is to see the conditions/clarity of the river. The higher the more water that is in and flowing correlates to

bad sport fishing. It is murky and turbulent. If the river is very high, it may become too dangerous to go out in a boat. In scenarios with low water, it may be impossible to navigate a boat in a river that is too shallow. If its low some spots may become impassable, preventing a boat from getting to prime fishing areas. For example, if there is a sudden increase in the river height upstream, this probably indicates that it rained in the river basin upstream and fishing conditions are likely going to be poor soon. If a river is decreasing in gage height, it indicates the river conditions are improving, but the rate of the decrease indicates how long ago the river peaked. The peak is considered the worst conditions.

Requirements Network

Required by		Description
Decision	Current River Conditions	The decision here is to make a determination on the current river conditions. It takes in raw data from river gages that have height, discharge and other information, and an analytical model that would help predict the clarity of the water. Again, this should be generalized. The raw data will have numerical values and the point of this decision is to convert them to a descriptive understanding (e.g good, bad, poor, etc.).

2nd Closest Upstream Data

External, Structured Input Data

The next closest upstream gage should be monitored for the same purposes the other upstream gages are. It is an attempt to understand the conditions of the river and what the conditions are going to be.

Requirements Network

Required by		Description
Decision	Current River Conditions	The decision here is to make a determination on the current river conditions. It takes in raw data from river gages that have height, discharge and other information, and an analytical model that would help predict the clarity of the water. Again, this should be generalized. The raw data will have numerical values and the point of this decision is to convert them to a descriptive understanding (e.g good, bad, poor, etc.).

Barometric Pressure

External, Structured Input Data

Barometric Pressure, or atmospheric pressure, has been shown to influence the feeding activity of fish. Since fish have to regulate their buoyancy in the water, changes in pressure are felt more acutely than land-mammals. The analogy here is pressure changes to fish are similar to migraine headaches. The discomfort pushes fish to deeper water and lose of appetite, which spells bad for fishermen. Many sportfish that fisherman target hunt for food by rushing up from the bottom and striking their food near the surface. The quick change in pressure from this activity puts strain on their buoyancy organ. If buoyancy is already giving a fish discomfort, it is less likely for them to strike, creating even more discomfort for themselves.

Requirements Network

Required by		Description
Decision	General Fishing Conditions	Conditions will lie on a spectrum. Some generalizations will have to be made. The expert with Fish-Feeding Knowledge should be making this decision.

Downstream Data

External, Structured Input Data

Downstream data from USGS river gages is used to gather more context on the conditions. It show what the conditions where in the targeted area you want to fish. From looking at the

conditions above and the conditions below, one can infer what the conditions between are. This is where the analytical model helps us.

Requirements Network

Required by		Description
Decision	Current River Conditions	The decision here is to make a determination on the current river conditions. It takes in raw data from river gages that have height, discharge and other information, and an analytical model that would help predict the clarity of the water. Again, this should be generalized. The raw data will have numerical values and the point of this decision is to convert them to a descriptive understanding (e.g good, bad, poor, etc.).

Lighting Conditions

External, Unstructured Input Data

The Bass species tend to feed in less-intense light conditions. This would include dawn, dusk and cloudy weather. Bright light pushes fish to deeper water, creating more difficulty to catch them.

Requirements Network

Required by		Description
Decision	General Fishing Conditions	Conditions will lie on a spectrum. Some generalizations will have to be made. The expert with Fish-Feeding Knowledge should be making this decision.

Weather Forecast

External, Unstructured Input Data

This is the weather forecast for the time we would potentially have clients on the water. Some clients may be willing to put up with drizzling rain while others may want sunny weather. It's up to the customer. This is separate from river conditions because we would see changing river conditions in the upstream river gages.

Requirements Network

Required by		Description
Decision	Reschedule for Better Conditions	This is to decide whether to reschedule when to take a client. It takes in River Conditions, General Fishing Conditions, Weather Forecast and the Customers' Impression Knowledge node.

Water Temperature

External, Structured Input Data

Water temperature effects the activity level of fish. Since they are cold blooded, it is easier for fish to be active when water temperatures are higher. If the temperature is too high though, their feeding activity drops. Warm water temperatures are correlated to low oxygen levels in the water, which fish need for activity like humans.

