# 55 YEARS OF COMETS (1970 – 2024)

## PART I OBSERVATIONAL AND STATISTICAL ANALYSIS

## **INTRODUCTION**

On Monday evening, February 2, 1970, when I was 11 years old and living on the southern outskirts of Alamogordo, New Mexico, I used information from the latest issue of the magazine Sky & Telescope to locate and observe my first comet, Comet Tago-Sato-Kosaka 1969g, which had been independently discovered by three Japanese amateur astronomers in October 1969 and which in January 1970 had become the first comet ever observed from space. On that fateful night, the comet appeared as a diffuse 5<sup>th</sup>-magnitude object near the bright star Hamal (Alpha Arietis), easily visible in 7x35 binoculars and dimly visible to the naked eye. In the 4.5-inch telescope that I had acquired a little over two weeks earlier. I could see a distinct central condensation within the diffuse coma. My best friend, Mark Bakke, had come over to my house (bringing his own 60-mm refractor), and we both enjoyed our first cometary observation; meanwhile, we showed the comet to the other members of my family, including my father and mother, my paternal grandmother, and my older brother Barry.

I would end up observing Comet Tago-Sato-Kosaka every night for the next week, noting on one night towards the end of that time that it appeared to be brighter and easier to see than it had been on that first night. I would later learn that the comet had undergone a brief upsurge in brightness near the time of this observation. A little over a month and a half later, I was thrilled to see a very bright comet, Comet Bennett 1969i, in the morning sky. Initially as bright as magnitude 0 and with a bright dust tail 10 degrees long or longer, it was a lovely sight in the pre-dawn eastern sky, and I followed it for the next month and a half as it faded. The morning after my first sighting, I made my first attempt at photographing a comet, with a handheld Brownie camera from the front doorstep of our house; although the results could hardly be considered "good" photographs, the comet was nevertheless "there."

From that point on, I was "hooked," and have attempted to observe just about every comet that has been within my capability to see, given the telescopes and information I had available at the respective times. (I have subsequently learned, of course, that the fortuitous circumstance of two consecutive bright comets, one of these being one of the 20<sup>th</sup> Century's "Great" comets, in such short order is definitely not the norm.) In addition to larger and better telescopes, and more and quicker access to information regarding comets (and other celestial phenomena) – and the advances in communications technology that have gone hand-inhand with this increase in information access – my personal life that underlies my comet observation activities has undergone a number of changes, twists and turns. These include graduation from high school (1976); attendance at and graduation (1980) from the U.S. Naval Academy; time in Naval service in southern California during the early 1980s; working at the Jet Propulsion Laboratory, including participating in various space missions, during the mid-1980s; attending graduate school at New Mexico State University and earning a Ph.D. (1992); initial employment at the New Mexico Museum of Space History and the later founding of my own research and educational organization in the early- to mid-1990s, and, since 1995, residing in the Sacramento Mountains east of Cloudcroft, New Mexico. They also include my first marriage (1985); the birth and raising of two sons; divorce (2010); a deep relationship in the early 2010s that, unfortunately, ended badly; a new relationship that began in 2017 and which has now resulted in a second marriage (2024); and (as of now) three grandchildren. Of the five

people who shared that first comet observation with me, only one (my brother Barry) is still alive; my grandmother passed away in 1973, my father in 2002, and my mother in 2013, while Mark was tragically killed in a firearms accident in 1984.

In at least some respects, the pinnacle of all this came with my discovery of Comet Hale-Bopp C/1995 O1 in July 1995 (just four months after my family and I had relocated to our mountain residence east of Cloudcroft). A year and a half later that object became the final "Great Comet" of the 20<sup>th</sup> Century and an icon in pop culture, both of which have contributed to its being the most widely-viewed comet in history. The fame and recognition (and, for a while, financial success) that comet brought me made it possible for me to have a reasonably successful, if unusual, career, which has included involvement in the commercial space industry, the leading of "science diplomacy" expeditions to Iran and elsewhere, eight years of teaching on-line University classes, and various types of scientific research involving comets and near-Earth asteroids.

Throughout all of this, I have continued to make visual observations of whatever comets were within my range of capability on a regular and systematic basis. However, various health issues that have come with advancing age, including a week-long period of hospitalization in mid-2018 which has required me to be on oxygen therapy ever since, have made this activity more and more physically challenging. Then, in September 2024 I suffered a bacterial lung infection and collapsed lung that forced me to spend three weeks hospitalized (including two weeks in Intensive Care), followed by over a week at a physical rehab facility. While I have since recovered from this, the entire episode, combined with all the other various physical challenges I have been dealing with, has convinced me that the time has come to bring this activity of systematic visual comet observing to a close. Accordingly, as of the end of 2024 I have "retired" from this lifelong endeavor. As of that time I had visually observed 760 comets (533 of these being "separate" comets with the remainder being additional returns of periodic comets within

that group of 533), and had made a total of 8147 visual observations of these comets.

At this time it feels appropriate to perform a detailed statistical analysis of all these observations of all these comets. There may not be any formal scientific significance to this, and of course there are numerous selection effects involved (such as my increasing capabilities as an observer over time as well as the increasing rate of comet discoveries over that same interval). But, it is important and interesting to me, so, for whatever it is worth, here goes . . .

I should note that, despite my "retirement," I have not walked away from visual observing entirely. For at least the near- to intermediate-term future, I expect to attempt observations of bright and/or interesting comets that might come along, although this will only be on an occasional, as opposed to a systematic, basis.

In that vein, one of the brightest and most interesting comets of recent years, Comet ATLAS C/2024 G3, passed through perihelion just two weeks after my "retirement," and although it was primarily an object for the southern hemisphere, I nevertheless succeeded in obtaining a couple of observations of it. I am accordingly including it within this analysis. I have also obtained one "post-retirement" observation of Comet 29P/Schwassmann-Wachmann 1, which I am also including within this analysis. With these inclusions, my lifetime comet tally is 761, which includes 534 separate comets, and a grand total of 8150 visual observations.

## **DESIGNATIONS AND NOMENCLATURE**

Prior to 1995 the IAU designated comets via a dual scheme: a discovery designation which included the year of discovery and a lower-case letter indicating the order of discovery (or recovery, for periodic comets) within that year, and a perihelion designation (usually assigned one to two years later) which included the year of perihelion passage and a

Roman numeral indicating the sequential order of perihelion passage within that year. (For example, my first comet, Tago-Sato-Kosaka, has a discovery designation of 1969g, denoting the 7th comet to be discovered in 1969, and a perihelion designation of 1969 IX, denoting the 9<sup>th</sup> comet known to have passed perihelion in 1969.) Beginning in 1995 the IAU switched to a single scheme: the year of discovery, followed by an uppercase letter signifying the half-month of a comet's discovery and a number indicating the sequential order of discovery within that halfmonth, for example, Comet Hale-Bopp's designation is C/1995 O1, denoting the first comet discovered during the second half of July 1995 (hence the letter "O"), with the "C" denoting a long-period comet (i.e., an orbital period in excess of 30 years. (An object originally designated as an asteroid, the scheme for which had long followed something similar except that the sequential number was instead another uppercase letter indicating the order of discovery, and numerical subscripts when necessary, would retain this designation if later found to be cometary.) When the IAU implemented this scheme it retroactively assigned the new scheme designations to pre-1995 comet discoveries, however for my purposes (in overall record-keeping and in this analysis) I am retaining the pre-1995 discovery designations for these comets. These were the designations the comets had been assigned at the times I was observing them, and accordingly are the ones I "know" them by.

"Routine" recoveries of periodic comets, which had been assigned letters in the old scheme, are no longer assigned designations in the new scheme. Instead, periodic comets have been assigned periodic numbers (in the style of "xxxP/<name>") in sequential order after a second return has been identified, either via recovery at a subsequent return or "prediscovery" observations at an earlier return. For my purposes here, for routine periodic comets recovered during and after 1995, as well as for "annual" periodic comets which did not receive designations in the old scheme, I identify them by designations of the form "xxxP-yy" where "yy" are the last two digits of the year of perihelion passage. The first two digits of the year in question can be assumed to be "19" if "yy" is "69" to "99" and "20" if "yy" is "00" to "24" (for now, anyway). For example, the return of Comet 6P/d'Arrest I observed in 1995 would be designated as "6P-95" and the return of this comet I observed in 2008 would be "6P-08."

