Douglas Steding

Please see attached letter and technical memorandum.

NORTHWEST RESOURCE
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May 14, 2018

Via Email and U.S. Mail

Rich Doenges
Ecology Southwest Regional Office
P.O. Box 47775
Olympia, WA 98504-7775

Re: WGHOGA comments on tentative permit application denial

Dear Rich:

On behalf of the Willapa Grays Harbor Oyster Growers Association (WGHOGA), we submit the enclosed technical memorandum and comments on the Washington State Department of Ecology's tentative denial of WGHOGA's application to use imidacloprid to control the burrowing shrimp infestation that is destroying its members' farms. When we first sat down to discuss this application back in November 2016, WGHOGA implored Ecology to let science drive its decision-making process. While I think all of us can acknowledge the controversial nature of this application, I still believe sound scientific reasoning and strict adherence to the highest scientific standards should have driven Ecology's decision-making process. Unfortunately, as evidenced by the issues detailed below, it seems like Ecology has cast aside objective, rational science, and has instead chosen a predetermined path that will not address the grave economic and ecological harm caused by this shrimp infestation.

To be blunt, the tentative denial is based on unsound science. Ecology has committed errors in applying basic scientific and toxicological principles such as using a "toxic endpoint" derived for surface water to evaluate impacts to sediment; ignored results of field studies and data generated by those studies that are not supportive of denial of the permit application; and engaged in interpretative gyrations when simpler explanations of empirical data dictated a different conclusion. These errors are detailed below and outlined fully in the technical memorandum accompanying this letter.

A. Ecology ignores multiple field studies to conclude that the proposed treatment would violate the Sediment Management Standards

In the memorandum supporting Ecology's tentative denial, Ecology, for the first time, concludes that the proposed treatment of burrowing shrimp would result in violation of Ecology's Sediment Management Standards due to "adverse effect to biological resources within the sediment impact zone above a minor adverse effects level" (B. Rogowski, memo of April 4, 2018). This conclusion is based on flawed scientific analysis **and ignores multiple on the record conclusions by Ecology to the contrary**. As more fully described in the attached technical memorandum, and as Ecology is aware, there were multiple studies performed under Ecology oversight by WGHOGA and independent researchers over a number of years during the investigations of using imidacloprid to control burrowing shrimp. Those studies include three trials in 2011, four trials in 2012, and one trial in 2014.[1]

Of those eight total trials, seven met Ecology's stated criteria for compliance with the Sediment Management Standards. Ecology analyzed all eight of the trials in the Final Environmental Impact Statement that it now is purportedly supplementing, noting that for two of those trials in (in Bay Center, Washington):

> "*Regardless, the* ***analysis of all the data*** *from this area* ***consistently failed to find a treatment effect****. That is, the invertebrates on the* ***treatment and control sites*** *were similar enough to one another that the data* ***showed no statistical differences*** *after 14 and 28 days, demonstrating* ***there was either no effect, or effect with recovery and recolonization****.*" (emphasis added, FEIS page 2-42)

In 2012, four more trials were performed. Again, in the Final Environmental Impact Statement, prepared by Ecology and part of the record here, Ecology concluded that:

> "*In general, non-target* ***effects on*** *the epibenthic and benthic* ***invertebrates from imidacloprid were absent to minimal*** *based on the statistical analyses requested by Ecology.*" (emphasis added, FEIS page 2-46);
>
> "*Minimal effects to epibenthic and benthic invertebrates means that if these organisms are affected by imidacloprid, they recover and recolonize quickly (i.e., within 30 days).*" (FEIS page 2-46); and,
>
> "***The composite result from the analysis of invertebrate endpoints is that imidacloprid application exhibited limited effects in both space***

[1] Ecology's website currently makes a statement about the 2014 data not being available for review during the preparation of the 2015 EIS. This statement is false, and those data were included in an appendix to the final EIS and Ecology's analysis of those data are discussed more fully in the accompanying technical memoranda.

> ***and time****. In most comparisons of data from the treatment and control plots,* ***a treatment effect of imidacloprid could not be demonstrated*** *for the invertebrate endpoints being tested, (see Hart Crowser 2013 and Booth 2013 for more details).*" (emphasis added, FEIS page 2-46)

Finally, in an appendix to the FEIS (finalized in 2015, after all the field trials had been conducted), Ecology wrapped up its understanding of imidacloprid impacts to benthic organisms by stating:

> "***To date experimental trials of imidacloprid have not shown significant impacts to non-target organisms. Sampling results have not exceeded the "minor adverse impacts" level in all but one sampling event. Testing data has shown that significant impacts have not been observed on the treated beds, and therefore won't be seen on or around the treated beds.***" *(FEIS 2.8.3.5).* (emphasis added, FEIS page 360, Appendix F page F-13)

Since that time, nothing has changed. No additional studies of imidacloprid in Willapa Bay or Grays Harbor have been performed. Despite the state of the science being the same with respect to empirical data on the impacts of burrowing shrimp infestation treatment using imidacloprid, Ecology does a complete reversal on all its prior analysis and conclusions in the FSEIS and the Rogowski memorandum supporting the denial of WGHOGA's application. We were especially perplexed that the Draft SEIS made findings similar to those in Ecology's EIS and written correspondence. Only the FSEIS reversed that substantial body of Ecology's findings.

B. Ecology applies a scientifically indefensible standard in concluding that there will be off-plot impacts due to water-based exposures from WGHOGA's proposed use of imidacloprid to control burrowing shrimp

In the memorandum supporting the tentative denial, Ecology concludes that untreated, or "off-plot" areas of Willapa Bay five times greater than the treated areas are expected to experience toxicity. This conclusion is primarily based on Ecology concluding that a 16.5 ppb "toxic endpoint" is one that results in immediate toxicity to organisms. I hope, sincerely, that Ecology's own toxicologists recognize the flaw in this analysis. As Ecology is well-aware, that 16.5 ppb "endpoint" is derived from a toxicology study that EPA used to select a 33 ppb "acute toxicity" criterion for imidacloprid exposure in marine invertebrates. EPA halved this value to develop a screening level for its analyses, but Ecology has instead incorrectly used this 16.5 ppb value as the acute toxicity criterion. In addition, EPA's acute toxicity criterion is based on toxicity from imidacloprid following 96 hours of exposure to imidacloprid in water. As detailed in the accompanying technical memorandum, and as Ecology should readily acknowledge given the past data collected, **imidacloprid that migrates off-plot rapidly dissipates because of dilution and breakdown**, so that off-plot areas experience exposures that can be measured in minutes, not 96 hours. And, more fundamentally, **Ecology ignored data contained in recent studies** that showed no mortality to crabs at concentrations at levels as high as 12,500 ppb for twenty minutes, much higher than any measured concentrations in Willapa Bay during field trials. To apply a standard that requires four days of exposure to produce toxicity to an environment where concentrations decrease over a span of minutes to hours is bad science.

C. Ecology's conclusion that the use of imidacloprid to control the burrowing shrimp infestation would result in Sediment Management Standard violations outside of the treated areas is not supported by the best available scientific evidence

As detailed more fully in the accompanying technical memorandum, **Ecology chose to ignore years of scientific information in concluding that the proposed use of imidacloprid would result in violation of Sediment Quality Standards outside of the area of application**. As Ecology is well-aware, the SMS do not contain a maximum acceptable concentration for imidacloprid in marine waters, and no data on off-plot invertebrates has been collected that could be used to assess the SMS's maximum biological effects pathway to regulatory compliance. Instead, Ecology chose to compare the same EPA criteria noted above to off-plot water and sediment samples. I have already discussed that the analysis of the water samples was fatally flawed because that standard does not comply with any reasonable toxicology principles given the difference between this 96-hour standard and the actual off-plot exposures of imidacloprid in water.

Ecology's analysis of potential impacts from off-plot imidacloprid in sediments was even less scientifically appropriate: Ecology went through the tortured analysis of applying surface water (i.e., water column) screening levels to sediment samples that were located in treated areas, and then tried to extrapolate those on-plot results to areas not treated with imidacloprid. Even the undergraduates to whom I taught basic environmental toxicology understood that substances at toxic concentrations differ, often by orders of magnitude, in water and sediment. Ecology's own regulations also contain numerous examples of standards for the same chemical that differ between water and sediment. And, more fundamentally, setting aside the mistake of using a water concentration to assess sediment toxicity, if Ecology's own "toxic endpoint" was applied to the data for off-plot concentrations of sediments that are available from past field trials, that analysis would show no potential for off-plot impacts to sediments through the use of imidacloprid to control burrowing shrimp. Again, this is faulty science that excludes the best available data, and that contains basic scientific errors that Ecology either missed or, even more shocking, ignored because those data would undermine Ecology's sought-after conclusion despite the findings of objective scientific analysis.

D. Ecology ignores, for the first time, the ecological benefit of control of burrowing shrimp

As detailed more fully in the accompanying technical memorandum, Ecology has conducted considerable analysis of the ecological impacts of expanding burrowing shrimp populations, and of the high biodiversity and productivity of oyster beds. Although that analysis is now largely ignored by Ecology, the science on this issue remains very clear: burrowing shrimp have severe ecological impacts on eelgrass, oysters, the structural complexity of intertidal habitats, and through these effects, ultimately produce negative ecological impacts to birds, salmon, and trout. If Ecology denies WGHOGA's permit, more than 1,000 acres of oyster beds will be destroyed and replaced by burrowing shrimp dominated mudflats. This will result in the loss of many billions of invertebrate animals and hundreds of thousands of pounds of invertebrate prey items that currently exist in Willapa Bay and Grays Harbor to feed predators like shorebirds and Dungeness crab and salmon. We are disappointed that scientists on the Ecology team failed to disclose or discuss these severe ecological impacts in documents they produced to support the proposed permit denial.

E. Procedurally, Ecology appears to have pre-determined its outcome, putting its thumb on the scales of science in the name of denying this permit application

We are now almost two and a half years into a permitting process that should have taken months. When I was first retained by WGHOGA, I was told by the Attorney General's Office that a permit application would take six months to process and get to a permitting decision. When WGHOGA first applied for the new permit in January 2016, Ecology responded by issuing requests for information on the Sediment Impact Zone application that went on for more than a year—with some of the requests being held back, and others delivered in response to WGHOGA responses to earlier requests for information. Other examples of delay by Ecology are obvious:

1) Ecology chose to compose a SEIS for this permit application, despite the lack of any clear legal requirement to do so;
2) Ecology then chose to fund and prepare the SEIS, despite WGHOGA offers to do so;
3) From Ecology's decision to prepare an SEIS until the actual contract was issued by the Department to a contractor took almost a year;
4) Ecology chose to conduct consecutive rather than concurrent public comment periods, and chose the longest of possible options for those comment periods;
5) In January 2018, Ecology promised a permitting decision by the end of the month, it did not come until months later;
6) Records produced by Ecology indicate that it had made the decision to deny the application in February, and then took more than a month to issue that decision.

Examples of the inherent bias of this process are also abundant. For instance, despite project proponents regularly being involved in the drafting of environmental review documentation, as noted above, Ecology declined any involvement by WGHOGA in drafting the SEIS. This was at a time that Ecology officials were also engaged in discussions with opponents of WGHOGA's proposal, even going so far as to take the egregious step of telling those opponents what type of records they should request from Ecology to prepare comments critical of WGHOGA's proposal. Then, Ecology essentially re-wrote the draft SEIS over a period of weeks, and not in response to comments received. But, as shown by comparison of documents produced by Ecology, such that

Ecology effectively undid what were carefully evaluated and discussed issues during the drafting of the SEIS by the contractor and Ecology team, following procedures agreed upon by all members of that team ahead of the drafting of the SEIS.

Even more remarkably, this was all done without the support of the contractor that drafted the SEIS, who choose to not participate in finalizing the SEIS because Ecology's requested edits were so objectionable as to touch "on our individual credibility as scientists and professionals." Such shockingly biased actions continued when I asked you for a meeting before finalizing the draft SEIS, with that request going unanswered, and in WGHOGA's broad and repeated attempts to craft a compromise throughout the past few months that would address Ecology's concerns and still allow for WGHOGA members to work on saving their farms.

In closing, despite requiring WGHOGA to go through extraordinarily complex, expensive, and time-consuming steps in applying for this permit, Ecology seemed determined from the onset to deny WGHOGA's application. That predetermined outcome is further evidenced by Ecology preemptively addressing in its cover letter transmitting the tentative denial WGHOGA's standing request to modify its permit application and obtain a permit that allows for limited treatment this summer to allow a program of scientific monitoring overseen by a panel of qualified scientists, to address the concerns and uncertainties raised by Ecology in the FSEIS. Similarly, Ecology vetoed, without even meeting to discuss, WGHOGA's offer that it recieve a conditional permit that addresses apparent ongoing concerns by Ecology about treating high organic carbon sediments.

The processing of this permit application by Ecology surely represents a low point in the history of the agency. Ecology has a fundamental duty to adhere to sound scientific process in its efforts to both protect the environment in Washington and ensure that businesses that do business within that environment do so in a sustainable manner, consistent with applicable laws and regulations. Although Ecology may be satisfied that its departure from sound science has resulted in an outcome that is consistent with its own ideology, the precedent set by the handling of this permit application is one that should be alarming for all businesses whose operations involve Ecology's regulatory oversight. And, in so blatantly departing from sound science, Ecology has seriously undermined its credibility—especially with regards to the difficult scientific and social issues that it wants to address. The rural communities, farmers, and agricultural sector in Washington—the heart of Washington's economy—deserve better from Ecology. At this point, the die seems to have been cast, and all parties must resign themselves to long and expensive cycles of litigation on this issue. However, if that is indeed the path that is taken, it is one that still does not address the critical issue of the economic and ecological destruction caused by the burrowing shrimp infestation.

Two years ago, I stood in the audience as Director Maia Bellon addressed a gathering of environmental lawyers, where she discussed extending a hand across a table and working collaboratively with dairy farmers in Eastern Washington. I sincerely hope that, moving forward, Ecology can again find that spirit of collaboration and immediately implement it in the form of an open, productive, collaboration with Departments of Agriculture and Natural Resources as these agencies and independent individuals become involved in trying to solve this difficult problem that continues unabated. As we remain mired in administrative process, it is important to keep in mind that the burrowing shrimp infestation continues, devastating not only WGHOGA members' farms, but publicly-owned tidelands, degrading the ecological quality of what has been an extraordinary resource and place in Southwest Washington.

Very truly yours,

Douglas J. Steding, Ph. D.

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MEMORANDUM

DATE: 12 May 2018

TO: Douglas Steding, Northwest Resource Law

FROM: Jeff Barrett

RE: **Analyses Related to Ecology's Proposed Denial of WGHOGA's Permit**

CC: David Beugli (WGHOGA), file

As requested, we have reviewed the memoranda prepared by staff at the Department of Ecology (Ecology) as support for the Ecology's tentative denial of WGHOGA's proposed NPDES permit to use imidacloprid to control burrowing shrimp on commercial shellfish beds in Willapa Bay and Grays Harbor. The memorandum from Rick Doenges essentially defers to information and conclusions developed by the Toxics Cleanup Program (TCP) as the basis for Water Quality recommendation of denial of WGHOGA's permit application. Accordingly, we have focused our efforts on the memorandum prepared by Barry Rogowski at TCP, dated April 4, 2018.

Mr Rogowski's memo cites two reasons WGHOGA's proposed permit does not comply with the Sediment Management Standards of Washington (SMS), and in particular the requirements for a Sediment Impact Zone (SIZ) authorization: 1) that the proposed use of imidacloprid cannot meet the requirement "that the discharge shall not have an adverse effect to biological resources within the sediment impact zone above a minor adverse effects level," and 2) that the proposed use of imidacloprid cannot meet the requirement "that the discharge shall not result in a violation of the SQS [Sediment Quality Standards] outside of the SIZ" (B. Rogowski, memo of April 4, 2018, page 3).

We have attached three separate documents that critically review Mr. Rogowski's claim that the proposed WGHOGA permit cannot meet requirements of the SMS. The attachments include review of information and analyses in the Rogowski memo itself, in the recently published Final Supplemental Environmental Impact Statement (FSEIS), and in the Final Environmental Impact Statement (FEIS), published in 2015, and incorporated by reference into the FSEIS as part of the administrative record.

- The attachment titled "Effects to Biological Resources Within the SIZ" addresses the first of Mr. Rogowski's claims, that WGHOGA's proposed permit cannot meet the minor adverse effects level requirement of the SMS within the SIZ.
- The attachment titled "SQS Outside the SIZ -Water" partially addresses Mr. Rogowski's claim that the proposed permit cannot avoid the violation of the SQS outside of the SIZ. Effects of the

proposed WGHOGA permit could produce effects outside of the SIZ through tidewater carrying imidacloprid from areas treated to control burrowing shrimp, or in sediments that contain imidacloprid following exposure to such tidewater. This attachment addresses the first of those two scenarios for impacts outside the SIZ.
- The attachment titled "SQS Outside the SIZ -Sediment" addresses the potential for SQS violations outside of the SIZ due to the second exposure pathway, sediments that contain imidacloprid following exposure to tidewater containing this chemical.

Each of the attachments ends with the conclusion that Ecology has failed to demonstrate that the proposed WGHOGA permit to use imidacloprid to control burrowing shrimp would result in violation of the SMS:

- Ecology's conclusion that the minor effects standard of the SMS would be violated within the SIZ is contradicted by written documentation and correspondence from the Department acknowledging that in seven of eight field trials of imidacloprid this standard was satisfied. Rogowski's memo refers only to the single trial that did not satisfy the criterion, an incomplete and inaccurate characterization of the administrative record.
- Ecology's conclusion that the SQS would be violated outside of the SIZ due to imidacloprid in water fails scientifically due to a number of errors and omissions in Ecology's analysis. The most serious of these is Ecology's use of a toxicity value derived from 96 hours of exposure to unvarying concentrations of imidacloprid to assess field exposures outside the SIZ that will last 15-30 minutes, with serial dilution of imidacloprid from incoming tidewaters during such exposures.
- Ecology's conclusion that the SQS would be violated outside of the SIZ due to imidacloprid in sediment fails scientifically because Ecology provides no data demonstrating such exposure. In addition, Ecology used toxicity criteria for imidacloprid in water to assess potential toxicity in sediments, a questionable approach for which Ecology provides no supporting information or analysis.

