

从天体配置到有效环境： 深海生命中介质传递、时间延迟与个体化的形式分析

以“深海命理学猜想”为条件性思想实验

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摘 要

一切主张“天体状态影响生命”的体系，无论其经验地位如何，在形式上都隐含一个极强的物理假设：环境对外部信号是透明的，即生命所接收的输入等于天体状态本身。本文把这一假设写成传递算子，并在一个明确标注为条件性的前提下考察它在海洋深处会发生什么；该前提是，存在某种尚未被认识的、天体与生命之间的耦合。本文的主要结果有二。其一，**出生时刻去相关定理**：当环境记忆核带有长延迟时，出生时刻的天体配置与生命实际进入的有效环境之间的相关系数趋于零，而有效环境的方差保持不变；即信息并未减少，只是对应于另一个时刻。其二，**个体化方差坍塌定理**：当环境滤波器的截止周期长于世代窗口时，同一队列内个体之间由外部强迫可解释的方差被压缩至滤波器增益的平方量级。将二者代入对八千米水深处传递函数的通道分解（光学、电磁、引力、物质运输），可得一个具体结论：在超深渊带，唯一在物理上可能个体化的天体输入是引潮势与低频地磁变化，二者均由日月主导，行星贡献被引潮势的立方律压制在 10^{-5} 以下，且均非光学。本文进一步证明多载体存储必然导出幂律记忆核，从而把原设想中并列的三个假说归约为一条具有依赖关系的链，并给出可测量清单与五条带明确证伪条件的预测。就实质而言，本文并未支持命理学；相反，它给出一条约束：任何试图物理化的星命体系都必须放弃普适性。剥去条件外壳后，其一般命题属于环境信号传递理论：一个开放系统所经历的外部环境，不等于外部环境本身，而等于它经过介质传递之后的像。

关键词： 环境传递函数；记忆核与延迟；超深渊带；引潮势；可证伪性

说明事项

状态。 本文是为讨论而流通的工作稿，属初步讨论论文，并非作者立场的最终陈述。章节编号、命题编号与表述均可能变动。

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参数取值与其来源。 表 2 中海水电导率取 $\sigma = 4 \text{ S m}^{-1}$ ，介于实用盐度标度 1978 所定义的参考值 $C(35, 15^\circ\text{C}, 0) = 4.2914 \text{ S m}^{-1}$ 与深层低温海水的相应值之间[18]；表 1 中漫射衰减系数取 $K_d = 0.02\text{--}0.04 \text{ m}^{-1}$ ，其下限对应最清澈天然水体的实测值[16]；表 4 的行星引潮强度由标准天文常数按 M/d^3 计算，行星距离取其最接近值；分潮频率与地球自转角速度 $\Omega = 7.292115 \times 10^{-5} \text{ s}^{-1}$ 取自标准潮汐与天文常数[13]。表 6 与图 2 中的浮力频率 $N = 10^{-3} \text{ s}^{-1}$ 、表 3 中的渡越时间参数 (T, s) 为算例取值，其作用是给出量级而非特定站位的观测。需强调：本文的两个主要定理与临界纬度结果不依赖上述任一取值；临界纬度由 $\sin \phi_{\text{crit}} = \omega/(2\Omega)$ 唯一确定，与 N 无关。

关联材料。 本文另有一个面向一般读者的中文通俗版本《深海物种的命理学猜想》，二者共享同一论证骨架，但通俗版未包含定理 4.1、定理 5.2 与定理 8.1 的证明，且在低频电磁通道的处理上不如本文准确（见本文注 3.11）。若二者有出入，以本文为准。

建议引用格式。 黄万鸿：《从天体配置到有效环境：深海生命中介质传递、时间延迟与个体化的形式分析：以“深海命理学猜想”为条件性思想实验》，工作稿。

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Status. This is a working draft circulated for discussion. It is a preliminary discussion paper and is not a finished statement of the position of its author. Sections, numbering and formulations are subject to change.

Language. This paper is issued in both Chinese and English. Where a sentence or a formulation is in doubt, the English version governs.

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Statement on the use of language models. Drafting, literature search and argumentative criticism for this paper were conducted in dialogue with large language models, specifically Claude (Anthropic) and ChatGPT (OpenAI). The claims, the structure, the selection of material and the position taken belong to the author. The bibliographic details of all references cited have been checked item by item.

Parameter values and their sources. The seawater conductivity $\sigma = 4 \text{ S m}^{-1}$ used in Table 2 lies between the reference value $C(35, 15^\circ\text{C}, 0) = 4.2914 \text{ S m}^{-1}$ defined by the Practical Salinity Scale 1978 [18] and the corresponding value for cold deep water. The diffuse attenuation coefficients $K_d = 0.02\text{--}0.04 \text{ m}^{-1}$ in Table 1 have as their lower bound the measured value for the clearest natural waters [16]. The planetary tidal strengths in Table 4 are computed as M/d^3 from standard astronomical constants, with planetary distances taken at closest approach. Tidal constituent frequencies and the Earth rotation rate $\Omega = 7.292115 \times 10^{-5} \text{ s}^{-1}$ follow standard tidal and astronomical constants [13]. The buoyancy frequency $N = 10^{-3} \text{ s}^{-1}$ in Table 6 and Figure 2, and the transit-time parameters (T, s) in Table 3, are worked-example values chosen to fix orders of magnitude, not observations from a specific station. It should be stressed that neither of the two main theorems nor the critical-latitude result depends on any of these choices: the critical latitude is fixed uniquely by $\sin \phi_{\text{crit}} = \omega/(2\Omega)$ and is independent of N .

Companion material. A Chinese popular-science version of this argument, *A Numerological Conjecture Concerning Deep-Sea Species*, shares the same argumentative skeleton but omits the proofs of Theorems 4.1, 5.2 and 8.1, and is less accurate in its treatment of the low-frequency electromagnetic channel (see Remark 3.11 of the present paper). Where the two diverge, the present paper governs.

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Discussion Paper Note

This paper is a preliminary discussion paper intended to share an evolving idea and invite further dialogue, criticism, revision, and independent development.

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1 引言

人类很早就试图在生命与天体之间建立联系。中国传统命理、西方占星以及其他星命体系在方法上差异极大，却共享一个隐含结构：生命诞生的时间位置，以及与之对应的天体配置，与该生命后续的性状之间存在某种关系。

这一结构的经验检验结果是清楚的。Carlson 的双盲实验[2]、以及 Dean 与 Kelly 对“时间双生子”数据的分析[3]，均未支持出生天体配置对人格或际遇具有可检测的效应。本文不打算重新评估这一经验结论，也不主张任何形式的星命术成立。

本文关心的是另一个问题，它在既有讨论中几乎没有被处理过：

如果把“天体状态影响生命”当作一个物理主张来认真对待并写成方程，那么这个方程隐含了关于传播介质的什么假设？当生命所处的介质从大气变成八千米海水时，这些假设会发生什么？

选择深海作为检验场景并非猎奇。2022 年的一次联合考察在伊豆-小笠原海沟 8336 m 深处拍摄到一尾狮子鱼（*Pseudoliparis* 属幼体），创下硬骨鱼的最大深度纪录；同一航次在邻近的日本海沟 8022 m 处以诱捕器捕获两尾 *Pseudoliparis belyaevi*，为迄今实际捕获的最深的鱼[8]。这样的生物提供了一个几乎理想的极端案例：它的出生时刻、经纬度与当时的天体历元原则上都可以确定，因此传统星命体系所需的全部输入一个不缺；但它所处的物理介质与地表相差之远，足以让“介质是否透明”这一通常被忽略的假设变得可以计算。

本文采用条件性推演。命题形式为：

设 **假设 P**：存在某种尚未被认识的物理过程，使得天体环境状态能够向生命系统输入具有生物学意义的信息。

求：在 P 成立的前提下，深海生命接收此种信息的时间结构与信息结构。

假设 P 自始至终是逻辑前件，从未被断言为真。这类推演的价值不在于支持 P，而在于：若推演结果足够强，它可能反过来约束甚至否定 P 的原始形态。本文的结论正属于此类（见第 10 节推论 10.1）。

同时需要指出，本文的推导可以分为两层。上层依赖假设 P；下层（即关于海洋作为信号传递系统的频率响应、延迟与记忆结构的部分）不依赖 P，它属于物理海洋学与线性响应理论的既有内容。把“天体”替换为任何一个外生驱动（太阳辐照、气候强迫、污染输入、人类活动），下层结论原封不动地成立。

本文所用的每一件工具都不是新的，这一点必须明确交代。

线性响应与记忆核。用卷积核与传递函数描述系统对外部强迫的响应是线性响应理论的标准内容；因果性对传递函数实部与虚部的约束即 Kramers-Kronig 关系。

海洋作为低通积分器。Hasselmann 的随机气候模型[7]已经确立了这一图像的经典形式：海洋对快速大气噪声的积分产生红谱响应。本文关于“海洋是低通滤波器”的一般断言完全属于该传统，并不新颖；本文所加的只是按物理通道分解并代入超深渊带的具体数值。

渡越时间分布。把水团输运写成渡越时间分布（transit-time distribution）是物理海洋学的成熟框架[6]；深层通风年龄的放射性碳与模式估计亦已有大量文献[1, 9, 4]。

内潮生成与地形。正压潮在地形上转换为内潮、临界坡条件、以及内波频带 $f < \omega < N$ ，均见于 Garrett 与 Kunze 的综述[5]。

海洋生物节律。昼夜、潮汐、半月与年节律及其内源振荡器已有系统综述[17, 15]；深海底栖鱼中与周期性流速相联系的行为与褪黑素模式，以及“潮流可充当授时因子”的提法，见Wagner 等[19]。

幂律记忆与分数阶动力学。多弛豫时标叠加导出幂律核、以及其对应的分数阶响应，是反常动力学的标准结果[10]。

在上述前提下，本文的增量是有限而具体的：

1. 把“出生时刻决定”这一命理学核心结构精确刻画为记忆核取 Dirac δ （命题 2.10），从而把一个通常被当作非科学的命题转化为一个可计算的滤波器问题；
2. 证明**出生时刻去相关定理**（定理 4.1），其中关键的是有效环境方差与延迟无关这一条，正是它排除了“深海环境单调因而无信息”的常见误读；
3. 提出并证明**个体化方差坍塌定理**（定理 5.2），把“命盘能否区分个体”这一功能性要求量化为一个谱积分；
4. 对超深渊带作四通道分解，得到一个具体推论：唯一可能个体化的天体输入是引潮势与低频地磁变化，行星被立方律排除（推论 6.1）；
5. 证明多载体存储必然导出幂律记忆核（定理 8.1），由此把原设想中并列的三个假说归约为一条依赖链，并诚实指出该通道对定理 5.2 的削弱；
6. 给出自我限制推论（推论 10.1）与一份带明确证伪条件的研究纲领。

第 2 节建立形式框架。第 3 节对深海传递函数作通道分解。第 4 与第 5 节给出两个主要定理。第 6 节确定幸存的天体变量。第 7 与第 8 节分别处理内生化与多模态存储。第 9 节讨论空间与地形。第 10 节给出场介导模型与自我限制推论。第 11 节给出可证伪化纲领，第 12 节列出局限。

2 形式框架

2.1 基本对象

定义 2.1 (天体状态过程). 设 $\Psi : \mathbb{R} \rightarrow \mathbb{R}^n$ 为天体状态过程， $\Psi(t)$ 表示时刻 t 的天体与近地宇宙环境的物理状态向量，其分量可取为日月与行星相对于参考点的方向余弦与距离、太阳辐照度、太阳风参数、行星际磁场分量、宇宙线通量等。要求 Ψ 为实值可测量的物理量，且相对于地球生命为外生。

定义 2.2 (有效环境). 设 $\Psi_{\text{eff}} : \mathbb{R} \rightarrow \mathbb{R}^m$ 为有效环境过程，即在生命体所处位置上真正与生物过程发生耦合的局部物理量：光照、压力扰动、温度、盐度、流速、化学梯度、局部电磁场等。

定义 2.3 (生物响应). 设 B 表示生命体某个可观测的后续特性（表型、节律参数、生活史参数、种群统计量等）。

在此记号下，假设 P 即断言 B 与 Ψ 之间存在统计上非平凡的依赖关系。

2.2 自然出生映射及其两个隐含假设

传统出生星盘或八字体系强调出生时刻 t_b 的天体配置。其抽象形式为

$$B = F(\Psi(t_b)) + \varepsilon. \quad (1)$$

公式 1 并非断言此类体系在实践中使用该数学形式；它提取的是其中隐含的**时间结构**：决定 B 的全部天体信息包含于单一时刻 t_b 的状态之中。该结构包含两个彼此独立、都很强的假设。

假设 2.4 (瞬时性 T). B 只依赖 Ψ 在 t_b 处的取值，不依赖 Ψ 的历史。

假设 2.5 (透明性 U). 生命体接收到的输入即天体状态本身， $\Psi_{\text{eff}} = \Psi$ ；介质不参与。

在地表大气条件下，假设 U 至少表面上无害。本文将证明，在八千米水深处它不是“近似不准”，而是定性错误；且一旦 U 失效，T 随之失效。

2.3 环境传递算子

真实因果链为

$$\Psi \longrightarrow \text{Earth system} \longrightarrow \text{local environment} \longrightarrow \Psi_{\text{eff}} \longrightarrow B. \quad (2)$$

定义 2.6 (环境传递算子). 存在依赖于生命体所处环境 $\mathcal{E}$ 的算子 $\mathcal{H}_{\mathcal{E}}$ ，使得 $\Psi_{\text{eff}} = \mathcal{H}_{\mathcal{E}}[\Psi]$ 。相应地，假设 P 的一般形式为

$$B = F(\mathcal{H}_{\mathcal{E}}[\Psi]) + \varepsilon. \quad (3)$$

公式 1 是公式 3 在 $\mathcal{H}_{\mathcal{E}} = \text{Id}$ 时的特例。

2.4 线性时不变近似及其代价

假设 2.7 (LTI). 在所关心的振幅范围内， $\mathcal{H}_{\mathcal{E}}$ 可近似为线性且时不变的算子。

这一近似的代价必须明说。真实海洋是强非线性的：内波破碎、湍流混合、生态阈值与临界转变均不满足线性叠加。使用 LTI 的理由有三。第一，外部天体扰动相对于海洋自身能量尺度是极小扰动（引潮加速度约 $10^{-7}g$ ），小扰动的一阶响应确实是线性的。第二，在缺乏显著季节调制的深层水体中，时不变性大致成立。第三，也是最重要的一点：**本文的两个主要定理在 LTI 失效时只会加强而非削弱**，因为非线性混合只会进一步破坏信号与出生时刻之间的对应关系。因此 LTI 在此是保守方向的近似。

命题 2.8 (核表示). 在假设 2.7 下，存在记忆核 K 使得

$$\Psi_{\text{eff}}(t) = \int_0^{\infty} K(\tau) \Psi(t - \tau) d\tau, \quad (4)$$

积分下限取 0 即因果性条件。其频域形式为

$$\hat{\Psi}_{\text{eff}}(\omega) = H(\omega) \hat{\Psi}(\omega), \quad H(\omega) = \int_0^{\infty} K(\tau) e^{-i\omega\tau} d\tau. \quad (5)$$

H 与 K 是同一对象的两种表示，因此下文可在“记忆”语言与“频谱”语言之间自由转换。

注 2.9. 因果性 $K(\tau) = 0, \tau < 0$ 蕴含 H 的实部与虚部满足 Kramers–Kronig 关系。其物理含义是：任何选择性衰减必然伴随色散延迟；衰减与延迟不是两件可以分别调节的事。这一点将在第 3 节以具体形式出现。