With the implementation of the new scheme, the usage of numerals attached to multiple periodic comets discovered by the same discoverer was formally discontinued. For my purposes, I have opted to keep those numerals for the comets that had formally received them prior to that time.

In the various lists I will give for individual comets a "comet no." This is the comet's number on my lifetime tally, added sequentially from my first one (no. 1) to my most recent one (no. 761). It has happened on a handful of occasions that an object I observed as an "asteroid" is later found to exhibit (or to have exhibited in the past) cometary activity, and I have accordingly added it to my tally retroactively. Rather than insert it into my tally at the time I observed it (which would accordingly affect the tally numbers for all subsequent comets), I have added such objects to my tally after the tally number for the most recently added comet at that time. (For example, if my tally at the time I made the retroactive addition was 460, the retroactively added comet would be no. 461.)

## WHAT ARE AND WHAT ARE NOT "COMETS"

The comets on my tally are comets that I have observed visually, i.e., with my naked eye, through binoculars, and/or through the eyepiece of one or more telescopes. Between 2000 and 2011 (most heavily concentrated during the first few years of that time interval) I imaged several comets with the CCD system I had operational at the time, but I do not include these comets unless I also observed them visually. Similarly, since 2017 I have imaged numerous comets remotely with CCDs attached to various telescopes of the Las Cumbres Observatory network, but, again, I do not include these comets unless I also observed them visually.

After an interval of 55 years there are obviously numerous periodic comets that I have observed on multiple returns. When I observed Comet 2P/Encke on my 2<sup>nd</sup> return in 1974 I established the precedent of counting additional returns of periodic comets as "new" comets on my tally, and have maintained that precedent ever since. (Depending upon when a comet passes through perihelion during the course of a year, the viewing circumstances can vary widely, and sometimes – perhaps as a result of orbital changes due to planetary perturbations – a comet may behave differently from one return to another, and thus in some ways acts as a "different" comet each time it returns.) As mentioned above, my current comet tally of 761 includes 534 separate comets, with the remaining 227 comets being additional returns of periodic comets contained within that total of 534.

The unusual Comet 29P/Schwassmann-Wachmann 1, which travels in a near-circular orbit between Jupiter and Saturn and which undergoes frequent and unpredictable outbursts, constitutes somewhat of a special case, since it is often visually detectable around aphelion. I have applied the same precedent to this comet that I have applied to other periodic comets, i.e., each "return" is counted as a "new" comet, with "return" in this case being defined as aphelion to aphelion. When I first observed this comet in early 1981 it was outbound from its perihelion passage in 1974, and all observations I made between that first one and the comet's aphelion in 1982 constitute its first "return." All observations I made between that aphelion, through its next perihelion passage in late 1989 and its next aphelion in early 1997, constitute its second "return," and so on. I am presently on my fourth "return" of this comet, with its having been at aphelion in late 2011 and at perihelion in early 2019; it is now outbound towards its next aphelion in late 2026.

It has become obvious over the past few decades that there is a nebulous dividing line between "comet" and "asteroid," with quite a few objects exhibiting characteristics of both of these. The IAU has assigned "dualdesignations" to some of these objects, i.e., both permanent asteroid numbers and short-period comet numbers, and I include any of these objects I observe as "comets" for purposes of my tally.

There are also quite a few "asteroids" that have exhibited cometary activity but that have not been designated as "comets" by the IAU; such objects are usually collectively described under the term "active asteroids." The activity in some of these objects does appear to be driven by sublimation of volatiles such as occurs in comets, but for other objects there are other mechanisms that appear to be responsible for the activity, for example, debris resulting from a collision with another object. At the same time, there have been some objects where the cometary activity appears to be due to one or more of these "other" mechanisms but where the IAU has nevertheless assigned periodic comet numbers to them.

Given all this, I have concluded that the most consistent course of action is to include any "active asteroid" as a "comet" for tally purposes, regardless of the mechanism that produced its cometary "activity," as long as the evidence for that activity is clear and convincing. I came to this conclusion after I had already observed some of the objects in question, and in some other instances the evidence for this activity came some time after I had observed the object in question; in these various cases I added the objects to my tally retroactively.

The following "asteroids" that I have observed have exhibited cometary activity and are accordingly included as "comets" on my tally, but have not been assigned cometary designations by the IAU:

(493) Griseldis: exhibited one outburst of cometary activity in 2015 which was very probably the result of a collision with another object. When I observed it during its 2019 "return" it was added to my tally "in sequence."

(596) Scheila: exhibited an outburst of cometary activity in late 2010 which detailed studies have indicated was almost certainly the result of

collision with another object. Scheila is bright enough such that it is visually detectable throughout its orbit, and I followed it on an occasional basis for several years after its outburst, during which time it passed through aphelion twice. Accordingly, following the precedent I have followed for Comet 29P, I have observed Scheila on three "returns" and thus it appears on my tally three times. (The first two "returns" were added retroactively, and the third "return" was added "in sequence.")

(3200) Phaethon: the apparent parent object of the Geminid meteor shower. While it has never appeared as anything other than stellar in observations made from the ground, it has on several occasions exhibited cometary activity such as a coma, tail, and non-asteroidal brightening in images taken with the STEREO spacecraft. The exact mechanism that produces this activity is still a matter of research – although it is clearly not due to sublimation of volatiles – and in some pieces of literature it has been described as a "rock comet." I have observed Phaethon on five separate returns. (The first three returns were added retroactively, and the latter two were added "in sequence.")

(3552) Don Quixote: an apparent "asteroid" in an orbit distinctly indicative of a short-period comet. The Spitzer Space Telescope (which is sensitive to infrared radiation) detected a coma and tail around this object during its 2009 return – the same return when I observed it – which appeared to be due to sublimation of volatiles. Weak cometary activity (coma and tail) was subsequently detected optically during its 2018 return. Don Quixote was added to my tally retroactively.

(65803) Didymos: the impact of the DART mission into Didymos' moon Dimorphos in 2022 produced a tail-like plume of debris that accompanied Didymos for the next few weeks. Didymos was added to my tally "in sequence."

(101955) Bennu: shortly after its arrival at Bennu in late 2018, the OSIRIS-REx mission detected numerous bursts of material off Bennu's surface over a period of several weeks. Ground-based studies, as well as

analysis by OSIRIS-REx itself, indicate that Bennu's surface contains hydrated clays, indicative of the presence of water which could, theoretically, be producing these bursts. I had observed Bennu during its discovery return and it was accordingly added to my tally retroactively.

A/2018 V3: images taken by the 3.6-meter Canada-France-Hawaii Telescope (CFHT) at Mauna Kea ten months after this object's perihelion passage show a distinct non-stellar appearance and a brightness profile indicative of very weak cometary activity. This object (which was discovered by PANSTARRS but which never received a formal name) was added to my tally retroactively.

There are some classes of objects that I do not consider as "comets" for tally purposes:

Two periodic comets have exhibited multiple components – that appeared as separate objects – on returns I have observed. In particular, I observed three additional components of Comet 73P/Schwassmann-Wachmann 3 during its return in 2006 (no. 385) and one additional component during its return in 2017 (no. 612), however I count this as only one comet during each of those returns. Similarly, I observed two additional components of Comet 141P/Machholz 2 during its discovery return in 1994 (no. 193) and one of these accompanying the main component during the subsequent return in 1999 (no. 273), however, again, I count this as only one comet during each of those returns.

Following the above discussion of "active asteroids," there are numerous objects that travel in cometary orbits but which have never exhibited cometary activity; these may very well be "extinct" or, perhaps, "dormant" comets. I have made attempts to observe several of these objects and have successfully done so for quite a few of them – three of them on two or more returns – but I do not include them as "comets" unless and until they exhibit some form of cometary activity (as indeed what happened with (3552) Don Quixote). One of these objects is one of

the recently-identified "dark comets," i.e., objects that exhibit distinct non-gravitational accelerations indicative of cometary activity but which (thus far) have not exhibited such activity itself. Should any of these objects exhibit cometary activity in the future (or be found to have done so in the past), I will add the object(s) in question to my tally retroactively.

There are also some asteroids, including some in the main asteroid belt, which some researchers have claimed have exhibited brightness behavior inconsistent with an asteroidal nature and which are thus possibly weakly active comets. I have observed some of these objects, including one on two "returns." Similarly, I have observed a non-asteroidal brightness behavior in the near-Earth asteroid (1566) Icarus, which has at some point also been considered as a possible weakly active comet. Should any of these objects – or, theoretically for that matter, any asteroid I have observed – be found to exhibit distinct cometary activity, I will add the object(s) in question to my tally retroactively.

