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Brief Communication

What Training and Skills Will the Ecotoxicologists of the Future Require?

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EDITOR'S NOTE:

This is 1 of 4 companion articles resulting from a SETAC Pellston Workshop® on "Improving the Usability of Ecotoxicology in Regulatory Decision-Making," held August 2015 in Shepherdstown, West Virginia, USA. The main workshop objectives were to improve the reliability and reproducibility of ecotoxicity studies, improve the use of peer-reviewed studies in regulatory risk assessment of chemicals, and improve the methods used in risk assessments when evaluating single or multiple lines of evidence.

ABSTRACT

Students and academic researchers conduct a diverse range of studies that add to the growing body of ecotoxicology research. Once an academic researcher entertains an applied research topic, there is potential for that research to be used in local, state, or federal regulatory decision or action. The ability of regulatory decision makers to use academic studies to inform decisions is dependent on: 1) the relevance of the experiment to regulatory decisions, 2) the reliability of the laboratory and the study itself, and 3) quality reporting of data such that study relevance and reliability are evident. The purpose of this brief communication is to highlight actions that can be taken by Society of Environmental Toxicology and Chemistry members to enhance the usability of academic research studies in regulatory decision making by promoting training, partnerships, and communication. *Integr Environ Assess Managem* 2017;13:580–584. © 2016 The Authors. *Integrated Environmental Assessment and Management* published by Wiley Periodicals, Inc. on behalf of Society of Environmental Toxicology & Chemistry (SETAC)

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INTRODUCTION

Students and academic researchers conduct a diverse range of studies that add to the growing body of ecotoxicology research. Academia encourages basic (or innovative) science, promoting new developments, novel methods, and creative thinking within the field of ecotoxicology. Yet, students and academic researchers frequently find themselves balancing basic scientific research with applied research topics, especially in the field of ecotoxicology. In such cases, an awareness of regulatory guidance and practice can increase the impact of academic ecotoxicology research.

Once an academic researcher entertains an applied research topic, there is potential for that research to be used in local, national, or international regulatory decision or action. Despite primary reliance on standardized studies conducted by industry, a number of regulatory programs increasingly may make use of studies published in the peer-reviewed literature and have established processes for doing so. For example, submission of pesticide dossiers in Europe requires the inclusion of recent peer-reviewed open literature on the pesticide that examines the effects on health, the environment, and nontarget species. The European Food Safety Authority (EFSA) has established principles for searching and assessing the reliability of this information (Organisation for Economic Co-operation and Development 2014). The US Environmental Protection Agency (USEPA) Office of Pesticide Programs also has published guidance for use in identifying, selecting, and evaluating open literature studies (USEPA 2011). There are other examples, but these serve to illustrate that, even if academic researchers are unaware that their data may ultimately be used in a regulatory setting, there is a good chance it will at least be examined if it relates to a chemical or product undergoing regulatory

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Table 1. Examples of partnerships and potential benefits to the academic, industry, and regulatory communities

Type of partnership	Example	Benefits
Cooperative training partnerships, internships, and research fellowships	US Environmental Protection Agency–University of Minnesota Cooperative Training	Prepare students for careers in industry and government
	European Food Safety Authority traineeships	
Government and industry participation in academic research	Government or industry scientist participates on a graduate committee or performs a priori review of study protocol	Increases the quality and relevancy of graduate research
Informal partnerships	Guest speakers, lecturers in classrooms	Introduces students to careers and issues in industry and government

review. To this end, we recommend that the academic ecotoxicology community recognize the regulatory relevance of their work and strive to produce reliable data that could be useful in regulatory decision making.

A Society of Environmental Toxicology and Chemistry (SETAC) Pellston® workshop was convened in August 2015 with the goal of providing a process to improve the documented quality of environmental toxicity research and, through enhanced communication among academia, industry, and regulatory agencies, to promote the appropriate use of these data in regulatory decisions. A further goal was to promote understanding of the advantages and disadvantages of standardized testing and the role and limitations of Good Laboratory Practices (GLP). The outcomes of the workshop are presented in detail in several papers (Hanson et al. 2016; Moermond et al. this issue; Rudén et al. this issue). The purpose of this brief communication is to highlight actions that can be taken by SETAC members to enhance the usability of academic research studies in regulatory decision making by promoting training, partnerships, and communication.