表 1: 光学通道在不同深度的透过率 I/I_0

深度	$K_d = 0.02 \text{ m}^{-1}$	$K_d = 0.03 \text{ m}^{-1}$	$K_d = 0.04 \text{ m}^{-1}$
200 m	$10^{-1.7}$	$10^{-2.6}$	$10^{-3.5}$
1000 m	$10^{-8.7}$	10^{-13}	10^{-17}
4000 m	10^{-35}	10^{-52}	10^{-70}
8000 m	10^{-70}	10^{-104}	10^{-139}

2.5 命理学的形式身份

命题 2.10. 公式 1 所表示的出生时刻决定模型，等价于记忆核取 Dirac δ :

$$K(\tau) = \delta(\tau) \iff H(\omega) \equiv 1 \iff \Psi_{\text{eff}}(t) = \Psi(t). \quad (6)$$

证明. 由 δ 的筛选性质与公式 4、公式 5 直接可得。□

命题 2.10 的意义在于它把一个通常被视为不可讨论的主张翻译成了一个明确的物理要求: $H \equiv 1$ 意味着环境是理想的全通、零延迟、无失真信道，其中所有频率的天体信号以相同增益、相同相位、零时延到达生命体。

于是问题化为一个可计算的问题，即求解公式 7 中的对象:

$$H_{\text{tot}}(z = -8000 \text{ m}, \omega) = ? \quad (7)$$

3 深海传递函数的通道分解

3.1 分解原理

关键的物理事实是: “天体信号”不是单一物理量。同一天体通过不同载体作用于地球，而这些载体在海水中的传播性质相差数十个数量级。因此正确的做法是按物理通道分解:

$$H_{\text{tot}}(z, \omega) = \sum_c H_c(z, \omega), \quad H_c = \prod_j H_{c,j}(\omega), \quad (8)$$

即并联通道求和、单通道内串联环节求积。下面逐条计算四个通道。

3.2 光学通道

可见光在海水中的衰减服从 Beer-Lambert 定律 $I(z) = I_0 e^{-K_d z}$ ，其中 K_d 为漫射衰减系数。在最清澈的天然水体中，蓝绿波段的 K_d 下限约为 0.02 m^{-1} [16]; 寡营养大洋一般取 $K_d \approx 0.02\text{--}0.04 \text{ m}^{-1}$ 。数值见表 1。

10^{-104} 需要一个量级参照: 可见光单光子能量约 $4 \times 10^{-19} \text{ J}$ ，太阳总辐射功率约 $4 \times 10^{26} \text{ W}$ 。即使把全部日光聚焦于一点，八千米深处在宇宙年龄尺度上也接收不到一个光子。故

$$H_{\text{opt}}(-8000 \text{ m}, \omega) = 0. \quad (9)$$

这不是“很弱”，而是通道关闭。其直接后果是: 一切以光为载体的天体信息（日出日落、月相、季节光周期、恒星可见性）在超深渊带不存在。

表 2: 电磁通道的趋肤深度与 8000 m 处衰减

频率	δ	$ H_{EM} $ at 8000 m
1 MHz	0.25 m	e^{-31800}
1 kHz	8.0 m	e^{-1006}
1 Hz	252 m	$\approx 10^{-14}$
10^{-2} Hz	2.5 km	0.041
10^{-4} Hz	25 km	0.73
半日潮频率 (12.42 h)	53 km	0.86

3.3 电磁通道

海水为导体。实用盐度标度 1978 以 $C(35, 15^\circ\text{C}, 0) = 4.2914 \text{ S m}^{-1}$ 为参考电导率[18], 深层低温海水的相应值较低, 故本文取代表值 $\sigma \approx 3\text{--}5 \text{ S m}^{-1}$ 。在良导体近似下 (位移电流可略), 场满足扩散方程 $\nabla^2 \mathbf{E} = \mu\sigma \partial_t \mathbf{E}$ 。设 $\mathbf{E} \propto e^{i(kz - \omega t)}$, 代入得 $k = \sqrt{i\mu\sigma\omega} = (1+i)\sqrt{\mu\sigma\omega/2}$, 虚部给出指数衰减, 衰减长度为趋肤深度

$$\delta(\omega) = \sqrt{\frac{2}{\mu\sigma\omega}} = \frac{503}{\sqrt{\sigma f}} \text{ [m]}, \quad |H_{EM}(z, \omega)| = \exp\left(-|z|\sqrt{\frac{\mu\sigma\omega}{2}}\right). \quad (10)$$

公式 10 是本文核心机制的一个缩影: 衰减指数正比于 $\sqrt{\omega}$, 频率越高衰减越剧烈。取 $\sigma = 4 \text{ S m}^{-1}$, $|z| = 8000 \text{ m}$, 得表 2。

结论是推导出来的而非假设的: **海水对电磁场是一个截止周期约在 $10^2\text{--}10^3 \text{ s}$ 的低通滤波器**。周期短于约百秒的扰动完全消失; 周期长于约一小时的变化则近乎完好通过。

这一点有一个常被忽略的后果, 本文将在第 6 节展开: 低频地磁变化 (如太阳静日变化 Sq, 周期一日, 中纬振幅数十 nT) 能够抵达超深渊海底。

3.4 引力通道

月球引潮力来自引力势的梯度差。在地心距 r 处, 引潮加速度量级为

$$a_{\text{tid}} \approx \frac{2GM r}{d^3}, \quad (11)$$

其中 d 为天体距离。注意 $a_{\text{tid}} \propto r$: 从海面到八千米深处, 相对变化仅

$$\frac{8 \text{ km}}{6371 \text{ km}} \approx 1.3 \times 10^{-3}. \quad (12)$$

引力不被海水屏蔽, 无趋肤深度、无介质吸收, 故

$$H_{\text{grav}} \approx 1, \quad \arg H_{\text{grav}} \approx 0. \quad (13)$$

这是超深渊带唯一近似满足假设 U 的通道。

此处需要一个技术分层, 不能含糊。引潮势本身瞬时无延迟; 而海洋对引潮势的动力学响应 (潮位、潮流、内潮) 则不是: 海洋是被强迫的、有共振与摩擦的力学系统, 其响应含振幅放大与相位滞后, 且强烈依赖海盆几何与海底地形[5]。记该环节为 $H_{\text{resp}}(\mathbf{x}, \omega)$, 则

$$H_{\text{tidal}} = H_{\text{grav}} \cdot H_{\text{resp}}. \quad (14)$$

关键在于 H_{resp} 的相位滞后量级为小时至日, 而非世纪。此外, 潮汐频谱由天体力学决定, 是一组尖锐谱线 (M2、S2、N2、K1、O1 及其叠频), 故该通道是窄带的。

表 3: 物质输运通道的低通衰减 $|H_{\text{adv}}| = e^{-\omega^2 s^2/2}$

输入周期	$s = 300 \text{ yr}$	$s = 500 \text{ yr}$
1 yr (年循环)	$e^{-1.8 \times 10^6}$	$e^{-4.9 \times 10^6}$
11 yr (太阳活动周)	$e^{-1.47 \times 10^4}$	$e^{-4.08 \times 10^4}$
10^2 yr	e^{-178}	e^{-494}
10^3 yr	0.17	0.007
$3 \times 10^3 \text{ yr}$	0.82	0.58
10^4 yr	0.98	0.95

3.5 物质输运通道

太阳能输入抵达深海的路径见公式 15:

$$\begin{aligned} \text{solar forcing} &\rightarrow \text{atmosphere} \rightarrow \text{surface ocean} \\ &\rightarrow \text{water-mass formation} \rightarrow \text{overturning} \rightarrow \text{deep ocean}, \end{aligned} \quad (15)$$

其物理本质是平流-扩散输运。设自表层源区至目标深海位置的渡越时间分布为 $G(\tau)$ [6], 则该通道的记忆核即 $K_{\text{adv}} = G$ 。取 G 为均值 T 、标准差 s 的高斯分布作为一阶近似, 其傅里叶变换有闭式解:

$$H_{\text{adv}}(\omega) = \int G(\tau) e^{-i\omega\tau} d\tau = \underbrace{e^{-i\omega T}}_{\text{纯延迟}} \cdot \underbrace{e^{-\omega^2 s^2/2}}_{\text{高斯低通}}. \quad (16)$$

公式 16 一次性给出两件事: 正比于平均渡越时间的纯相位延迟, 与截止频率 $\omega_c \sim 1/s$ 的低通滤波。这正是前述 Kramers-Kronig 关系的一个具体实例。

数值方面, 北太平洋深层水的通风年龄量级为 10^3 年: 西北太平洋约 2200 m 水深处底栖-浮游有孔虫的 ^{14}C 年龄差为 1030–1630 年, 与该处现今的表观通风年龄相当[1]; 最老的东北太平洋深层水表观年龄超过 2400 年[9]; 全球模式给出西太平洋最老水团年龄约 1494 年, 其组分年龄跨度 500–5000 年[4]。取 $T \approx 10^3 \text{ yr}$ 、 $s \approx 300\text{--}500 \text{ yr}$, 得表 3。

表 3 是本文的关键定量结果之一: **经物质输运抵达深海的太阳信号, 任何快于千年尺度的成分都被彻底抹平**; 年循环的残余为 e^{-10^6} 量级, 在任何物理意义上不存在。同时该通道携带约一千年的相位延迟。

3.6 合成

将四通道按公式 8 叠加, 得

$$H_{\text{tot}}(-8000 \text{ m}, \omega) \approx \underbrace{H_{\text{tidal}}(\omega)}_{\text{窄带、无延迟}} + \underbrace{H_{\text{EM}}(\omega)}_{\text{周期} \gtrsim 10^3 \text{ s 通过}} + \underbrace{e^{-i\omega T} e^{-\omega^2 s^2/2}}_{\text{延迟} \sim 10^3 \text{ yr}} + \underbrace{0}_{\text{光学}}. \quad (17)$$

图 1 给出各通道幅值随输入周期的变化。

注 3.1 (对通俗表述的一处修正). 把这一结果概括为“深海只听得见历史”是不准确的。准确的表述是: **光学通道全频段关闭, 热与物质通道被延迟约 10^3 yr 并低通滤波; 而引力通道与低频电磁通道在周期长于约一小时时基本畅通**。因此深海并非只接收历史; 它接收的是一个由“无延迟的引力与低频电磁”加上“延迟千年的物质印记”构成的双层结构, 中间缺失的是以光和热为载体的、日至世纪尺度的信息, 而那恰是传统星命体系所依赖的全部频段与载体。

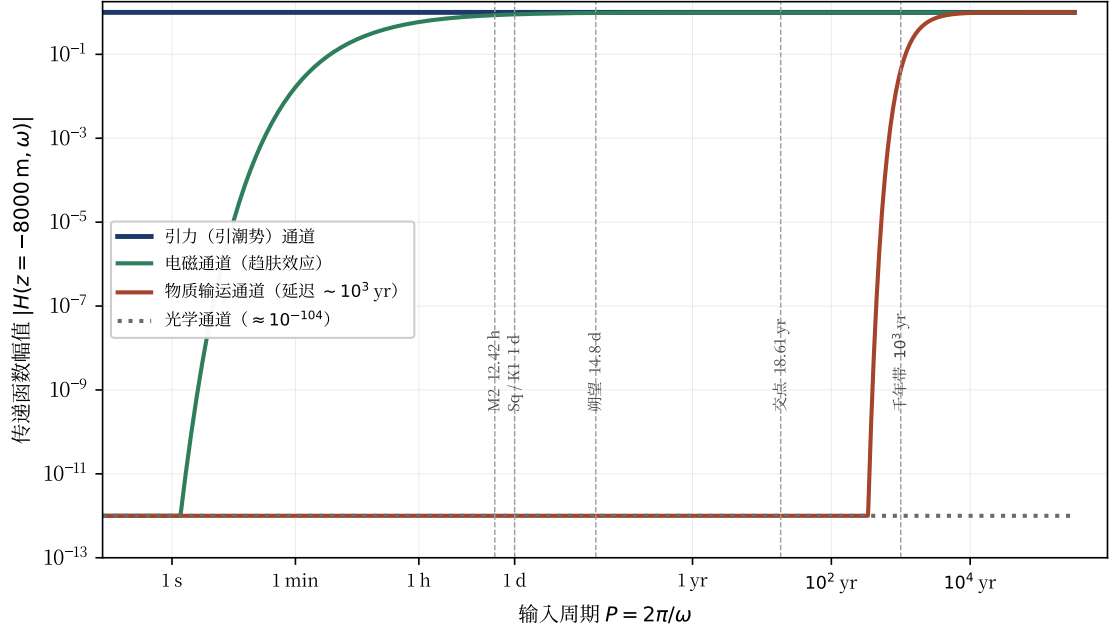


图 1: 八千米水深处四个通道的传递函数幅值 $|H|$ 随输入周期的变化。光学通道在全频段关闭（图中置于绘图下限，实际值约 10^{-104} ）；电磁通道在周期短于约 $10^2\text{--}10^3$ s 时被趋肤效应切断；引力通道近似全通；物质输运通道仅在千年以上周期传递，并附带约 10^3 yr 的相位延迟。虚线标出主要天文周期。

无论如何， H_{tot} 与命题 2.10 所要求的 $H \equiv 1$ 相差极远：假设 U 在此不是近似不准，而是定性错误。

4 出生时刻去相关

4.1 设定

设 Ψ 为零均值宽平稳过程，自协方差

$$C(\tau) = \mathbb{E}[\Psi(t)\Psi(t+\tau)], \quad C(0) = \sigma_\Psi^2, \quad (18)$$

并满足混合条件 $C(\tau) \rightarrow 0$ ($\tau \rightarrow \infty$)。这一条件是温和的：它只要求足够久远的天体状态与当前状态渐近无关，对与气候相关的太阳与地球物理过程均成立。

设记忆核为固定形状 K_0 的平移：

$$K_T(\tau) = K_0(\tau - T), \quad \int K_0 = 1, \quad K_0 \in L^1, \quad (19)$$

即延迟 T 、展宽由 K_0 决定。有效环境为 $\Psi_{\text{eff}}(t) = \int K_T(\tau)\Psi(t-\tau) d\tau$ 。

4.2 定理与证明

定理 4.1 (出生时刻去相关). 在上述设定下：

- (i) $\text{Var}(\Psi_{\text{eff}})$ 与延迟 T 无关；

(ii) $\text{Cov}(\Psi(t_b), \Psi_{\text{eff}}(t_b)) \rightarrow 0$ 当 $T \rightarrow \infty$;

(iii) 因而相关系数 $r(T) \rightarrow 0$ 。

证明. (ii) 作代换 $u = \tau - T$:

$$\text{Cov}(\Psi(t_b), \Psi_{\text{eff}}(t_b)) = \int K_T(\tau) C(\tau) d\tau = \int K_0(u) C(u + T) du. \quad (20)$$

由 C 有界、 $C(u + T) \rightarrow 0$ 逐点成立、 $K_0 \in L^1$, 控制收敛定理给出该积分趋于零。

(i) 同一代换:

$$\text{Var}(\Psi_{\text{eff}}) = \iint K_T(\tau) K_T(\tau') C(\tau - \tau') d\tau d\tau' = \iint K_0(u) K_0(u') C(u - u') du du', \quad (21)$$

