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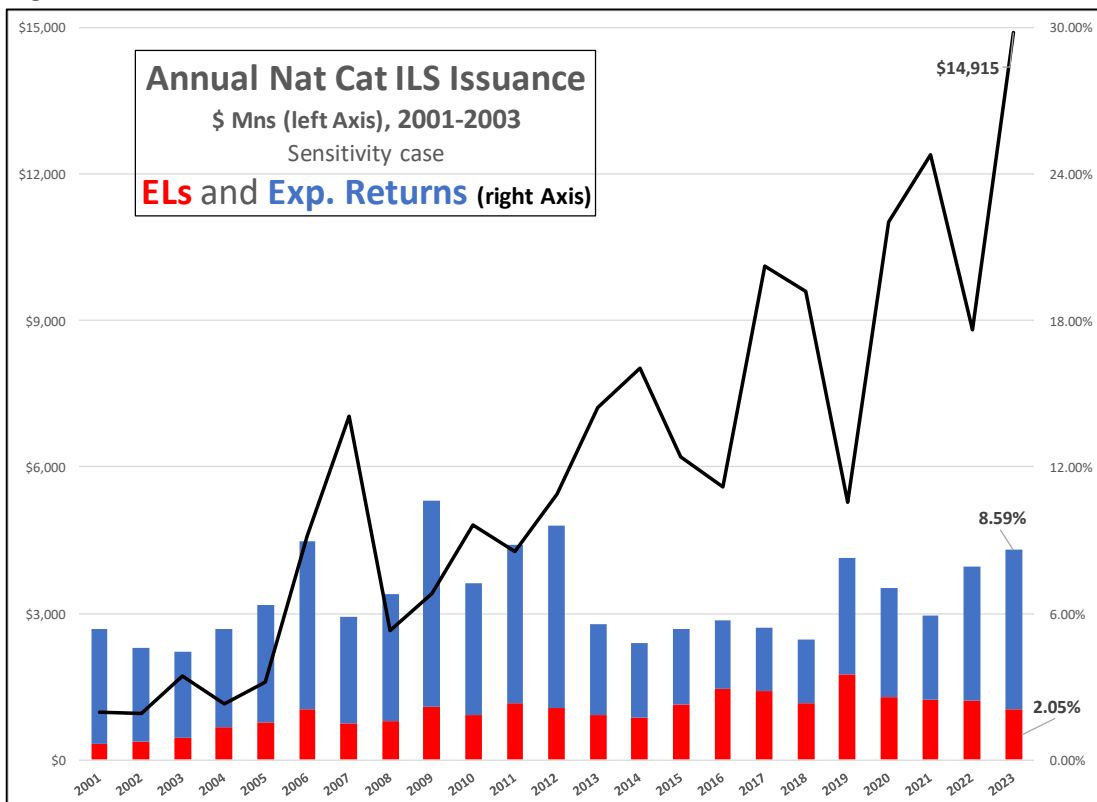
## The Natural Catastrophe ILS Market, 2001-2023 and Its Analysis

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### Preliminaries

The Insurance-Linked Securities [ILS] market is approximately a quarter of a century old. It is a small (but somewhat transparent and growing) window into the traditional (and near opaque) reinsurance market for natural catastrophes. Uniquely for the securities market, each ILS private placement comes with a formal quantified risk analysis, laying out the expected loss [EL] and other statistics for that security. Also uniquely, since 2006 the ILS market was the first one to

Figure 1



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This paper shall not be considered an offer to sell or the solicitation of an offer to buy securities. All information has been obtained from sources both public and private that are believed to be reliable but the authors make no representation as its ultimate accuracy. The views and opinions are those of the authors and are not intended to guarantee any level of financial performance, risk exposure or investment outcome.

publish one “climate-change” related metric based on the warm sea surface temperature in the North Atlantic. In 2023 the market further distinguished itself, for investors, by delivering spectacular high double-digit returns. Moreover, its longer run returns over 2001-2023 compare very favorably with other fixed income securities. The analysis in this paper seeks to examine the record of this ILS market in addressing the following questions.

- a) Are actual losses consistent with the ELs in the issue-provided risk analysis?
- b) Is there a bias to overestimating, or underestimating, EL?
- c) Is the warm sea-surface metric consistent with a rise in actual loss?
- d) Is that warm sea-surface metric increasing or not?
- e) What is the source of high sustained returns for all 23 years under study?
- f) Is it possible to discern which perils are better priced than others?
- g) What is the source of the spectacular returns of 2023?

These questions are examined in detail, based on available data over 23 years. Seemingly simple questions have surprisingly complicated answers, involving primary and secondary market data and implicit models of loss expectations. However, the analysis herein is an empirical one without heavy mathematics or statistics. For those concerned about climate change, the answers revealed in the data might give one pause. Or perhaps require a better framing of climate change questions. They also suggest, despite investor cries to the contrary, that ELs bias towards the conservative.

## Introduction

In May 2006 EQECAT, the modeling company, provided the risk analysis for an ILS issue called Casablanca which covered Florida wind risk. They did it in innovative fashion. In the first pages of the investor document, they gave expected loss numbers and probabilities for a “short-term” case and then later in the document gave the previously used “longer-term” EL. Two EL’s? Yes, the short-term case was higher because the sea surface temperature in the North Atlantic was higher than was thought would be the case over the long term (the EL provided in all previous ILS issues). The practice was immediately followed by the other modelers, Applied Insurance Research [AIR, now Verisk] and Risk Management Services [RMS]. Investors were left to choose which they thought more relevant. But, more importantly, it provided concrete evidence of the ILS market trying to assess and incorporate the effect of “climate change” emanating from one source – warming sea surface temperatures.

The two ELs differed significantly for the wind-exposed Casablanca ILS deal. The short-term annual EL was 34% higher<sup>2</sup> than the long-term, Standard, EL. So too was the “probability of

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<sup>2</sup> This figure is for a single US wind-exposed Casablanca ILS deal. For much of this paper, we will examine the effect of the Sensitivity case on the whole portfolio of Nat Cat issues, some of which are not US wind exposed. For reference, approximately 60% of all deals include some US wind coverage. We are interested in comparing all Nat Cat loss versus expectations in the aggregate. In Section III we will return temporarily to just the wind-exposed deals.

first loss” [PFL] up a similar amount, 36%. The latter implies that the warm water would cause more frequent loss-causing storms. However, when combined, those statistics imply that the average severity of such storms would increase only slightly.

The practice (of two data sets) has now continued for 17 years, and the market generally uses the short-term ELs (variously now referred to as the Warm Sea Surface Temperature case [WSST] or Sensitivity case) rather than the [SSST] or Standard case. Indeed, newcomers to the market often start from the assumption of there being only one EL – the higher, warm water one.

One question after 17 years is, was the shift to the WSST case justified? AIR responsibly examined<sup>3</sup> that question after 10 years of use and showed that loss-causing storm frequency over the prior two decades generally appeared to conform to the projected short-term warm water PFLs or frequencies. However, storm counts and losses are not the same things. To our knowledge the question has not been examined in loss terms. Our review of losses focuses on that question among others. It also raises the question whether even the standard EL measures were not too conservative in the first place.

The recent annual returns for 2023 from hedge funds specializing in ILS averaged 14% and Cat ILS indices showed spectacular near-20% returns. This has excited a great deal of attention. Longer-term ILS returns for the whole history of the ILS market are also impressive – more than 5% on top of the floating rate. Where do such returns come from? Could the pricing of ILS be based on ELs that are too conservative, i.e., are the ELs too high, even in the standard case? These deceptively simple questions are surprisingly difficult to answer conclusively.

## Organization of the Paper

Our objective is not only to address the questions already raised, but also to document and record the existing data that will bear on these questions. Accordingly, the first section presents the background data about the natural catastrophe<sup>4</sup> [Nat Cat] ILS market. Section II explores, by asking some important questions, exactly what is meant by the statistical expectation of loss. How are the risks summarized and presented to cedants (sponsors, issuers) and assumers (investors, buyers) of the risk. Further to suggest ways of projecting expectation over time. Section III deals with actual loss and the difficulties of measuring loss in the ILS market. Section IV reverts to exclusively North America wind-exposed deals and examines the trends of changing expectations of the effects of climate change. Section V looks specifically at the breakdown of realized and expected loss by peril and/or region. Section VI inserts price into the analysis to examine which peril is providing the best returns and is the source of the sustained high returns from ILS as an asset class. Finally, Section VII diverts from long term patterns of loss expectation and realizations to explore why the returns in 2023 were so spectacularly high. The paper

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<sup>3</sup> “A Retrospective on 10 Years of Modeling Hurricane Risk in a Warm Ocean Climate” AIR – Issue Brief 2015.

<sup>4</sup> The data analyzed is for natural catastrophe only. Not included are ILS deals covering, Health, Mortgages, Mortality, Pandemic, Cyber risks, and small private ILS. First cousins of Nat Cat ILS, Collateralized Re transactions and ILWs, are also not included.

concludes with some observations and recommendations. The text of the paper is presented in simple numeric terms with graphs and illustrative numbers. Additional statistical Tables and Graphs updated from previous Loss File analyses in 2020<sup>5</sup> and 2022<sup>6</sup> are presented in the Appendix for completeness.

## Section I - Summary of ILS Market Background

To provide the context for the loss and expectations under examination, a complete table of data is compiled and presented in Table 1. Every calendar year, new deals with differing terms and conditions of Nat Cat ILS are issued. Table 1 collapses those multiple issues each year into a single weighted average annual issue. This process allows capture of year-to-year growth in amount and type of issue and the shifts in expectation and pricing over time as well as capturing the whole history in the Totals line.

Thus, reading across the row for last year, 2023, Table 1 shows that a total of \$14,915 Mn of principal was issued in 94 separate securities (see also Figure 1). This was a record year in the 23 years under consideration in both amount and number of securities. The weighted average month of issue was early July with planned maturity in August, a little over three years later.

The average size of an issue in 2023 was \$159 Mn with a spread (coupon or premium at issue) of 8.59% (see also Figure 1). The average Standard (long-term) risk statistics for these issues were an EL of 1.91% and PFL of 2.49%. In the Sensitivity (short-term) case the EL was 2.05% and the PFL was 2.68%. In this Sensitivity case, these two (EL and PFL numbers) imply that when there is a loss, it is expected to amount to a 76.71% loss of principal (severity). But note that this is almost exactly equal to the expected severity in the Standard case – 76.92%. This is the basis for the assertion in the Introduction that the Sensitivity case implies that losses are expected to be higher, because of more storms, not because of more severe storms.

The Multiple for 2023 (the ratio of Spread over EL and an important measure of relative pricing) is 4.2 for the Sensitivity case versus 4.5 in the Standard case. Finally, the 2023 issues had an average maturity of 3.1 years – already noted as July 2023 to August 2026). However, in the last column, for the period under study, 2001-2023 inclusive, only 0.5 years of the 2023 issues have an impact on this study.

