


dia: An R package for the National Oceanic and Atmospheric Administration dam impact analysis

Daniel S. Stich¹, Julie L. Nieland², and Timothy F. Sheehan²

¹ Biology Department and Biological Field Station, State University of New York at Oneonta, NY 13280 USA ² National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, MA 02543 USA  Corresponding author

DOI: [10.xxxxxx/draft](https://doi.org/10.xxxxxx/draft)

Software

- [Review](#) 
- [Repository](#) 
- [Archive](#) 

Editor: [Open Journals](#) 

Reviewers:

- [@openjournals](#)

Submitted: 01 January 1970

Published: unpublished

License

Authors of papers retain copyright and release the work under a Creative Commons Attribution 4.0 International License ([CC BY 4.0](#)).

Summary

Anadromous (sea-run) fishes such as Atlantic salmon *Salmo salar* have been greatly diminished globally through pollution, overfishing, and construction of dams ([Limburg & Waldman, 2009](#)). Life-history-based simulation models are commonly used for planning and implementing fisheries recovery activities for many diadromous species (e.g., Nieland et al. (2013); Barber et al. (2018); Stich et al. (2019); Zydlewski et al. (2021)). However, many institutionalized decision-support tools historically relied on closed-source or paid software prior to expansion of open-source development. For example, the National Oceanic and Atmospheric Administration (NOAA) Dam Impact Analysis (DIA) was originally created as a stochastic life cycle model for Atlantic salmon in the @RISK add-in within Microsoft Excel ([Nieland et al., 2013](#)). We created the dia package ([Stich et al., 2021](#)) for the R programming language ([R Core Team, 2022](#)) as a freely accessible, open-source implementation of these tools that will promote transparency in planning and decision making and improve the availability and quality of these tools over time.

Statement of need

dia is an R-based implementation of the previously closed-source life cycle model of Atlantic salmon population dynamics that is used to understand sensitivity of species recovery decisions to naturogenic and anthropogenic marine and freshwater influences. It was developed to assess sensitivity of restoration outcomes to uncertainty in life-history inputs alongside the impacts of dams and restoration activity decisions. The DIA model uses empirical life-history estimates (e.g., survival), predictive flow and resulting flow-specific dam survival modeling, and other empirical data in freshwater and marine environments to simulate consecutive generations of Atlantic salmon under varying environmental conditions or management decisions. Management decisions include fish passage rates at dams, fishery harvest rates, and numbers and locations for hatchery stocking of fish ([Nieland et al., 2013](#)). Since development, it has been used for mechanistic exploration of key life-history uncertainties within the context of species recovery ([Nieland et al., 2015](#)) and to support decision making at federally regulated hydropower dams in the USA (e.g., National Marine Fisheries Service (2013); Nieland & Sheehan (2020)).

We created dia for use by fisheries researchers, managers, and practitioners interested in understanding population dynamics of intensively managed endangered Atlantic salmon in the USA. The R package maintains the core routines from the original closed-source version of the model by replicating spreadsheet-based calculations, and incorporates original data and parameter sets as built-in objects that serve as default values for arguments of the primary user-facing functions.

The two primary user-facing functions within the dia package are the run_dia() and

42 `run_dia_shiny()`, which provide redundant interfaces for using Dam Impact Analysis models
43 in different ways. The `run_dia()` function provides an extensible interface to DIA that can
44 be used for long-run simulation or decision-optimization studies, and allows incorporation
45 of user-specified data sets such as flow-correlated survival probabilities at dams and in
46 free-flowing river reaches, marine survival and other life-history inputs, or fish-stocking data.
47 The `run_dia_shiny()` function deploys a graphical user interface using the shiny package
48 (Chang et al. (2022)) that is less extensible but more easily used by fishery managers and
49 practitioners who may be less familiar with programming. `run_dia_shiny()` also includes
50 exportable results from simulation models including .csv or other flat-file formats and default
51 plots through the ggplot2 R package [Hadley Wickham (2016); H. Wickham et al. (2019);
52 Figure 1]. Both can be deployed on networked servers as any other R or shiny application to
53 improve accessibility or facilitate use on high performance computers for large simulations.
54 The GitHub repository (Stich et al., 2021) includes additional instructions for installation and
55 a variety of potential uses of `run_dia()` and `run_dia_shiny()` in addition to shorter examples
56 in the package help files. While implementation is currently limited to the Penobscot River as
57 a priority conservation water in the USA, it provides increased flexibility for extending this
58 approach to Atlantic salmon and other sea-run fish globally.