Contributions of Academic Research

Use of academic research to inform regulatory decisions has a number of advantages. Academia provides a large body of research that can be used to confirm or challenge previous studies and regulatory risk assessments, with new studies providing additional lines of evidence that can be used to strengthen the risk assessment process. Second, academic research introduces novel methods and new approaches that may increase the ecological relevance of the regulatory decision. Data and information on species, chemicals, or exposure scenarios not covered by the regulatory framework can help to broaden the regulatory risk assessment while supporting higher-tier assessments and weight-of-evidence assessments. These test results or assessment outputs are important lines of evidence that can be used to support environmental decisions. Lastly, academic research can identify new regulatory issues and provide the background for the development of new guidance. Academic studies can address problems still not fully covered by the regulatory guidelines (e.g., endocrine effects, multiple stressor effects testing, pollinator risk assessment) and provide scientific information for the development of new guidelines to address these problems.

Training Students for Careers in Ecotoxicology

Although we are in no way dismissing the important role of basic academic research, it is prudent for students to understand the world of industry and government science. Many students are funded through grants from industry and government and will go on to work in these sectors. Membership statistics for SETAC show that approximately 55% of recent graduates (defined as members who have graduated from an undergraduate or graduate program within the past 3 years) are currently working in business, government, or nonprofit sectors, whereas about 45% take careers in academia. This poses the question: Are students being trained appropriately for the jobs that are available in environmental toxicology?

THREE AREAS FOR IMPROVED TRAINING

Regulatory Relevance of Academic Research

It would be extremely beneficial if academic training of students in ecotoxicology included raising awareness of the regulatory framework. Many young ecotoxicologists learning their trade in academic institutes probably have little, if any, contact with regulators, and hence would have, at best, only a fragmentary awareness of environmental regulatory procedures. For example, many may well not know what an Environmental Quality Standard (EQS) of a chemical is, let alone how it was derived and how it is enforced. Academic research would almost certainly be much improved if those conducting it (both young and older) had better knowledge of how regulators work.

Academic research is not commonly designed or executed with the purpose of supporting regulatory decision making. However, if every academic researcher had a fundamental knowledge of the regulatory context of their research, there is much that could be done to increase the regulatory relevance of their data, often in small but significant ways. Considerations such as choice of test organism, organism life stage, exposure concentration and duration, and other test

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conditions can dramatically alter the usability of these studies for regulatory review (Ågerstrand et al. 2011; Moermond et al. this issue; Rudén et al. this issue). For example, data generated with a tropical species may not be suitable for a risk assessment for a temperate region. Similarly, test concentrations that do not reflect environmentally relevant exposure concentrations will, at best, introduce uncertainty into a risk assessment, and the results will often be excluded outright from the review.

In many instances, academic ecotoxicology experiments are conducted to investigate a novel end point or to determine an impact in a nontraditional test species. Both of these types of studies carry considerable merit. Consider the potential impact these studies could have if they were designed and conducted with a consideration of regulatory acceptable protocols and standards. For reasons explained in the introduction, we argue that academic researchers should be aware of regulatory ecotoxicology guidelines and available standardized methods (such as those from the Organisation for Economic Co-operation and Development and USEPA). Unfortunately, the further removed a study design is from any applicable guideline, the less likely that study will be fully used in regulatory risk assessment. Regulatory ecotoxicology study guidelines give key information related, but not limited, to study design (e.g., replication, controls, and exposure), animal husbandry, and reporting requirements.

Without any modification to the study itself, academic researchers can highlight the biological relevance of their work by framing their research in context and reporting their methods such that the study can be repeated by others. Realistically, thorough reporting of study conditions can mean the difference between a study being useful for regulatory decisions or being excluded from review (Ågerstrand et al. 2011; Hanson et al. 2016).

