Dworshak Reservoir Nutrient Restoration Project Update

April 2013 Clearwater Region

Idaho Fish and Game Program Staff

- **Sean Wilson,**
  Senior Fishery Research Biologist
  sean.wilson@idfg.idaho.gov
  (208) 799-5010
- **Andy Dux,**
  Principal Fishery Research Biologist
  andy.dux@idfg.idaho.gov
  (208) 769-1414
- **Joe DuPont,**
  Regional Fishery Manager
  joe.dupont@idfg.idaho.gov
  (208) 799-5010

Project Partners

- **U.S. Army Corps of Engineers, Walla Walla District**

  Paul Pence
  Natural Resources Manager
  (208) 476-1258
  paul.j.pence@usace.army.mil

  John Bailey
  Fishery Biologist
  (509) 527-7123
  john.c.bailey@usace.army.mil

  Lonnie Mettler
  Chief, Nat. Res. Mngt. Section
  (509) 527-7131
  lonnie.e.mettler@usace.army.mil

- **Advanced Eco-Solutions**
  Darren Brandt,
  President
  (509) 226-0146
  darren.brandt@adveco-sol.com

Daphnia zooplankton

This newsletter is designed to provide information about the Dworshak Reservoir Nutrient Restoration Project. Please take a few minutes to review the information provided. We hope it helps you to better understand the project history, results to date, and our upcoming plans.

If you find this newsletter interesting, share it with others who might be interested. If you have questions or want to share your thoughts, please give us a call or send us an email. Contact information for our program staff are listed on the left margin of this newsletter.

Dworshak Dam blocks access to the North Fork Clearwater River Basin for steelhead and salmon. These fish historically brought important nutrients from the ocean back to the basin.

When did the project start and how long will it last?

The Idaho Department of Fish and Game (IDFG) and U.S. Army Corps of Engineers (Corps) have partnered to test whether nutrient restoration can work to benefit fishing and other recreational use on Dworshak Reservoir. A pilot project began in 2007 to evaluate this management strategy because of the potential benefits to the ecological function of the reservoir and the public interest in enhancing recreation. It was started as a pilot project to simply test the idea and then determine whether it works well enough to continue over the long-term. We originally hoped this decision could be made at the end of 2011 but did not have enough information at that time, largely because we had to stop nutrient additions for over a year. However, we re-started nutrient applications in 2012 and plan to continue the pilot study through 2017. At the end of the pilot period, we should have enough information to determine whether nutrient additions have worked as well as intended. We will then determine whether the program should be continued over the long-term.

What requirements must be met to add nutrients?

In order for nutrients to be applied to the reservoir, there are certain permitting requirements that must be met. In 2011, the Corps was issued a multi-year permit by the Environmental Protection Agency that allows them to apply nutrients to Dworshak Reservoir. This permit is called a National Pollutant and Discharge Elimination System (NPDES) permit. The permit stipulates numerous water quality criteria that must be met in order for nutrient applications to continue. Essentially, the permit is the regulatory tool that EPA uses to assure that nutrients are not being added in a way that will jeopardize water quality in Dworshak Reservoir. To meet permitting requirements, the Corps and IDFG conduct intensive water quality sampling throughout the nutrient application period. Samples are sent to laboratories for analysis and results are reported to EPA and Idaho Department of Environmental Quality (IDEQ).

In addition to having an EPA permit, the Corps completed an Environmental Assessment (EA) in 2012. This was done in accordance with the National Environmental Policy Act (NEPA). An EA provides evidence and analysis for a proposed action, in this case nutrient application, that indicates whether any significant impacts are likely to occur. After a public comment period and reviews, the EA was completed with a finding of no significant impact.

Both IDFG and the Corps work very closely with regulatory agencies, such as EPA and IDEQ, to keep them informed of project activities. To date, nutrient applications have been conducted without violating any permit criteria. We will continue to monitor nutrient applications closely, but all results to date indicate that applications can be done without any negative water quality impacts.

"IDFG completed an economic survey in 2011 that estimated over $4 million are spent annually by anglers visiting Dworshak Reservoir"

How much does the project cost?