DRAFT

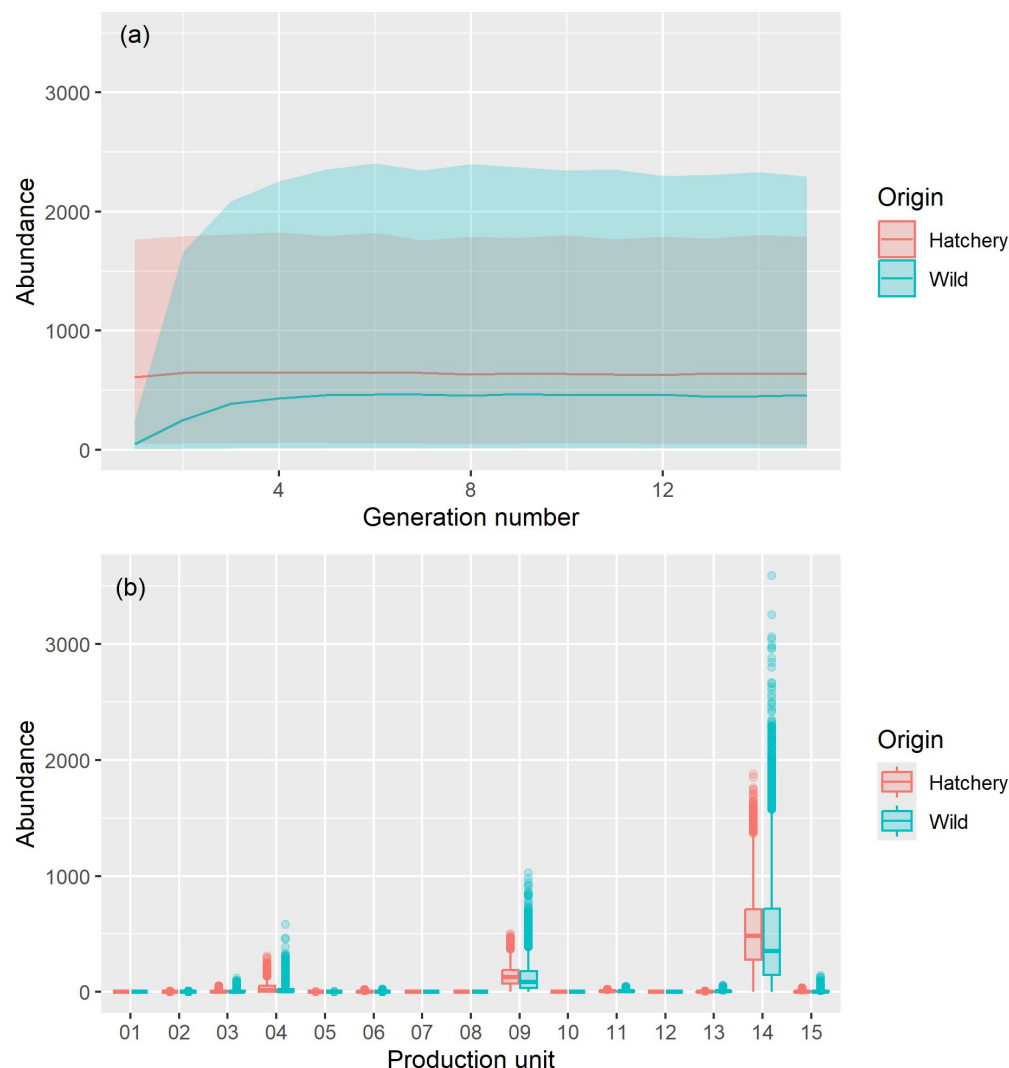


Figure 1: Figure1. Example graphical outputs using the default argument values (Nieland & Sheehan (2020)) for `run_dia()` to run 10,000 simulations, showing (a) the number of two-sea-winter adult females of hatchery or wild origin returning to the watershed during each generation, and (b) the number of those fish returning to each production unit within the watershed after 15 generations.