Research Reliability

As mentioned previously, regulatory risk assessment generally relies on standardized studies conducted by industry according to established guidelines and GLP regulations. Data requirements are strict, and studies that meet GLP regulations are given greater consideration over non GLP studies, which are generally viewed (correctly or not) as less reliable. Most academic laboratories do not operate as GLP-compliant laboratories, although some do strive to emulate comprehensive, GLP-like training, documentation, and methodologies. In other instances, none of the attributes of GLPs are implemented. Students and their faculty advisors should be trained, at the minimum, to understand the principles of quality assurance (QA) and GLP requirements and, ideally, to strive toward those same quality criteria in their respective laboratories. The principles of GLP are inherently logical for those wanting to perform sound research, and most are not as burdensome as one might initially think.

In an initial attempt to improve the current situation, a set of "Principles of Sound Ecotoxicology" has been proposed by a group of environmental scientists containing academics, regulators, and scientists working in both government laboratories and industry (Harris et al. 2014). If academic scientists applied those principles, or at least the most appropriate ones, to their own research, including training young scientists in their relevance and use, it is very likely that the quality of published research in ecotoxicology would improve. This improvement would be of great benefit to regulators, who could then, with confidence, make more use of that academic research. Further, the study must be documented and reported such that study design, data reliability, and regulatory relevance are evident.

Interdisciplinary Training

Environmental science—and ecotoxicology by association—began as decidedly interdisciplinary fields compared with the traditional natural sciences (biology, chemistry, and so on). However, as the bodies of knowledge in these fields have grown, and done so very rapidly, scientists have become more specialized in their areas of research, often at the expense of the broader viewpoint. Students—and their faculty advisors—may now be "experts" in one particular approach (e.g., measuring global gene expression of an organism exposed to an environmental stressor), but may have little knowledge or practical expertise of other, highly relevant factors (e.g., how a test chemical will behave in the environment or how to measure concentrations of that chemical). For any ecotoxicology study to be maximally useful to regulators, it needs to combine sound environmental biology with equally sound environmental chemistry, and ideally equally sound experimental design and data analysis. Any ecotoxicology curriculum inherently balances this need for a broad understanding of concepts (e.g., environmental biology, environmental chemistry, and mathematics and/or statistics) with a focus on specialized training. Interdisciplinary training opportunities allow students to gain expertise in different aspects of their field, complementing their area of research and broadening their perspective as a researcher.

Given the current pressure on scientists to deliver results at the forefront of their particular field, which tends to lead to specialization, perhaps it is unreasonable to expect that such a broad training be provided to every student; however, it should be the goal. An alternative strategy to a truly interdisciplinary academic training program is for biologists to have the opportunity to work closely with environmental chemists and scientists with well-developed numerical expertise, such as statisticians. Despite this being an obvious partnership, it occurs surprisingly infrequently: It is rare for the best biologists in our area of research to combine their skills and expertise with those of our best chemists. However, when it does occur, high-quality research can be produced that neither discipline could produce on its own (see, e.g., Margiotta-Casaluci et al. 2014, 2016).

Thus, we strongly encourage closer collaboration among the different disciplines within ecotoxicology. Ideally, if a student researcher was based in a Biology Department, he or she would spend some of her time in the Chemistry Department of her university or research organization, or vice versa, of course. However, this is not always possible, for

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a variety of reasons; for example, the university of one of the authors of this article no longer has a Chemistry Department, or even up-to-date analytical facilities located elsewhere. In such situations, an alternative strategy is required. One very good strategy is to encourage young scientists, and even their faculty advisors, to spend time in institutes other than their own. Academic exchanges often lead to major benefits, not only for the scientists who do the relocating (temporarily) to another laboratory, but also for the host laboratory, which gains expertise it would otherwise not have.