Project costs are shared between IDFG and the Corps. The Corps pays for the fertilizer, application of the fertilizer, and consulting fees for the nutrient specialists who determine the amount of nutrients to add to the reservoir each week. These costs typically are about $160,000 per year. IDFG pays for all costs associated with reservoir monitoring, including water quality, plankton, and kokanee sampling. This amounts to about $215,000 per year.

The funds that IDFG uses to pay for this project are not from license buyers. Instead, they are funds received from the Bonneville Power Administration to offset the negative impacts that Dworshak Dam has had on fish. We have to compete with other projects in the Columbia Basin for these funds.

This clearly is not an inexpensive project and you might be wondering whether it is worth the cost. Certainly, we are trying to determine whether fertilization will provide the desired benefits to the reservoir and fishery. If we determine that it is not effective, then we'll discontinue the project. However, if it works well then we will try to continue fertilization into the future. The important part is that we are attempting to improve the fishery and increase recreation opportunity in the reservoir. IDFG conducted an economic survey in 2011 that estimated over $4 million were spent annually by anglers visiting Dworshak Reservoir. Keep in mind that 2011 was a year in which the kokanee population was impacted by high entrainment losses and poor fish growth. An improved fishery should result in even more money being brought to local communities by anglers.

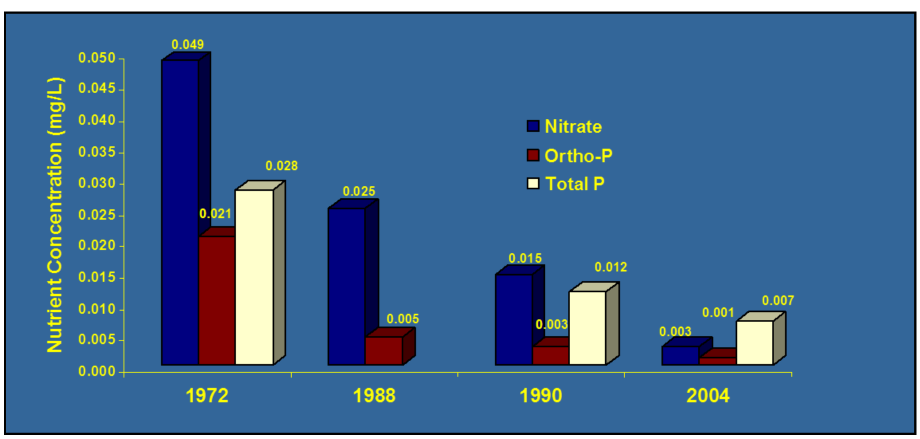
Why is it necessary to add nutrients to the reservoir?

Reservoirs go through a natural aging process after they are created. When a reservoir is first filled it submerges trees, grasses, and other vegetation. The breakdown of this vegetation releases nutrients into the water. The first several years after a reservoir is filled are typically the most nutrient rich conditions in a reservoir. Eventually there will be less vegetation below the high water line to provide nutrients. In Dworshak Reservoir, there is almost no vegetation below the high water line. Think about what the shorelines look like when the water level is drawn down each year. The banks do not have vegetation on them in most places.

As a reservoir ages, eventually, the rivers and streams that flow into a reservoir become the main source of nutrients. Each spring the North Fork Clearwater and other streams flowing into Dworshak provide a nutrient pulse to the reservoir. But, these nutrients only last for awhile and nitrogen is typically used up by late-July. Afterwards, nutrients decrease rapidly and reservoir productivity declines. Low reservoir productivity leads to less food for kokanee and other fish.

The idea behind adding nutrients to the reservoir is to restore nitrogen (the limiting nutrient) and offset the effects of declining nutrient levels. Excessive amounts are not added, but instead small amounts of nitrogen are added that can readily be used up by organisms low on the food chain. Benefitting organisms low on the food chain provides more food for those higher up the food chain. This eventually should provide more food for kokanee that, in turn, can be eaten by larger fish like bull trout and smallmouth bass.

Another nutrient problem is the loss of nutrients that steelhead and salmon once provided to the North Fork Clearwater River Basin. Historically, these fish would return from the ocean to spawn each year. When the fish died, their carcasses would decompose and the nutrients they brought from the ocean would be released into the streams. These nutrients made the streams above the reservoir more productive and benefitted fish, such as bull trout and cutthroat trout. Steelhead and salmon can no longer access the river and streams above the dam, but kokanee in the reservoir migrate upstream of the reservoir to spawn. Kokanee die after spawning and their carcasses provide nutrients to these streams. If nutrient restoration in the reservoir can effectively improve the kokanee population, then they will transport more nutrients upstream like steelhead and salmon once did. This should benefit the cutthroat trout and bull trout fisheries above the reservoir.