Turning to the whole 23-year period in the bottom lines of the table, there was a total issuance of \$137,622 Mn in 978 securities. That is an average of 43 issues per year with a principal of \$141 Mn.

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<sup>5</sup> The Loss File - Natural Catastrophe ILS, 2001-2020. The Geneva Papers – Insurance Risk in theory and Practice, 2021. Also available at [www.Lanefinancialllc.com](http://www.Lanefinancialllc.com)

<sup>6</sup> ILS Losses 2022 – Expectations, Realizations, and Implications. Proceedings of the China International Conference on Insurance and Risk Management, Harbin. July 2023. Also available at [www.Lanefinancialllc.com](http://www.Lanefinancialllc.com)

**Table 1**

**Characteristics of Annual ILS Nat Cat Issuance - Expected Losses etc.**

2001 - 2023; \$ Mn																						
Year	Annual Total	# of Tranches	Wghtd Avg	Maturity Date	Wghtd Avg	Avg	Wghtd Avg	Principal	Premium	PFL	EL	Wghtd Avg	CEL LGD	Multiple Non-Adjusted	Wghtd Avg	CEL LGD	Multiple Non-Adjusted	Wghtd Avg	Term	Fixed	Term to Date	
																						Issued
2001	\$964	11	7/17/2001	12/17/2003	\$88	5.35%	1.06%	0.66%	8.1	1.06%	0.66%	62.5%	8.1	1.06%	0.66%	62.5%	8.1	2.4	2.4		2.4	
2002	\$956	20	7/20/2002	4/27/2005	\$48	4.57%	1.09%	0.76%	6.0	1.09%	0.76%	70.0%	6.0	1.09%	0.76%	70.0%	6.0	2.8	2.8		2.8	
2003	\$1,720	29	9/8/2003	4/25/2007	\$59	4.41%	1.11%	0.87%	5.1	1.11%	0.87%	78.3%	5.1	1.11%	0.87%	78.3%	5.1	3.6	3.6		3.6	
2004	\$1,143	16	9/3/2004	11/12/2007	\$71	5.34%	1.79%	1.32%	4.1	1.79%	1.32%	73.5%	4.1	1.79%	1.32%	73.5%	4.1	3.2	3.2		3.2	
2005	\$1,588	15	8/25/2005	3/2/2008	\$106	6.35%	1.94%	1.54%	4.1	1.94%	1.54%	79.2%	4.1	1.94%	1.54%	79.2%	4.1	2.5	2.5		2.5	
2006	\$4,581	61	8/10/2006	2/6/2009	\$75	8.93%	2.47%	1.84%	4.9	2.77%	2.08%	74.56%	4.9	2.77%	2.08%	75.14%	4.9	2.5	2.5		2.5	
2007	\$7,031	60	7/20/2007	5/29/2010	\$117	5.85%	1.90%	1.39%	4.2	2.03%	1.48%	73.18%	4.2	2.03%	1.48%	73.18%	4.2	2.9	2.9		2.9	
2008	\$2,636	26	5/23/2008	3/15/2011	\$101	6.78%	2.07%	1.46%	4.6	2.26%	1.59%	70.24%	4.6	2.26%	1.59%	70.24%	4.6	2.8	2.8		2.8	
2009	\$3,398	31	8/15/2009	6/1/2012	\$110	10.61%	2.46%	1.99%	5.3	2.71%	2.17%	80.36%	5.3	2.71%	2.17%	80.36%	5.3	2.8	2.8		2.8	
2010	\$4,799	40	8/6/2010	8/22/2013	\$120	7.22%	2.20%	1.66%	4.3	2.40%	1.81%	75.76%	4.3	2.40%	1.81%	75.76%	4.3	3.0	3.0		3.0	
2011	\$4,270	33	8/11/2011	11/26/2014	\$129	8.79%	2.75%	2.16%	4.1	2.96%	2.32%	78.35%	4.1	2.96%	2.32%	78.35%	4.1	3.3	3.3		3.3	
2012	\$5,455	42	6/17/2012	9/3/2015	\$130	9.57%	2.42%	1.94%	3.9	2.62%	2.11%	80.49%	3.9	2.62%	2.11%	80.49%	3.9	3.2	3.2		3.2	
2013	\$7,210	40	7/10/2013	10/20/2016	\$180	5.58%	2.13%	1.64%	4.4	2.40%	1.85%	77.01%	4.4	2.40%	1.85%	77.01%	4.4	3.3	3.3		3.3	
2014	\$8,026	35	6/29/2014	1/24/2018	\$229	4.76%	2.19%	1.56%	3.0	2.41%	1.74%	72.08%	3.0	2.41%	1.74%	72.08%	3.0	3.6	3.6		3.6	
2015	\$6,218	30	6/20/2015	11/26/2018	\$207	5.36%	2.99%	2.08%	2.6	3.26%	2.27%	69.81%	2.6	3.26%	2.27%	69.81%	2.6	3.4	3.4		3.4	
2016	\$5,590	37	7/15/2016	3/12/2020	\$151	5.71%	3.48%	2.63%	2.2	3.86%	2.91%	75.46%	2.2	3.86%	2.91%	75.46%	2.2	3.7	3.7		3.7	
2017	\$10,111	66	6/1/2017	12/10/2020	\$153	5.39%	3.48%	2.61%	2.1	3.77%	2.82%	74.93%	2.1	3.77%	2.82%	74.93%	2.1	3.5	3.5		3.5	
2018	\$9,594	47	5/11/2018	12/12/2021	\$204	4.93%	2.90%	2.17%	2.3	3.08%	2.30%	74.84%	2.3	3.08%	2.30%	74.84%	2.3	3.6	3.6		3.6	
2019	\$5,284	33	7/28/2019	4/14/2023	\$160	8.26%	4.16%	3.20%	2.6	4.51%	3.47%	76.97%	2.6	4.51%	3.47%	76.97%	2.6	3.7	3.7		3.7	
2020	\$11,023	75	6/23/2020	8/5/2023	\$147	7.02%	3.10%	2.36%	3.0	3.38%	2.56%	75.92%	3.0	3.38%	2.56%	75.92%	3.0	3.1	3.1		3.1	
2021	\$12,397	73	6/27/2021	12/17/2024	\$170	5.89%	3.12%	2.31%	2.5	3.35%	2.48%	73.99%	2.5	3.35%	2.48%	73.99%	2.5	3.5	3.5		3.5	
2022	\$8,813	64	5/23/2022	7/20/2025	\$138	7.90%	2.83%	2.23%	3.5	3.09%	2.43%	78.79%	3.5	3.09%	2.43%	78.79%	3.5	3.2	3.2		3.2	
2023	\$14,915	94	7/12/2023	8/11/2026	\$159	8.59%	2.49%	1.91%	4.5	2.68%	2.05%	76.71%	4.5	2.68%	2.05%	76.71%	4.5	3.1	3.1		3.1	
Totals	\$137,722	978		7/6																		
Annual Averages*	\$5,988	43			\$141	6.76%	2.71%	2.05%	3.5	2.94%	2.22%	75.44%	3.5	2.94%	2.22%	75.44%	3.5	3.3	3.3		2.78	

\* The first three #s in this row are simple derivation from Totals #s; others are weighted averages of columns i.e tantamount to weighted averages from raw data.

Notes :- Includes all 144A Nat Cat issues with complete investor statistics. Does not include private ILS or Section 20 ILS.

Some listings of this table in prior publications did not convert the discount on zero coupon issues to yield-equivalents. Hence there may be small differences in #s.

Shaded area prior to introduction of WSST Statistics

The remaining numbers in the bottom row are the weighted average of the years presented. Since all 978 issues are collapsed into the annual figures, this means that the weighted average of these years is the same as taking a weighted average of the whole data set.

Thus, the number best representing the spread on all 978 issues is 6.76%. Similarly, the Sensitivity case for PFL and EL for the whole 978 issues are the pair 2.94% and 2.22% respectively. Essentially that last line is a single deal that represents what has transpired 978 times over the past 23 years.

**Section II - Using EL Summaries for Initial Answers to Preliminary Questions**

Having this truly representative single ILS for the whole data set allows us to make first estimates of the answers to some of the important questions.

- a) How much have ELs increased from the introduction of the Sensitivity case? Answer: about 8.3% (=2.22%/2.05%) but note this is for the whole portfolio.
- b) How many deals would we expect to experience a loss in 23 years?  
Answer: A total of 78 deals would be expected to experience a loss using the Sensitivity

WSST #	PFL w	# of ILS	
	2.94%		978
Year 1	1	28.8	949.2
Year 2	1	27.9	921.3
Year 3	0.78	21.2	
	2.78	78.0	2648

case. During the first year, 28.8 (=2.94%\*978) of 978 deals would have experienced a loss. In the second year of the remaining unimpaired deals, 27.9 (=2.94%\*950.2) would be expected to experience a loss. In the third full year it would be 27.2 deals using the same logic. However, the representative deal has a maturity of only 2.78 years, so it would expect only 21.1 deals (=27.1\*0.78) in that third year. Thus, the total number of deals expected to experience a loss, in the Sensitivity case, would be 78 (=28.2+27.9+21.1). See inset table. The Standard case would show 72 deals with a loss.

- c) Based on the Sensitivity ELs what \$ losses should the market have experienced?  
Answer: \$8,346 Mn.

The details of how this was obtained are like b) but are laid out in tabula form below.

# of ILS EL wsst	978 2.22%	Coverage (Begin Yr)	Loss In Yr
Year 1	1	\$137,722	\$3,062
Year 2	1	\$134,660	\$2,994
Year 3	0.78	\$131,666	\$2,289
	2.78	\$375,351	\$8,346

d) What would be expected losses under the Standard case?

Answer: \$7,707 Mn (= \$8,346/1.083% referring to answer a) above).

There are two other questions it will also be useful to explore:

e) How many years of coverage, because most ILS are multi-year deals, has the ILS Nat Cat provided in the last 23 years. And, related to that, how much monetary coverage (Limit) has been given?

Answer: 2,648 years and \$375,351 Mn respectively. Similar reasoning is utilized in each table above.

Readers will appreciate that all these questions and answers are utilizing a fundamental relationship of expectations, frequency, and severity as well as time on risk. That relationship is simply,

$$EL = PFL * CEL$$

Where Conditional Expected Loss [CEL] is severity of loss. For those more familiar with the analysis of corporate bonds, the more accepted phrase is Loss Given Default [LGD]. It is assumed that EL and PFL are on the same time basis, e.g. annual.

It should be noted that readers may get slightly different answers if they try to verify the calculations above. This may be due to insufficient decimal places in the numbers displayed in Table 1. There is also a more subtle point to make concerning the generation of the slightly different answers. In the foregoing the use of EL assumes the smooth processing of expected losses with *all* the remaining limit facing the same expected loss rate each year. A slightly different model is shown in the Appendix. In it, it is assumed that losses can take place in any year but will only affect the unimpaired deals, not the residuals from prior impaired deals. A model such as this is required if one wishes to capture the various effects over time, as needed for some of the Appendix graphics, rather than in the aggregate. Fortunately, the differences between these models are small 1-1.5% and are recorded here simply to recognize the importance of implicit model assumptions for intertemporal conclusions.