PARTNERSHIPS

Cross-sector partnerships (among academia, business, and government) promote communication and collaboration within SETAC and provide learning and teaching opportunities for all participants (Table 1). Training or internship programs offer students the opportunity to work directly with government or industry scientists. As an example, the USEPA Office of Research and Development laboratory in Duluth, Minnesota, USA, initiated a cooperative agreement with the University of Minnesota called the "The Cooperative Training Partnership in Aquatic Toxicology and Ecosystem Research." The purpose of this partnership is for USEPA scientists to train students in aquatic toxicology and ecosystem research. In addition, University of Minnesota faculty members can participate in the process by co-advising the students. In this type of partnership model, both the student and the faculty advisor gain insight into the conduct of research at the USEPA Duluth Laboratory (https://www.epa.gov/aboutepa/about-mid-continent-ecology-division-med-epas-national-health-and-environmental-effects).

In Europe, EFSA offers students paid traineeships as well as unpaid short-term study visits (6 months to 1 year). Trainees have the opportunity to work directly with EFSA and gain hands-on experience in EFSA risk assessment. (More information on this training opportunity is available online at: http:://www.efsa.europa.eu/en/careers/youngprofessionals.)

Governmental and industry participation in academic research can take place in less formal capacities as well. For example, an academic researcher may ask a government or industry scientist to perform an a priori review of his or her study protocol to evaluate its suitability for regulatory application and identify any areas of improvement. This type of noncontractual partnership could greatly improve the experiment itself, as well as the quality of the outcomes. The inclusion of a government or industry scientist on a thesis or dissertation committee may have much the same effect for student-driven research. Government or industry scientists participating as guest lecturers in the classroom may introduce students to career options outside of academia and issues that are relevant to students' future careers in the business or government sectors.

ROLE OF SETAC

As a society with members from academia, business, and government, SETAC benefits from a diverse range of professional viewpoints and expertise. Each sector contributes differently to the society, and partnerships between sectors strengthen both SETAC and, in turn, the fields of ecotoxicology and environmental chemistry. For this reason, SETAC is in a unique position to help meet the training objectives described in this study.

SETAC offers a venue for training and collaboration between students and professionals in all sectors. Workshops, short courses, and conferences provide training for principal investigators, research faculty, and students to promote continuing education on new topics in regulatory environmental toxicology. Student Advisory Councils within the geographic units of SETAC provide a voice for student members and advocate for student interests. The Student-Mentor program that exists during SETAC conferences promotes communication and networking between students and professionals, which can be leveraged into formal or informal partnerships. Regional SETAC chapters provide additional venues for training and partnerships at the local level.

An ongoing mentorship program within SETAC would be one way to increase learning and dialogue between students and industrial and governmental professionals on regulatory ecotoxicology. This type of mentorship program could be modeled after the Student-Mentor program at conferences and implemented at the regional or national level. The mentor would take an active interest in the student's project and career, particularly in the area of increasing the student's understanding of regulatory ecotoxicology. Students would have the opportunity to interact with their mentor repeatedly throughout their time in academia. Students and professionals interested in participating would register through SETAC and be assigned a mentorship partnership based on technical interests, location, or other factors. In the end, a mentorship program enables those not in the academic sector a mechanism by which they can influence student training. Although this type of mentorship program has been discussed before in SETAC, perhaps it is time to reinvigorate the idea.

Another avenue for increasing awareness and understanding of data quality and regulatory impact would be through the SETAC Europe Certified Environmental Risk Assessors program. This certification program through SETAC Europe, which began in 2015, provides participants a range of courses on topics related to regulatory ecotoxicology, environmental chemistry, and environmental risk assessment. The certification also requires the student to complete an internship during the training program and at least 2 years of on-the-job training.

CONCLUSIONS

The ability of regulatory decision makers to use academic studies to inform decisions is dependent on the following factors: 1) the relevance of the experiment to regulatory decisions, 2) the reliability of the study itself, and 3) quality reporting of data such that study relevance and reliability are evident. Although most academic laboratories do not conduct research solely for the purpose of informing regulatory risk assessments, many of these researchers will produce data that will be considered for such use.

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A willingness by academic researchers to consider the potential regulatory application of their work will increase the utility of their data. Similarly, increases in the reliability and reporting of academic data will encourage regulators and regulatory agencies to invest expertise and, in some cases, funding toward future applicable research in academia.

Drawing from work put forth from the August 2015 SETAC Pellston workshop, as well as our own experiences in the field, we conclude with a list of actions to be taken toward the goal of increasing the regulatory impact of academic research, improving the reliability of academic data, and fostering cooperation among all sectors of SETAC.