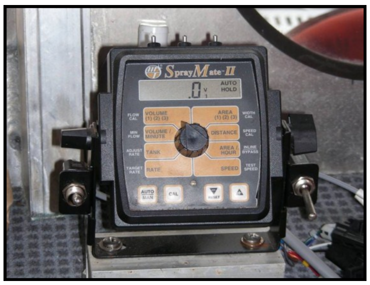
Nutrient concentrations in Dworshak Reservoir have declined substantially since the reservoir was created in 1972. Nitrogen is now the limiting nutrient and the ratio of nitrogen to phosphorus is low.

How are nutrients added to the reservoir? Are they a health hazard?

The U.S. Army Corps of Engineers (Corps) handles all aspects of the nutrient applications. Nitrogen is the limiting nutrient in Dworshak Reservoir, so urea ammonium nitrate (a nitrogen fertilizer) is added to the reservoir. The liquid fertilizer is applied weekly, typically from May through September.

After being ordered, the fertilizer is delivered to Dworshak Dam and stored in commercial agricultural tanks until it is used. The storage tanks are located behind locked gates and have secondary containment around them to prevent escape to the environment in the event of spills or leaks.

The Corps barge with fertilizer truck onboard.



GPS linked application controller

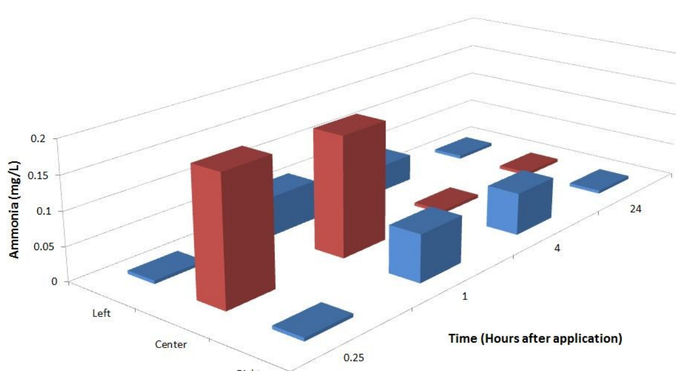
The fertilizer is transferred to an application truck and driven onto the Corps maintenance barge. Once on board, application hoses are connected to the tank, the tank is pressurized and the computer controlled application system is activated. The application system is an agricultural spray system that is linked to GPS satellites. This is the same system that is used in agricultural spray equipment across the country.

The barge travels up the lake following the centerline of the reservoir at approximately 6 mph. The fertilizer application system automatically adjusts for variances in speed along the route to ensure proper dosing in each lake section. Prop wash from the barge allows for mixing of the fertilizer into the water column. This system has proven to be very accurate in evenly delivering fertilizer the length of the lake.

When the weekly fertilizer application is complete, the barge is tied off in the Grandad area to await the return trip downstream the following week. During this time, the barge is secured offshore and all valves are locked to prevent any unwanted tampering or vandalism. To date we have experienced no tampering or unexpected discharge of fertilizer.

So what happens to the fertilizer once it goes into the water? Some folks have expressed concerns over being exposed to it while they are swimming or recreating in the water. Could all this fertilizer going into the lake cause health problems?

Until recently, we have relied on reports from other projects that noted a rapid uptake of supplemented nutrients. Last summer, we took water samples behind the barge while it was making a normal fertilizer run. This was done in early September, when the amount of fertilizer being added was near the peak and the reservoir level was near its lowest. Samples were taken from a spot in the wake of the barge and two spots 20 yards to either side of the barge, which were located using a GPS. Water was collected from a depth of three feet and analyzed for ammonia content, along with other measures of nitrogen. As expected, ammonia levels in the water behind the barge spiked immediately after the application (see figure below). However, the additional ammonia could no longer be detected after two hours. At the sites to the sides of the barge wake, a spike of ammonia was detected an hour after the barge passed and lasted until four hours after the application. The highest level of ammonia detected was 0.19 mg/L. Under the conditions at the time of the application, humans should avoid long-term exposure to levels above 1.1 mg/L and short term exposure to levels above 3.8 mg/L. Therefore, even under a heavier application, the concentration of ammonia directly behind the barge is well below the long-term exposure limits and also does not come close to levels that cause alarm for short term exposure. This information further demonstrates that nutrient application is being done in a manner that does not pose a risk to human health for those recreating on the reservoir.