As we discussed, we have also developed a fourth attachment, titled "Ecological Benefits of Shrimp Control." Assessment of the ecological effects of WGHOGA's proposed permit to use imidacloprid to control burrowing shrimp is scientifically incomplete if it does not include an analysis of the ecological effects of conversion of commercial oyster beds to burrowing shrimp habitat that will occur if Ecology denies WGHOGA's permit application. The FEIS Ecology published in 2015 contains an extensive analysis of this tradeoff in ecological costs and benefits, but the FSEIS and Rogowski memo do not. Our attachment reviews and expands upon Ecology's previous analysis to demonstrate that such conversion resulting from permit denial by Ecology will have significant negative ecological impacts to eelgrass, oysters, habitat structure, and invertebrate prey populations important to shorebirds, waterfowl, and salmonid fishes.

We appreciate the opportunity to conduct this work, and hope that it assists WGHOGA in its attempts to obtain Ecology's approval for its proposed NPDES permit.

Effects to Biological Resources Within the SIZ

Ecology states that one of the two reasons WGHOGA's proposed permit does not meet the Sediment Impact Zone (SIZ) requirements of the Sediment Management Standards (SMS) of the state is that the proposed use of imidacloprid cannot meet the requirement "that the discharge shall not have an adverse effect to biological resources within the sediment impact zone above a minor adverse effects level" (B. Rogowski, memo of April 4, 2018, page 3). With respect to WGHOGA's permit, the SIZ would be those areas treated with imidacloprid to control burrowing shrimp, areas commonly referred to as "on-plot" in the scientific studies that have been done with imidacloprid in Willapa Bay. Ecology further states that it is denying WGHOGA's permit because "Ecology's review of the benthic abundance monitoring data indicates that a benthic abundance test within the SIZ would fail, given the significant decline in abundance of crustacean and polychaete invertebrates compared to the control site during the 2011 field trial in Willapa Bay and Cedar River." (B Rogowski memo, page 4). The FSEIS also includes extensive discussion of the 2011 field trial results for Cedar River, and again concludes that they demonstrate WGHOGA's proposed permit would result in "significant, unavoidable adverse impacts" to invertebrates in areas treated with imidacloprid.

Some background is needed in order to understand what the term "fail" means, as used in Rogowski's memo supporting permit denial. As outlined in the Rogowski memo, violations of the SMS are allowed within a SIZ as long as the contamination (in this case imidacloprid) does "not exceed a maximum chemical concentration or level of biological effects" (Rogowski memo, page 3). Because the state's SMS do not define criteria for a maximum acceptable chemical concentration of imidacloprid, Ecology has instead used the "maximum biological effects level" pathway of the SMS to determine compliance with the SMS within the SIZ, specifically by determining if the proposed used of imidacloprid to treat burrowing shrimp will result in biological impacts that are "at or below a 'minor adverse biological effects level' " within the SIZ (subsequently referred to here as the "minor effects standard;" both quotes from Rogowski memo, page 4). To do this Ecology developed a series of biological metrics evaluating invertebrate responses to imidacloprid exposure. The test of whether imidacloprid treatment of burrowing shrimp complies with the SMS within the SIZ is, under Ecology's protocol, determined by comparing the invertebrate populations on plots treated with imidacloprid to those on control plots not exposed to imidacloprid:

> *The proposed discharge will have more than a minor adverse biological effect (and thus be in exceedance of the maximum biological effects criteria) if the biological test determination demonstrates the following result: the test sediment (i.e., sediment where the discharge has occurred) has less than 50% of the reference sediment mean abundance of any two of the major taxa (i.e., Class Crustacea, Phylum Mollusca, or Class Polychaeta) and the test sediment abundances must be statistically different from the reference sediment abundances (t test, $p \leq 0.05$).* (Rogowski memo, page 4).

Rogowski's memo is not accurate with respect to the criteria the Department decided to use to determine whether the proposed discharge of imidacloprid under WGHOGA's permit will violate the SMS within the SIZ. As detailed in other correspondence from Ecology (e.g., memo from Jason Landskron to B. Rogowski dated April 7,2015 and included as Appendix E to the

FEIS; Ecology 2015), taxonomic richness was also selected. In addition, Ecology committed to consider other metrics if they were developed and submitted as part of any tests of the effects of imidacloprid:

> *For this application of imidacloprid in Willapa Bay and Gray's Harbor, Ecology staff began developing the metrics and data analysis methods for interpretation in 2009, before any data were collected. After a review of the existing Puget Sound criterion, the scientific literature, and internal discussion, Ecology staff recommended an approach that combined recent scientific thinking and the Puget Sound criterion. Several references have evaluated benthic community metrics and concluded that taxonomic richness of certain groups of benthic organisms can be used to evaluate the health of the benthic community.* [citations omitted] *For this application, taxonomic richness (number of different species or taxa present) is used in addition to abundance (number of organisms) for the three taxonomic groups listed in the Puget Sound marine criterion – Polychaetes, Molluscs, and Crustaceans. Ecology has stated in previous memos that the benthic community metrics that it will use to consider impacts include:*
>
> - *Crustacean abundance and taxonomic richness*
> - *Polychaete abundance and taxonomic richness*
> - *Mollusk abundance and taxonomic richness*
>
> *For these metrics, Ecology will be looking for a 50% reduction compared to a control or reference site, consistent with the Puget Sound marine criteria. If the permittee chooses to report other metrics, they may be considered as additional information in the site-specific assessment.* (J. Langskron April 7, 2015 memo, page 250 of FEIS, page 18-19 of memo).

WGHOGA submitted quantitative data for another metric, species diversity calculated using the Shannon Diversity index, a statistical measure that looks both at how many types of animals are present, and how even or uneven the abundances of each of those types of animals are. Ecology included this "diversity" index in its analysis of invertebrate results obtained during field trials of imidacloprid treatments to control burrowing shrimp.

So ultimately Ecology evaluated nine different invertebrate tests for each of the field trials of imidacloprid in Willapa Bay: abundance, taxonomic richness, and diversity for each of the three taxonomic groups: polychaetes, mollusks and crustaceans. The omission in the B. Rogowski memo of the six metrics related to taxonomic richness and diversity is difficult to explain, as they were a key part of the process used by Ecology to assess the impacts of imidacloprid on invertebrates within the SIZ.

Another omission in Rogowski's memo, or in most of the FSEIS, is that experimental trials of imidacloprid following the same experimental protocol as that used for the 2011 Cedar River trials have been conducted eight times: three times in 2011, four times in 2012, and once in 2014. The trials in 2012 and 2014 were conducted following an Ecology reviewed and approved Sampling and Analysis Plan (SAP, Hart Crowser 2012, Hart Crowser 2014). A SAP had been submitted to Ecology in 2011, but was not finalized and approved before the field trials began. However, for the 2011 field trials WGHOGA and Ecology worked together, along with personnel from Washington State University, University of

Washington, and the Pacific Shellfish Institute, to develop sampling and analysis methods that were subsequently memorialized in the SAP documents covering 2012, and 2014. Thus, all eight trials are directly comparable to one another, and their results, collectively, represent a considerable body of scientific evidence on what happened in Willapa Bay when imidacloprid was applied to control burrowing shrimp.

These field trial data are particularly important for two reasons. First, they represent a true test of the potential effects of applying imidacloprid to control burrowing shrimp, as proposed by WGHOGA. The great majority of the toxicology data on imidacloprid reviewed in the FEIS, FSEIS, and in EPA's Risk Assessment (EPA 2017), use laboratory studies in which invertebrates are kept in aquaria and exposed to imidacloprid for a period of time, typically 96 hours for tests of "acute" effects, and 28 days for tests of "chronic" effects. And the great majority of these laboratory data investigating the toxicity of imidacloprid have been conducted on freshwater insects, which are not a good model for assessing effects to saltwater polychaetes, crustaceans, and mollusks, as Ecology's test protocol calls for. Extrapolating from the result of laboratory studies to estimate impacts of WGHOGA's proposed used of imidacloprid to control burrowing shrimp also has many, as the field application involves much more limited periods of exposure due to tidal dilution. In addition, use of imidacloprid in Willapa Bay and Grays Harbor involves variables like sunlight-related breakdown of imidacloprid, a diverse assemblage of different types of invertebrates (most lab studies investigate effects on only a single animal type), variable temperatures and water quality conditions, the presence of dissolved chemicals in seawater, etc. By contrast, the field studies done in Willapa Bay in 2011, 2012, and 2014 are actual tests of the effects of imidacloprid in the real environment where WGHOGA intends to treat burrowing shrimp. And the trials in 2011, 2012, and 2014 were explicitly designed to apply imidacloprid in locations, amounts, and methods as those being proposed by WGHOGA to control burrowing shrimp. Thus, the field trial data are scientifically a much better indicator of potential effects of WGHOGA's permit application than any amount of laboratory experiments.

The second reason the field trial data are particularly important is because they can be used to assess whether impacts to invertebrates occur when imidacloprid is carried by the rising tide from areas of application (on-plot locations) to areas not directly treated (off-plot locations). All data on invertebrates for the 2011, 2012, and 2014 trials are for on-plot areas that were directly treated with imidacloprid, which then remained on the plots for 2-4 hours until the rising tide arrived. Imidacloprid concentrations, and therefore expected impacts to invertebrates, would be at a maximum for these on-plot areas. By contrast, as detailed elsewhere, off-plot areas experience only short exposure to lower levels of imidacloprid, with rapid dilution of any imidacloprid by the rapidly rising tidewaters. Thus, the response of invertebrates on-plot, as identified by these data, would represent a much greater impact than that experienced by invertebrates off-plot, for which no data on invertebrates have been collected. By extension, if on-plot invertebrates did not experience impacts that exceed the Sediment Management Standards (SMS) of Washington, then off-plot areas did not either.

This frames the importance of the major conclusions of Ecology's review of the 2011, 2012, and 2014 field trials, conclusions that Ecology has totally ignored in their denial of the WGHOGA permit application: **of the eight field trials in Willapa Bay, seven met Ecology's stated criteria for compliance with the Sediment Management Standards (SMS), including the Sediment Impact Zone(SIZ) regulations**. Only the 2011 Cedar River trial cited by Ecology in its permit denial did not. And Ecology, in its prior analysis of those Cedar River data, listed multiple reasons why that trial was different, that the results needed to be treated with caution, and a repeat trial was needed to confirm or refute the results of the original trial. Yet now, Ecology, in both the Rogowski memo and the FSEIS, ignore those prior cautions about the Cedar River trial, instead treating it as the definitive result that can be used to predict future impacts if WGHOGA's permit is approved. To do so, they also had to ignore the results of the other seven trials where impacts to invertebrates met the minor impact standard of the SMS. No explanation or justification is given by Ecology for either of these decisions.

The 2015 FEIS (Ecology 2015) was prepared and published by Ecology. It is their document, and as noted in the FSEIS, it is incorporated by reference in the FSEIS. The results reported for the 2011, 2012, and 2014 field trials in the FEIS have not changed (e.g., were not reanalyzed for the FSEIS[1]), the pass/fail criteria for compliance with the SMS have not changed (virtually identical language is used to describe them in the FEIS from 2015 and B. Rogowski's memo), and no change in the conclusions that trials passed the SMS criteria have been made. In other words, the analysis of the 2011, 2012, and 2014 field trials in the FEIS remains scientifically valid and regulatorily relevant today, despite any new analysis or literature review in the FSEIS. Accordingly, we reviewed the FESIS in detail to find Ecology's assessment of the effects on invertebrates observed in the 2011, 2012, and 2014 experimental trials of imidacloprid in Willapa Bay, as well as Ecology's determination of whether those results were in compliance with the SMS minor effects standard. As noted above, all invertebrate data from these trials was collected on-plot (i.e., in the areas directly treated with imidacloprid to control burrowing shrimp). These treated areas would, by definition, constitute the SIZ if WGHOGA's permit had been operational at the time of the trials. The results of our review follow. Text in italics is taken directly from the FEIS:

1. The FEIS contains an extensive analysis of the 2011, 2012, and 2014 trials in Willapa Bay.
    a. Section 2.8.3.5 contains individual sections covering trials in 2011, and 2012. A partial analysis of the 2014 data in the main body of the FEIS, and a complete analysis of these data in Appendix E of the FEIS, are also included.
2. The FEIS analysis of the 2011 data includes extensive analysis and interpretation of the three trials that were conducted that year (two at Bay Center, one at Cedar River):
    a. For the two sites at Bay Center: *In general, before imidacloprid application, the control and treatment plots at the Bay Center sites were similar for about half of the absolute abundance, taxonomic richness, and diversity metrics for crustaceans, polychaetes, and molluscs. Statistical tests for treatment effects of imidacloprid were more definitive for these measures than for metrics that were not similar before treatment. Regardless, the* ***analysis of all the data*** *from this area* ***consistently failed to find a treatment effect****. That is, the invertebrates on the* ***treatment and control sites*** *were similar enough to one another that the data* ***showed no statistical differences*** *after 14 and 28 days, demonstrating* ***there was either no effect, or effect with recovery and recolonization****.* (emphasis added, FEIS page 2-42)

[1] The results of on-plot monitoring of imidacloprid in water and sediment samples in 2014 were reviewed in the FSEIS and Rogowski memo, but the results reported are unchanged from those analyzed in the FEIS and its Appendices.

b. For the Cedar River site, a different conclusion was reached: *Results of the analyses showed a decrease in abundance for most crustacean and polychaete species on the treatment plot, while a general increase was seen in the control plot. These differences were seen at both 14 and 28 days after treatment. While not conclusive, these results are consistent with an interpretation that imidacloprid reduced the number of polychaetes and crustaceans on the treatment plot, and that the decline lasted for at least 28 days following treatment, at least for some species.* (FEIS, page 2-42).
c. Ecology, however, acknowledges that other invertebrate comparisons between treatment and control plots at Cedar River did not show a treatment effect. In fact, of the nine comparisons of invertebrates on treatment and control plots, seven of the nine did not show an effect of imidacloprid. And even for the two that did, abundance of polychaetes and crustaceans, Ecology acknowledges that some types of animals were recovering by 28 days.:
    i. **A treatment effect** [of imidacloprid on invertebrates] **was not evident for the three endpoints for molluscs (abundance, taxonomic richness, and Shannon diversity), or for richness and diversity in polychaetes or crustaceans**. (emphasis added, FEIS page 2-42).
    ii. *However, the data also* ***show that the abundances of some species*** [in the treatment plot] ***increased 28 days after treatment****.* (emphasis added, FEIS page 2-42)
d. Ecology also raises concerns about whether the Cedar River results are accurate or representative of the effects of imidacloprid on invertebrates generally. They repeatedly note differences between the treatment and control sites that made interpretation difficult, and sediment conditions not found at any other site tested in 2011, 2012 or 2014:
    i. *This* [differences in invertebrates between treatment and control plots at the time of imidacloprid application] *makes interpretation of subsequent differences between treated and control sites more difficult (i.e., are differences due to imidacloprid, or to unequal starting conditions?). The problem was especially evident in Cedar River where some species were as much as 30 times more abundant in the treatment plot than in the control plot at the time of imidacloprid application.* (FEIS page 2-42)
    ii. *Given the poor initial match between the treatment and control sites in Cedar River in 2011, and the mixed results with respect to a treatment effect in data from that trial, another study in the Cedar River area is planned for the summer of 2015* (FEIS page 2-42)
    iii. *Whole sediment binding rates of imidacloprid were calculated for 51 samples...Initial bind rates ranged from 17.4 to 39.5 percent at the Palix River and Leadbetter Point treatment plots, while the Cedar River treatment plot had an initial binding rate of 89.8 percent.* (FEIS page 2-44)
    iv. *Data on sediment binding of imidacloprid indicate that it binds more readily to sediments that are higher in total organic carbon (TOC) (e.g. at the Cedar River*

treatment plot), and appears to be more persistent, than in sediments with lower concentrations of TOC (Palix River and Leadbetter Point treatment sites). At the Cedar River site, the concentration of imidacloprid bound to sediment decreased from approximately 28 percent one day after treatment to approximately ten percent 56 days after treatment. At the other two sites with lower TOC, imidacloprid concentrations had declined to less than five percent only 28 days after treatment (Grue and Grassley 2013). (FEIS page 2-44)

3. The FEIS analysis of the 2012 field data includes extensive analysis and interpretation of the four trials that were conducted that year (two at Palix, two at Leadbetter). Ecology states that imidacloprid treatments did not produce an impact on invertebrates that could be detected in comparisons to untreated control plots.
    a. *In general, non-target* ***effects on*** *the epibenthic and benthic* ***invertebrates from imidacloprid were absent to minimal*** *based on the statistical analyses requested by Ecology.* (emphasis added, FEIS page 2-46)
    b. A footnote in the FEIS explains *Minimal effects to epibenthic and benthic invertebrates means that if these organisms are affected by imidacloprid, they recover and recolonize quickly (i.e., within 30 days).* (FEIS page 2-46).
    c. *......* ***The composite result from the analysis of invertebrate endpoints is that imidacloprid application exhibited limited effects in both space and time****. In most comparisons of data from the treatment and control plots,* ***a treatment effect of imidacloprid could not be demonstrated*** *for the invertebrate endpoints being tested, (see Hart Crowser 2013 and Booth 2013 for more details).* [emphasis added, FEIS page 2-46)
4. Ecology also cites to its internal documents stating that the results of the 2012 trials are consistent with the requirements of the Sediment Management Standards of the state:
    a. *Ecology reviewed the results of the 2012 experimental trials and determined that, based on the current review of those studies, "****Imidacloprid impacts to benthic and epibenthic communities appear to be minor based on the Sediment Management Standards regulatory framework.*** *The dynamic estuarine environment provides conditions for rapid recolonization of treated plots at this level of treatment. ..... (WAC 173-204-410)" (Ecology Memo July 30, 2013).* (emphasis added, FEIS page 2-46)
5. The main body of the FEIS contains an analysis of part of the 2014 data collected in a trial at Stony Point that year. The 2014 trial was unique in that a very large, contiguous area was treated with imidacloprid. The 90 acre trial (most previous trials involved applying imidacloprid on areas 5-10 acres in size) was a test of possible cumulative effects that could come from treating multiple 5-10 acre plots at the same time, as WHOGA had proposed under its permit. It was also meant to test if recolonization of treated areas by invertebrates would be hindered when the distance to untreated areas was much greater than in prior trials.
    a. Results for 2014 for efficacy (i.e., imidacloprid effectiveness in reducing burrowing shrimp density) are analyzed, but other data for the 2014 trials *were finalized after the publication of the Draft EIS* (FEIS page 2-46).

b. In response to public comments, Ecology notes: *The 2014 study closely followed the methodologies of the previous studies but differed in terms of scale of the treatment areas. Several commentators expressed an interest in reviewing the results from the 2014 studies. We have therefore attached the report and Ecology's review of the studies in Appendix E.* (FEIS page 2-46; reviewed separately below)

6. While deferring to Appendix E for the details of Ecology's analysis of the 2014 data, the FEIS does offer overall conclusions about the results of that trial:
    a. *The scale of the treatment areas in the 2014 study are similar in size to many of the expected commercial application areas.* ***Ecology*** *views the results of this data report as consistent with previous studies and* ***has determined that the imidacloprid applications in 2014 do not exceed the Sediment Management Standards****. Specifically, the effects of imidacloprid at a commercial scale treatment cannot be discerned from seasonality and site variation or that relative recovery or recolonization is occurring within the 14- day period between the treatment date and the first round of samples.* (emphasis added, FEIS page 2-47).

