REQUEST FOR QUOTATION (RFQ)

FOR SERVICES

Project Title:	**Review of SEAPODYM code for its suitability for parallelization**
Nature of the services	SEAPODYM is a quantitative spatio-temporal dynamics model of population dynamics. It's parameterized using maximum likelihood estimation approach and integration of geo-referenced datasets obtained from industrial fishing and scientific campaigns. Its computer code (written in C++) is the implementation of the numerical solver for partial differential equations (PDEs) with initial and boundary conditions. The **objective of this work** is to undertake a review of the SEAPODYM computer code, and to provide potential solution(s) to enable a parallel execution of this computer code while preserving its current functionalities of performing numerical simulations and optimization runs with the model.
Location:	Home based
Date of issue:	13/12/2022
Closing Date:	27/01/2023
SPC Reference:	22-4905

Contents

Part 1: INTRODUCTION

1.1 About the Pacific Community (SPC)

The Pacific Community (SPC) is the principal scientific and technical organisation of the Pacific region, established by treaty in 1947 with the signing of the *Agreement Establishing the South Pacific Commission* (the Canberra Agreement).

Our unique organisation covers more than 20 sectors and is renowned for knowledge and innovation in such areas as fisheries science, public health surveillance, geoscience and conservation of plant genetic resources for food security.

For more information about SPC and the work that we do, please visit our website: https://www.spc.int/.

1.2 SPC's procurement activities

SPC's procurement activities are guided by the principles of high ethical standards, value for money, open competition and social and environmental responsibility and are carried out under our Procurement Policy.

For further information or enquiries about SPC's procurement activities, please visit the procurement pages on our website: https://www.spc.int/procurement or email: procurement@spc.int

1.3 SPC's Request for Quotation (RFQ) Process

At SPC, procurement valued at more than EUR 2,000 and less than or equal to EUR 45,000 requires an evaluation of at least three quotations to determine the offer that provides the best value for money through a Request for Quotation (RFQ) process.

This RFQ sets out SPC's requirements for a project and it asks you, as a bidder, to respond in writing in a prescribed format with pricing and other required information.

Your participation confirms your acceptance of SPC's conditions of participation in the RFQ process.

Part 2: INSTRUCTIONS TO BIDDERS

2.1 Background

SPC invites you to submit a quotation to deliver the services as specified in Part 3.

SPC has compiled these instructions to guide prospective bidders and to ensure that all bidders are given equal and fair consideration. Please read the instructions carefully before submitting your bid. For your quotation to be considered, it is important that you provide all the prescribed information by the closing date and in the format specified.

2.2 Submission Instructions

You must **submit your quotation and all supporting documents** in English or in French and as an attachment to an email sent to innas@spc.int and with the subject line of your email as follows: **Submission 22-4905**.The email should also be copied to **rfq@spc.int.**

The supporting documents expected in this RFQ are:

- The Conflict-of-Interest Declaration form completed
- Completed Technical proposal form
- Most recent Curriculum Vitae with three references

- Cover letter
- Detailed work-plan with tentative timelines

Your submission must be clear, concise and complete and should only include a quotation and information that is necessary to respond effectively to this RFQ. Please note that you may be marked down or excluded from the procurement exercise if your submission contains any ambiguities or lacks clarity.

Bids will be evaluated on the basis of information received by **17:00 (GMT+11)** on **27/01/2023**.

2.3 Evaluation & Contract Award

Each quotation validly received will be assessed against the evaluation criteria matrix set out in Part 4. Any changes in the evaluation criteria will result in the RFQ process being re-issued.

SPC may award the contract once it has determined that a bidder has met the prescribed requirements and the bidder's proposal has been determined to be substantially responsive to the RFQ documents, provide the best value for money (highest cumulative score) and best serve the interests of SPC.

In the event of a bid being accepted, procurement will take place under SPC's General Terms and Conditions of Contract and depending on the value or nature of the procurement, the award will be made by issuing a purchase order or a signed and dated contract, or both.

2.4 Key Contacts

Please contact SPC should you have any doubt as to what is required or if we can help answer any questions that you may have.

The Senior Fisheries Scientist (Tuna Population Modelling) will be your primary point of contact for this RFQ and can be contacted at innas@spc.int. You should copy any communications into **rfq@spc.int**.

Details will be kept of any communications between SPC and bidders. This assists SPC to ensure transparency of the procurement process. While SPC prefers written communication in the RFQ process, at any point where there is phone call or other conversation, SPC expects to keep a file note of the exchange, with all forms of communication with prospective bidders to be retained as source documents for the procurement of the services.

2.5 Key Dates

Please see the proposed procurement timetable in the table below. This timetable is intended as a guide only and while SPC does not intend to depart from the timetable, it reserves the right to do so at any stage.