Requirements Network

Required by		Description
Decision	General Fishing Conditions	Conditions will lie on a spectrum. Some generalizations will have to be made. The expert with Fish-Feeding Knowledge should be making this decision.

Fish-Feeding Knowledge

Know how– Expertise

This knowledge is connecting the water temperature, barometric pressure and lighting conditions data, and understanding of fish-feeding activity based on these exterior markers. In other words, being able to understand if the information correlates to good fishing. As an example, imagine if two input-data nodes are considered satisfactory, but the third is considered poor for fishing. Just how poor does it have to be to negate the other satisfactory input-data nodes? Expertise would be able to decide on these controversial cases. An expert would also know the ranges that are considered acceptable for each input-data node. For example, barometric may be able to stray 15% in either direction from its mean and be satisfactory, but temperature has a different acceptable range. Also, deviation from the mean in one direction may be worse than deviation in the other. For example, 5% below the median temperature may be worse than 5% above the median value. An expert would understand the interactions between the input data and how it all relates to determining the General Fishing Conditions decision.

Requirements Network

Required by		Description
Decision	General Fishing Conditions	Conditions will lie on a spectrum. Some generalizations will have to be made. The expert with Fish-Feeding Knowledge should be making this decision.

Analytical Model for Turbidity Conditions

Know how– Analytic Insight

This model is meant to predict the clarity of the water at the area where you want to fish. The inputs to the model are the upstream and downstream data, and the outputs would be clarity of the water. To train this model, I would use a dataset where gage height and discharge are the independent features, and the dependent variable would be a turbidity value from a downstream gage. The turbidity value is a scientific measurement of how clear a liquid is, or how well someone can see through it. The higher the turbidity value, the less clear the liquid is. Particles floating in the water would make the water murky, raising the turbidity. When it rains, sediment is pulled into the river as water runs off the land. These particles remain suspended in the water if the river is flowing well.

Requirements Network

Required by		Description
Decision	Current River Conditions	The decision here is to make a determination on the current river conditions. It takes in raw data from river gages that have height, discharge and other information, and an analytical model that would help predict the clarity of the water. Again, this should be generalized. The raw data will have numerical values and the point of this decision is to convert them to a descriptive understanding (e.g good, bad, poor, etc.).

Customers' Impression

Know how– Best Practice

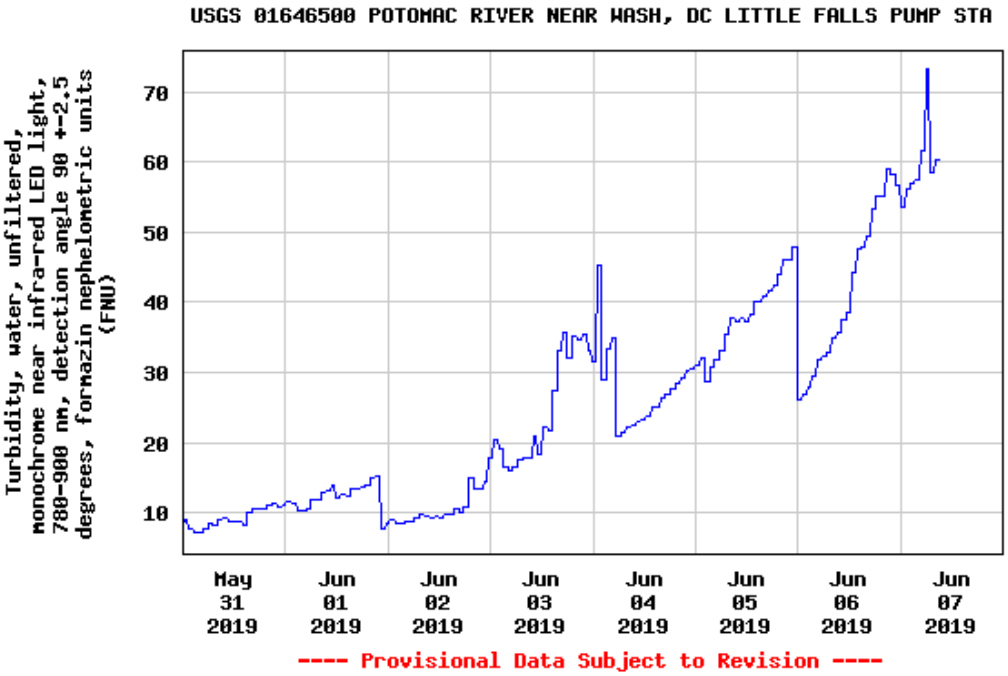
This knowledge node is to determine what impression does the business want to leave on the clients. We may want to guarantee a particular customer perfect conditions. They may be well connected, and we hope to have them speak favorably of our services. They may live locally and we hope to have them book a guide with us again. This is part of marketing as well. To start a guide business and gain traction as a reputable guide, we probably want our first few clients to have great conditions so your reputation starts off in good standing.