Finally in this section we note that we have yet to answer the questions concerning the appropriateness of model expectations vis-à-vis climate change from warmer sea surface



temperatures. We can simply state that we would expect it to increase losses over the period by \$639 Mn (= answer c, \$8,346, minus answer d, \$7,707). To check the reality of this in the real world we need to compare those numbers to actual experience.

### Section III - Actual or Realized Losses

Our record of actual losses 2001-2023 is listed in Table 2A and Table 2B. The data is broken into two tables to reflect the fact that actual losses are recorded slowly over time. If a large storm causes losses that will likely affect some ILS security, the first place this shows up is in the secondary market pricing of that outstanding ILS deal.

To illustrate the process, say a three-year, \$100 Mn, deal named Naples Re because of its focused exposure, was issued in 2020. Two years later, hurricane IAN hits Florida very close to Naples (September 2022). Issued at par, i.e., a price of \$100, after IAN the price of that bond would drop to, say, a price of \$30 – a 70% drop in price. That is a signal to the market that Naples Re will suffer and realize a major loss of principle.

Prices of other ILS may also drop, e.g., a hypothetical Boston Re may drop to \$95 – not because of expectations of a real loss to Boston Re but because the IAN loss may be big enough to cause a real loss of reinsurance capital elsewhere in the system, causing reinsurance rates to move higher. It may pay a Boston Re holder to take a small loss of a few dollars to buy any newly issued ILS with higher premium rates, post IAN.

Thus, there is a big difference between the price action of Naples Re and Boston Re. It is this, both are mark-to-market [M-T-M] losses but Boston Re is unlikely to realize any loss from IAN while the price drop of 70% of Naples Re is a signal that there is a high probability that it will have a real loss. And the first guess is about 70% of principal. But where do you draw the line between a signal that the loss will not be realized and one where the signal is that some loss will be realized? Our answer is \$80. It is not entirely arbitrary; it is based on observation. But we could change our minds – as does the market. For the present, however, Tables 2A and 2B assume that any deal bid at \$80 or less has a real chance of experiencing a real loss.

Obviously, in our hypothetical example, Naples Re would fall into that category. It would appear first in the second part of Table 2B. Over time the ceding reinsurer will be reporting to its reinsurers its internal estimates of its Naples loss. It might cause the ILS price to rise or fall some more. Meanwhile Naples Re is still on-risk until maturity.

After maturity, the issuer might agree that the loss from IAN is at least 50% of the principal. And the indenture of the bond may require him to pay that minimum to the reinsured in a timely fashion. At this point Naples Re moves up to the top part of Table 2B. Afterwards, the remaining principal is \$50, and it would be priced at \$60 because the original M-T-M estimate, if it stays the same, of \$30 on par implies another \$20 on the remaining \$50. Therefore, the new price is \$60.



**Table 2A**

**History of ILS with Natural Catastrophe Losses**

(Listed in Loss Event Sequence)

Lane Financial LLC													
Loss Issues also 12/30/2023 (+ indicates Aggregate Loss)	Month of Event	Agg ILS	Issue Date	Original Maturity	Extended Maturity	Spread at issue	Actual or Estimated Loss as a % of Par	Actual or Fully Paid Loss	Partially Paid Known Losses	Market Implied Losses (bid <80)	Total Actual and Est Loss	Payments to Investors	Loss Triggering Event
<b>ILS with Natural Catastrophe Paid Loss of Principal Known and Closed</b>													
Kamp Re	Aug-05		7/28/2005	3/14/2008	12/14/2010	5.30%	76%	\$144			\$144	\$46	Katrina, Wilma
Nelson Re Class G 2008-I	Sep-08		6/6/2008	6/6/2011	6/6/2012	12.00%	56%	\$38			\$38	\$30	Ike
Muteki Ltd.	Mar-11		5/24/2008	5/24/2011		4.40%	100%	\$300			\$300		Tohoku Earthquake
Mariah Re 2010-I	Mar-11	+	11/15/2010	1/8/2014		6.25%	100%	\$100			\$100		US Windstorms - Tornado Loss
Mariah Re 2010-II	Mar-11	+	12/16/2010	1/8/2014		8.50%	100%	\$100			\$100		US Windstorms - Tornado Loss
Multicat Mexico 2012-1 C	Sep-14		10/5/2012	12/4/2015	3/4/2016	7.50%	50%	\$50			\$50	\$50	Patricia
Gator Re 2014-1 A	Jan-17	+	3/10/2014	1/9/2017	11/3/2017	6.50%	18%	\$35			\$35	\$165	Aggregate Loss
Residential Re 2013-2 1*	Aug-17	+	12/02/13	12/06/17	3/6/2019	20.00%	75%	\$60			\$60	\$20	Harvey, Irma, CA WF Aggregate Loss
Residential Re 2014-1 10	Aug-17	+	05/22/14	06/06/18	9/6/2020	15.00%	100%	\$80			\$80	\$20	Harvey, Irma, CA WF Aggregate Loss
Residential Re 2015-1 11	Aug-17	+	05/29/15	06/06/19	9/6/2020	6.00%	80%	\$80			\$80	\$20	Harvey, Irma, CA WF Aggregate Loss
Residential Re 2017-1 10	Aug-17	+	5/3/2017	6/6/2018		17.50%	100%	\$50			\$50	\$102	Harvey, Irma, CA WF Aggregate Loss
Atlas IX 2015-1	Aug-17	+	02/10/15	01/07/19	1/7/2021	7.00%	30%	\$48			\$48	\$15	Harvey, Irma, Maria Aggregate Loss
Loma Re 2013-1 C	Aug-17	+	12/30/13	01/08/18	1/8/2021	17.00%	100%	\$50			\$50	\$2	Harvey, Irma, Maria Aggregate Loss
Casablanca Re 2017-1 C	Aug-17	+	06/10/17	06/04/20	6/4/2023	16.00%	0%	\$5			\$5	\$0	Harvey, Irma, CA WF Aggregate Loss
Residential Re 2016-1 10	Aug-17	+	05/11/16	06/06/20	6/6/2023	11.50%	0%	\$52			\$52	\$13	Harvey, Irma, CA WF Aggregate Loss
Espada Re 2016-1	Aug-17	+	03/01/16	06/06/20	6/6/2023	5.75%	0%	\$1			\$1	\$49	Harvey, Irma, CA WF Aggregate Loss
Manatee Re 2016-1 C	Sep-17		3/10/2016	3/13/2019		16.25%	100%	\$20			\$20		Irma, Maria
CAR 113 Class A (Mexico)	Sep-17		8/4/2017	8/11/2020		4.50%	100%	\$150			\$150		Chiapas EQ
Citrus Re 2015-1 C	Sep-17		4/8/2015	4/9/2020		9.00%	100%	\$30			\$30		Irma
Citrus Re 2015-1 B	Sep-17		04/08/15	04/09/18	4/9/2020	6.00%	100%	\$98			\$98		Irma
Citrus Re 2016-1 D	Sep-17		02/24/16	02/25/19	2/25/2021	7.50%	78%	\$117			\$117	\$33	Irma
Citrus Re 2016-1 E	Sep-17		02/24/16	02/25/19	8/25/2019	10.50%	100%	\$100			\$100		Irma
Citrus Re 2017-2 B	Sep-17		05/11/17	03/18/20		10.75%	100%	\$35			\$35		Irma
Blue Halo 2016-1 B	Sep-17	+	06/16/16	06/21/19	6/21/2022	19.75%	87%	\$48			\$48	\$7	Matthew, Harvey, Irma, Florence
Citrus Re 2017-1 A	Sep-17		03/13/17	03/18/20	3/20/2023	6.00%	100%	\$125			\$125		Irma
Caelus Re V 2017-1 D	Sep-17	+	05/04/17	06/05/20	6/5/2024	9.25%	0%	\$125			\$125	\$11	Harvey, Irma, CA WF, Aggregate
Akibare Re 2016-1	Sep-18	+	03/04/16	04/07/20	4/7/2024	2.50%	100%	\$200			\$200		Jebi
Caelus Re V 2018-1 D	Sep-17	+	05/10/18	06/07/21	6/7/2025	10.50%	100%	\$75			\$75		Harvey, Irma, CA WF, Aggregate
Residential Re 2018 1 11	Nov-18	+	05/14/18	06/06/19	6/6/2022	11.75%	100%	\$100			\$100		California Wildfires
Cal Phoenix 2018-1	Nov-18	+	08/02/18	08/13/21		7.50%	100%	200			\$200		California Wildfires
Frontline Re 2018-1 B	Nov-18		06/26/18	07/06/22		11.75%	100%	100			\$100		Michael
CAR 120	May-19		02/07/18	02/15/21		6.00%	30%	\$60			\$60	\$140	Peru EQ
Atmos Re DAC A	Nov-19		02/06/19	02/14/22		4.50%	100%	\$51			\$51		Italy Severe Weather
Caelus Re VI 2020-2 C	Aug-20	+	02/27/20	06/07/23		12.75%	100%	\$40			\$40		CA WF, Aggregate
Catahoula Re 2020-1 A	Aug-21		05/11/20	05/09/23		3.52%	100%	\$60			\$60		Ida
Manatee Re III 2019-1 B	Aug-21		05/30/19	06/07/22	6/8/2026	9.82%	100%	\$20			\$20		Ida
Sanders III 2022-2 C	Feb-21		5/31/2022	6/7/2023		11.75%	100%	\$38			\$38		Ian, WS Uri
CAR 124 B	Dec-21		11/22/2019	12/2/2022	3/2/2023	5.65%	35%	\$53			\$53		Odette
	38						76%	\$3,037			\$3,037		

**Table 2B**

**History of ILS with Natural Catastrophe Losses**

(Listed in Loss Event Sequence)