There are a handful of objects that have exhibited what could be considered "cometary" activity but which I do not consider as "comets" for my tally:

Mercury: sodium atoms from its surface and (very thin) atmosphere are "blown" back by the solar wind to form a "tail" in the same manner that a comet's tail is formed. Images of Mercury taken with detectors sensitive to the light of sodium atoms show this "tail," which does in fact give it a cometary appearance.

Ceres: infrared data from the Herschel Space Telescope and in situ measurements taken by the Dawn spacecraft indicate the presence of water vapor emission around Ceres, likely caused by a sublimation process similar to what occurs in comets, probably due to some form of cryovolcanism. Pluto: a thin atmosphere was detected around Pluto as it approached perihelion in 1989 and was studied in detail by the New Horizons mission when it passed by that world in 2015. Pluto's presence within the Kuiper Belt is also somewhat suggestive of a possible cometary nature.

From a purely practical perspective, since I have observed Mercury and Ceres numerous times over the decades I have been active, the matter of how many "returns" I have observed would be a problematical issue. At least for Pluto that would not be a problem, since all my observations would be included within one "return."

## **POSSIBLE CONTINUING COMETS**

The current (2019 perihelion passage) "return" of Comet 29P/Schwassmann-Wachmann 1 (no. 498) is still ongoing at this writing, and the comet does not pass through aphelion under September 2026. It continues to undergo outbursts – indeed, it was subsiding from a pair of large outbursts when I obtained my "final" observation in late December 2024, and has in fact undergone two more outbursts in early 2025. To mark the 55<sup>th</sup> anniversary of my first comet observation, I observed this comet on the evening of February 2, 2025. I do not necessarily plan to attempt any further observations, but it is theoretically possible that it might undergo one or more additional large outbursts that might prompt me to observe it again.

The "Centaur" Comet 174P/Echeclus P/2000 EC98 (no. 384) underwent an outburst in late 2005, over nine years before perihelion passage (April 2015) when it was located at a heliocentric distance of slightly over 13 AU, and I successfully obtained a handful of observations in early 2006 before the outburst subsided. During the years since then it has undergone three additional outbursts, two of which I have successfully observed (the most recent of which was in late 2017). Echeclus does not pass through aphelion until November 2032 and it is theoretically possible it might undergo additional outbursts before then, although it is doubtful that I might attempt observations of any such event.

At this writing, Comets ATLAS C/2022 E2 (no. 750) and ATLAS C/2021 G2 (no. 756) are both still bright enough to be visually detectable with my 41-cm telescope, and Comet Tsuchinshan-ATLAS C/2023 A3 (no. 749) is now in the process of emerging into the morning sky after conjunction with the sun, however all of these comets are quite faint – no brighter than 13<sup>th</sup> or 14<sup>th</sup> magnitude – and I have no plans to attempt any observations of them, unless there are reports of large outbursts in which case it is possible I might make such attempts.

## PERIODIC COMETS/REPEAT COMETS

Of the 497 periodic comets that have been assigned periodic comet numbers as of this writing, I have successfully observed 154 of them (30.1%). There are a handful of periodic comets that I observed on their respective discovery returns that should be assigned periodic comet numbers when they are first recovered on a future return, and thus this number (and percentage) will change retroactively.

As I listed above, there are 6 numbered "active asteroids" I have observed that have not been designated as "comets" by the IAU but which I include as "comets" on my tally.

There are two "dual designated" comets that I have observed; both of these are Centaurs:

95P/Chiron = (2060) Chiron	1 return:	1996 (no.	196)
174P/Echeclus = (60558) Echeclus	1 return:	2015 (no.	384)

Of the 154 numbered periodic comets that I have observed, I have observed 88 of them (57.1%) on two or more returns, and 66 of them (42.9%) on just a single return. As listed above, of the 6 numbered "active asteroids" that I count as "comets," I have observed 2 of them on two or more returns and 4 of them on just a single return.

I have observed the following periodic comets on 5 or more returns:

Year of Perihelion Passage No.

2P/Encke (14 returns)

1971	4
1974	11
1980	39
1984	65
1990	145
1994	183
1997	231
2000	280
2003	343
2007	402
2013	531
2017	610
2020	683
2023	744

81P/Wild 2 (8 returns)

1978 (D)	26
1984	67
1990	146
1997	223
2003 (s)	332
2010	463
2016	590
2022	727

# 19P/Borrelly (7 returns)

1981	43
1987	107
1994	190
2001 (s)	292
2008	436
2015	585
2022	711

# 45P/Honda-Mrkos-Pajdusakova (7 returns)

1974	13
1990	144
1995	207
2001	291
2011	490
2016	609
2022	718

## 22P/Kopff (6 returns)

1983	55
1996	213
2002	313
2009	448
2015	572
2022	719

# 41P/Tuttle-Giacobini-Kresak (6 returns)

1973	9
1990	137
1995	200
2001	286
2006	390
2017	613

## 46P/Wirtanen (6 returns)

1986	92
1991	162
1997	224
2002	316
2008	416
2018	653

## 65P/Gunn (6 returns)

50
126
210
331
450
619

# 67P/Churyumov-Gerasimenko (6 returns)

1982	53
1996	206
2002	315
2009	444
2015 (s)	577
2021	704

## 73P/Schwassmann-Wachmann 3 (6 returns)

1990	140
1995	202
2001	284
2006	385
2017	612
2022	721

## 88P/Howell (6 returns)

103
245
349
457
566
678

# 96P/Machholz 1 (6 returns)

93
161
300
405
507
733

## 116P/Wild 4 (6 returns)

1990 (D)	138
1996	208
2003	327
2009	447
2016	589
2022	714

# 4P/Faye (5 returns)

1984	69
1991	163
1998	259
2006	393
2021	703

## 6P/d'Arrest (5 returns)

1976	23
1982	51
1995	198
2008	435
2021	705

## 10P/Tempel 2 (5 returns)

1983	57
1988	119
1999	265
2010	475
2015	584

# 21P/Giacobini-Zinner (5 returns)

1985 (s)	82
1998	248
2005	370
2012	497
2018	642

26P/Grigg-Skjellerup (5 returns)

24
49
102
429
526

## 43P/Wolf-Harrington (5 returns)

1984	72
1991	149
1997	233
2004	341
2016	601

## 62P/Tsuchinshan 1 (5 returns)

1985	80
1998	240
2004	361
2017	630
2023	747

78P/Gehrels 2 (5 returns)

1989	131
1997	234
2004	353
2012	492
2019	654

## 141P/Machholz 2 (5 returns)

1994 (D)	193
1999	273
2005	368
2015	581
2020	690

185P/Petriew (5 returns)

2001 (D-c)	294
2007	400
2012	506
2018	636
2023	738

(3200) Phaethon (5 returns)

1985 (r)	559
2005 (r)	560
2008 (r)	561
2016	607
2017	633

D: discovery return

D-c: discovery return, where I confirmed (or co-confirmed) the discovery

s: encountered by a spacecraft mission during the return

r: retroactive addition to my comet tally

Of the 154 numbered periodic comets I have observed, I observed 45 of them on their discovery return, and I observed one of the numbered "active asteroids" on my tally on its discovery return. Of the 45 numbered periodic comets I observed on their discovery returns, I confirmed (or co-confirmed) 4 of them. I observed 8 of the numbered periodic comets on their "re-discovery" returns, and confirmed 2 of these re-discoveries. I also confirmed the recovery of Comet 109P/Swift-Tuttle on its 1992 return (no. 173). I visually recovered Comet 37P/Forbes on its 1999 return (no. 262). Via the Las Cumbres Observatory network I recovered three of the returning periodic comets in my tally: 15P/Finlay on its 2021 return (no. 702); 13P/Olbers on its 2024 return (no. 752), and 333P/LINEAR on its 2024 return (no. 759).

### 10 LONGEST-PERIOD PERIODIC COMETS I HAVE OBSERVED ON TWO OR MORE RETURNS

(The given orbital periods are those that the comets in question exhibited at the most recent return during which I observed them.)

Year of Perihelion No.