平移 T 在被积函数中完全抵消, 因 C 仅依赖差值。

(iii) 由 (i)(ii) 及 $r = \text{Cov} / (\sigma_\Psi \sigma_{\text{eff}})$ 立得。□

注 4.2 (频域表述). 等价地, $\text{Cov} = \frac{1}{2\pi} \int e^{i\omega T} \overline{\hat{K}_0(\omega)} S(\omega) d\omega$, 其中 S 为 Ψ 的谱密度。只要 $\hat{K}_0 S \in L^1$, 由 Riemann–Lebesgue 引理即得 $T \rightarrow \infty$ 时积分趋于零。

4.3 解释

第 (ii) 条是预期之中的。定理的实质内容在第 (i) 条: **延迟并不削弱有效环境自身的变异性**。深海环境依然高度结构化、承载大量信息, 只是它承载的是另一个时刻的信息。

这一条排除了一个常见误读, 即“深海环境单调稳定因而无可推算”。定理 4.1 说的恰恰相反: 方差没有丢失, 丢失的是方差与出生时刻之间的对应关系。用一个类比: 这不是一张模糊的照片, 而是一张清晰的、拍摄于一千年前的照片。

代入 § 3 的物质输运通道, 若 Ψ 的自相关时间为 τ_c (太阳活动的相关时间为十年至百年量级) 而 $T \approx 10^3 \text{ yr}$, 则 $r \lesssim |\rho(T)| \approx 0$: 出生时刻的太阳状态对该水体环境所携带的信息量在数值上不可区分于零。

注 4.3 (适用范围). 定理 4.1 适用于带长延迟的通道, 即 § 3.6 中的物质输运项。它不适用于引力通道与低频电磁通道, 二者的延迟为小时量级。这一限制在第 6 节起决定性作用。

5 个体化方差的坍缩

5.1 功能性要求的量化

任何排盘体系都须满足一个最低限度的功能性要求: **出生时刻不同的个体应得到不同的命盘**。否则该体系在信息论意义上是空的: 同一队列内所有个体获得同一结果, 则不具备任何区分能力。将此要求量化如下。

定义 5.1 (个体化方差). 给定出生时间窗口 W (可理解为一个世代或一个可比较队列), 有效环境 Ψ_{eff} 在该窗口内个体之间的方差定义为

$$V_W = \frac{1}{\pi} \int_{|\omega| > 2\pi/W} |H(\omega)|^2 S(\omega) d\omega. \quad (22)$$

定义 5.1 的理由: Ψ_{eff} 是谱密度为 $|H|^2 S$ 的平稳过程; 在长度为 W 的窗口内, 周期长于 W 的成分表现为该窗口内所有个体共有的常数偏移, 不能区分任何个体; 只有周期短于 W 的成分才能在窗口内不同出生时刻上取到不同值。故可个体化的方差即高通部分。

5.2 定理

定理 5.2 (个体化方差坍缩). 若传递函数在 $|\omega| > \omega_c$ 上满足 $|H(\omega)| \leq \varepsilon$, 且 $\omega_c < 2\pi/W$, 则

$$V_W \leq \varepsilon^2 \sigma_\Psi^2 \cdot \text{const.} \quad (23)$$

即当环境滤波器的截止周期长于世代窗口时, 个体化方差被压缩至 ε^2 量级。

证明. 在积分区域 $|\omega| > 2\pi/W > \omega_c$ 上有 $|H|^2 \leq \varepsilon^2$, 故

$$V_W \leq \frac{\varepsilon^2}{\pi} \int_{|\omega| > 2\pi/W} S(\omega) d\omega \leq \frac{\varepsilon^2}{\pi} \int_{-\infty}^{\infty} S(\omega) d\omega \propto \varepsilon^2 \sigma_\Psi^2. \quad (24)$$

□

5.3 代入超深渊带

物质输运通道的截止周期约为 $2\pi s \approx 2-3 \times 10^3 \text{ yr}$ 。狮子鱼的世代时间为年量级; 即使把队列窗口放宽至一个世纪,

$$W = 10^2 \text{ yr} \implies \varepsilon = |H_{\text{adv}}|_{P=10^2 \text{ yr}} \approx e^{-178}, \quad V_W \lesssim e^{-356} \sigma_\Psi^2. \quad (25)$$

推论 5.3. 经由物质输运通道, 同一世纪出生的全部深海个体共享同一有效天体环境; 其间差异不是“小”, 而是数值上的零。换言之, 若深海存在某种“命盘”, 其经由该通道的分辨率单位是千年而非时辰: 它可以区分唐代的鱼与今天的鱼, 却无法区分今日上午与今日下午出生的两条鱼。

定理 5.2 比定理 4.1 更强。后者说的是“对应错了时刻”, 前者说的是“在该通道上不存在个体这一层级”。

注 5.4 (适用范围与后文的削弱). 与注 4.3 同理, 定理 5.2 对物质输运通道是严格的, 对引力与低频电磁通道不适用。此外, 第 8 节将证明多模态生物-地球化学通道具有幂律而非指数的高频衰减, 因而只是显著削弱、并未消灭个体化方差。这两点共同界定了本定理的有效边界。

6 幸存通道与可个体化的天体变量

由注 4.3 与 5.4, 两个定理并未清空全部通道。本节确定究竟什么幸存下来。

6.1 引潮势本身即日月星历

引潮势不是笼统的“月球影响”, 而是由日月位置精确决定的解析函数。对天体 j , 其在地球表面的二阶引潮势为

$$V_j(\mathbf{x}, t) = \frac{GM_j r^2}{d_j(t)^3} P_2(\cos \theta_j(t)) + \dots, \quad (26)$$

表 4: 各天体的引潮力相对强度（月球 = 1；行星取最近距离）。按 M/d^3 由标准天文常数计算。

天体	相对引潮强度
月球	1
太阳	0.46
金星	5.7×10^{-5}
木星	7.2×10^{-6}
火星	3.1×10^{-6}
水星	5.5×10^{-7}
土星	2.5×10^{-7}

其中 θ_j 为天体的天顶角， P_2 为二阶勒让德多项式。总引潮势 $V = \sum_j V_j$ 因而是日月（及行星）位置的连续函数。

由 $H_{\text{grav}} \approx 1$ ，可得一个直接而有些出人意料的结论：

深海生命并未丢失日月的位置信息。它以引力势的形式、近乎无损地接收到完整的日月配置，只是从未“看见”过它们。

该通道天然包含多层周期：半日潮（12.42 h）、全日潮、朔望周期（14.77 d）、近点月（27.55 d）、太阳年（S2/K1 的年调制）、月球近地点进动（8.85 yr）以及月球交点退行（18.61 yr）。因此其时间结构从小时延伸至十八年，且全部来自引力、全部来自日月。

6.2 立方律对行星的排除

由公式 26，引潮强度 $\propto M_j/d_j^3$ 。这一立方律的后果极为严厉。以月球为 1 归一化，取各行星最接近时的距离，得表 4。

6.3 低频地磁通道

由表 2，周期长于约一小时的电磁变化可抵达超深渊海底。相关的天然源包括：太阳静日变化（Sq，周期一日，中纬振幅数十 nT，源于太阳加热电离层，因而编码地方太阳时）、磁暴与环电流变化、以及太阳活动周的长期调制。

对此必须给出三点限定。第一，其相对调制幅度小：数十 nT 相对于 $3-5 \times 10^4$ nT 的稳态地磁场约为 10^{-3} 。第二，深海生物对该量级变化的感受能力尚未确立，磁感受机制本身仍在争论之中；因此该通道的生物学相关性目前只能作为条件性陈述。第三，其天体内容是太阳活动与太阳方位，而非星命体系所依赖的行星几何；行星对地磁扰动的贡献可忽略。

6.4 主推论

推论 6.1 (日月幸存、行星排除)。在超深渊带，唯一在物理上可能个体化的天体输入是引潮势与低频地磁变化。二者

- (a) 均由日月主导，行星在引潮势中被压制至 10^{-5} 以下、在地磁扰动中可忽略；
- (b) 均非光学，与“可见天空”无关；

(c) 均不受定理 4.1 与 5.2 的约束，因其延迟为小时量级、且在日尺度上变化，满足定义 5.1 的个体化条件。

因此，若坚持为超深渊生命构造一张“出生盘”，该盘上只能有太阳与月亮，不能有行星；且其中的日月不是黄道上的符号，而是引潮势与地磁变化中的两个物理量。

6.5 实证接口

推论 6.1 的引力分支具有直接的实证支撑。海洋时间生物学已在多种海洋生物中记录昼夜、潮汐、半月、月与年节律，并区分外部周期驱动的节奏与内源振荡器维持的节奏[17, 15]。在深海，Wagner 等在约 1000 m 深处的两种底栖鱼中观察到与周期性流速变化相联系的行为与褪黑素模式，并提出潮流可充当深海底栖动物的授时因子[19]。

即“深海生物以潮汐对时”并非猜想，而是已发表的观测。本文的贡献只是把它放回完整的传递函数框架，说明为何偏偏是潮汐幸存。

7 内生化：锁相与遗传编码

外部周期不必持续实时输入：生命系统可将长期存在的外部规律部分内生化。本节把这一设想形式化，并指出其中一处必须纠正的层次混淆。

7.1 锁相条件

设生物内部存在自持相位振子，固有角频率 ω_0 ，受角频率 ω_f 的外部周期以强度 ε 驱动：

$$\dot{\phi} = \omega_0 + \varepsilon \sin(\omega_f t - \phi). \quad (27)$$

令 $\psi = \omega_f t - \phi$ 、 $\Delta\omega = \omega_f - \omega_0$ ，得 Adler 方程[12]

$$\dot{\psi} = \Delta\omega - \varepsilon \sin \psi. \quad (28)$$

不动点存在的充要条件为

$$|\Delta\omega| \leq \varepsilon, \quad (29)$$

即锁相 (entrainment) 条件；其在参数平面上张开的区域为 Arnold 舌，宽度 2ε ，锁定相位差 $\psi^* = \arcsin(\Delta\omega/\varepsilon)$ 。

7.2 相位扩散与节律记忆时间

撤去外部驱动后，

$$\dot{\phi} = \omega_0 + \xi(t), \quad \langle \xi(t)\xi(t') \rangle = 2D \delta(t - t'), \quad (30)$$

相位方差线性增长 $\text{Var}(\phi(t)) = 2Dt$ 。定义节律记忆时间 T_{mem} 为相位误差累积至四分之一周期所需时间：

$$\sqrt{2DT_{\text{mem}}} = \frac{\pi}{2} \implies T_{\text{mem}} = \frac{\pi^2}{8D}. \quad (31)$$

公式 31 给出一个可直接测量的量：将生物移入恒定条件，观测自由运行节律失去相位相干性所需时间。

表 5: 记忆载体与其特征弛豫时标

载体	特征时标
蛋白质构象与代谢状态	秒-小时
表观遗传标记	天-代际
微生物群落组成	月-年
生态网络结构	年- 10^2 yr
基因组中的选择印记	10^3 - 10^6 yr
沉积物化学梯度	10^3 - 10^6 yr
海底矿物与沉积记录	10^6 - 10^8 yr

7.3 两层记忆结构

此处必须纠正一处常见的混淆。 T_{mem} 的量级是天至周，至多至月；它绝不可能是千年。因此“内源振荡器保存了古老天文周期”这一说法在相位层面是错误的。

但它在另一层面成立，且更为重要：

相位是短期记忆，周期是长期记忆。

ω_0 本身，即内部节拍的快慢，由基因编码，不依赖环境维持，而依赖遗传与选择维持。生物钟基因所决定的自由运行周期（哺乳类约 23–25 h，潮汐节律生物约 12.4 h）是一份被写入基因组、跨越地质时间的外部周期副本。正确的内生化表述因而是两层结构：

$$\underbrace{\Psi(t) \longrightarrow \phi(t)}_{\text{锁相；记忆 } T_{\text{mem}} \sim \text{天}} \implies \underbrace{\langle \omega_f \rangle \longrightarrow \omega_0}_{\text{演化；记忆 } \sim \text{地质时间}} \text{ (遗传编码)}. \quad (32)$$

于是“宇宙记忆”真正的存放位置不是某个个体的相位，而是物种基因组中被选择固化的周期参数。一条超深渊狮子鱼体内若存在 12.4 h 的内源周期，该数值是月球写入其祖先基因组的：月球从未照亮它，却定义了它的时间单位。

8 多模态存储与幂律记忆核

历史环境信息未必集中存放于单一载体，而可能分散于遗传、表观遗传、蛋白质网络、微生物组、生态关系、地球化学梯度与沉积记录之中。本节表明，这一定性设想可以推进为一个定量结论。

8.1 载体与弛豫时标

每种载体具有各自的特征弛豫时间 $1/\lambda$ ，见表 5。其中最后一行并非夸张：Morono 等发现好氧微生物可在距今 1.015 亿年的大洋沉积物中持续存活[11]，为“环境记忆弛豫时间上界”提供了 10^8 yr 的实测值。

8.2 从多弛豫时标到幂律

定理 8.1 (多载体存储导出幂律核). 设总记忆核为各载体指数弛豫的叠加

$$K(\tau) = \int_0^\infty p(\lambda) e^{-\lambda\tau} d\lambda, \quad (33)$$

其中 p 为弛豫率的密度。若载体时标在若干数量级上大致均匀铺开, 即 $p(\lambda) \propto \lambda^{\alpha-1}$ ($0 < \alpha < 1$), 则

$$K(\tau) \propto \tau^{-\alpha}. \quad (34)$$

证明. 由伽马积分 $\int_0^\infty \lambda^{\alpha-1} e^{-\lambda\tau} d\lambda = \Gamma(\alpha) \tau^{-\alpha}$ 代入 公式 33 即得。□

公式 33 是力学中 Prony 级数的连续版本; 定理 8.1 本身是反常动力学中的标准结果[10]。此处的用途在于: “多模态存储” 这一定性主张, 一旦写成 公式 33, 就必然导出长尾记忆核, 无需另行假设。

8.3 三项后果

(1) **无特征时间尺度。** 当 $\alpha \leq 1$ 时平均延迟 $\langle \tau \rangle = \int \tau K / \int K$ 发散: 系统不存在 “记多久” 的单一答案, 而在所有尺度上均保留部分记忆。

(2) **分数阶响应。** $K(\tau) \sim \tau^{-\alpha}$ 对应

$$H(\omega) \propto (i\omega)^{\alpha-1}, \quad (35)$$

即分数阶动力学。其相位滞后为常数 $(\alpha - 1)\pi/2$, 与频率无关, 这是一个可在数据中直接检验的指纹 (见预测 4)。

(3) **对定理 5.2 的削弱。** 由 公式 35, $|H(\omega)| \propto \omega^{-(1-\alpha)}$: 高频衰减是幂律的而非指数的。物质运输通道对百年周期的压制为 e^{-178} (数值为零), 而多模态通道对同一周期的压制只是一个幂律因子, 可能仅一至两个数量级。

注 8.2. 因此更准确的结论是: 定理 5.2 的个体化方差坍塌对平流运输通道严格成立, 对多模态生物-地球化学通道只是显著削弱而未归零。这恰恰意味着该通道是整个图景中最不确定、也最值得实证研究的一条: 它是唯一同时具备长记忆与部分快速响应的通道。

8.4 三个假说的归约

原设想中并列的三个假说, 至此被收进一条具有依赖关系的链:

- **多模态环境编码假说**提供微观机制: 多载体 $\Rightarrow$ 多弛豫时标;
- 由定理 8.1, 它导出**历史轨迹调控假说**所需的长尾核 $K(\tau) \sim \tau^{-\alpha}$, 后者不再是独立假设;
- **内生宇宙记忆假说**由 § 7 拆分为两层: 短期相位记忆 (量级为天, 不承载古老信息) 与遗传编码的周期记忆 (承载地质时间尺度的信息)。