Ammonia concentrations measured behind and to the sides of the barge at various time periods after nutrient application. Even immediately after application the ammonia levels do not reach high enough levels to pose a health risk.

Nitrogen is applied from the tanker truck via pipes off the back of the barge and mixed into the water column by the prop wash.

What effects did fertilization have on water quality and plankton?

Reservoir monitoring is a critical part of the nutrient project. Nine months per year, IDFG is out on the water collecting samples needed to make sure the project is in compliance with state and Federal regulations, while getting the necessary information to make adjustments to the fertilizer applications and see how the plankton communities are changing. Maintaining good water quality is a primary concern. Two measures of water quality that are watched closely are water clarity and chlorophyll (a measure of the amount of 'green' in the water). As a rule, water clarity is considered good if a Secchi disc (a standard size black and white circle) can typically be seen at a depth of 10 feet or more. This rule was met or exceeded for all years that the reservoir was fertilized. Regulatory agencies also require that the amount of chlorophyll typically not exceed 3 micrograms per liter. The amount of chlorophyll remained below this mark for every year that the reservoir was fertilized. In fact, chlorophyll has stayed the same regardless of whether or not fertilizer was added.

" Nine months per year, IDFG is out on the water collecting samples needed to make sure the project is in compliance with state and Federal regulations, while getting the necessary information to make adjustments to the fertilizer applications and see how the plankton communities are changing"

Plankton, which forms the base of the food chain in lakes and reservoirs, is the key to the success of this project. The kinds of plankton that grow are just as important as how much of it grows. While some types of plankton provide good quality food for fish and the things fish eat, other types of plankton are either low quality food or cannot be eaten at all. Simply growing more plankton will do no good unless it provides good quality food for kokanee and other fish.

Phytoplankton, or algae, are the first step in this process. These are small plants that use nutrients from the water and energy captured from the sun to grow and reproduce. Some of these are the right size and provide the nutrition that zooplankton, the small creatures that many fish feed on, can use to grow. Others form large colonies that can't be eaten by zooplankton due to their size or their ability to produce toxins. Thus, we need to look at both how much algae is growing and what types are growing.

Due to year to year variation in climate, such as the amount of rain and sun, we see a lot of variation in the average amount of algae in the reservoir. However, the amount of algae in the reservoir tends to be about the same for years when it was fertilized and years when it wasn't. What has changed is the portion of algae that can be eaten by zooplankton. By the second year of the project, the proportion of edible algae increased by 50%. This means that there was more algae that could be eaten by zooplankton, which in turn becomes food for fish.

Of course, the reason to grow more edible algae is to grow more zooplankton. As the project progressed, we saw a gradual building of the numbers of zooplankton in the reservoir. In years that the reservoir was fertilized, we saw on average 50% more zooplankton than years that is wasn't. As with phytoplankton, the type of zooplankton is as important as how much. Kokanee grow best when they eat large zooplankton. Kokanee also prefer to eat a particular species, known as Daphnia. Daphnia are large, easy for kokanee to catch, and very nutritious. In years that we fertilized, we saw on average 50% more Daphnia than in years we didn't. These Daphnia also tended to be 10% larger. Together, the number and weight are used to determine the biomass (the total weight) of all Daphnia in the reservoir. In years that we fertilized, we saw on average, nearly twice the biomass of Daphnia compared to years we didn't fertilize.

Will species other than kokanee benefit from nutrient restoration?

While the primary goals of the nutrient project focus on improving the kokanee fishery, other fish species stand to benefit from this project if it works effectively. Smallmouth bass and bull trout eat kokanee and should have more available food if kokanee biomass increases. Also, juvenile smallmouth bass may take advantage of increased zooplankton abundance.