The FEIS Appendix E is a 19 page memorandum written by Jason Landskron, a PE in the Toxics Cleanup Program at Ecology. It is written to Barry Rogowski, and is dated April 7, 2015. The title is "Willapa Grays Harbor Oyster Growers Association (WGHOGA) NPDES Permit – 2014 Benthic Data Report Review."

1. Mr. Landskron states that the purpose of the memo is to *provide technical analysis and discussion of the data provided [from the 2014 field trial]. Further the focus of this review is on imidacloprid effects to the benthic invertebrate community* ***and to assess regulatory compliance with the Sediment Management Standards (SMS)*** *and Sampling Analysis Plan Appendix (SAPA) where applicable*" (emphasis added, FSEIS page 246, memo page 1).
    a. Although the focus of the report is on the 2014 trial, Mr. Landskron also discusses results from the trials in 2011, and 2012. Of most interest is the end of the memo when, considering all the trial results, he summarizes the effects of imidacloprid on invertebrates, decides if SMS standards have been met, and makes recommendations for the approval or denial of the then pending permit (allowing WGHOGA to treat 2,000 acres/year with imidacloprid).
    b. Mr. Landskron discusses the process for analyzing the invertebrate data, including the use of a complex *data analysis decision tree* chart (included in his memo) that prioritizes statistical comparisons when the data are suitable, and a site-specific assessment when they are not. He is unambiguous in saying that the data analysis process was developed and approved by Ecology in a collaborative effort with outside scientists:
        i. *For this application of imidacloprid in Willapa Bay and Gray's Harbor, Ecology staff began developing the metrics and data analysis methods for interpretation in 2009, before any data were collected*. (FEIS page 249, memo page 4)

ii. *Ecology acknowledges that in a dynamic estuary, there can be spatial variability such that the control site and test sites have some differences that are not related to the treatment. These can affect the subsequent tests that compare the mean values between the two sites. In consideration of this, Ecology has determined some alternative approaches for statistical comparison may be warranted in such a case.* (FEIS page 250, memo page 5)

iii. *The statistically based study design and data analysis process incorporated years of work and collaboration between Donna Podger (Ecology), Russ McMillan (Ecology), Lorraine Reed (TerraStat), and Steve Booth (Pacific Shellfish Institute). It anticipates the potential for site variability and inability for a study plot to match a control which is why there are site-specific evaluation end-points in the data analysis decision tree. The only alternative to this site-specific analysis approach was to disregard data and possibly the entire study if the study plot was too variable and did not statistically match the control.* (FEIS page 263, memo page 18)

iv. [For the 2011 field trials] *[e]ven though the SAP had not been approved by Ecology, the sampling design, described above, was incorporated into the study and thus, the collected benthic data was interpreted using the mutually agreed upon procedures.* (FEIS page 253, memo page 8)

c. Mr. Landskron makes numerous references that conditions at the Cedar River site were different than those in all other trials, or made analysis of the results difficult:

    i. *"all but one of the study locations* [Cedar River] *have occurred in areas of low total organic carbon (less than 1% TOC) or high oceanic flushing. (*FEIS page 261, memo page 16)

    ii. *"One site feature in particular, the Total Organic Carbon (TOC) percentage of the sediment, was significantly elevated at the Cedar River site compared to any other site where benthic testing occurred including 2012 and 2014 studies."* (FEIS page 254, memo page 9)

    iii. *The 2011 study focused on two specific areas of Willapa Bay including Cedar River, ... The control and treatment plots [at Cedar River] were not equivalent pre-treatment for many of the metrics.* (FEIS page 261, memo page 16)

d. Mr. Landskron analyzes the Cedar River data and notes that Ecology has concluded that treatment with imidacloprid impacted invertebrates. But Mr. Landskron also makes clear that any failure to meet the SMS criteria was limited to just two of nine invertebrate metrics tested, polychaete and crustacean abundance.

    i. *The results of the Cedar River site show that the treatment site decreased 60 to 86% in crustacean abundance and decreased 55 to 72% in polychaete abundance at 14 and 28 days after treatment (DAT), compared to the control plot which increased 44 to 75% in polychaetes abundance and increased (-3%) to 42% in crustacean abundance. Based upon the required site-specific analysis, TCP determined that the imidacloprid application caused an exceedance of the minor adverse effects threshold per the SMS for both polychaete and crustacean* *abundance at 14 and 28 days on the Cedar River plot. Benthic recovery to pre-treatment abundance levels was not observed during the study period.* (FEIS page 254, memo page 9)

   ii. *While there are many variables which could have contributed to the negative decline in abundance of crustaceans and polychaetes at the Cedar River site, Ecology concluded that the application of imidacloprid was the primary cause.* (FEIS page 254, memo page 9)

e. Having concluded that Cedar River demonstrated negative impacts to invertebrates from imidacloprid, Mr. Landskron then goes on to sequentially analyze results for the other 2011 sites, the 2012 sites, and the 2014 site. He consistently concludes that they did not demonstrate significant impacts to invertebrates from imdacloprid exposure. In many cases he also explicitly states that the sites meet Ecology's SMS standards:

   i. For the two Bay Center sites tested in 2011: "*based on the results of the site-specific analysis, effects of imidacloprid treatment were not discernible from seasonality and site variation or that relative recovery had occurred within the 14-day period between the treatment and first round of samples. Decreasing trends in polychaete abundance on the Nuprid and Mallet plots were also seen in the control. Similarly, these trends can also be seen in the crustacean abundance. Further, much of the data of each metric falls within the same or overlapping statistical interquartile range. TCP determined that the* ***benthic community at the Bay Center site had recovered by day 14 and that the field trial at Bay Center would meet the SMS regulatory requirements*** *if a NPDES permit were issued, provided other conditions were met*". (emphasis added, FEIS page 254, memo page 9)

   ii. For the four trials in 2012 (2 each at Bay Center and Leadbetter): ***imidacloprid impacts to benthic communities appeared to be minor based on the Sediment Management Standards regulatory framework*** *and Ecology's site-specific analysis of the data. The treated plots appeared to recolonize with benthic invertebrates within 14 days, so that* ***imidacloprid effects after 14 days could not be discerned from natural variability on the plots****.* (emphasis added, FEIS page 255, memo page 10)

   iii. For the single trial in 2014 on a large 90 acre plot at Stony Point: *Then the* [treatment and control] *plots were compared 14 DAT and 28 DAT. There were 12 metrics evaluated from the 2014 data (18 if counting diversity). These are shown in Table 1 and again in Appendix B. Ten of the 18 (56%) metrics passed the comparison to the control, meaning benthic recolonization had occurred and that* ***there was no discernible effect of imidacloprid to the benthic community at 14 DAT or 28 DAT*** *as defined by the study design. The remaining 8 metrics required Ecology's site-specific evaluation due to significant differences between the control and treatment plots, which are evaluated in the next sections of this memo.* ***In cases where the control and treatment metric were statistically equivalent, all metrics passed****.* (emphasis added, FEIS page 257, memo page 12)

iv. And for the 2014 data results for mollusks at Stony Point using the site-specific analysis part of the data analysis decision tree protocol: *The Stony Point treatment plot was significantly more abundant for Mollusks than the control plot as well as containing a different community composition. The mean abundance and species composition on the control plot remained relatively consistent during the study period. On the treatment plot, the mean abundance increased 10% at 14DAT and increased 38% by 28DAT, relative to 1 day before treatment (DBT).* (FEIS page 261, memo page 16)

v. And the 2014 data results for crustaceans at Stony Point using the site-specific analysis part of the data analysis decision tree protocol: *Most of the species on the treatment plot were observed to increase by 14DAT although at a ratio lower than the control plot. However, by 28DAT the crustacean population had increased nearly 81%. These changes were typically plot-wide and not specific to a specific core or region on the plot. Further, the community composition was similar across the study period for both the treatment and control plot.* (FEIS page 261, memo page 16)

vi. And a summary of the 2014 Stony Point site specific analyses he had conducted: *The 2014 Stony Point control and treatment plots were not equivalent pre-treatment for 8 of the 18 metrics analyzed. Upon further review of those metrics requiring site-specific analysis, it appears that the* ***effects of imidacloprid cannot be discerned from seasonality and site variation or that relative recovery or recolonization is occurring within the 14-day period*** *between the treatment date and first round of samples.* (emphasis added, FEIS page 261, memo page 16)

f. In his "Conclusions" section, Mr. Landskron considers all the trials conducted in 2011, 2012, and 2014, and offers his overall assessment of what these studies indicate are the effects to invertebrates in on-plot areas treated with imidacloprid:

i. *[A]ll but one of the study locations [Cedar River] have occurred in areas of low total organic carbon (less than 1% TOC) or high oceanic flushing.* ***In these areas, which represent a large proportion of Willapa Bay****, the data suggest that the benthic community has a high recolonization potential in response to* ***imidacloprid applications to control burrowing shrimp*** *and* ***would fulfill the requirement of the SMS under a Sediment Impact Zone,*** *should one be permitted in a Final NPDES permit, provided all other requirements of the SMS are met (AKART, BMPs, etc.)****.*** (Emphasis added, FEIS page 261, memo page 16)

ii. *There are many variables to explain why an* ***effect*** *[of imidacloprid on invertebrates]* ***was observed at Cedar River and not in other areas of Willapa Bay****, but based on the information collected thus far and literature review of the properties of imidacloprid, the degree of oceanic flushing, distribution of sediment grain size, and total organic carbon content are the most likely reasons for the variable degree of imidacloprid toxicity observed.* (emphasis added, FEIS pages 261-262, memo pages 16-17)

g. In a concluding section approving WGHOGA's field data report for the 2014 trials, Mr. Landskron offers a final overall assessment of the suitability of imidacloprid use in Willapa Bay:
    i. *In general, I concur with the conclusions stated in the data report and recommend agency approval.* ***Central Willapa Bay appears to be highly productive and capable of rapid recolonization or recovery of the benthic community in response to a temporary disturbance, as long as the persistence of the applied pesticide is brief.*** *Based on the studies conducted to date, the sandy and well-flushed sediments of central Willapa Bay have been demonstrated to fit this characterization.* (emphasis added, FEIS page 262, memo page 17

The FEIS Appendix F contains responses to public comments received on the DEIS. In a response to comments from the Xerces Society, Ecology offers an overall summary of its findings about the effects of imidacloprid based on the experimental trials in 2011, 2012, and 2014:

1. ***To date experimental trials of imidacloprid have not shown significant impacts to non-target organisms. Sampling results have not exceeded the "minor adverse impacts" level in all but one sampling event. Testing data has shown that significant impacts have not been observed on the treated beds, and therefore won't be seen on or around the treated beds.*** *(FEIS 2.8.3.5).* (emphasis added, FEIS page 360, Appendix F page F-13)
2. *The potential effects of imidacloprid use for the control of burrowing shrimp in Willapa Bay and Grays Harbor have been studied extensively over the past six years. Studies have included investigations of chemical residues, laboratory and field toxicity using surrogate and local species, and biological field sampling under commercial use conditions.* ***The overriding weight of evidence indicates that imidacloprid treatment will not significantly impact the endemic species or the ecology of these waters, and will not significantly impact human health.*** *The use of imidacloprid in Willapa Bay and Grays Harbor will be limited in both timing and spatial scope. To reduce the impact of the burrowing shrimp species on shellfish production, these products will be used to treat targeted beds approximately once every 3 - 4 years on a rotating basis (although applications in consecutive years are allowed). Not all shellfish beds require treatment, dependent on the resident population of burrowing shrimp.* ***There are approximately 45,000 acres of tidelands in Willapa Bay, with only 20% used for commercial shellfish (largely oysters and clams). In Grays Harbor, shellfish are grown commercially on only 3% of the 9,000 acres of tideland. These facts indicate that exposure will be significantly limited within the two water bodies.*** *The Willapa Bay and Grays Harbor systems both experience significant flushing associated with daily tidal patterns, with major* ***daily tidal fluctuations ranging between six and ten feet****. This extensive water exchange is necessary for commercial shellfish production and provides several critical inputs into these environments. Tidal flows* ***provide water dilution and movement, increasing opportunities for rapid dissipation of imidacloprid****. Tidal changes also bring in water that is rich in nutrients and microorganisms, supporting more rapid metabolic breakdown of chemicals such as imidacloprid. This* ***rapid breakdown and subsequent decline in concentrations is supported in multiple residue studies involving water and sediments associated with treated beds and adjacent channels****. Based on these observations,* ***exposures of***

> ***non-target organisms to biologically active concentrations of imidacloprid would be significantly limited and brief****. Numerous studies have been conducted on the effects of imidacloprid on estuarine and marine organisms. Results indicate that the* ***majority of surrogate and endemic species are not sensitive to environmentally relevant concentrations of imidacloprid. This includes fish, mollusks, polychaetes and some crustaceans****. Although there are some indications of toxicity to specific crustaceans, the impact is expected to be minor because of limited exposures and rapid re-colonization.* (emphasis added, pages 360-361 FEIS, Appendix F pages F-14 to F-15).

Conclusions: Beginning in 2009, Ecology worked to modify existing Puget Sound standards of the SMS for the regulatory analysis of imidacloprid treatments to control burrowing shrimp in Willapa Bay and Grays Harbor. The resulting framework for determining regulatory compliance with the SMS for areas within a proposed SIZ uses comparisons between invertebrate populations on areas treated with imidacloprid to those on untreated control sites. Ecology finalized the protocol in 2012 and has used it consistently since. This protocol was developed by Ecology, not by WGHOGA, and it explicitly understood that many of the comparisons would involve non-statistical comparisons between treatment and control sites when statistical tests (e.g., t-tests) would not be valid, as discussed in Appendix E of the FEIS. Hence, reference in the Rogowski memo that "Ecology has determined that the results of benthic abundance monitoring as proposed cannot be used to show that the proposed discharge would pass a benthic abundance test (TerraStat, January 2, 2018; FSEIS 2018)" is both factually wrong, and appears to depend, in part, on an analysis conducted in January 2018 that was never disclosed to the public. While inferring intent always involves some speculation, we have concluded that this claim is a *post hoc* attempt to discredit the extensive on-plot invertebrate data collected in 2011, 2012, and 2014, and Ecology's prior determinations that these trials meet the minor effects standard of the SMS of the state.

Because those results, and Ecology's determination that they meet the requirements of the SMS, are both overwhelming, and unambiguous. Data from a large number of field trials investigating the effects of imidacloprid on invertebrates are available thanks to the work of investigators from WGHOGA, Washington State University, University of Washington, the Pacific Shellfish Institute, and also thanks to considerable work and effort by Ecology's own staff. Ecology's FSEIS and B. Rogowski's memo both try to justify a decision to deny WGHOGA's permit based on effects to invertebrates, and both make much of "uncertainty" about the effects of imidacloprid on these animals. Yet with eight experimental trials involving hundreds of acres of imidacloprid treatments, work conducted under scientific protocols reviewed and approved by Ecology, and using methods were explicitly designed to apply imidacloprid in locations, amounts, and methods similar to those being proposed by WGHOGA to control burrowing shrimp, a claim of uncertainty is only scientifically credible if the results of those eight field trials are confusing and ambiguous.

And that is certainly not the case. In seven of the eight trials the same result was observed: any effects of imidacloprid to invertebrates on the treated areas was minor, localized, and short-term. Ecology's own scientific expert who reviewed all data from the 2011, 2012, and 2014 trials (Jason Landskron) is on record as concluding that a treatment effect of imidacloprid, that is documentation that impacts to invertebrates exceeded the minor effects standard of the Sediment Impact Zone portion of the SMS, did not occur in these seven trials. Given this, as well as work in the FEIS, Ecology expressly concluded that these seven trials met the requirements of the Sediment Management Standards of the state. Ecology summarized the results of this work concisely in response to comments in the FEIS:

> ***To date experimental trials of imidacloprid have not shown significant impacts to non-target organisms. Sampling results have not exceeded the "minor adverse impacts" level in all but one sampling event. Testing data has shown that significant impacts have not been observed on the treated beds, and therefore won't be seen on or around the treated beds.***
>
> ***The overriding weight of evidence indicates that imidacloprid treatment will not significantly impact the endemic species or the ecology of these waters, and will not significantly impact human health.***

These field trials are the best possible test of the real-world effects of the treatment of burrowing shrimp being proposed by WGHOGA. They demonstrate, conclusively, that on-plot invertebrate populations do not exhibit impacts from imidacloprid exposure that makes those populations substantially different than those on control areas not treated with imidacloprid. Given these field data, laboratory studies in aquaria using static concentrations of imidacloprid on a single type of animal are at best a secondary indicator of potential impacts, and at worst, are not relevant at all, particularly given the exposures times of most such studies exceed those expected in the field by a minimum of 6-fold (24 hours exposure in the lab versus 2-4 hours on-plot) and up to 168-fold (28 days in the lab versus 2-4 hours). We are aware of only one laboratory study that tried to mimic the short exposure times that on-plot invertebrates would experience (Patten and Norelius 2017), and Ecology largely ignored the results of that study which showed that very high concentrations of imidacloprid (e.g., 500 ppb) were required to produce even sub-lethal effects.

The Draft SEIS, in reviewing all available data, including new scientific literature published since the EIS was finalized, repeatedly came to this conclusion about the effects of imidacloprid on invertebrates: "impacts are expected to be localized and short-term." And while the draft SEIS acknowledged that the results for the 2011 Cedar River trial did lead to a conclusion that imidacloprid had affected 2 of the 9 invertebrate metrics tested (polychaete abundance, crustacean abundance), the recognition of the unique conditions of that trial, including particularly large differences between treatment and control plots before application of imidacloprid, and high organic carbon levels in the sediments, led Ecology to view this trial as cautionary, rather than as an indicator of what could be expected with imidacloprid in other areas.