这一归约本身即形式化的收益: 三条并列猜想被替换为一条可依次检验的推理链。

表 6: 临界坡所选中的周期 ($N = 10^{-3} \text{ s}^{-1}$, $\phi = 30^\circ$)

海底坡度 γ	被选中的周期
0.001	23.9 h
0.01	23.7 h
0.05	19.8 h
0.10	14.2 h

9 空间结构：带通、临界坡与临界纬度

传统体系的输入结构为 $X_{\text{trad}} = (t, \phi, \lambda)$ ，即出生时间、纬度与经度，其背后是“时间与地表位置足以确定宇宙配置环境”这一断言。本节表明，在海洋中该断言以三个层次逐级失效。

9.1 深度

设两个生命在相同 t_b, ϕ, λ 出生，一在 $z \approx 0$ 、一在 $z \approx -8000 \text{ m}$ 。二维地图上二者“同地出生”，但由 § 3 的全部结果，其传递函数在多个通道上相差数十个数量级。最低限度的修正为 $X = (t, \phi, \lambda, z)$ 。

9.2 地形：频率选择而非振幅调节

海底地形不是被动背景。深海内波（含内潮）的频率被夹于两个物理边界之间：

$$f < \omega < N, \quad f = 2\Omega \sin \phi, \quad (36)$$

其中 f 为科里奥利参数 (Ω 为地球自转角速度)， N 为浮力频率。即海洋对内波天然是一个**带通滤波器**，其低频边界由纬度决定、高频边界由层结决定。

内波能量沿与水平面成固定夹角的射线传播，斜率为

$$\tan \theta(\omega) = \sqrt{\frac{\omega^2 - f^2}{N^2 - \omega^2}}. \quad (37)$$

当海底坡度恰等于该射线斜率时（临界坡），能量转换与聚焦达到极大[5]。反解可得坡度 γ 所选中的频率

$$\omega_{\text{sel}} = \sqrt{\frac{\gamma^2 N^2 + f^2}{1 + \gamma^2}}. \quad (38)$$

取 $N = 10^{-3} \text{ s}^{-1}$ 、 $\phi = 30^\circ$ ，得表 6。

即：处于同一深度的两个生命，仅因海底坡度不同，就生活在被调谐至不同频率的有效环境之中。地形改变的不是信号强弱，而是振幅、频率、相位、延迟与传播路径的整套结构。

9.3 临界纬度

带通条件 公式 36 中的 $\omega > f$ 有一个具体后果。令 $\omega = f$ 得临界纬度

$$\sin \phi_{\text{crit}} = \frac{\omega}{2\Omega}. \quad (39)$$

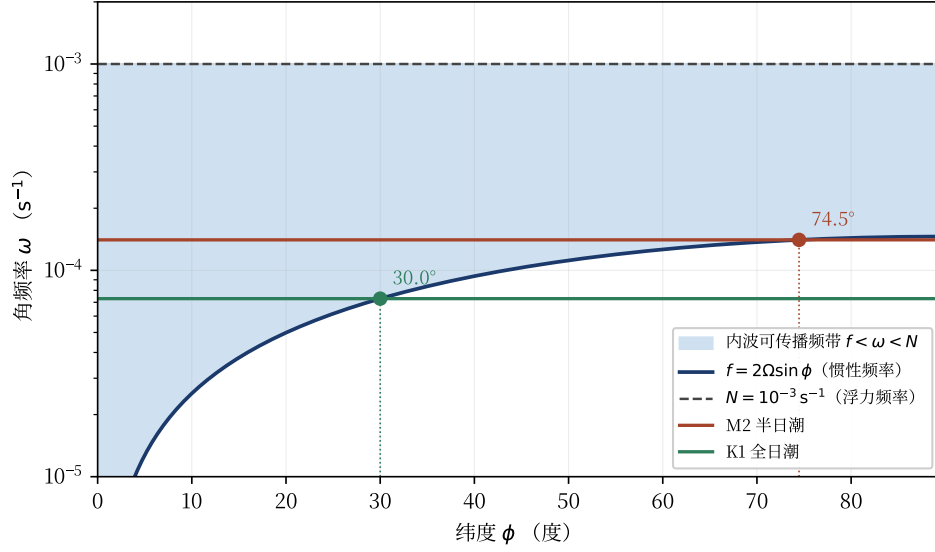


图 2: 内波可传播频带 $f < \omega < N$ 随纬度的变化。 $f = 2\Omega \sin \phi$ 随纬度上升，在 $\phi = 30.0^\circ$ 与 $\phi = 74.5^\circ$ 处分别越过 K1 与 M2 频率，此即两个分潮的临界纬度。

代入两个主要分潮：M2 (12.4206 h) 给出 $\phi_{\text{crit}} = 74.5^\circ$ ，K1 (23.9345 h) 给出 $\phi_{\text{crit}} = 30.0^\circ$ (图 2)。值得注意的是，公式 39 中不含 N ：临界纬度仅由分潮频率与地球自转角速度 $\Omega = 7.292115 \times 10^{-5} \text{ s}^{-1}$ 决定[13]，因而与层结的取值无关，也不依赖图 2 中为作图所设的 $N = 10^{-3} \text{ s}^{-1}$ 。即半日内潮无法传播至南北纬 74.5° 以外，全日内潮无法传播至南北纬 30° 以外。

因此，月球对深海的引力“授时”存在一条真实的纬度边界：低纬海沟与中纬海沟中的生命所能接收的月球周期成分不是强弱之别，而是有无之别。

由此得到一个值得注意的结构重合：纬度确实进入了深海的有效环境描述，但其机制并非黄道几何，而是地球自转经由科里奥利参数对可传播频带的限定。同一个自变量，两种完全不同的物理路径。

9.4 出生环境状态

综合上述，替代 (t, ϕ, λ) 的完整描述为

$$X_{\text{birth}} = (t_b, \phi, \lambda, z, \mathcal{T}, (\rho, T, S, \mathbf{u}, N), \mathcal{G}, \mathcal{M}_{\text{hist}}), \quad (40)$$

其中 $\mathcal{T}$ 为海底几何， $(\rho, T, S, \mathbf{u}, N)$ 为水体的密度、温度、盐度、流场与层结， $\mathcal{G}$ 为局部地质与沉积环境， $\mathcal{M}_{\text{hist}}$ 为该地点自身携带的历史状态。位置由此不再是坐标，而是一个包含介质、地形、场与历史的关系状态。

表 7: 两类模型的对照

	配置模型	场介导模型
形式	$B = F(\Psi(t_b))$	$B = F(\mathcal{H}_\varepsilon[\Psi])$
输入	天体配置	天体配置经环境变换后的有效场
介质地位	透明 (假设 U)	构成性的传递系统
普适性	预设普适	依环境而异

10 讨论：场介导模型与自我限制

10.1 从配置模型到场介导模型

传统体系隐含的普适性主张是：同一天体配置蕴含同一类型的生命影响。但由公式 3，真正与生命耦合的是 $\mathcal{H}_\varepsilon[\Psi]$ ，而 $\mathcal{H}$ 依赖环境，故

$$\mathcal{H}_{\text{mountain}} \neq \mathcal{H}_{\text{plain}} \neq \mathcal{H}_{\text{shallow}} \neq \mathcal{H}_{\text{abyssal}} \neq \mathcal{H}_{\text{hadal}}. \quad (41)$$

同一星象不蕴含同一有效宇宙环境。相应的模型转向可概括如表 7。

10.2 自我限制推论

推论 10.1 (自我限制). 假设 P 一旦被认真对待并写成物理形式，即推翻其自身的普适形态。

论证. 若天体与生命之间存在物理耦合，则该耦合必须通过某种物理载体实现；任何物理载体的传播都受介质支配 (§ 3)；介质随环境而变，故 $\mathcal{H}_\varepsilon$ 随环境而变；由公式 3， B 对 Ψ 的依赖关系因而随环境而变。故一个声称对一切生命普遍有效的星命体系，不可能同时具有物理基础与普适性。□

推论 10.1 的表述值得强调：**命理学越是试图物理化，就越必须放弃普适性；这两者不能兼得。** 一个为“给假设 P 一个机会”而作的推演，最终给出的是对它的一条严格约束。

10.3 与经验检验的关系

本文的结论与 Carlson[2]、Dean 与 Kelly[3] 的经验否定结论并不冲突，而是从不同方向到达相容的位置：经验研究表明效应不存在；本文表明，即便假定效应存在，其结构也不可能是星命体系所设想的那一种。二者共同缩小了假设 P 的可能形态空间。

10.4 去除条件外壳后的一般命题

若把“天体”替换为任一外生驱动，则本文下层的全部内容化为一条与星象无关的一般命题：

一个开放系统所经历的外部环境，不等于外部环境本身，而等于外部环境经过介质传递之后的像；该传递具有自身的频率响应、延迟与记忆。

该命题在气候归因、生态响应评估、污染物追踪与公共政策的时滞分析中同样成立，且在那些领域具有直接的实践意义：以当前强迫解释当前状态，在存在长记忆核的系统中是系统性错误。本文的第 4、5 两节可视为该错误的两种量化形式。

表 8: 本文引入的可测量量及其估计方法

量	含义	估计方法
$K(\tau)$	环境记忆核	输入-输出序列的正则化反卷积
α	幂律核指数	谱斜率拟合; 常相位滞后检验
T, s	渡越时间均值与展宽	^{14}C 、CFC、 SF_6 示踪剂反演
$\varepsilon, \Delta\omega$	锁相强度与失谐	Arnold 舌实验 (变频驱动)
D, T_{mem}	相位扩散系数与节律记忆时间	恒定条件下自由运行实验
V_W	个体化方差	同队列个体间有效环境量的方差分解

11 可证伪化与研究纲领

一个永不失败的猜想不具科学价值。本节列出可测量量并给出带明确证伪条件的预测。

11.1 可测量量

11.2 预测与证伪条件

预测 1 (深度梯度). 沿陆地→浅海→深海→超深渊的梯度, 光周期相关节律的功率应单调下降至消失, 而潮汐周期节律的功率应保持或上升。

证伪: 若在超深渊生物中检测到稳健的年光周期节律, 且无法由食物垂直通量的季节性解释, 则 § 3.2 的通道分析错误。

预测 2 (分潮的纬度边界). 比较低纬 ($< 30^\circ$) 与中纬 ($30^\circ-74^\circ$) 海沟生物的内源周期成分, 全日周期成分应在 30° 以外显著减弱。

证伪: 若中高纬海沟生物普遍表现出强全日内潮相关节律, 则 § 9.3 的带通论证在生物学层面不成立。

预测 3 (记忆核长尾). 估计深海生态变量对外部强迫的响应核。模型比较 (AIC/BIC) 应显示长尾核优于 $K = \delta$ 的瞬时模型。

证伪: 若 $\hat{K}(\tau)$ 在 $\tau > 10 \text{ yr}$ 上的质量占比不显著异于零, 则历史轨迹调控在该系统中不成立。

预测 4 (常数相位滞后). 若定理 8.1 的机制成立, 深海生物-地球化学变量对宽带强迫的响应应表现出与频率无关的相位滞后 $(\alpha - 1)\pi/2$ 。

证伪: 若观测到的相位滞后随频率线性增长 (纯延迟) 或迅速趋零 (瞬时响应), 则该机制不适用。

预测 5 (个体化来源). 在同一队列内, 深海个体之间由外部天体输入可解释的表型方差, 应仅能由潮汐相位 (及可能的地磁日变相位) 解释。

证伪: 若发现与行星位置或太阳黄经相关、且强于潮汐相位的个体间差异, 则推论 6.1 的立方律论证被推翻。

11.3 数据可得性的坦白评估

预测 3 与预测 4 目前最可能的结果是“数据不足以判定”。深海长时间序列极其稀缺, 而分辨千年尺度的记忆核所需的正是千年尺度的观测或高质量代用指标[14]。这是本文全部环节中最

脆弱的一处。

正因如此，本文的重心置于定理 4.1 与 5.2：二者只依赖已知的物理传递性质，不依赖任何未经观测的生物学耦合。即便假设 P 完全为假，这两个定理关于深海环境时间结构的内容依然成立。

12 局限

1. **LTI 是近似**（假设 2.7）。真实海洋是非线性的；本文已论证该近似在此为保守方向，但在其他用途上须重新审查。
2. **通道分解是理想化的**。公式 8 的并联可加性预设各通道间无交叉耦合，而真实系统中存在（如洋流切割地磁场产生的运动感应电磁场即引力通道向电磁通道的泄漏）。
3. **生物学耦合环节未建模**。本文只处理 $\Psi \rightarrow \Psi_{\text{eff}}$ ，未处理 $\Psi_{\text{eff}} \rightarrow B$ 。后者的非线性、阈值与选择性接收可能显著改变结论。
4. **地磁通道的生物学相关性未定**（§ 6.3）。相关陈述均为条件性。
5. **渡越时间分布取高斯是便利选择**。真实 TTD 通常偏斜且具长尾[6]，这会削弱定理 5.2 的锐度，方向与注 8.2 一致。
6. **假设 P 未被支持**。本文自始至终未主张天体-生命耦合存在。全部结论的形式均为条件句。

13 结论

本文把“天体状态影响生命”这一主张写成传递算子，并在明确标注为条件性的前提下考察其在八千米水深处的形态。主要结果为两个定理与一个推论。

定理 4.1 表明，长延迟通道使出生时刻的天体配置与有效环境渐近去相关，而有效环境的方差保持不变；信息未减少，只是对应于另一时刻。定理 5.2 表明，当环境滤波器的截止周期长于世代窗口时，个体化方差坍缩至滤波器增益的平方量级：在该通道上不存在“个体”这一层级。推论 6.1 则确定了幸存者：在超深渊带，唯一可能个体化的天体输入是引潮势与低频地磁变化，二者均由日月主导、均非光学，行星被引潮势的立方律排除至 10^{-5} 以下。

定理 8.1 进一步表明，多载体存储必然导出幂律记忆核，从而把原设想中并列的三个假说归约为一条依赖链，同时也界定了定理 5.2 的有效边界。

就实质而言，本文并未为任何星命体系提供支持。推论 10.1 给出的是相反方向的约束：任何试图物理化的星命体系都必须放弃普适性。

而剥去条件外壳之后剩下的，是一条与星象无关、却适用范围广泛的命题：一个开放系统所经历的外部环境，不等于外部环境本身，而等于它经过介质传递之后的像。对于一条生活在八千米深处的鱼而言，这意味着它所进入的并非一个从零开始的世界，而是一个已经运行了很久、并把这段运行编码在水团、沉积物、微生物群落与自身基因组之中的动力系统。

From Celestial Configuration to Effective Environment: A Formal Analysis of Medium, Delay and Individuation in Deep-Sea Life

The “deep-sea astrological conjecture” as a conditional thought experiment

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Abstract

Any system that holds celestial states to influence life, whatever its empirical standing, implicitly assumes something very strong in physical terms: that the environment is transparent to external signals, so that the input received by an organism equals the celestial state itself. This paper writes that assumption as a transfer operator and, under a premise explicitly marked as conditional, namely that some as yet unrecognised coupling between celestial states and life exists, asks what becomes of it in the deep ocean. Two results follow. The first is a **natal decoupling theorem**: when the environmental memory kernel carries a long delay, the correlation between the celestial configuration at the moment of birth and the effective environment the organism actually enters tends to zero, while the variance of that effective environment is unchanged; information is not lost, it corresponds to a different moment. The second is an **individuating variance collapse theorem**: when the cut-off period of the environmental filter exceeds the generational window, the between-individual variance within a cohort that external forcing can explain is compressed to the square of the filter gain. Substituting these into a channel decomposition of the transfer function at eight kilometres depth (optical, electromagnetic, gravitational, material transport) yields a concrete conclusion: in the hadal zone the only astronomical inputs that can physically individuate are the tidal potential and low-frequency geomagnetic variation, both dominated by the Sun and Moon, with planetary contributions suppressed below 10^{-5} by the cube law of the tidal potential, and neither of them optical. The paper further shows that storage across multiple carriers necessarily yields a power-law memory kernel, thereby reducing three originally parallel hypotheses to a single chain of dependence, and it supplies a list of measurable quantities together with five predictions carrying explicit falsification conditions. In substance the paper does not support astrology; it yields a constraint in the opposite direction: any astrological system that seeks to be physicalised must abandon universality. Stripped of its conditional shell, its general proposition belongs to the theory of environmental signal transmission: the external environment an open system experiences is not the external environment itself, but its image after transmission through a medium.