STAGE	DATE
RFQ sent to potential vendors	13/12/2022
RFQ Closing Date	27/01/2023
Award of Contract	15/02/2023
Commencement of Contract	1/03/2023
Conclusion of Contract	31/05/2023

2.6 Legal and compliance

Confidentiality: Unless otherwise agreed by SPC in advance or where the contents of the RFQ are already in the public domain when shared with the bidder, bidders shall at all times treat the contents of the RFQ and

any related documents as confidential. SPC will also treat the information it receives from the bidders as confidential.

Conflict of interest: Bidders must take all necessary measures to prevent any situation of conflict of interest. You must notify SPC in writing as soon as possible of any situation that could constitute a conflict of interest during the RFQ process. If you have any familial connection with SPC staff, this must be declared, and approval will then be sought for you to engage in the RFQ process. **In support of your response to this RFQ, you must submit to SPC the Conflict-of-Interest Declaration form available on our procurement page website:** https://spc.int/procurement.

Breach of this requirement can result in SPC terminating any contract with a successful bidder.

Currency, validity, duties, taxes: Unless specifically otherwise requested, all proposals should be in EURO and must be net of any direct or indirect taxes and duties, and shall remain valid for 120 days from the closing date. The successful bidder is bound by their proposal for a further 60 days following notification they are the preferred bidder so that the contract may be awarded. No price variation due to escalation, inflation, fluctuation in exchange rates, or any other market factors shall be accepted at any time during this period.

No offer of contract or invitation to contract: This RFQ is not an offer to contract or an invitation by SPC to enter into a contract with you.

Privacy: The bidder is to comply with the requirements of applicable legislation and regulatory requirements in force for the use of personal data that is disclosed for the purposes of this RFQ. SPC will handle any personal information it receives under the RFQ in line with its Privacy Policy, and the Guidelines for handling personal information of bidders and grantees.

Warranty, representation, assurance, undertaking: The bidder acknowledges and agrees that no person has any authority to give any warranty, representation, assurance or undertaking on behalf of SPC in connection with any contract which may (or may not) follow on from this RFQ process.

2.7 Complaints process

Bidders that consider they were not treated fairly during any SPC procurement process may lodge a protest. The protest should be addressed to complaints@spc.int. The bidder must provide the following information: (1) full contact details; (2) details of the relevant procurement; (3) reasons for the protest, including how the alleged behaviour negatively impacted the bidder; (4) copies of any documents supporting grounds for protest; (5) the relief that is sought.

Part 3: TERMS OF REFERENCE

A. Background/context

The SPC Oceanic Fisheries Programme undertakes a broad range of tuna fisheries and tuna ecosystem monitoring and analysis work. This work is supported by the development of the SEAPODYM ecosystem and tuna model. SEAPODYM parameterization is based on the set of quantitative methods, including maximum likelihood estimation approach integrating massive geo-referenced datasets obtained from industrial fishing and scientific campaigns. The use of quantitative methods is necessary to obtain the estimates of the temporal dynamics of the modelled population, its spatial structures and main biological parameters that are derived from and coherent with observations.

The computer code of SEAPODYM is the implementation of the numerical solver for partial differential equations (PDE) with initial and boundary conditions (eqs. 1.1-1.3 in SEAPODYM Reference Manual, 2022). These PDEs describe the population dynamics of tuna or other highly migratory species in four dimensions, age, time and two-dimensional space. The PDEs are discretised on a regular grid and approximated using the finite-difference method. The time derivatives are approximated according to an implicit Euler scheme in two half-steps, resulting in the spatial operator splitting in x and y dimensions and the integration method called alternate-direction implicit (ADI). The age dimension is discretised into age classes and the age derivative is approximated with the first order finite difference outside of the iterative ADI solver, i.e., between the time steps. More details about the numerical method can be found in the SEAPODYM reference manual (2022).

The SEAPODYM numerical code is written in C++. It is the open-source and can be accessed in GitHub (https://github.com/PacificCommunity/seapodym-codebase/). The current code structure is designed as to allow the direct mode to solve the underlying PDEs and the inverse (adjoint) mode to enable solving the optimization problem based on the analytically computed gradient of the likelihood function of model parameters and observations (catch, length-frequency of catch and tagging data). The optimization is done by the iterative quasi-Newton method. The **objective of this work** is to enable a parallel execution of this computer code while preserving its current functionalities of performing numerical simulations and optimization runs with the model.

B. Purpose, objectives, scope of services

The work will be conducted in two phases:

1. exploratory study including the code familiarization, identification and design of working solution(s) for its parallelization;
2. implementation of a proposed solution for code parallelization.