All of that interpretation changed with Ecology's publication of the FSEIS. Numerous text changes, evident in comparisons between the DSEIS and FSEIS, show where Ecology changed the language to convert a conclusion of no impact or limited impact, to a conclusion of a larger impact, or confusingly, a conclusion of scientific uncertainty. No reference to the public comments on the DSEIS is provided to justify these changes, and no new studies are offered that Ecology had not already reviewed in its development of the DSEIS. Thus, no scientific justification for either referencing the 2011 Cedar River study as the definitive result on the effects of imidacloprid on invertebrates, or for the 100+ language changes to increase the negative outlook on imidacloprid in the FSEIS are offered. Without a basis in new information provided by the public, or some other new study not evaluated in the DSEIS, these changes are not due to "new science about imidacloprid" as Ecology has claimed in its press release announcing the tentative denial of WGHOGA's permit.

Separately, in both the DSEIS and FSEIS Ecology references potential impacts to invertebrates in off-plot areas not directly treated with imidacloprid as follows: "impacts could extend to off-plot areas, particularly those closest to the treated plot that would be exposed to the highest concentrations of imidacloprid as it is carried off-plot." The 2011, 2012, and 2014 field trials support this conclusion. But those trials also strongly support the conclusion that where off-plot impacts do occur, they too will be localized and short-term, and that they will not lead to impacts that exceed the requirements of the SMA standards of the state. On-plot invertebrates are exposed to high levels of imidacloprid, as noted in the FSEIS, and that high imidacloprid exposure persists for 2-4 hours until the rising tidewaters (treatments are done at low tide) cover the treated areas and dilute any imidacloprid that is present. Off-plot areas, by contrast, are exposed only to a transient plume of imidacloprid as it is carried off the treated areas. Not all off-plot areas are exposed, only those in the plume coming off the plot. And invertebrates at any given location will experience rapidly diluting concentrations of imidacloprid, as the tidewaters rise 2-2.8 centimers/minute on the incoming tide. So, if, as shown in the 2011, 2012, and 2014 trials, invertebrate impacts on-site are short-term and meet the criteria of the SMS, so by extension do any off-plot invertebrates exposed to imidacloprid. Ecology's conclusion that each acre treated with imidacloprid will result in significant effects to invertebrates on 8 acres (FSEIS) or 5 acres (B. Rogowski memo) off-plot are, accordingly, scientifically unsupportable.

The Rogowski memo claims that WGHOGA's proposed permit does not meet the Sediment Impact Zone (SIZ) requirements of the Sediment Management Standards (SMS) of the state because it will violate the requirement "that the discharge shall not have an adverse effect to biological resources within the sediment impact zone above a minor adverse effects level" (B. Rogowski, memo of April 4, 2018, page 3). This is factually incorrect, as evidenced by both the scientific data, and Ecology's own written correspondence.

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Washington Department of Ecology (Ecology), Water Quality Program. 2018. Final Supplemental Environmental Impact Statement for Control of Burrowing Shrimp using Imidacloprid on Commercial Oyster and Clam Beds in Willapa Bay and Grays Harbor, Washington. Publication 18-10-002. Olympia, WA. 886 pages.

SQS Outside the SIZ - Water

Ecology states that one of the two reasons WGHOGA's proposed permit does not meet the Sediment Impact Zone (SIZ) requirements of the Sediment Management Standards (SMS) of the state is that the proposed use of imidacloprid cannot meet the requirement "that the discharge shall not result in a violation of the SQS [Sediment Quality Standards] outside of the SIZ" (B. Rogowski, memo of April 4, 2018, page 3). The term "outside of the SIZ" is important as standards for the SMS and SQS are different for areas inside a SIZ and outside a SIZ. With respect to WGHOGA's permit, the SIZ would be those areas treated with imidacloprid to control burrowing shrimp, areas commonly referred to as "on-plot" in the scientific studies that have been done with imidacloprid in Willapa Bay. All other areas would be outside of the SIZ, areas commonly referred to as "off-plot" in the scientific studies that have been done.

No quantitative standard for assessing whether an impact outside of the SIZ exists. As for areas within the SIZ, the state's SMS do not define criteria for a maximum acceptable chemical concentration of imidacloprid outside the SIZ. And no data on invertebrates in off-plot areas are available with which to pursue the "maximum biological effects level" pathway of the SMS to determine compliance with the SQS.[2]

Instead, Ecology has made an *ad hoc* decision to use EPA (2017) developed criteria for toxicity of imidacloprid in water to determine if violations of the SQS would occur off-plot. The first part of this analysis by Ecology involved comparing a criterion for acute toxicity from EPA to the concentration of imidacloprid in off-plot water quality samples taken on the day imidacloprid was applied to areas of Willapa Bay as part of the field trials in 2012 and 2014. The analysis here focuses on this first evaluation by Ecology. A second evaluation, using data on imidacloprid in off-plot sediments, was also conducted by Ecology. We detail elsewhere that there is no evidence that imidacloprid in off-plot sediments will result in toxicity to invertebrates in these areas.

Ecology claims that treatment of burrowing shrimp with imidacloprid will result in significant effects to invertebrates in off-plot areas due to exposure to imidacloprid in water (e.g., B. Rogowski, April 4, 2018 memorandum, page 7). This conclusion is not based on any data demonstrating impacts to off-plot invertebrates. Instead, it is based on an assessment of past monitoring data measuring how far off-plot imidacloprid has been detected, and the concentrations in those locations. These concentrations are then compared by Ecology to an acute toxicity criterion for saltwater invertebrates published by EPA in its 2017 Risk Assessment of imidacloprid (EPA 2017). Because off-plot water concentrations of

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[2] Patten and Norelius (2017) include data on Dungeness crab impacts from imidacloprid exposure in off-plot areas. But almost all of their data were collected on lands that would be included in the SIZ of future imidacloprid applications under the proposed permit, and in any case the data lack the comparison to controls necessary to make the quantitative comparisons required by Ecology's methodology to assess whether effects exceed the minor effects standard of the SMS.

imidacloprid have been detected at concentrations above the EPA criterion, Ecology concludes mortality and sub-lethal impacts to invertebrates will occur off-plot. Specifically, they say their modeling indicates "the area exposed to levels exceeding the EPA acute marine biological endpoint for imidacloprid off plot is greater than five times the size of the spray plot location" (B. Rogowski, page 8). Ecology specifically concludes that invertebrates in any off-plot area that are exposed to water containing imidacloprid at levels above this EPA endpoint are expected to experience toxicity.

This approach to assessing off-plot impacts, and the resulting conclusion that off-plot impacts to invertebrates will occur, is scientifically flawed for a variety of reasons:

7. Ecology's conclusion is based on inference, not actual data documenting that off-plot impacts to invertebrates occur.
8. Ecology ignores that the off-plot water measurements of imidacloprid taken during the 2011, 2012, and 2014 field trials are not representative. Samples were selectively taken to maximize the likelihood that imidacloprid would be detected.
    a. Researchers did directional sampling, following tidal waters as they flowed off the plots, or drainage channels leading off the plots. Although this directional sampling confirmed that there are plumes of imidacloprid in select areas, or in drainage channels adjacent to plots, these data do not define the total area exposed, or the average concentrations of imidacloprid off-plot organisms not in those sampled plumes are likely to experience.
    b. The sampling methodology for water samples was to collect only the leading edge of the rising tide, with no additional samples as the tidal depth increased. These samples are an instantaneous measure of imidacloprid concentrations in the leading edge of the rising tidewaters. This sample type was selected in the sampling design reviewed and approved by Ecology because such samples were expected to have the highest concentrations of imidacloprid, off-plot.
    c. So off-plot data on imidacloprid concentrations in water are not representative of average conditions expected off-plot. Off-plot water sampling was not designed to define average conditions, rather it was designed to identify the maximum distance imidacloprid could be detected off-plot, and the highest concentrations experienced at those distances.
9. Ecology ignores the effects of tidal dilution in reducing off-plot toxicity to invertebrates.
    a. Ecology's use of the imidacloprid concentrations observed in off-plot water samples to assess effects to invertebrates is scientifically flawed. It ignores that invertebrates at any given off-plot location will experience rapid and significant dilution in imidacloprid concentrations due to increasing water depth from the incoming tide.
    b. At any given off-plot site, the water depth is expected to increase by 2-2.8 centimeters/minute once the leading edge of the tide reaches that location (Felsot and Ruppert 2002, Patten and Norelius 2017).
    c. The water sampling methodology used to collect the samples Ecology analyzed requires about 5 cm of depth (i.e., the advancing waters of the tide must be about 5 cm deep: Hart Crowser 2013). If we call this moment the water samples were taken time 0, and

using the more conservative rate of depth increase of 2 cm/min, the depth at any location would double to 10 cm in 2.5 minutes, then double again to 20 cm in 7.5 minutes, 40 cm in 17.5 minutes, 80 cm in 37.5 minutes, and 160 cm in 77.5 minutes. Thus, the water depth at each location where an off-plot water sample was collected would double in 2.5 minutes, increase 4-fold in 7.5 minutes, 16-fold in 37.5 minutes, and 32-fold in about an hour and 15 minutes.

d. All of this extra water at a given water sampling location will, of course, dilute the imidacloprid that is present. On a volumetric basis the dilution would be very large, but even if tidal waters that follow the leading edge of the tide continue to contain some imidacloprid, an invertebrate present at the sampling location will experience a rapidly declining concentration of imidacloprid, and therefore a rapidly declining potential for toxic effects.

e. Felsot and Ruppert (2002) repeatedly sampled water at fixed, off-plot locations, from the leading edge of the rising tidewaters, until the water depth (80 cm) was too deep to sample (about 40 min). They found that imidacloprid levels were not detectable 15-30 minutes after first arrival of the leading edge of the tide, despite using two times more imidacloprid for their trial than was proposed by WGHOGA or used in the 2011, 2012, and 2014 field trials (1 pound active ingredient/acre vs 0.5 lbs a.i./acre).

f. Ecology in the FSEIS acknowledges that rising tidewaters will lead to dilution, but nowhere in the FSEIS or Rogowski memo is there a specific analysis of how this dilution would modify imidacloprid exposure or toxicity to invertebrates in off-plot locations.

g. Ecology also does not provide an analysis of how exposures to imidacloprid in off-plot locations compare to those of on-plot areas where imidacloprid was directly applied to sediments, and no dilution occurred for 2-4 hours after treatment. Lacking any comparison in the magnitude or duration of exposure in off-plot versus on-plot areas Ecology would have difficulty using the on-plot invertebrate data to infer or estimate off-plot effects if it had been interested to do so.[3]

10. Ecology misapplies EPA's 2017 criterion in its analysis of off-plots impacts to invertebrates.

    a. EPA (2017) defined "acute" exposure to mean an organism is exposed to imidacloprid for 24-96 hours. Studies of less than 24 hours exposure were excluded from consideration by EPA.

    b. Ecology ignored this basic limitation of EPA 2017. Instead, for off-plot impacts to invertebrates they assumed that any area instantaneously exposed to imidacloprid concentrations greater than the "EPA toxic endpoint" (Ecology's terminology) would experience biological impacts.

    c. The scientific study EPA used to set the "acute toxicity value" for saltwater invertebrates (Ward 1991) was a 96 hour trial.

        i. Ward (1991) determined the LC_{50}, for a mysid or opossum shrimp (*Mysidopsis bahia*, now *Americamysis bahia*). This species is commonly used in laboratory

[3] Fortunately, as detailed elsewhere, analysis of on-plot invertebrate data by Ecology consistently found that imidacloprid treatments were in compliance with the SMS and SIZ. By extension, and as discussed below, off-plot invertebrate data would, if collected, also have shown such compliance.

toxicity testing. The LC_{50} was the concentration that killed 50% of test organisms after 96 hours of exposure to a constant concentration of imidacloprid

ii. The 96 hour LC_{50} was 33 parts per billion (ppb) of imidacloprid.

iii. Ward (1991) found no mortality after 96 hours at 31.9 ppb in one of the two experiments, and no mortality after 96 hours at 13.3 ppb in a second experiment. He concluded a value of 13.3 ppb constituted the 96 hour No Observed Effects Concentration (NOEC) for imidacloprid, meaning neither toxicity or sub-lethal effects were observed at the concentration.

d. EPA accepted the LC_{50} value of 33 ppb as the acute toxicity value for exposure to imidacloprid lasting 24-96 hours. EPA then divided this value by 2 (technically applied a Level of Concern of 0.5) to develop a 16.5 ppb "risk presumption category" called "Acute Risk."

   i. Acute Risk is defined as "potential for acute risk to non-target organisms which may warrant regulatory action in addition to restricted use classification" (emphasis added; EPA 2017, page 85)

   ii. The risk presumption category is equivalent to another common toxicology term, the threshold of concern: it does not identify the level at which toxicity occurs, rather it indicates a level at which concerns about toxicity are triggered.

e. Ecology inappropriately used the risk presumption category value of 16.5 to estimate toxicity to invertebrates in off-plot areas, instead of the correct toxicity value of 33 ppb.

f. Ecology also ignored that both the toxicity value and the risk presumption category value apply to exposures of 24 hours or more.

g. Ecology also ignored that EPA's underlying study used to determine the toxicity value and the risk presumption category value (Ward 1991) involved continuous exposure to fixed concentrations of imidacloprid for 96 hours. By contrast, as noted above, off-plot areas experience a continually decreasing concentration of imidacloprid due to rapid dilution by the incoming tide.

h. Ecology ignored data in a study it included in the SEIS (Patten and Norelius 2017) that did look at the effect of short-term exposures of imidacloprid. The authors worked on planktonic and juvenile forms of Dungeness crab, looking for tetany (a sub-lethal effect involving temporary paralysis) and mortality due to imidacloprid exposure. They found:

   i. No effects on planktonic crab exposed to 100 ppb imidacloprid for 2 hours, or in juvenile crabs, for 24 hours.

   ii. No effects on either type of crab exposed to 500 ppb for 10 minutes

   iii. Crab exposed to 12,500 ppb for 20 min recovered once exposure to imidacloprid ended.

   iv. No difference in molting rates of crab exposed to up to 2,500 ppb for 2 hours compared to crab not exposed to imidacloprid.

i. Ecology also ignored the data in Patten and Norelius (2017) that examined how dilution in imidacloprid concentrations, like that expected in off-plot areas due to incoming tidewaters, affected tetany and mortality in Dungeness crab. They conducted a trial with imidacloprid as follows:

i. Exposure to 500 ppb for 4 minutes. This is approximately 3X higher than the average imidacloprid concentration they have measured on-plot or adjacent to plots using Ecology's water quality sampling protocol (e.g., at the leading edge of the tidal waters).
ii. Exposure to 250 ppb for the next 4 minutes
iii. Exposure to 125 ppb for the next 8 minutes
iv. Exposure to 65 ppb for the next 16 minutes
v. Exposure to 32 ppb for the next 32 minutes
vi. Exposure to 16 ppb for the next 72 minutes
vii. Exposure to 8 ppb for the remaining 360 minutes until a total of 6 hours of exposure to imidacloprid was reached.
viii. The authors found no tetany or mortality in any crab exposed to imidacloprid in this trial.

j. Ecology misrepresents off-plot concentrations of imidacloprid, emphasizing extreme values and failing to present average values observed in these datasets (e.g., B. Rogowski, April 4, 2018 memo, page 7).
   i. Data on average concentrations off-plot were available, and should have been presented
      1. Patten and Norelius (2017), report that the average value of imidacloprid in water at or adjacent to treated plots was 170 ppb (128 samples total). Given this average is for water located on or immediately adjacent to treated plots, it should represent the maximum average expected in off-plot areas.
      2. Data presented in Grue and Grassley (2013, included in FSEIS) on results of off-plot monitoring in 2011 in Willapa Bay can be used to develop average off-plot concentrations. Across the 45 samples they took the average off-plot concentration was 55.1 ppb (Attached Table 1). Only 5 of these (11 percent) exceeded 200 ppb.
      3. Felsot and Ruppert (2002) report average imidacloprid concentrations in water of 0.5-17.7 ppb 15 meters from treated plots, and 1-13.2 ppb 152 meters from treated plots.
   ii. These average concentrations are much lower than the high concentrations selectively cited in Ecology's SEIS and B. Rogowski's memo. Data from these studies demonstrate that most off-plot areas will experience no imidacloprid in areas not within the plumes or drainage channels coming off of treated plots, and only modest concentrations of imidacloprid when they are located in those plumes/channels.

k. Ecology cites Patten and Norelius (2017) as support for their conclusion that off-plot impacts will occur to planktonic forms of Dungeness crab (e.g., FSEIS page 1-31).
   i. As with their more general analysis of off-site impacts to invertebrates, Ecology provides no data to document off-plot effects to planktonic crab. Instead, they

again assume toxicity anywhere the EPA acute risk presumption category level of 16.5 ppb is instantaneously exceeded.

ii. Patten and Norelius provide no data to support Ecology's use of 16.5 ppb to infer impacts to planktonic forms of Dungeness crab. The authors instead report sub-lethal effects in planktonic crab only at much higher levels of imidacloprid exposure.

l. Ecology cites Osterberg et al. (2012) as support for their conclusion that off-plot impacts will occur to planktonic forms of Dungeness crab (e.g., FSEIS page 1-31).

i. No specific data or findings from the study are presented by Ecology to support their contention.

ii. This study was excluded by EPA 2017 in its determination of toxicity values to marine invertebrates because it failed their data quality standards, and was therefore deemed a "qualitative" study rather than a quantitative one.

iii. Even if Osterberg et al. had been used, it's estimated toxicity values were much higher than Ward 1991. The 24 hour LC50 reported by the authors was 312 ppb for planktonic blue crab, and 817 ppb for blue crab juveniles when they used commercial formulations of imidacloprid (i.e., same as would have been used by WGHOGA under their proposed permit).

iv. Osterberg et al. also reported an LC_{50} for planktonic blue crab of 10 ppb (again after 24 hours of exposure) in one of their trials using reagent grade imidacloprid. However, these results are irrelevant because WGHOGA would not be able to obtain or use this analytically pure form of imidacloprid that lacks stabilizers, wetting agents and other ingredients that are present in commercially available imidacloprid. Notably, the LC50 for juvenile blue crab using analytic grade imidacloprid was 1,112 ppb, or more than the LC50 using commercially available forms. Inconsistencies like this likely explain why EPA chose not to use this study in its Risk Assessment (EPA 2017).