Keywords: environmental transfer function; memory kernel and delay; hadal zone; tidal potential; falsifiability

1 Introduction

Human beings have long sought a connection between life and the heavens. Traditional Chinese numerology, Western astrology and other astral systems differ greatly in method, yet share an

implicit structure: the temporal position at which a life begins, and the celestial configuration corresponding to it, stand in some relation to that life's later properties.

The empirical verdict on this structure is clear. Carlson's double-blind experiment [2] and Dean and Kelly's analysis of the "time twins" data [3] found no support for a detectable effect of natal celestial configuration on personality or fortune. This paper does not reassess that empirical conclusion, nor does it argue that any form of astral divination holds.

What this paper is concerned with is a different question, one that existing discussion has scarcely treated:

If the claim that celestial states influence life is taken seriously as a physical claim and written as an equation, what does that equation assume about the medium of propagation? And when the medium in which an organism lives changes from the atmosphere to eight kilometres of seawater, what becomes of those assumptions?

The choice of the deep sea as a test setting is not a matter of curiosity. In 2022 a joint expedition filmed a snailfish (a juvenile of the genus *Pseudoliparis*) at 8336 m in the Izu-Ogasawara Trench, setting the maximum depth record for a bony fish; on the same expedition, two specimens of *Pseudoliparis belyaevi* were caught in baited traps at 8022 m in the neighbouring Japan Trench, the deepest fish yet physically captured [8]. Such an organism furnishes a near-ideal extreme case: its time of birth, its coordinates and the celestial ephemeris at that time can in principle all be determined, so every input a traditional astral system requires is available; yet the physical medium it inhabits is so far removed from the land surface that the usually neglected assumption of transparency becomes calculable.

This paper proceeds by conditional inference. The form of the proposition is:

Let **Assumption P**: there exists some as yet unrecognised physical process by which celestial environmental states can input biologically meaningful information into living systems.

Required: under P, the temporal and informational structure by which deep-sea life receives such information.

Assumption P is throughout a logical antecedent, never asserted as true. The value of such inference lies not in supporting P but in this: if the result is strong enough, it may in turn constrain or even negate P in its original form. The conclusion of this paper is of that kind (see Corollary 10.1 in Section 10).

It should also be noted that the derivation has two layers. The upper layer depends on Assumption P; the lower layer, which concerns the frequency response, delay and memory structure of the ocean as a signal transmission system, does not, and belongs to the existing content of physical oceanography and linear response theory. Replace "celestial" with any exogenous driver (solar irradiance, climate forcing, pollutant input, human activity) and the lower-layer conclusions hold unchanged.

Every tool used here is an existing one, and this must be stated plainly.

Linear response and memory kernels. Describing a system's response to external forcing by a convolution kernel and a transfer function is standard linear response theory; the

constraint causality imposes on the real and imaginary parts of the transfer function is the Kramers–Kronig relation.

The ocean as a low-pass integrator. Hasselmann’s stochastic climate model [7] established the classical form of this picture: the ocean’s integration of fast atmospheric noise produces a red response spectrum. The general claim that the ocean is a low-pass filter belongs entirely to that tradition and is not novel here; what is added is the decomposition by physical channel and the substitution of hadal values.

Transit-time distributions. Writing water-mass transport as a transit-time distribution is a mature framework in physical oceanography [6]; radiocarbon and model estimates of deep ventilation ages are likewise extensive [1, 9, 4].

Internal tide generation and topography. The conversion of the barotropic tide into internal tides over topography, the critical slope condition, and the internal-wave band $f < \omega < N$ are all found in the review by Garrett and Kunze [5].

Marine biological rhythms. Daily, tidal, semilunar and annual rhythms and their endogenous oscillators have been systematically reviewed [17, 15]; behavioural and melatonin patterns linked to cyclic current flow in deep-sea demersal fish, and the proposal that tidal flow may act as a zeitgeber, are due to Wagner et al. [19].

Power-law memory and fractional dynamics. That a superposition of relaxation timescales yields a power-law kernel, and the corresponding fractional response, are standard results in anomalous dynamics [10].

Against that background, the increment offered here is limited and specific:

1. characterising the core structure of natal determination precisely as a memory kernel equal to the Dirac δ (Proposition 2.10), thereby converting a proposition usually treated as unscientific into a calculable filter problem;
2. proving the **natal decoupling theorem** (Theorem 4.1), of which the essential part is that the variance of the effective environment is independent of the delay, which rules out the common misreading that the deep sea is monotonous and therefore carries no information;
3. proposing and proving the **individuating variance collapse theorem** (Theorem 5.2), which quantifies the functional requirement that a chart be able to distinguish individuals as a spectral integral;
4. decomposing the hadal transfer function into four channels, yielding a concrete corollary: the only astronomical inputs capable of individuating are the tidal potential and low-frequency geomagnetic variation, with the planets excluded by the cube law (Corollary 6.1);
5. proving that multi-carrier storage necessarily yields a power-law memory kernel (Theorem 8.1), thereby reducing three originally parallel hypotheses to a chain of dependence, while stating candidly how that channel weakens Theorem 5.2;
6. giving a self-limitation corollary (Corollary 10.1) and a research programme with explicit falsification conditions.

Section 2 establishes the formal framework. Section 3 decomposes the deep-sea transfer function by channel. Sections 4 and 5 give the two main theorems. Section 6 identifies the surviving astronomical variables. Sections 7 and 8 treat endogenisation and multimodal storage. Section 9 discusses space and topography. Section 10 gives the field-mediated model and the self-limitation corollary. Section 11 gives the falsification programme, and Section 12 lists limitations.

2 Formal framework

2.1 Basic objects

Definition 2.1 (Celestial state process). Let $\Psi : \mathbb{R} \rightarrow \mathbb{R}^n$ be the *celestial state process*, $\Psi(t)$ denoting the physical state vector of the celestial and near-Earth cosmic environment at time t . Its components may be taken as direction cosines and distances of the Sun, Moon and planets relative to a reference point, solar irradiance, solar wind parameters, interplanetary magnetic field components, cosmic ray flux, and so on. Ψ is required to be a real-valued measurable physical quantity and to be exogenous with respect to terrestrial life.

Definition 2.2 (Effective environment). Let $\Psi_{\text{eff}} : \mathbb{R} \rightarrow \mathbb{R}^m$ be the *effective environment process*: those local physical quantities at the organism's location that actually couple to biological processes: light, pressure fluctuation, temperature, salinity, current velocity, chemical gradients and local electromagnetic fields.

Definition 2.3 (Biological response). Let B denote some observable later property of the organism (phenotype, rhythm parameters, life-history parameters, population statistics).

In this notation, Assumption P asserts that a statistically non-trivial dependence holds between B and Ψ .

2.2 The natal mapping and its two implicit assumptions

Traditional natal charts and Bazi systems emphasise the celestial configuration at the moment of birth t_b . Abstractly,

$$B = F(\Psi(t_b)) + \varepsilon. \quad (\text{E1})$$

Equation E1 does not assert that such systems use this mathematical form in practice; it extracts the *temporal structure* implicit in them: all the celestial information determining B is contained in the state at the single instant t_b . That structure contains two mutually independent and individually strong assumptions.

Assumption 2.4 (Instantaneity T). B depends only on the value of Ψ at t_b , not on the history of Ψ .

Assumption 2.5 (Transparency U). The input received by the organism is the celestial state itself, $\Psi_{\text{eff}} = \Psi$; no medium intervenes.

At the land surface, Assumption U appears at least superficially harmless. This paper shows that at eight kilometres depth it is not merely a poor approximation but qualitatively wrong; and that once U fails, T fails with it.

2.3 The environmental transfer operator

The real causal chain is

$$\Psi \longrightarrow \text{Earth system} \longrightarrow \text{local environment} \longrightarrow \Psi_{\text{eff}} \longrightarrow B. \quad (\text{E2})$$

Definition 2.6 (Environmental transfer operator). There exists an operator $\mathcal{H}_{\mathcal{E}}$, depending on the environment $\mathcal{E}$ in which the organism sits, such that $\Psi_{\text{eff}} = \mathcal{H}_{\mathcal{E}}[\Psi]$. The general form of Assumption P is accordingly

$$B = F(\mathcal{H}_{\mathcal{E}}[\Psi]) + \varepsilon. \quad (\text{E3})$$

Equation E1 is the special case of Equation E3 with $\mathcal{H}_{\mathcal{E}} = \text{Id}$.

2.4 The linear time-invariant approximation and its cost

Assumption 2.7 (LTI). Within the amplitude range of interest, $\mathcal{H}_{\mathcal{E}}$ may be approximated as a linear, time-invariant operator.

The cost of this approximation must be stated. The real ocean is strongly nonlinear: internal wave breaking, turbulent mixing, ecological thresholds and critical transitions all violate linear superposition. There are three reasons for using LTI nonetheless. First, external celestial perturbations are extremely small relative to the ocean’s own energy scale (tidal acceleration of order $10^{-7}g$), and the first-order response to a small perturbation is indeed linear. Second, in deep water lacking marked seasonal modulation, time invariance holds approximately. Third, and most importantly: **the two main theorems of this paper are strengthened, not weakened, if LTI fails**, since nonlinear mixing can only further destroy the correspondence between signal and moment of birth. LTI is therefore a conservative approximation here.

Proposition 2.8 (Kernel representation). *Under Assumption 2.7 there exists a memory kernel K such that*

$$\Psi_{\text{eff}}(t) = \int_0^{\infty} K(\tau) \Psi(t - \tau) d\tau, \quad (\text{E4})$$

where the lower limit 0 is the causality condition. In the frequency domain,

$$\hat{\Psi}_{\text{eff}}(\omega) = H(\omega) \hat{\Psi}(\omega), \quad H(\omega) = \int_0^{\infty} K(\tau) e^{-i\omega\tau} d\tau. \quad (\text{E5})$$

H and K are two representations of the same object, so the language of “memory” and that of “spectrum” may be exchanged freely below.

Remark 2.9. Causality, $K(\tau) = 0$ for $\tau < 0$, implies that the real and imaginary parts of H satisfy the Kramers–Kronig relations. Physically: *any selective attenuation is necessarily accompanied by dispersive delay*; attenuation and delay are not two separately adjustable things. This appears in concrete form in Section 3.

2.5 The formal identity of astrology

Proposition 2.10. *The natal determination model of Equation E1 is equivalent to the memory kernel being the Dirac δ :*

$$K(\tau) = \delta(\tau) \iff H(\omega) \equiv 1 \iff \Psi_{\text{eff}}(t) = \Psi(t). \quad (\text{E6})$$

Table E1: Transmittance I/I_0 of the optical channel at various depths

Depth	$K_d = 0.02 \text{ m}^{-1}$	$K_d = 0.03 \text{ m}^{-1}$	$K_d = 0.04 \text{ m}^{-1}$
200 m	$10^{-1.7}$	$10^{-2.6}$	$10^{-3.5}$
1000 m	$10^{-8.7}$	10^{-13}	10^{-17}
4000 m	10^{-35}	10^{-52}	10^{-70}
8000 m	10^{-70}	10^{-104}	10^{-139}

Proof. Immediate from the sifting property of δ together with Equation E4 and Equation E5. $\square$

The significance of Proposition 2.10 is that it translates a claim usually treated as undiscussable into a definite physical requirement: $H \equiv 1$ means the environment is an ideal **all-pass, zero-delay, distortion-free channel**, in which signals at every frequency reach the organism with the same gain, the same phase and no time lag.

The question thus becomes calculable: the object to be determined is the one written in Equation E7, the transfer function of eight kilometres of seawater.

$$H_{\text{tot}}(z = -8000 \text{ m}, \omega) = ? \quad (\text{E7})$$

3 Channel decomposition of the deep-sea transfer function

3.1 The principle of decomposition

The key physical fact is that a “celestial signal” is not a single physical quantity. The same body acts on the Earth through different carriers, and those carriers differ by tens of orders of magnitude in their propagation through seawater. The correct procedure is therefore to decompose by physical channel:

$$H_{\text{tot}}(z, \omega) = \sum_c H_c(z, \omega), \quad H_c = \prod_j H_{c,j}(\omega), \quad (\text{E8})$$

summing over parallel channels and multiplying over the links in series within a channel. Four channels are computed below.

3.2 The optical channel

Visible light attenuates in seawater according to the Beer–Lambert law $I(z) = I_0 e^{-K_d z}$, with K_d the diffuse attenuation coefficient. In the clearest natural waters the lower bound of K_d in the blue-green is about 0.02 m^{-1} [16]; for oligotrophic ocean one generally takes $K_d \approx 0.02\text{--}0.04 \text{ m}^{-1}$. Values are given in Table E1.

10^{-104} requires a reference scale: a visible photon carries about $4 \times 10^{-19} \text{ J}$, and the Sun radiates about $4 \times 10^{26} \text{ W}$. Even if all sunlight were focused to a point, eight kilometres down would not receive a single photon over the age of the universe. Hence

$$H_{\text{opt}}(-8000 \text{ m}, \omega) = 0. \quad (\text{E9})$$

Table E2: Skin depth and attenuation at 8000 m for the electromagnetic channel

Frequency	δ	$ H_{\text{EM}} $ at 8000 m
1 MHz	0.25 m	e^{-31800}
1 kHz	8.0 m	e^{-1006}
1 Hz	252 m	$\approx 10^{-14}$
10^{-2} Hz	2.5 km	0.041
10^{-4} Hz	25 km	0.73
semidiurnal tidal frequency (12.42 h)	53 km	0.86

This is not “very weak” but channel closure. The immediate consequence: all celestial information carried by light (sunrise and sunset, lunar phase, seasonal photoperiod, the visibility of stars) does not exist in the hadal zone.

3.3 The electromagnetic channel

Seawater is a conductor. The Practical Salinity Scale 1978 takes $C(35, 15^\circ\text{C}, 0) = 4.2914 \text{ S m}^{-1}$ as its reference conductivity [18]; the corresponding value for cold deep water is lower, so a representative $\sigma \approx 3\text{--}5 \text{ S m}^{-1}$ is used here. In the good-conductor approximation (displacement current negligible) the field satisfies the diffusion equation $\nabla^2 \mathbf{E} = \mu\sigma \partial_t \mathbf{E}$. With $\mathbf{E} \propto e^{i(kz - \omega t)}$ one obtains $k = \sqrt{i\mu\sigma\omega} = (1+i)\sqrt{\mu\sigma\omega/2}$; the imaginary part gives exponential attenuation over the skin depth

$$\delta(\omega) = \sqrt{\frac{2}{\mu\sigma\omega}} = \frac{503}{\sqrt{\sigma f}} \text{ [m]}, \quad |H_{\text{EM}}(z, \omega)| = \exp\left(-|z|\sqrt{\frac{\mu\sigma\omega}{2}}\right). \quad (\text{E10})$$

Equation E10 is a miniature of the paper’s central mechanism: the attenuation exponent is proportional to $\sqrt{\omega}$, so higher frequencies die faster. With $\sigma = 4 \text{ S m}^{-1}$ and $|z| = 8000 \text{ m}$ one obtains Table E2.