1. 38P/Stephan-Oterma (37.9 years)

1980	38
2018	649

2. 27P/Crommelin (27.9 years)

1984	64
2011	489

3. 473P/NEAT (22.5 years)

2001 (D)	296
2024	754

4. 161P/Hartley-IRAS (21.5 years)

1984 (D)	63
2005	374

5. 155P/Shoemaker 3 (17.1 years)

1985 (D)	91
2002	328

6. 192P/Shoemaker-Levy 1 (16.4 years)

1990 (D)	146
2007	423

7. 290P/Jaeger (15.2 years)

1999 (D)	253
2014	534

8. 29P/Schwassmann-Wachmann 1 (14.8 years)

1974	47
1989	111
2004	226
2019	498

9. 8P/Tuttle (13.6 years)

1980	40
2008	415

10. 63P/Wild 1 (13.2 years)

1999	276
2013	519

D: discovery return

I have observed the following as-yet-unnumbered periodic comets on their respective discovery returns. If/when they are recovered they should presumably receive permanent numbers.

Jupiter-family comets (P < 20 years):

Haneda-Campos 1978j	30	(probably disintegrated)
Shoemaker-Levy 9 1993e	178	(destroyed)
Vales P/2010 H2	473	(possibly disintegrated)
McNaught P/2013 J2	528	
NEOWISE P/2014 L2	547	
ATLAS P/2021 Q5	708	

Halley-type comets (20 years < P < 200 years)

Levy 1991q	159
LINEAR C/1999 S3	269
BATTERS C/2001 W2	298
LONEOS C/2001 OG108	302

LINEAR C/2002 CE10	340
SWAN P/2005 T4	382
Siding Spring P/2006 HR30	394
La Sagra P/2012 NJ	505
Nevski C/2013 V3	535
Borisov C/2014 Q3	552
PANSTARRS C/2014 W11	564
SWAN-Xingming C/2015 F5	571
NEOWISE C/2015 X8	588
Weiland C/2018 K1	645
ATLAS C/2020 M3	685
NEOWISE C/2022 P1	724
ATLAS C/2023 E1	735
ATLAS C/2024 M1	760

Comet 75P/Kohoutek, which I observed on its 1987 return (no. 112), and Comet 85P/Boethin, which I observed on its 1986 return (no. 89), have not been seen since those respective returns, and have recently been reassigned the designations 75D/Kohoutek and 85D/Boethin, respectively. Comet 168P/Hergenrother, which I observed on its 2012 return (no. 511), underwent large outbursts and exhibited distinct signs of fragmentation and other evidence of disintegration on that return, and was missed on its subsequent return; it may, too, soon receive a "D" designation.

I have observed one interstellar comet:

2I/Borisov I/2019 Q4 no. 670

## **COMET "FAMILIES"**

The following comets I've observed are members of apparent "families:"

Kreutz sungrazers

Lovejoy C/2011 W3 no. 500

Other "families"

Liller 1988a	no. 116
Tabur C/1996 Q1	no. 219
SWAN C/2015 F5	no. 569
ATLAS C/2019 Y1	no. 671
Levy 1988e	no. 117
Shoemaker-Holt 1988g	no. 118

The following comets were found to share very similar orbits to comets that appeared in the past, and thus may also be members of "families:"

Borisov C/2016 R3	no. 606
ATLAS C/2019 Y4	no. 673

#### PERIHELION

The 761 comets I have observed have ranged in perihelion distance (q) from 0.006 AU for Comet Lovejoy C/2011 W3 (no. 500) to 8.454 AU for Comet 95P/Chiron P/1977 UB (no. 196). The average perihelion distance for the 761 comets is 1.523 +/- 1.008 AU and the median perihelion distance is 1.368 AU.

28 comets (3.7%) have a perihelion distance less than 0.2 AU, and 15 comets (2.0%) have a perihelion distance greater than 5.0 AU; an additional 6 comets have a perihelion distance between 4.0 and 5.0 AU, giving a total of 21 comets (2.8%) with perihelion distances greater than 4.0 AU.

Rank	Comet	q (AU)	no.
1.	Lovejoy C/2011 W3	0.006	500
2.	ISON C/2012 S1	0.012	529
3.	SOHO C/2015 D1	0.028	567
4.	ATLAS C/2024 G3	0.094	761
5.	NEAT C/2002 V1	0.099	323
6.	Machholz 1985e	0.106	83
7.	ASAS C/2004 R2	0.113	356
8.	96P/Machholz 1 96P-23	0.116	733
9.	96P/Machholz 1 96P-12	0.124	507
10.	96P/Machholz 1 96P-02	0.124	300
11.	96P/Machholz 1 96P-07	0.125	405
12.	96P/Machholz 1 96P-91	0.126	161
13.	96P/Machholz 1 1986e	0.127	93
14.	Phaethon (3200)-85	0.140	559
15.	Phaethon (3200)-05	0.140	560
16.	Phaethon (3200)-08	0.140	561

#### **Top 25 Smallest Perihelion Distances**

17.	Phaethon (3200)-18	0.140	633
18.	Phaethon (3200)-16	0.140	607
19.	Kohoutek 1973f	0.142	10
20.	SOHO C/1998 J1	0.153	242
21.	Machholz 1988j	0.165	120
22.	Bradfield C/2004 F4	0.168	350
23.	McNaught C/2006 P1	0.171	395
24.	SWAN C/2004 V13	0.181	364
25.	Kudo-Fujikawa C/2002 X5	0.190	324

# **Top 25 Largest Perihelion Distances**

Rank	Comet	q (AU)	no.
1.	95P/Chiron P/1977 UB	8.454	196
2.	Skiff C/1999 J2	7.110	277
3.	LINEAR C/2010 S1	5.900	494
4.	174P/Echeclus P/2000 EC98	5.817	384
5.	29P/Schwassmann-Wachmann 1 29P-89	5.772	111
6.	29P/Schwassmann-Wachmann 1 29P-19	5.767	498
7.	29P/Schwassmann-Wachmann 1 29P-04	5.724	226
8.	McNaught C/2005 L3	5.593	408
9.	McNaught C/2009 F4	5.455	520
10.	29P/Schwassmann-Wachmann 1 29P-74	5.448	47
11.	P/Shoemaker-Levy 9 1993e	5.380	178
12.	NEAT C/2001 B2	5.306	289
13.	LINEAR C/2003 WT42	5.191	383
14.	LINEAR C/2001 K5	5.184	306
15.	LONEOS C/2006 S3	5.131	480
16.	ATLAS C/2021 G2	4.982	756
17.	Spacewatch C/2011 KP36	4.883	600
18.	Dalcanton C/1999 F2	4.719	266
19.	PANSTARRS C/2015 V1	4.267	632
20.	ATLAS C/2019 T4	4.242	715

21.	LINEAR C/1999 K8	4.201	270
22.	LINEAR C/2017 B3	3.921	664
23.	NEOWISE C/2014 N3	3.882	551
24.	PANSTARRS C/2015 O1	3.730	621
25.	ATLAS C/2022 E2	3.666	750

## **OBSERVATIONAL INTERVAL**

The average observational interval for all 761 comets is 144.24 +/-361.67 days. The median observational interval is 66 days.

The longest observational interval is 5251 days, for the 2004 "return" of Comet 29P/Schwassmann-Wachmann 1 (no. 226). There are 39 comets (5.1% of the total) that have an observational interval of 0, i.e., only a single observation.

Of the 761 comets, 62 (8.1%) have an observational interval of over 1 year, 28 (3.7%) have an observational interval of over 18 months, 15 (2.0%) have an observational interval of over 2 years, 10 (1.3%) have an observational interval of over 3 years, and 5 (0.7%) have an observational interval of over 4 years.

## **Top 25 Longest Observational Intervals**

Rank	Comet	Int (days)	No.
1.	29P/Schwassmann-Wachmann 1 29P-04	5251	226
2.	29P/Schwassmann-Wachmann 1 29P-19	4783*	498
3.	174P/Echeclus P/2000 EC98	4362	384
4.	29P/Schwassmann-Wachmann 1 29P-89	3140	111
5.	Scheila (596)-17	1827	624
6.	Scheila (596)-12	1434	623
7.	Scheila (596)-22	1416	669
8.	LONEOS C/2006 S3	1302	480
9.	96P/Chiron P/1977 UB	1189	196
10.	LINEAR C/2010 S1	1096	494
11.	PANSTARRS C/2017 K2	1047	699
12.	Hale-Bopp C/1995 O1	1038	199
13.	Christensen C/2006 W3	972	422
14.	McNaught C/2005 L3	769	408

15.	ATLAS C/2019 L3	737	692
16.	Garradd C/2009 P1	677	478
17.	Spacewatch C/1997 BA6	672	256
18.	Siding Spring C/2007 Q3	643	441
19.	Broughton C/2006 OF2	624	410
20.	1P/Halley 1982i	622	85
21.	Catalina C/2013 US10	614	550
22.	PANSTARRS C/2012 K1	595	525
23.	Wilson 1986l	573	95
24.	LINEAR C/2003 K4	569	348
25.	Bowell 1980b	565	46

\*some possibility of additional observations in the future

## WITH RESPECT TO PERIHELION

Average comet: My first observation was  $72.11 \pm 237.21$  days before perihelion, and my final observation was  $72.03 \pm 211.14$  days after perihelion.