11. Ecology ignores results from studies in 2011, 2012, and 2014 evaluating effects to invertebrates following on-plot exposure to imidacloprid[4].

a. Extensive invertebrate data evaluating the effects of imidacloprid on invertebrates are available for on-plot areas (i.e., from the 2011, 2012, and 2014 field trials in Willapa Bay), whereas no such data are available for off-plot locations.

b. Both the FSEIS and Rogowski memo consistently discuss that on-plot concentrations of imidacloprid are much higher than those off -plot. For example:

This set of samples [2014 Nisbet Plot] *documented a decrease in imidacloprid concentrations with distance as follows: on-plot = 290 ppb, 62 meters = 0.55 ppb, 125 meters = 0.14 ppb, 250 meters = not detectable, 500 meters = 0.066 ppb, and shoreline = not detectable.* (FSEIS page 3-14)

[4] An extensive analysis of imidacloprid effects on-plot (i.e., in WGHOGA's proposed SIZ) is provided elsewhere. The material presented here repeats some of the main conclusions of that analysis.

c. As noted above, on-plot invertebrates are directly exposed to imidacloprid, and this imidacloprid is not diluted for 2-4 hours. So on-plot invertebrates experience both higher concentrations of imidacloprid and for longer durations.
d. Yet despite higher concentrations and exposures, Ecology has consistently concluded that tests evaluating the effects of imidacloprid to on-plot invertebrates meet the minor effects standard of the SMS. For example:

> *To date experimental trials of imidacloprid have not shown significant impacts to non-target organisms. Sampling results have not exceeded the "minor adverse impacts" level* [of the SMS] *in all but one sampling event. Testing data has shown that significant impacts have not been observed on the treated beds, and therefore won't be seen on or around the treated beds. (FEIS 2.8.3.5).* (FEIS page 360, Appendix F, page F-13)

e. If lower imidacloprid concentrations and exposure times do not lead to significant negative effects on invertebrates on-plot, then by reasonable scientific inference they would not lead to significant negative effects in off-plot areas where invertebrates are exposed to lower concentrations, and for much shorter exposure times.

Summary: Ecology claims use of imidacloprid to treat burrowing shrimp will lead to off-site exposure of invertebrates from imidacloprid at levels that will cause biological impacts. Given these presumed impacts, Ecology goes on to speculate that planktonic lifeforms could also be affected by off-plot concentrations of imidacloprid in water, and that reductions in large invertebrates from this exposure could impact fish and birds by reducing the available food base available to them. Ultimately, as noted in the Rogowski memo, Ecology concludes WGHOGA's proposed permit does not meet a Sediment Impact Zone (SIZ) requirement of the Sediment Management Standards (SMS) "that the discharge shall not result in a in a violation of the SQS [Sediment Quality Standards] outside of the SIZ" (B. Rogowski, memo of April 4, 2018, page 3).

Recalling that the SIZ under WGHOGA's proposed permit would include any area directly treated with imidacloprid to control burrowing shrimp, the area referred to by Rogowski as "outside of the SIZ" means areas that are not directly treated, that is, areas uniformly referred to as "off-plot" areas in prior scientific work in Willapa Bay. The only way off-plot areas will be exposed to imidacloprid under the proposed permit is through rising tidewaters carrying imidacloprid from treated areas to non-treated areas. This movement of imidacloprid from treated areas to non-treated areas could lead to exposure to imidacloprid in either the tidewater itself, or in sediments that absorb some imidacloprid from those waters as they pass over them. The analysis here has examined Ecology's assessment of the first of these two exposure pathways, through imidacloprid contained in tidewaters moving off-plot.

As shown above, Ecology has failed to demonstrate that off-plot impacts to invertebrates will occur from water-based exposures. They do not provide any data on invertebrates or other biological communities to conclusively demonstrate that off-plot impacts occur, except for a small dataset from Dungeness crab surveys reported by Patten and Norelius (2017) for areas immediately adjacent to treated plots (close enough that the observed crabs likely came from on-plot areas). Instead Ecology uses an intellectually simplified process to infer off-plot effects: wherever imidacloprid occurs off-plot at concentrations that exceed criteria in EPA (2017), biological impacts are deemed to have occurred.

This line of reasoning fails scientifically because:

1. The water quality samples Ecology discusses were, by experimental design, taken in locations and ways that maximized the chance that imidacloprid would be detected, and that the concentrations observed would be the maximum for each of those off-plot locations. The off-plot water quality samples were not taken to provide data on representative off-plot exposures.
2. Ecology failed to provide any data on average imidacloprid exposures in off-plot areas, instead selectively citing extreme values. This misrepresents the potential exposures to imidacloprid in water in off-plot areas under WGHOGA's proposed permit.
3. Ecology ignored the effects of tidal dilution in reducing imidacloprid exposure in off-plot areas.
4. Ecology used the wrong acute toxicity value from EPA (2017) to evaluate potential off-plot impacts.
5. Even if Ecology had used the correct EPA acute toxicity value, EPA intended that value to apply to exposures of 24-96 hours, but off-plot areas are not exposed to imidacloprid in tidewaters for 24 hours or more.
6. The toxicity standard Ecology used to assess potential off-plot impacts was obtained by EPA from a study (Ward 1991) that examined imidacloprid toxicity over 96 hours, yet Ecology applies this standard to off-plot imidacloprid exposures lasting 15-30 minutes.
7. The toxicity standard Ecology used to assess potential off-plot impacts was 16 ppb. The Ward (1991) study from which this 16 ppb standard is derived reported that no mortality or even sub-lethal effects were noted at 13.3 ppb over 96 hours of exposure (i.e., reported a 96 hour NOEC of 13.3 ppb).
8. Ecology ignored data in the FSEIS demonstrating that short-term toxicity to imidacloprid is 31 times greater than the EPA derived toxicity standard they used when tidal dilution in off-plot areas is accounted for.
9. EPA failed to discuss the extensive datasets and analyses of on-plot effects to invertebrates, or the Department's repeated conclusion that despite much higher exposures to imidacloprid, and for longer durations than in off-plot locations, invertebrates in treated areas were generally indistinguishable from those on control areas that were not exposed to imidacloprid.
10. Ecology failed to extrapolate the results of the on-plot studies of imidacloprid on invertebrates to invertebrates in off-plot areas, either as a whole, as with appropriate consideration of the reduced exposure times and concentrations invertebrates in off-plot areas experience.

For the many reasons noted above, Ecology's conclusion that WGHOGA's proposed permit does not meet SQS standards outside the SIZ due to water-based exposure to imidacloprid is not supported by accurate or credible analyses of the existing science. Instead, the existing science strongly supports the conclusion that invertebrates in off-plot areas will experience at most only localized, short-term effects that are indistinguishable from the extensive spatial and temporal variation in invertebrate communities in Willapa Bay and Grays Harbor that Ecology has noted in its FEIS and FSEIS documents. By extension, Ecology's conclusions that lethal and sub-lethal impacts could occur to off-plot animals, and that impacts to off-plot invertebrate communities could lead to indirect impacts to birds and fish that feed on these invertebrates, are not scientifically supported.

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Table 1: 2012 Off-Plot Sediment Water Data from Grue and Grassley 2013

Non-detects Replaced with LOQ (0.02 ppb), Drainage Channel Data Excluded, Distance from Plot Added

Matrix	Site	Treatment	Sampling	Day	Sample Point	Distance from Plot	Imid Conc (ppb)
Water	Leadbetter	Mallet®	Spray	Day	1	480	0.02
Water	Leadbetter	Mallet	Spray	Day	3	240	0.02
Water	Leadbetter	Mallet	Spray	Day	5	120	0.02
Water	Leadbetter	Mallet	Spray	Day	7	60	0.02
Water	Leadbetter	Mallet	Spray	Day	8	60	0.02
Water	Leadbetter	Mallet	Spray	Day	10	60	6
Water	Leadbetter	Mallet	Spray	Day	14	60	2.7
Water	Leadbetter	Mallet	Spray	Day	17	60	5
Water	Leadbetter	Mallet	Spray	Day	18	60	9.2
Water	Leadbetter	Mallet	Spray	Day	19	60	0.46
Water	Leadbetter	Mallet	Spray	Day	20	120	1.3
Water	Leadbetter	Mallet	Spray	Day	21	120	1.7
Water	Leadbetter	Nuprid	Spray	Day	10	60	16
Water	Leadbetter	Nuprid	Spray	Day	14	60	11
Water	Leadbetter	Nuprid	Spray	Day	17	60	45
Water	Leadbetter	Nuprid	Spray	Day	18	60	310
Water	Leadbetter	Nuprid	Spray	Day	19	60	170
Water	Leadbetter	Nuprid	Spray	Day	20	120	25
Water	Leadbetter	Nuprid	Spray	Day	21	120	59
Water	Leadbetter	Nuprid	Spray	Day	22	120	260
Water	Leadbetter	Nuprid	Spray	Day	23	240	71
Water	Leadbetter	Nuprid	Spray	Day	24	240	59
Water	Leadbetter	Nuprid	Spray	Day	25	240	15
Water	Leadbetter	Nuprid	Spray	Day	26	480	35
Water	Leadbetter	Nuprid	Spray	Day	27	480	0.19
Water	Leadbetter	Nuprid	Spray	Day	28	480	0.094
Water	Palix	Mallet	Spray	Day	7	60	0.26
Water	Palix	Mallet	Spray	Day	8	60	0.31
Water	Palix	Mallet	Spray	Day	10	60	0.66
Water	Palix	Mallet	Spray	Day	14	60	0.02
Water	Palix	Mallet	Spray	Day	17	60	130
Water	Palix	Mallet	Spray	Day	18	60	3.1
Water	Palix	Mallet	Spray	Day	19	60	0.23
Water	Palix	Mallet	Spray	Day	20	120	0.02
Water	Palix	Nuprid	Spray	Day	10	60	1.3
Water	Palix	Nuprid	Spray	Day	14	60	0.02
Water	Palix	Nuprid	Spray	Day	20	120	120
Water	Palix	Nuprid	Spray	Day	21	120	1.4
Water	Palix	Nuprid	Spray	Day	22	120	15
Water	Palix	Nuprid	Spray	Day	23	240	0.02
Water	Palix	Nuprid	Spray	Day	24	240	650
Water	Palix	Nuprid®	Spray	Day	25	240	210
Water	Palix	Nuprid	Spray	Day	26	480	0.043
Water	Palix	Nuprid	Spray	Day	27	480	200
Water	Palix	Nuprid	Spray	Day	28	480	46
						Overall Average=	55.1

SQS Outside the SIZ - Sediment

Introduction: Ecology states that one of the two reasons WGHOGA's proposed permit does not meet the Sediment Impact Zone (SIZ) requirements of the Sediment Management Standards (SMS) of the state is that the proposed use of imidacloprid cannot meet the requirement "that the discharge shall not result in a in a violation of the SQS [Sediment Quality Standards] outside of the SIZ" (B. Rogowski, memo of April 4, 2018, page 3). No quantitative standard for assessing whether an impact outside of the SIZ exists. As for areas within the SIZ, the state's SMS do not define criteria for a maximum acceptable chemical concentration of imidacloprid outside the SIZ. And no data on invertebrates in off-plot areas are available with which to pursue the "maximum biological effects level" pathway of the SMS to determine compliance with the SQS. Instead, to assess off-plot compliance with SQS standards, Ecology has chosen to compare imidacloprid toxicity criteria developed by EPA (2017) to data on off-plot concentrations of imidacloprid in water and sediments. The first part of this analysis by Ecology involved comparing a criterion for acute toxicity from EPA to the concentration of imidacloprid in off-plot water quality samples taken on the day imidacloprid was applied to areas of Willapa Bay as part of the field trials in 2012 and 2014. We detail elsewhere that Ecology's analysis of the effects of imidacloprid in off-plot water fails due to a number of omissions and errors in their work. The analysis here focuses on the second of the two evaluations of off-plot effects by Ecology: potential effects due to invertebrate exposure in off-plot sediments.

The second part of Ecology's analysis involves potential exposure of invertebrates to imidacloprid in the so called "porewater" of sediments. When sediments are exposed to imidacloprid, either directly because they have been treated with this chemical, or indirectly as when imidacloprid in tidal waters passes over sediments in off-plot areas, some imidacloprid can pass into the sediments. Laboratory studies can determine how much of this sediment-based imidacloprid is contained in water that exists between the individual sediment grains, the porewater. The FSEIS and the Rogowski memo cite data on concentrations of imidacloprid that were measured in the porewater of sediments exposed during the 2014 field trial. For example:

> *One day post treatment, concentrations in porewater ranged from 4.7 to 100 ppb, and three of eight samples exceeded the acute marine endpoint of 16.5 ppb, and all samples exceeded the chronic marine endpoint. Although concentrations (range 0.09 to 3.1 ppb) declined over 14 days, 6 of 8 (75%) samples exceeded the EPA chronic marine endpoint of 0.16 ppb. At 28 days post treatment, concentrations (range 0.11 to 1.2 ppb) continued to exceed the EPA chronic marine endpoint in 5 of 8 (63%) samples. No data were collected after 28 days so it is uncertain as to when sediment porewater declined to below the EPA chronic marine endpoint.* (Rogowski memo, page 5).

There are two problems with this porewater analysis by Ecology. First, Ecology is applying EPA's standards for toxicity of imidacloprid in water to concentrations of imidacloprid in sediments. Ecology provides no data or analysis to justify using a water standard for sediments. And EPA (2017) at no point applies its water quality standards to sediments. Imidacloprid in sediment porewater may have different toxicities than in surface water due to a variety of factors such as temperatures, light, binding to dissolved carbon or other substances, etc. Ecology notes none of these scientific uncertainties related to its analysis using the EPA criteria.

The second problem with Ecology's analysis of sediment porewater is that all the results they discuss are from on-plot samples, in the area that would be covered by a SIZ. They provide no information on sediment porewater concentrations outside of the SIZ, and therefore they provide no information on whether imidacloprid in sediments would result in a violation of the "SQS outside of the SIZ" as claimed in the Rogowski memo. As discussed in a separate analysis, Ecology developed a protocol for directly assessing whether the SQS is violated within the SIZ that involves measurements of invertebrate abundance, richness, and diversity on treatment and control plots. So, whether sediment porewater concentrations in the SIZ exceed EPA water quality criteria or not is irrelevant. Ecology has quantitative data on invertebrates for imidacloprid effects within the SIZ, and has concluded in writing, based on these data, that in seven of eight field trials with imidacloprid the minor effects standard of the SQS were not violated. The same is true for comparisons of the EPA criteria with imidacloprid concentrations in surface water in the SIZ, which both the SEIS and Rogowski memo cite; they are irrelevant in determining compliance with the SQS within the SIZ. In any case, and by extension, sediment porewater data from on-plot sediments have no relevance to assessing potential impacts due to imidacloprid in sediment porewater in off-plot areas.[5]

Although Ecology failed to use data on imidacloprid concentrations in sediments off-plot to determine whether the SQS standards would be exceeded, they had a significant database to do so; off-plot sediment porewater studies that were collected as part of the 2012 field trials. These trials were conducted under an Ecology approved Sampling and Analysis Plan (SAP), and the results of the field trials were subsequently reviewed and approved by Ecology. Ecology provides no explanation for why it did not review or analyze these data.

We did review those 2012 data on sediment porewater in off-plot locations, in detail. And although we do not believe that the EPA (2017) water quality criteria can be applied to assess toxicity in sediment porewater, we followed Ecology's approach in doing so. Thus, our results represent what Ecology would have found if they had analyzed the 2012 off-plot sediment porewater data using the same methods they used to assess on-plot porewater data from the 2014 trial.

12. Off-plot sampling of sediments was a major focus of the 2012 field work in Willapa Bay. Off-plot sampling of sediments was done for 4 experimental trials. One trial was done with the liquid form of imidacloprid (Nuprid), and one with the granular form of imidacloprid (Mallet) at each of two locations, referred to as Palix and Leadbetter.

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[5] We find it interesting that the EPA's (2017) acute and chronic criteria for imidacloprid toxicity in water can be exceeded within the SIZ, in surface water and porewater, and yet empirical measures of invertebrate abundance, richness, and diversity show that the SQS minor effects standard is not exceeded. This is good evidence that EPA's criteria are too conservative to accurately assess the effects of imidacloprid in the real-world applications proposed by WGHOGA in their permit application. It also indicates that these water-based toxicity criteria do a poor job of predicting effects based on sediment porewater concentrations of imidacloprid.

13. A systematic sampling design was used on all plots (see attached Figure 1 and Figure 2, from Grue and Grassley 2013)
    a. Nuprid plots involved 18 off-plot sediment sampling locations. Mallet plots involved 22 locations.
    b. In both types of sites three different transects extended from the edge of the treatment plots (see sampling points 17-28 in Figures 1 and 2) in a direction that corresponded to the direction the rising tidewaters followed as they crossed the plot and then traveled off-plot (the "plume"). Samples were taken at various distances along the transect (60 meters, 120 m, 240 m, and 480 m). These samples were designed to maximize both the probability of encountering imidacloprid off-plot, and of measuring the maximum concentrations of imidacloprid in these off-plot locations.
    c. Both types of sites also included sediment samples perpendicular to the plume (see sampling points 10 and 14 in Figures 1 and 2). Although not in the main plume, these "lateral sites" were designed to determine if imidacloprid was also spreading out to off-plot areas outside the plume.
    d. Both types of sites included sampling in drainage channels that carried water off the treated areas at low tide after application of imidacloprid, but before the arrival of the rising tide (see sampling points 29-32 in Figure 1 and 1-8 in Figure 2). One such drainage channel was sampled on each Nuprid site, and two were sampled at each Mallet site (hence the higher total number of off-plot sediment sampling locations on Mallet sites). Samples were taken at various distances along transects that followed along the deepest part of each drainage channel (60 meters, 120 m, 240 m, and 480 m). Although these drainage channels are small in size, and hence do not cover very much off-plot ground, Ecology asked that they be sampled to determine if they were prone to particularly high concentrations of imidacloprid.
14. The sampling protocol that Ecology approved for sampling off-plot sediments (and water) involved using screening criteria based on a literature review of the toxicity of imidacloprid. Specifically, Ecology decided to use a 21-day chronic toxicity standard of 0.6 ppb as the screening criteria for sediment porewater (Hart Crowser 2012).
    a. Ecology concluded that when sediment porewater concentrations of imidacloprid were less than 0.6 ppb toxicity to invertebrates was unlikely.
    b. Further, Ecology concluded that the concentration of imidacloprid in off-plot sediment porewater would be expected to decrease as the distance from the treatment plot increased. This was expected because the further from the treatment plot, the more rising tidewaters would be expected to have diluted any imidacloprid that had been carried off the plot by those tidewaters.
    c. Combining these two concepts, Ecology approved a sampling design in which sediment samples along the transects (including the drainage channel samples) would be analyzed first for those sampling locations closest to the treatment plot. If the porewater concentration of these closest samples exceeded 0.6 ppb, then the next closest sample along the transect would also be analyzed. This process continued for other samples at greater distances as needed until the results for a sediment sample indicated

imidacloprid concentrations of less than 0.6 ppb. Once this result was achieved no additional samples at greater distances on the transect were analyzed for imidacloprid concentrations.