Acknowledgements

We acknowledge contributions from Rory Saunders, Tara Trinko-Lake, Jeffrey Murphy, and Justin Stevens in the original development of the NOAA Dam Impact Analysis model. This work was funded by NOAA National Marine Fisheries Service Northeast Fisheries Science Center, with additional support from the SUNY Oneonta Biological Field Station. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

References

- Barber, B. L., Gibson, A. J., O'Malley, A. J., & Zydlewski, J. (2018). Does what goes up also come down? Using a recruitment model to balance alewife nutrient import and export. *Marine and Coastal Fisheries*, 10(2), 236–254. <https://doi.org/10.1002/mcf2.10021>

- 70 Chang, W., Cheng, J., Allaire, J. J., Sievert, C., Schloerke, B., Xie, Y., Allen, J., McPherson,
71 J., Dipert, A., & Borges, B. (2022). *Shiny: Web application framework for R*. <https://doi.org/10.32614/CRAN.package.shiny>
- 72
- 73 Limburg, K. E., & Waldman, J. R. (2009). Dramatic declines in North Atlantic diadromous
74 fishes. *BioScience*, 59(11), 955–965. <https://doi.org/10.1525/bio.2009.59.11.7>
- 75 National Marine Fisheries Service. (2013). *National marine fisheries service endangered species*
76 *act biological opinion amendment of license for the mattaceunk project f/NER/2013/9640*.
77 National Oceanic; Atmospheric Administration. <https://repository.library.noaa.gov/view/noaa/55737>
- 78
- 79 Nieland, J. L., & Sheehan, T. F. (2020). Quantifying the effects of dams on Atlantic salmon
80 in the Penobscot River watershed, with a focus on Weldon Dam. In *Northeast Fisheries*
81 *Science Center Reference Document 19-16*. National Oceanic; Atmospheric Administration.
82 <https://doi.org/10.25923/v67x-kk62>
- 83 Nieland, J. L., Sheehan, T. F., & Saunders, R. (2015). Assessing demographic effects of
84 dams on diadromous fish: a case study for Atlantic salmon in the Penobscot River, Maine.
85 *International Council for the Exploration of the Sea Journal of Marine Science*, 72(8),
86 2423–2437. <https://doi.org/10.1093/icesjms/fsv083>
- 87 Nieland, J. L., Sheehan, T. F., Saunders, R., Murphy, J. S., Trinko Lake, T., & Stevens, J. R.
88 (2013). Dam impact analysis model for Atlantic salmon in the Penobscot River, Maine.
89 In *Northeast Fisheries Science Center Reference Document 13-09*. National Oceanic;
90 Atmospheric Administration. <https://repository.library.noaa.gov/view/noaa/4559>
- 91 R Core Team. (2022). *R: A language and environment for statistical computing*. R Foundation
92 for Statistical Computing. <https://www.R-project.org/>
- 93 Stich, D. S., Nieland, J. L., & Sheehan, T. F. (2021). dia: Atlantic salmon dam impact analysis
94 (DIA) for R. In *GitHub repository*. GitHub. <https://doi.org/10.5281/zenodo.13376045>
- 95 Stich, D. S., Sheehan, T. F., & Zydlewski, J. D. (2019). A dam passage performance standard
96 model for American shad. *Canadian Journal of Fisheries and Aquatic Sciences*, 76(5),
97 762–779. <https://doi.org/10.1139/cjfas-2018-0008>
- 98 Wickham, Hadley. (2016). *ggplot2: Elegant graphics for data analysis*. Springer-Verlag New
99 York. <https://doi.org/10.32614/CRAN.package.ggplot2>
- 100 Wickham, H., Averick, M., Bryan, J., Chang, W., D'Agostino McGowan, L., François, R.,
101 Golem, G., Haye, A., Henry, L., Hester, J., Kuhn, M., Lin Pedersen, T., Milne, E., Bach, S.
102 M., Müller, K., Jeroen Oo, D., Seidel, D. P., V., ... Yutani, H. (2019). Welcome to the tidyverse.
103 *Journal of Open Source Software*, 4(43), 1686. <https://doi.org/10.21105/joss.01686>
- 104 Zydlewski, J., Stich, D. S., Roy, S., Bailey, M., Sheehan, T., & Sprankle, K. (2021). What
105 have we lost? Modeling dam impacts on American shad populations through their native
106 range. *Frontiers in Marine Science*, 8. <https://doi.org/10.3389/fmars.2021.734213>