ACTION ITEMS

Actions to be taken by business and government are as follows:

- Initiate partnerships with students, faculty advisors, and research institutions.
- Participate in academic research through review of research protocols, graduate student committees, guest lecturing, career panels, among others.
- Provide training for student and faculty researchers on laboratory, data, and reporting requirements for non GLP studies to be applicable to regulatory decisions.

Actions to be taken by students and academic researchers are as follows:

- Seek out opportunities for interdisciplinary training at one's own university or at another institute or laboratory.
- Invite business and government experts to participate in academic research through review of research protocols, graduate student committees, guest lecturing, career panels, among others.
- Work with regulators to understand data and reporting requirements for non GLP studies to be applicable to regulatory decisions.
- Train students in the basic principles of test guidelines and QA and GLP regulations that are used in industry.
- Consider the potential regulatory impact of academic research throughout the research process.

Actions to be taken by SETAC are as follows:

- Offer training on reliability and relevance of ecotoxicology studies for regulatory decision making. For example topics, see Moermond et al. (this issue) and Rudén et al. (this issue).
- Create and support partnerships among business, government, and industry scientists.
- Reinvigorate a mentoring program to connect SETAC student members with members in industry and government.
- Challenge researchers and students to consider the potential regulatory impact of their studies early in the study design and implementation.
- Advocate that SETAC journals adopt high-quality reporting requirements (Hanson et al. 2016).

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REFERENCES

Ågerstrand M, Küster A, Bachmann J, Breitholtz M, Ebert I, Rechenberg B, Rudén C. 2011. Reporting and evaluation criteria as means towards a transparent use of ecotoxicity data for environmental risk assessment of pharmaceuticals. *Environ Pollut* 159:2487–2492.

Hanson ML, Wolff BA, Green JW, Kivi M, Panter GH, Warne MS, Ågerstrand M, Sumpter JP. 2016. How we can make ecotoxicology more valuable to environmental protection. *Sci Total Environ* 578:228–235.

Harris CA, Scott AP, Johnson AC, Panter GH, Sheahan D, Roberts M, Sumpter JP. 2014. Principles of sound ecotoxicology. *Environ Sci Technol* 48:3100–3111.

Margiotta-Casaluci L, Owen SF, Cummings RI, de Polo A, Winter MJ, Panter GH, Rand-Weaver M, Sumpter JP. 2014. Quantitative cross-species extrapolation between humans and fish: The case of the anti-depressant fluoxetine. *PLOS ONE* 9:e110467.

Margiotta-Casaluci L, Owen SF, Huerta B, Rodriguez-Mozaz S, Kugathas S, Barcelo D, Rand-Weaver M, Sumpter JP. 2016. Internal exposure dynamics drive the Adverse Outcome Pathways of synthetic glucocorticoids in fish. *Sci Rep* 6:21978.

Moermond C, Beasley A, Breton R, Junghans M, Laskowski R, Solomon K, Zahner H. 2017. Assessing the reliability of ecotoxicological studies: An overview of current needs and approaches. *Integr Environ Assess Manag* 13:640–651.

Organisation for Economic Co-operation and Development. 2014. Chapter 3 Data evaluation. In: Manual for the assessment of chemicals. Paris (FR): Organisation for Economic Co-operation and Development. 13 p. [cited 2016 August 13]. http://www.oecd.org/fr/env/ess/risques/manualfortheassessmentofchemicals.htm

Rudén C, Adams J, Ågerstrand M, Brock TCM, Buonsante V, Poulsen V, Schlekat CE, Wheeler JR, Henry TR. 2017. Assessing the relevance of ecotoxicological studies for regulatory decision-making. *Integr Environ Assess Manag* 13:652–663.

[USEPA] US Environmental Protection Agency. 2011. Evaluation guidelines for ecological toxicity data in the open literature. Procedures for screening, viewing, and using published open literature toxicity data in ecological risk assessments. Washington (DC): USEPA, Office of Pesticide Programs. 74 p.

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