Median comet: My first observation was 39 days before perihelion, and my final observation was 44 days after perihelion.

For 193 comets (25.4%), I did not obtain my first observation until after perihelion. Of these, 60 (31.1%, 7.9% of the total) were not discovered or recovered until after perihelion.

My first observation for 22 comets (2.9%) came more than one year before perihelion, and my first observation for 2 comets (0.3%) did not come until more than one year after perihelion.

My final observation for 168 comets (22.1%) came before perihelion. My final observation for 17 comets (2.2%) came more than one year after perihelion.

# TOP 25 EARLIEST FIRST OBSERVATIONS WITH RESPECT TO PERIHELION

Rank	Comet	Pre-T (days)	No.
1.	174P/Echeclus P/2000 EC98	3389	384
2.	29P/Schwassmann-Wachmann 1 29P-04	2707	226
3.	29P/Schwassmann-Wachmann 1 29P-19	2624	498
4.	Scheila (596)-22	915	669
5.	Scheila (596)-17	913	624
6.	29P/Schwassmann-Wachmann 1 29P-89	742	111
7.	PANSTARRS C/2017 K2	638	699
8.	LINEAR C/2010 S1	631	494
9.	Hale-Bopp C/1995 O1	618	199
10.	Christensen C/2006 W3	573	422
11.	LONEOS C/2006 S3	568	480
12.	Scheila (596)-12	523	623
13.	Garradd C/2009 P1	504	478
14.	PANSTARRS C/2012 K1	450	525
15.	Catalina C/2013 US10	443	550
16.	Broughton C/2006 OF2	404	410
17.	ATLAS C/2019 L3	390	692
18.	P/Shoemaker-Levy 9 1993e	386	178
19.	95P/Chiron P/1977 UB	382	196
20T	Spacewatch C/1997 BA6	375	256
20. <b>-</b> T	LINEAR C/2011 F1	375	499
22.	65P/Gunn 65P-10	371	450
23.	Siding Spring C/2007 Q3	365	441
24.	Mueller 1993a	362	176
25.	Bowell 1980b	354	46

# TOP 25 LATEST FIRST OBSERVATIONS WITH RESPECT TO PERIHELION

Rank	Comet	Pre-T (days)	No.
1.	29P/Schwassmann-Wachmann 1 29P-74	-2637	47
2.	McNaught C/2009 F4	-402	520
3.	Dalcanton C1999 F2	-289	266
4.	213P/Van Ness P/2005 R2	-228	381
5.	33P/Daniel 33P-08	-217	449
6.	121P/Shoemaker-Holt 2 1989j	-214	125
7.	NEAT C/2001 B2	-195	289
8.	17P/Holmes 17P-07	-173	414
9.	Russell-Watson C/1996 P2	-165	218
10.	LINEAR C/2017 B3	-161	664
11.	Heck-Sause 1973a	-147	8
12.	57P/du Toit-Neujmin-Delporte 57P-96	-143	217
13.	19P/Borrelly 19P-15	-139	585
14.	121P/Shoemaker-Holt 2 P/1995 Q3	-136	225
15.	Borisov C/2013 V2	-127	565
16.	205P/Giacobini 205P-15	-126	583
17.	PANSTARRS C/2022 JK5	-115	743
18.	Levy 1988e	-114	117
19.	IRAS 19830	-101	66
20.	Shoemaker-Holt 1988g	-96	118
21.	McNaught C/2011 R1	-91	517
22.	154P/Brewington 1992p	-85	171
23.	Churyumov-Solodovnikov 1986i	-84	94
24.	88P/Howell 1987h	-76	103
25. <b>-</b> T	LINEAR C/2002 CE10	-71	340
25T	22P/Kopff 22P/22	-71	719

# TOP 25 EARLIEST FINAL OBSERVATIONS WITH RESPECT TO PERIHELION

Rank	Comet	Post-T (days)	No.
1.	P/Shoemaker-Levy 9 1993e	-364	178
2. <b>-</b> T	Shoemaker-Holt-Rodriguez 1988h	-254	121
2. <b>-</b> T	PANSTARRS C/2020 K1	-254	723
4.	240P/NEAT 240P-18	-231	627
5.	199P/Shoemaker 4 P/2008 G2	-220	437
6.	Helin-Lawrence 19911	-201	156
7.	Evans-Drinkwater C/1996 J1	-195	214
8.	Helin-Lawrence 1992q	-171	172
9.	65P/Gunn 65P-17	-148	619
10.	116P/Wild 4 1994v	-141	208
11. <b>-</b> T	65P/Gunn 65P-82	-139	50
11. <b>-</b> T	4P/Faye 4P-99	-139	259
13.	22P/Kopff 22P-02	-131	313
14.	78P/Gehrels 2 78P-19	-127	654
15.	NEOWISE C/2014 N3	-122	551
16.	81P/Wild 2 1983s	-121	67
17.	LINEAR C/2007 G1	-107	428
18. <b>-</b> T	116P/Wild 4 116P-22	-105	714
18. <b>-</b> T	ATLAS C/2021 G2	-105	756
20.	47P/Ashbrook-Jackson 1985a	-97	84
21.	LINEAR C/2011 F1	-96	499
22.	110P/Hartley 3 110P-01	-94	283
23.	ATLAS C/2021 P4	-89	716
24.	Phaethon (3200)-05	-86	560
25.	LINEAR C/2002 O7	-85	333

# TOP 25 LATEST FINAL OBSERVATIONS WITH RESPECT TO PERIHELION

Rank Comet

Post-T (days) No.

1.	29P/Schwassmann-Wachmann 1 29P-74	2985	47
2.	29P/Schwassmann-Wachmann 1 29P-04	2544	226
3.	29P/Schwassmann-Wachmann 1 29P-89	2398	111
4.	29P/Schwassmann-Wachmann 1 29P-19	2159*	498
5.	174P/Echeclus P/2000 EC98	973	384
6.	Scheila (596)-17	914	624
7.	Scheila (596)-12	911	623
8.	95P/Chiron P/1977 UB	808	196
9.	LONEOS C/2006 S3	734	480
10.	McNaught C/2005 L3	547	408
11.	Scheila (596)-22	501	669
12.	LINEAR C/2010 S1	465	494
13.	1P/Halley 1982i	438	85
14.	McNaught C/2009 F4	426	520
15.	Hale-Bopp C/1995 O1	420	199
16.	PANSTARRS C/2017 K2	409	699
17.	Christensen C/2006 W3	399	422
18.	17P/Holmes 17P-07	357	414
19.	ATLAS C/2019 L3	347	692
20.	Griseldis (493)-19	344	651
21.	ATLAS C/2019 T4	343	715
22.	LINEAR C/2003 K4	331	348
23.	Wilson 1986l	323	95
24.	17P/Holmes 17P-14	320	545
25.	Meier 1978f	312	28

\*some possibility of additional observations in the future

## NUMBER OF OBSERVATIONS

For this analysis an "observation" is defined as one observation of a given comet on one given night. Observations of multiple components of a comet on one given night are collectively considered as one "observation."

For the 761 comets, the average number of observations per comet is (rounded to the nearest whole number) 11 (mathematically, 10.7 + 14.1). The median number of observations is 7.

The comet with the most observations is Comet Hale-Bopp C/1995 O1 (no. 199), with 182 observations. For periodic comets with all returns combined, the comet with the most observations is 29P/Schwassmann-Wachmann 1, with 383 observations over 4 returns.

Of the 761 comets, 39 (5.1%) have only a single observation, and an additional 79 comets (10.4%) have only two observations.

Of the 761 comets, 11 (1.4%) have 50 or more observations, and 4 (0.5%) have 100 or more observations.