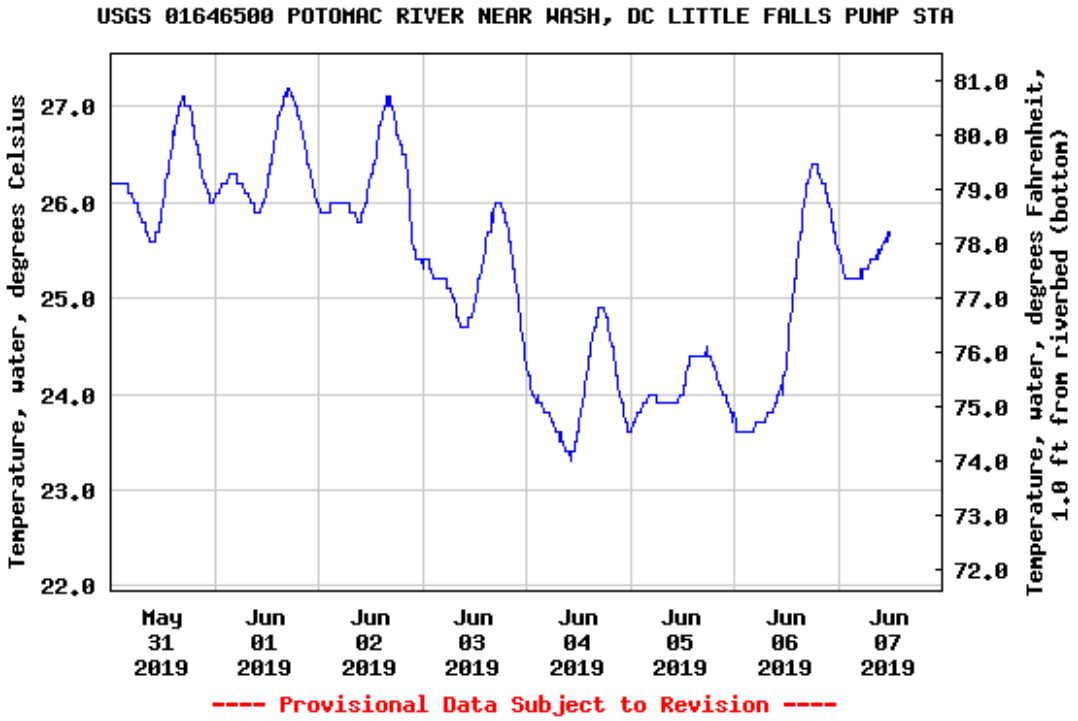
Requirements Network

Required by		Description
Decision	Reschedule for Better Conditions	This is to decide whether to reschedule when to take a client. It takes in River Conditions, General Fishing Conditions, Weather Forecast and the Customers' Impression Knowledge nodes.

Appendix B

Here are a few examples of data retrieved from the United States Geological Survey river gages. These will be used to determine the Current River Conditions (United States Geological Survey, 2019)




USGS 01646500 POTOMAC RIVER NEAR WASH, DC LITTLE FALLS PUMP STA
Temperature, water, degrees Celsius
27.0
26.0
25.0
24.0
23.0
22.0
81.0
80.0
79.0
78.0
77.0
76.0
75.0
74.0
73.0
72.0
Temperature, water, degrees Fahrenheit, 1.0 ft from riverbed (botton)
May 31 2019
Jun 01 2019
Jun 02 2019
Jun 03 2019
Jun 04 2019
Jun 05 2019
Jun 06 2019
Jun 07 2019
---- Provisional Data Subject to Revision ----