The conclusion is derived, not assumed: **seawater is a low-pass filter for electromagnetic fields with a cut-off period of order $10^2\text{--}10^3 \text{ s}$** . Disturbances with periods shorter than about a hundred seconds vanish entirely; variations with periods longer than about an hour pass nearly intact.

This has a consequence often overlooked, developed in Section 6: *low-frequency geomagnetic variation, such as the solar quiet daily variation S_q , of period one day and amplitude some tens of nT at mid-latitudes, does reach the hadal seafloor.*

3.4 The gravitational channel

The lunar tide-raising force arises from the gradient of the gravitational potential. At geocentric distance r the tidal acceleration is of order

$$a_{\text{tid}} \approx \frac{2GM r}{d^3}, \quad (\text{E11})$$

with d the distance to the body. Note $a_{\text{tid}} \propto r$: from the sea surface to eight kilometres depth the relative change is only

$$\frac{8 \text{ km}}{6371 \text{ km}} \approx 1.3 \times 10^{-3}. \quad (\text{E12})$$

Gravity is not screened by seawater, and there is neither skin depth nor absorption, so

$$H_{\text{grav}} \approx 1, \quad \arg H_{\text{grav}} \approx 0. \quad (\text{E13})$$

This is the only channel in the hadal zone that approximately satisfies Assumption U.

One technical stratification must not be blurred. The tidal *potential* itself is instantaneous and undelayed; the ocean’s *dynamical response* to it (tidal elevation, tidal currents, internal tides) is not, for the ocean is a forced mechanical system with resonance and friction, whose response involves amplitude amplification and *phase lag* and depends strongly on basin geometry and seafloor topography [5]. Writing that link as $H_{\text{resp}}(\mathbf{x}, \omega)$,

$$H_{\text{tidal}} = H_{\text{grav}} \cdot H_{\text{resp}}. \quad (\text{E14})$$

The essential point is that the phase lag of H_{resp} is of order hours to days, not centuries. Furthermore, the tidal spectrum is fixed by celestial mechanics and consists of sharp lines (M2, S2, N2, K1, O1 and their compound frequencies), so this channel is *narrowband*.

3.5 The material transport channel

Solar energy input reaches the deep sea along the path given in Equation E15:

$$\begin{aligned} \text{solar forcing} &\rightarrow \text{atmosphere} \rightarrow \text{surface ocean} \\ &\rightarrow \text{water-mass formation} \rightarrow \text{overturning} \rightarrow \text{deep ocean}, \end{aligned} \quad (\text{E15})$$

which is physically advective–diffusive transport. Let $G(\tau)$ be the transit-time distribution from a surface source region to the target deep location [6]; the channel’s memory kernel is $K_{\text{adv}} = G$. Taking G Gaussian with mean T and standard deviation s as a first approximation, its Fourier transform is closed-form:

$$H_{\text{adv}}(\omega) = \int G(\tau) e^{-i\omega\tau} d\tau = \underbrace{e^{-i\omega T}}_{\text{pure delay}} \cdot \underbrace{e^{-\omega^2 s^2/2}}_{\text{Gaussian low-pass}}. \quad (\text{E16})$$

Equation E16 delivers two things at once: a pure phase delay proportional to the mean transit time, and a low-pass filter with cut-off $\omega_c \sim 1/s$. This is a concrete instance of the Kramers–Kronig relation noted above.

Numerically, ventilation ages for North Pacific deep water are of order 10^3 yr: benthic–planktonic foraminiferal ^{14}C age differences at about 2200 m in the northwestern North Pacific are 1030–1630 yr, comparable to the present-day apparent ventilation age there [1]; the oldest northeast Pacific deep water has an apparent age above 2400 yr [9]; a global model gives the oldest western Pacific water mass an age of about 1494 yr, composed of sources spanning 500–5000 yr [4]. Taking $T \approx 10^3$ yr and $s \approx 300$ –500 yr gives Table E3.

Table E3 is one of the paper’s key quantitative results: **of the solar signal arriving in the deep sea by material transport, every component faster than the millennial scale has been erased**; the residue of the annual cycle is of order e^{-10^6} , non-existent in any physical sense. The channel simultaneously carries a phase delay of about a thousand years.

Table E3: Low-pass attenuation of the material transport channel, $|H_{\text{adv}}| = e^{-\omega^2 s^2/2}$

Input period	$s = 300 \text{ yr}$	$s = 500 \text{ yr}$
1 yr (annual cycle)	$e^{-1.8 \times 10^6}$	$e^{-4.9 \times 10^6}$
11 yr (solar cycle)	$e^{-1.47 \times 10^4}$	$e^{-4.08 \times 10^4}$
10^2 yr	e^{-178}	e^{-494}
10^3 yr	0.17	0.007
$3 \times 10^3 \text{ yr}$	0.82	0.58
10^4 yr	0.98	0.95

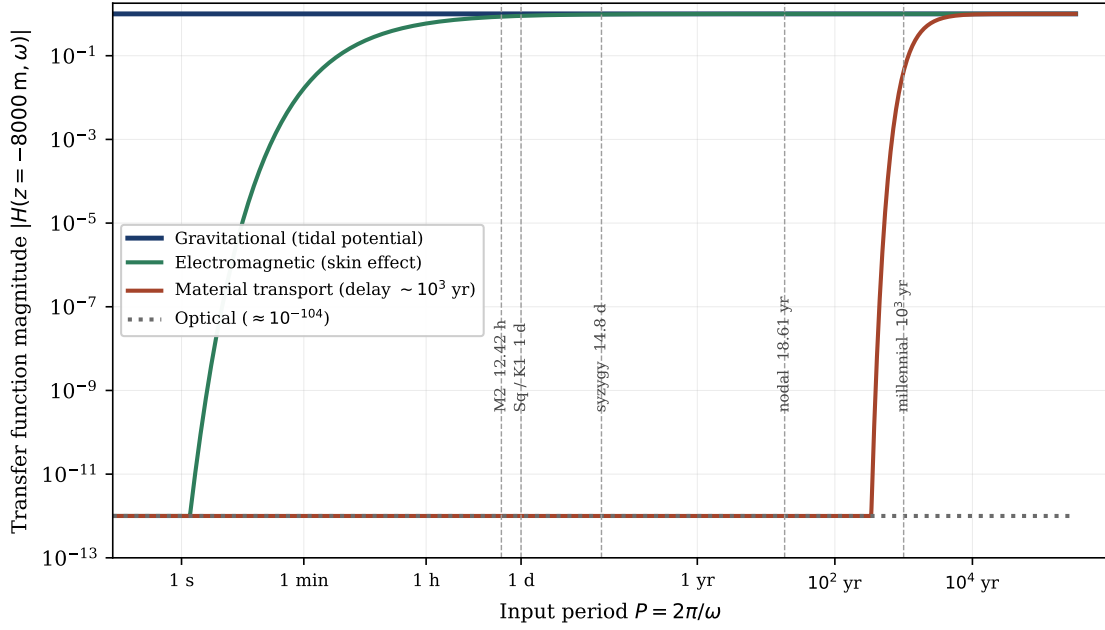


Figure E1: Transfer function magnitude $|H|$ of the four channels at eight kilometres depth as a function of input period. The optical channel is closed across the whole band (drawn at the plot floor; its actual value is about 10^{-104}); the electromagnetic channel is cut off by the skin effect for periods shorter than about 10^2 – 10^3 s; the gravitational channel is approximately all-pass; the material transport channel transmits only at periods above a millennium, with a phase delay of about 10^3 yr. Dashed lines mark the principal astronomical periods.

3.6 Synthesis

Superposing the four channels by Equation E8,

$$H_{\text{tot}}(-8000 \text{ m}, \omega) \approx \underbrace{H_{\text{tidal}}(\omega)}_{\text{narrowband, no delay}} + \underbrace{H_{\text{EM}}(\omega)}_{\text{periods } \gtrsim 10^3 \text{ s pass}} + \underbrace{e^{-i\omega T} e^{-\omega^2 s^2/2}}_{\text{delay } \sim 10^3 \text{ yr}} + \underbrace{0}_{\text{optical}}. \quad (\text{E17})$$

Figure E1 shows the magnitude of each channel against input period.

Remark 3.1 (A correction to a popular formulation). It is inaccurate to summarise this as “the deep sea hears only history”. The accurate statement is: **the optical channel is closed across the whole band, and the thermal and material channel is delayed by about 10^3 yr and low-pass filtered; but the gravitational channel and the low-frequency electromagnetic channel are largely open for periods longer than about**

an hour. The deep sea therefore does not receive only history; it receives a two-layer structure of undelayed gravitational and low-frequency electromagnetic input plus a millennially delayed material imprint. What is missing in between is information *carried by light and heat* on scales from a day to a century, precisely the band and the carriers on which traditional astral systems depend.

In any case H_{tot} is far from the $H \equiv 1$ required by Proposition 2.10: Assumption U here is not a poor approximation but a qualitative error.

4 Natal decoupling

4.1 Setting

Let Ψ be a zero-mean wide-sense stationary process with autocovariance

$$C(\tau) = \mathbb{E}[\Psi(t)\Psi(t+\tau)], \quad C(0) = \sigma_\Psi^2, \quad (\text{E18})$$

satisfying the mixing condition $C(\tau) \rightarrow 0$ as $\tau \rightarrow \infty$. This is mild: it requires only that sufficiently remote celestial states be asymptotically independent of the present, which holds for climate-relevant solar and geophysical processes.

Let the memory kernel be a fixed profile K_0 translated by T :

$$K_T(\tau) = K_0(\tau - T), \quad \int K_0 = 1, \quad K_0 \in L^1, \quad (\text{E19})$$

i.e. delay T with spread set by K_0 . The effective environment is $\Psi_{\text{eff}}(t) = \int K_T(\tau)\Psi(t-\tau) d\tau$.

4.2 Theorem and proof

Theorem 4.1 (Natal decoupling). *Under the above setting:*

- (i) $\text{Var}(\Psi_{\text{eff}})$ is independent of the delay T ;
- (ii) $\text{Cov}(\Psi(t_b), \Psi_{\text{eff}}(t_b)) \rightarrow 0$ as $T \rightarrow \infty$;
- (iii) hence the correlation coefficient $r(T) \rightarrow 0$.

Proof. (ii) Substituting $u = \tau - T$,

$$\text{Cov}(\Psi(t_b), \Psi_{\text{eff}}(t_b)) = \int K_T(\tau)C(\tau) d\tau = \int K_0(u)C(u+T) du. \quad (\text{E20})$$

Since C is bounded, $C(u+T) \rightarrow 0$ pointwise and $K_0 \in L^1$, dominated convergence gives that this integral tends to zero.

(i) With the same substitution,

$$\text{Var}(\Psi_{\text{eff}}) = \iint K_T(\tau)K_T(\tau')C(\tau-\tau') d\tau d\tau' = \iint K_0(u)K_0(u')C(u-u') du du', \quad (\text{E21})$$

in which the translation T cancels entirely because C depends only on the difference.

(iii) Follows from (i), (ii) and $r = \text{Cov} / (\sigma_\Psi \sigma_{\text{eff}})$. $\square$

Remark 4.2 (Frequency-domain form). Equivalently $\text{Cov} = \frac{1}{2\pi} \int e^{i\omega T} \overline{\hat{K}_0(\omega)} S(\omega) d\omega$, with S the spectral density of Ψ . Provided $\overline{\hat{K}_0} S \in L^1$, the Riemann–Lebesgue lemma gives that the integral tends to zero as $T \rightarrow \infty$.

4.3 Interpretation

Part (ii) is expected: the longer the delay, the weaker the relation. The substance of the theorem is part (i): **delay does not diminish the variability of the effective environment itself**. The deep-sea environment remains highly structured and information-bearing; it simply bears information about a different moment.

This rules out a common misreading, namely that the deep sea is monotonous and stable and therefore offers nothing to compute. Theorem 4.1 says the opposite: the variance is not lost; what is lost is its correspondence with the moment of birth. By analogy: this is not a blurred photograph but a sharp photograph taken a thousand years ago.

Substituting the material transport channel of Section 3, if the autocorrelation time of Ψ is τ_c (solar activity has a correlation time of decades to a century) while $T \approx 10^3$ yr, then $r \lesssim |\rho(T)| \approx 0$: the information the solar state at birth carries about that water mass is numerically indistinguishable from zero.

Remark 4.3 (Scope). Theorem 4.1 applies to channels with long delay, i.e. the material transport term. It does *not* apply to the gravitational or low-frequency electromagnetic channels, whose delays are of order hours. This restriction is decisive in Section 6.

5 Collapse of individuating variance

5.1 Quantifying the functional requirement

Any chart-casting system must satisfy a minimal functional requirement: *individuals born at different times should receive different charts*. Otherwise the system is empty in the information-theoretic sense: if all individuals in a cohort receive the same result, it has no discriminating power. Quantify this as follows.

Definition 5.1 (Individuating variance). Given a birth-time window W (a generation, or a comparable cohort), the *between-individual* variance of Ψ_{eff} within that window is

$$V_W = \frac{1}{\pi} \int_{|\omega| > 2\pi/W} |H(\omega)|^2 S(\omega) d\omega. \quad (\text{E22})$$

The rationale: Ψ_{eff} is a stationary process with spectral density $|H|^2 S$; within a window of length W , components with periods longer than W appear as a constant offset shared by all individuals in the window and cannot distinguish anyone, whereas only components with periods shorter than W take different values at different birth times inside it. The individuating variance is therefore the high-pass part.

5.2 Theorem

Theorem 5.2 (Collapse of individuating variance). *If the transfer function satisfies $|H(\omega)| \leq \varepsilon$ for $|\omega| > \omega_c$, and $\omega_c < 2\pi/W$, then*

$$V_W \leq \varepsilon^2 \sigma_\Psi^2 \cdot \text{const.} \quad (\text{E23})$$

That is, when the cut-off period of the environmental filter exceeds the generational window, the individuating variance is compressed to order ε^2 .

Proof. On the domain of integration $|\omega| > 2\pi/W > \omega_c$ one has $|H|^2 \leq \varepsilon^2$, so

$$V_W \leq \frac{\varepsilon^2}{\pi} \int_{|\omega| > 2\pi/W} S(\omega) d\omega \leq \frac{\varepsilon^2}{\pi} \int_{-\infty}^{\infty} S(\omega) d\omega \propto \varepsilon^2 \sigma_\Psi^2. \quad (\text{E24})$$

□

5.3 Substituting the hadal zone

The cut-off period of the material transport channel is about $2\pi s \approx 2\text{--}3 \times 10^3$ yr. The generation time of a snailfish is of order years; even widening the cohort window to a century,

$$W = 10^2 \text{ yr} \implies \varepsilon = |H_{\text{adv}}|_{P=10^2 \text{ yr}} \approx e^{-178}, \quad V_W \lesssim e^{-356} \sigma_\Psi^2. \quad (\text{E25})$$

Corollary 5.3. *Through the material transport channel, all deep-sea individuals born in the same century share one and the same effective celestial environment; the difference among them is not small but numerically zero. Equivalently, if a “chart” exists in the deep sea, its resolution through this channel is the millennium, not the hour: it can distinguish a Tang-dynasty fish from a present-day one, but not two fish born this morning and this afternoon.*

Theorem 5.2 is stronger than Theorem 4.1. The latter says the wrong moment has been matched; the former says that on this channel the level of “the individual” does not exist.