In future years we hope to have more funding available to study the effects that fertilization has on species besides kokanee. But, for now we are focusing our monitoring on kokanee since they will be most sensitive to changes in the reservoir from fertilization.

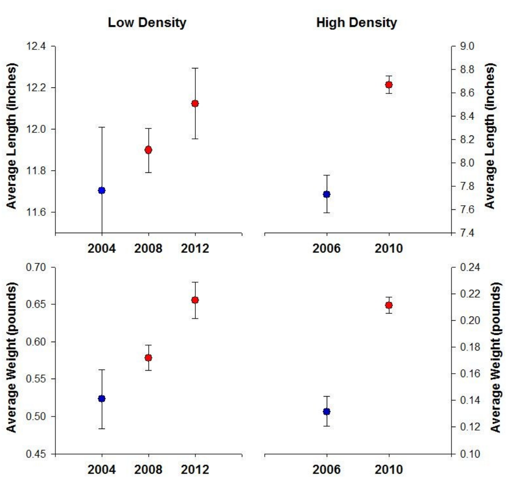
Kokanee spawn in streams upstream of the reservoir and they transport nutrients from the reservoir during this process. If kokanee biomass increases from fertilization, more nutrients will be transported to streams entering the reservoir. Increased nutrients in streams means more food for stream-dwelling fish, such as cutthroat trout and bull trout. Eventually, this may lead to improved fishing above the reservoir.

Kokanee die after spawning and their carcasses release nutrients into streams above Dworshak Reservoir.

Has the kokanee population benefitted from nutrient restoration?

For IDFG, the primary goal of the nutrient project is better fishing. The best way to do this for kokanee is through their stomachs. By providing more food, kokanee can grow larger or be more numerous. Either of these is expected to provide better fishing on the reservoir. If you're a fisherman this sounds good, but how has it worked?

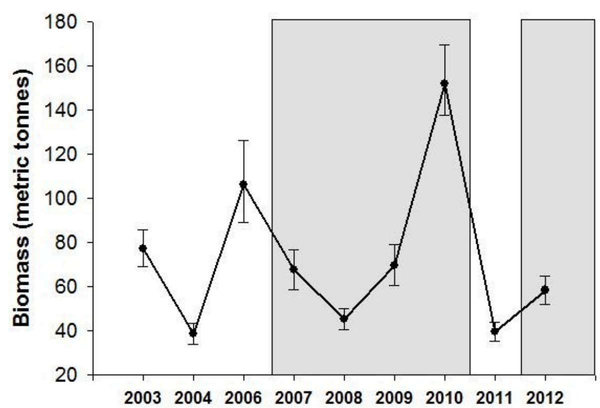
Assessing kokanee growth is difficult. Kokanee tend to be larger when there are fewer of them and smaller when there are a lot of them. This makes sense if you think about it. If there are fewer fish, then each one gets more food. The more they eat, the bigger they get. By the second year of the nutrient project, the kokanee were as big as they had been in recent years. That means the project was working, right? Not so fast. The number of kokanee was way down that year, so we would expect to see larger fish. By the fourth year, we were back to small fish again. So maybe it wasn't the nutrients after all. But we were back up to nearly record numbers of fish in the reservoir by then, so we shouldn't expect them to be very big. The question we need to answer is, "How big would they have been if we didn't fertilize?"



Non-fertilized years are shown in blue and fertilized years are shown in red. In both low and high density years, kokanee were longer and weighed more when fertilization occurred. This indicates that growth conditions have been better for kokanee as a result of nutrient restoration.

A simple way to get at this is to compare the size of kokanee in years when their numbers were similar, one with fertilizer and one without. There are two groupings of years we can use for this, one with low fish numbers and one with high numbers. The years 2004, 2008 and 2012 are years of low fish numbers. We fertilized in 2008 and 2012, but not in 2004. In 2008, the average length of a two year old kokanee wasn't much bigger than in 2004, but the fish in 2008 weighed 10% more. In 2012, two year old kokanee were the largest that we've ever been able to capture in our trawl surveys. These fish were also 25% heavier than the average two year old in 2004. The years 2006 and 2010 had high numbers of fish. We fertilized in 2010 but not 2006. In 2010, the average adult fish was about an inch longer than in 2006 and weighed 50% more.