15. The use of screening criteria in the Ecology approved SAP for off-plot sediments resulted in many samples not being analyzed because they were "downstream" of another station that had sediment porewater concentrations of 0.6 ppb or less.
    a. In the 2012 study no off-plot sediment porewater sample, at any distance, had a concentration of 0.6 ppb or more at 14 days after the imidacloprid treatment. Thus, no data are available for off-plot sediment porewater at 28 or 56 days except for a single drainage channel site sampled at 28 days because it was not properly sampled at 14 days (this datum is ignored).
16. Another issue is that Ecology is now using the EPA (2017) water quality criteria for imidacloprid to screen for sediment porewater toxicity, not the 0.6 ppb used to analyze the 2012 trials.
    a. These EPA criteria are 16 ppb[6] for acute exposures lasting 24-96 hours, and 0.16 ppb for chronic exposures lasting from 21-28 days or more.
    b. We assume that Ecology would have applied the EPA acute toxicity criterion to assess the toxicity of off-plot sediment porewater results that were collected 1 day after the imidacloprid treatments, and the chronic toxicity criterion to assess toxicity in the off-plot sediment porewater results collected 14 days and 28 days after the imidacloprid treatments.
17. We analyzed each of the four trials conducted in 2012 separately (e.g., Palix Nuprid trial, Leadbetter Mallet trial, etc.). However, within each trial we combined all off-plot data into a single dataset (i.e., data from the plume transects, lateral sites, and drainage channels were all combined).
    a. We assigned the limit of quantitation for sediment porewater in the 2012 trials (0.04 ppb) to all non-detect (i.e., zero) values in keeping with standard Ecology procedures for treatment of non-detect data.
18. The results of our analysis are included in the Attached Table 1.
    a. The average concentrations of imidacloprid in off-plot sediments a day after imidacloprid treatment were 3.04 ppb (Palix Nuprid trial), 2.39 ppb (Palix Mallet), 7.41 ppb (Leadbetter Nuprid trial) and 0.15 ppb (Leadbetter Mallet trial).
    b. Every single off-plot sediment porewater concentration at 1 day after imidacloprid treatment except 1 was below the EPA acute toxicity criterion (46 of 47 comparisons). The single exception was a value of 64 ppb in a drainage channel at the Leadbetter Nuprid site.
    c. The average concentration of imidacloprid in off-plot sediments 14 days after imidacloprid treatment were 0.09 ppb (Palix Nuprid trial), 0.29 ppb (Palix Mallet), and 0.07 ppb (Leadbetter Nuprid trial). Because no sample 1 day after treatment at the

[6] Elsewhere we explain that the correct threshold for acute toxicity from EPA (2017) is actually 33 ppb, based on a 96 hour study by Ward (1991) used by EPA to set its criterion. However, Ecology has used 16 ppb, or ½ this value. in the FSEIS Although we believe this to be scientifically incorrect, we use the 16 ppb threshold here as we assume Ecology would have done so if they had conducted this analysis.

Leadbetter Mallet trial had a concentration of 0.6 ppb or more, no sampling occurred at this site at day 14.

   d. 78.6 percent of the off-plot sediment porewater concentrations at 14 days after imidacloprid treatment were below the EPA chronic toxicity criterion (22 of 28 comparisons). Note this count includes porewater samples that were below the chronic criterion 1 day after treatment, as we know these samples would have been below the chronic criterion if they had been sampled at day 14.
   e. The reduction in off-plot sediment porewater concentrations of imidacloprid in individual sampling locations between 1 day after treatment and 14 days after treatment ranged from 99.94 percent to 33.33 percent. Averages were 90.15 percent (Palix Nuprid trial), 70.67 percent (Palix Mallet trial) and 96.12 percent (Leadbetter Nuprid trials).

19. These results are strikingly different from those reported by Ecology in the FSEIS and Rogowski's memo for the on-plot sediment porewater samples from the 2014 field trial.
    a. Ecology reports that porewater concentrations on-plot 1 day after imidacloprid application in 2014 ranged from a low of 4.7 ppb to a high of 100 ppb. This low value is higher than 40 of the 47 concentrations (81.1 percent) measured on day 1 in off-plot sediment porewater in 2012.
    b. Ecology reports that 75 percent of the sediment porewater concentrations on-plot 14 days after imidacloprid application in 2014 exceeded the EPA chronic toxicity criterion. Our analysis of sediment porewater concentrations off-plot 14 days after the 2012 imidacloprid applications found almost the exact opposite result: 78.6 percent of the porewater samples were below the EPA chronic criterion.
20. Our results using Ecology's methods to analyze off-plot porewater concentrations show that if Ecology had done this analysis themselves they would have had to conclude that the data do not support a conclusion that SQS standards would be violated in off-plot areas by imidacloprid treatments to control burrowing shrimp.
    a. Only 1 of 47 samples 1 day after treatment exceeded the EPA acute toxicity criterion Ecology is using.
    b. Only 6 of 28 samples 14 days after treatment exceeded the EPA chronic toxicity criterion Ecology is using.
    c. Given the rate of decrease in off-plot imidacloprid concentrations averaged 70.67 to 96.12 percent in the 14 days from day 1 to day 14, it is highly likely the remaining 6 samples would have been below the EPA chronic criterion by day 28, and a virtual certainty that they would have been by day 56 if the sampling protocol had required that samples on those dates be taken.

Conclusions: One of the two reasons Ecology lists for tentatively denying WGHOGA's permit is they have concluded that imidacloprid treatments to control burrowing shrimp cannot meet the Sediment Management Standards requirement "that the discharge shall not result in a violation of the SQS outside of the SIZ" (B. Rogowski, memo of April 4, 2018, page 3). Any location where imidacloprid would be applied to control burrowing shrimp under the proposed permit is, by definition, within the SIZ. So Ecology's basis for denial is that they have concluded that areas outside those treated with imidacloprid will be in violation of the SQS. The only way these "off-plot" areas will be exposed to imidacloprid under the proposed permit is through rising tidewaters carrying imidacloprid from treated areas to non-treated areas. This movement of imidacloprid from treated areas to non-treated areas could lead to exposure to imidacloprid in either the tidewater itself, or in sediments that absorb some imidacloprid from those waters as they pass over them. The analysis here has focused on the second potential pathway for impacts to off-plot areas: exposure to imidacloprid in sediments.

Ecology's FSEIS and the memo supporting a denial determination by Barry Rogowski both present data on the concentration of imidacloprid in the free water between sediment particles, referred to as "porewater." Their analysis is limited to evaluation of the data from the 2014 field trial in Willapa Bay. Ecology's use of these data does nothing to support its conclusion that the SQS will be violated outside the SIZ, because none of these 2014 porewater data were collected from areas that would be outside the SIZ if the permit was operational, that is they were all collected "on-plot." Given the detail of the analysis of these 2014 data presented in the FSEIS and Rogowski memo, it is difficult to understand how Ecology mistakenly used on-plot data as support for the conclusion that the SQS would be violated off-plot.

Ecology's review of the 2014 sediment porewater data had a second problem: they assessed the potential for toxicity in sediments using EPA-derived toxicity criteria for imidacloprid in surface waters. Ecology provides no data or analysis to show that a water quality criterion for imidacloprid toxicity can be used to assess sediment porewater toxicity of this chemical. Indeed, Ecology does not even acknowledge the many unknows associated with using a water quality criterion for analysis of sediments, including such things as differences in temperature, oxygen levels, light, and dissolved substances. Having reviewed the EPA document from which Ecology obtained its water quality criteria (EPA 2017), we can confirm that nowhere in the 250+ page document does EPA ever apply its water quality criteria to sediments or sediment porewater.

Although the 2014 sediment porewater data have no value in determining whether the SQS would be violated outside the SIZ under WGHOGA's proposed permit, Ecology does possess a very extensive set of data that could have been used for such an analysis; sediment porewater collected from off-plot sampling locations during the four field trials of imidacloprid in 2012. Ecology was presented with these data as part of the SAP Field Report for the 2012 field trials (Hart Crowser 2014), as well as in a comprehensive report by the scientific lead for the 2012 sediment field work, Dr. Chris Grue of the University of Washington (Grue and Grassley 2103). The sampling of off-plot sediments was a major focus of the 2012 field trials, which used a systematic distribution of off-plot stations located at distances up to 640 meters (1,575 feet) from the areas being treated with imidacloprid.

We analyzed these 2012 off-plot sediment porewater data using the same approach that Ecology used to analyze the 2014 on-plot data: we compared sediment porewater concentrations to EPA surface water toxicity criteria, using the EPA acute toxicity criterion to evaluate sediment porewater concentrations present 24 hours after application of imidacloprid, and the EPA chronic toxicity criterion for the concentrations present in sediments 14 days after application of imidacloprid. This analysis yielded the following results:

- 97.8 percent of the off-plot porewater samples were below the EPA acute toxicity criterion 1 day after imidacloprid application.
- 78.6 percent of the off-plot porewater samples were below the EPA chronic toxicity criterion 14 days after imidacloprid application.

We also found that the rate of decrease in off-plot imidacloprid concentrations in porewater averaged 70.7 to 96.1 percent in 14 days (i.e., between samples taken 1 day after treatment and those taken 14 days after treatment). Given this rate of decrease we have high confidence that the 21 percent of off-plot samples that exceeded the EPA chronic toxicity criterion would have been below this criterion by 28 days after imidacloprid treatment had they been sampled at that time.

For the reasons noted above, Ecology's conclusion that WGHOGA's proposed permit does not meet SQS standards outside the SIZ due to sediment-based exposure to imidacloprid is not supported by accurate or credible analyses of the existing science. Instead, the existing science strongly supports the conclusion that invertebrates in off-plot areas will experience no effects from imidacloprid in off-plot sediments.

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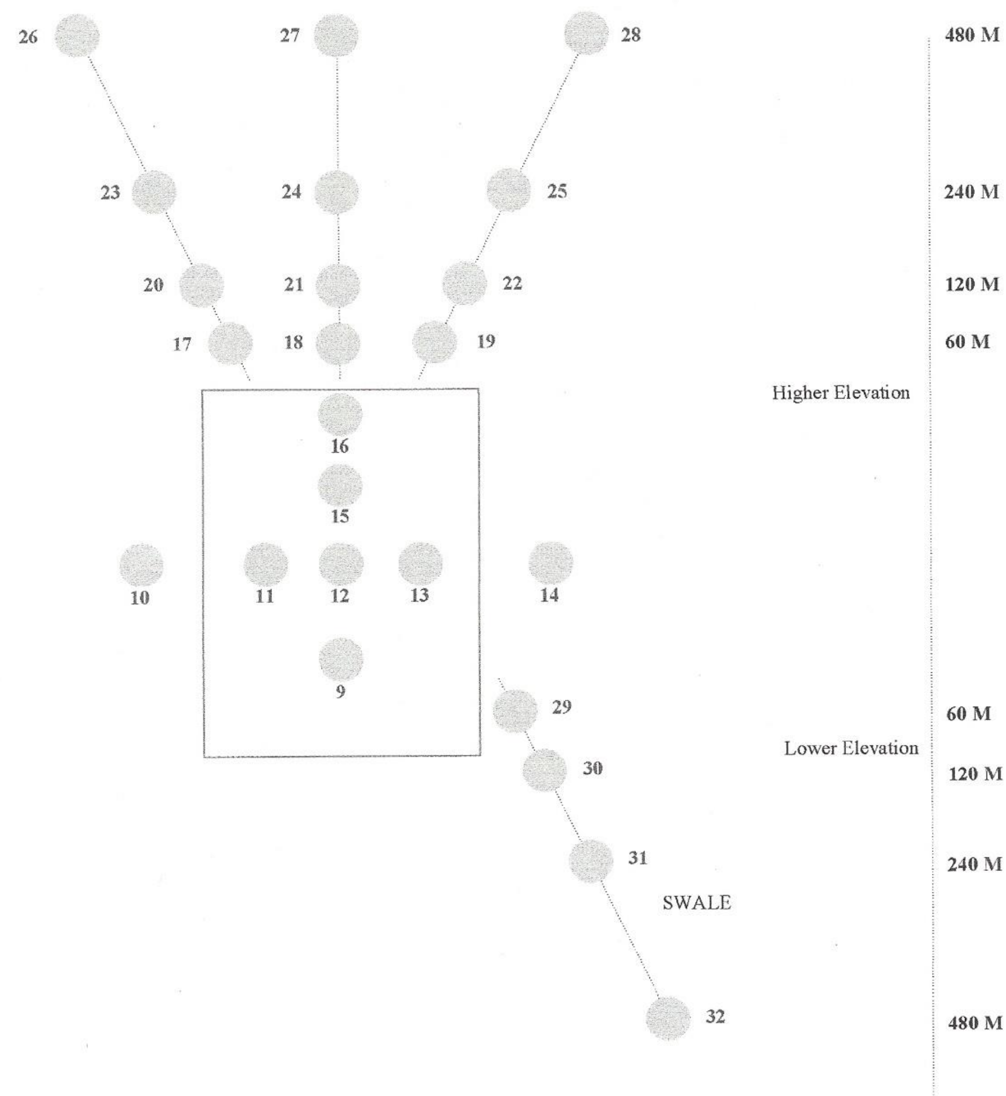
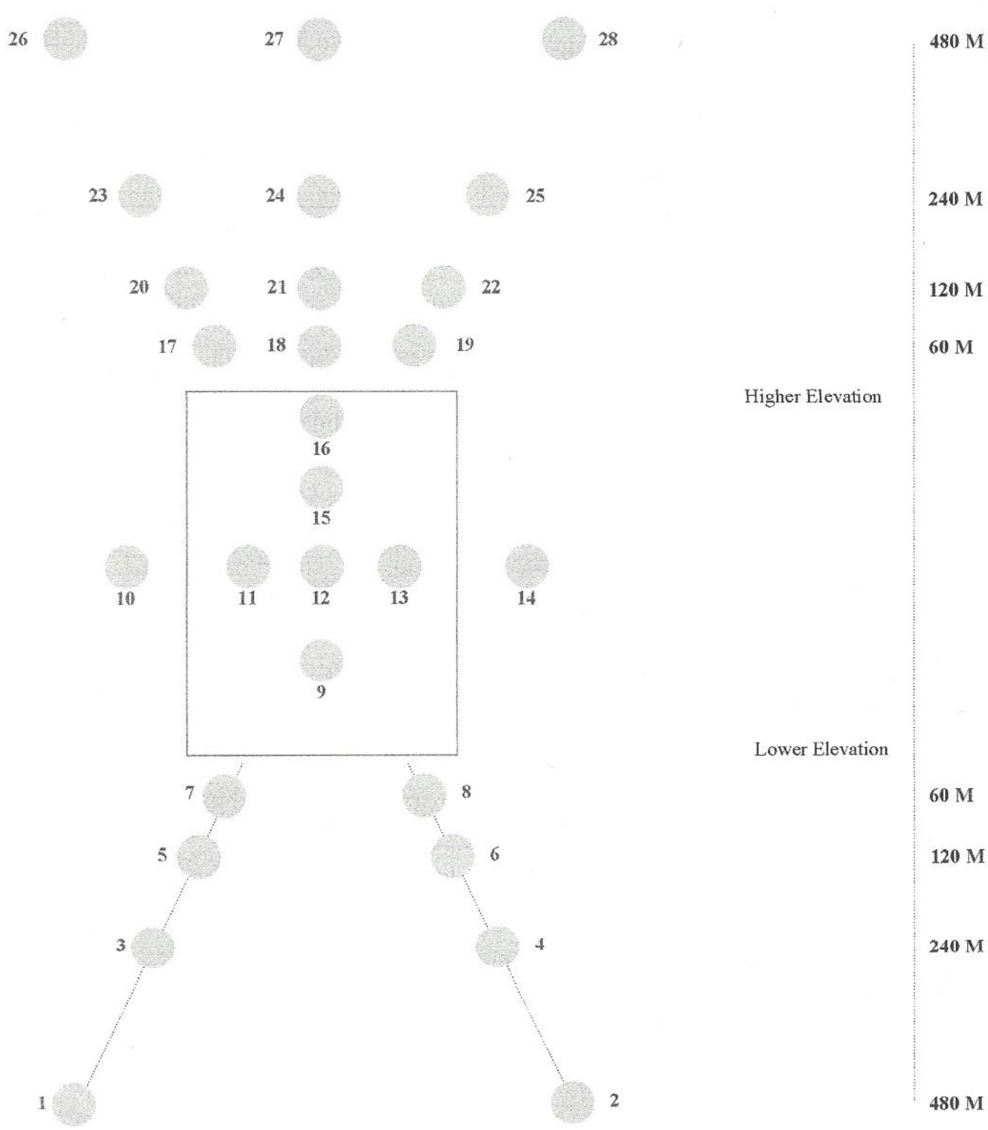
Figure 1. Standardized sampling point locations and numbering system for Nuprid® plots in 2012. Table 2 describes which sampling points were associated with each matrix (water, whole sediment, sediment pore water, and eelgrass).



Shaded circle without concentration values or notes indicate no sample was required under the SAP.
IE = iteratively excluded ND = below detection limit SNC = sample not collected

Figure 2. Standardized sampling point locations and numbering system for Mallet® plots in 2012. Table 3 describes which sampling points were associated with each matrix (water, whole sediment, sediment pore water, and eelgrass).