This RFQ is for the first Phase. The commencement and the duration of the second phase will be conditioned on the results and proposed solutions recommended in the first phase. These terms will be fixed once SPC will finish the review of the concept note expected as an outcome of the exploratory study. The second phase will be subject to a separate RFQ process.

Potential solutions and caveats

Although the contractor is free to propose other solutions, SPC suggests exploring two potentially parallelizable parts of the SEAPODYM computer code: 1) the numerical solver, which takes up to 80% of execution time and contains two loops, where the linear systems of the ADI method (eqs. 2.30 and 2.31 in the Reference Manual) are solved in x and y directions; and/or 2) the age loop, thus enabling the parallel execution of the PDE solvers. The latter can be implemented in two ways: 1) without

conceptual changes, thus preserving the aging implementation in the current code, or 2) modifying the numerical resolution of aging by implementing a cohort-wise (cohort here is the group of fish born at the same time) spatio-temporal dynamics model.

In both solutions described above, a major caveat that makes the parallelization of SEAPODYM with parameter estimation challenging is the use of the adjoint method and related memory control. While the adjoint is known to be the most efficient method to provide the analytical (subject to machine precision error) gradient of a function of multiple parameters, it requires saving and restoring the variables that are used in the adjoint operations during the backward run. In most adjoint routines of the SEAPODYM code these variables are recomputed, but the iterative implicit ADI method relies heavily on the memory stack, where all intermediate model states are stockpiled in the strict order according to the integration of the model PDEs with the age derivative.

Currently, the direct and the adjoint code of SEAPODYM use the objects and the memory management functions implemented in the AUTODIF library (see Autodif User's Manual, 2021). The AUTODIF library controls memory allocation, storing and restoring the model variables. Three buffers are declared and used: i) gs_var_buffer stores dvariables (variables depending on variable parameters) and all AUTODIF objects used in the code; ii) cmpdiff_buffer stores the intermediate variables required by the adjoint code, and iii) gradstack_buffer stores the information necessary to calculate derivatives via automatic differentiation. Note, the third buffer is used for computing likelihoods only, and it can be envisaged to get rid of it by writing the corresponding adjoint code. In any case, the alternative implementation of buffers may be warranted to allow its splitting and hence independence of parallel processes.

Outputs/Deliverables

Phase 1. Exploratory study and design of the working solution

Expected outputs:

1. A concept note describing the design of the working solution (s) for the SEAPODYM code parallelization. This report should provide the estimate of theoretical speed-up of SEAPODYM code given the number of processors according to Amdahl law.

2. A "toy model" example providing the proof of concept for the proposed solution(s) of the model code parallellization.

C. Timelines

In total, 3 months from the commencement of the contract.

D. Reporting and contracting arrangements

The Contractor will be responsible to the Deputy Director (Oceanic Fisheries Programme). The Senior Fisheries Scientist (Tuna Population Modelling) will be the primary contact point for the Contractor on all technical matters pertaining to this work.

Any travel costs and consultation related expenses must be included in the financial proposal and will be confirmed in the contract, in addition to consultancy fees due to the consultants.

All outputs and reporting timelines relating to this work will be detailed in the contract between the Contractor and SPC.

E. Skills and qualifications

- At least 5 years of relevant practical experience in parallel programming.
- Tertiary qualification in fields of Computer Science or a related field.
- Demonstrated experience with code optimisation is desirable.

F. Scope of Bid Price and Schedule of Payments

The bidder must include computation of contract price which should include professional fees, management and operating costs, travel costs, per diems, and any other administrative costs.

The payment will be based on the following milestones as follows:

Milestone/deliverables	Deadline	% payment
Contract signature & project commencement	01/03/2023	20
Acceptance of concept note and toy model outputs by SPC	31/05/2023	80
TOTAL		100

G. Annexes to the Terms of Reference

Annex A. SEAPODYM Manual

Part 4: PROPOSAL EVALUATION MATRIX

4.1 Competency Requirements & Score Weight

The evaluation matrix bellow reflects the obtainable score specified for each evaluation criterion (technical requirement) which indicates the relative significance or weight of the items in the overall evaluation process.

Evaluation criteria	Score Weight (%)	Points obtainable
Mandatory requirements		
• **Business registration**	**Mandatory requirements.** Bidders will be disqualified if any of the requirements are not met	
Technical requirements		
Technical requirement 1: At least 5 years of relevant practical experience in parallel programming	40%	40
Technical requirement 2: Tertiary qualification in fields of Computer Science or a related field	40%	40
Technical requirement: Demonstrated experience with code optimisation is desirable	10%	10
Other: Demonstrated plan and ability to undertake and deliver the scope of work within the specified timelines outlined in the RFQ	10%	10
Total Score	**100%**	**100**