Lane Financial LLC																				
Loss Issues a/o 12/29/2023 (+ Indicates Aggregate Loss)	Month of Event	Agg ILS	Issue Date	Original Maturity	Extended Maturity	Spread at issue	Actual or Estimated Loss as a % of Par	Actual or Fully Paid Loss	Partially Paid Known Losses	Market Implied Losses (bid <80)	Total Actual and Est Loss	Payments to Investors	Loss Triggering Event							
<b>ILS with Natural Catastrophe Partial Paid Losses of Principal and are still Outstanding</b>																				
Caelus Re V 2018-1 B	Sep-17	+	05/10/18	06/07/21	6/7/2025	4.50%	100%		\$75	\$0	\$75		Harvey, Irma, CA WF, Aggregate							
Caelus Re V 2018-1 C	Sep-17	+	05/10/18	06/07/21	6/7/2025	7.50%	100%	\$122	\$175	\$63	\$175		Harvey, Irma, CA WF, Aggregate							
Caelus Re V 2017-1 C	Sep-17	+	05/04/17	06/05/20	6/5/2024	6.50%	97%	\$32	\$73	\$41	\$73		Mania							
Frontline Re 2018-1 A	Oct-18		6/26/2018	7/6/2026		7.00%	89%	\$203	\$222	\$19	\$222		Michael, Ian							
Sanders II 2019-1 B	Aug-20	+	03/28/19	04/07/23	4/7/2026	12.25%	100%	\$264	\$300	\$36	\$300		CA Wildfires, TS Uri, Texas Freeze							
Manatee Re III 2019-1 A	Aug-21		05/30/19	06/07/22	6/8/2026	6.11%	98%	\$13	\$7	\$7	\$20		Ida							
Herbie Re 2020-2 C	Sep-22	+	10/29/2020	1/6/2023	1/8/2026	16.00%	63%	\$6	\$9	\$9	\$16		Ian, USCS, TurkeyEQ							
Kilimanjaro III 2019-1 A	Sep-22		12/12/2019	12/19/2023	12/19/2024	15.75%	22%	\$13	\$21	\$21	\$34		Ian							
Kilimanjaro III 2019-2 A	Sep-22		12/12/2019	12/19/2023	12/19/2024	15.75%	22%	\$13	\$21	\$21	\$34		Ian							
Claveau Re 2021-1	Sep-22	+	7/6/2021	7/8/2025		17.25%	42%	\$26	\$63	\$37	\$63		TurkeyEQ							
		10					74%	\$766	\$244	\$244	\$1,010									
<b>Currently Outstanding ILS with M-T-M Implied Natural Catastrophe Loss of Principal</b>																				
Caelus Re V 2017-1 B	Sep-17		05/04/17	06/05/24		4.50%	2%		\$2	\$2	\$2	\$135	Harvey, Irma, CA WF, Aggregate							
Caelus Re V 2018-1 A	Sep-17	+	05/10/18	06/07/21	6/7/2025	3.50%	32%		\$40	\$40	\$40		Harvey, Irma, CA WF, Aggregate							
Caelus Re VI 2020-2 A	Aug-20	+	02/27/20	07/07/23	6/7/2027	5.50%	100%		\$75	\$75	\$75		CA WF, Aggregate							
Caelus Re VI 2020-2 B	Aug-20	+	02/27/20	07/07/23	6/7/2027	7.75%	100%		\$75	\$75	\$75		CA WF, Aggregate							
Sanders II 2020-1 B	Feb-21		03/30/20	04/07/24		12.75%	45%		\$45	\$45	\$45		TS Uri							
Pelican IV Re 2021-1 A	Aug-21		05/08/21	05/07/24		2.25%	100%		\$75	\$75	\$75		Ida							
Pelican IV Re 2021-1 B	Aug-21		5/6/2021	5/7/2024		5.25%	100%		\$50	\$50	\$50		Ida							
Integrity Re II 2020-1 A	Sep-22		3/24/2020	4/12/2023	4/12/2028	7.25%	100%		\$149	\$149	\$149		Ian							
Herbie Re 2021-1 A	Sep-22	+	5/25/2021	6/6/2025		17.25%	45%		\$68	\$68	\$68		Ian							
Astro Re 2021-1	Sep-22		7/9/2021	7/8/2025		8.00%	35%		\$14	\$14	\$14		Ian							
3264 Re 2021-1	Sep-22	+	12/22/2021	1/8/2025		19.00%	25%		\$25	\$25	\$25		Ian							
Residential Re 2019-1 12	Sep-22		5/24/2019	9/6/2023	6/6/2026	8.15%	34%		\$20	\$20	\$20	\$30	Ian							
Residential Re 2021-1 11	Sep-22		5/20/2021	6/6/2025		9.91%	23%		\$23	\$23	\$23		Ian							
Bonanza Re 2023-1 B	Sep-22		1/11/2023	1/8/2024	1/8/2026	20.00%	65%		\$42	\$42	\$42		Ian							
Matterhorn Re 2020-2 A	Dec-23		2/3/2020	1/8/2024	1/8/2027	5.00%	55%		\$44	\$44	\$44		E US Storm							
Sanders II 2020-1 B	Feb-21		3/30/2020	4/7/2024		12.60%	55%		\$55	\$55	\$55		Aggregate - URI, TX Freeze							
CAR 128	Oct-23		3/6/2020	3/13/2024		6.50%	50%		\$63	\$63	\$63		Ontis							
Integrity Re 2019-1 A	Sep-22		5/29/2019	6/12/2028		5.54%	50%		\$25	\$25	\$25		Ian							
Bonanza Re 2022-1 A	Sep-22		3/16/2022	2/16/2025		5.78%	25%		\$34	\$34	\$34		Aggregate							
Integrity Re 2022-1 A	Sep-22		5/16/2022	6/6/2025		7.07%	25%		\$19	\$19	\$19		Ian							
Topanga Re 2021-1 B	Jun-23		12/22/2021	1/8/2026		16.80%	25%		\$15	\$15	\$15		Aggregate							
Bonanza Re 2023-2	Sep-22		12/22/2023	1/8/2025		23.00%	23%		\$16	\$16	\$16		Aggregate							
		22					48%		\$973	\$973	\$973	\$165								
Issues with actual and/or M-T-M loss:													<b>70</b>	Average extension period, when extended:	<b>2.68</b>	<b>9.02%</b>	<b>69%</b>	<b>\$1,217</b>	<b>\$4,958</b>	<b>\$966</b>

Loss Payments indicated are believed accurate although specifics on loss payments - particularly interim payments - are often opaque.

\* Spread: Issued at a discount; discount amount shown.

# Interim and final payments are shown in top section, bottom section includes outstanding ILS; the latter ILS are excluded from the count in the lower section to avoid duplication.

Let's further assume that Naples Re matured at the end of 2023. It may not disappear from Table 2B immediately as the reinsured can request several extensions of final settlement to get the precise loss number. Furthermore, while the deal is off-risk for further events, it is still live for development risk and is quoted and theoretically could be traded. If we assume that he is allowed 4 quarterly extensions the reinsurer will have to settle by the end of 2024. At that point the loss is "Known and Closed" and those are the ones in Table 2A.

This is a long way of describing what is in Tables 2A and 2B. It is also to say that these numbers are difficult to get for non-investors. So, they are correct ... as far as we know. Estimates must be recognized as a work in progress or "development". The summation of all those explanations is as follows. Total losses experienced by the Nat Cat ILS market from 2001 until end of 2023 are \$4,958 Mn. That is made up of \$2,975 Known and Closed, \$1,010 Mn of Partially Paid loss and \$973 Mn of pure M-T-M losses.

Those Totals were occasioned by losses to 70 deals which had an issued principal of \$7,155 Mn<sup>7</sup>. Their weighted average premium was 9.02% and their size was around \$100 Mn – smaller than the average of \$141 Mn. They were risky deals. Of those that extended the settlement period, the average extension was 2.7 years. These are interesting statistics, but the disquieting part is the total estimated actual loss relative to expectations.

Just to refresh ourselves.

Standard Estimate of loss	\$7,707 Mn.
Sensitivity Estimate of loss	\$8,346 Mn.
Realized + M-T-M, or Actual, loss	\$4,958 Mn.

Not only is there no evidence that the Sensitivity case of loss estimates is reflected in experience, but there is also little support for the idea that experience matches the Standard case. The Sensitivity case EL is 68% higher than actual; the Standard case is 55% higher. There are several possible inferences that can be drawn at this point.

- 1) Our methodology is wrong, incomplete.
  - 2) The market is wrong, i.e., the M-T-M will change.
  - 3) The risk models are wrong - too conservative., i.e., ELs are too high.
- OR some combinations, plus
- 4) Investors have been "lucky".

These are uncomfortable conclusions. One could argue that 23 years is too short a time to draw conclusions. However, it is not really 23 years. It is 978 annual experiments over 2.78 years

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<sup>7</sup> As an aside, 49.08% of this \$7,155 Mn were categorized as Aggregate deals carrying a weighted average coupon of 11.13%. The remainder were Occurrence deals carrying a coupon of 6.98%.

implying a total annual coverage of 2,648 years that is being examined. Surely that is statistically enough to draw some conclusions.

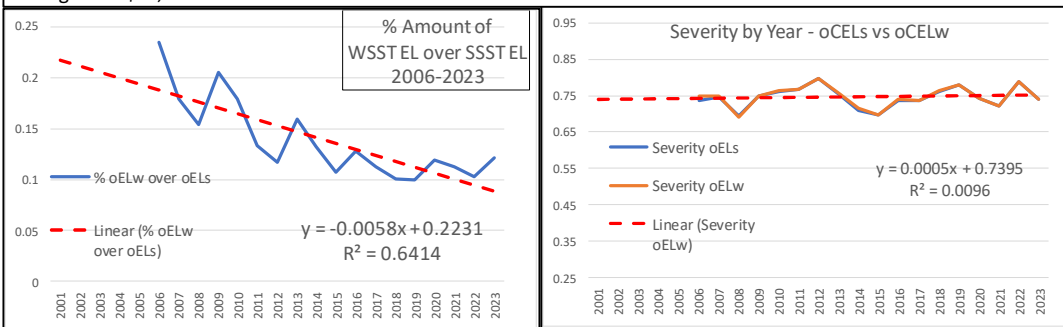
### Section IV - Overly (?) Conservative ELs – Dissecting the WSST EL’s

Both the Standard and the Sensitivity estimated ELs exceed the actual observed ELs, and that is for the whole portfolio. Remember the Sensitivity case exceeds the Standard case only for North American wind-exposed deals. In this section we dig more deeply into just that class of ILS. Table 3 lays out the history of North American wind exposures covered in all the deals issued since 2006, when the Sensitivity case was first introduced.