The biomass, or total weight of all the kokanee in the reservoir, was also 50% more in 2010 than in 2006, even though we estimated slightly more fish in 2006. While fish were smaller in 2010 than they would be in a year with fewer fish, they were much longer and heavier than we saw with similar numbers prior to fertilization. This indicates that the nutrient program is resulting in better kokanee growth.



Biomass of kokanee increased substantially during the fourth year of fertilization (2010). In 2011, many kokanee were entrained through the dam and nutrient applications were not conducted. As a result, biomass dropped substantially. Nutrient additions were resumed in 2012 and the kokanee population is already showing signs of improvement.

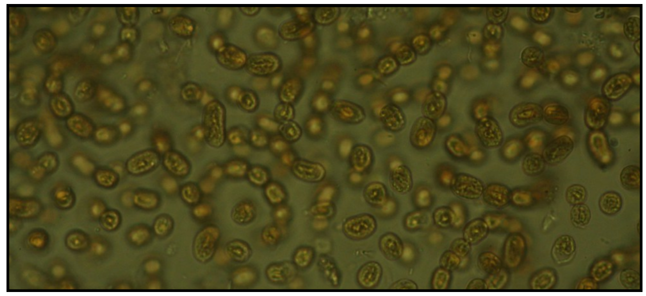
It is important to understand that it takes a few years for fertilization to benefit higher levels of the food chain, such as kokanee. We were just starting to see what looked like a very positive response from kokanee to the fertilization project when we had to stop adding nutrients. So, we still need more information to fully understand the effects that fertilization has on kokanee. As a result, we have decided to continue the pilot study for several more years to make sure we have enough information to best decide whether fertilization works well and should be continued over the long-term.

Has the nutrient project caused more blue-green algae?

While the goal of the nutrient project is to grow more beneficial algae, there has been a lot of concern that it has caused more blue-green algae as well. Why is this a concern? Well, not all blue-green algae, but certain types, can produce toxins that can be harmful to people, pets and livestock. These types do not produce the toxins all the time, but no one knows when they will, so they should be avoided whenever they reach high concentrations.

"In years that we didn't fertilize using a nitrogen-based fertilizer, Anabaena was the dominant form of algae during the late summer. In years that we did fertilize, we saw a lot less Anabaena "

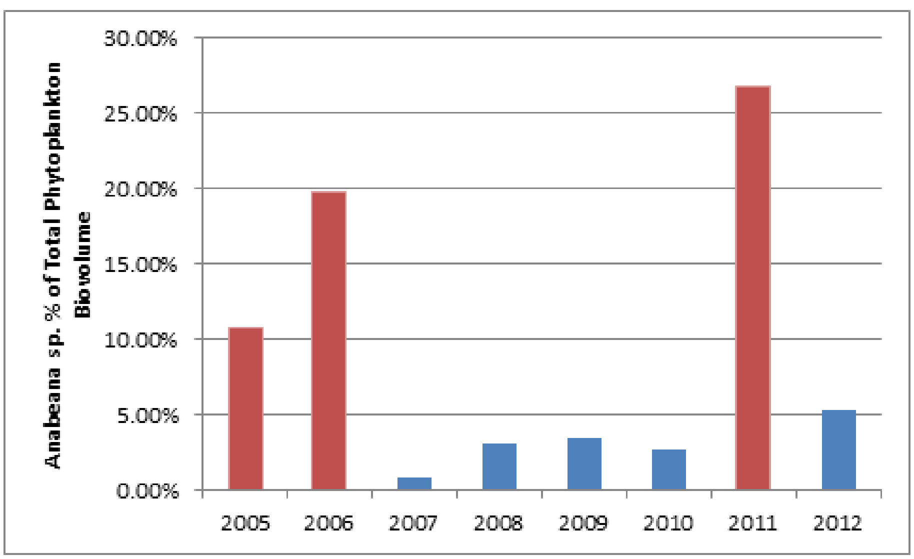
Plants, including algae, need a source of fixed nitrogen, that is ammonia or nitrate, in order to grow. Some plants, like peas and lentils, can take nitrogen out of the air and convert it to a form that can be used by all plants. Farmers may use a crop rotation where they use these types of plants to put nitrogen back into the soil. In lakes, certain types of blue-green algae perform this role. When the lake runs out of fixed nitrogen, these blue-green algae take over. Since they can use nitrogen from the air, they can continue to grow when other types of algae can't. Unfortunately, these types of algae can't be eaten by zooplankton and many can produce toxins. In Dworshak Reservoir, these types of algae commonly become dominant in late summer and early fall once the nitrogen that is available to other plants has been exhausted. Putting nitrogen into the water in a form that other plants can use favors the growth of beneficial types of algae over harmful blue-greens.