Shaded circle without concentration values or notes indicate no sample was required under the SAP.
IE = iteratively excluded ND = below detection limit SNC = sample not collected

Table 1: Analysis of Off-Plot Pore Water Data from 2012 Trials

From Grue and Grassley (2013)   LOQ = 0.04, used for all non-detects

Location	Trial	Sample Point	Conc. Day 1 (ppb)	Exceed EPA Acute Criterion?	Conc. Day 14 (ppb)	Exceed EPA Chronic Criterion?	Percent Reduction Day 1-14
Palix	Nuprid	10	3.4	N	0.04	N	98.82%
Palix	Nuprid	14	3.4	N	0.1	N	97.06%
Palix	Nuprid	17	0.55	N	0.3	Y	45.45%
Palix	Nuprid	18	1.8	N	0.04	N	97.78%
Palix	Nuprid	19	1.4	N	0.05	N	96.43%
Palix	Nuprid	21	4.8	N			
Palix	Nuprid	22	4.4	N			
Palix	Nuprid	24	11	N			
Palix	Nuprid	25	1	N			
Palix	Nuprid	27	3.9	N			
Palix	Nuprid	28	0.8	N			
Palix	Nuprid	29	8	N	0.04	N	99.50%
Palix	Nuprid	30	1	N	0.04	N	96.00%
Palix	Nuprid	31	0.1	N		N	
Palix	Nuprid	32	0.08	N		N	
		Average=	3.04		0.09		90.15%
Palix	Mallet	1	0.5	N			
Palix	Mallet	2	0.1	N		N	
Palix	Mallet	3	3.7	N			
Palix	Mallet	4	0.8	N			
Palix	Mallet	5	2.3	N			
Palix	Mallet	6	4.8	N			
Palix	Mallet	7	10	N	0.4	Y	96.00%
Palix	Mallet	8	8	N	0.2	Y	97.50%
Palix	Mallet	10	1.4	N	0.1	N	92.86%
Palix	Mallet	14	1.6	N	0.4	Y	75.00%
Palix	Mallet	17	0.8	N	0.4	Y	50.00%
Palix	Mallet	18	0.2	N	0.1	N	50.00%
Palix	Mallet	19	0.6	N	0.4	Y	33.33%
Palix	Mallet	20	0.5	N			
Palix	Mallet	22	2.5	N			
		25	0.4	N			
		Average=	2.39		0.29		70.67%
Leadbetter	Nuprid	10	0.1	N		N	
Leadbetter	Nuprid	14	0.1	N		N	
Leadbetter	Nuprid	17	0.2	N		N	
Leadbetter	Nuprid	18	0.1	N		N	
Leadbetter	Nuprid	19	0.1	N		N	
Leadbetter	Nuprid	29	1.3	N	0.1	N	92.31%
Leadbetter	Nuprid	30	0.6	N			
Leadbetter	Nuprid	31	64	Y	0.04	N	99.94%
Leadbetter	Nuprid	32	0.2	N			
		Average=	7.41		0.07		96.12%
Leadbetter	Mallet	7	0.04	N		N	
Leadbetter	Mallet	8	0.2	N			
Leadbetter	Mallet	10	0.4	N			
Leadbetter	Mallet	14	0.01	N		N	
Leadbetter	Mallet	17	0.2	N			
Leadbetter	Mallet	18	0.1	N		N	
Leadbetter	Mallet	19	0.1	N		N	
		Average=	0.15				

Totals for Exceedance Acute Criterion= 46 No/1 Yes

Totals for Exceedance of Chronic Criterion= 22 No/6 Yes

Ecological Benefits of Burrowing Shrimp Control

Introduction: Ecology's FSEIS, and the memo prepared by Barry Rogowski to support the tentative decision to deny Ecology's permit, contain numerous references to the potential impacts of imidacloprid on the ecology of Willapa Bay and Grays Harbor. For example, the potential to affect birds and fish through reduction of invertebrates that they feed on is discussed (e.g., FSEIS pages1-9, 3-34), even though the FSEIS acknowledges that direct effects to these animal groups is unlikely due to the extremely low toxicity of imidacloprid to vertebrate animals. The potential for sub-lethal effects to invertebrates across these estuaries is also raised (e.g., FSEIS page 1-45), although data showing any such sub-lethal effects are limited to studies of paralysis (tetany) in Dungeness crab exposed to imidacloprid.

The data show, and we have acknowledged elsewhere, that using imidacloprid to control burrowing shrimp leads to short-term impacts to some non-target invertebrates on-plot. This is hardly a surprise as imidacloprid is toxic to a wide range of invertebrates. What would be a surprise is if imidacloprid, or any chemical for that matter, was toxic only to burrowing shrimp. Fortunately, burrowing shrimp do appear to be particularly susceptible to imidacloprid. Because they live in deep burrows, when imidacloprid causes paralysis (tetany) in them it is believed that they are unable to maintain water currents through their burrows and they suffocate. Invertebrates living on the surface of sediments, or in the shallow parts of those sediments do not share this same vulnerability to suffocation when and if they also experience tetany. We have long believed that the field trial data documenting that imidacloprid treatments do not lead to violation of the minor effects standard of the SMS reflects the reality that many on-plot invertebrates are not killed by the chemical. The presence of many types of larger, non-mobile types of organisms (e.g., clams) 14 days after treatment is hard to explain under the alternate hypothesis that imidacloprid treatments kill most organisms on the areas where it is applied, but that these organisms "recolonize" the treated areas before sampling 14 days or 28 days after treatment. In all likelihood, both mechanisms come into play after an area is treated with imidacloprid to control burrowing shrimp: some organisms are not killed, others recolonize and replace those that were.

If we acknowledge that control of burrowing shrimp leads to impacts to non-target organisms in the areas where it is applied, do these localized impacts have any larger effects to the ecology of Willapa Bay and Grays Harbor? One important indicator that the answer to this question is "No" comes from simple mathematics. As noted in the FSEIS:

> *The 2016 WGHOGA proposal for the use of imidacloprid combined with IPM practices to control burrowing shrimp on commercial clam and oyster beds would authorize chemical applications to up to 485 acres per year within* ***Willapa Bay (1.1 percent*** *of total tideland acres exposed at low tide), and up to 15 acres per year within* ***Grays Harbor (0.04 percent*** *of total tideland area exposed at low tide).* (emphasis added, FSEIS, page 1.6)

When such small areas of a large estuary are going to be treated with imidacloprid it requires quite a stretch to conclude that ecological impacts would extend to the estuary as a whole. For example, Ecology in the FSEIS notes some concerns that reducing burrowing shrimp with imidacloprid could impact species that feed on burrowing shrimp (e.g., FSEIS page 2-20). When 98.9 percent (Willapa Bay) or 99.96 percent (Grays Harbor) of the land area will not be treated to control burrowing shrimp, it is difficult to credibly claim a larger ecological effect from imidacloprid treatments. Even considering all 5 years of WGHOGA's proposed permit, and assuming the full authorized acreage will be treated every year, and that no acre is ever retreated in those 5 years, the total area of the estuaries that would experience burrowing shrimp control would be 5.5 percent of Willapa Bay and 0.2 percent of Grays Harbor[7]. Our experience is that few ecological studies have ever been able to discern an ecosystem level effect due to a perturbation that affected 5 percent of less of the land area involved. Perturbations due to highly toxic and persistent pollutants, such as mercury, can be an exception. But as the FSEIS notes repeatedly, imidacloprid is highly water soluble, it breaks down in the presence of sunlight, and the daily tidal cycle of Willapa Bay and Grays Harbor result in rapid destruction and/or dilution of imidacloprid to levels that are not toxic. Given the simplicity and scientific relevance of an area-based analysis of impacts, we were surprised to see that most discussion of this ameliorating factor in evaluating WGHOGA's proposed permit was deleted in the FSEIS after being discussed in the DSEIS.

Without considering this area-based analysis, Ecology in the FSEIS and the Rogowski memo conclude that imidacloprid treatments could have important consequences to the ecology of Willapa Bay and Grays Harbor. But unsaid in any of their analysis or arguments is what are the effects to the ecology of Willapa Bay and Grays Harbor if burrowing shrimp are left uncontrolled? The FSEIS does acknowledge that oyster farmers in Willapa Bay and Grays Harbor have a lost significant amount of shellfish farm acreage in the past few years and that hundreds more acres are likely to be lost in the next few years. This replacement of oyster beds with burrowing shrimp dominated areas constitutes a change in the type of habitats present in these estuaries. There is a considerable amount of published scientific information with which to predict how this habitat conversion will affect both the types and abundance of invertebrates that are present, and more broadly, how it will affect some key components of the ecology of Willapa Bay and Grays Harbor. Thus, to answer the question "What are the ecological impacts of WGHOGA's proposed use of imidacloprid?" it is necessary to look not just at the absolute effects of those imidacloprid treatments, but also on the relative magnitude of those effects compared to the ecological effects of the habitat conversion from oyster beds to burrowing shrimp habitat that will occur if those imidacloprid treatment are prohibited by Ecology.

A great deal of published scientific information on the effects of burrowing shrimp on the ecology of the land areas it occupies was available to Ecology in the period 2014-2015, when the Department was writing and ultimately published the FEIS for WGHOGA's original permit. Ecology in the FEIS conducted

[7] We acknowledge here that Ecology has claimed off-plot effects to 8 acres (FSEIS) or 5 acres (Rogowski memo) of Willapa Bay and Grays Harbor for every acre treated with imidacloprid. We detail elsewhere why these claims of off-plot impacts are not supported by the available scientific information.

an extensive review and analysis of this literature. Ecology has largely chosen not to reference or discuss this prior review and analysis of the scientific literature in the FSEIS, despite it's relevance to analyzing the larger ecological effects of expanding populations of burrowing shrimp in these coastal estuaries. Nor has Ecology used this information to estimate the specific ecological impacts expected from the conversion from oyster beds to burrowing shrimp dominated areas that will result from denial of WGHOGA's permit.

A quick summary of the scientific literature review in the FEIS on the effects of burrowing shrimp is this: 1) they have profound effects on the physical habitat in which they live, and 2) many of the changes they create result in substantial negative impacts to eelgrass, other types of invertebrates, and to birds and fish:

21. Eelgrass is an extremely valuable component of shoreline marine environments, and its preservation and restoration is a key goal of the state of Washington (see for example https://www.dnr.wa.gov/programs-and-services/aquatics/aquatic-science/nearshore-habitat-eelgrass-monitoring). Ecology's FEIS discusses both the negative effects that burrowing shrimp can have on eelgrass, and the potential benefits to eelgrass where burrowing shrimp are controlled using imidacloprid:

    a. *Interactions of Burrowing Shrimp and Eelgrass. The native eelgrass Zostera marina is an important part of the tide flat ecosystem in Willapa Bay and Grays Harbor. It contributes to a healthy functioning ecosystem that also includes shellfish beds and mud/sand flats. Eelgrass habitats are highly productive and provide structure and refuge for many species of fish and invertebrates, foraging habitat for migratory waterfowl, and spawning substrate for forage fish like Pacific herring (Dumbauld et al. 2003; Wyllie- Echeverria et al. 2009; Wyllie-Echeverria et al. 2004; Phillips 1984). Eelgrass does this by helping to stabilize the sediment and by reducing current speeds (Wyllie-Echeverria et al. 2009). In Willapa Bay, eelgrass provides habitat for many species of benthic invertebrates. Eelgrass also provides nursery and feeding habitats for juvenile salmon and Dungeness crab (Thom et al. 2003).*

    Burrowing shrimp act to limit eelgrass presence by disrupting the sediment and making it too soft for eelgrass roots and rhizomes (Dumbauld and Wyllie-Echeverria 2003; Hosack et al. 2006). Dumbauld and Wyllie-Echeverria found a strong increase in eelgrass abundance in areas where carbaryl was experimentally applied to burrowing shrimp. WGHOGA members have observed that the elimination of eelgrass from areas with high levels of burrowing shrimp is somewhat dependent on the shrimp species present (personal communication with a WGHOGA member, June 15, 2014). In addition, the increased turbidity and sedimentation associated with burrowing shrimp also hinder eelgrass growth by decreasing the ability of the plants to photosynthesize (Dumbauld and Wyllie-Echeverria 2003). This is likely elevation-dependent, with increased turbidity affecting the lower depth distribution of eelgrass. Thus, eelgrass present at lower *elevations is likely to be affected more than eelgrass present at higher elevations.* (FEIS pages 3-4 and 3-5

b. *They* [burrowing shrimp] *also alter habitat structure by displacing seagrasses (Dumbauld and Wyllie-Echeverria 2003)* (FEIS page 3-3).
c. *Burrowing shrimp control using imidacloprid treatments could indirectly promote enhanced shellfish and eelgrass density and coverage where habitat was no longer limited by burrowing shrimp activity. Enhanced shellfish and eelgrass density could improve the biodiversity of benthic invertebrates on commercial shellfish beds in Willapa Bay and Grays Harbor.* (FEIS, page 1-19)
d. *Burrowing shrimp control* [with imidacloprid] *indirectly promotes native eelgrass (Z. marina) density and coverage, and therefore could indirectly improve foraging habitat for fish under either Alternative 2 or Alternative 3.* (FEIS, page 3-50)

22. Ecology also specifically analyzes the benefits to birds and fish of using imiacloprid to control burrowing shrimp due to the benefits such control would have to eelgrass:
    a. *Eelgrass provides an important foraging habitat for many species of birds. Under Alternative 1* [the no action alternative in which no permit is issued to WGHOGA], *a reduction in native eelgrass density and coverage could result from sediment disruption caused by an increased number of burrowing shrimp on untreated commercial shellfish beds. This may affect bird foraging habitat on these tidelands; however, these areas would be small in relation to total tideland acreage in Willapa Bay and Grays Harbor. Disrupted habitats would affect the prey availability of crustaceans and molluscs on which shorebirds feed in the sediment, resulting in reduced bird presence in untreated areas. Species of interest include the red knot, sandpipers, and plovers. Waterfowl that feed on submerged vegetation would also be affected by reduced foraging habitat from mechanical harvest* [that WGHOGA might use if they could not control burrowing shrimp with imidacloprid]. *These species include mallards, brant, ducks, and geese.* (FEIS page 3-48).
    b. *Improvements to native eelgrass density and coverage as a result of burrowing shrimp control using imidacloprid treatments could also improve foraging habitat and prey diversity for birds, including the red knot, other shorebirds, and waterfowl species.* (FEIS page 1-21
    c. *A red knot* [a shorebird listed as a species of concern in Washington] *preferred prey organism (Macoma clams) would benefit from stable sediments following burrowing shrimp control (Buchanan et al. 2012), whereas in the presence of burrowing shrimp, Macoma clams occur at a depth that exceeds the bill length of the red knot.* (FEIS page 1-21)
    d. *Red knot feed on Macoma clams in particular, which benefit from stable sediments after burrowing shrimp control (Buchanan et al. 2012). Red knot do not feed on commensal clams associated with burrowing shrimp because their bill limits foraging depth. Waterfowl species such as brant, ducks, and geese could also benefit from the expansion of submerged vegetation found in eelgrass and shellfish beds as a result of burrowing shrimp control.* (FEIS page 1-50)

e. *Improvements to native eelgrass (Z. marina) density and coverage as a result of burrowing shrimp control using imidacloprid treatments could also improve foraging habitat for fish*. (FEIS page 1-20)

23. Ecology also discusses the scientific literature on the negative effects of burrowing shrimp on other invertebrates in Willapa Bay and Grays Harbor:
    a. *Bird 1982 and Posey (1985) reported that burrowing shrimp can significantly affect the benthic community in which they live. High densities of ghost shrimp reduce both species composition and abundance of other types of invertebrates in benthic communities. Other studies found burial of invertebrates and general sediment disturbance by burrowing shrimp can substantially affect the composition of infaunal and epifaunal invertebrates in the sediments (Dumbauld et al. 2001; Ferraro and Cole 2007; Posey 1986). Deposit-feeding polychaetes, bivalves, tube-dwelling tanaids and amphipods (e.g., Corophium spp.), and other sedentary species were reduced in numbers in areas where dense populations of ghost shrimp were present. Reductions resulted from the frequency of sediment disruption, resuspension of fine particles, and increased soft sediments (Dumbauld et al., unpublished).* (FEIS page 3-3)
    b. *They* [burrowing shrimp] *can re-suspend up to 50 percent of the sediment, causing increases in turbidity and sediments that have a quality similar to quicksand (Posey 1985). This softening of the sediment causes oysters to sink into the substrate and suffocate (Dumbauld et al. 2001) and decreases available habitat for benthic algae and sediment-dwelling invertebrates.* (FEIS page 3-9)
    c. *Ghost shrimp burrow through the sediments constantly to feed, moving large quantities of sediment to the surface (Milne et al. 2002), disrupting the structure of the mudflat substrate by resuspending fine sediments, and fluidizing the sediment surface which causes surface dwelling organisms to sink into the mud (Peterson 1977; Brenchley 1981; Bird 1982; Posey et al. 1991; Dumbauld 1994; and Tamaki 1994).* (FEIS page 3-33)
    d. *Increased densities of burrowing shrimp could result in decreased biodiversity and increased sedimentation (Dumbauld and Wyllie-Echeverria 1997; Colin et al. 1986). High densities of burrowing shrimp have been associated with lower numbers of Dungeness crab, oysters, and other shellfish due to competitive exclusion and habitat modification caused by the shrimp (Doty et al. 1990; Brooks 1995; Dumbauld and Wyllie- Echeverria 1997).* (FEIS page 3-48)
    e. *Shellfish and native eelgrass beds provide important habitats for many species of benthic invertebrates, including Dungeness crabs, polychaete worms, and settling planktonic larvae. A reduction in shellfish, and a reduction in eelgrass densities and coverage would result from sediment disruption caused by the expansion of burrowing shrimp on untreated commercial shellfish beds under Alternative 1* [the no action alternative in which no permit is issued to WGHOGA]. *The effect of a reduction in shellfish and native eelgrass habitat function would likely further reduce the diversity of species where burrowing shrimp dominate (Hosack et al. 2006).* (FEIS page 3-48)
24. Ecology also discusses the ecological value of shellfish beds:

a. *Ecology of Oyster-Dominated Communities. A diverse assemblage of plants and animals is associated with oyster beds. These include animals attached to oyster shell, such as red algae, barnacles, and mussels, in addition to animals that live under and around the shell, such as crabs and various fish species. The composition of oyster-dominated communities is a reflection of the diversity of micro-habitats associated with oysters. This contrasts sharply with the more homogeneous habitats of bare mud and sand flats (WDF and ECY 1992), including areas dominated by burrowing shrimp.* (FEIS page 3-5)
b. *Oyster beds provide important ecosystem services such as water filtration, resulting in decreased suspended solids, turbidity, and increased denitrification; habitat for epibenthic invertebrates such as crabs; carbon sequestration; and stabilization of adjacent habitats and the shoreline (Grabowski and Peterson 2007). They provide habitat for other molluscs, polychaetes, and crustaceans (Lenihan et al. 2001, Rothschild et al. 1994), and refuge habitat for juvenile fish and mobile crustaceans (Coen et al. 1999, Grabowski et al. 2005).* (FEIS, page 3-5)

The above sections of Ecology's FEIS summarize the results of dozens of published scientific studies that collectively indicate that burrowing shrimp negatively impact plants, other invertebrates, birds, and fish. None of the reviewed studies in the FEIS concluded that burrowing shrimp increase the abundance or density of other types of invertebrates, other than commensal species that live in shrimp burrows. And none of the reviewed studies concluded that burrowing shrimp have positive effects on eelgrass or oyster habitats, with their associated high levels of biological diversity and production. The FEIS doesn't conclude these things because they are not true. Instead, [b]*urrowing shrimp are considered* [to be] *ecosystem engineers because of their ability to control and structure the benthic community* (FEIS page 3-3). This means that they so modify the habitats where they live that they severely limit the types and numbers of organisms that can coexist with them. By extension, the meaning of this with respect to the ecology of Willapa Bay and Grays Harbor is that expansion of burrowing shrimp will result in reductions in other habitats and species, many of which are important to birds, fish and invertebrates.