**Table 3**

NA WIND-EXPOSED ILS			Wghtd Avg	Wghtd Avg	Wghtd Avg	Wghtd Avg	Wghtd Avg	Wghtd Avg	Wghtd Avg % Increase
Year	Amount	# Of Deals	PFLs	ELs	CELs	PFLw	ELw	CELw	ELw/ELs
2001									
2002									
2003									
2004									
2005									
2006	\$1,448	25	4.41%	3.25%	73.8%	5.4%	4.02%	74.9%	23.5%
2007	\$1,645	17	2.98%	2.23%	74.7%	3.5%	2.63%	74.9%	17.9%
2008	\$1,398	14	2.21%	1.54%	69.5%	2.6%	1.77%	69.0%	15.4%
2009	\$2,176	18	1.90%	1.42%	74.8%	2.3%	1.72%	74.8%	20.5%
2010	\$2,750	24	1.93%	1.47%	76.2%	2.3%	1.73%	76.4%	17.9%
2011	\$2,302	21	2.87%	2.20%	76.8%	3.2%	2.50%	76.9%	13.4%
2012	\$3,513	30	2.72%	2.17%	79.7%	3.0%	2.42%	79.7%	11.7%
2013	\$5,010	31	2.51%	1.90%	75.5%	2.9%	2.20%	75.9%	15.9%
2014	\$6,303	28	2.40%	1.70%	70.9%	2.7%	1.93%	71.6%	13.2%
2015	\$4,443	22	3.57%	2.48%	69.6%	3.9%	2.75%	69.7%	10.7%
2016	\$3,670	31	4.63%	3.42%	73.8%	5.2%	3.85%	74.0%	12.8%
2017	\$6,382	49	4.15%	3.05%	73.6%	4.6%	3.40%	73.7%	11.2%
2018	\$4,979	28	3.41%	2.60%	76.2%	3.7%	2.86%	76.4%	10.0%
2019	\$4,075	26	4.55%	3.55%	78.1%	5.0%	3.91%	77.9%	9.9%
2020	\$7,255	53	3.53%	2.62%	74.2%	3.9%	2.93%	74.2%	11.9%
2021	\$7,190	47	3.55%	2.56%	72.1%	3.9%	2.85%	72.2%	11.3%
2022	\$7,153	50	3.01%	2.38%	78.9%	3.3%	2.62%	78.7%	10.3%
2023	\$8,552	56	2.70%	1.99%	74.0%	3.0%	2.24%	74.0%	12.1%
Total or Avg	\$80,242	570	3.17%	2.36%	74.6%	3.6%	2.68%	74.7%	13.9%

Note that these totals include not just the single peril wind-exposed deals, but the multi-peril deals where the wind is but one component exposure of the ILS. An example might be an ILS which covers both wind and earthquake exposure for North America. Even though only part of the whole, EL statistics for the Standard and Sensitivity case for wind expectations are usually separately quoted from quake loss in



the risk analysis, which also gives the combined number. Regrettably, the respective PFLs are not usually given.

Examining the totals in Table 3, note that the wind exposure constitutes \$80,242 Mn of the whole portfolio of risk – hence the earlier assertion that it constitutes 60% ( $=\$80,242 \text{ Mn}/\$137,722 \text{ Mn}$ ) of the whole 23-year issuance.

Now the reason the sensitivity case was introduced was to reflect the assessment that warm sea surface temperatures would cause more frequent and perhaps more violent hurricanes and therefore greater insured loss. Table 3 shows how that initial estimate has changed over time.

To address the obvious component first, the models clearly see no significant change in the expected severity of storms – the CEL. In 2006 it was estimated in the Standard scenario as a 73.8% loss rising to 74% in 2023. That’s almost a rounding error. The Sensitivity case has similarly not changed much either, from 74.9% in 2006 falling to 74.7% in 2023. The lower right inset graph shows that even when the CELs have moved inter-year, they have moved in tandem. The two lines in the graph lie on top of one another. Their correlation is 99.3%. In other words, the modelers still believe that the sea surface temperature could lead to higher loss – but not because the severity of storms is affected by “Climate Change”.

The implication is that the dominant “Climate Change” effect is on increased frequency of loss-causing storms. But the modelers’ assessment of that has changed over time, in surprising fashion. One might expect given the recently announced record busting sea surface temperatures of 2023 that it would be rising<sup>8</sup>. The numbers tell a different story.

In 2006 the modelers upped their Standard EL on the average exposed deals by 23.5% from an EL of 3.25% to 4.02% - the last column of Table 3 – to accommodate more storms. By 2023 the amount by which they adjusted the Standard case had dropped. They only increased the Sensitivity case over and above the Standard case by 12.1%. The lower left inset graph shows the trend. On average it has dropped by a half a percentage point (half a storm) every year since 2006. Clearly the initial frequency estimates were too conservative, or the modelers would not be lowering those estimates over time.

There are, of course, other potential explanations for this change of mind. Perhaps the more frequent storms are not land falling in North America. Or perhaps the modelers are revising their Standard longer-term model higher (but if it is observable in the trends, we could only see 5 bps to offset that drop of half a storm a year). Perhaps the rise in sea surface temperatures was less than expected or did not show up in the Atlantic as much as the Pacific. Whichever explanation is used to ameliorate the numbers, it seems clear that the modelers were too conservative initially and are slowly changing their mind about storm frequency. One would hope they would do that, if that is what new data is telling them each year.

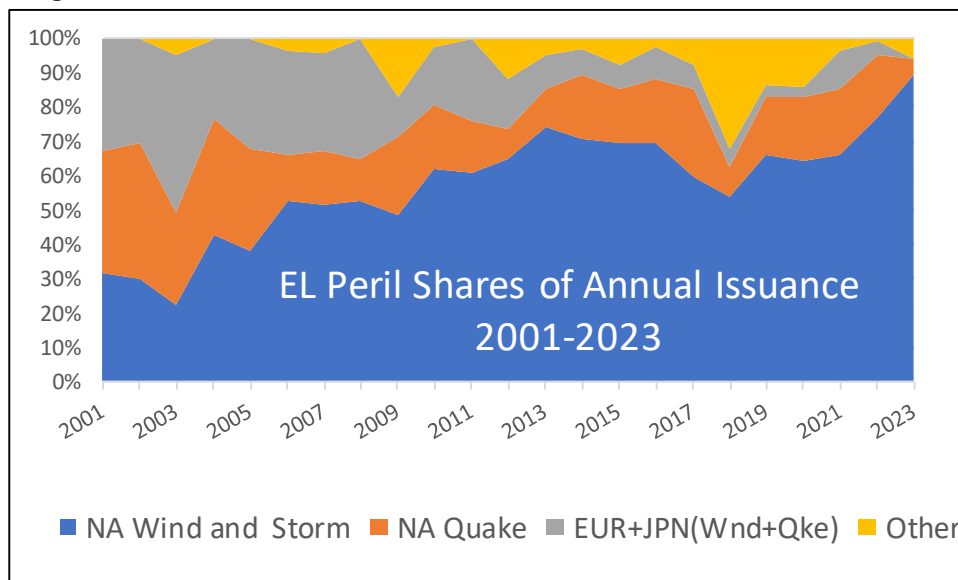
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<sup>8</sup> See for example the Financial Times, March 17, 2024. “Oceans set new temperature records more than 365 days in a row”.

## Section V - Breaking Expected and Actual Losses into Component Perils

It seems clear that the Sensitivity case expectations started out too conservatively but are being revised downwards. That still leaves the comparison of overall expectations being high relative to experience. In this section we ask, is that the case for all perils? We have yet to drill down to the perils themselves. The Sensitivity case in the previous section only applies to US or North American Wind and Storm. Perhaps allowing for a closer peril breakdown will expose better where the model problems are, if indeed there are any. Consider Figure 2. It shows the breakdown of the EL into its component perils – here grouped as four categories - NA Wind, NA Quake, European and Asian Wind and Quake, and Other.

**Figure 2**



North American Wind and Storm includes Hurricanes and Severe Convective Storms [SCS] in the US, Canada, and Mexico. Similarly, North American Earthquake includes US, Canadian and Mexican Earthquake. European and Asian Wind and Quake is self-explanatory. “Other” includes Australian Wind and Quake, World Bank covered risks in the

Philippines, Chile, and Peru together with Inland Flood and Wildfire risks in the US and Japan. In the early days of the ILS market the division of Wind and Quake in to three regions, US, Europe, and Japan and Other, was relatively simple, but as more risks and regions have been included, the classification has been more difficult and debatable. Here we have consolidated into four groups, the most controversial of which is “Other”. Arguably Inland Flood and Wildfire could be part of North American Wind and Storm. Ditto Japan Inland Flood in Asia. We have kept them separate as they are relatively new, and their modeling is still evolving.

The relative share of the component perils shows that the NA Wind share of EL has grown over time. It shows the relative dominance of US Wind in the components of EL. Two additional notes should be recorded. First, the share of EL is not the same as the share of Limit or Principal since the principal sizes can overlap. In multi-peril bonds the principal can be exhausted by any one peril or by peril combinations. A second note is the data for 2023 is incomplete at the time of writing. This distorts the optics of the final year’s market share somewhat. However, since we look to use the weighted average share over time it will not have such a big impact in our numeric calculations.

The average shares of EL have been lifted from the bottom of Table 4. Thus, in the Standard case the EL shares are 60.2%, 18.9%, 11.7% and 9.2% for the four categories. And, in the Sensitivity case the shares are 63.7%, 17.2%, 10.6% and 8.5%.

In Table 5 we apply these to our aggregate or Total ELs to estimate how much loss was expected from each peril. In the Standard case where the total EL was \$7,707 Mn this would imply that we would expect \$4,640 Mn of loss to emanate from NA Wind, \$1,457 Mn from NA Quake, \$902 Mn from European and Asian Wind and Quake, and \$708 Mn from Other Perils.

**Table 5**

		Appportioning Estimated and Actual Losses by Peril or Geography			
		NA Wind and Storm	NA Quake	EURO + Jap (Wind and	Other
Standard	% of EL	60.2%	18.9%	11.7%	9.2%
EL (\$Loss)	\$7,707	\$4,640	\$1,457	\$902	\$708
Sensitivity	% of EL	63.7%	17.2%	10.6%	8.5%
EL (\$Loss)	\$8,346	\$5,319	\$1,433	\$888	\$707
Realized	% of Actual	80.3%	3.0%	11.1%	5.6%
# of Actual Losses	70	61	1	3	5
Actual Loss	\$4,958	\$3,981	\$150	\$551	\$278
Over estimate					
Standard	55%	17%	871%	64%	155%
Sensitivity	68%	34%	855%	61%	154%

The second set of rows similarly breaks down the Sensitivity case EL of \$8,346 Mn into its components. The third set of rows in Table 5 refers to actual loss as captured in Table 2A and 2B. Recall that the Total loss was \$4,958 Mn including estimates of known and closed as well as those still in various stages of development. In the left column of Tables 2A and 2B is a note on the triggering event causing the loss. We use that to allocate loss to each of the four component categories. Some are easily categorized, e.g., the Katrina loss to NA Wind and the Chiapas earthquake is clearly NA Quake.

Other deals are aggregate loss rather the occurrence loss. Thus, some deals in the list show multiple causes of loss, e.g., Hurricane IAN, US Convective Storm, and Turkey Earthquake. Rather than make a stab at what part of the loss was caused by which peril – which we do not know – we assume that the one first triggering the loss is the dominant amount of the loss. It is a crude rule but usable.

That being understood, the allocation of actual loss is as follows, 80.3% of all listed losses in Table 2A and 2B are US Wind losses. Sixty-one are listed. Thus, of the \$4,958 Mn of total actual loss, \$3,981Mn is attributable to NA Wind. The other three categories are respectively \$150 Mn, \$551 Mn, and \$278 Mn.