## **TOP 25 COMETS WITH MOST OBSERVATIONS**

Rank	Comet	Observations	No.
1.	Hale-Bopp C/1995 O1	182	199
2.	29P/Schwassmann-Wachmann 1 29P-	04 181	226
3.	29P/Schwassmann-Wachmann 1 29P-	19 136*	498
4.	1P/Halley 1982i	100	85
5.	Christensen C/2006 W3	64	422
6.	Garradd C/2009 P1	62	478
7. <b>-</b> T	29P/Schwassmann-Wachmann 1 29P-	89 58	111
7. <b>-</b> T	Machholz C/2004 Q2	58	355

9. <b>-</b> T	LONEOS C/2006 S3	54	480
9. <b>-</b> T	LINEAR C/2010 S1	54	494
11.	Lovejoy C/2014 Q2	51	556
12.	Bowell 1980b	46	46
13. <b>-</b> T	Broughton C/2006 OF2	44	410
13. <b>-</b> T	PANSTARRS C/2011 L4	44	504
13. <b>-</b> T	PANSTARRS C/2012 K1	44	525
16.	LINEAR C/2002 T7	43	338
17. <b>-</b> T	Levy 1990c	42	141
17. <b>-</b> T	McNaught C/2005 L3	42	408
19.	Wilson 1986l	41	95
20.	Catalina C/2013 US10	38	550
21. <b>-</b> T	Bradfield 1987s	37	105
21. <b>-</b> T	Meunier-Dupouy C/1997 J2	37	230
21. <b>-</b> T	153P/Ikeya-Zhang P/2002 C1	37	301
21. <b>-</b> T	LINEAR C/2003 K4	37	348
21. <b>-</b> T	Lulin C/2007 N3	37	432

\*some possibility of additional observations in the future

#### TOP 25 PERIODIC COMETS WITH MOST OBSERVATIONS (ALL OBSERVED RETURNS COMBINED)

Rank	Comet	Observations	Returns
1.	29P/Schwassmann-Wachmann 1	383*	4
2.	81P/Wild 2	114	8
3.	1P/Halley	100	1
4.	2P/Encke	93	14
5.	19P/Borrelly	88	7
6.	10P/Tempel 2	86	5
7.	22P/Kopff	84	6
8. <b>-</b> T	88P/Howell	81	6
8. <b>-</b> T	(596) Scheila	81	3

21P/Giacobini-Zinner	80	5
67P/Churyumov-Gerasimenko	78	6
46P/Wirtanen	75	6
65P/Gunn	73	6
116P/Wild 4	72	6
9P/Tempel 1	69	4
73P/Schwassmann-Wachmann 3	69	6
103P/Hartley 2	67	4
6P/d'Arrest	60	5
45P/Honda-Mrkos-Pajdusakova	57	7
78P/Gehrels 2	52	5
71P/Clark	50	4
4P/Faye	48	5
43P/Wolf-Harrington	47	5
62P/Tsuchinshan 1	44	5
17P/Holmes	42	2
41P/Tuttle-Giacobini-Kresak	42	6
	21P/Giacobini-Zinner 67P/Churyumov-Gerasimenko 46P/Wirtanen 65P/Gunn 116P/Wild 4 9P/Tempel 1 73P/Schwassmann-Wachmann 3 103P/Hartley 2 6P/d'Arrest 45P/Honda-Mrkos-Pajdusakova 78P/Gehrels 2 71P/Clark 4P/Faye 43P/Wolf-Harrington 62P/Tsuchinshan 1 17P/Holmes 41P/Tuttle-Giacobini-Kresak	21P/Giacobini-Zinner 80   67P/Churyumov-Gerasimenko 78   46P/Wirtanen 75   65P/Gunn 73   116P/Wild 4 72   9P/Tempel 1 69   73P/Schwassmann-Wachmann 3 69   103P/Hartley 2 67   6P/d'Arrest 60   45P/Honda-Mrkos-Pajdusakova 57   78P/Gehrels 2 52   71P/Clark 50   42 47   62P/Tsuchinshan 1 44   17P/Holmes 42   41P/Tuttle-Giacobini-Kresak 42

\*some possibility of additional observations in the future

#### **PEAK BRIGHTNESS**

Of the 761 comets, the average peak brightness that I have observed is magnitude  $10.7 \pm 3.0$ , and the median peak brightness is magnitude 11.4.

I have observed 69 comets (9.1%) for which I observed a peak brightness of magnitude 6.0 or brighter. Of these, I have observed 47 comets (6.2%) with my unaided eye.

I have observed 19 comets (2.5%) for which I observed a peak brightness of magnitude 14.5 or fainter. Of these, for 7 comets (0.9% of the total) I observed a peak brightness of magnitude 15.0 or fainter.

The brightest comet I have observed is Comet McNaught C/2006 P1 (no. 395), for which I measured a peak brightness of magnitude -4 (during daytime) on 2007 January 13. The faintest brightness I have ever measured is magnitude 15.4, for Comet 95P/Chiron P/1977 UB (no. 196) during my sole observation during its 1998 opposition (1998 May 2).

## **TOP 20 BRIGHTEST COMETS**

Rank	Comet	Peak Mag.	No.
1.	McNaught C/2006 P1	-4	395
2.	West 1975n	-3	20
3.	ATLAS C/2024 G3	-2	761
4.	Hale-Bopp C/1995 O1	-1.1	199
5T	Bennett 1969i	0	2
5T	Hyakutake C/1996 B2	0.1	212
7. <b>-</b> T	NEOWISE C/2020 F3	0.6	676
7. <b>-</b> T	Tsuchinshan-ATLAS C/2023 A3	1	749
9.	PANSTARRS C/2011 L4	1.5	504
10.	1P/Halley 1982i	1.9	85

11.	17P/Holmes 17P-07	2.3	414
12.	IRAS-Araki-Alcock 1983d	2.5	56
13. <b>-</b> T	Kohoutek 1973f	3	10
13. <b>-</b> T	153P/Ikeya-Zhang P/2002 C1	2.8	301
15.	NEAT C/2001 Q4	3.1	339
16.	Aarseth-Brewington 1989a1	3.2	133
17.	Levy 1990c	3.5	141
18.	LINEAR C/2001 A2	3.6	290
19. <b>-</b> T	NEAT C/2002 V1	3.7	322
19. <b>-</b> T	Machholz C/2004 Q2	3.7	355

The above table reflects the fact that some brightness measurements for the brightest comets are very approximate, having been made in daylight (for Comets C/2006 P1 and C/2024 G3) and/or at low altitude during bright twilight, and also the fact that the magnitude parameters for some of my very earliest comets are educated "guesstimates" somewhat in hindsight.

## **INTERVAL BETWEEN TALLY ADDITIONS**

For the purposes of these calculations, I consider "date 0" to be the date I acquired my first telescope, i.e., January 17, 1970. I added my first comet 16 days later.

The average interval between additions to my tally is  $26.4 \pm 35.9$  days, and the median interval is 17.5 days.

There have been two occasions when I have added three comets to my tally during a single night:

1993 December 14 (evening)

Comet 2P/Encke 2P-94	no. 181
Comet 76P/West-Kohoutek-Ikemura 1993o	no. 182
Comet 31P/Schwassmann-Wachmann 2 31P-94	no. 183

2001 August 7 (morning)

Comet 48P/Johnson 48P-11	no. 491
Comet 78P/Gehrels 2 78P-12	no. 492
Comet 130P/McNaught-Hughes 130P-11	no. 493

There have been 39 additional occasions when I have added two comets to my tally during a single night. One five of those occasions, I added one comet during the evening hours (i.e., before local midnight) and the other comet during the morning hours (i.e., after local midnight); on one of those occasions, the date change at midnight also corresponded to a change of the month. There have been two additional occasions when I added two comets on the same calendar date, one in the morning and one during the following evening; these accordingly correspond to two consecutive nights. The longest interval between two consecutive tally additions is 366 days, between Comet Toba 1971a (no. 6) and Comet Bradfield 1972f (no. 7).

I have added 343 comets (45.1%) during the evening hours and 418 comets (54.9%) during the morning hours. I added one of the morning-added comets, Comet ATLAS C/2024 G3 (no. 761), during daytime, before local noon.

## **CALENDAR MONTHS**

The various totals for each calendar month, for comet discoveries, comets passing through perihelion, and comets added to my tally, are listed below. I have included rankings for the top three months and bottom three months in each category.