It is possible to generate an estimate of the impacts of the ecological effects of the conversion of oyster beds and other habitat types, to burrowing shrimp dominated habitat. One of the studies reviewed in the FEIS by Ecology is Ferraro and Cole (2007). In this study the authors took sediment samples from a range of different habitat types, including eelgrass, oyster beds, and areas dominated by ghost shrimp, which is by far the most abundant and widespread of the two burrowing shrimp species in Willapa Bay and Grays Harbor. They then counted, weighed, and analyzed all the invertebrates in those samples, and then tabulated them by habitat type for a number of different metrics like number of species present, abundance of animals, etc. A summary of their findings is reproduced in the attached Table 1, with one addition: for each metric we have ranked the different habitat types.

1. The habitat types they examined were, from left to right on Table 1: habitats dominated by eelgrass, cordgrass, mud shrimp, ghost shrimp, and oyster beds[8]; mud/sand flats not obviously dominated by one of the other habitat types; and subtidal areas that are only exposed on the lowest of low tides. Cordgrass (*Spartina*) is an invasive, non-native plant that was present in Willapa Bay at the time of their study, that has since been eliminated.
2. The metrics they evaluated were: number of invertebrate species present, the total abundance (i.e., count) of all invertebrates present; the biomass or weight of all invertebrates present; the number of types of invertebrates that belonged to one of three feeding groups, deposit feeders, suspension feeders, or facultative feeders; and three measures of the overall population structure of the invertebrate community that was present, Swartz's Dominance Index, Brillouin's Index, and Habitat Species Richness.
    a. Swartz's Dominance Index is an indicator of whether a small number of animal species dominate the groups in the collected samples.
    b. Brillouin's Index in a measure of the diversity of animals in all the samples taken collectively. It is sensitive to the presence of rarer species found in small numbers or in only a small number of individual samples.
    c. HSR uses the sample data to estimate the total number of species present at the ecosystem level (e.g., within a particular habitat type within Willapa Bay)
3. For all metrics low scores in the rankings we produced are ecologically favorable, high scores for the rankings are not.
4. The number of species the authors observed in the different habitat types ranged from 26 in oyster beds and eelgrass (collectively they represent the 1st and 2nd best scores, so their ranking is 1.5 each), to 4 in subtidal areas (rank of 7). Ghost shrimp habitat had 7 species and ranked last among the intertidal habitats (rank of 6).
5. The total abundance of invertebrates ranged from 336 (per 0.01 square meter(m^2)) in oyster beds (rank of 1), to 7 in subtidal areas (rank of 7). Ghost shrimp habitat had 12 animals and ranked last among the intertidal habitats (rank of 6).
6. The biomass of invertebrates ranged from 0.5 grams (per 0.01 m^2) in eelgrass (rank of 1), to 0.01 grams in subtidal habitats (rank of 7). Oyster beds had 0.48 grams and ranked 2, whereas ghost shrimp habitat had 0.02 grams, and ranked last among the intertidal habitats.
7. Considering all the metrics evaluated by the authors, eelgrass habitats had the lowest overall rank (average rank of 1.72), followed by oyster beds (average rank of 2.0). Ghost shrimp had the worst average ranking of all intertidal habitat types (average rank of 6.0).
8. For every one of the metrics examined, ghost shrimp habitat had the worst ranking (i.e., worst ecological outcome) of all of the intertidal habitats.

[8] We note here that ground-based oyster operations in Willapa Bay and Grays Harbor frequently contain eelgrass, but the dominant habitat features are oyster shell, individual oysters, and oyster clusters.

So the Ferraro and Cole (2007) study shares the same findings on the ecological value of the different habitat types as those Ecology found in its FEIS: eelgrass and oyster bed habitats have a rich biodiversity of species, and large numbers of animals. Burrowing shrimp dominated habitats have few species, and few animals. We want to acknowledge that the sampling methods that Ferraro and Cole used were not well designed to capture burrowing shrimp located deep in burrows. So their estimates of biomass for ghost shrimp habitat are presumably low. But their sampling approach was well designed to develop estimates of the abundance of animals and the number of species, and we would expect little difference in these values for ghost shrimp ground even if animals in deep burrows were missed.

Above we said that to understand the ecological effects of WGHOGA's proposed use of imidacloprid to control burrowing shrimp it was necessary to examine the relative magnitude of those effects compared to the ecological effects of the habitat conversion from oyster beds to burrowing shrimp habitat that will occur if imidacloprid treatments are not conducted. The consistent and scientifically compelling result is that a diverse, abundant and structurally complex community of oysters, other invertebrates and eelgrass will be replaced with a simplified, sparse and species-poor habitat dominated by burrowing shrimp and a few commensal species that live with them in their burrows. Ecologically this change results in positive ecological effects to the birds and fish that feed on burrowing shrimp (e.g., green sturgeon), and negative ecological effects on those birds and fish that feed in or on the eelgrass and oyster beds that burrowing shrimp displace.

The "ecological losers" when oyster beds are converted to burrowing shrimp habitat in Willapa Bay and Grays Harbor include two important groups, salmonid fishes, and birds. Loss of eelgrass present within oyster beds will negatively affect salmonid fishes, as eelgrass has repeatedly been shown to be important to these fish as both refuge and foraging areas. And shorebirds with beaks too short to reach burrowing shrimp (the great majority), and waterfowl that feed on eelgrass, will have fewer suitable areas for foraging, and lower prey densities. The very high biomass and abundance of invertebrates on shellfish beds, combined with the cover provided to juvenile crab, fish and other invertebrates from the shells and shellfish clusters, are also lost as a resource to salmonid fishes and shorebirds as these beds are converted into burrowing shrimp habitat.

The conversion of diverse and productive intertidal habitats to burrowing shrimp dominated areas with low diversity and low numbers of animals has been ongoing for years. Researchers, such as Dr. Brett Dumbauld at the Department of Agriculture, are currently analyzing the ecosystem-level changes in eelgrass habitat in Willapa Bay and other coastal estuaries, and the relationship between these changes and burrowing shrimp. While data on the conversion of eelgrass to burrowing shrimp habitat may be scientifically "in progress," there is already a very good dataset on a different habitat conversion: the conversion of oyster beds to burrowing shrimp habitat.

The Ecology FEIS, prepared in 2015, and based on information mostly from 2014 or before reports:

> *As noted, burrowing shrimp can make sediments too soft and unstable for clam and oyster survival. It is estimated that burrowing shrimp have* ***eliminated commercial shellfish production on more than 3,000 acres of tide lands in Willapa Bay and Grays Harbor*** *(i.e., approximately 25 percent of the historically farmed acreage) (Burrowing Shrimp Control Committee 1992).* (emphasis added, FEIS page 3-4)

> *Alternative 1: No Action – No Permit for Pesticide Applications. Under the No Action Alternative, cessation of chemical applications for burrowing shrimp control would affect approximately* ***600 acres*** *of 45,000 tideland acres within Willapa Bay (1.3 percent of total tideland acres), and approximately* ***200 acres*** *of 34,460 tideland acres within Grays Harbor (0.6 percent of total tideland acres).* (emphasis added, FEIS page 3-47)

And from the Ecology FSEIS:

> *Information provided with the 2016 WGHOGA NPDES permit application responds to a question from Ecology and others about the estimated economic consequences of not being able to control burrowing shrimp on commercial clam and oyster beds in Willapa Bay and Grays Harbor. WGHOGA members were surveyed and asked to project their bed losses over the next 5 years (2017 through 2022).* [citation omitted] *WGHOGA growers estimated cumulative losses of approximately* ***500 acres*** *of* [oyster] *seed or nursery ground,* ***575 acres*** *of* [oyster] *fattening beds, and more than* ***530*** *acres of clam beds by 2022 (Miller Nash Graham & Dunn, February 13, 2017).* (emphasis added, FSEIS page 2-7)

Collectively, these estimates indicate approximately 3,000 acres of shellfish beds have already been lost to burrowing shrimp, and another 800 to 1,075 acres of oyster beds are at risk of loss. To frame these losses in terms of potential ecological impacts to Willapa Bay and Grays Harbor we return to the Ferraro and Cole (2007) dataset. Using the values they report, it is possible to get an estimate of the number of invertebrates, and the biomass of invertebrates that are lost when an acre of oyster beds is replaced by an acre of burrowing shrimp habitat (Table 2).

Table 2: Ferraro and Cole (2007) Data for Oyster Beds and Ghost Shrimp Habitats

Oyster Beds Versus Ghost Shrimp Beds	Oyster Bed Invertebrate Abundance (Number per 0.01 Square Meter)	Ghost Shrimp Habitat Invertebrate Abundance (Number per 0.01 Square Meter)	Abundance Difference (Number of Animals Per Acre)	Oyster Bed Invertebrate Biomass (grams per 0.01 Square Meter)	Ghost Shrimp Habitat Invertebrate Biomass (Grams per 0.01 Square Meter)	Biomass Difference (Pounds Per Acre)
	336	12	131,118,264	0.48	0.02	409.54

In the Ferraro and Cole study oyster beds averaged 324 more invertebrates per 0.01 meter sample than ghost shrimp habitats. When this figure is expanded from 0.01 meters to acres, that difference equates to more than 131 million more invertebrate animals on an acre of oyster bed than on an acre of ghost shrimp habitat. For biomass of invertebrates a similar expansion leads to 409 pounds more invertebrates per acre of oyster bed than on an acre of ghost shrimp habitat. As we noted above, biomass values of ghost shrimp habitat in Ferraro and Cole are low because shrimp located deep in burrows were not sampled. So our value of 409 more pounds of invertebrates in oyster beds is not correct in an absolute sense. But it still has value because if reflects the biomass of invertebrates other than burrowing shrimp, that is, the biomass of invertebrates that are eaten by fish and birds that are not able to feed on burrowing shrimp in deep burrows.

Finally, we can multiply these differences in the abundance and biomass of invertebrates on oyster beds times the area of oyster beds that have already been lost, and those that are expected to be lost if the WGHOGA permit is rejected. For the 3,000 acres of shellfish beds already lost to burrowing shrimp[9]:

131,118,264 animals/acre * 3,000 acres = 393,350,000,000 (393 billion animals)

409.54 pounds invertebrates/acre * 3,000 acres = 1,228,620 pounds of invertebrates

And for the 1,075 acres estimated to be lost in the future if the WGHOGA permit is denied (from FSEIS):

131,118,264 animals/acre * 1,075 acres = 140,950,000,000 (140 billion animals)

409.54 pounds invertebrates/acre * 1,075 acres = 440,256 pounds of invertebrates

Conclusion: There are a significant number of published scientific studies examining the effects of burrowing shrimp on eelgrass, oyster beds, and other intertidal habitats. Ecology's FEIS includes a substantial survey and review of a number of these studies, with a focus on those that were done in Willapa Bay and Grays Harbor. That literature review, and the underlying scientific studies, present a consistent and unambiguous set of conclusions about the effects of burrowing shrimp:

1. Burrowing shrimp impact eelgrass habitats.
2. Burrowing shrimp impact oyster beds.
3. Areas dominated by burrowing shrimp have very low species biodiversity, especially compared to eelgrass habitat and oyster beds.
4. Areas dominated by burrowing shrimp have a very small number of individual invertebrate animals, especially compared to eelgrass habitat and oyster beds.

[9] Historically most shellfish production in Willapa Bay and Grays Harbor has been for oysters. We therefore assume that this 3,000 acre figure consists entirely of oyster beds, but acknowledge that a small number of these acres were likely clam ground.

5. Areas dominated by burrowing shrimp have a very low biomass of invertebrate animals other than burrowing shrimp, especially compared to eelgrass habitat and oyster beds.
6. Areas dominated by burrowing shrimp have very low levels of habitat structure used for shelter and rearing by fish and invertebrates, especially compared to eelgrass habitat and oyster beds.
7. Burrowing shrimp reduce the abundance and availability of invertebrates that are prey for shorebirds that have beaks too short to access burrowing shrimp (the majority).
8. Burrowing shrimp reduce the abundance of eelgrass fed on by waterfowl.
9. Burrowing shrimp reduce the availability of eelgrass and its related invertebrates that are important to salmon and trout species.

Put bluntly, burrowing shrimp are very good at creating habitat for burrowing shrimp, but they are terrible at creating anything else, including habitat for eelgrass, oysters, or other invertebrate species. Consequently, except for those few species that can access and eat burrowing shrimp in their burrows, every acre of oyster habitat that is lost to burrowing shrimp represents an ecological loss to bird and fish species that feed in Willapa Bay and Grays Harbor.

Our analysis using the Ferraro and Cole study indicates that every acre of oyster bed habitat that is converted to burrowing shrimp habitat results in the loss of 131 million invertebrate animals and 409 pounds of invertebrates other than burrowing shrimp. We recognize that the values from one study are not definitive. Other, similar studies would get different numbers, and they would perhaps be less dramatic that those presented here. But there are many studies that document the same thing that Ferraro and Cole (2007) do: there are dramatically lower numbers of invertebrate animals, species biodiversity, and biomass of invertebrates (other than burrowing shrimp) on areas dominated by shrimp than on oyster beds. So past losses of oyster beds to burrowing shrimp in Willapa Bay and Grays Harbor represent a significant ecological loss to the many species that feed on invertebrates other than burrowing shrimp, and to those that rear in eelgrass and oyster reef habitats that burrowing shrimp replace.

And by extension, if Ecology denies WGHOGA’s permit, and 1,000+ acres of oyster beds are consequently lost to burrowing shrimp in the coming years, many billions of invertebrate animals, and hundreds of thousands of pounds of invertebrate prey items that currently exist in Willapa Bay and Grays Harbor to feed predators like shorebirds, and Dungeness crab and salmon, will disappear. As will the habitat structure present in these oyster beds, and in the eelgrass found within many of those beds, that serve as shelter and rearing areas for Dungeness crab and many fish. In return for these losses, Willapa Bay and Grays Harbor will contain another 1,000+ acres of mudflats with very low structural diversity for shelter and rearing, and an invertebrate community collapsed down to a relative handful of species, one that is dominated by two species of burrowing shrimp that are located too deep to be available as prey for most birds, fish or Dungeness crab.

Above we acknowledged that the use of imidacloprid to treat burrowing shrimp will impact non-target invertebrates where it is applied, but that to understand the ecological consequences of this impact it was necessary to look at the relative effect of imidacloprid impacts versus impacts that occur when oyster beds are converted to burrowing shrimp habitat. The FEIS literature review cited above, and our analysis of differences in the invertebrates on oyster beds and on ghost shrimp beds, both make very clear that a significant ecological impact occurs when oyster beds are lost to burrowing shrimp. By contrast, and as discussed elsewhere in detail, the vast majority of empirical field data make clear that imidacloprid impacts on non-target invertebrates are localized, temporary, and meet the minor effects standard of the Washington state SMS.

Ecology, in both the FSEIS and Rogowski's memo, fail to discuss or analyze the impacts of burrowing shrimp on eelgrass habitats or other invertebrates. Nor do they discuss how burrowing shrimp affect the food chain depended upon by shorebirds, waterfowl, or salmonid fishes. And they include no analysis of what their recommended denial of WGHOGA's permit means in terms of habitat conversion from oyster beds to burrowing shrimp. Nor do they undertake any analysis of the resulting ecological changes that would occur in Willapa Bay and Grays Harbor as a result of that conversion. Given that Ecology undertook none of these analyses, its conclusion that imidacloprid use would impact the ecology of Willapa Bay and Grays Harbor, and in particular the birds, fish and Dungeness crab in those estuaries, represents an incomplete, and scientifically-biased review of the relevant science.

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Table 1: Analysis of Ferraro and Cole (2007) Data

Metric	Eelgrass Habitat	Rank of Eelgrass Habitat	Cordgrass Habitat	Rank of Cordgrass Habitat	Mud Shrimp	Rank of Mud Shrimp Habitat	Ghost Shrimp	Rank of Ghost Shrimp Habitat	Oyster Beds	Rank of Oyster Bed Habitat	Mud/Sand	Rank of Mud and Sand Habitat	Subtidal Areas	Rank of Subtidal Habitat
Number of Species	26	1.5	20	3	19	4	7	6	26	1.5	14	5	4	7
Abundance of Animals	308	3	374	1	159	4	12	6	336	2	86	5	7	7
Biomass of Animals	0.5	2	0.57	1	0.32	4	0.02	6	0.48	3	0.22	5	0.01	7
Deposit Feeder Abundance	186	2	180	3	120	4	7.4	6	237	1	39	5	3.4	7
Suspension Feeder Abundance	33	1	8	3	6	4	0.51	6	18	2	3.2	5	0.33	7
Facultative Feeder Abundance	25	3	87	1	20	4.5	2.3	6	28	2	20	4.5	0.88	7
Swartz's Index	5.1	1	3.8	4	4.7	3	3.2	6	4.8	2	3.7	5	2.5	7
Brillouin's Index	0.9	1	0.78	4	0.86	2.5	0.5	6	0.86	2.5	0.67	5	0.35	7
Habitat Species Richness	116	1	60	5	72	4	43	6	115	2	78	3	41	7
Average Rank Across Metrics=		1.72		2.78		3.78		6.00		2.00		4.72		7.00