The last couple of lines relate these to their respective expectations in each category. The closest is NA Wind risk just 17% away from Standard case expectations. The furthest away from expectations is NA Quake. We would have expected 8 times as much earthquake loss as was realized, approximately one and a half times as much loss from our “Other” category, and 50%



more from our European and Asian Wind and Quake component. If investors got lucky, then it is in the non-wind areas. Conversely, one could argue that if the models are too conservative, it is in those areas that conservatism exists.

One should concede, however, that either of these conclusions depends on whether our assumptions are correct, both in allocating the expectations to peril components and in allocating our actual risks to those same categories. Notwithstanding, in the next Section we push those assumptions even further by looking at where ILS profits come from.

## Section VI - Where Excess ILS Profits Come From

**Table 6**

<b>Comparative ILS Performance - by PERIL/REGION</b>				<b>NA Wind</b>	<b>NA Quake</b>	<b>EU+JPN</b>	<b>Other</b>
Sensitivity Case	Years	<b>23</b>	EL%(wsst)	63.7%	17.2%	10.6%	8.5%
	Period	2001-2023					
<b>Coverage</b>							
	Years of ILS Coverage (wsst)	2,648		1,688	455	282	224
	\$s of Coverage (\$Mn) (wsst)	\$375,351		\$239,208	\$64,443	\$39,922	\$31,779
<b>Losses</b>							
	Expected % Loss on All Issues (wsstEL)	2.22%		1.41%	0.38%	0.24%	0.19%
	Expected \$ amount of ILS Loss (\$Mn)	\$8,346		\$5,319	\$1,433	\$888	\$707
	Actual \$ amount of ILS Loss (\$Mn)	\$4,958		\$3,981	\$150	\$551	\$278
<b>Revenue (Gross)</b>							
	Loss-Free Income (% on Coverage)	6.76%		4.31%	1.16%	0.72%	0.57%
	Total Loss-Free Income (\$Mn)	\$25,374		\$16,170	\$4,356	\$2,699	\$2,148
<b>Profit or Net Income</b>							
	Expected Annual Rate of Profit	4.54%	% Per Unit	4.54%	4.54%	4.54%	4.54%
	Actual Annual Rate of Profit	5.44%	% Per Unit	5.10%	6.53%	5.38%	5.89%
	Annual Benefit of Actual over Expected		% Per Unit	0.56%	1.99%	0.84%	1.35%
	Contribution to Portfolio	0.90%	% of Portfolio	0.36%	0.34%	0.09%	0.11%

Table 6 lays out the calculation when looking at profits in total and the various lines of business or perils. It lays out the same numbers as we have already remarked upon in the first column of numbers and identifies them under the titles of Coverage, Losses, Revenue and Profit or Net Income. Thus, applying the Sensitivity case peril breakdown to the coverage line shows \$239,208 Mn is NA Wind coverage, \$64,443 Mn is NA Quake, \$39,922 Mn is Europe and Asia, and \$31,779 Mn is Other. Since we are mixing single peril and multi-peril bonds in the analysis, one might wish for more precise ways of dividing up the totals. However, for ELs that division is probably less problematic than it might be for the Pricing or Frequencies.

In the Revenue section we apportion the price proportionate to the relative EL shares. Thus, the weighted average premium of 6.76% implies a total loss-free revenue of \$25,374 Mn divided into \$16,170 Mn, \$4,356 Mn, \$2,699 Mn, and \$2,148 Mn to each of the four categories.

Apportioning revenue by EL is a common enough practice but one would like something a little more sophisticated – proportioned by Tail-risk perhaps. Be that as it may, we proceed with the results of our cruder analysis.

The bottom line shows that in total we would have expected revenues of 6.76 % and ELs of 2.22%. The whole market could have expected a net annual profit margin or return of 4.54% (=6.76%-2.22%). In fact, since realizations were less than expected, the net annual profit margin, or return, was 5.44%. This means that on average the Nat Cat ILS provided an extra 90 bps annually (=5.44%-4.56%) over expectations.

Reported ILS hedge fund returns over time, whether reported from actual ILS hedge fund performance or from the various Cat Bond indices shows average annual returns in the mid to high 5%'s. So, our 5.44% is consistent with those numbers.

It is when we break that return into its components that we see something different. In the incremental profit margins experienced, the incremental margin is 56bps for NA Wind. Then it is 199bps for NA Quake, 84bps for European and Asian Wind and Quake and 135bps for Other. Clearly NA Wind is more tightly priced, although, it must be stated again, that is if our allocation of price or revenue is correctly made.

Of course, the market writes much less Earthquake and Other amounts of business than it does of NA Wind. When the contribution of each peril is considered, the contribution to overall profits to the incremental 90bps of profit on the whole portfolio works out as follows. NA Wind 36bps, NA Quake 34bps, 9bps European and Asian Wind and Quake, and 11bps from Other. Viewed from a portfolio perspective then, the non-NA Wind sectors are important for a diversifying effect, but only NA Quake stands out from a portfolio contribution effect. Perhaps the conservatism that appears to be in the models is mostly centered around NA Quake. The models are expecting more Quakes than we have experienced.

**Section VII - Why Was 2023 Such a Profitable Year for Nat Cat ILS**

At the end of 2022 estimates of actual losses from Nat Cat ILS for the preceding 22 years was \$ 5,308 Mn. In this 2023 annual update, losses are documented as \$4,958 Mn. This is a net drop in Actual losses of \$350 Mn. Since we can't have negative loss, this can only arise when the market revises its opinion of estimated losses – communicated through it M-T-M estimates of loss – secondary market price quotations. Closer inspection shows that Mr Market's change of mind revolves mostly around Hurricane IAN. The inset table shows the story, at 9/30/ 2022, four days

IAN	# of Ian Impacted ILS	Implied IAN ILS Loss
9/30/2022	24	\$1,857
12/30/2022	20	\$1,021
12/30/2023	15	\$581

after IAN hit, using our \$80 cut off point 24 deals were identified as likely to experience real loss, implying an estimate of \$1,857 Mn loss, a large sum. Ninety days later at year end that number dropped to 20 such deals. Much of the reasoning involved the absence of serious Flood damage from IAN. That caused estimated IAN losses to drop to \$1,021 Mn. Then, during the course of 2023, further revisions of the IAN loss took place so that at year end the implied loss was \$581 Mn. The year-end-to-year-end IAN loss dropped by \$440 Mn. On an outstanding ILS base of approximately \$40,000 Mn<sup>9</sup> this, in itself, added approximately 100bps to any calculation of return.

Add to this the revision of the pricing multiple from an average 4.5 on Jan. 1, 2023 down to 3.5, for a 2% EL ILS, means that approximately 200bps were added to returns from non-impaired ILS due to the Multiple reverting to the mean.

We can add to these two other simplified measures of return. The average issued rate, from Table 1 during 2023 was 8.59%. The floating rate for ILS, as a result of Federal Reserve tightening, of approximately 5% and the ingredients for high returns are all in place.

Floating Rate	5.00%
Average Premium	8.59%
Revision of IAN	1.00%
Compression of Multiple	<u>2.00%</u>
Implies a total of	16.59%.

Results will vary from one hedge fund to another, each of whom pursues slightly different strategies, so the above gives a false sense of precision, but we can easily see that high to mid double digit returns in 2023 should have accrued to most funds.

## Conclusions and Comments

This is the third paper in the last few years where we have tried to gage the consistency of market actions in the real world with the theoretical world of statistical expectations of outcomes for the Nat Cat ILS market. Traditional Nat Cat reinsurers - Swiss Re, Munich Re, et. al., and traditional Nat Cat brokers Aon, Guy Carpenter, et.al., put out annual reports about the state of their respective markets, but few subject their data to public scrutiny and the analytic, possibly academic, depth we think the subject deserves. And the ILS market presents a unique opportunity for such rigor – provided data is made available.

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<sup>9</sup> This would include other non-Nat Cat ILS outstanding during the year which most ILS hedge funds would be invested in to some degree.

In this third paper<sup>10</sup> we have taken a slightly different analytic attack to answer some pressing questions. The prior approach was to look at cumulative issuance of ILS by identifying key ILS parameters as the annual weighted average of each year's issuance. This collapses issuance into each year's representative issue. That way the effect of expected loss can be traced intertemporally. This time we have taken the further step of collapsing the cumulative issuance to a single issue representing the whole market, which if issued 978 times would duplicate the expectations of the market. Some precision is lost intertemporally, but the benefit is that it allows quicker answers.

Among those answers we have shown that the ILS market has retreated somewhat on its measurement of the effect of warm sea surface temperatures in the North Atlantic. It has also been shown that actual market losses continue to lag expectations of loss. This reinforces the notion that model expectations are too conservative rather than too optimistic. Optimistic or wrong, being the cry that is heard whenever one year's losses exceed that year's expectations.

Indeed, in terms of the long-term performance of the ILS market, it is an average annual 90bps better than might have been expected given pricing and expectations at the issue of each bond. Most of that quantitatively comes from underwriting NA Wind risk but on a per unit of risk basis an almost equal amount comes from NA Quake risk, given its experience. Other risk categories underwritten provide diversification benefits but make smaller contributions to the extra 90bps of average annual profit. Their pricing is tight.

Finally, while actual losses in a single year may have dropped from one year to another, 2023 is the first year we can recall where actual cumulative losses dropped from the previous year's cumulative total. That drop, and its effects through the secondary market of market hardening at the start of the year, followed by multiple compression during the year, accounts for the very high total returns experienced in 2023.