For the purposes here, I consider the recovery of a periodic comet as a "discovery." For "annual" comets, i.e., those that are observable (with suitably large telescopes and instrumentation) throughout their orbits, I have defined "recovery" as being the first-reported earliest observation following the comet's aphelion. (By this definition, my visual observations constitute the "recoveries" of (596) Scheila on its 2017 and 2022 "returns.")

The average value would be 63.4 events per month, for each category of event.

MONTH	DISCOV	ERY	PERIHELION ADD		PERIHELION AD		DD	
January	73	2 <sup>nd</sup> -T	67		64			
February	34	$12^{th}$	55	11 <sup>th</sup>	50	$10^{\text{th}}$		
March	62		67		65			
April	50	11 <sup>th</sup>	71	$2^{nd}$	46	$11^{\text{th}}$		
May	79	1 <sup>st</sup>	62		66			
June	63		35	$12^{\text{th}}$	42	$12^{th}$		
July	67		61		66			
August	71		58		83	1 <sup>st</sup>		
September	73	$2^{nd}$ -T	69	3 <sup>rd</sup> -T	75	$2^{nd}$ -T		
October	63		69	3 <sup>rd</sup> -T	62			
November	67		57	$10^{\text{th}}$	75	$2^{nd}$ -T		
December	59	$10^{\text{th}}$	90	1 <sup>st</sup>	67			

I have observed 31 comets (4.1%) that were discovered, that passed through perihelion, and that I added to my tally all within the same calendar month. I have observed 73 comets (9.6%) that were discovered, that passed through perihelion, and that I added to my tally all within different calendar years.

The following are what I consider to be the "best" comet to have the event in question during each calendar month:

#### DISCOVERY

MONTH	YEAR	COMET	No.
January	1996	Hyakutake C/1996 B2	212
February	2002	153P/Ikeya-Zhang P/2002 C1	301
March	2020	NEOWISE C/2020 F3	676
April	2024	ATLAS C/2024 G3	761
May	2007	17P/Holmes 17P-07	414
June	2018	46P/Wirtanen 46P-18	653
July	1995	Hale-Bopp C/1995 O1	199
August	2006	McNaught C/2006 P1	395
September	1975	West 1975n	20
October	1982	1P/Halley 1982i	85
November	1989	Aarseth-Brewington 1989a1	133
December	1969	Bennett 1969i	2

#### PERIHELION

MONTH	YEAR	COMET	No.
January	2007	McNaught C/2006 P1	395
February	1976	West 1975n	20

March	1970	Bennett 1969i	2
April	1997	Hale-Bopp C/1995 O1	199
May	1996	Hyakutake C/1996 B2	212
June	2006	73P/Schwassmann-Wachmann 3 73P-06	385
July	2020	NEOWISE C/2020 F3	676
August	1982	Austin 1982g	52
September	2024	Tsuchinshan-ATLAS C/2023 A3	749
October	1990	Levy 1990c	141
November	1987	Bradfield 1987s	105
December	1973	Kohoutek 1973f	10

## ADD

MONTH	YEAR	COMET	No.
January	2025	ATLAS C/2024 G3	761
February	1976	West 1975n	20
March	1970	Bennett 1969i	2
April	2020	NEOWISE C/2020 F3	676
May	1983	IRAS-Araki-Alcock 1983d	56
June	1995	6P/d'Arrest 6P-95	198
July	1995	Hale-Bopp C/1995 O1	199
August	1985	1P/Halley 1982i	85
September	2006	McNaught C/2006 P1	395
October	2007	17P/Holmes 17P-07	414
November	1989	Aarseth-Brewington 1989a1	133
December	2023	Tsuchinshan-ATLAS C/2023 A3	749

#### NAMES

A total of 258 individual names appear within the list of the 761 comets. Of these, 223 (86.4%) are of actual people, 23 (8.9%) are observatories or survey programs, 5 (1.9%) are spacecraft or space-based telescopes, and 7 (2.7%) are mythological, fictional, or allegorical characters. One comet has not received a name.

119 (46.1%) of the names (including "Hale") appear only once in the tally.

#### **TOP 20 COMMONLY OCCURRING NAMES**

Rank	Name	Entries	Separate Comets
1.	LINEAR	76	71
2.	PANSTARRS	31	30
3.	Rob McNaught	28	25
4.	ATLAS	22	22
5T	Carolyn Shoemaker	21	16
5T	Don Machholz	21	12
7. <b>-</b> T	David Levy	18	15
7. <b>-</b> T	NEAT	18	12
9.	Malcolm Hartley	17	9
10.	Paul Wild	16	3
11. <b>-</b> T	SWAN	14	14
11. <b>-</b> T	Johann Encke	14	1
13. <b>-</b> T	William Bradfield	13	13
13. <b>-</b> T	Arnold Schwassmann	13	3
13. <b>-</b> T	Arno Wachmann	13	3
16.	William Tempel	11	4
17.	Horace Tuttle	10	4
18. <b>-</b> T	NEOWISE	9	9
18. <b>-</b> T	Lemmon	9	9

18. <b>-</b> T	Catalina	9	8
18. <b>-</b> T	Tom Gehrels	9	2

The top name on this list, LINEAR, alone accounts for 10.0% of the entire tally and 13.3% of all the separate comets I have observed.

#### **APPROACHES TO EARTH**

Of the 761 comets, 32 (4.2%) have approached to within 0.2 AU of Earth during their respective apparitions. Of these, 12 (1.6%) have approached to within 0.1 AU of Earth.

#### **TOP 25 CLOSEST EARTH-APPROACHING COMETS**

Rank	Comet	Delta_min (AU)	No.
1.	(101955) Bennu 1999 RQ36	0.015	660
2.	460P/PANSTARRS P/2016 BA14	0.024	595
3.	IRAS-Araki-Alcock 1983d	0.031	56
4.	252P/LINEAR 252P-16	0.036	592
5.	209P/LINEAR 209P-14	0.055	543
6.	45P/Honda-Mrkos-Pajdusakova 45P-1	1 0.060	490
7.	Sugano-Saigusa-Fujikawa 1983e	0.063	58
8.	(3200) Phaethon (3200)-18	0.069	633
9.	(65803) Didymos (65803)-22	0.071	725
10.	46P/Wirtanen 46P-18	0.077	653
11.	73P/Schwassmann-Wachmann 3 73P-	06 0.079*	385
12.	45P/Honda-Mrkos-Pajdusakova 45P-1	6 0.083	609
13.	Hyakutake C/1996 B2	0.102	212
14.	300P/Catalina P/2005 JQ5	0.103	375
15.	Suzuki-Saigusa-Mori 1975k	0.104	17
16.	364P/PANSTARRS 364P-23	0.121	734
17.	103P/Hartley 2 103P-10	0.121	477
18.	(3200) Phaethon (3200)-08	0.121	561

19.	41P/Tuttle-Giacobini-Kresak 41P-17	0.142	613
20.	169P/NEAT 169P-05	0.147	378
21.	6P/d'Arrest 1976e	0.151	23
22.	P/Haneda-Campos 1978j	0.154	30
23.	45P/Honda-Mrkos-Pajdusakova 45P-95	0.169	207
24.	222P/LINEAR P/2009 MB9	0.173	461
25.	26P/Grigg-Skjellerup 1977b	0.182	24

\*This value is for the primary component (component C). I also observed (as separate entities) components B, G, and R, which passed 0.067, 0.065, and 0.064 AU from Earth, respectively.

#### **TOP 10 LONGEST COMETARY TAILS**

Rank	Comet	Tail (degrees)	No.
1.	Hyakutake C/1996 B2	70	212
2.	West 1975n	26	20
3.	1P/Halley 1982i	25	85
4. <b>-</b> T	Hale-Bopp C/1995 O1	18	199
4. <b>-</b> T	Tsuchinshan-ATLAS C/2023 A3	18	749
6.	Kohoutek 1973f	15	10
7.	NEOWISE C/2020 F3	12	676
8.	Bennett 1969i	>10	2
9.	Bradfield C/2004 F4	8.5	350
10. <b>-</b> T	SOHO C/1998 J1	8	242
10. <b>-</b> T	153P/Ikeya-Zhang P/2002 C1	8	301

#### **COMETS VISITED BY SPACECRAFT**

The following comets I have observed were encountered by spacecraft missions during the returns in which I observed them.