Remark 5.4 (Scope and the later weakening). As in Remark 4.3, Theorem 5.2 is strict for the material transport channel and does not apply to the gravitational or low-frequency electromagnetic channels. Moreover, Section 8 shows that the multimodal biogeochemical channel has power-law rather than exponential high-frequency attenuation, so that it weakens individuating variance substantially without eliminating it. These two points together delimit the theorem’s domain of validity.

6 Surviving channels and individuating variables

By Remarks 4.3 and 5.4, the two theorems do not empty every channel. This section identifies what survives.

6.1 The tidal potential is itself a solar–lunar ephemeris

The tidal potential is not a vague “lunar influence” but an analytic function fixed by the positions of the Sun and Moon. For body j the second-degree tidal potential at the Earth’s surface is

$$V_j(\mathbf{x}, t) = \frac{GM_j r^2}{d_j(t)^3} P_2(\cos \theta_j(t)) + \cdots, \quad (\text{E26})$$

Table E4: Relative tide-raising strength of celestial bodies (Moon = 1; planets at closest approach), computed as M/d^3 from standard astronomical constants

Body	Relative tidal strength
Moon	1
Sun	0.46
Venus	5.7×10^{-5}
Jupiter	7.2×10^{-6}
Mars	3.1×10^{-6}
Mercury	5.5×10^{-7}
Saturn	2.5×10^{-7}

with θ_j the zenith angle of the body and P_2 the second Legendre polynomial. The total potential $V = \sum_j V_j$ is thus a continuous function of the positions of the Sun, Moon and planets.

Since $H_{\text{grav}} \approx 1$, a direct and somewhat unexpected conclusion follows:

Deep-sea life has not lost the positional information of the Sun and Moon. It receives the complete solar–lunar configuration nearly losslessly, in the form of a gravitational potential, having never “seen” either of them.

This channel naturally contains several periodicities: the semidiurnal tide (12.42 h), the diurnal tide, the syzygy cycle (14.77 d), the anomalistic month (27.55 d), the solar year (annual modulation of S2/K1), the precession of lunar perigee (8.85 yr) and the regression of the lunar node (18.61 yr). Its temporal structure thus extends from hours to eighteen years, entirely gravitational and entirely solar–lunar.

6.2 Exclusion of the planets by the cube law

From Equation E26 the tidal strength scales as M_j/d_j^3 , and the consequences of this cube law are severe. Normalising the Moon to 1 and taking planetary distances at closest approach gives Table E4.

6.3 The low-frequency geomagnetic channel

By Table E2, electromagnetic variations with periods longer than about an hour reach the hadal seafloor. Relevant natural sources include the solar quiet daily variation (Sq, period one day, amplitude some tens of nT at mid-latitudes, driven by solar heating of the ionosphere and therefore encoding *local solar time*), magnetic storms and ring-current variations, and long-term modulation by the solar cycle.

Three qualifications are required. First, the relative modulation is small: tens of nT against a steady geomagnetic field of $3\text{--}5 \times 10^4$ nT is about 10^{-3} . Second, whether deep-sea organisms can sense variations of that magnitude has not been established, and the mechanism of magnetoreception itself remains disputed; the biological relevance of this channel can therefore only be stated conditionally. Third, its astronomical content is *solar activity and solar position*, not the planetary geometry on which astral systems rely; the planetary contribution to

geomagnetic disturbance is negligible.

6.4 The main corollary

Corollary 6.1 (The Sun and Moon survive; the planets are excluded). *In the hadal zone the only astronomical inputs that can physically individuate are the tidal potential and low-frequency geomagnetic variation. Both*

- (a) *are dominated by the Sun and Moon, the planets being suppressed below 10^{-5} in the tidal potential and negligible in geomagnetic disturbance;*
- (b) *are non-optical, and unrelated to the “visible sky”;*
- (c) *are unconstrained by Theorems 4.1 and 5.2, since their delays are of order hours and they vary on the daily scale, satisfying the individuating condition of Definition 5.1.*

Consequently, if one insists on constructing a natal chart for hadal life, that chart may contain only the Sun and the Moon and no planets; and the Sun and Moon on it are not symbols on the ecliptic but two physical quantities in the tidal potential and in geomagnetic variation.

6.5 The empirical interface

The gravitational branch of Corollary 6.1 has direct empirical support. Marine chronobiology has recorded daily, tidal, semilunar, lunar and annual rhythms in many marine organisms and distinguishes rhythms driven directly by external periodicity from those maintained by endogenous oscillators [17, 15]. In the deep sea, Wagner et al. observed behavioural and melatonin patterns associated with cyclic current flow in two demersal fish species at about 1000 m depth, and proposed that tidal flow may act as a zeitgeber for deep-sea benthic animals [19].

That deep-sea organisms keep time by the tide is thus not a conjecture but a published observation. The contribution here is only to place it back in a complete transfer function framework, explaining *why it is precisely the tide that survives*.

7 Endogenisation: entrainment and genetic encoding

External periodicity need not be supplied continuously in real time: a living system may partly internalise a long-standing external regularity. This section formalises that idea and identifies one confusion of levels that must be corrected.

7.1 The entrainment condition

Let the organism contain a self-sustained phase oscillator of natural angular frequency ω_0 , driven at angular frequency ω_f with strength ε :

$$\dot{\phi} = \omega_0 + \varepsilon \sin(\omega_f t - \phi). \quad (\text{E27})$$

With $\psi = \omega_f t - \phi$ and $\Delta\omega = \omega_f - \omega_0$ one obtains the Adler equation [12]

$$\dot{\psi} = \Delta\omega - \varepsilon \sin \psi. \quad (\text{E28})$$

A fixed point exists if and only if

$$|\Delta\omega| \leq \varepsilon, \quad (\text{E29})$$

the entrainment condition, whose region in the parameter plane is the Arnold tongue of width 2ε , with locked phase difference $\psi^* = \arcsin(\Delta\omega/\varepsilon)$.

7.2 Phase diffusion and rhythm memory time

Removing the external drive,

$$\dot{\phi} = \omega_0 + \xi(t), \quad \langle \xi(t)\xi(t') \rangle = 2D \delta(t - t'), \quad (\text{E30})$$

the phase variance grows linearly, $\text{Var}(\phi(t)) = 2Dt$. Define the rhythm memory time T_{mem} as the time for the phase error to accumulate to a quarter cycle:

$$\sqrt{2DT_{\text{mem}}} = \frac{\pi}{2} \implies T_{\text{mem}} = \frac{\pi^2}{8D}. \quad (\text{E31})$$

Equation E31 gives a directly measurable quantity: move the organism into constant conditions and observe how long the free-running rhythm takes to lose phase coherence.

7.3 A two-level memory structure

One common confusion must be corrected here. T_{mem} is of order days to weeks, at most months; it cannot possibly be a millennium. The claim that endogenous oscillators preserve ancient astronomical periodicities is therefore false at the level of *phase*.

It is nonetheless true, and more importantly true, at another level:

Phase is short-term memory; period is long-term memory.

ω_0 itself, that is, how fast the internal beat runs, is genetically encoded. It is maintained not by the environment but by inheritance and selection. The free-running period fixed by clock genes (about 23–25 h in mammals, about 12.4 h in tidally rhythmic organisms) is a copy of an external period written into the genome and carried across geological time. The correct statement of endogenisation is thus a two-level structure:

$$\underbrace{\Psi(t) \longrightarrow \phi(t)}_{\text{entrainment; memory } T_{\text{mem}} \sim \text{days}} \implies \underbrace{\langle \omega_f \rangle \longrightarrow \omega_0}_{\text{evolution; memory } \sim \text{geological time}} \text{ (genetically encoded)}. \quad (\text{E32})$$

“Cosmic memory” is therefore stored not in an individual’s phase but in the period parameter fixed by selection in the species genome. If a hadal snailfish carries an endogenous period of 12.4 h, that number was written into its ancestors’ genome by the Moon: the Moon has never illuminated it, yet the Moon defines its unit of time.

Table E5: Memory carriers and their characteristic relaxation timescales

Carrier	Characteristic timescale
Protein conformation and metabolic state	seconds–hours
Epigenetic marks	days–generations
Microbial community composition	months–years
Ecological network structure	years– 10^2 yr
Selection imprints in the genome	10^3 – 10^6 yr
Sediment chemical gradients	10^3 – 10^6 yr
Seafloor minerals and sedimentary records	10^6 – 10^8 yr

8 Multimodal storage and the power-law memory kernel

Historical environmental information need not be held in a single carrier; it may be distributed across genetic, epigenetic, proteomic, microbial, ecological, geochemical and sedimentary records. This section shows that this qualitative idea can be pushed to a quantitative conclusion.

8.1 Carriers and relaxation timescales

Each carrier has its own characteristic relaxation time $1/\lambda$ (Table E5). The last row is not hyperbole: Morono et al. found aerobic microbes persisting in marine sediment as old as 101.5 million years [11], giving a measured upper bound of 10^8 yr for environmental memory.

8.2 From multiple relaxation timescales to a power law

Theorem 8.1 (Multi-carrier storage yields a power-law kernel). *Let the total memory kernel be a superposition of exponential relaxations,*

$$K(\tau) = \int_0^\infty p(\lambda) e^{-\lambda\tau} d\lambda, \quad (\text{E33})$$

with p the density of relaxation rates. If carrier timescales are spread roughly uniformly over several decades, i.e. $p(\lambda) \propto \lambda^{\alpha-1}$ with $0 < \alpha < 1$, then

$$K(\tau) \propto \tau^{-\alpha}. \quad (\text{E34})$$

Proof. Substitute the Gamma integral $\int_0^\infty \lambda^{\alpha-1} e^{-\lambda\tau} d\lambda = \Gamma(\alpha) \tau^{-\alpha}$ into Equation E33. $\square$

Equation E33 is the continuous version of a Prony series in mechanics, and Theorem 8.1 is a standard result in anomalous dynamics [10]. Its use here is this: **once the qualitative claim of multimodal storage is written as Equation E33, a long-tailed memory kernel follows necessarily, with no further assumption.**

8.3 Three consequences

(1) No characteristic timescale. For $\alpha \leq 1$ the mean delay $\langle \tau \rangle = \int \tau K / \int K$ diverges: there is no single answer to “how long does it remember”, and partial memory is retained at every scale.

(2) **Fractional response.** $K(\tau) \sim \tau^{-\alpha}$ corresponds to

$$H(\omega) \propto (i\omega)^{\alpha-1}, \quad (\text{E35})$$

i.e. fractional dynamics, whose phase lag is the constant $(\alpha - 1)\pi/2$, *independent of frequency*, a fingerprint testable directly in data (see Prediction 4).

(3) **A weakening of Theorem 5.2.** By Equation E35, $|H(\omega)| \propto \omega^{-(1-\alpha)}$: high-frequency attenuation is power-law, not exponential. The material transport channel suppresses a centennial period by e^{-178} (numerically zero), whereas the multimodal channel suppresses the same period only by a power-law factor, possibly of one or two orders of magnitude.

Remark 8.2. The accurate conclusion is therefore: the collapse of individuating variance in Theorem 5.2 holds strictly for the *advective transport channel*, and for the *multimodal biogeochemical channel* constitutes a substantial weakening rather than an elimination. This makes that channel the most uncertain, and the most worth investigating empirically, in the whole picture, since it is the only one combining long memory with partial fast response.

8.4 Reduction of the three hypotheses

The three originally parallel hypotheses are thereby collected into a chain of dependence:

- the **multimodal environmental encoding hypothesis** supplies the microscopic mechanism: many carriers $\Rightarrow$ many relaxation timescales;
- by Theorem 8.1 it *entails* the long-tailed kernel $K(\tau) \sim \tau^{-\alpha}$ required by the **historical-trajectory regulation hypothesis**, which is thus no longer independent;
- the **endogenised cosmic memory hypothesis** is split by Section 7 into two levels: short-term phase memory (of order days, carrying no ancient information) and genetically encoded period memory (carrying information on geological timescales).

This reduction is itself the yield of formalisation: three parallel conjectures are replaced by one chain that can be tested in sequence.

9 Spatial structure: bandpass, critical slope and critical latitude

The input structure of traditional systems is $X_{\text{trad}} = (t, \phi, \lambda)$, that is, time of birth, latitude and longitude, behind which lies the assertion that time and surface position suffice to fix the cosmic configuration environment. This section shows that the assertion fails in the ocean at three successive levels.

9.1 Depth

Let two organisms be born at the same t_b, ϕ, λ , one at $z \approx 0$ and one at $z \approx -8000$ m. On a two-dimensional map they are born “in the same place”, but by all the results of Section 3 their transfer functions differ by tens of orders of magnitude on several channels. The minimal correction is $X = (t, \phi, \lambda, z)$.

Table E6: Periods selected by the critical slope ($N = 10^{-3} \text{ s}^{-1}$, $\phi = 30^\circ$)

Seafloor slope γ	Selected period
0.001	23.9 h
0.01	23.7 h
0.05	19.8 h
0.10	14.2 h

9.2 Topography: selection of frequency, not of amplitude

Seafloor topography is not a passive background. The frequency of deep-sea internal waves, internal tides included, is confined between two physical boundaries:

$$f < \omega < N, \quad f = 2\Omega \sin \phi, \quad (\text{E36})$$

with f the Coriolis parameter (Ω the Earth's rotation rate) and N the buoyancy frequency. That is, **the ocean is intrinsically a bandpass filter for internal waves**, its low-frequency edge fixed by latitude and its high-frequency edge by stratification.

Internal wave energy propagates along rays making a fixed angle with the horizontal, of slope

$$\tan \theta(\omega) = \sqrt{\frac{\omega^2 - f^2}{N^2 - \omega^2}}. \quad (\text{E37})$$

When the seafloor slope equals that ray slope (the critical slope), energy conversion and focusing are maximal [5]. Inverting, the frequency selected by a slope γ is

$$\omega_{\text{sel}} = \sqrt{\frac{\gamma^2 N^2 + f^2}{1 + \gamma^2}}. \quad (\text{E38})$$

With $N = 10^{-3} \text{ s}^{-1}$ and $\phi = 30^\circ$ one obtains Table E6.

Thus two organisms at the same depth, differing only in the slope beneath them, live in effective environments tuned to different frequencies. Topography alters not signal strength but the whole structure of amplitude, frequency, phase, delay and propagation path.

9.3 Critical latitude

The condition $\omega > f$ in Equation E36 has a concrete consequence. Setting $\omega = f$ gives the critical latitude

$$\sin \phi_{\text{crit}} = \frac{\omega}{2\Omega}. \quad (\text{E39})$$

For the two principal constituents: M2 (12.4206 h) gives $\phi_{\text{crit}} = 74.5^\circ$, and K1 (23.9345 h) gives $\phi_{\text{crit}} = 30.0^\circ$ (Figure E2). Note that Equation E39 does not contain N : the critical latitude is fixed solely by the constituent frequency and the Earth's rotation rate $\Omega = 7.292115 \times 10^{-5} \text{ s}^{-1}$ [13], and is therefore independent of the stratification, including the value $N = 10^{-3} \text{ s}^{-1}$ adopted for plotting Figure E2. Semidiurnal internal tides thus cannot propagate poleward of 74.5° , and diurnal internal tides cannot propagate poleward of 30° .