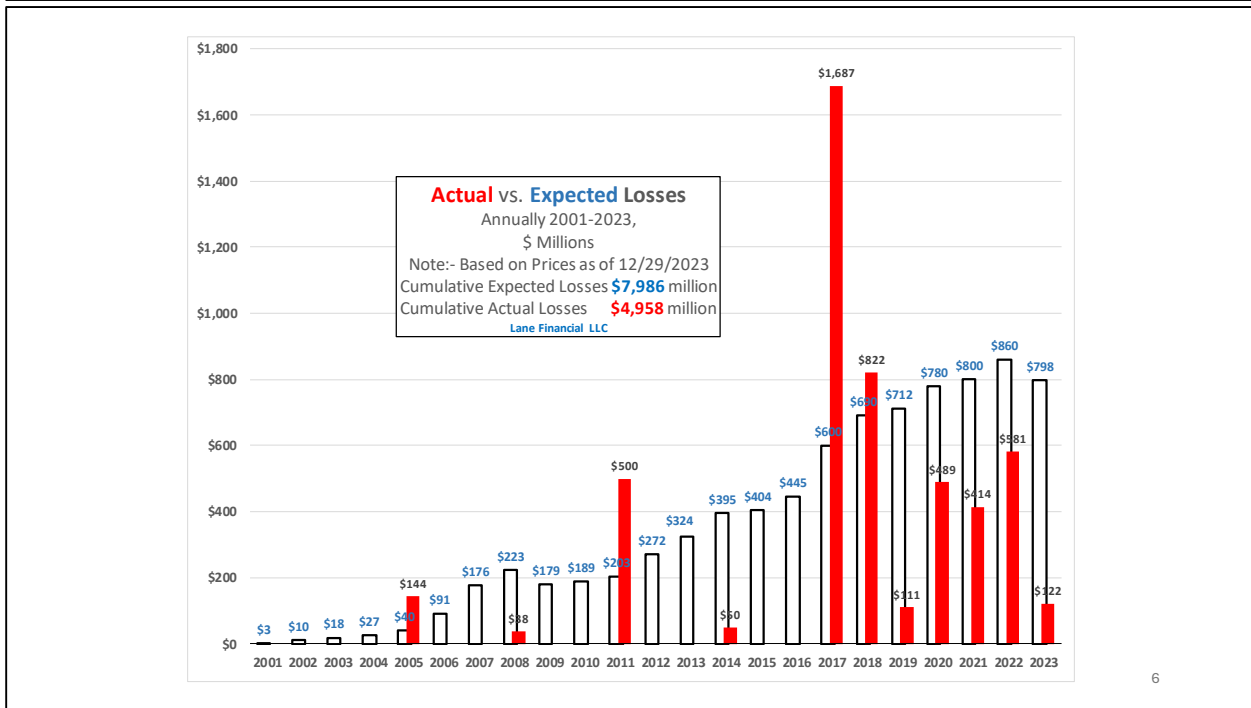
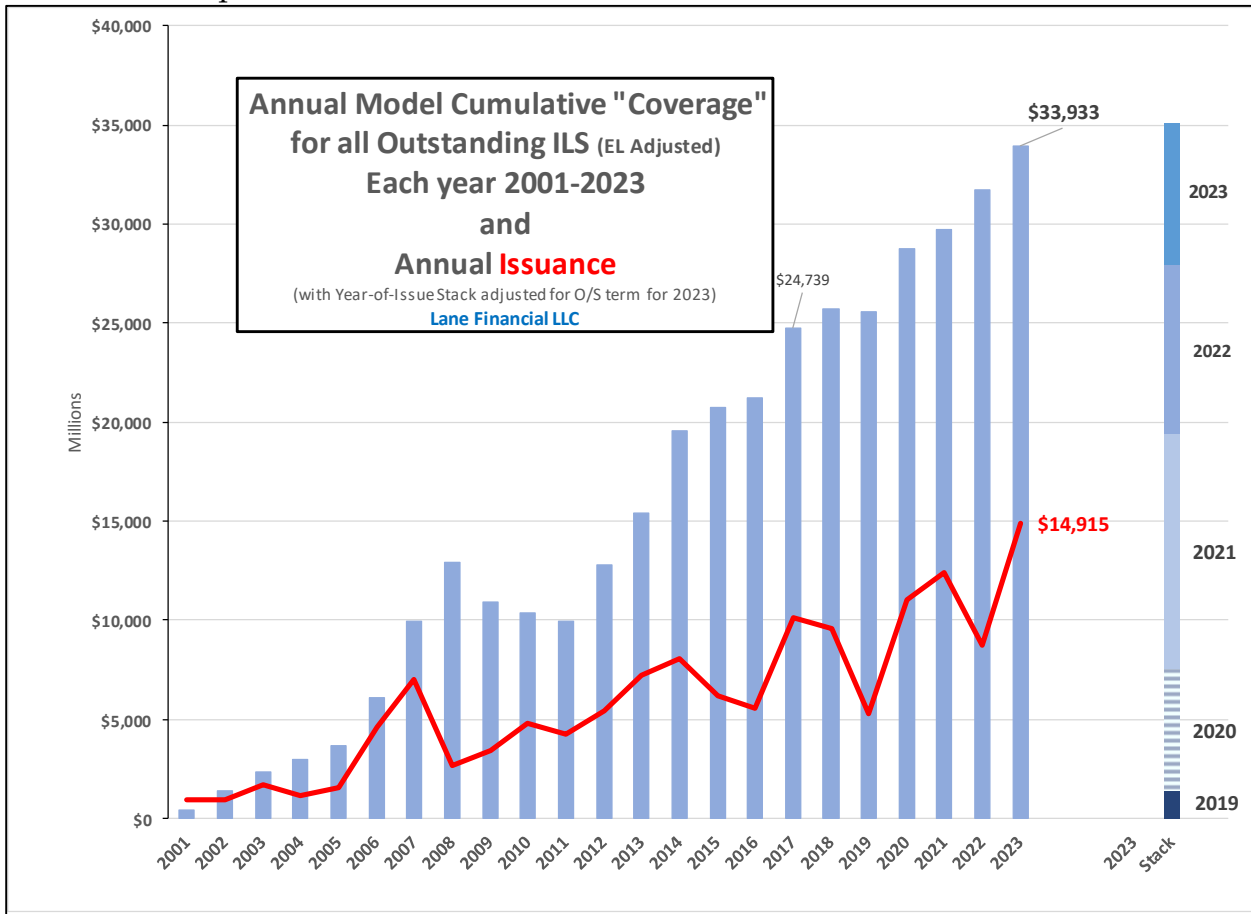
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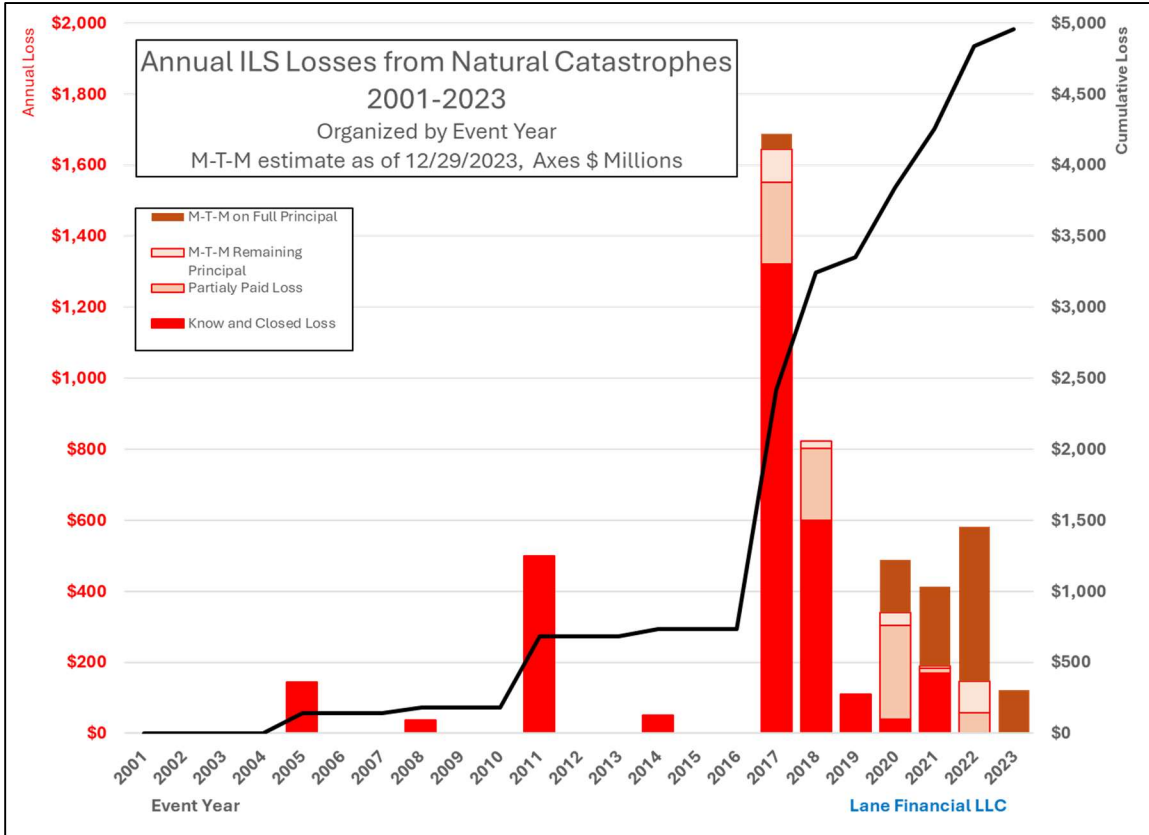
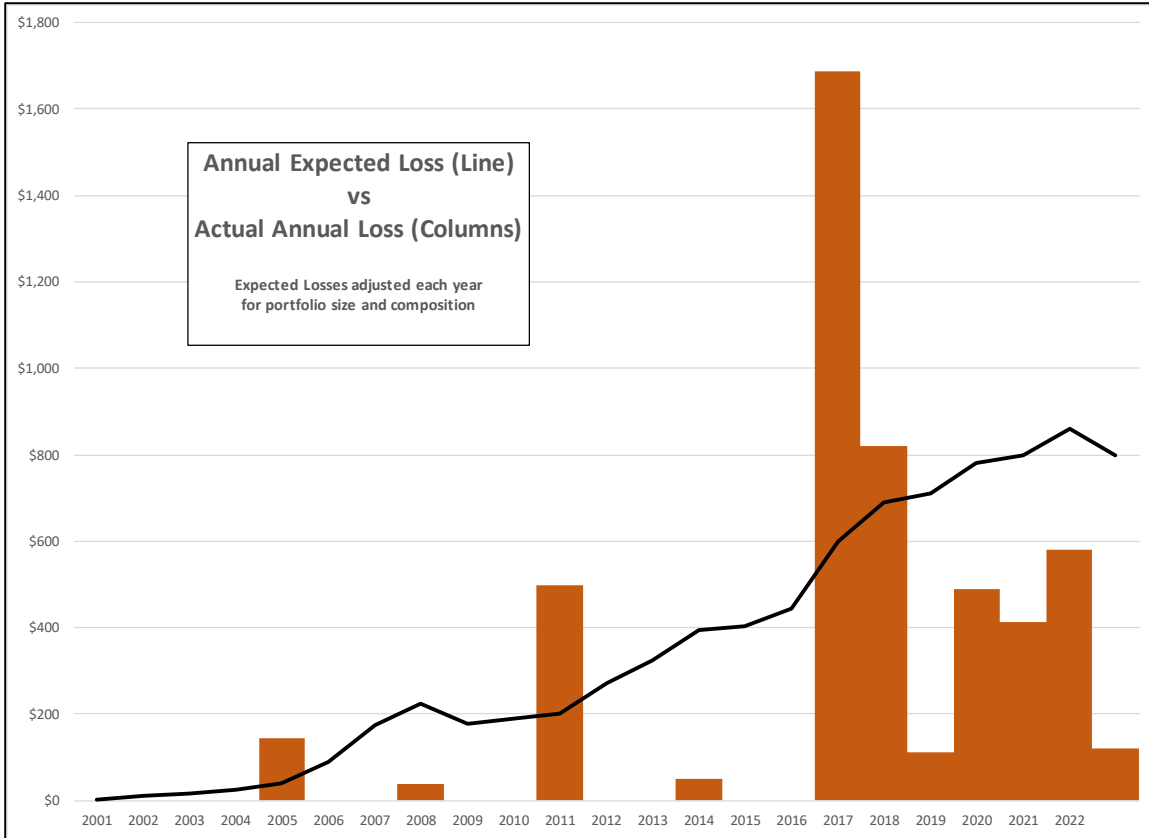
<sup>10</sup> In this and previous papers we are grateful for data provided by Verisk [formerly AIR Worldwide]. Any mistakes in analysis of the data provided is solely the responsibility of Lane Financial LLC. We are also grateful for market data provide by Aon Capital Markets and at times also by the Capital market divisions of Guy Carpenter, Swiss Re and Goldman Sachs.