Comet	No.	Spacecraft
21P/Giacobini-Zinner 1984e	82	International
		Cometary Explorer
1P/Halley 1982i	85	Sakigake, Suisei,
-		Vega 1, Vega 2,
		Giotto
19P/Borrelly 19P-01	292	Deep Space 1
81P/Wild 2 81P-03	332	Stardust
9P/Tempel 1 9P-05	367	Deep Impact
103P/Hartley 2 103P-10	477	EPOXI (repurposed
		Deep Impact)
67P/Churyumov-Gerasimenko 67P	-15 577	Rosetta

The following comets I have observed were also encountered by spacecraft missions but not during the returns during which I observed them:

Comet	Spacecraft	Return
26P/Grigg-Skjellerup	Giotto	1992
9P/Tempel 1	Stardust	2011
(101955) Bennu	OSIRIS-REx	2019, 2020, 2021

#### **RECORD OBSERVATIONS**

Largest heliocentric distance: Value: 13.049 AU Comet: 174P/Echeclus P/2000 EC98 (no. 384) Date: 2006 January 10

Smallest heliocentric distance: Value: 0.119 AU Comet: ATLAS C/2024 G3 (no. 761) Date: 2025 January 14

Largest geocentric distance: Value: 13.022 AU Comet: 174P/Echeclus P/2000 EC98 (no. 384) Date: 2006 January 10

Smallest geocentric distance: Value: 0.019 AU Comet: (101955) Bennu 1999 RQ36 (no. 660) Date: 1999 September 19

Smallest elongation: Value: 5.5 degrees Comet: McNaught C/2006 P1 (no. 395) Date: 2007 January 13

Farthest north: Value: Declination +89d 56' Comet: Boattini C/2008 J1 (no. 430) Date: 2008 October 30 Farthest south: Value: Declination -75d 06' Comet: PANSTARRS C/2016 M1 (no. 629) Date: 2019 February 1

My record for most comets observed in one night is 15, which took place on the night of March 21-22, 2009. My record for most comets observed in one year is 39, set in 2015. My record for most comet observations made in one year is 334, set in 2008.

#### **MISCELLANEOUS COMMENTS**

There have been four occasions when I observed two comets within the same telescopic field of view:

1994 June 9: Comet McNaught Russell 1993v (no. 186) Comet Takamizawa-Levy 1994f (no. 187)

1996 February 19: Comet 65P/Gunn 65P-96 (no. 210) Comet 22P/Kopff 1994s (no. 213)\* \*added to my tally

2019 September 7 Comet ASASSN C/2018 N2 (no. 657) Comet 260P/McNaught 260P-19 (no. 666)

2023 August 27 Comet 29P/Schwassmann-Wachmann 1 29P-19 (no. 498) Comet Nishimura C/2023 P1 (no. 742) There have been three occasions when I have observed two comets within the same binocular field of view:

1996 June 16 Comet Hale-Bopp C/1995 O1 (no. 199) Comet 22P/Kopff 1994s (no. 213)

1996 June 24 Comet Hale-Bopp C/1995 O1 (no. 199) Comet 22P/Kopff 1994s (no. 213)

2014 February 8 Comet Lovejoy C/2013 R1 (no. 532) Comet LINEAR C/2012 X1 (no. 533)

There have been two occasions when I have observed two comets simultaneously with my naked eye:

2004 April 29 Comet LINEAR C/2002 T7 (no. 338) Comet Bradfield C/2004 F4 (no. 350)

2007 December 30 Comet 17P/Holmes 17P-07 (no. 414) Comet 8P/Tuttle 8P-08 (no. 415) I have observed three comets telescopically during daylight hours, i.e., the sun's being above the horizon:

Comet Hale-Bopp C/1995 O1 (no. 399):	1997 March 4
Comet McNaught C/2006 P1 (no. 395):	2007 January 12 2007 January 13 2007 January 14
Comet ATLAS C/2024 G3 (no. 761):	2025 January 14

I obtained my daytime observation of Comet Hale-Bopp by following it for one minute past sunrise. I obtained my daytime observations of Comet McNaught and Comet ATLAS during broad daylight by utilizing altitude and azimuth offsets from the sun.

I have never succeeded in observing a comet during a total solar eclipse. I have observed numerous comets during total (and deep partial) lunar eclipses – the first occasion being Comet Bowell 1980b (no. 46) during the eclipse on 1982 July 5-6 – and on three occasions I have added comets to my tally during total lunar eclipses:

2003 November 8	Comet Tabur C/2003 T3 (no. 344)
2015 September 27	Comet 10P/Tempel 2 10P-15 (no. 584)
2022 May 15	Comet PANSTARRS C/2021 O3 (no. 717)

I have observed comets from 10 states within the U.S. (four of which I have lived within during the times in question), plus the District of Columbia:

Arizona California (resident) Colorado Maryland (resident) New Mexico (resident) Oklahoma Tennessee Texas (resident) Utah Washington

I have observed comets from six countries outside the U.S.:

Australia Indonesia Iran Mexico New Zealand Zimbabwe

I have observed comets from locations in international waters:

Caribbean Sea Pacific Ocean

I have made unsuccessful visual attempts for an additional 281 comets that are not on my tally. (Some of these are returns of periodic comets that I have successfully observed on other returns.) When I had my CCD imaging system operational during the early- to mid-2000s I imaged 13 comets which I did not observe visually. (I unsuccessfully attempted all of them.) I did successfully visually observe one of them (201P/LONEOS) on a subsequent return (in 2015, no. 563).

Since 2017, and up to this writing, I have remotely imaged 81 comets via the Las Cumbres Observatory network that I have not observed visually. It is conceivable that in the future I might visually observe a handful of those I have recently imaged.

I have visually observed 30 "asteroids" (25 of these being separate objects, the other 5 being additional returns of four of those objects) that I consider as reasonable candidates for being "extinct" or "dormant" comets that conceivably could show cometary activity in the future (or be found to have done so in the past) and thus eligible to be added to my tally retroactively. (In theory, this statement could apply to any asteroid I have observed). One of these objects, (139359) 2001 ME1, is a recently-identified "dark comet" that exhibits non-gravitational accelerations suggestive of cometary outgassing. Another object, (65407) 2002 RP120, is a "Damocloid," i.e., an inactive object in a Halley-type or long-period orbit.

When I had my CCD imaging system operational during the early- to mid-2000s I imaged one of these objects – 2000 DG8, a "Damocloid" – that I did not observe visually (although I did attempt it, unsuccessfully).

As of this writing I have remotely imaged 12 of these objects via the Las Cumbres Observatory network that I did not observe visually. Two of these are objects that I have visually observed during previous returns.

#### **"BEST" COMETS**

The following list is my semi-objective, semi-subjective determination of what I consider to be the "best" comets I have ever observed. The rankings include factors like brightness, tail length, ease of visibility, and placement in the sky, as well as a subjective "feel" of the comet's overall spectacle and its personal effect on me.

## **TOP 25 "BEST" COMETS**

Rank	Comet	No.
1.	West 1975n	20
2.	Hale-Bopp C/1995 O1	199
3.	Hyakutake C/1996 B2	212
4.	Bennett 1969i	2
5.	Tsuchinshan-ATLAS C/2023 A3	749
6.	NEOWISE C/2020 F3	676
7.	McNaught C/2006 P1	395
8.	ATLAS C/2024 G3	761
9.	1P/Halley 1982i	85
10.	153P/Ikeya-Zhang P/2002 C1	301
11.	Kohoutek 1973f	10
12.	IRAS-Araki-Alcock 1983d	56
13.	17P/Holmes 17P-07	414
14.	Levy 1990c	141
15.	NEAT C/2001 Q4	339
16.	LINEAR C/2001 A2	290
17.	Machholz C/2004 Q2	355
18.	46P/Wirtanen 46P-18	653
19.	PANSTARRS C/2011 L4	504
20.	Lovejoy C/2014 Q2	556
21.	Bradfield 1974b	11

22.	Aarseth-Brewington 1989a1	133
23.	Lulin C/2007 N3	432
24.	Kobayashi-Berger-Milon 1975h	16
25.	Bradfield C/2004 F4	350

The "best" (i.e., most spectacular and awe-inspiring) comet observation I have made is of Comet West 1975n (no. 20) from the parking lot of White Sands National Monument (now White Sands National Park), New Mexico, on the morning of March 3, 1976.

16 Springs Canyon, New Mexico, USA February 23, 2025