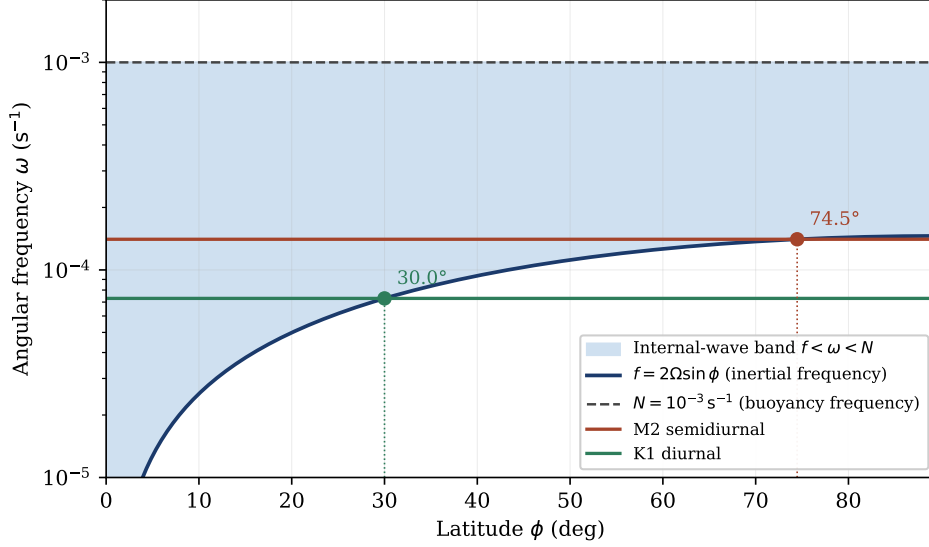


Figure E2: The internal-wave propagation band $f < \omega < N$ as a function of latitude. $f = 2\Omega \sin \phi$ rises with latitude and crosses the K1 and M2 frequencies at $\phi = 30.0^\circ$ and $\phi = 74.5^\circ$ respectively; these are the critical latitudes of the two constituents.

There is therefore a real latitudinal boundary to the Moon's gravitational timekeeping in the deep sea: the lunar periodic components available to life in a low-latitude trench and in a mid-latitude trench differ not in strength but in existence.

This yields a structural coincidence worth noting: **latitude does enter the description of the deep-sea effective environment, but by a mechanism that is not ecliptic geometry; it enters through the constraint that the Earth's rotation, via the Coriolis parameter, places on the propagable band.** One variable, two entirely different physical routes.

9.4 The birth environment state

Collecting the above, the complete description replacing (t, ϕ, λ) is

$$X_{\text{birth}} = (t_b, \phi, \lambda, z, \mathcal{T}, (\rho, T, S, \mathbf{u}, N), \mathcal{G}, \mathcal{M}_{\text{hist}}), \quad (\text{E40})$$

with $\mathcal{T}$ the seafloor geometry, $(\rho, T, S, \mathbf{u}, N)$ the density, temperature, salinity, velocity field and stratification of the water column, $\mathcal{G}$ the local geological and sedimentary environment, and $\mathcal{M}_{\text{hist}}$ the historical state carried by the site itself. Position thereby ceases to be a coordinate and becomes a relational state comprising medium, topography, field and history.

10 Discussion: the field-mediated model and self-limitation

10.1 From configuration model to field-mediated model

The universality implicit in traditional systems is that the same celestial configuration entails the same type of influence on life. But by Equation E3 what actually couples to life is $\mathcal{H}_{\mathcal{E}}[\Psi]$,

Table E7: The two classes of model compared

	Configuration model	Field-mediated model
Form	$B = F(\Psi(t_b))$	$B = F(\mathcal{H}_\mathcal{E}[\Psi])$
Input	celestial configuration	configuration after environmental transformation
Status of medium	transparent (Assumption U)	a constitutive transmission system
Universality	presupposed	environment-dependent

and $\mathcal{H}$ depends on the environment, so

$$\mathcal{H}_{\text{mountain}} \neq \mathcal{H}_{\text{plain}} \neq \mathcal{H}_{\text{shallow}} \neq \mathcal{H}_{\text{abyssal}} \neq \mathcal{H}_{\text{hadal}}. \quad (\text{E41})$$

The same sky does not entail the same effective cosmic environment. The corresponding shift of model is summarised in Table E7.

10.2 The self-limitation corollary

Corollary 10.1 (Self-limitation). *Once Assumption P is taken seriously and written in physical form, it overturns its own universal version.*

Argument. If a physical coupling holds between the heavens and life, that coupling must be realised through some physical carrier; the propagation of any physical carrier is governed by the medium (Section 3); the medium varies with the environment, so $\mathcal{H}_\mathcal{E}$ varies with the environment; by Equation E3 the dependence of B on Ψ therefore varies with the environment. Hence an astral system claiming universal validity for all life cannot simultaneously possess a physical basis and universality. $\square$

The formulation deserves emphasis: **the more astrology seeks to be physicalised, the more it must abandon universality; it cannot have both.** An inference undertaken to give Assumption P a chance ends by supplying a strict constraint upon it.

10.3 Relation to the empirical tests

The conclusion here does not conflict with the negative empirical findings of Carlson [2] and of Dean and Kelly [3]; the two arrive at compatible positions from different directions. The empirical work shows the effect is absent; this paper shows that even if it were present, its structure could not be the one astral systems envisage. Together they narrow the space of admissible forms for Assumption P.

10.4 The general proposition once the conditional shell is removed

Replacing “celestial” with any exogenous driver turns the entire lower layer of this paper into a proposition with nothing to do with the stars:

The external environment an open system experiences is not the external environment itself, but its image after transmission through a medium;

Table E8: Measurable quantities introduced in this paper and methods of estimation

Quantity	Meaning	Method of estimation
$K(\tau)$	environmental memory kernel	regularised deconvolution of input–output series
α	power-law kernel exponent	spectral slope fit; constant-phase-lag test
T, s	mean and spread of transit time	^{14}C , CFC, SF_6 tracer inversion
$\varepsilon, \Delta\omega$	entrainment strength and detuning	Arnold tongue experiment (variable-frequency drive)
D, T_{mem}	phase diffusion and rhythm memory time	free-running experiment in constant conditions
V_W	individuating variance	variance decomposition across a birth cohort

that transmission has its own frequency response, its own delay and its own memory.

The proposition holds equally in climate attribution, ecological response assessment, pollutant tracing and lag analysis in public policy, where it carries direct practical weight: explaining a present state by present forcing is a systematic error in systems with long memory kernels. Sections 4 and 5 may be read as two quantifications of that error.

11 Falsification and research programme

A conjecture that can never fail has no scientific value. This section lists measurable quantities and gives predictions with explicit falsification conditions.

11.1 Measurable quantities

11.2 Predictions and falsification conditions

Prediction 1 (Depth gradient). *Along the gradient land $\rightarrow$ shallow sea $\rightarrow$ abyssal $\rightarrow$ hadal, the power of photoperiod-related rhythms should decline monotonically to zero, while the power of tidal-period rhythms should persist or rise.*

Falsification: *robust annual photoperiodic rhythms detected in hadal organisms and not explicable by seasonality of vertical food flux would refute the channel analysis of Section 3.*

Prediction 2 (Latitudinal boundary of constituents). *Comparing endogenous period components in trench organisms at low latitude ($< 30^\circ$) and mid latitude (30° – 74°), the diurnal component should weaken markedly beyond 30° .*

Falsification: *if mid- and high-latitude trench organisms generally show strong diurnal internal-tide rhythms, the bandpass argument of Section 9 fails biologically.*

Prediction 3 (Long tail of the memory kernel). *Estimating the response kernel of deep-sea ecological variables to external forcing, model comparison (AIC/BIC) should favour a long-tailed kernel over the instantaneous model $K = \delta$.*

Falsification: *if the mass of $\hat{K}(\tau)$ for $\tau > 10$ yr is not significantly different from zero, historical-trajectory regulation does not hold in that system.*

Prediction 4 (Constant phase lag). *If the mechanism of Theorem 8.1 holds, the response of deep-sea biogeochemical variables to broadband forcing should exhibit a frequency-independent*

phase lag of $(\alpha - 1)\pi/2$.

Falsification: *an observed phase lag growing linearly with frequency (pure delay) or tending rapidly to zero (instantaneous response) would rule the mechanism out.*

Prediction 5 (Source of individuation). *Within a single cohort, the between-individual phenotypic variance attributable to external astronomical input should be explicable only by tidal phase (and possibly geomagnetic diurnal phase).*

Falsification: *between-individual differences correlated with planetary positions or solar ecliptic longitude, and stronger than those correlated with tidal phase, would overturn the cube-law argument behind Corollary 6.1.*

11.3 A candid assessment of data availability

The most likely outcome for Predictions 3 and 4 at present is that the data cannot decide. Deep-sea long time series are extremely scarce, and resolving a millennial-scale memory kernel requires observations or high-quality proxies on precisely that scale [14]. This is the most fragile link in the paper.

For that reason the weight of the paper rests on Theorems 4.1 and 5.2: both depend only on known physical transmission properties and on no unobserved biological coupling. Even if Assumption P is entirely false, what those two theorems say about the temporal structure of the deep-sea environment still holds.

12 Limitations

1. **LTI is an approximation** (Assumption 2.7). The real ocean is nonlinear; the approximation has been argued to be conservative here, but must be re-examined for other uses.
2. **The channel decomposition is idealised.** The additivity of Equation E8 presupposes no cross-coupling between channels, whereas real systems have it, since motionally induced electromagnetic fields, generated as currents cut the geomagnetic field, are a leak from the gravitational channel into the electromagnetic one.
3. **The biological coupling link is not modelled.** Only $\Psi \rightarrow \Psi_{\text{eff}}$ is treated here, not $\Psi_{\text{eff}} \rightarrow B$. Nonlinearity, thresholds and selective reception in the latter could change the conclusions substantially.
4. **The biological relevance of the geomagnetic channel is undetermined** (Section 6). All statements about it are conditional.
5. **A Gaussian transit-time distribution is a convenience.** Real TTDs are typically skewed and long-tailed [6], which would blunt Theorem 5.2 in the same direction as Remark 8.2.
6. **Assumption P is not supported.** At no point is a celestial–biological coupling claimed to exist. All conclusions are conditional in form.

13 Conclusion

This paper writes the claim that celestial states influence life as a transfer operator and, under an explicitly conditional premise, examines its form at eight kilometres depth. The main results are two theorems and one corollary.

Theorem 4.1 shows that a long-delay channel asymptotically decouples the natal celestial configuration from the effective environment while leaving the variance of that environment unchanged; information is not lost but corresponds to a different moment. Theorem 5.2 shows that when the cut-off period of the environmental filter exceeds the generational window, the individuating variance collapses to the square of the filter gain: on that channel the level of “the individual” does not exist. Corollary 6.1 identifies the survivors: in the hadal zone the only astronomical inputs capable of individuating are the tidal potential and low-frequency geomagnetic variation, both dominated by the Sun and Moon and neither optical, with the planets excluded below 10^{-5} by the cube law of the tidal potential.

Theorem 8.1 further shows that multi-carrier storage necessarily yields a power-law memory kernel, reducing three originally parallel hypotheses to a chain of dependence while delimiting the validity of Theorem 5.2.

In substance the paper offers no support to any astral system. Corollary 10.1 gives a constraint in the opposite direction: any astral system seeking to be physicalised must abandon universality.

What remains once the conditional shell is stripped away is a proposition with nothing to do with the stars and with wide application: the external environment an open system experiences is not the external environment itself, but its image after transmission through a medium. For a fish living eight kilometres down, this means that what it enters is not a world beginning from zero, but a dynamical system that has been running for a long time and has encoded that running in its water masses, its sediments, its microbial communities and its own genome.

参考文献 / References

- [1] Minoshima, K., Kawahata, H., Irino, T., Ikehara, K., Aoki, K., Uchida, M., Yoneda, M., & Shibata, Y. (2007). Deep water ventilation in the northwestern North Pacific during the last deglaciation and the early Holocene (15–5 cal. kyr B.P.) based on AMS ^{14}C dating. *Nuclear Instruments and Methods in Physics Research B*, 259(1), 448–452.
- [2] Carlson, S. (1985). A double-blind test of astrology. *Nature*, 318, 419–425.
- [3] Dean, G., & Kelly, I. W. (2003). Is astrology relevant to consciousness and psi? *Journal of Consciousness Studies*, 10(6–7), 175–198.
- [4] England, M. H. (1995). The age of water and ventilation timescales in a global ocean model. *Journal of Physical Oceanography*, 25(11), 2756–2777.
- [5] Garrett, C., & Kunze, E. (2007). Internal tide generation in the deep ocean. *Annual Review of Fluid Mechanics*, 39, 57–87.

- [6] Haine, T. W. N., & Hall, T. M. (2002). A generalized transport theory: Water-mass composition and age. *Journal of Physical Oceanography*, 32(6), 1932–1946.
- [7] Hasselmann, K. (1976). Stochastic climate models. Part I. Theory. *Tellus*, 28(6), 473–485.
- [8] Jamieson, A. J., Maroni, P. J., Bond, T., Niyazi, Y., Kolbusz, J., Arasu, P., & Kitazato, H. (2023). New maximum depth record for bony fish: Teleostei, Scorpaeniformes, Liparidae (8336 m, Izu-Ogasawara Trench). *Deep-Sea Research Part I: Oceanographic Research Papers*, 199, 104132. <https://doi.org/10.1016/j.dsr.2023.104132>
- [9] Matsumoto, K. (2007). Radiocarbon-based circulation age of the world oceans. *Journal of Geophysical Research: Oceans*, 112, C09004. <https://doi.org/10.1029/2007JC004095>
- [10] Metzler, R., & Klafter, J. (2000). The random walk's guide to anomalous diffusion: A fractional dynamics approach. *Physics Reports*, 339(1), 1–77.
- [11] Morono, Y., et al. (2020). Aerobic microbial life persists in oxic marine sediment as old as 101.5 million years. *Nature Communications*, 11, 3626.
- [12] Pikovsky, A., Rosenblum, M., & Kurths, J. (2001). *Synchronization: A Universal Concept in Nonlinear Sciences*. Cambridge University Press.
- [13] Pugh, D., & Woodworth, P. (2014). *Sea-Level Science: Understanding Tides, Surges, Tsunamis and Mean Sea-Level Changes*. Cambridge University Press.
- [14] Rogers, A. D. (2015). Environmental change in the deep ocean. *Annual Review of Environment and Resources*, 40, 1–38.
- [15] Schnytzer, Y., et al. (2021). The rhythm of many: Biological rhythms in the marine environment, from macro-scale planktonic ecosystems to micro-scale holobionts. *Frontiers in Marine Science*, 8, 744169.
- [16] Smith, R. C., & Baker, K. S. (1981). Optical properties of the clearest natural waters (200–800 nm). *Applied Optics*, 20(2), 177–184.
- [17] Tessmar-Raible, K., Raible, F., & Arboleda, E. (2023). Rhythms and clocks in marine organisms. *Annual Review of Marine Science*, 15, 509–538.
- [18] UNESCO (1981). *Background Papers and Supporting Data on the Practical Salinity Scale 1978*. UNESCO Technical Papers in Marine Science, No. 37.
- [19] Wagner, H. J., Kemp, K., Mattheus, U., & Priede, I. G. (2007). Rhythms at the bottom of the deep sea: Cyclic current flow changes and melatonin patterns in two species of demersal fish. *Deep Sea Research Part I*, 54(11), 1944–1956.