APPENDIX – Additional Graphics.  
(Being updates of Graphics used in previous Papers)

- Page 21. Cumulative Outstandings, net of Expected Losses, over time.  
Expected Loss over Time (Standard Case).  
(Note slight differences in Amounts when timing of deals is included.)
- Page 22. Annual Evolution of Losses over time vs Annual Expectations over time.  
Annual Actual Losses over time broken down by status of Loss – Known, Partial or M-T-M.
- Page 23. A schematic of implicit model used for intertemporal calculations.
- Page 24. A Table of SIGMA Global losses vs. the fraction of those losses picked up by ILS.  
A Graph of ILS vs SIGMA Global losses (\$Millions vs. \$Billions)
- Page 25. Average Excess Returns over Expected over Three different horizons.
- Page 26. Realized vs Expected Severity of Loss

## Additional Graphics







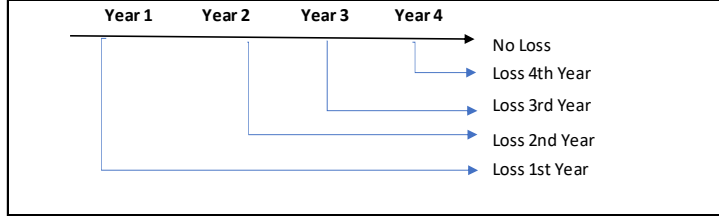
**978 ILS ISSUES WITH TYPICAL CHARACTERISTICS and SIMPLISTIC LOSS PROCESS**

Loss Process - S Single Loss: any one year: magnitude CEL% (approx 75%) of Limit: Reve

Term 4 years

Amount (\$ Mn) **\$141**

INPUTS  
 Spread **6.76%**  
 EL **2.22%**  
 PFL **2.94%**  
 IMPLIES  
 CEL **75.5%**



Loss	Prob
No Loss	0.00%
Loss 4th Year	75.5%
Loss 3rd Year	75.5%
Loss 2nd Year	75.5%
Loss 1st Year	75.5%

	Year 0	End year 1	End year 2	End year 3	End year 4	# of ILS experiencing a loss	
# Unimpaired ILS	978	949.2	921.3	894.3	868.0	Total	E Lifetime PFL
# Impaired ILS		28.8	27.9	27.1	26.3	110.0	11.25%
Avg Loss of Limit		75.5%	75.5%	75.5%	75.5%	Total Loss	Lifetime EL
\$ Expected Loss		\$3,057	\$2,968	\$2,880	\$2,796	\$11,701	8.50%
<b>EL</b> i.e., Loss as a % of Limit		2.22%	2.22%	2.22%	2.22%		
Limit after loss Mn	\$137,722	\$134,665	\$131,697	\$128,817	\$126,021		
Limit as Fraction of start		0.9778	0.9563	0.9353	0.9150		
EL as fraction of Initial		2.22%	2.15%	2.09%	2.03%		
Revenue		\$9,103	\$8,903	\$8,708	\$8,519	Avg Ann Revenue	E Lifetime Rev
						\$8,808	\$35,233

# How big (important?) is the ILS market?

There is a point of view that the ILS, or at least the alternative, market (which would include ILWs and Collateralized Re transactions) is about 10%-20% of the whole traditional Nat Cat Reinsurance market. This viewpoint arises because at year end major players in the market

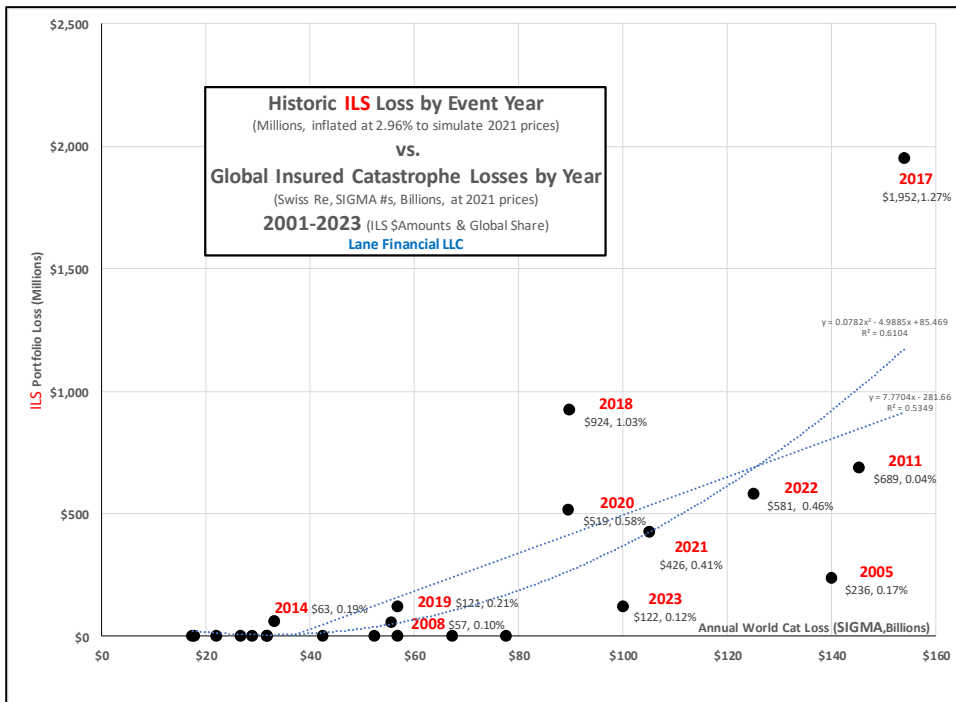
ILS LOSSES RELATIVE TO SIGMA GLOBAL INSURED LOSSES	SIGMA \$Bn	SIGMA \$Bn	SIGMA Implied	ILS \$Mn	ILS % of SIGMA	ILS inflated	ILS % of SIGMA
	Original Report	2021 Prices	Inflation or Development	Original Loss	Original ILS Loss	Inflated at 2.96%	Inflated # of SIGMA #s
	2001	\$10.0	\$17.4	2.80%			
2002	\$11.4	\$21.9	3.48%				
2003	\$16.2	\$26.7	2.81%				
2004	\$46.7	\$67.2	2.16%				
2005	\$78.3	\$140.0	3.70%	\$144	0.18%	\$236	0.17%
2006	\$11.8	\$17.7	2.73%				
2007	\$23.3	\$31.6	2.21%				
2008	\$44.7	\$55.6	1.70%	\$38	0.09%	\$57	0.10%
2009	\$22.4	\$28.8	2.12%				
2010	\$39.9	\$56.7	3.25%				
2011	\$110.0	\$145.2	2.81%	\$500	0.45%	\$689	0.47%
2012	\$71.3	\$77.6	0.95%				
2013	\$37.0	\$42.5	1.72%				
2014	\$27.7	\$33.1	2.56%	\$50	0.18%	\$63	0.19%
2015	\$25.0	\$31.7	4.04%				
2016	\$45.9	\$52.3	2.64%				
2017	\$133.0	\$154.0	3.74%	\$1,687	1.27%	\$1,952	1.27%
2018	\$76.0	\$89.7	5.70%	\$822	1.08%	\$924	1.03%
2019	\$53.0	\$56.7	3.42%	\$111	0.21%	\$121	0.21%
2020	\$81.0	\$89.5	10.54%	\$489	0.60%	\$519	0.58%
2021	\$111.0	\$105.0	0.00%	\$414	0.37%	\$426	0.41%
2022	\$125.0	\$125.0	0.00%	\$581	0.46%	\$581	0.46%
2023	\$100.0	\$100.0	0.00%	\$122	0.12%	\$122	0.12%
23 Year Totals & %Aves	\$1,301	\$1,566	2.83%	\$4,958	0.22%	\$5,690	0.22%
Wghtd Avg			0.38%				0.36%

2022, 2023 Preliminary Reports and /or Swiss Re Explorer  
Italics indicate a graphic source

Lane Financial LLC

produce numbers showing the capital deployed in the traditional market and the alternative market. There is roughly \$500 Bn of traditional market capital and \$100 Bn of alternative capital, although different players will present quite different numbers. Often displayed on a graph where the two are added together it gives a distorted view of the size of the alternative markets.

Traditional capital is leveraged capital, alternative capital is not. Their relative sizes can be better compared by the work they do. How much loss each market picks up is perhaps a better measure of their relative size. We therefore produce updated versions of one table and one graph showing ILS market size in this context.



Please Note that in this graphic, \$ Billions of losses are compared on the horizontal Global SIGMA axis with \$ Millions of losses on the vertical axis for the ILS market.

# Average returns from the ILS market over different horizons

One final cross check of model to reality is to check what returns ILS investors could have expected and what they got over different horizons – The past 23 years, the past 10 years, and the Past 5 years. Clearly, the 2023 results have pushed up the past 5 years numbers.

<b>Comparative ILS Performance - over time and against experience</b>				
	<b>Years</b>	<b>23</b>	<b>10</b>	<b>5</b>
	<b>Period</b>	<b>2001-2023</b>	<b>2014-2023</b>	<b>2019-2023</b>
<b>Coverage</b>				
	Years of ILS Coverage	2,699	1,656	995
	\$s of Coverage (\$Mn)	\$360,986	\$261,689	\$149,654
<b>Frequency of Loss</b>				
	Expected # of ILS with a Loss (wsst PFL)	77	55	35
	Actual Number of ILS with Loss	70	65	33
<b>Losses</b>				
	Expected % Loss on All Issues (wsstEL)	2.15%	2.32%	2.46%
	Expected \$ amount of ILS Loss (\$Mn)	\$7,762	\$6,080	\$3,681
	Actual \$ amount of ILS Loss (\$Mn)	\$4,958	\$4,276	\$1,717
<b>Revenue (Gross)</b>				
	Total Loss-Free Income (\$Mn)	\$24,763	\$17,139.6	\$10,397.5
	Loss-Free Income (% on Coverage)	6.86%	6.55%	6.95%
<b>Profit or Net Income</b>				
	Expected Annual Rate of Profit	4.71%	4.23%	4.49%
	Actual annual Rate of Profit	5.49%	4.92%	5.80%
	Annual Benefit of Actual over Expected	0.78%	0.69%	1.31%

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(Calculations are done over time and as a result differ slightly from this year’s methods.)