Blue-green algae from Dworshak Reservoir viewed under a microscope. Notice the string-like shape of the cells. Because of they form large colonies, blue-greens cannot be easily eaten by zooplankton.

So has this worked? That depends on the type of blue-green algae. There are four types that have been found in Dworshak Reservoir that produce toxins, of which Anabaena is the most common. In years that we didn't fertilize using a nitrogen-based fertilizer, Anabaena was the dominant form of algae during the late summer. In years that we did fertilize, we saw a lot less Anabaena (see figure below).

While fertilization may be able to reduce the amount of blue-greens, they won't be eliminated. So how do you know if it's safe to go in the water? IDFG and the Corps will monitor for blue-green algae, both as part of the regular water sampling program, and also whenever we are out on the water. If high concentrations are observed, the public will be informed and notices will be posted. Even when a bloom occurs, blue-green algae are usually only of a concern in areas where they are concentrated by wind. These will occur along shorelines and in coves where the wind concentrates the algae. This may form bands of green, or mats of algae along the shoreline. Always avoid swimming in or letting pets drink from these areas.



Anabaena (blue-green algae) response in fertilized (blue bars) and unfertilized years (red bars). Anabaena decreased during fertilization and bounced back quickly in 2011 when fertilization did not occur. It then decreased substantially in 2012 when fertilization was resumed..

Dworshak Reservoir kokanee fishing forecast for 2013

Spring is coming and it will soon be time to be out on the water. From the comments I received, last year was a great year for kokanee fishing on Dworshak Reservoir. Although fish numbers weren't as high as we expected, the fish were bigger than we've ever seen before, with many reaching 13 inches in length. I'm sure many of you are wondering if we can get a repeat this year. Here's the lowdown on what we know and how we think the fishery will shape up.

Last year we estimated there were around 85,000 two year old kokanee (the larger kokanee we all like to catch) in Dworshak Reservoir during July (see Table 1 below). This was fewer than expected due to low survival through winter and spring runoff. This year, we could have twice as many two year old kokanee if survival through winter and spring runoff is normal. If survival is low again, we will likely see similar numbers of two year old kokanee this year as we did last year.

But the number of fish isn't the only thing that determines how good kokanee fishing will be. Past research shows that as kokanee get larger, they are easier to catch. Of course, most of us prefer to put larger fish in the cooler as well. This year, the two year old kokanee are already about 10 inches in length. Typically, they don't get this big until July. As such, it looks like we are in for another year of big fish. What ultimately will influence how big these fish get is how many of these fish survive through winter and spring runoff. If survival is good, these fish may not be quite as large as last year (more fish competing for food), but if survival is poor again, we could have even bigger fish this year than last year. Bottom line, this should be another great year for kokanee fishing on Dworshak Reservoir. Stay tuned for our update after we finish our trawl in mid-April.

"Bottom line, this should be another great year for kokanee fishing on Dworshak Reservoir"

Table 1. Estimates of kokanee abundance by age-class from 2010-2012 in Dworshak Reservoir.

Year	Age 1	Age 2	Age 3
2012	340,809	85,023	6,343
2011	361,416	230,836	0
2010	1,177,439	1,030,226	1,483

Acknowledgments:

We appreciate the partnerships and support from the many individuals, organizations, and agencies that help us to achieve our mission, including:

Bonneville Power Administration (funding)
U.S. Army Corps of Engineers (funding)
Advanced Eco-Solutions
Countless IDFG staff and volunteers
Countless Corps staff
Dr. John Stockner
Dr. Frank Wilhelm
Am-Test Laboratories
Ben Scofield
Jan Brady (BPA)
U.S. Environmental Protection Agency
Idaho Dept. of Environmental Quality
IDFG Clearwater Fish Hatchery
USFWS Dworshak National Fish Hatchery
Idaho Fish Health Lab